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Reliability of Serviceability and Strength of Deep Foundations Embedded in (p-y) Sand Below Water Table Subjected to Lateral Cyclic Loading

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Reliability of Serviceability and Strength of Deep Foundations Embedded in (p-y) Sand Below Water Table Subjected to Lateral Cyclic Loading

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ABSTRACT

Piles are used in many engineering applications especially when we have weak soil that cannot support the proposed structure, also when we have a scour issue with the soil (especially in designing foundations for bridges), or when large uplift capacity is needed. In many engineering applications the piles are subjected to lateral loads as well as axial loads.

Many design variables (uncertainties) affect the behavior of laterally loaded piles and the pile-soil system and their modeling. In reality when engineers are faced with uncertainties, they use a factor of safety to design the structure or a component, which is a conservative approach.

Reliability is a probabilistic method of analysis that provides consistent measurements for propagation of uncertainties and unifying framework for risk assessment. For this reason it is used instead of the factor of safety to provide a systematic account for the uncertainties and a rational procedure for the design.

DEDICATION

This thesis is dedicated to my family members, my husband Ziad, my kids Marwan and Tareq. And especially my Father Salah and Mother Awatif for their efforts in raising and teaching me to reach this achievement.

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NOMENCLATURE

A_s = Dimensionless coefficient.

ε_{50} =Strain at which 50% of the soil (sand) is mobilized.

B_s = Dimensionless coefficient.

B = Width of the pile.

β = Reliability index of the pile.

COV (M_{max}) = Coefficient of variation of pile bending moment.

COV (Y_{TOP}) = Coefficient of variation of pile head deflection.

$C_{p\phi}$ =Passive pressure factor.

D = Diameter of member piles in a group.

EI = Flexural stiffness of the beam.

f_m = p- multiplier.

ϕ = Angle of internal friction.

ϕ_t = Top flexural rotation of the pile.

G_e = Pile group efficiency.

H_c = Characteristic shear load.

H_t =Horizontal load applied at the ground line.

γ' = Unit weight of the soil.

k = Coefficient of subgrade reaction.

k_s = Subgrade soil modulus.

K_a = Coefficient of active lateral earth pressure of Rankine type.

K_o = Coefficient of earth pressure at rest.

M_c = Characteristic moment load.

M_t = the moment at the ground line.

M_{max} = Maximum bending moment of the investigated pile.

M_{max}^{o} = Mean value of pile bending moment.

M_{max}^{M} = Margin of safety of pile bending moment.

$(M_{max}^{M})^{o}$ = Mean value of margin of safety of pile bending moment.

M_{max}^{Max} = Maximum allowable bending moment of the pile.

μ_F = Mean value of the load.

μ_M = Mean value of the margin of safety.

μ_Q = Mean value of the capacity.

N_r = the number of rows.

P = Horizontal force applied to pile head.

p = Soil response.

P_G = Force applied to the cap pf primary pile group.

P_f = Probability of failure.

Pgp = Lateral load resistance of a pile in a group that is p-value for the pile in the group.

P_s = The ultimate soil resistance.

P_{sd} = The ultimate soil resistance associated with lower part of the pile.

$(P_s)_g$ = The ultimate lateral load capacity of the pile group.

$(P_s)_s$ = The lateral load capacity of single pile.

P_{st} = The ultimate soil resistance associated with upper part of the pile.

Psp = Lateral load resistance of a single pile that is p-value for a single pile.

S_x = Covariance matrix for random variable.

σ_F = Standard deviation of the load.

σ_M = Standard deviation of the margin of safety.

σ_P =Representative passive pressure of soil.

σ_Q = Standard deviation of the capacity.

σM_{max} = Standard deviation of maximum bending moment.

σM_{max}^{M} = Standard deviation of margin of safety of maximum bending moment.

σM_{max}^{Max} = Standard deviation of maximum allowable bending moment.

σY_{TOP} = Standard deviation of pile head deflection.

σY_{TOP}^{M} = Standard deviation of margin of safety of pile head deflection.

σY_{TOP}^{Max} = Standard deviation of maximum allowable deflection of pile head.

T_m = Relative stiffness of pile under bending moment.

T_p = Relative stiffness of pile under horizontal force.

$Var(M_{max})$ = Variance of maximum bending moment.

$Var(Y_{TOP})$ = Variance of pile head deflection.

y = Deflection of the pile at a arbitrary depth.

Y_{TOP} = Top lateral deflection.

Y_{TOP}^{o} = Mean value of pile head deflection.

Y_{TOP}^{M} = Margin of safety of pile head deflection.

$(Y_{TOP}^{M})^{o}$ = Mean value of margin of safety of pile head deflection.

Y_{TOP}^{Max} = Maximum allowable deflection of pile head.

CHAPTER ONE

INTRODUCTION

1.1 Laterally loaded pile

Piles are mainly used to transmit axial forces, from various structures, to the subsoil. Piles are used in many engineering application especially when there is weak soil that cannot support the proposed structure. They are also used when there is scour issue with the soil (especially in designing foundations for bridges), or when large uplift capacity is needed. Since the main structural forces are gravity loads, the majority of piles are constructed to carry these vertical loads. However, many structures which must be constructed on piles are not only subjected to vertical gravity forces, but also to horizontal forces. In order to transmit these horizontal forces through pile as axial forces, some of the piles should be constructed as inclined piles (battered piles). Construction of inclined piles in most of the cases is either not possible or if possible not feasible from a economical point of view. For such structures, piles, constructed vertically, must be designed not only to transmit vertical forces, but also to transmit horizontal forces to subsoil. The horizontal force that is exerted to the piles may result from the following:

- Wind forces acting on buildings, bridges, large signs or other structures,
- Centripetal forces from vehicular traffic on curved bridges,
- Loads on bridges resulting from accelerating, braking or turning of vehicles,
- Lateral seismic forces from earthquake,
- Forces acting on offshore or near shore structures resisting ocean wave or water currents,
- Lateral loads acting on earth retaining structure and dams.

In case of axially loaded pile, the design of a pile can be accomplished by solving the equations of static equilibrium. On the other hand, the analysis of a pile under lateral loading requires the solution of non-linear differential equation. The solution is possible if non-linear relationships of soils, represented by p-y curves are employed. This solution represents the soil resistance as a function of pile deflection along the length of a pile. Iteration must be employed because the soil response is a non-linear function of pile deflection and of position along the length of pile. The iteration by finite difference method leads to compatibility between pile deflection and soil resistance, while the iteration by finite element method leads not only to compatibility between pile deflection and soil resistance but also condition of equilibrium.

1.2 Objective

The performance of the laterally loaded pile depends on a number of parameters, called design variables. In this thesis these design variables are summarized as:

- pile bending stiffness, EI
- pile diameter, B
- submerged unit weight, γ'
- angle of internal friction of soil, Φ
- modulus of sub-grade reaction, k
- lateral load, P

In order to accomplish efficient and optimum design it is important to study and visualize the behavior of laterally loaded pile embedded in soil. A well designed pile should have its top lateral deflection or rotation at the top within certain limits. This means that lateral deflection and rotation of pile at the top are the measures of engineering performance of the pile. Calculation of deformation of laterally loaded pile is lengthy and complicated. Unlike axial deformation under vertical loads, lateral deformation is substantial which must be taken into account.

Traditionally, the design of infrastructure involves consideration of only initial conditions, loads, geometry, and material properties as the primary input variables for structural analysis without taking into account the result of material degradation due to environmental effects with time. Such an approach does not adequately assess the actual service life of the structure. With the concept of serviceability limit state design, structures to be designed to maintain desired serviceability throughout the span of time for which the structure is designed for. The structure will have a good performance if it provides an acceptable level of serviceability when constructed as well as throughout its designed lifetime. As part of infrastructure that supports the superstructure, laterally loaded piles require maintenance services, future rehabilitations, renovations and replacements. The deterioration of the pile-soil system results in increase of deformations especially top lateral deflection, y and top flexural rotation $ø_t$ of the pile. The key factors that cause such deterioration of pile-soil system are material degradation due to aging and construction quality. It is therefore essential to develop a method that provides a theoretical basis for assessment of change of maximum deformations expressed in terms of possible changes of material properties.

The uncertain performance of deep foundations is affected by many factors such as spatial variation of soil properties, limited soil exploration programs, uncertainties in the parameters determined by various testing methods and analysis, limited calculations models or error in the models as well as uncertainties in loads. Every site is considered as unique in terms of subsurface conditions that vary spatially within a site. The variability of subsurface conditions within and between sites leads to uncertainty in the information needed in geotechnical design. These uncertainties have been traditionally accounted for through a variety of conservative design practices such as:

- use of extreme loading conditions
- conservative soil properties
- safety factor

The uncertainties exist in soil-pile system due to many factors as discussed above. There is a need to account for these uncertainties in the parameters that affect the performance of the pile system. In reliability analysis, the uncertainties are represented by Coefficients of Variation (COV). The COV of different type of parameters contribute to overall performance of the pile-soil system. A probabilistic analysis gives therefore more insight into significant components of an investigated problem than parametric analysis. Moreover the probabilistic assessments are valuable complements to deterministic analysis.

The objective of this study is to perform the reliability analysis of laterally loaded single piles and pile groups embedded in sand below water table subjected to cyclic loading. Statistical analysis (determination of Var(Y_{Top}), Var M($_{Max}$), Y^{o}_{Top}, M^{o}_{Max}) is used to assess the laterally loaded pile and pile group embedded in p-y sand for ultimate and serviceability limit state (M_{Max}^{M} and Y_{Top}^{M}) through probabilistic modeling and reliability analysis. The goals behind this study are:

1. To investigate dimensionless parameter i.e. coefficient of variation (COV) of the function of random variables such as maximum deflection Y_{Top} (connected with Serviceability Limit State) and maximum bending moment M_{Max} (connected with Ultimate Limit State).
2. To investigate the effect of the random design variables on the performance of the pile soil system for ultimate strength and serviceability limit state (M_{Max}^{M} and Y_{Top}^{M}) for single pile and pile group.
3. To investigate the effect of the pile length (short or long pile), the pile type (single pile or group of piles), and the effect of boundary condition at piles head (free head or fixed head) on the performance of the system.
4. Investigate the effect of random design variables on the reliability indices and corresponding probability of failure of the pile-soil system for strength and serviceability.

5. To set recommendations for further research on laterally loaded single piles and pile groups with more complex loads such as dynamic loads or piles in seismic areas. Also future research may consider different type of soil, different soil conditions or piles on rock.

1.3 Thesis stages:

- Investigation of the uncertainties of the M_{Max} and Y_{Top} caused by uncertainties of physical property of the pile-soil system.
  The determination of each component of covariance matrix $Cov(Y_{Top,}, M_{Max})$ is conducted in this study.

  In the pile-soil system, the effect of each random design variable (EI, B, γ', k, ϕ, P) on $Y_{Top,}$, M_{Max} requires determination of partial derivatives of Y_{Top} and M_{Max} with respect to their random variables in the vicinity of the mean value of random variables (EI^o, B^o, γ'^o, k^o, ϕ^o, P^o). In numerical analysis, it is done by changing the input value of one parameter at a time by $(\text{e.g.} \pm 5\%, \pm 10\%, \pm 15\%, \cdots \pm 40\%)$ in order to asses the effect of this change to determine e.g. $\left.\frac{\partial Y_{Top}}{\partial EI}\right|_o$ in the vicinity of mean value of all other parameters.

  In particular, the assessment of each term $\left.\frac{\partial Y_{Top}}{\partial EI}\right|_o$ and $\left.\frac{\partial M_{MAX}}{\partial EI}\right|_o$ is conducted based (in general) on the expansion of arbitrary function $f(\bar{x})$ of many variables arranged in vector $\bar{x}$, in Taylor's series in the following way:

$$f(\bar{x}) = f(\bar{x}^o) + \sum_{i=1}^{n} (x_i - x_i^o) \left.\frac{\partial f(\bar{x})}{\partial x_i}\right|_o \qquad (1\text{-}1)$$

where:

$$\{f(\bar{x})\} = \{M_{max}, Y_{Top}\}$$

- Determination of the variance of Y_{Top} and variance of M_{Max}
- Investigate the results for the coefficient of variation COV (Y_{Top}) vs. COV (random variables) and COV (M_{Max}) vs. COV (random variables) for single pile and pile group to evaluate the effect of each random variable on the performance of the system to identify, which random variable has more influence on the system performance.

- Calculate the reliability index β and corresponding probability of failure of (Y_{Top} & M_{Max}) for single piles and pile groups and investigate the effect of each random parameter expressed by COV (EI, B, γ', k, ϕ, P) on reliability indices β defined by equation (2.8 Chapter Two).

- Compare the reliability index β and probability of failure with the standard recommended values.

All the above stages were investigated for single pile and pile groups for different boundary conditions (free head, fixed head) and different pile lengths from (2T to 10T), where T is the relative stiffness factor. The characteristic parameter for pile group is defined by spacing between piles. Thus in investigation of pile group the spacing was changed between 3D to 5D.

1.4 Thesis Layout

This thesis consists of six chapters, which are identified as:

Chapter two contains a review of the literature relevant to the topic of this thesis, that is connected with reliability analysis of laterally loaded piles imbedded in (p-y) sand below water table. This chapter discusses the theory of laterally loaded piles and methods of analysis. It also discusses the reliability analysis and probabilistic methods, the research and development of the reliability analysis and its effect on the analysis of laterally loaded piles.

Chapter three presents the theoretical formulation of p-y curve of sand below water table subjected to cyclic loading for single pile and pile group. It also highlights the development of p-y curve for piles and the research in the field.

Chapter four shows the numerical investigation of laterally loaded piles, the random variables associated with the pile-soil system with the relevant theoretical formulation. Chapter four presented a complete sample calculation to show the numerical procedure used in this thesis to conduct reliability analysis on laterally loaded single pile and pile group. This chapter deals with the general terms and formulation used for probabilistic modeling and reliability analysis.

Chapter five provides a discussion on the results of the analysis conducted in this thesis.

Chapter six identifies the conclusion that came out of the study and recommends areas for future research.

In addition to the above chapters, this thesis includes the following appendices:

Appendices A and B present the analysis of the results for single isolated pile in forms of tables and charts.
Appendices C and D display the analysis of the results of pile group with (3D) spacing. Where, D is the pile diameter.
Appendices E and F give the analysis of the results of pile group with (5D) spacing.

CHAPTER TWO
LITRATURE REVIEW

2.1 Analysis of Laterally Loaded Piles

2.1.1 General

Modeling piles behavior is very important in today's engineering applications because of the pile effect on the structure behavior, the overall structure stability and safety. It becomes more critical when the pile or group of piles are carrying loads from high rise buildings subjected to significant lateral wind loads or complex bridges and interchanges carrying heavy traffics and subjected to seismic loads. For all above reasons piles attract interest of engineers to study their behavior, modeling techniques, and factors affecting their capacity and stability under specified loads. Many researchers have investigated the laterally loaded pile behavior. The ultimate resistance of piles and the deflection due to a lateral loading are complex due to the interactions between the pile and the surrounding soil. For single piles, lateral loading is a problem of soil-structure interaction, in which pile deflection depends on the soil response and soil response depends on pile deflection. For closely spaced pile groups, this behavior is more complex for single pile due to the decrease of group efficiency because of close pile spacing and the distribution of the load from the superstructure to each of the supporting piles. Types of design or analysis can be categorized into several approaches depending on how piles and soils are modeled and summarized as:

- Linear Elastic Method
- Ultimate Load Method
- Nonlinear p-y Method

In the late 1940s and 1950s when energy companies built offshore structures that were designed to sustain relatively large horizontal loads from waves, the concept of the response of the soil as a function of the lateral deflection of pile, y, was developed. Since then, full scale testing and the digital computer allowed the development of the p-y curve method (American Petroleum Institute, API, 1987). Nonlinear soil behavior is described in terms of soil reaction, p, versus lateral deflection of pile, y, curves, based on analysis of field load test and laboratory tests. The characteristics of soil, as well as the stiffness of pile have a pronounced effect of such performance of pile as top lateral deflection Y_{Top}, and maximum bending moment, M_{max}. Those design parameters (variables) are described as:

- pile bending stiffness, EI
- pile diameter, B
- submerged unit weight, γ'
- angle of internal friction of soil, Φ
- modulus of sub-grade reaction, k

Reese et al. (1970) used a finite difference method for analysis of laterally loaded single pile and pile group. Reese provided a thorough description of the p-y-method for group of piles and an overview of different p-y-curves. LPILE PLUS program was used to model the single pile test. The initial input soil parameters were adjusted to obtain a good match between the measured and computed results. This refined soil profile was then used to model the pile group in GROUP program (Reese et al. 1996).

Evans and Duncan 1982 (Evan et al. 1982) developed the elastic continuum concept for piles which is based on the subgrade modulus concept for soil. The subgrade modulus method is based on the assumptions that the reaction forces exerted on a beam resting on an elastic foundation is proportional at every point to the deflection of the beam at that point. This concept was introduced by Winkler in 1867.

The subgrade modulus concept treats the soil as a series of springs and does not account for its continuity. In the elastic continuum procedure, soils are modeled as continuum and soil modulus is homogeneous, isotropic or increasing linearly with depth. The elastic continuum procedures have the important advantage over the subgrade modulus method of enabling analysis to be made for group action of piles under lateral loads. However, they provide somewhat uncertain results and are somewhat difficult to apply in many practical cases, especially in layered soils. A major problem with using this procedure is the determination of an appropriate reaction modulus (E_{py}), as it varies with pile properties, depth below the ground surface and the pile deflection.

Evans and Duncan 1982 introduced the procedure that can be applied to a wide variety of conditions to estimate the non-linear load-deformation and the bending moments in laterally loaded single pile or pile group, by using dimensional analysis technique. The Limit State Analysis procedures developed by Evans & Duncan (1982) (Evans et al 1982) can be used to estimate the ultimate pile capacity for a given set of soil and pile properties. In the extended work of Duncan, M. J., Levison, H. F., & Budd, S. M., (Duncan et al. (1994)), they presented the characteristic-load method (CLM) which is based on the earlier work of Evans & Duncan (1982). A series of solutions were generated with nonlinear p-y curves for soils and pile head conditions. The results were analyzed with the view to obtain simple equations that could be used for rapid prediction of the response of piles under lateral loading. It can be used to check computer output from more sophisticated analysis.

The non-linear p-y method provides the best fit between the calculated behavior of laterally loaded piles and the behavior measured in full scale tests.

2.1.2 Elastic Soil Subgrade Modulus:

The main soil parameter in the analysis of laterally loaded single pile and group of piles under lateral loading is the soil reaction (subgrade) modulus,

defined as the resistance of the soil at a point along the pile divided by the deflection of the pile at that point. The soil reaction modulus is a function of both the depth below the ground surface z and the deflection of the pile y.

The subgrade modulus is based on assumptions introduced by Winkler in 1867, that:

a) The reaction forces exerted on a beam resting on an elastic foundation are proportional at every point to the deflection of the beam at that point.

b) The elastic foundation deforms only in the area beneath the load.

The first of the assumptions leads to the definition of the subgrade modulus as:

k_s=-p/y (2.1)

k_s= subgrade (soil) modulus (force/length^2)

p= soil reaction

y= deflection of the beam in units of length

Using a subgrade modulus, as defined by Eq. (2.1), the basic differential equation for a laterally loaded pile is expressed as:

$$EI\frac{d^4y}{dx^4}+k_s y=0 \qquad (2.2)$$

If the value of k_s is constant with depth, simple closed form solution is available for Eq. (2. 2) (Hetenyi 1946). Hetenyi modeled the interaction between the soil and the pile using the concept of subgrade reaction, this analysis is based on the assumption that the soil reaction p is proportional to the deflection of the pile y. The soil reaction divided by the deflection is called the soil modulus E_s. in 1946 Hetenyi developed a solution for E_s constant with depth. Poulos and Davis (1980) present tables of non-dimensional coefficients for the determination of deflection, slope, bending moment and shear for free head, fixed head piles when subjected to lateral loads, where k_s is assumed constant with depth. In their

model, Poulos and Davis calculated the responses of a pile by solving the deferential equations of deflection curve using finite element analysis.

In 1958, McClelland and Focht (Focht 1973) introduced the p-y method to take into account the nonlinearity of soil reaction modulus. In their research, they concluded that the soil reaction modulus is not just a soil property but it is a function of the pile diameter, deflection, and soil properties. The nonlinear p-y method is considered as the most appropriate method for evaluating the pile-soil interaction. This method provides the best fit between the calculated behavior of the laterally loaded piles and the real test results using full scale tests. The soil behavior is described in terms of soil strength parameters (γ': a submerged unit weight, Φ: an angle of internal friction of soil, k: a modulus of subgrade reaction).

In 1956 Matlock & Reese (Reese et al. 1956) introduced a non-dimensional method of analysis for single pile, followed by Matlock development of p-y model in 1970 (Matlock 1970). Matlock measured the bending moment of a pile using strain gages, then calculated the deflection by double integrating the bending moment curve. The American Petroleum Institute (API) conducted extensive research in the area of laterally loaded piles that lead to the publication of the General Practice Recommendations for Planning Designing and Constructing of Offshore Structures in 1987.

2.2 Group of Piles

Piles are most often used in groups. The models that are used for the group of piles must address two problems: the efficiency of closely-spaced piles under lateral loading; and the distribution of the loading to each of the piles in the group, a problem in mechanics. If one can assume that the procedures are accurate for analyzing a single pile under lateral loading, the problem of the distribution of the loading to each of the piles in a group can be solved exactly. The response of laterally loaded piles installed in group closely spaced (when center-to-center spacing between piles is less than 6 times pile diameter) is very different from that of single isolated pile. This difference in the behavior is due to the fixity and lateral resistance (Mokwa & Duncan 2001) provided by pile cap and the interaction between the pile and soil (pile-soil-pile interaction).

The easiest way to analyze the pile group is to assume that the pile cap is rigid and only axial load is applied. In the beginning, most of the researchers presented their work under these assumption, such as Culmann in 1866 (Terzaghi 1956), Brennecke & Lohmeyer in 1930 (Terzaghi 1956), Vetter in 1939 (Terzaghi 1956). However in 1950, Hrennikoff considered a laterally loaded pile as an elastic beam on an elastic foundation with uniform stiffness and this was the method which presents the potential for analytical treatment of the pile-soil interaction system.

Because of the variability of soil and the complex nature of constitutive models, theoretical solutions are currently unavailable for computing the efficiency of a particular pile. Piles in closely spaced groups behave differently than single isolated piles when loaded laterally because of pile-soil-pile interactions that take place in the group. Deflections and bending moments of piles in closely spaced groups are greater than deflections and bending moments of single piles at the same load per pile, because of these interaction effects.

Brown et al. (1988) initially proposed the p-multiplier concept. The p-y curves of single pile are modified to account for the influence of the interaction between the different piles in the group. As shown in Figure 2.1, the p-multiplier f_m is the reduction factor of soil resistance p for the same deflection of y. The p-y curve is compressed in the direction of p, so that the soil resistance, p, of piles in-group will be smaller than the soil resistance of single piles.

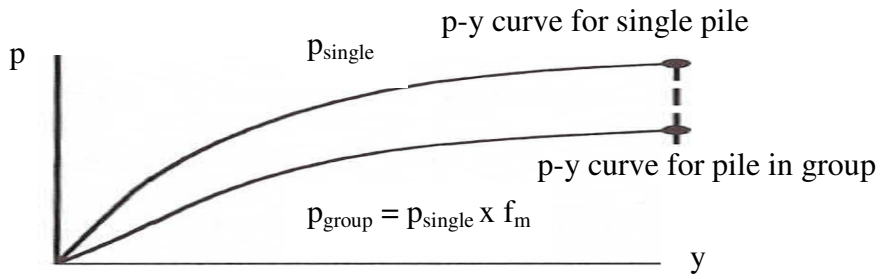


Figure 2.1: The concept of p-multiplier (f_m) (Brown et al. 1988)

The approach for analyzing the behavior of a pile in a group is similar to the approach used for analysis of a single pile, except that the p-values (soil resistance) are reduced using a p-multiplier to account for the reduced resistance due to the interaction between piles. The piles and pile cap then can be analyzed as a whole to calculate the deflections and forces. The computer programs, which are based on the p-multipliers method, are also readily available in recent years and are in continuous development to incorporate broader spectrum of variables, such as dynamic effects, that affect the behavior of laterally loaded pile groups. The p-multipliers method is also used to carry out the reliability analysis of pile groups in this research.

The values of p-multiplier proposed by Brown et al. (1988) are the result of an isolated pile embedded in dense sand subjected to cyclic loading and a full-

scale test for pile group. Brown and Shie (1991) also presented the p-multipliers from the result of 3-D finite element analysis. Mokwa and Duncan (2001a) carried full-scale field tests to study the lateral resistance provided by the pile cap and concluded that the pile cap, in some circumstances, constitute a substantial percentage of the total lateral resistance of the group.

Cox et al. (1984), Brown and Reese (1985), Morrison and Reese (1986), McVay et al. (1995), Ruesta and Townsend (1997), McVay et al. (1998) and Rollins et al. (1998) suggested different values for the p-multiplier, fm, based on the centrifuge or full-scale tests in different type of soils.

Through combining the research work that had been done before, Mokwa and Duncan (2001b) proposed a way to construct the value of p-multiplier, f_m, for all kinds of soil. They collected and reviewed over 350 journal articles and other publications pertaining to lateral resistance, testing, and analysis of pile caps, piles and pile groups. The results from these tests were assimilated into tables and charts, from which the trends and similarities can be observed. Ilyas et al. (2004) proposed a centrifuge model test study of laterally loaded pile groups in clay. A series of centrifuge model tests has been conducted in their research to examine the behavior of laterally loaded pile groups in normally consolidated and over consolidated kaolin clay. The pile groups have a symmetrical plan layout consisting of 2, 2x2, 2x3, 3x3 and 4x4 piles with a center-to-center spacing of three or five times the pile width. The piles are connected by a solid aluminum pile cap placed just above the ground level. It is established that the pile group efficiency reduces significantly with increasing number of piles in a group. The tests also reveal the shadowing effect phenomenon in which the front piles experience larger load and bending moment than that of the trailing piles. The shadowing effect is most significant for the lead row piles and considerably less significant for subsequent rows of trailing piles. They also pointed out that the approach adopted by many researchers of taking the average performance of piles in the same row is found to be inappropriate for the middle rows, of piles for

large pile groups as the outer piles in the row carry significantly more load and experience considerably higher bending moment than those of the inner piles.

2.3 Reliability Analysis

2.3.1 Introduction

Reliability is a probabilistic method of analysis that provides consistent measurements for propagation of uncertainties and unifying framework for risk assessment (K. K. Phoon et al., 2003). It is the capacity of a system to perform the required function for a desired period of time without failure, in specified environment and with desired confidence. Reliability analysis is a quantifying of sources of failures with emphasis on the most significant contributors towards the overall system.

Uncertainties are present in geotechnical engineering and geotechnical system such as deep foundation. The uncertain performance of pile–soil system is affected by many factors such as spatial variation of soil properties, limited soil exploration programs, uncertainties in the parameters determined by various testing methods and analysis, limited calculation models and the uncertainties in the applied loads (K. K Phoon and F. H. Kulhawy, 1999). In reality, absolute safety or zero probability of failure cannot be achieved. In deterministic analysis with uncertainties, engineers use the factor of safety based on their experience and engineering judgment, which is a conservative estimate of the design parameters, while in probabilistic analysis, economical design can be achieved by properly balancing the risk of failure, consequence of failure and the initial cost. Because of the uncertainties accompanied with the soil-pile system, reliability analysis merely removes the need of guesswork (Phoon et al.(2003a)), and provides an accurate assessment of the uncertainties using the mean value

(expected value), variance and or coefficient of variation (COV) of random variables to evaluate reliability indices of the structure (Phoon et al.(2003a).

All geotechnical engineering project start with site exploration and soil testing to obtain the properties and distribution of soil. After that analysis is conducted to estimate the response of the soil under applied load. Errors, often of unknown magnitude, are introduced in all three phases of a project. Over 40 years ago, Casagrande (1965) mentioned that there should be a proper balance among the risk of failure due to these unknown errors, consequences of failure, and the initial cost. To achieve above mentioned criteria, geotechnical engineer uses the conventional factor of safety approach, which is based on experience and it is logical too. However, it is very common to use the same value of factor of safety for different kinds of design, such as long-term slope stability, without regard to the degree of uncertainty involved in its calculation. The same value of factor of safety is applied to the widely varying degree of uncertainty. On the other hand, reliability analysis differentiates between the situation where the uncertainties are particularly high or low and also it takes into account the combined effect of uncertainties on structure . Christian et al. (1994)express some about reliability method.

Many of the structural related reliability –based design codes have been put into practice in mid 1970s, such as BSI 1974; NKB 1978;ACI 1983.However geotechnical design community has been slow in assimilating this new design methodology.

Ruiz (1984,1986) analyzed the laterally loaded pile in soft clay using reliability analysis(First-Order Second-Moment Method) .Folse (1989) also used the same (FOSM) method for the lateral displacement of the pile top and for first yielding of pile material. The pile was loaded with set of forces and moment and randomized p-y curve was used. Using the single axially loaded piles, single laterally loaded piles and pile groups, API (American Petroleum Institute) has

conducted a comprehensive reliability analysis to evaluate the error, optimum cost, and reliability associated with the conventional method for offshore pile design. Hansen, Madsen and Tjelta (1995),considered the pile-soil interaction in their study.

In reliability analysis the variables which significantly influence the judgment of safety or failure, and which are characterized by substantial uncertainties are called random variables. When an analysis of a structure is conducted, it gives a certain result. If the analysis is performed for (N) number of times on the same structure with different outcome every time, then in probabilistic theory, each analysis result is known as an event and all possible results are form a space of event. In the analysis of laterally loaded piles, the events are represented in terms of serviceability and strength (Y_{Top} & M_{Max}). Every event has some probability assigned to it. The function of the event (Y_{Top} & M_{Max}) which fulfills certain conditions is known as function of random variable (EI, B, γ', k, Φ, P).

The uncertainties (random variables) connected to the parameters of pile material (pile bending stiffness, EI, and pile diameter, b), soil surrounding the pile (γ', submerged unit weight, Φ, angle of internal friction of soil, k, modulus of subgrade reaction) and applied load (lateral load P) are considered to be affecting the performance of pile (Y_{Top} & M_{Max}).

A simple application of reliability theory is shown in the figure below:

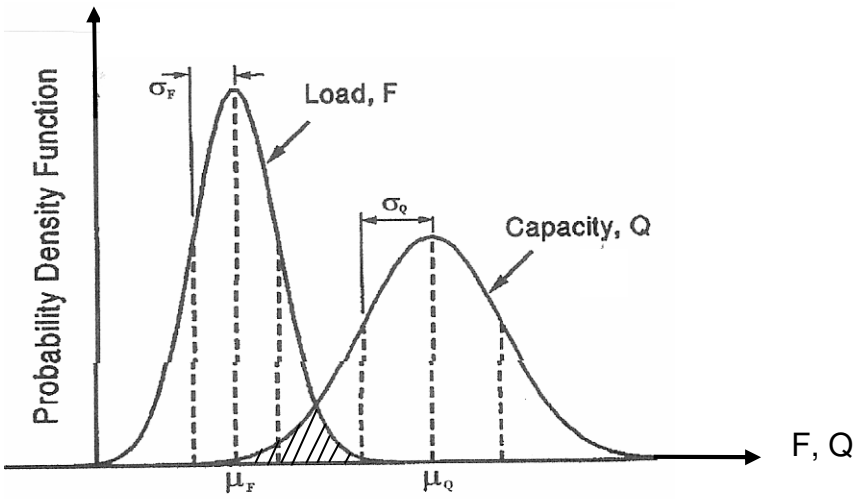


Figure 2.2: Reliability assessment for normally distributed load and capacity (Phoon et al, 2003)

Uncertain design quantities, such as the load (F) and the capacity (Q), are modeled as random functions of the design variables, while design risk is quantified by the probability of failure. The basic reliability problem is to evaluate the probability of failure by applying statistics of F and Q, which typically include the mean (μ_F and μ_Q) and the standard deviation (σ_F and σ_Q). If both Q & F are normally distributed, then the safety margin (M= Q-F) also is normally distributed with the mean value (μ_M) and variance (σ_M^2) (Melchers 1999) given as:

$$\mu_M = \mu_Q - \mu_F \tag{2.3}$$

$$\sigma_M^{\ 2} = \sigma_Q^{\ 2} + \sigma_F^{\ 2} \tag{2.4}$$

The overlapped area shown in Figure 2.2 is directly proportional to the failure. Structural reliability methods are often used to evaluate the failure performance of geotechnical structure, thus the probability of failure is taken as an index known as the reliability index (β) which is defined as:

$$\beta = \frac{\mu_M}{\sigma_M} = \frac{\mu_Q - \mu_F}{\sqrt{\sigma_Q^2 + \sigma_F^2}} \tag{2.5}$$

One critical aspect in determining the reliability index is the explicit definition of the limit state function of the system. In a problem involving multidimensional random variables, the limit state function is the boundary separating the safe domain from the failure domain. In this summary, Figure 2.2 can be used to investigate the reliability of serviceability (Y_{Top}) or strength (M_{Max}) of the pile-soil system subjected random load P. In serviceability, the load and capacity curves can be replaced by Y_{Top} and Y_{Top}^{max}, therefore Eq. 2.3, 2.4, and 2.5 become:

$$Y_{Top}{}^{M} = Y_{Top}{}^{Max} - Y_{Top} \tag{2.6}$$

$$\sigma^{2}{}_{Y_{TOP}}{}^{M} = \sigma^{2}{}_{Y_{Top}}{}^{Max} + \sigma^{2}{}_{Y_{Top}} \tag{2.7}$$

$$\beta = \frac{\left(Y_{Top}{}^{M}\right)^{o}}{\sigma_{YTop}{}^{M}} \tag{2.8}$$

where:

$\sigma_{Y_{Top}}{}^{M}$ = standard deviation of margin of safety of pile head deflection (serviceability).

$\left(Y_{Top}{}^{M}\right)^{o}$ = mean value of margin of safety of pile head deflection (serviceability).

$$\left(\sigma_{Y_{Top}}\right)^{2} = VAR\left(Y_{Top}\right) \tag{2.9}$$

$$\left(\sigma_{Y_{Top}}{}^{Max}\right)^{2} = VAR\left(Y_{Top}{}^{Max}\right) \tag{2.10}$$

Cornell in 1969 developed the First-Order Second-Moment Reliability Method (FOSM) (Cornell, C. A. (1969)). The name “First-Order Second-Moment Reliability Method” is based on the first-order Taylor series approximation of the limit state function and uses second moment statistics (mean and variance (or covariance) of the function of random variables). The margin of safety (Limit State Function) can be determined as:

For serviceability, it is defined as:

$$Y_{Top}^{M} = Y_{Top}^{Max} - Y_{Top} \tag{2.11}$$

For strength, it has the following form:

$$M_{Max}^{M} = M_{Max}^{Max} - M_{Max} \tag{2.12}$$

where:

Y_{Top}^{Max} = maximum allowable deflection of pile head,

M_{Max}^{Max} = maximum allowable bending moment of the pile,

Y_{Top}= deflection of the investigated pile,

M_{Max} = maximum bending moment of the investigated pile.

While the mean value of the function of the random variables (Y_{Top}, M_{Max}) is the best estimate of the Y_{Top} and M_{Max} variable without conservatism, the variance or standard deviation is used to assess the uncertainty of functions Y_{Top}, M_{Max}. In general, the convenient way of defining of uncertainties is by means of covariance Cov(Y_{Top}, M_{Max}) as discussed in chapter four.

The probabilistic assessment of the performance of the pile-soil system is described by the expected values of Y_{Top}^{o}, and M_{Max}^{o} whereas the covariance matrix Cov(Y_{Top}, M_{Max}) of maximum lateral deflection and maximum bending moment defined as:

$$Cov(Y_{Top}, M_{Max}) = \begin{bmatrix} Var(Y_{Top}) & Cov(Y_{Top}, M_{Max}) \\ Cov(M_{Max}, Y_{Top}) & Var(M_{Max}) \end{bmatrix} \tag{2.13}$$

The determination of the variance of Y_{Top}, that is Var(Y_{Top}), which is the random function of random variables (EI, b, γ', k, Φ, P) is obtained in accordance to FOSM method by means of the following formula:

$$\mathrm{Var}\left(Y_{Top}\right)=\left(\left.\frac{\partial Y_{Top}}{\partial EI}\right|_{o}\right)^{2}*\mathrm{Var}(EI)+\left(\left.\frac{\partial Y_{Top}}{\partial \phi}\right|_{o}\right)^{2}*\mathrm{Var}(\phi)+\left(\left.\frac{\partial Y_{Top}}{\partial k}\right|_{o}\right)^{2}*\mathrm{Var}(k)+$$
$$\left(\left.\frac{\partial Y_{Top}}{\partial B}\right|_{o}\right)^{2}*\mathrm{Var}(B)+\left(\left.\frac{\partial Y_{Top}}{\partial \gamma'}\right|_{o}\right)^{2}*\mathrm{Var}(\gamma')+\left(\left.\frac{\partial Y_{Top}}{\partial P}\right|_{o}\right)^{2}*\mathrm{Var}(P) \quad (2.14)$$

where the notation $|_o$ means that the assessment of derivative of Y_{Top} is conducted in the vicinity of it mean value of Y_{Top}^{o}.

Similarly, the determination of the variance of M_{Max} is obtained by the following formula:

$$\mathrm{Var}\left(M_{Max}\right)=\left(\left.\frac{\partial M_{Max}}{\partial EI}\right|_{o}\right)^{2}*\mathrm{Var}(EI)+\left(\left.\frac{\partial M_{Max}}{\partial \phi}\right|_{o}\right)^{2}*\mathrm{Var}(\phi)+\left(\left.\frac{\partial M_{Max}}{\partial k}\right|_{o}\right)^{2}*\mathrm{Var}(k)+$$
$$\left(\left.\frac{\partial M_{Max}}{\partial B}\right|_{o}\right)^{2}*\mathrm{Var}(B)+\left(\left.\frac{\partial M_{Max}}{\partial \gamma'}\right|_{o}\right)^{2}*\mathrm{Var}(\gamma')+\left(\left.\frac{\partial M_{Max}}{\partial P}\right|_{o}\right)^{2}*\mathrm{Var}(P) \quad (2.15)$$

2.3.2 Methods of Reliability Analysis

Many methods have been developed and used for reliability assessments, they are:

1- **Stress-strength Interference Method:** it is still widely used because of its simplicity. This method assumes that stress and strength are statically independent parameter, an assumption which is not correct in all cases.

In 1986 Sundararajan (Sundararajan, 1986), derived a stress strength equation for general failure criteria which is given by:

$$p_f = \int_{-\infty}^{\infty} F_C(l)F_L(l)dl \quad (2.16)$$

where P_f is the probability of failure and $F_L(.)$ & $F_C(.)$ are the cumulative density functions of L, l (load) and C (capacity), respectively.

2- **First- Order Second-Moment Reliability Methods:** this method is developed by Cornell in 1969 (Cornell 1969). Its name (First-Order Second-Moment Reliability Method) because it is based on the First-Order Taylor Series expansion of the limit state function which uses second moment statistics (mean and variance (or covariance) of the function of random variables. While the mean value is the best estimate of Y_{Top} and M_{Max} without conservatism, the variance or standard deviation is used to assess the uncertainty of functions Y_{Top} and $M_{Max.}$.

   This method requires more computation than the stress-strength method, but it is less restrictive and applicable to wider range of problems.

3- **Simulation Based Reliability Method:** Computer based analytical model is developed to predict the behavior of the system. If uncertainties are involved then the model need to be evaluated several times. Each simulation cycle is based on a certain randomly selected set of input parameters. Output parameters such as (Y_{Top} and M_{Max}) are calculated from the model. Statistical methods are used to get the mean, variance, or distribution type of output parameters. The most recent simulation method is Monte Carlo simulation technique.

4- **Probabilistic Finite Element Method:** The above methods are limited to application of simple structures with linear behavior. If the geometry of the system or the applied loads are complex, or if the material has nonlinear behavior, then finite element methods are required with the statistical method such as First- Order Second-Moment to analyze the structure. Beacher (Baecher & Ingra 1981) used this technique also more information on this method is available in Probabilistic Structural Mechanics Handbook by C.(Raj) Sundararajan (1995).

2.3.3 Risk Assessment and Probability of Failure

Risk Analysis and Assessment of Failure in Engineering and Economics introduces the fundamental concepts, techniques, and applications to evaluate the probability of an event and its consequences on the potential failure of the system. However there is no generally accepted definition of the term risk.

The risk is assessed based on the situation, for example, the risks that may affect a large number of people simultaneously are less tolerable than risks of individual accidents. After the risk assessment is completed, we get expected costs of failures for a project. By taking into account this expected cost of failure and other costs such as initial and maintenance cost, we can theoretically evaluate the project to get optimum value of reliability index.

As mentioned before, the overlapped area shown in Figure 2.2 is directly proportional to the failure. Structural reliability methods are often used to evaluate the failure performance of geotechnical structure. The probability of failure is assessed by an index known as the reliability index (β).

The reliability indices for most geotechnical components and systems lie between 1 and 5, corresponding to probabilities of failure ranging from about 0.16 to $3x10^{-7}$ (Melchers, 1999). Table 2.1 shows relationship between reliability indices (β) and probability of failure (p_f).

Table 2.1: Relationship between Reliability Index (β) and Probability of Failure (p_f) (US Army Corps for Engineers 1997)

Reliability Index (β)	Probability of Failure (p_f)	Expected Performance Level
1.0	0.16	Hazardous
1.5	0.07	Unsatisfactory
2.0	0.023	Poor
2.5	0.006	Below Average
3.0	0.001	Above Average
4.0	0.00003	Good
5.0	0.0000003	High

Probability of failure (p_f) decreases as the reliability indices (β) increases.

In principle, the most economical target probability of failure (p_T) can be determined by conducting cost-benefit analysis, as shown in Figure 2.3.

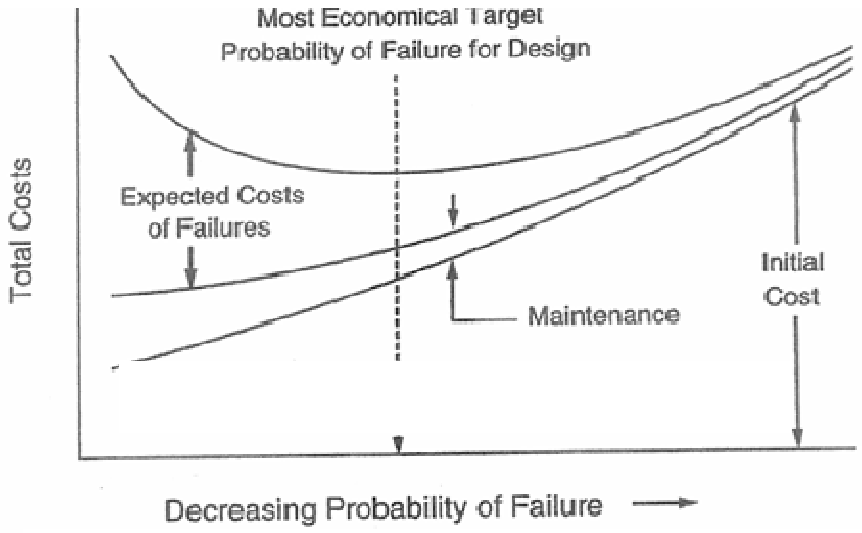


Figure 2.3: Cost-Benefit Analysis (Phoon et al, 2000)

By studying the variation of the initial cost, maintenance costs, and the expected failure costs with p_f, it is possible theoretically to arrive at the most economical target probability of failure for design. This approach is not yet practical because of the difficulties in evaluating failure costs (e.g. cost of human lives) and the effect of component failure on the system. Another approach is to set the value of p_T at a level that is comparable with the failure rates estimated from actual case histories (Figure 2.4).

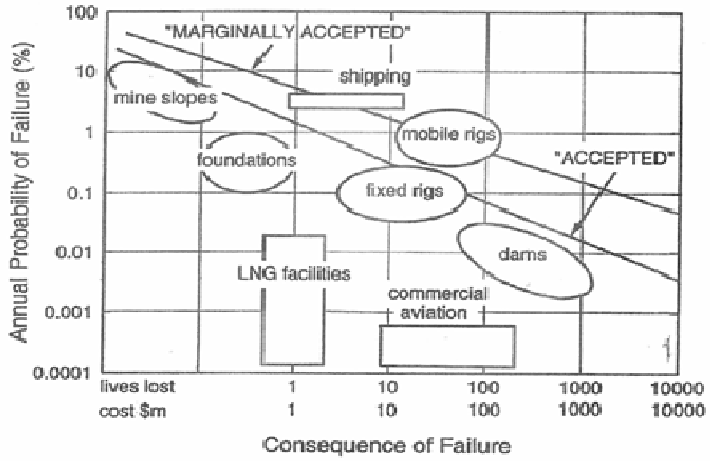


Figure 2.4: Empirical Rates of Failure for Civil Engineering Facilities (Beacher 1987)

However, comparing the theoretical probability of failure derived from reliability computations with a value established by actual case histories is not straightforward. It has been noted that the theoretical probability of failure usually is significantly smaller than the actual failure rate. This result is not surprising, because the safety of a design is not affected by uncertainties underlying design calculations alone. It also can be severely compromised by factors such as poor construction and human errors.

The common practice for selecting a target probability of failure for design is to calculate the theoretical probabilities of failure implicit in existing working stress designs and to use those values as a basis for selecting an appropriate

value of p_T. While this approach is empirical, it does possess a major advantage of keeping the new design methodology compatible with the existing experience base.

CHAPTER THREE

BEHAVIOR OF LATERALLY LOADED PILE EMBEDDED IN SAND

3.1 Behavior of laterally loaded pile embedded in sand

When a pile is loaded by lateral force, the pile deflects creating soil resistance to pile movement due to applied force. A schematic representation of laterally loaded pile is given in Figure 3.1.

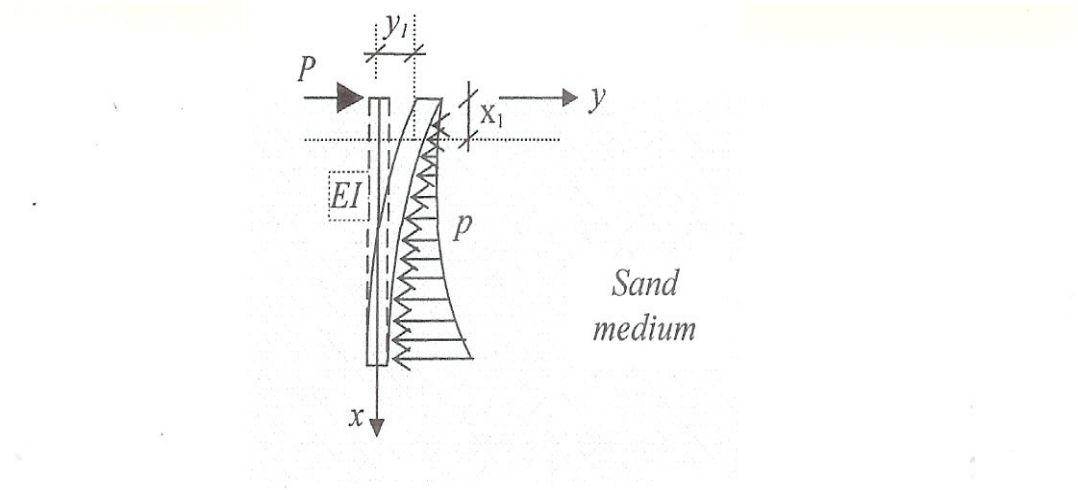
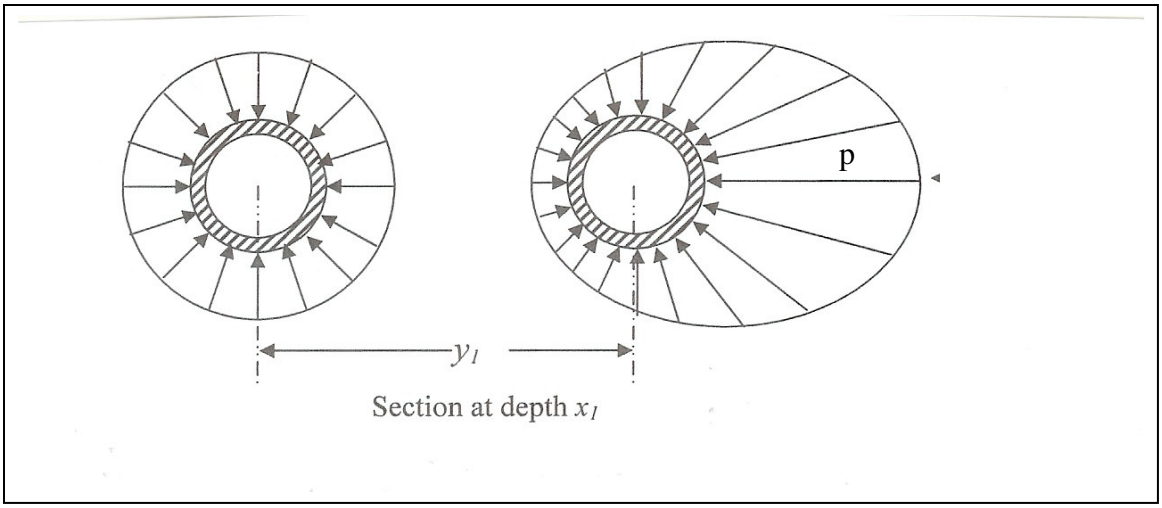
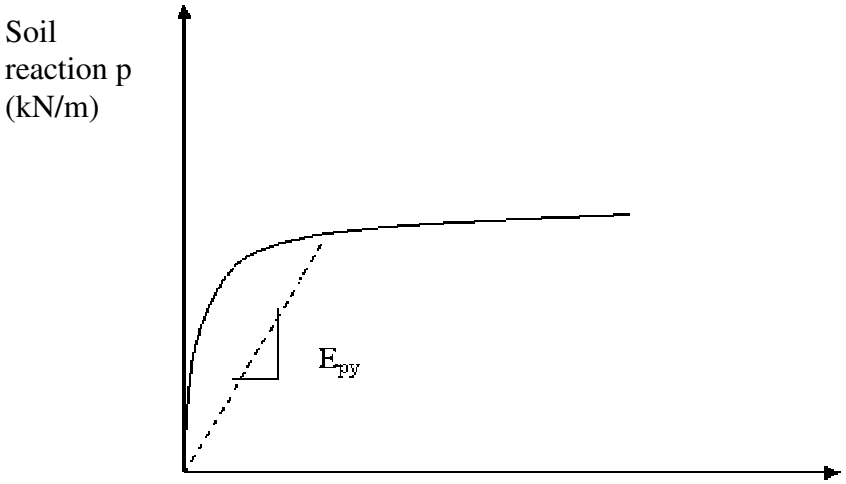


Figure 3.1: Laterally loaded pile embedded in sand

Without application of lateral load, the pile embedded in soil is subjected to static soil pressure; under applied lateral force P, the pile deflects and active pressure, and frictional force makes the analysis more complicated. Assuming pile deflection y_1 at a depth x_1 due to the application of force P as shown in Figure 3.1, a qualitative diagram at depth x_1 can be drawn showing soil reaction acting on the pile. If a horizontal force P is applied to the pile head in the y direction as shown in Figure 3.1, resultant of soil response p will be in y direction as shown qualitatively in the Figure 3.2.



(a) (b)



(c)

Figure 3.2: Soil Reaction on Laterally Loaded Pile (Reese et al 2001)

Figure 3.2 shows a pile under lateral loading, the uniform distribution of the stresses at the pile section shown in Figure 3.2 (a) represent the state of stress on the pile wall when the pile is installed, but no bending or deflection in the pile exists. In this case the soil reactions are normal to the pile wall. When the lateral load P is increased, the pile started to deflect a distance y_t, and the distribution of the unit lateral stress will be similar to that shown in Figure 3.2 (b). The lateral stress will increase on the front side of the pile and decrease on the

back side. Distribution of the unit lateral stresses will result in the quantity called soil reaction (p) which acts opposite in direction to y_t. The dimension of the soil reaction is load per unit length along the pile. These units are identical to those of the solution of the equation of beam on an elastic soil.

The soil reaction modulus can be defined as the slope of the secant of a p-y curve (Figure 3.2 (c)) and it is denoted by E_{py}.

The analysis of the pile under lateral loading is a problem of soil-structure interaction; that is, the deflection of the pile is dependent on the soil response and the soil response is a function of pile deflection. Thus, the problem cannot be solved by the equations of static equilibrium, but a differential equation must be solved to obtain the deflection of the pile. Iteration must be employed because the soil response is a non-linear function of pile deflection and position along the length of the pile.

The pile can be considered as a beam supported by soil reaction p developed due to defection of the pile as a result of horizontal force P or bending moment M applied at the top of the pile. The differential equation that governs the relationship of the force and deformation along the length of the pile when modeled as discussed in chapter two of this thesis is the following:

$$EIy^{IV} + p = 0 \qquad (3.1)$$

where:

EI = is the flexural stiffness of the beam.

y = is the deflection of the pile at a depth x,

p = is the resultant reaction of soil acting on the pile per unit length of the pile due to the deflection of the pile caused by application of load P at pile head.

Equation 3.1 applies when the soil mass is unaffected by the installation process of the pile and have no slippage or separation of the interface with the pile and the surrounding soil. In practice, the variety of boundary conditions at the

top of the pile is possible. The condition of equilibrium and compatibility has to be satisfied. If a pile extends upwards to support a road sign, the two boundary conditions consists of a shear and a moment. If a pile extends upward to form a part of the superstructure, the two boundary conditions consist of a shear and a rotational restraint. In order to select the proper magnitude of the rotational restraint, iteration between pile foundation and the superstructure is usually necessary. If a pile extends upward and is embedded in a concrete mat such as the base of a retaining wall, an acceptable solution in some cases is to assume that the pile head is fully fixed against rotation. The shear force may be selected by dividing the total load of the wall by the number of piles. There may be occasions when the deflection at the pile head is one of the known boundary conditions. For example, a bridge may be constructed in such a way that the lateral deflection of the pile head is limited to known amount. The model pile may be either in free or fixed head condition. In order to solve Eq. 3.1 the pile-soil system has to be represented by appropriate model.

Piles usage increases with the need for more stable structures in wide ranges of engineering applications, especially high rise buildings, bridges and complex structures, and also when the actual soil conditions doesnot meet the design criteria for projects. The stability and capacity of single pile or group of piles need to be studied carefully; usually we start with defining appropriate material properties for pile. Analysis should be carried out to check piles capacity against applied loads, vertical, lateral and overturning moment to insure adequate capacity to sustain the applied loads. Soil-pile interaction is very important in checking pile strength. Serviceability and strength requirements should be checked and verified. If the load on a single pile or group of piles is purely axial then it can be analyzed by simply, solving the equation of static equilibrium. In contrast, if the lateral loading is applied, analysis goes through the cumbersome solution of nonlinear differential equation. The lateral loads on piles is key subject in designing piles especially in seismic areas that inherent seismic loads and may leads to collapse or damage of the structure if not analyzed and designed properly .

The analysis and design of laterally loaded single pile or group of piles is affected by many parameters that should be known and studied carefully:

1. Type of the pile.
2. Nature of loading.
3. Type of boundary condition at pile head.
4. Soil-pile interaction, which means the type of soil surrounding the pile (this will affect choosing an appropriate p-y curve and other soil properties).
5. Analysis method, modeling technique used (discussed in Chapter 2).

3.2 Type of laterally loaded pile

Based on their use in engineering practice, laterally loaded piles are divided into two major categories:

3.2.1 Active piles

Active type piles used when the loads are applied mainly to pile top. This group includes; the piles foundation for offshore platforms, bridges, high – rise structures, overhead signs.

3.2.2 Passive piles

Passive type piles used when the loads are applied mainly along the pile length, This group include retaining wall and piles in a moving slope.

3.3 Nature of loading

Four types of loads are encountered in practice, they are: static, cyclic, sustained, and seismic or dynamic. The engineer must select the p-y curves to be used in a particular design by giving careful consideration to the nature of the loading.

3.3.1 Static loading

It is a short term, monotonic loading applied to a pile. It is seldom used in real engineering applications, but the p-y curve obtained from this kind of loading can be used as a baseline for representing the effect of other more complicated loading .

3.3.2 Cyclic loading

Many structures are subjected to cyclic or repeated lateral loads. Wind gusts, traffic loads on curved bridges, current and wave loads, and ice loads are example of cyclic loading.

The effect of cyclic loading is not very profound in case of sands and stiff clay above water level, whereas, for saturated clay below water table, loss of soil resistance due to cyclic loading can be serious. Experiments by Reese et al. (1975), shows that stiff clay is pushed away from a pile on ground surface due to cyclic loading. When the next cycle of load is applied, water comes out of the opening with force and causes scour of clay with additional loss of soil resistance.

3.3.3 Sustained loading

Retaining walls, bridges and abutments are subjected to sustained loading. A pile in granular soil can be expected to undergo only a small amount of additional deflection, or perhaps none, depending on the magnitude of the unit stresses that exist around the pile. Analytical solution for sustained loading is not available in theory yet because the parameters it needs is not clearly defined, rather in some cases we can solve it by experiments. This can be done by installing test pile and subject it to sustained loads.

3.3.4 Dynamic loading

Laterally loaded pile can be subjected to the dynamic load such as earthquake, vibration from machines, vehicle traffic on bridges, and installation of pile besides the existing pile. For the static load case, soil resistance can be related to the stress–strain characteristics of the soil, but for dynamic load, the inertia effect comes into effect too. Thus, the p-y curve cannot be directly used for analysis of piles in case of dynamic loading. On top of that, for granular soil, liquefaction of soil happens. Details are given elsewhere: Woods & Stokoe (1985); Gazetas & Mylonakis (1998); Ramshaw et al. 1998).

3.4 Boundary condition

Analysis of laterally loaded pile requires the solution of beam-column differential equation and to solve this equation, boundary condition needs to be specified. Without the boundary condition the structure is considered as free body. Three type of boundary condition at the top of the pile usually are defined as:

- **Free Head:** As shown in Figure 3.3 (a), the top of the pile can freely rotate and move in lateral direction when subjected to horizontal load and / or moment .
- **Fixed Head:** The pile is embedded in a pile cap or other structure, which is assumed to be stiff enough to prevent rotation of the top of the pile, can move laterally Figure 3.3 (b).
- **Pure Moment:** When the vertical load of super – structure acts eccentrically at the foundation. In this case, pile top can rotate but can’t move laterally Figure 3.3 (c).

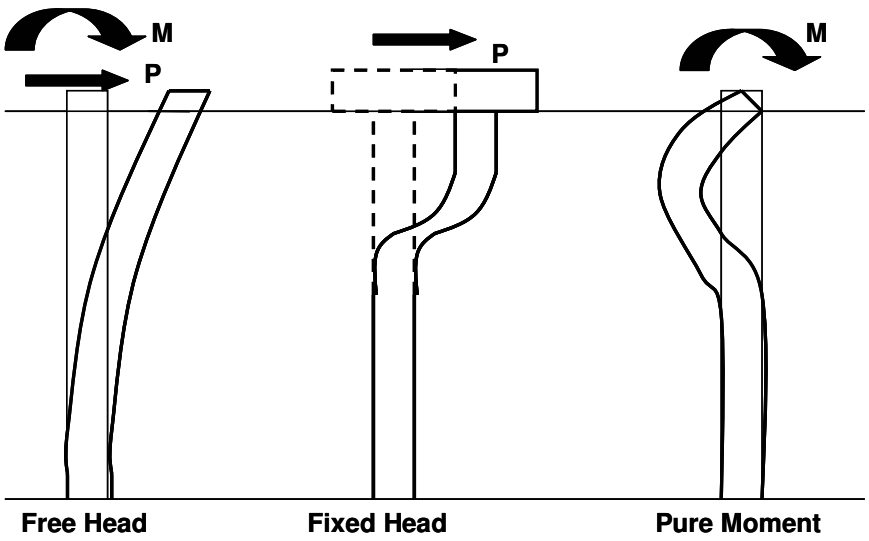


Figure 3.3 Pile Head Boundary Conditions

The above three situations are adequate to analyze any laterally loaded pile, but for other boundary conditions, refer to Reese & Van Impe (2001).

3.5 p-y relationships used to model the sand around a pile

In this approach the pile-soil system is modeled as one dimensional beam, with the pile resting on adjacent soil. The p-y relationship, developed by Cox, Reese and Grubbs (1974), connects the soil resistance p to pile's deflection y at arbitrary depth x below the surface through p-y curves. For a particular depth there is a p-y curve, unique for a sample of sand but to represent the entire medium of sand adjacent to the pile in question families of infinite number of p-y curves have to be drawn. This model uses common soil strength parameters to

simulate the soil resistance-deflection behavior. It is developed for sand adjacent to the pile. It is based on extensive field studies of piles embedded in soil. An extensive series of tests were performed at a site on Mustang Island, near Corpus Christi (Cox, Rees, and Grubbs, 1974). Two steel pipe piles, 0.61m (24 inch) in diameter, were driven into sand in a manner to stimulate the driving of an open-ended pipe, and were subjected to lateral loading. The embedded length of the piles was 21.0m (69 feet). One of the piles was subjected to short-term loading and the other to repeated loading. The soil at the site was uniformly graded, fine sand with an angle of internal frication (Φ=39^o). The submerged unit weight was 10.37 kN/m (66 lb/ft). The water surface was maintained a few inches above the mud line throughout the test program. This model is applicable to sand above and below ground water table.

The correlation that has been developed for predicting soil responses have been based on the best estimate of the properties of the in-situ soil with no adjustment for the effects on soil properties of the method of installations. The logic supporting the approach is that the effect of pile installation on soil properties are principally confined to a zone of soil close to the pile surface, while a mass of soil of several diameters from the pile is stressed as lateral deflection occurs. There are instances, for example, if a pile is jetted into place, a considerable volume of soil could be removed with a significant effect on the soil response.

The formulation of p-y sand model employs the ultimate soil resistance p_s, which is the continuous function of spatial variable x that starts from the soil surface and is directed downwards along the pile axis in the top part of the soil. For arbitrary depth, x, the graphical representation of the p-y relationship is shown in Fig. 3.4. Three values of lateral deflection y denoted as y_k, y_m and y_u established the characteristic points of p-y curve. They are shown in Figure 3.4 and marked as points 0, 1, 2 and 3. They are assessed based on the pile's width b as:

$$y_m = \frac{b}{60} \tag{3.2}$$

$$y_u = \frac{3b}{80} \tag{3.3}$$

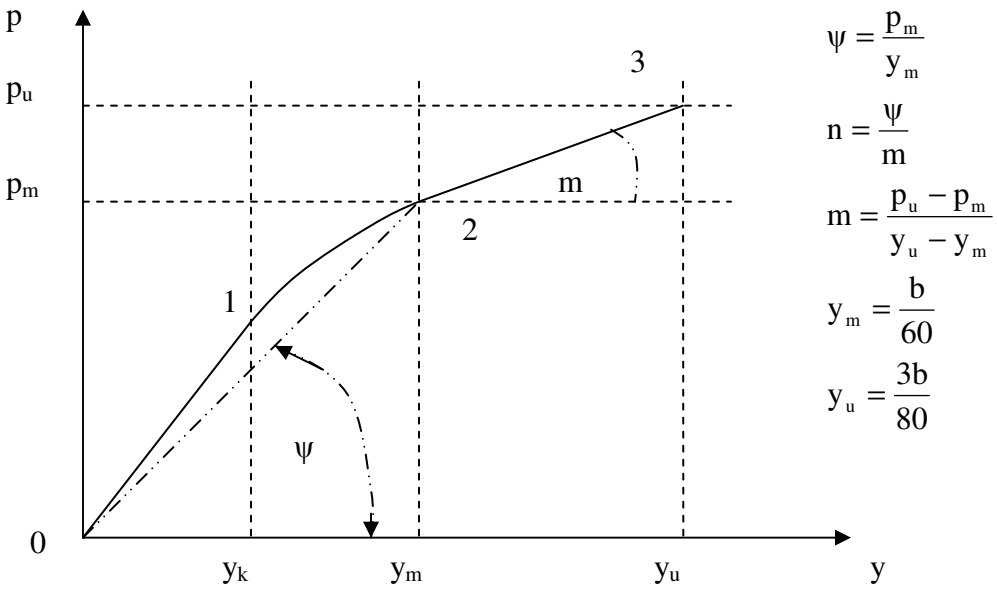


Figure 3.4 Typical p-y curve for sand at arbitrary depth x>0

As found in the experiment, the value of y_k depends on type of sand whereas those of y_m and y_u are independent of type of sand. Expression for derivation of y_k will be shown later. The ordinates of points 2 and 3 are defined as p_m and p_u, respectively, and are described as:

$$p_m = p_s * B_s \tag{3.4}$$

$$p_u = p_s * A_s \tag{3.5}$$

where:

p_s = the ultimate soil resistance,

A_s and B_s= dimensionless coefficients which depend on depth x and are shown in Figure 3.5 and Figure 3.6, respectively, as a function of normalized quantity x/b as proposed by Reese et al. (1974).

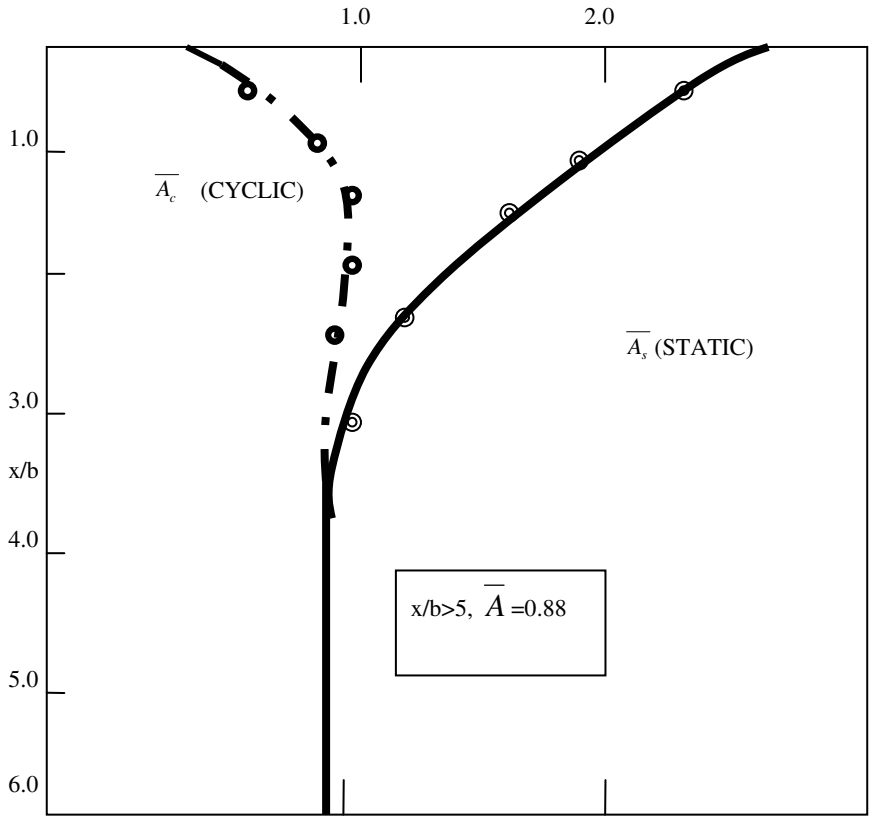


Figure 3.5 Values of coefficient A_s (Reese et al., 1974)

The key constitutive relationship of nonlinear type for arbitrary depth x that passes through points 1 and 2 of Figure 3.4 is given as:

$$p = C * y^{\frac{1}{n}} \tag{3.6}$$

The exponent n can be expressed by means of p_m and y_m as follows:

$$n = p_m/(y_m * m) \tag{3.7}$$

The constant, m can be expresses as:

$$m = \lfloor p\ * (A_s - B_s) \rfloor/(y_u - y_m) \tag{3.8}$$

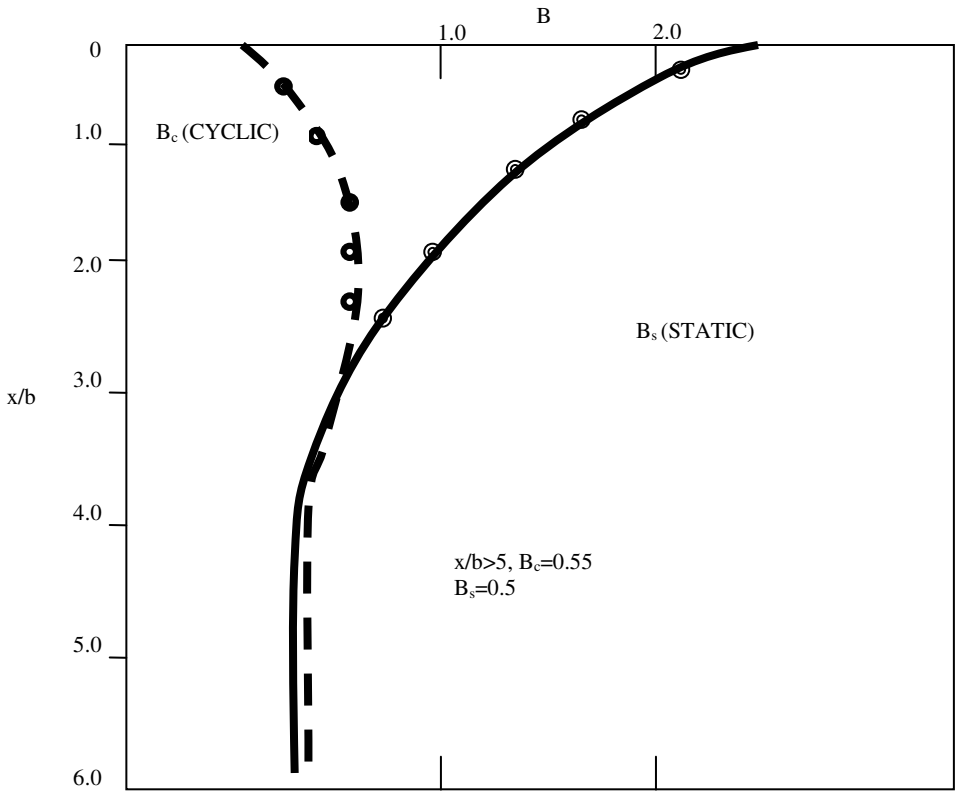


Figure 3.6 Values of coefficient B_s(Reese et al., 1974)

The Eq. 3.4 and Eq. 3.5 can be interpreted by means of Figure 3.4. The parameter m represents the gradient of point 2 with respect to point 3 whereas the ratio p_m/y_m of Eq. 3.4 is the gradient of point 0 with respect to point 2. Taking into account relationships 3.2 and 3.3, the parameter m can be also expressed as:

$$m = p_s(A_s - B_s)/(3 * b/80 - b/60) \tag{3.9}$$

Eq. 3.9 shows that in fact m is dependent on the ultimate soil resistance p_s and dimensionless coefficient A_s as well as B_s. Substitution of Eq. 3.9 together with Eq. 3.4 into Eq. 3.5 enables one to express n as:

$$n = 1.25/(A_s/B_s - 1) \tag{3.10}$$

This means that exponent 1/n of Eq. 3.10 can be written in the following form:

$$1/n = 0.8(A_s/B_s - 1) \tag{3.11}$$

The C value of Eq. 3.6 can be established from the fact that physical relationship given by Eq. 3.6 must be satisfied at point 2 of Figure 3.4. Thus,

$$p_m = C * (y_m)^{\frac{1}{n}} \tag{3.12}$$

Substituting Eq. 3.4 for p_m and Eq. 3.11 for exponent in Eq. 3.12 we arrive at:

$$C = B_s p_s (60/b)^{0.8(\frac{A_s}{B_s}-1)} \tag{3.13}$$

Substitute Eq. 3.13 and Eq. 3.11 into Eq. 3.6, the p-y relationship that finally combining passes through points 0, 1, and 2 is given as:

$$p = B_s p_s (60y/b)^{0.8(\frac{A_s}{B_s}-1)} \tag{3.14}$$

The p-y model of sand discussed in the initial stage of deformation described between points 0, 1, that is for $y \leq y_k$ is defined by the following relationship:

$$p = kxy \tag{3.15}$$

where:

k, is the coefficient of sub grade reaction.

The sand at this stage of deformation is called to be in linear phase and Eq. 3.15 represents the portion of the curve between point 0 and 1.

The physical behavior of sand when subjected to lateral deformations y_m is described by the following relationship:

$$p = p_s\left[B_s + \left(y - \frac{b}{60}\right)\frac{A_s - B_s}{0.021b}\right] \qquad (3.16)$$

It is worth noting that for constant depth x, Eq. 3.16 defines bi-linear behavior. When the lateral deformations approach $y = y_u$ the soil reaction p_u is given by Eq. 3.5. The graphical representation of Eq. 3.5 which describes plastic flow is shown in Figure 3.4. For any value of deflection greater than y_u , that is for $y > y_u$, Eq. 3.5 remains valid.

At value of $y=y_k$, the soil (sand) pressure obtained from Eq. 3.14 and Eq. 3.15 should be the same. So, equating the value of p from Eq. 3.14 and Eq. 3.15 after inserting, $y= y_k$, the following is obtained:

$$y_k = \left[\frac{B_s p_s}{kx}\left(\frac{60}{b}\right)^{0.8\left(\frac{A_s}{B_s}-1\right)}\right]^{\left(\frac{1.25}{2.25-\frac{A_s}{B_s}}\right)} \qquad (3.17)$$

The ultimate soil resistance in sand, p_s per unit length of pile is a function of depth x and there is a characteristic depth x_r above which the soil resistance p_{st} is given by Eq. 3.18 (Cox, Reese, and Grubbs, 1974).

$$p_{st} = \gamma' x\left[\frac{K_\circ x\ \tan\phi\ \tan\beta}{\tan(\beta-\phi)\tan\alpha} + \frac{\tan\beta}{\tan(\beta-\phi)}\left(b + \tan\beta\ \tan\alpha\right) + K_\circ x\ \tan\beta\left(\tan\phi\ \sin\beta - \tan\alpha\right) - K_a b\right]$$

(3.18)

And the ultimate soil resistance in sand, p_{sd} below x_r is given by Eq. 3.19 as:

$$p_{sd} = K_a b\gamma'(\tan^8\beta - 1) + K_\circ\beta\gamma' x\ \tan\phi\ \tan\beta \qquad (3.19)$$

where:

γ' = submerged unit weight of sand,

ϕ = angle of internal friction,

$\alpha = \phi/2$,

$\beta = 45 + \frac{\phi}{2}$

K_a = the coefficient of active lateral earth pressure of Rankine's type = $\tan^2(45 - \phi/2)$

K_o = coefficient earth pressure at rest = 0.4,

b = width of pile at depth x.

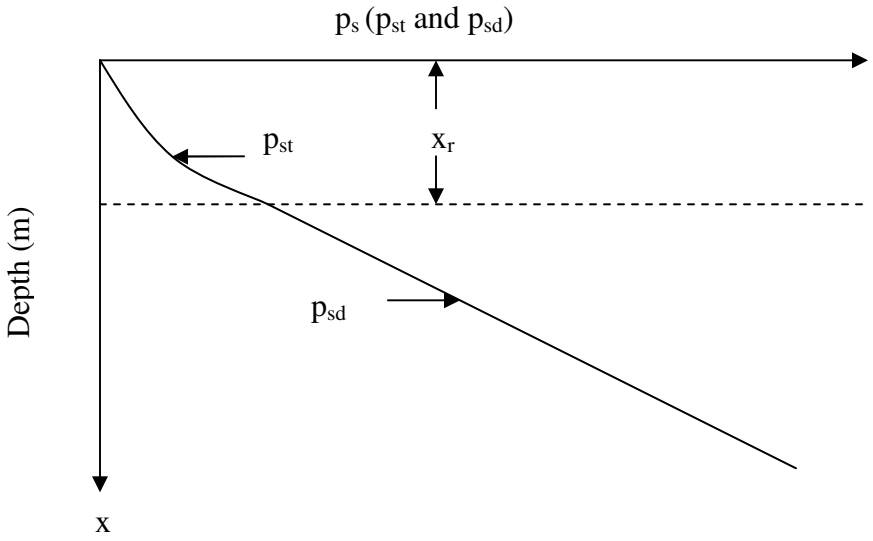


Figure 3.7 Variability of ultimate soil resistance p_s (p_{st} and p_{sd}) of qualitative type around laterally loaded piles embedded in sand.

At depth $x=x_r$, p_{st} and p_{sd} assure the continuity of ultimate soil pressure p_s. So equating them, the following relationship for x_r is established.

$$x_r = \frac{b\tan\beta\left[K_a\tan^7\beta + K_\circ\tan\phi\tan^3\beta\frac{1}{\tan(\beta-\phi)}\right]}{\frac{K_\circ\tan\phi\sin\beta + \tan^2\beta\sin\alpha}{\tan(\beta-\phi)\cos\alpha} + K_\circ\tan\beta\left(\tan\phi\tan\beta - \tan\alpha\right)} \qquad (3.20)$$

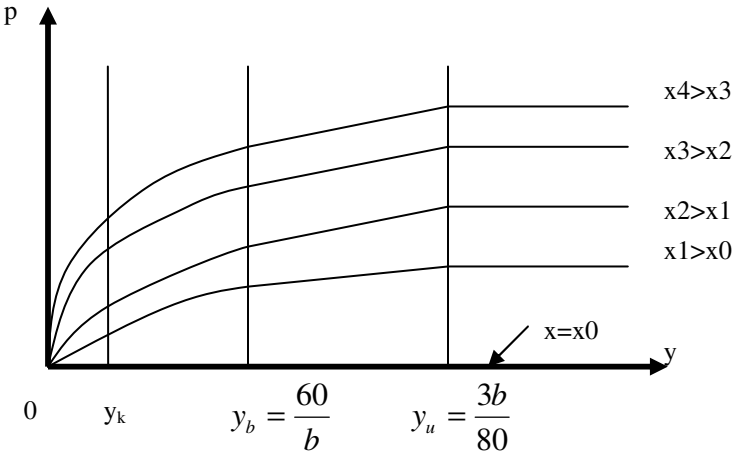


Figure 3.8 Family of p-y curves for different value of x

A graphical presentation of ultimate soil pressure p_s with respect to depth x is given in Figure 3.8. For a constant value of x depending on the different value of deformation, y, starting from low to high, sand in the vicinity of the pile under lateral load passes through four phases. They are linear elastic, nonlinear elastic, bi-linear elastic and plastic flow phase. All four phases are represented by a p-y curve, uniquely for that value of depth x.

Choosing different values of depth x a series of p-y curves are required to model the sand around the pile throughout the length of the pile. A qualitative diagram showing a series of such p-y curves are given in Figure 3.8. The components of p-y curves above x_r are summarized in Figure 3.9 (a). The components of p-y curves below x_r are summarized in Figure 3.9 (b).

$$p_{st} = \gamma' x\left[\frac{K_\circ x\ \tan\phi \sin\beta}{\tan(\beta-\phi)\tan\alpha} + \frac{\tan\beta}{\tan(\beta-\phi)} * (b + x\ \tan\beta\ \tan\alpha + K_\circ x\ \tan\beta(\tan\phi \sin\beta - \tan\alpha) - K_a b\right] \quad (3.21)$$

where,

p_{st} = the ultimate soil resistance associated with upper part of pile

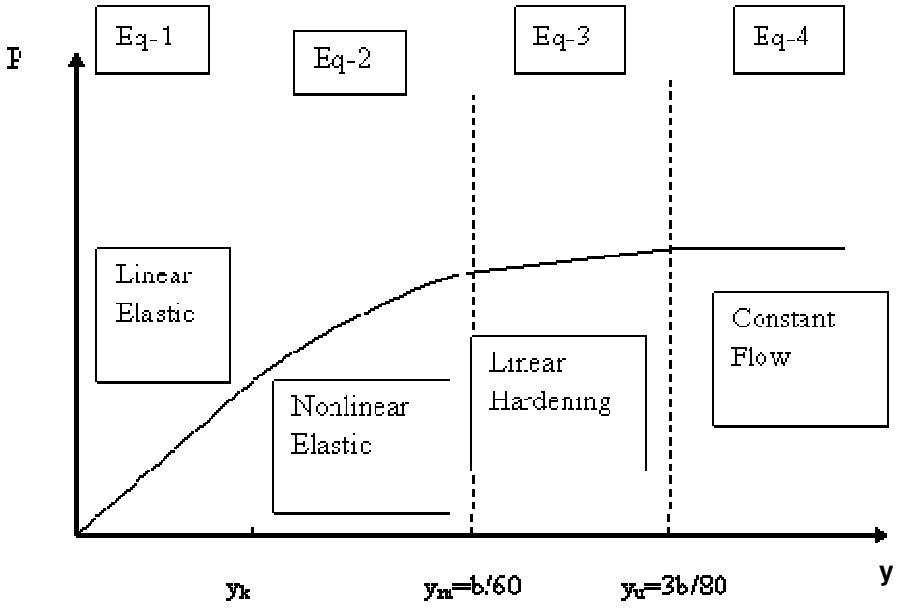


Figure 3.9 (a) Components of p-y curve above x_r

Eq-1: kxy

Eq-2: $p = B_s p_{st} (60y/b)^{0.8(A_s/B_s - 1)}$

Eq-3: $p = p_{st}[B_s + 48(y - b/60(A_s - B_s)/b]$

Eq-4: $p_u = p_{st} * A_s$

$$P_{sd} = K_a b \gamma' (\tan^8\beta - 1) + K_o \beta \gamma' x \tan\phi \tan\beta \qquad (3.22)$$

where,

p_{sd} = the ultimate soil resistance associated with lower part of pile

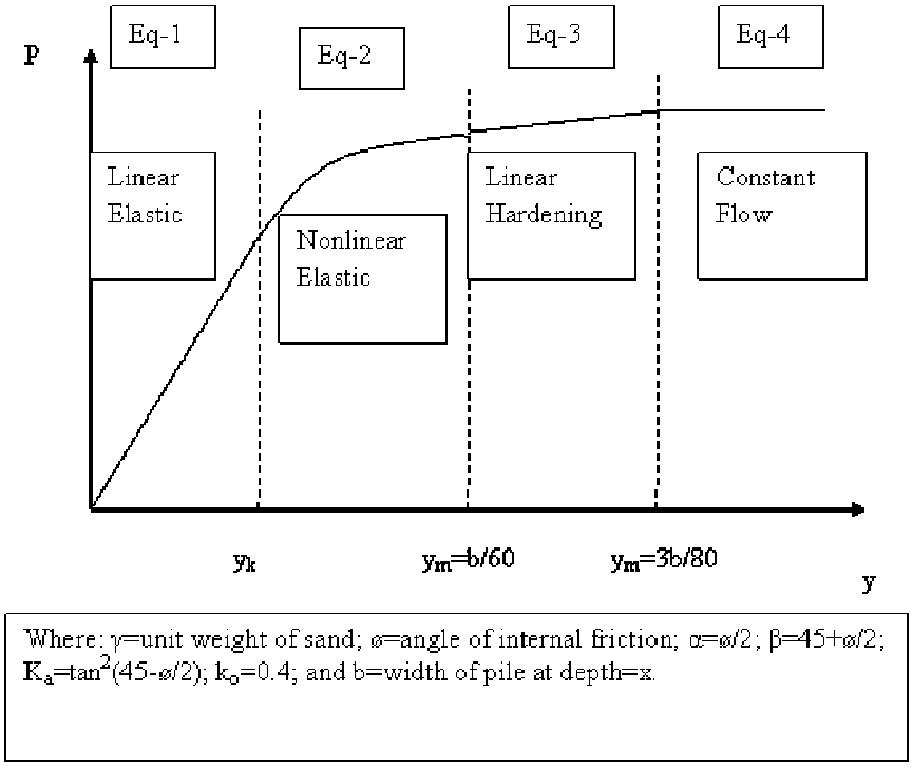


Figure 3.9(b) Components of p-y curve below x_r

Eq-1: kxy

Eq-2: $p = B_s p_{sd} (60y/b)^{0.8(A_s/B_s - 1)}$

Eq-3: $p = p_{sd}\left[B_s + 48(y - b/60(A_s - B_s)/b\right]$

Eq-4: $p_u = p_{sd} * A_s$

3.6 Computer program COM624P used in the investigation of single piles

For any horizontal force or bending moment applied to the pile, a deflection y and a soil resistance p can be calculated by solving the differential equation of beam using boundary condition and p-y curves through iterations. But this would be a time consuming and difficult process because of the following reasons.

a) Non-linear relationship exists between soil resistance and deflection.

b) Deflection is a non-linear function of load applied and soil response.

c) There are many segments of p-y curves.

d) Pile deflection being substantial has to be considered in calculation.

e) Defection and soil response depend on depth, x.

f) Depending on the pile length, soil strength, stiffness of pile and applied load the pile may deform in many different modes. For example the behavior of a long pile shows that the deflection oscillates back and forth about the axis of the un-deformed pile so that there are a number of points of zero deflection.

These predicaments have been overcome through the use of computer program COM624P. The numerical investigations are conducted by the finite difference program COM624P of Wang and Reese (1993). The technology on which the program is based is the widely-used p-y curves method. The program solves the differential equation involving the pile-beam giving pile deflection, rotation, bending moment, and shear by using iterative procedure because of the non-linear response of the soil. This program can be used not only to analyze laterally loaded single pile with various pile head conditions and loadings, but

also groups of pile by applying the p-multiplies to the pile. Through the use of COM624P a large number pile cases have been analyzed which would otherwise have not been possible.

3.7 FB-Pier software

The University of Florida, Bridge Software Institute (BSI), with the support of the Florida Department of Transportation and the Federal Highway Administration, developed FB- Pier program (2001). The program also employs p-y method for soil with non-linear finite element analysis. This software is an integrated program, which both analyzes and design the structure of piles/ piers. The program had the capability to analyze and design single piers, or pile, piles and pile caps, high mast signs and retaining walls. The structural model includes both linear and non-linear (concrete cracking, steel yielding and soil non-linearity etc.) features. In this study, a pile is modeled as a one-dimensional beam with nodes along the pile length and the soil is modeled as a nonlinear spring simulated by p-y curves. A lateral force is applied at the pile head with a different boundary condition, such as free head or fixed head.

3.8 Group of Piles

In the field, piles are often arranged in groups, and the behavior of a pile differs substantially from that of a single pile. Evidently a group of piles can support a bigger load than a single pile. But piles lose efficiency when used in a group, that is, a single isolated pile carries more load than when used in a group. The deflection of piles in group is greater than deflections of single pile at the same load pile. This is because of the pile-soil-pile interaction, that is, a pile being a member of a pile group shares the soil area of resistance with other pile or piles. All the members of piles group are tied together by a rigid concrete pile cap at the ground surface. The response of a laterally loaded pile within a group

of closely spaced piles is often substantially different than the response of a single isolated pile. Pile connection to the cap may be fully restrained, pinned or in between of these two extremes. In this study, individual piles in a group are treated as single piles after ascertaining the portion, carried by the pile in question, of total load applied to the group as a whole. Each member pile is represented as a beam supported laterally by soil, which is modeled using nonlinear load versus deflection curves, the p-y curves. General arrangement of piles in a (3x3) group is shown in Figure 3.10.

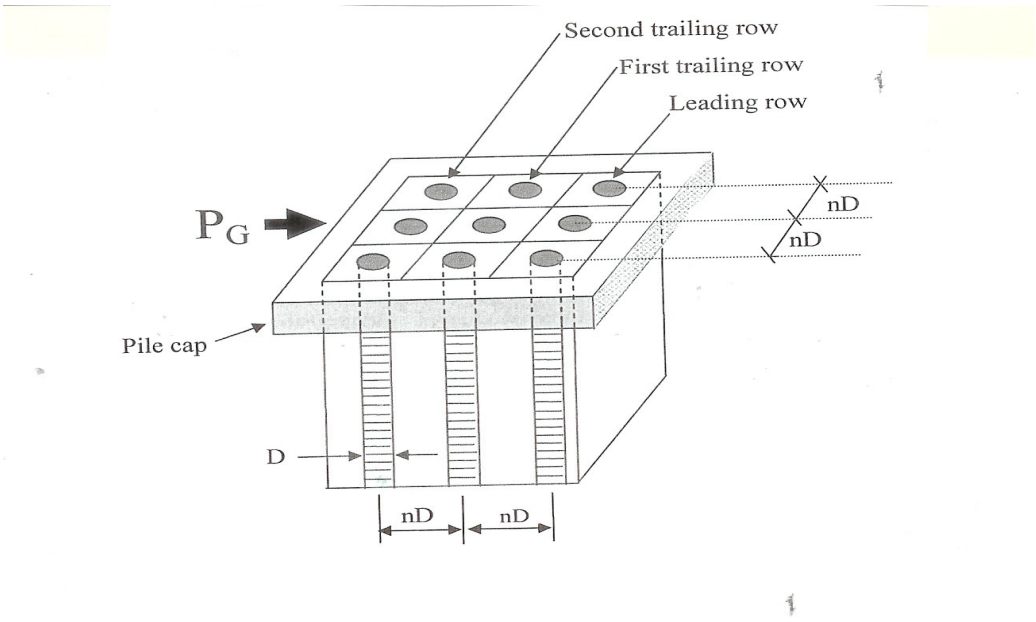


Figure 3.10 (3x3) pile group and pile cap in group of piles (Mokwa and Duncan, 2001)

The rows of pile stretch perpendicular to the line action of the force. The orientation of rows is shown in Figures 3.11 and 3.12. Measurement of displacement and stresses in full-scale and model pile group tests indicate that piles in the same group carry unequal lateral loads, because of their location within the group and the spacing between them. This unequal distribution of load among the rows of plies is called the shadowing effect. In closely spaced piles of

a group there occurs the overlapping of areas of resistance and as a result unequal reduction of soil resistance. The closer the piles are the more pronounced the effect of shadowing is. For spacing of 6D, D being the diameter of pile, the shadowing effect is very small and often neglected. So, piles in a group with spacing 6D or more usually are treated as single piles. Piles in the leading row experience the greatest amount of soil reaction followed by that of 1st trailing row and then 2nd. In this research the member piles in the groups are modeled by the same method p-y that is used for piles, except that p-values in the p-y are reduced multiplying by a p-multiplier, f_m to account for reduced efficiencies caused by pile-soil-pile interaction.

3.9 p-multiplier, f_m employed to model pile group

The concept of p-multiplier was introduced by Brown et al.(1985) as discussed in chapter 2 of this thesis. They proposed the p-multiplier through large-scale test on pile group and isolated pile embedded in dense sand. In this research p-multipliers f_m, proposed by Mokwa and Duncan (2001) are employed. Mokwa and Duncan (2001) studied results from eleven experimental research work to determine p-multipliers f_m, for pile group of different pile sizes and different pile spacing. Twenty nine separate tests were performed by different research teams in all of these eleven studies. Mokwa and his team ascertained the value of p-multipliers through back analysis using results from instrumented pile-group and single pile load tests.

When a pile group is laterally loaded, the lateral resistance of any pile in the group is equal to the product of load resistance of a single pile, that can be obtained dividing total load applied to the pile group by number of piles in the group, and p-multiplier assigned to the pile in question by virtue of its position in the group and spacing of the plies in the group. When a pile group is laterally loaded, the lateral load resistance p_{gp} of a pile in the group is equal to the product of load resistance of a single pile p_{sp} and p-multiplier denoted as f_m assigned to the pile.

Thus;

$$p_{gp} = f_m p_{sp} \qquad (3\text{-}23)$$

p_{gp} = the lateral load resistance of pile in group,

p_{sp} = the lateral load resistance of single pile,

f_m = p-multiplier.

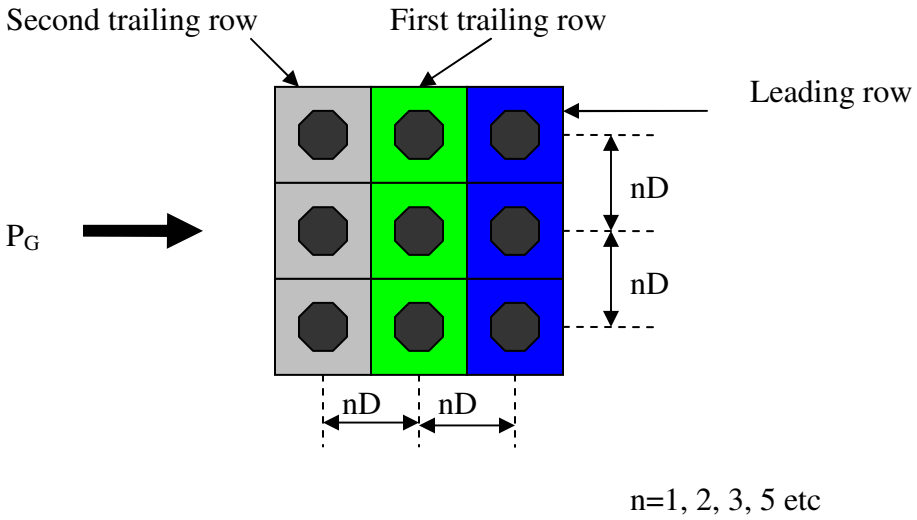


Figure 3.11 Orientation of rows in a plan of group of piles.

Mokwa and Duncan (2001) presented the recommended p-multiplier values as functions of pile spacing and pile location within the group in the form of a chart shown in Figure 3.13. As suggested, the bending moment computed for the leading row corner piles should be increased if the spacing normal to the direction of load is less than 3D. The values of p-multipliers, f_m for leading row through 3rd trailing row are shown in Figure 3.13 for pile spacing 1D to 6D. For

pile spacing higher than 6D the f_m value is 1. The value of f_m is essentially the same for third, fourth and subsequent trailing rows.

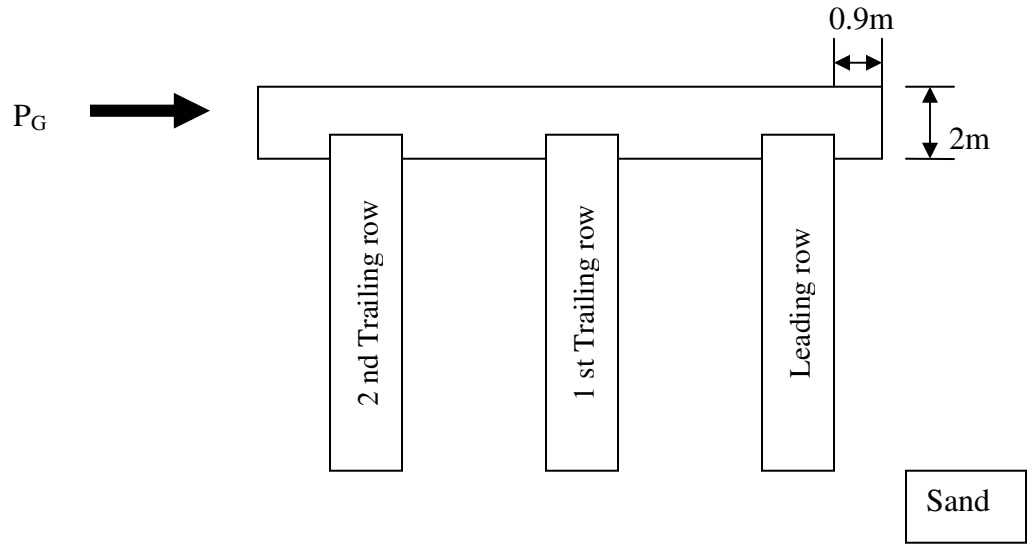


Figure 3.12 Geometrical characteristics of pile group

3.10 Efficiency of pile group

Mokwa and Duncan (2001) have shown relation between f_m and group efficiency. Overall efficiency G_e of a group, as they defined is the ultimate lateral capacity $(P_s)_g$ of the group of n number of plies divided by lateral capacity of a single pile times n.

$$G_e = \frac{(p_s)_g}{n(p_s)_s} \qquad (3\text{-}24)$$

where:

n- number of piles,

G_e – the pile group efficiency,

$(P_s)_g$- the ultimate lateral load capacity of the pile group,

$(P_s)_s$ – the lateral load capacity of single pile.

Eq. 3.24, when written in terms of f_m becomes

$$G_e = \frac{\sum_{i=1}^{N_r} f_{mi}}{N_r} \qquad (3.25)$$

N_r= the number of rows

f_{mi} = the p-multiplier f_m of the i-th row.

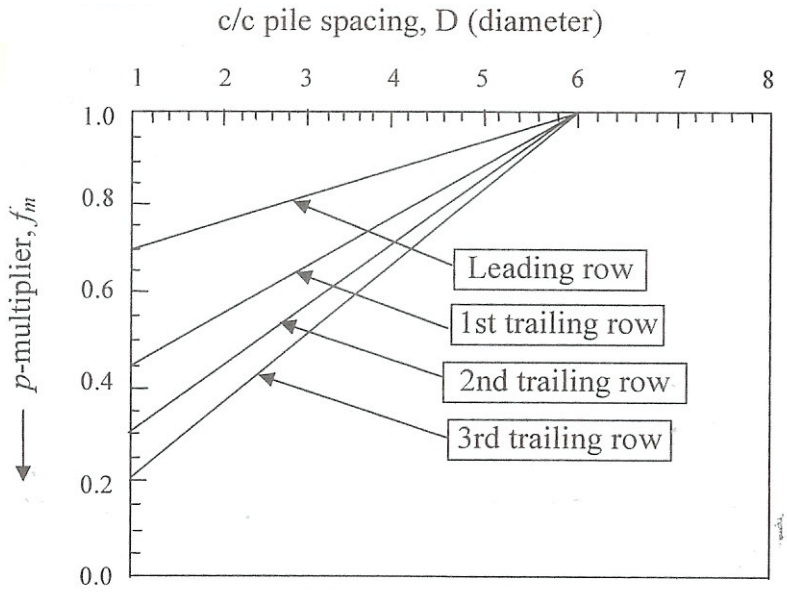


Figure 3.13 Proposed p-multiplier design curves (Mokwa and Duncan, 2001)

Notes:

1-The term row used in this chart refers to piles aligned perpendicular to the direction of applied load.

2-Use the f_m values recommended for the third trailing row for all rows beyond the third trailing row.

3- Bending moments and shear forces computed for the leading row corner piles should be adjusted as follows:

side by side spacing	corner pile factor
3D	1.0
2D	1.2
1D	1.6

The (FB-Multipier) is a non-linear, finite element analysis, soil-structure interaction program. Lateral load applied to the pile cap is regarded as applied to the pile group and is denoted by P_G whereas lateral force imposed on individual member pile as a result of P_G applied to the pile group is denoted by Pg.

CHAPTER FOUR

THEORETICAL BASIS FOR APPLICATIO OF RELIABILITY THEORY TO ANALYSIS OF LATERALLY LOADED PILES

In real engineering projects and in solving engineering problems, uncertainties are present too often, and this is also the case in analysis and design of geotechnical problems and geotechnical systems. In daily engineering applications, we may find that the problem has one or more uncertainties in its parameters, and in most cases we insure that these design parameters have a conservative estimate and insure sufficient safety factor to account for the uncertainties. While, in reliability analysis, the uncertainties in design parameters are evaluated rationally by combining the appropriate component of uncertainties.

4.1 Uncertainties in Soil

In general, an uncertain performance of deep foundations is affected by many factors such as spatial variation of soil properties, limited soil exploration programs, and uncertainties in the parameters determined by various testing methods and analysis, limited calculation models as well as uncertainties in loads. Every site is considered as unique in terms of subsurface conditions that vary spatially within a site. The variability of subsurface conditions within and between sites leads to uncertainty in the information needed in geotechnical design.

Geotechnical reliability analysis began in earliest about 1970. Many studies were conducted to predict geotechnical variability (Spry et al. 1988; Kulhawy et al. 1992). Today, reliability analysis appears to be in the threshold of entering mainstream geotechnical practice. Risk assessment, often incorporating

reliability analysis, is now employed by major public works agencies and private sector.

Three main causes of uncertainty in soil profile modeling were identified, they are:

- Natural heterogeneity (in-situ variability of soil)
- Measurements error
- Error in transformation model

First one occurs due to variation in mineral composition and geological history, varying depth of strata during soil formation, and fluctuations in moisture content and density of soil. Clearly, no amount of site exploration can supply sufficient information for a detailed deterministic description of the local variation at the site; only probabilistic model can capture the important features with a minimum number of additional soil parameters. Second cause, measurement error, happens due to sample disturbance, test imperfections, and human factors. Soil profile characteristics must be judged from field or laboratory investigation of a limited number of soil samples. This is called statistical uncertainty and it can be decreased at the expense of additional testing.

The effect of the above mentioned sources on the overall uncertainty in design soil property depends on site conditions, quality precautions on sampling procedure and equipment, and the accuracy of transformation model.

4.2 Random variables

In reliability analysis the variables which significantly influence the judgment of safety or failure, and which are characterized by substantial uncertainties are called **random variables**.

When we conduct an analysis on a structure, it gives us certain result. If we perform the analysis for **(N)** number of times on the same structure with

different outcome every time, then each analysis result is known as an **event** and all possible results from **a space** of **event**. Every event has some probability assigned to it. The function of event which fulfills certain conditions is known as function of random variable.

The uncertainties connected to the parameters of pile material (EI, B), soil surrounding the pile (k, γ' , Φ), and applied load (lateral load P) are considered to be affecting the performance of pile up to greater extent. Therefore, these parameters are taken as random variables for probabilistic analysis.

4.2.1 Cumulative Distribution and Probability Density Functions:

In probabilistic analysis, random variables are represented by their cumulative distribution function and probability density function.

1. **Cumulative Distribution Function (CDF) :** suppose **X** is an random variables of discrete type or continuous type, then cumulative distribution function is given by,

$$F_x(x) = P\{X \le x\}, \quad \text{where} \cdots -\infty \le x \le \infty \tag{4.1}$$

The value for CDF varies between 0 and 1. Example of a CDF for continuous random variable **X** is shown in Figure 4.1 (A).

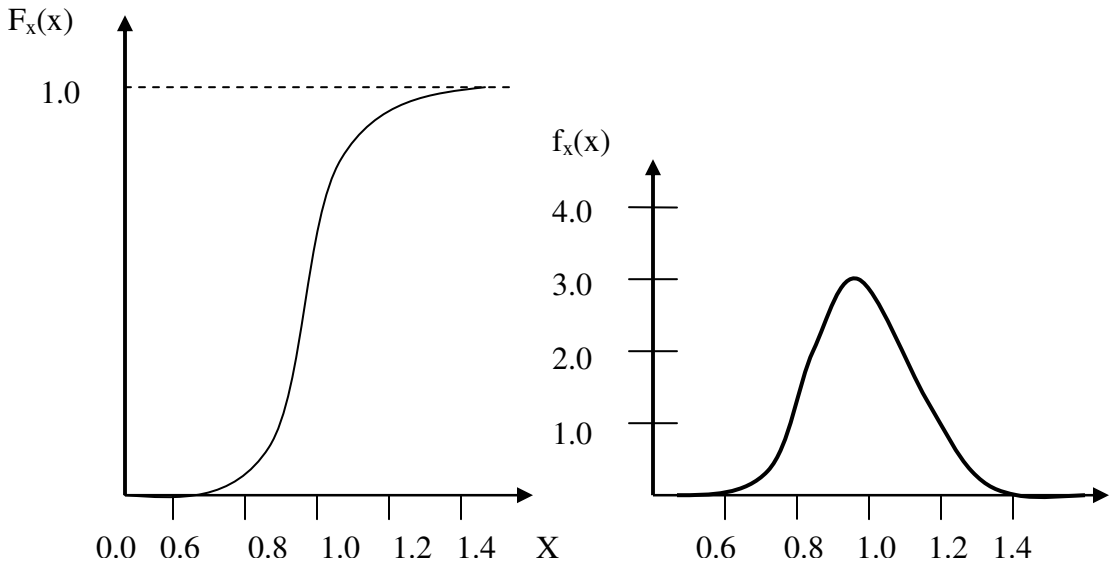
2. **Probability Density Function (PDF):** The first derivative of the cumulative density function is known as probability density function $f_x(x)$ of the continuous random variable **X**.

$$f_x(x) = \frac{dF_x(x)}{dx} \tag{4.2}$$

or,

$$F_x(x) = \int_{-\infty}^{x} f_x(x)dx \tag{4.3}$$

We can also say that integration of PDF gives CDF. The example of PDF for the continuous random variable **X** is shown in Figure 4.1 (B).



(A) Cumulative Distribution Function (B) Probability Density Function

Figure 4.1 Representatives of Random Variables

4.2.2 Statistical description of random variable

The properties of random variable can be described either graphically or analytically. Graphical presentation includes the frequency histograms. Analytical description can be given through following parameters:

1. **Mean Value (Expected Value) (X):** The mean value of discrete random variable X is equal to the arithmetic mean of the test results (i.e. all the values of X).

$$X^{\circ} = \frac{1}{n}\sum_{i=1}^{n} X_i \qquad (4.4)$$

where, n $\rightarrow$ number of results (or all values of X)

2. **Variance (VarX) :** It measures the scattering of the discrete random variable (X) from the mean value (X°).

$$\mathrm{VarX} = \frac{1}{n-1}\sum_{i=1}^{n}(X_i - X^{\circ})^2 \qquad (4.5)$$

3. **Standard Deviation (σ_X):** It is the positive square root of variance of X.

$$\sigma_X = \sqrt{\mathrm{VarX}} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(X_i - X^{\circ})^2} \qquad (4.6)$$

4. **Coefficient of variation (COV_x):** It is the ratio of standard deviation of discrete random variable X (σ_X) to mean value of X.

$$\mathrm{COV}_x = \frac{\sigma_x}{X^{\circ}} \qquad (4.7)$$

COV_x is a non-dimensional quantity.

5. **Covariance ($Cov(X_i, X_j)$):** If more than one random variable is present. The definition of variance is extended to covariance. For the random variables X_i and X_j , covariance is given by ,

$$\mathrm{Cov}\,(X_i, X_j) = \frac{1}{n-1}\sum_{i,j=1}^{n}(X_i - X_i^{\circ})(X_j - X_j^{\circ}) \qquad (4.8)$$

6. **Covariance matrix:** The variance and covariance for set random variables can be put into matrix and is called covariance matrix.

$$[S_X] = \begin{bmatrix} \mathrm{Var}(X_1) & \mathrm{Cov}(X_1,X_2) & \mathrm{Cov}(X_1,X_3)\ldots\ldots\ldots\ldots & \mathrm{Cov}(X_1, X_n) \\ \mathrm{Cov}(X_2,X_1) & \mathrm{Var}(X_2) & \mathrm{Cov}(X_2,X_3)\ldots\ldots\ldots\ldots & \mathrm{Cov}(X_2, X_n) \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ \mathrm{Cov}(X_n, X_1) & \ldots\ldots\ldots & \ldots\ldots\ldots\ldots & \mathrm{Var}(X_n) \end{bmatrix} \qquad (4.9)$$

4.2.3 Types of random variables:

The common types of random variables used in structural reliability analysis are:

- Uniform Random Variable
- Normal Random Variable
- Lognormal Random Variable
- Gamma Distribution
- Extreme Type III (Weibull Distribution)
- Poisson Distribution

For this study only normal random variable is needed and hence is discussed here in detail. All other kinds of random variables are talked about in brief.

For uniform random variable, the PDF function has a constant value for all possible values of random variable within a certain range. The random variable X is lognormal random variable, if function of random variable Y = In(X). A lognormal random variable is defined for positive values only. It is widely used in structural reliability analysis. The gamma distribution random variables are useful to characterize the probabilistic nature of the extreme values (largest or smallest values) of some phenomenon over time. The Poisson distribution is a discrete probability distribution that can be used to calculate CDF for the number of occurrences of a particular event in a time or space interval (for example, the occurrence of the number of earthquakes within a certain time interval). For details on these random variables, refer “Probability, Random Variables and Stochastic Processes” by Papoulis and Unnikrishna Pillai (2002).

4.2.3.1 Normal Random Variable (Gaussian Distribution)

The normal distribution is one of the most important distributions in probability and statistics. If X is a random variable with mean value X° and standard deviation, σ_X then its PDF is given by:

$$f_x(X) = \frac{1}{\sigma_x \sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{X - X^{\circ}}{\sigma_x} \right)^2 \right] \qquad (4.10)$$

PDF for normal random variable has bell shaped curve with its symmetry around the mean value X°. The shape of the curve depends on the variance or standard deviation of X. The PDF curve of Fig. 4.2.(a) has higher Var(X) than the PDF curve of Fig. 4.2 (b). Therefore, as the Var(X) decreases the curve for PDF gets steeper and narrower.

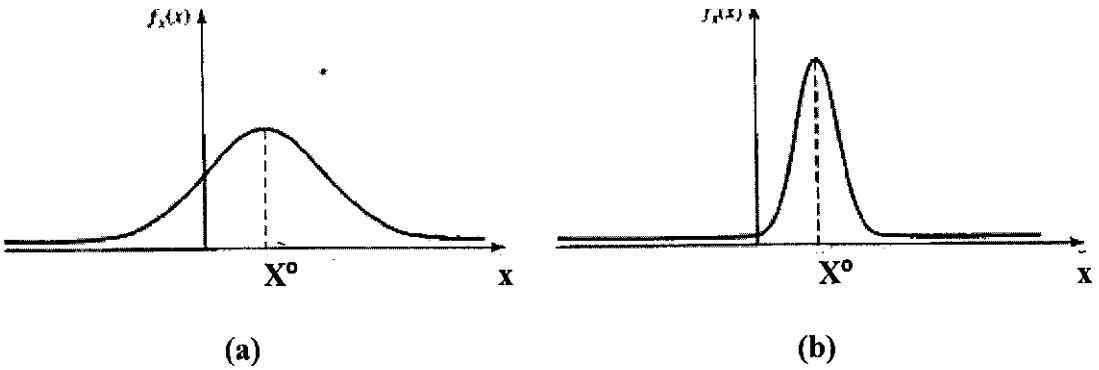


Figure 4.2: Normal Random Variable

4.2.4 Statistical Linearization method:

Let the function $f(\overline{X})$ describe the performance of pile structure (for example, pile head deflection) which linearly depends on the vector of random design variables (related to pile material, soil, and lateral load) X. Then, f(X) is given by,

$$f(\overline{X}) = a_\circ + a_1 X_1 + a_2 X_2 + ... + a_n X_n = a_\circ + \sum_{i=1}^{n} a_i X_i \qquad (4.11)$$

where, $a_\circ, a_1, ...a_n$ are constants

The mean value of function of random variable $f^\circ(\overline{X})$, is given as,

$$f^\circ(\overline{X}) = a_\circ + \sum_{i=1}^{n} a_i X_i^\circ \qquad (4.12)$$

Using Eq.4.5, the variance for function of random variable Var $(f(\overline{X}))$ can be given by,

$$\mathrm{Var}(f(\overline{X})) = E\left(\left(f(\overline{X}) - f^\circ(\overline{X})\right)^2\right) \qquad (4.13)$$

$$\mathrm{Var}(f(\overline{X})) = E\left(f(\overline{X})^2 - f^\circ(\overline{X})^2\right) \qquad (4.14)$$

Therefore,

$$\mathrm{Var}(f(\overline{X})) = \sum_{i=1}^{n}\sum_{j=1}^{n} a_i a_j \mathrm{Cov}(X_i, X_j) \qquad (4.15)$$

If the n random variables are uncorrelated with each other,
Cov (X_i, X_j)=0 for $i \neq j$

Thus Eq.4.15 simplifies to

$$\mathrm{Var}(f(\overline{X})) = \sum_{i=1}^{n} a_i^2 \mathrm{Var}(X_i) \qquad (4.16)$$

If there is more than one function of random design variables for the performance of pile structure (for example, pile head deflection and maximum bending moment in pile), then the number of functions can be expressed in matrix form as,

$$\{f(\overline{X})\} = [C]\{\overline{X}\} \qquad (4.17)$$

where, [C] is a matrix of order m x n with real elements.
And,

$$\{f(\overline{X})\}^T = \{f_1(\overline{X}), f_2(\overline{X}), f_3(\overline{X}), ..., f_n(\overline{X})\} \qquad (4.18)$$

$$\overline{X^{T}} = \{X_1, X_2, X_3, ..., X_n\} \tag{4.19}$$

$$\overline{X^{\circ T}} = \{X_1^{\circ}, X_2^{\circ}, X_3^{\circ}, ..., X_n^{\circ}\} \tag{4.20}$$

$$\begin{Bmatrix} f_1(\overline{X}) \\ f_2(\overline{X}) \\ \vdots \\ f_n(\overline{X}) \end{Bmatrix} = \begin{bmatrix} C_{11} & C_{12} & \cdots & C_{1n} \\ C_{21} & C_{22} & \cdots & C_{2n} \\ \vdots & \vdots & & \vdots \\ C_{m1} & \cdots & \cdots & C_{mn} \end{bmatrix} \begin{Bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{Bmatrix} \tag{4.21}$$

.

This means that arbitrary component of function {f ($\overline{X}$)} can be determined as;

$$f_k = \sum_{i=1}^{n} C_{ki} X_i \tag{4.22}$$

The mean value of the function of random variable is given as,

$$f_k^{\circ} = \sum_{i=1}^{n} C_{ki} X_i^{\circ} \tag{4.23}$$

In the same way the second arbitrary function can be given as,

$$f_l = \sum_{j=1}^{n} C_{lj} X_j \tag{4.24}$$

Then $\mathrm{Cov}(f_k, f_l)$ is given as;

$$\mathrm{Cov}(f_k, f_l) = E\{(f_k - f_k^{\circ})(f_l - f_l^{\circ})\} \tag{4.25}$$

$$\mathrm{Cov}(f_k, f_l) = E\left\{\left(\sum_{i=1}^{n} C_{ki} X_i - \sum_{i=1}^{n} C_{ki} X_i^{\circ}\right)\left(\sum_{j=1}^{n} C_{lj} X_j - \sum_{j=1}^{n} C_{lj} X_j^{\circ}\right)\right\} \tag{4.26}$$

$$\mathrm{Cov}(f_k, f_l) = \sum_{i=1}^{n} C_{ki} \sum_{j=1}^{n} C_{lj} E\left\langle (X_i - X_i^{\circ})(X_j - X_j^{\circ})\right\rangle \tag{4.27}$$

It can also be written as;

$$\left[S_{f(\overline{X})}\right] = [C][S_X][C]^T \tag{4.28}$$

where $\left[S_{f(\overline{X})}\right]$ is the covariance matrix for the functions of random variables and $[S_x]$ is the covariance matrix for random variables.

If n design random variables are independent of each other,

Cov (X_i, X_j) =0 for $i \neq j$

This means that the covariance matrix for random variable $\overline{X}$ will be given as:

$$[S_X] = \begin{bmatrix} \mathrm{Var}X_1 & 0 & \cdots & \cdots & 0 \\ 0 & \mathrm{Var}X_2 & \cdots & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & 0 \\ 0 & 0 & 0 & 0 & \mathrm{Var}X_n \end{bmatrix} \tag{4.29}$$

All these values are valid regardless of the PDF of the random variables.

Instead of linear function, suppose function {f ($\overline{X}$)} is a non-linear function of random variables $\overline{X}$. The expansion of the function in Taylor series in the vicinity of mean value $\overline{X^{\circ}}$ of $\overline{X}$ gives,

$$f(\overline{X}) \approx f(\overline{X^{\circ}}) + \sum_{i=1}^{n} (X_i - X_i^{\circ}) \frac{\partial f(\overline{X})}{\partial X_i}\bigg|_{\text{Evaluated at\_}\overline{X^{\circ}}} \tag{4.30}$$

Suppose more than one number of functions of random variables are present. Then, the above equation is given as:

$$\{\overline{f}(\overline{X})\} \approx \{\overline{f}(\overline{X^{\circ}})\} + \left[\frac{\partial \overline{f}(\overline{X^{\circ}})}{\partial X_i}\right]\{X_i - X_i^{\circ}\} \tag{4.31}$$

where, $\left[\frac{\partial \overline{f}(\overline{X^{\circ}})}{\partial X_i}\right]$ is a structural sensitivity matrix and is given as;

$$\left[\frac{\partial f(\overline{X^{o}})}{\partial X_i}\right] = \begin{bmatrix} \frac{\partial f_1(\overline{X^{o}})}{\partial X_1} & \frac{\partial f_1(\overline{X^{o}})}{\partial X_2} & \cdots & \cdots & \frac{\partial f_1(\overline{X^{o}})}{\partial X_n} \\ \frac{\partial f_2(\overline{X^{o}})}{\partial X_1} & \frac{\partial f_2(\overline{X^{o}})}{\partial X_2} & \cdots & \cdots & \frac{\partial f_2(\overline{X^{o}})}{\partial X_n} \\ \vdots & \vdots & \ddots & & \vdots \\ \frac{\partial f_n(\overline{X^{o}})}{\partial X_1} & \frac{\partial f_n(\overline{X^{o}})}{\partial X_2} & \cdots & \cdots & \frac{\partial f_n(\overline{X^{o}})}{\partial X_n} \end{bmatrix} \tag{4.32}$$

$\{\overline{f}(\overline{X})\}$, $\overline{X}$, $\overline{X^{\circ}}$ are same as given in Eq. 4.18, 4.19, & 4.20.

The covariance matrix of the functions of random variables is given by,

$$[S_f] = \left[\frac{\partial f\left(\overline{X}^{\circ}\right)}{\partial X_i}\right][S_X]\left[\frac{\partial f\left(\overline{X}^{\circ}\right)}{\partial X_i}\right]^T \quad (4.33)$$

Where $[S_f]$ is an covariance matrix for function and $[S_X]$ is a covariance matrix for random variable. Both $[S_f]$ and $[S_X]$ are symmetric matrix.

4.2.5 First-Order Second-Moment Reliability:

This method is developed by Cornell in 1969. It is called "First–Order Second-Moment Reliability Method " because it is based on the first-order Taylor series approximation of the limit state function and uses only second moments statistics i.e. mean and variance (or covariance) of function of random variables.

The mean is intended to be a best estimate without conservatism, while the variance or standard deviation is used to represent the uncertainty. The function is given as:

$$g(f) = f^{\text{Resist}} - f^{\text{Current}} \quad (4.34)$$

where mean and variance of g(f) is,

$$\left(g(f)\right)^{o} = \left(f^{\text{Resist}}\right)^{o} - \left(f^{\text{Current}}\right)^{o} \quad (4.35)$$

and,

$$\text{Var}\left(g(f)\right) = \text{Var}\left(f^{\text{Resist}}\right) + \text{Var}\left(f^{\text{Current}}\right) \quad (4.36)$$

or,

$$\sigma^2_{g(f)} = \sigma^2_{f^{\text{Resist}}} + \sigma^2_{f^{\text{Current}}} \quad (4.37)$$

The probability of failure is given by:

$$P_f = P(f^{Resist} - f^{Current} < 0) = P(g(f) < 0) = \varphi\left(-\frac{(g(f))^o}{\sigma(g(f))}\right) \quad (4.38)$$

$$P_f = 1 - \varphi\left(\frac{(f^{Resist})^o - (f^{Current})^o}{\sqrt{\sigma^2_{f^{Resist}} + \sigma^2_{f^{Current}}}}\right) \quad (4.39)$$

where ϕ is the cumulative distribution function for a function of standard normal variable and the ratio of mean to the standard deviation of g(f) is known as reliability index.

$$\beta = \left(\frac{(g(f))^o}{\sigma_{g(f)}}\right) \quad (4.40)$$

or,

$$\beta = \left(\frac{(f^{Resist})^o - (f^{Current})^o}{\sqrt{\sigma^2_{f^{Resist}} + \sigma^2_{f^{Current}}}}\right) \quad (4.41)$$

The value of $\overline{f^{Current}}$ are obtained from structural analysis and probabilistic modeling of laterally loaded pile structure, but as $\overline{f^{Resist}}$ is independent of the pile-soil interaction i.e. not a function of design random variables. The $\overline{f^{Resist}}$ value has to be assess using design codes and other literature.

We know that laterally loaded pile is analyzed as beam- column and its resistance statistics is available in Table 4.1

Table 4.1 Typical load and resistance statistics for structures (Data from Ellingwood et al. 1982)

	COV(%)
Load*	
Dead	10
Live	25
Wind	37
Snow	26
Earthquake	136
Resistance	
Concrete	
Flexure beams	8 to 14
Short columns	12 to 16
Slender columns	12 to 17
Shear beams	17 to 21
Steel	
Tension members	11
Compact beams, uniform moment	13
Axially loaded columns	14
Beam columns	15
Aluminum	
Tension members	8
Beams	8 to 13
Columns	8 to 14
Glue-laminated timber beams	18

* Fifty years maximum load effects.

The above formulation may be generalized to N number of function of random design variables. Let the limit state function be given as:

$$g(\bar{f}) = g(f_1, f_2, f_3, ..., f_n) \tag{4.42}$$

A Taylor series expansion of the limit state function about the mean values gives,

$$g(\bar{f}) = g(\bar{f}^{\circ}) + \sum_{i=1}^{n} \frac{\partial g}{\partial f_i}\left(f_i - f_i^{\circ}\right)\Big|_{\text{Evaluated at the mean values}} \tag{4.43}$$

The first-order approximate means and variance is given by,

$$g(\bar{f})^{\circ} = g(f_1^{\circ}, f_2^{\circ}, f_3^{\circ}, ..., f_n^{\circ}) \tag{4.44}$$

and

$$\mathrm{Var}(g(f)) = \sigma_{g(f)}^2 \approx \sum_{i,j=1}^{n} \frac{\partial g}{\partial f_i}\frac{\partial g}{\partial f_j}\mathrm{Cov}(f_i, f_j) \tag{4.45}$$

If the variables are statistically independent, then the variance becomes,

$$\mathrm{Var}(g(f)) = \sigma_{g(f)}^2 \approx \sum_{i=1}^{n}\left(\frac{\partial g}{\partial f_i}\right)^2 \mathrm{Var}(f_i) \tag{4.46}$$

Therefore, reliability index connected to serviceability and ultimate strength is given by:

$$\beta_{YTop} = \frac{\left(Y_{Top}^{Resist}\right)^{o} - \left(Y_{Top}^{Current}\right)^{o}}{\sqrt{\mathrm{Var}\left(Y_{Top}^{Resist}\right) + \mathrm{Var}\left(Y_{Top}^{Current}\right)}} \tag{4.47}$$

$$\beta_{Mmax} = \frac{\left(M_{Max}^{Resist}\right)^{o} - \left(M_{Max}^{Current}\right)^{o}}{\sqrt{\mathrm{Var}\left(M_{Max}^{Resist}\right) + \mathrm{Var}\left(M_{Max}^{Current}\right)}} \tag{4.48}$$

No code requirements are available for the reliability index in an ultimate limit state but Nordic Committee on Building Regulation (NKB)(1978) have suggested some values, given in Table 4.2 below. For serviceability limit state NKB suggested a reliability index greater than 1 to 2 for a one year period.

Table 4.2 Reliability indices (failure probabilities) connected to ultimate strength for a 1 year reference period (Madsen et al. 1995)

Failure Type Consequences	Ductile with reserve capacity	Ductile	Brittle
Less serious	3.1 (10^{-3})	3.7(10^{-4})	4.2(10^{-5})
Serious	3.7 (10^{-4})	4.2(10^{-5})	4.7(10^{-6})
Very serious	4.2 (10^{-5})	4.7(10^{-6})	5.2 (10^{-7})

4.3 NUMERICAL INVESTIGATIONS

The goal of this study is to perform the statistical analysis of laterally loaded single isolated pile and pile group embedded below water table. The theoretical formulation of probabilistic and reliability analysis of laterally loaded piles are presented by means of equations which discussed earlier in Chapter 4. Those formulas provide a theoretical approach in general fashion ready for numerical investigation. In order to demonstrate the importance of each of the design variables and to find out the reliability index with respect to variability of design variables, the numerical investigations are needed.

In this chapter, the reliability analysis of piles is carried out in a numerical fashion. The typical design variables are determined based on the usually used parameters. The reliability indices of laterally loaded piles embedded in sand below water table with respect to the top deflection and maximum bending moment are plotted in figures with respect to different piles with lengths 3T and 10T (the 'T' here represents the relative stiffness factor determined in section 4.3.2 are analyzed in the method presented in this chapter. The outcomes of typical cases of the reliability analyses of top deflection and maximum bending moment are presented in this chapter.

4.3.1 The determination of typical design parameters

Introducing the concept of statistical homogeneity of soil properties, we can represent a site by means of mean value and standard deviation, or coefficient of variation. The coefficient of variation is defined as standard deviation divided by mean value.

In this study, the mean values of design parameters are taken based on the design values used in practice and the COV of design parameters are taken as varying from 5% to 40%, this is achieved by changing the random variables ($\pm 5\%$).

Pile properties

The pile used in this study is a standard hollow steel pipe HSS 406 x13 (Diameter) defined by "Hollow Structural Sections to ASTM A 500 Grade C", which is issued by Canadian Institute of Steel Construction 2000. The pile width B is 406 mm, which is the diameter of the pile.

The section properties of the pile are the following and presented below:

Young's Modulus, E= 200 Gpa
Moment of Inertia, I=305x10^6 mm^4
Outside diameter B: 406 mm
Design thickness t: 13 mm
Area A: 15,700 mm^2
Weight: 1.52 kN/m
Allowable Stress: 317 MPa
Plastic Moment= $Z\sigma_y = (b-t)^2 * t * \sigma_y$ = 689.5 kN-m

Soil properties:

Submerged Unit Weight= $\gamma' =$ 10.5 kN/m^3.

Angle of internal friction $= \varphi = 30^{\circ}$

Soil Modulus= $k =$ 16300 kPa/m^3

All the above value for soil design are taken from the manual of program COM624, as recommended by authors of p-y models.

4.3.2 Determination of relative stiffness factor T of pile

In a limit analysis, the soil–pile system is considered to reach a point of failure when the full passive resistance is mobilized along the entire length of the pile. The soil-pile system is shown in Figure (4.3). Short pile either rotates (for free head piles) or translates laterally for fixed head piles. Long piles fail by formation of one plastic hinge for a free head pile to two plastic hinges for a fixed head pile, respectively. Before analyzing laterally loaded pile using software, we need to determine the length of piles, based on the relative stiffness factor T so that we can anticipate the failure mechanism and the arrangement of piles in group. If the embedded length of the pile is between (5T-10T), the pile is considered a “long pile, while the pile is considered short if the length is less than 4.5T. The pile is embedded in sand located below water table. Its physical behavior is described by p-y model of Cox, Reese and Grubbs (1974). The pile-soil system forms interaction system that has the same deformation at the pile-soil interface. The sand surrounding the pile is considered as nonlinear springs with coefficient of subgrade reaction k.

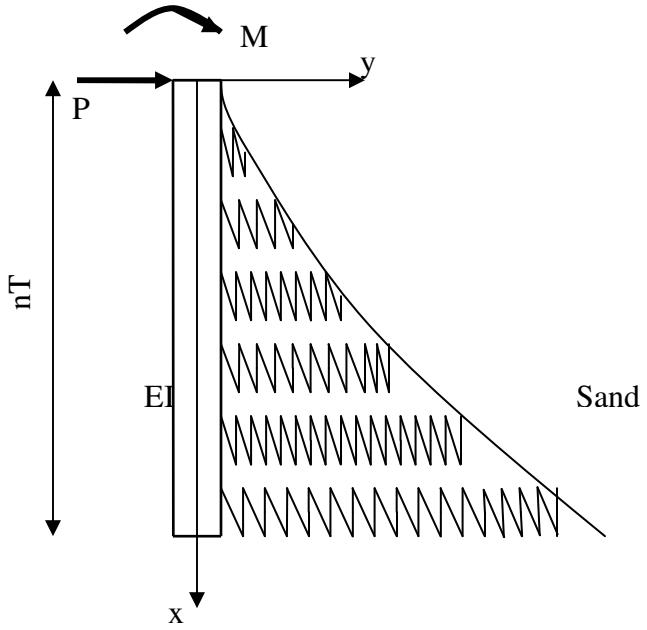


Figure 4.3 Geometry of pile, soil properties and type of load in sand.

The numerical calculation of a relative stiffness for sample pile with different boundary conditions in sand are shown below:

<u>1- Determination of relative stiffness factor, T for free head pile subjected to lateral force</u>:

Relative Stiffness Factor, $T_p = \sqrt[3]{\frac{y_t EI}{A_y H_t}}$

Where:

A_y=2.43 (Constants, Evans & Duncan 1982)

B_y=1.62 (Constants, Evans & Duncan 1982)

y_t=deflection of the pile at the ground line.

H_t=horizontal load applied at the ground line.

Value of y_t and H_t where obtained from the formulation prepared by (Evans & Duncan 1982), called Characteristic Load and Moment Method. This method include the following steps:

calculate the characteristic shear load (H_c)

$$H_c = \lambda B^2 E R_I \left(\frac{\sigma_p}{E R_I} \right)^m (\varepsilon_{50})^n$$

where:

$\lambda = 1$ (dimensionless parameter for plastic clay and sand)

B= diameter of pile

E=young modulus for pile material

RI, Moment of Inertia Ratio $= \frac{I}{\frac{\pi b^4}{64}} = 0.23$

I = moment of inertia of the pile

σ_P=Representative passive pressure of soil,

$$\sigma_p = 2C_{p\varphi}\gamma' b \tan^2(45 + \frac{\varphi}{2}) = 76.734 \text{ kN/m}^2$$

ε_{50} = Strain at which 50% of the soil (Sand) is mobilized,

$\varepsilon_{50} = 0.002$ (Comp 624P, 1993),

K_a, Active soil pressure coefficient,

$$K_a = \tan^2(45 - \frac{\varphi}{2}) = 0.33$$

$C_{p\varphi}$ =Passive pressure factor

$$C_{p\varphi} = \frac{\varphi}{10} = \frac{30}{10} = 3$$

Exponent, m=0.57, for horizontal force (Evans & Duncan, 1982),

Exponent, n=-0.22, for horizontal force (Evans & Duncan, 1982),

$$H_c = \lambda B^2 E R_I \left(\frac{\sigma_p}{E R_I} \right)^m (\varepsilon_{50})^n$$

$$= 1*(0406)^2*200*10^6*0.23*\left(\frac{76.734}{200*10^6*0.23} \right)^{0.57} (0.002)^{-.22}$$

= 15145 kN

$\frac{y_t}{b} = 0.12$ (From Evans & Duncan 1982)

y_t=0.12*0.406=0.0487 m

$\frac{V_t}{V_c} = \frac{H_t}{H_c} = 0.011$ (From Evans & Duncan 1982)

H_t=0.011xH_c=0.011x15145=166.59 kN

$T_p = \sqrt[3]{\frac{y_t EI}{A_y H_t}}$ =1.94 (for horizontal force)

2- Determination of relative stiffness factor, T for free head pile subjected to bending moment on pile:

T_m =The relative stiffness factor for pure moment

$$T_m = \sqrt[2]{\frac{y_t EI}{B_y M_t}}$$

M_t =the moment at the ground line.

Calculate the characteristic moment load, M_c

$$M_c = \lambda B^3 ER_I \left(\frac{\sigma_p}{ER_I}\right)^m (\varepsilon_{50})^n$$

$$=1*(0406)^3*200*10^6*0.23*\left(\frac{76.734}{200*10^6*0.23}\right)^{0.4}(0.002)^{-.15}$$

=38201 kN-m (for pile subjected to horizontal force H_t)

where,

Exponent, m=0.40, for moment M_c,

Exponent, n=-0.15, for moment M_c,

$\frac{M_t}{M_c} = 0.0122$ (From Evans & Duncan 1982)

M_t= 0.0122x38201=466.05 kN-m

$$T_m = \sqrt[2]{\frac{y_t EI}{B_y M_t}} = 1.98 \text{ m}$$

3-Determination of relative stiffness factor, T for fixed head pile subjected to lateral force:

A_y =0.93 for fixed head pile

$\frac{y_t}{b} = 0.02$ (From Evans & Duncan 1982)

$\frac{H_t}{H_c} = 0.0075$ (From Evans & Duncan 1982)

H_t=0.0075x15145=113.59 kN

y_t=0.02x0.406=0.00812 m

$$T_p = \sqrt[3]{\frac{y_t EI}{A_y H_t}} = 1.67 \text{ (for horizontal force on fixed head pile)}$$

Table 4.3 Length of piles and relative stiffness factors T for different boundary conditions used in the analysis

Boundary Conditions	Pile Length, L (Short Pile)	Pile Length, L (Long Pile)	Relative Stiffness Factor (T)
Free head pile under lateral load	2T, 3T, 4T, 4.5T	5T, 6T, 7T, 8T, 9T,10T	1.94 m
Fixed head pile under lateral load	2T, 3T, 4T, 4.5T	5T, 6T, 7T, 8T, 9T,10T	1.67 m
Free head pile under bending moment	2T, 3T, 4T, 4.5T	5T, 6T, 7T, 8T, 9T,10T	1.98 m

4.3.3 Development of p-y curve

The sand around the pile is modeled by p-y curves proposed by Cox, Reese and Gubbs, Cox et al. (1974) as discussed in Chapter 3 of this thesis. The software COMP624 and FB_PIER have a different type of p-y curve imbedded in the program and used in the modeling and analysis.

$$\beta = 45 + \frac{\varphi}{2} = 60^{\circ}$$

$$\alpha = \frac{\varphi}{2} = 15^{\circ}$$

Coefficient of earth pressure at rest= $k_{\circ} = 0.4$

$$x_r = \frac{b\tan\beta\left[k_a\tan^7\beta + k_{\circ}\tan\varphi an\varphi^3\beta\frac{1}{\tan(\beta-\varphi)}\right]}{\frac{k_{\circ}\tan\varphi an\varphi s + \tan^2\beta\sin\alpha}{\tan(\beta-\varphi)\cos\alpha} + k_{\circ}\tan\beta an\beta(\tan\beta - \tan\alpha)}$$

=5.04 m

$$y_m = \frac{b}{60} = 0.00676 \text{ m}$$

$$y_u = \frac{3b}{80} = 0.015 \text{ m}$$

$$y_k = \left[\frac{B_s p_s}{kx}\left(\frac{60}{b}\right)^{0.8\left(\frac{A_s}{B_s}-1\right)}\right]^{\left(\frac{1.25}{2.25-\frac{A_s}{B_s}}\right)}$$

$$p_{st} = \gamma' x\left[\frac{k_{\circ}x\tan\varphi\tan\varphi}{\tan(\beta-\varphi)\tan\alpha} + \frac{\tan\beta}{\tan(\beta-\varphi)}(b + \tan\beta an\beta ta + k_{\circ}x\tan\beta\tan\beta(\sin\beta - \tan\alpha a - k_a b\right]$$

$$p_{st} = 20.062x^2 + 11.383x \qquad (4.49)$$

$$P_{sd} = k_a b\gamma\gamma(\tan^8\beta - 1) + k_o\beta\gamma' x\tan\varphi\tan\varphi$$

$$P_{sd} = 121.4\,x \qquad (4.50)$$

Different values for y_k, ultimate soil resistance p_s which consist of p_{st} and p_{sd} above and below x_r are obtained for different values of x using equations shown in Fig. 3.9 a & b, sample of p-y curves are shown in Fig. 4.4 below:

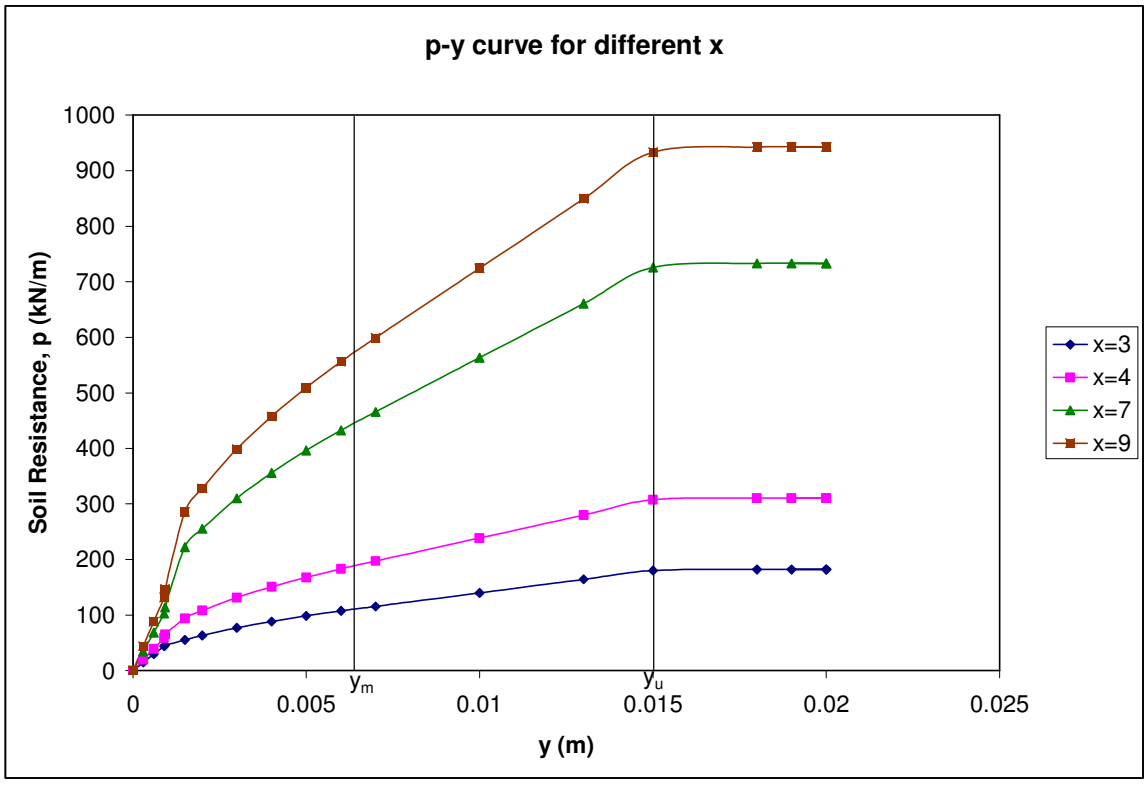


Figure 4.4: p-y curves at different depth, x

p_s value were calculated at different points along the length of the pile using Eq. 4.49 & 4.50 depending on point location from x_r. Then the deflection is calculated at each point depending on the location linear, nonlinear elastic, linear hardening and constant flow (plastic zone) as discussed in Chapter 3 of this thesis. These values are used to construct the p-y curve.

4.3.4 Pile Mesh Sensitivity Analysis to Investigate Model Accuracy

to check model accuracy the following parameters have been considered:

1-Three Loading Conditions are Investigated P= (30, 80 & 150 kN).

2-The Thesis model was based on 80 mesh segment along pile depth.

3- Different mesh density is investigated by changing the mesh to (25, 30, 35, 70, 7 5 & 80) and the Y_{TOP} and M_{max} are calculated for each type of load and mesh density.

4- The Percentage error are calculated to check the model accuracy.

5- All the above analysis were conducted on pile length = 10T = 19.4 m

Table 4.4 P=30 kN, the pile mesh is changed with increments 25,30 and 35

P "kN"	Mesh Division/Pile	Y_{TOP} "m"	M_{max} "kN-m"	Max % Difference of Y_{TOP} "m"	Max % Difference of M_{max} "m"	
30	25	0.00436	41.3	0.06	0.05	This percentage error is between mesh=25 and the mesh=80
	30	0.00429	40.5	0.04	0.03	This percentage error is between mesh=30 and the mesh=80
	35	0.00425	40.2	0.03	0.02	This percentage error is between mesh=35 and the mesh=80

Table 4.5 P=80 kN, the pile mesh is changed with increments 25,30 and 35

P "kN"	Mesh Division/Pile	Y_{TOP} "m"	M_{max} "kN-m"	Max % Difference of Y_{TOP} "m"	Max % Difference of M_{max} "m"	
80	25	0.0184	137	0.03	0.02	This percentage error is between mesh=25 and the mesh=80
	30	0.0183	136	0.02	0.01	This percentage error is between mesh=30 and the mesh=80
	35	0.0181	134	0.01	0.00	This percentage error is between mesh=35 and the mesh=80

Table 4.6 P=150 kN, the pile mesh is changed with increments 25,30 and 35

P "kN"	Mesh Division/Pile	Y_{TOP} "m"	M_{max} "kN-m"	Max % Difference of Y_{TOP} "m"	Max % Difference of M_{max} "m"	
150	25	0.0467	293	0.03	0.01	This percentage error is between mesh=25 and the mesh=80
	30	0.0463	293	0.02	0.01	This percentage error is between mesh=30 and the mesh=80
	35	0.0461	292	0.01	0.00	This percentage error is between mesh=35 and the mesh=80

Table 4.7 P=30 kN, the pile mesh is changed with incriments 70,75 and 80

P "kN"	Mesh Division/Pile	Y_{TOP} "m"	M_{max} "kN-m"	Max % Difference of Y_{TOP} "m"	Max % Difference of M_{max} "m"	
30	70	0.00416	39.6	NA	NA	
	75	0.00414	39.5	0.48	0.25	This percentage error is between mesh=70 and the mesh=75
	80	0.00413	39.4	0.24	0.25	This percentage error is between mesh=75 and the mesh=80

Table 4.8 P=80 kN, the pile mesh is changed with increments 70,75 and 80

P "kN"	Mesh Division/Pile	Y_{TOP} "m"	M_{max} "kN-m"	Max % Difference of Y_{TOP} "m"	Max % Difference of M_{max} "m"	
80	70	0.018	135	NA	NA	
	75	0.018	135	0.00	0.00	This percentage error is between mesh=70 and the mesh=75
	80	0.0179	134	0.56	0.75	This percentage error is between mesh=75 and the mesh=80

Table 4.9 P=150 kN, the pile mesh is changed with incriments 70,75 and 80

P "kN"	Mesh Division/Pile	Y_{TOP} "m"	M_{max} "kN-m"	Max % Difference of Y_{TOP} "m"	Max % Difference of M_{max} "m"	
150	70	0.0456	292	NA	NA	
	75	0.0456	292	0.00	0.00	This percentage error is between mesh=70 and the mesh=75
	80	0.0455	291	0.22	0.34	This percentage error is between mesh=75 and the mesh=80

Investigating the above results, we can calculate the % of error between mesh=70 and mesh=80 as:

1-The Differences in Y_{Top} varies between (0.2-0.56) %

2-The Differences in M_{max} varies between (0.25-0.75) %

3- Using mesh of (70-80 segment /pile) is considered appropriate and accurate since the percentage error is very small and some of the values didn't change by changing the mesh more than 70 (the % error approximately = zero).

4-The difference between mesh=25 to mesh =80 is calculated to be varied between (0 to 6%), see tables above.

CHAPTER FIVE

DISCUSSION ON RESULTS

Probabilistic modeling and reliability analysis is conducted on laterally loaded single pile and pile group embedded in sand below water table to get coefficient of variation (COV) and reliability index (β) for ultimate limit state (M_{max}) and serviceability limit state (Y_{Top}) for various loading. The probability of failure is estimated using Melcher's tables for probability of failure (Melcher 2000) & the calculated reliability index.

The COV obtained from this study can be used by engineers as guideline to estimate the unavailable data and uncertainties, especially when the data obtained from site exploration and laboratory testing is not sufficient to carry out a design of laterally loaded structure.

The reliability index obtained from reliability analysis is helpful in checking the structure for limit states. In 1978, Nordic Committee on Building Regulation has suggested some values of reliability index for serviceability and ultimate limit states. The reliability index(β) (Eq.2.8) for pile head deflection (Y_{Top}) should be greater than or equal to 2 and the reliability index for maximum bending moment (M_{max}) should be greater than or equal to 3.7. (Refer Table 4.2)

5.1 Discussion on the results of laterally loaded free head single long (10T) pile

The outlined theoretical and numerical approach was implemented in the probabilistic analysis of laterally loaded pile of length =10T (where T is the relative stiffness factor). The laterally loaded piles are very specific geotechnical structures that their performance depends on their length. Typically, the laterally loaded piles with L>=5T deform in flexible fashion, whereas piles of length L<=4T deform through rotation about a point located at the pile axis. The comparative analysis of the performance of long and short piles shows that in case of long piles, the failure of pile structure precedes the development of soil plastic phase

on the soil surface. As far as short pile-soil system is due to excessive soil deformation developed on the soil surface whereas the pile structure itself is far from structural failure. These differences in the performance of short and long piles entail different distributions of physical soil phases along the pile axis of long piles and short ones. Consequently, the notation of maximum performance requires to be addressed in different way to short and long pile-soil system.

As the study undertaken on laterally loaded pile is very comprehensive, the discussion on the results of each kind of pile is divided into three parts i.e. discussion connected to the probabilistic modeling, reliability analysis and probability of failure.

5.1.1 Discussion on the probabilistic modeling of free head single long (10T) pile

Probabilistic modeling is divided into two parts. One is connected with the pile head deflection (Y_{Top}) and another one with the maximum bending moment in pile (M_{max}).

The pinnacle intention in carrying out probabilistic modeling is to get the values of Var(Y_{Top}) and Var(M_{max}), which will be further needed in performing the reliability analysis. The second reason is to get values of COV(Y_{Top}) and COV(M_{max}), which will be useful to practicing engineers and researchers in assuming the unavailable data from site exploration and laboratory tests.

In probabilistic modeling, each random design variables is varied individually at some constant rate by keeping other variables at their mean value. When the random design variable, B (diameter of pile where soil reaction is action), is varied at the rate of 5% from its mean value, the COV(Y_{Top}) has changed in some specific pattern (Fig.A.19 through A.24, Appendix A). As we go away from the mean value of variable (B), the COV(Y_{Top}) is increasing uniformly. The applied lateral load at pile head also exhibits same effect on the COV(Y_{Top}).

For the same value of COV (B), COV(Y_{Top}) is higher for higher lateral load. Above points are true for the rest of the random designs variables (P, EI, k, γ',and Φ) and the same rate of change for (B) connected with COV(Y_{Top}) apply to the other design variables. The affect of variability of these variables is different on Y_{Top}. Variable (Φ) has more influence and affects more with highest COV(Y_{Top}), then comes variable (P), after that variable (γ'), then variable (EI), then variable (B), and at the end variable (k) (Fig.A.1 through A.36, Appendix A). For COV (γ') equal to 40% COV(Y_{Top}) is around 40 % (refer to Fig. 5.1) for lateral load P=150kN. The same observation about (γ') is also mentioned by K.K. Phoon and F.H. Kulhawy in their paper ''Characterization of geotechnical variability''.

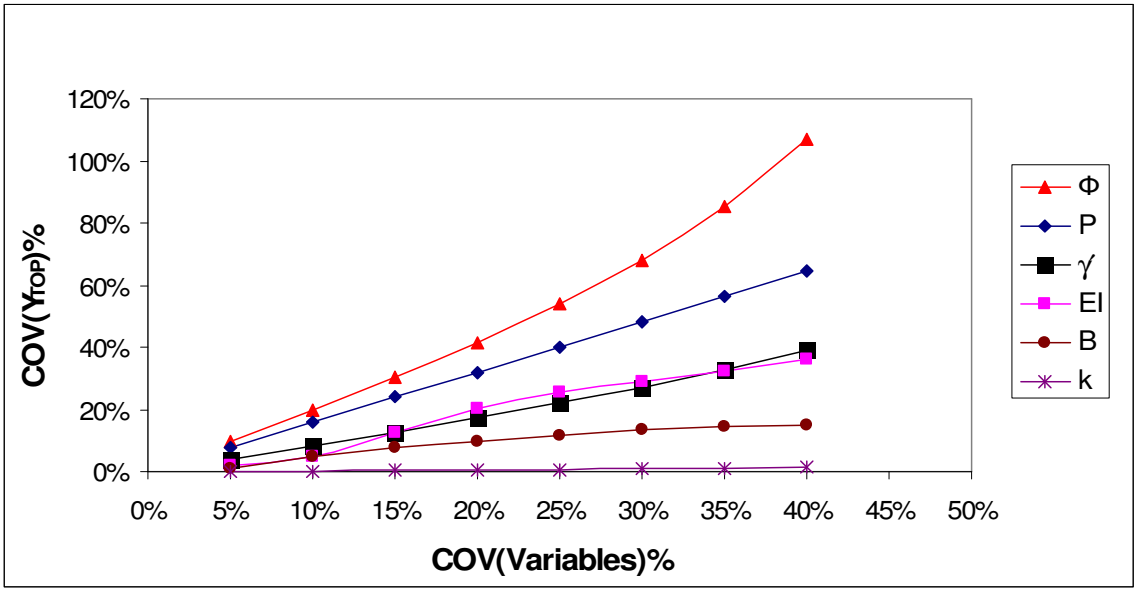


Fig. 5.1 Effect of different variables on COV(Y_{Top}) for free head single long pile (10T) at lateral load P=150kN.

For the case COV(M_{max}), the random design variable (P) has considerable influence, then design variable (Φ). All the other variable (γ'), (B), (EI), and (k) cause comparatively small change (Fig. A.79 through A.114, Appendix A). When the COV (B, EI, and k) equal to 40%, the COV(M_{max})is less then 10% especially for random variable k, the value for COV(M_{max}) is around 1% for lateral load P=150kN (refer to Fig. 5.2). It means that maximum bending moment of laterally

loaded pile is not affected by variable k and EI. Similar to the case of COV(Y_{Top}), COV(M_{max}) is also growing as the lateral load goes higher.

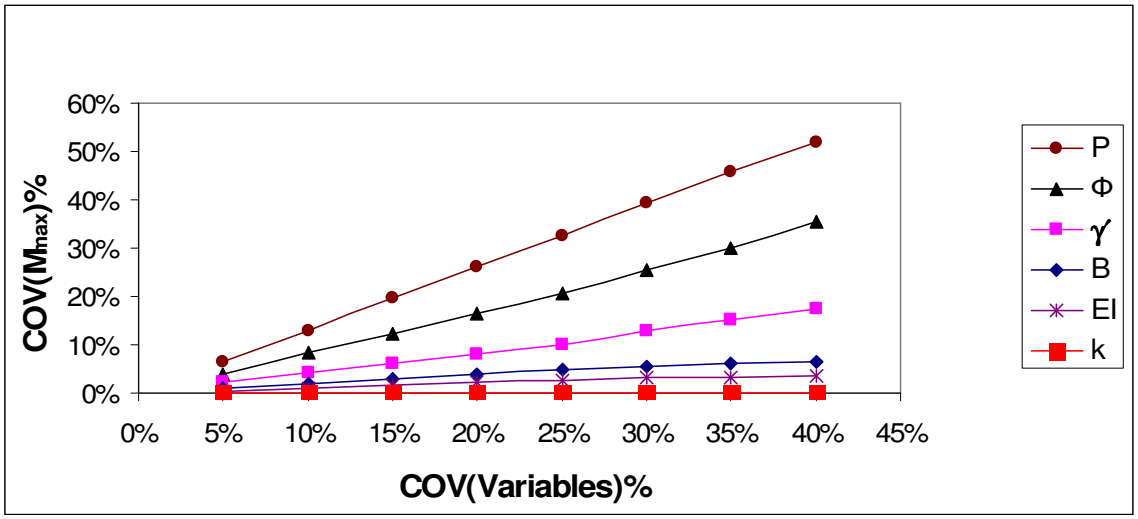


Fig. 5.2 Effect of different variables on COV(M_{max}) for free head single long pile (10T) at lateral load P=150kN.

5.1.2 Discussion on the reliability analysis and probability of failure of free head single long (10T) pile

The key objective for conducting reliability analysis is to check the safety of the structure (here laterally loaded piles) through reliability index (β). Safety is connected with two parameters. First is ultimate limit state (maximum bending moment in pile, M_{max}) and the second one, serviceability limit state (pile head deflection, Y_{Top}). For M_{max}, reliability index (β) should be greater than or equal to 3.7 and for Y_{Top}, (β) should be greater than or equal to 2 (refer to Table 2.1).

We have seen in the last section that when COV(variable) increases COV(Y_{Top}) and COV (M_{max}) rises too. Therefore as per the definition of reliability index (Eq.2.5), it should go down with the increase in COV(variable). The results obtained from the reliability analysis for free head 10T pile proves the above point (refer to Sections A.2, and A.5, Appendix A). Figure 5.3 below illustrate the reliability index (β(Y_{Top})) for free head single pile with P=150 kN.

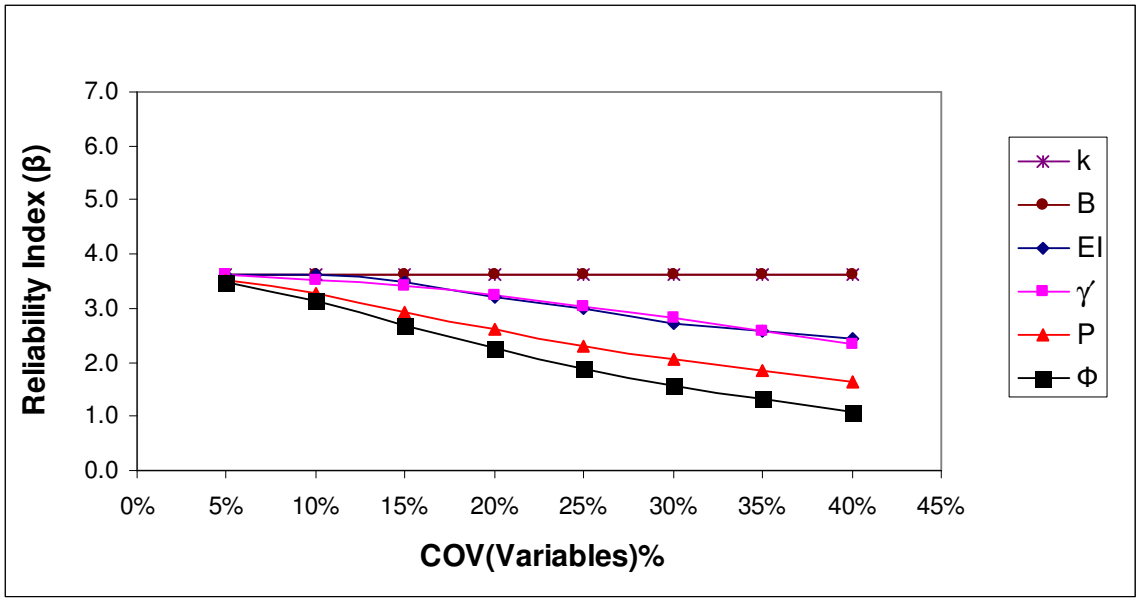


Fig. 5.3 Reliability Index connected with β_{YTop} for free head single long pile (10T) with lateral load P=150kN.

The results show that the angle of internal friction Φ has the most influence on the reliability index connected to $Y_{Top.}$ When Φ increases the reliability index β decreases (refer to Fig.A.37 through A.42, Appendix A), this indicates a smaller safety of the pile. The second sensitive parameter is the lateral load P, as the load increases the reliability index is going down (refer to Fig.A.67 to A.72, Appendix A), it shows that for the lateral load 30kN, 60kN, 90kN and 120kN the reliability index is more than 2, but when lateral load reaches 150kN the reliability index reduces to around 2.0 when the COV(P) is around 30% from the mean value, which is very close to the failure and fails after this point when the COV(P) exceeds 30% to reach a reliability index (β) of 1.65 at 40%. Results also indicate that the reliability index is very sensitive to the random variable(Φ). The top point of free head long piles fail at 30% of COV(Φ) for load 150kN, while the system is safe under all other lateral loads. In descending order, the variables affecting reliability index connected to Y_{Top} are (Φ, P, **γ'**, EI, B, and k). In fact, variables k and B have smaller effect on reliability index connected to Y_{Top}.

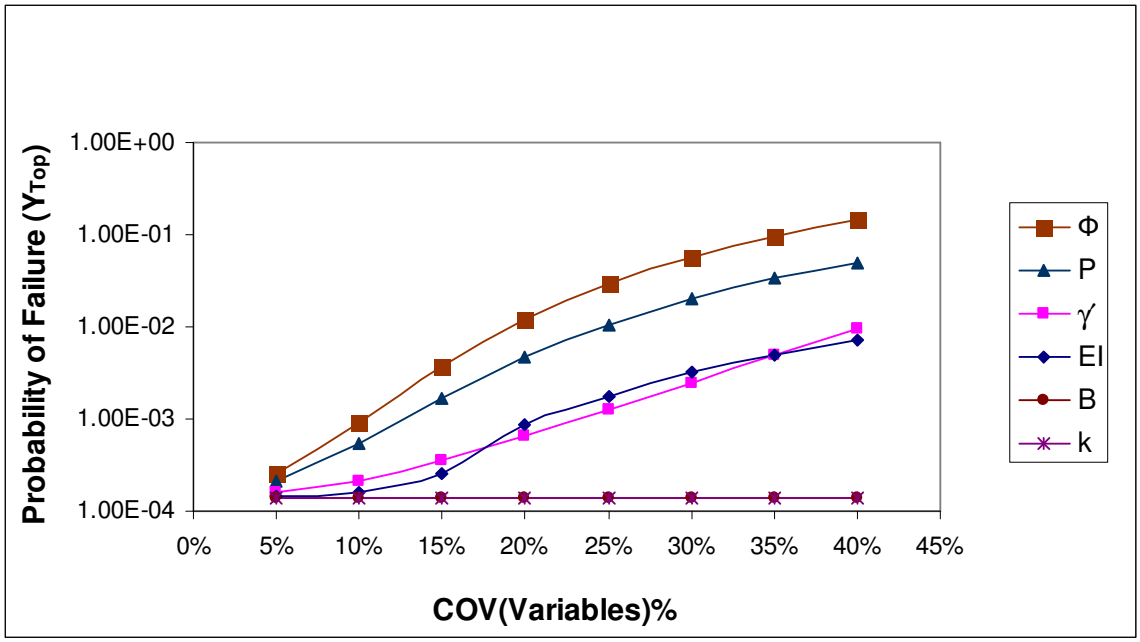


Fig. 5.4 Probability of Failure connected with Y_{Top} for free head single pile (10T) with P=150kN.

From Fig. 5.4 above, we can determine that the angle of internal friction, Φ has significant influence on the probability of failure of the pile with magnitude of about 0.1 for lateral load P=150kN, then the influence of the lateral load P comes in the second place, then random variables γ' and EI, while B and k has the least effect on the probability of failure.

In case of reliability index β_{Mmax} connected to M_{max}, reliability index and probability of failure are sensitive to lateral load, P, then to the angle of internal friction, Φ. When the lateral load, P, and angle of internal friction, Φ are within 5% from its mean value the pile is safe and the probability of failure is small. When the design variables (P & Φ) is increased by more than 10% from its mean value for (lateral load, P=150kN), the system become less safe and the probability of failure is increased (refer to Fig. A.115 through A.120 for angle of internal friction (Φ) and Fig. A.145 through A.150 for the lateral load P, Appendix A). The free head long (10T) pile structure is safe for all lateral loads i.e. 30kN, 60kN, 90kN, 120kN and 150kN for design variables (γ', EI, B, and k) (refer to Fig. A.115 through A.150, Appendix A). Results also indicate that variables (Φ and P) are

showing noticeable effect on reliability index and probability of failure of the system connected to M_{max} (Fig. 5.5 and 5.6), the probability of failure of the system is increased when the reliability index decreased. The influence of other design variables is negligible.

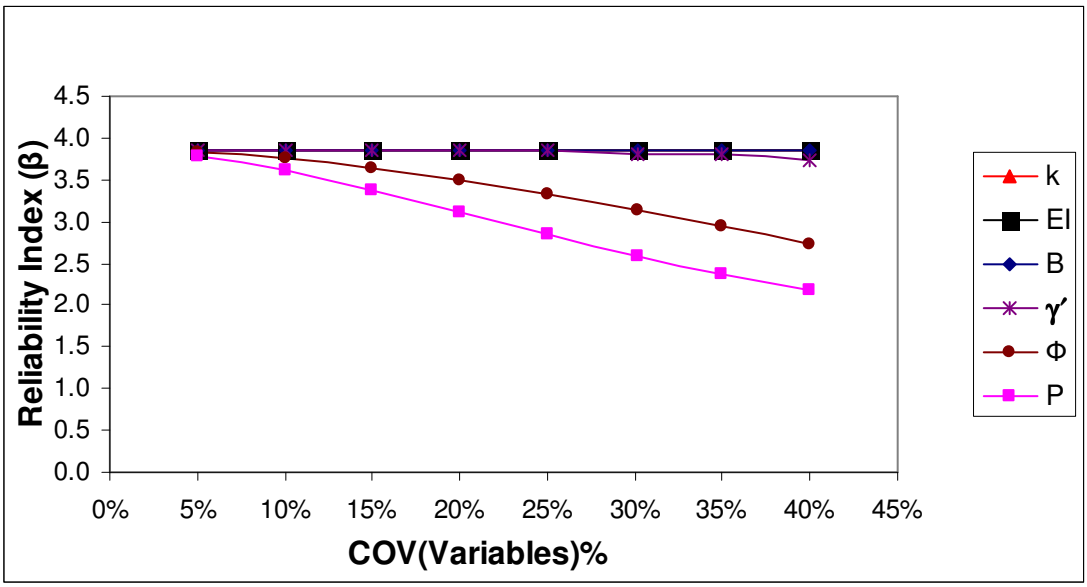


Fig. 5.5 Reliability Index connected with β_{Mmax} for free head single pile (10T) with P=150kN.

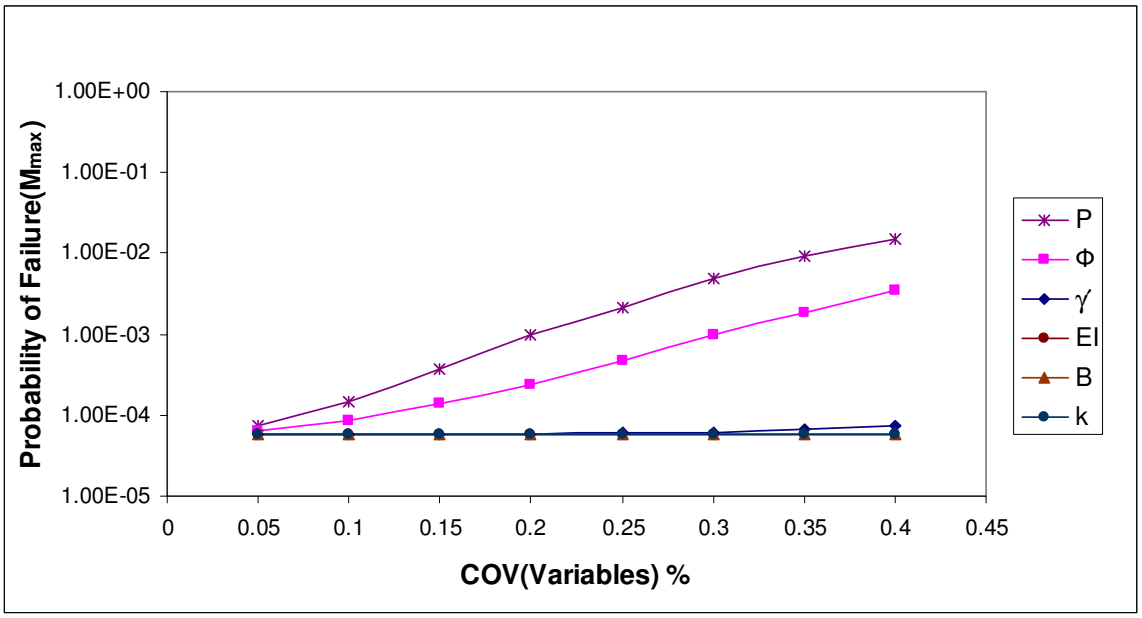


Fig. 5.6 Probability of Failure connected with M_{max} for free head single pile (10T) with P=150kN

5.2 Discussion on the results of laterally loaded fixed head single long (10T) pile

The difference between the fixed head single pile discussed here and the free head pile discussed in the previous section is in the boundary condition. In the case of fixed pile, the pile is assumed to be embedded in pile cap. The connection will be stiff enough to prevent rotation.

5.2.1 Discussion on the probabilistic modeling of fixed head single Long (10T) pile

Compared to free head long pile, COV(Y_{Top}) of fixed head long pile has almost the same pattern of COV(Variables) and almost the same values when the pile is subjected to larger lateral loadings (100kN, 150kN, 200kN, 250kN, and 300kN).

Variable (Φ) has more influence and affects more with highest COV(Y_{Top}), then comes variable (P), after that variable (γ'), then variable (EI), then variable (B), and at the end variable (k)(refer Fig.B.1 through B.36, Appendix B). For COV (γ') equal to 40% COV(Y_{Top}) is around 37% (refer Fig. 5.7) for lateral load P=300kN.

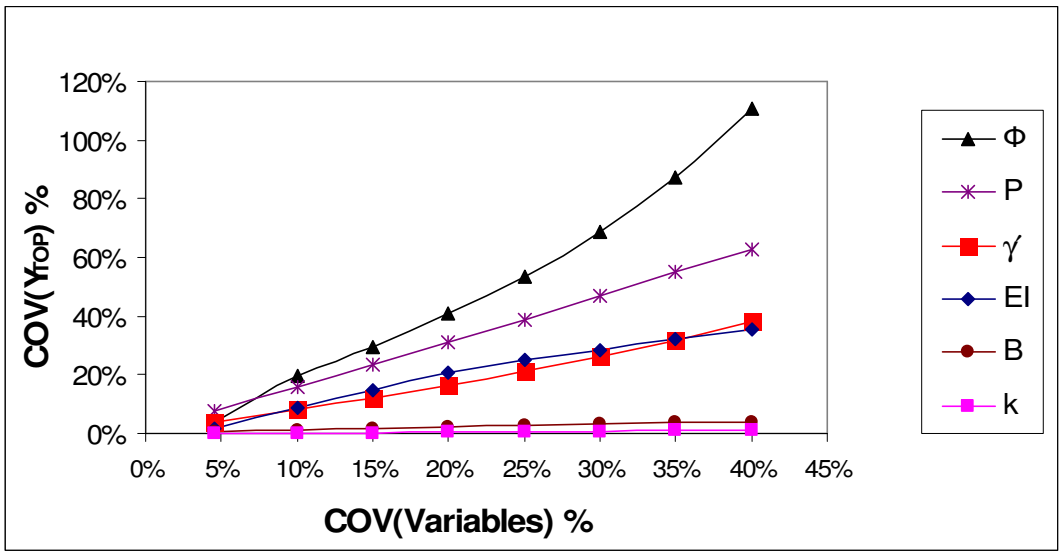


Fig. 5.7 Effect of different variables on COV(Y_{Top}) for fixed head single long pile (10T) at lateral load P=300kN.

For the case COV(M_{max}), the random design variable (P) has considerable influence, then variable (Φ). All the other variable γ', B, EI, and k cause comparatively small change (Fig. B.79 through B.114, Appendix B). When the COV (B, EI, γ', and k) equal to 40%, the COV(M_{max}) is less then 10%, especially for random variable k, the value for COV(M_{max}) is around 1% for lateral load P=300kN (refer Fig. 5.8). It means that maximum bending moment of laterally loaded pile is not affected by variable k and EI. Similar to the case of COV(Y_{Top}), COV(M_{max}) is also growing as the lateral load goes higher

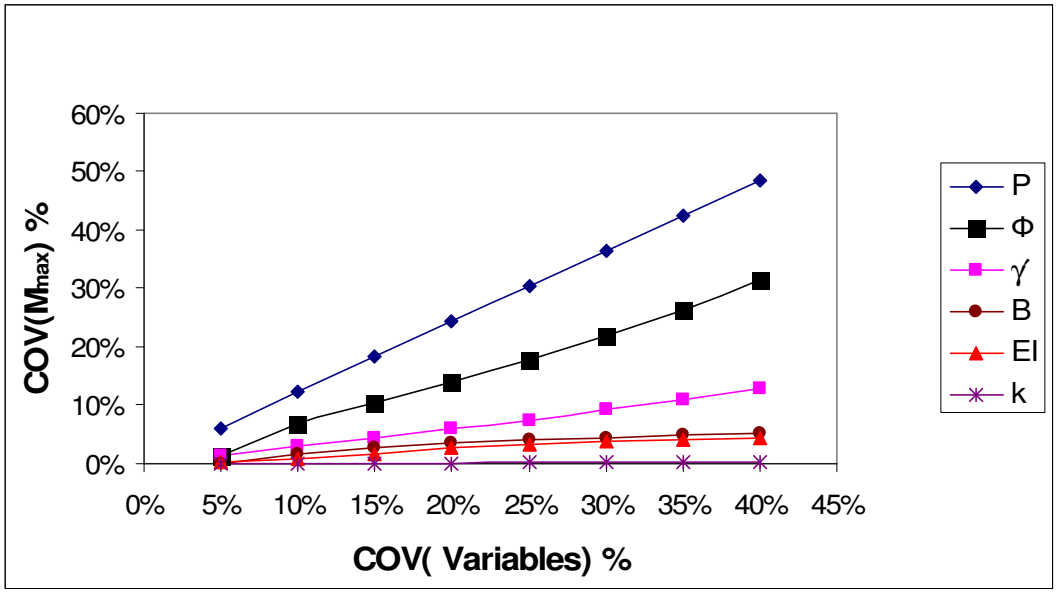


Fig. 5.8 Effect of different variables on COV(M_{max}) for fixed head single long pile (10T) at lateral load P=300kN.

5.2.2 Discussion on the reliability analysis and probability failure of fixed head single long (10T) pile

The results show that the angle of internal friction Φ has the most influence on the reliability index connected to Y_{Top}, when Φ increases the reliability index β decreases (refer to Fig.B.37 through B.42, Appendix B). The second sensitive parameter is the lateral load P, as the load increases the reliability index is going down (refer to Fig.B.67 to B.72, Appendix B), it shows

that for the lateral load 100kN, 150kN, 200kN, 250kN and 300kN the reliability index is more than 2 and the system is safe under all lateral loads (refer to Fig.5.9 and Fig.5.10). Results also indicate that the reliability index is very sensitive to the random variable(Φ). In descending order, the variables affecting reliability index connected to Y_{Top} are (Φ, P, γ', EI, B, and k) (refer to Fig.B.37 through B.78, Appendix B). In fact, the variables k and B have smaller effect on reliability index, β_{YTop} connected to Y_{Top}.

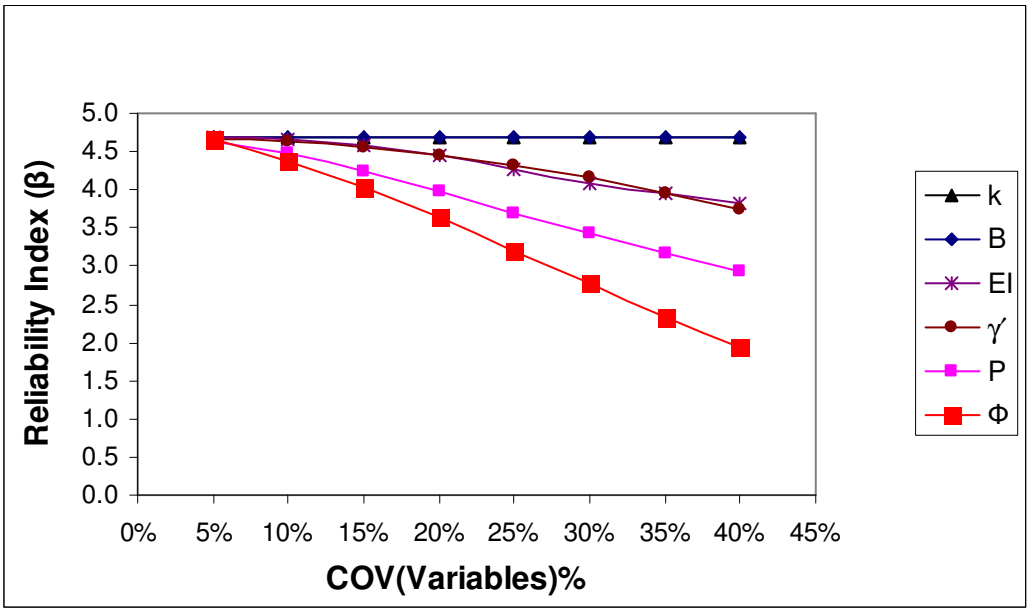


Fig. 5.9 Reliability Index β_{YTop} connected with Y_{Top} for fixed head single long pile (10T) with lateral load P=300kN.

From Fig. 5.10, we can determine that the angle of internal friction, Φ has significant influence on the probability of failure of the pile with magnitude of less than 0.1 for lateral load P=300kN, and then the influence of the lateral load P comes in the second place, then variables γ' and EI, while B and k has the least effect on the probability of failure.

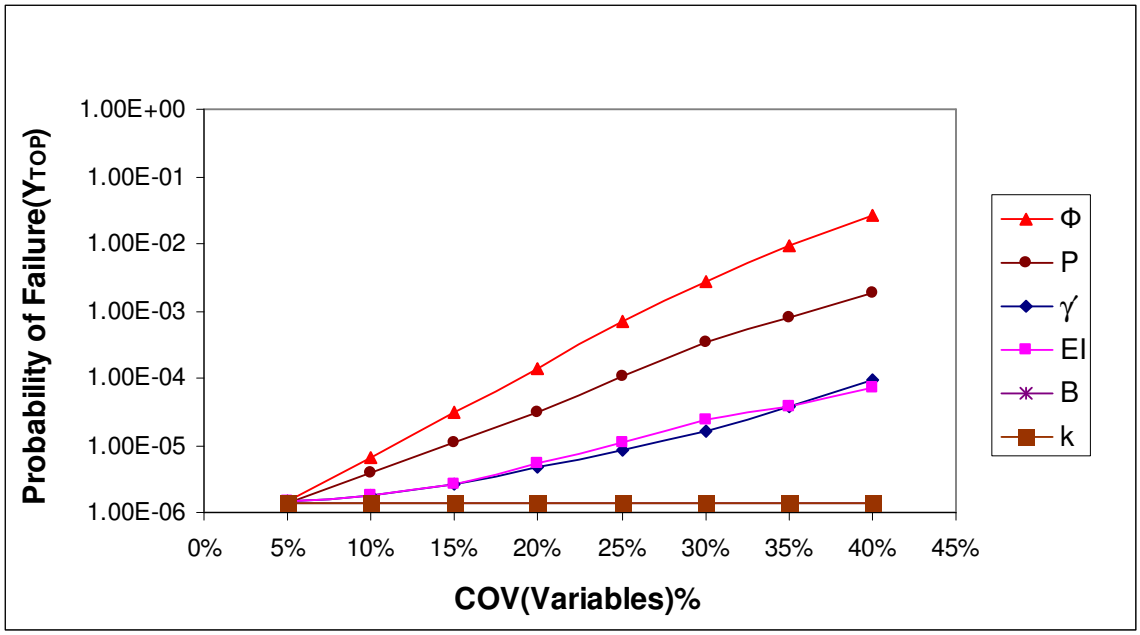


Fig. 5.10 Probability of Failure connected with Y_{Top} for fixed head single pile (10T) with P=300kN.

In case of reliability index β_{Mmax} connected to M_{max}, reliability index and probability of failure are sensitive to lateral load, P, then the angle of internal friction, Φ. The piles are unsafe with respect to the strength and fail under lateral loads 200kN, 250kN, and 300kN under all design variables. The fixed head long (10T) pile structure is safe for lateral loads i.e. 100kN for all design variables (P, Φ, γ', EI, B, and k) (refer to Fig.B.115 through B.156). For lateral force P=150kN, the pile fails when design variable P increased more than 20% from its mean value. Results also indicate that variables Φ and P are showing noticeable effect on reliability index and probability of failure of the system connected to M_{max} (Fig. 5.11 and 5.12), the probability of failure of the system is increased when the reliability index decreased (Eq. 4.39). The influence of other variables is smaller with variables B & K effect is negligible.

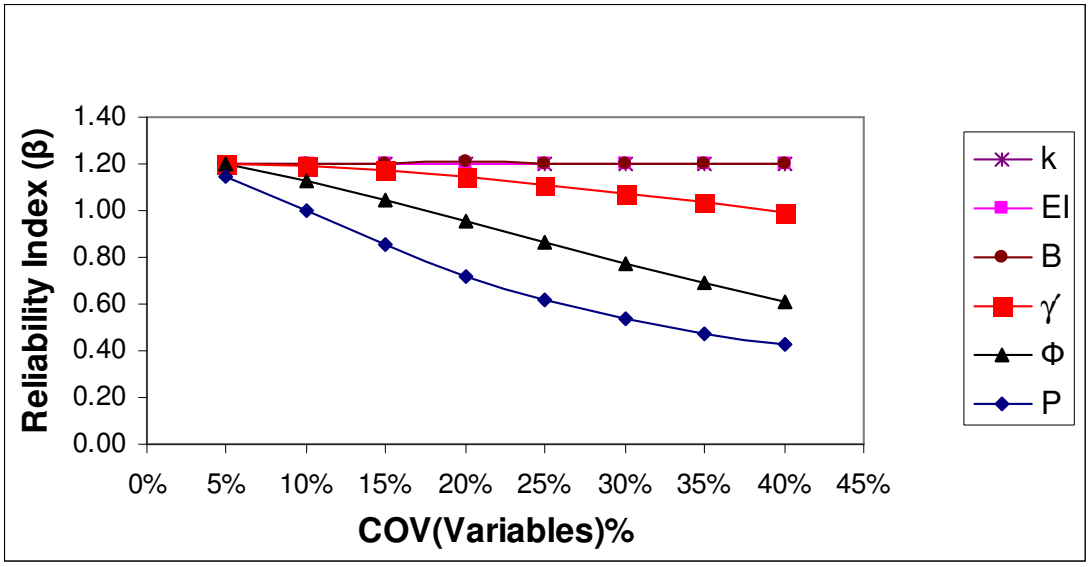


Fig. 5.11 Reliability Index connected with M_{max} for fixed head single pile (10T) with P=300kN.

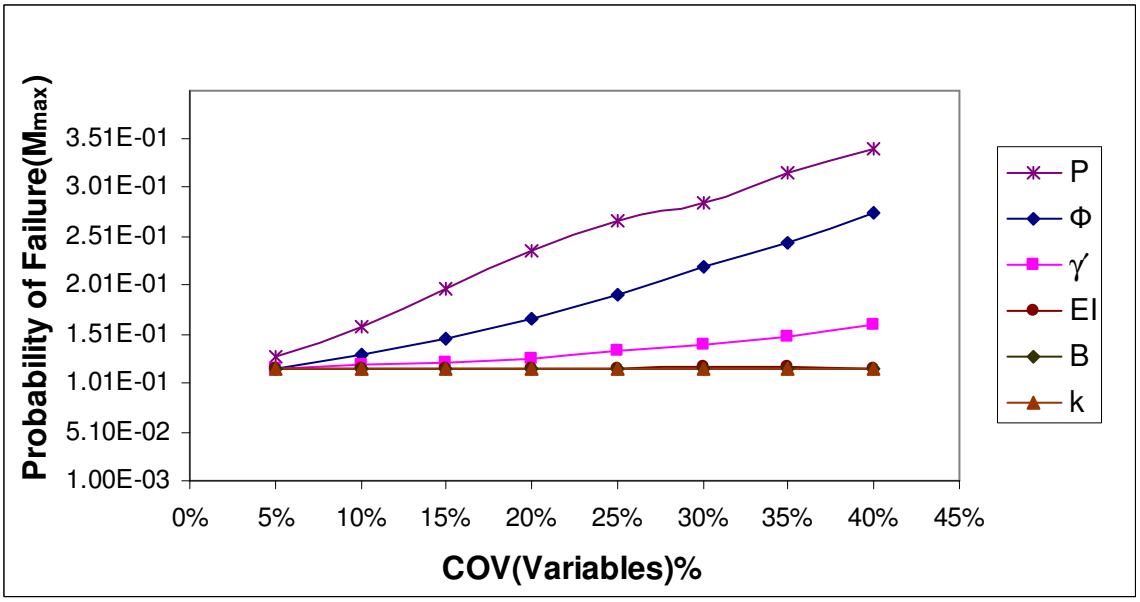


Fig. 5.12 Probability of Failure connected with M_{max} for fixed head single pile (10T) with P=300kN

Fig.5.12 indicates that the probability of failure for M_{max} increased for all design variables with lateral load 300kN.

5.3 Discussion on the results of laterally loaded hinged head long (10T) pile group with (3D) spacing.

The behavior and response of laterally loaded pile closely spaced within group of piles is different than the behavior and response of laterally loaded single isolated pile. The group of piles discussed in this study consist of 9 long (10T) piles (refer to Fig 3.5 Chapter 3) with center to center spacing of 3D.

Group of piles usually has a pile cap to transfer the load from the superstructure to the piles and surrounding soil. In this case the boundary condition at pile head is considered hinged in the analysis, which is the same as free head boundary condition used for the analysis of single isolated pile and has the same restraint at pile head.

5.3.1 Discussion on the probabilistic modeling of hinged head long (10T) pile group (3D) spacing

$COV(Y_{Top})$ connected to COV(B) for hinged head long pile group (3D) spacing is different in value and in curve pattern from $COV(Y_{Top})$ connected to COV(B) for hinged head single long pile(refer to Fig. C.1 through C.36, Appendix C). The COV(B) connected with Y_{Top} has bigger value in case of group of long piles with (3D) spacing than the case of single long pile (Fig. C.19 through C.23, Appendix C). This is related to the fact that the piles in group are spaced closely and cause the effect of B to be higher than of the case of single pile. In case of COV(Φ) the results indicate that it has a great influence on the $COV(Y_{TOP})$ (refer to Fig.C.1 through C.6, Appendix C). The curve between COV(EI) connected with Y_{Top} has slight difference in pattern and value in the case of hinged long pile group (3D) spacing than the long single free head pile. The value of COV(EI) in case of 3D hinged group of piles is higher than the COV(EI) for single free head hinged pile.

From Fig. 5.13, the variables affecting $COV(Y_{Top})$ in descending order are (Φ, P, γ', EI, B, and k). In fact, variables k has smallest effect connected to Y_{Top}.

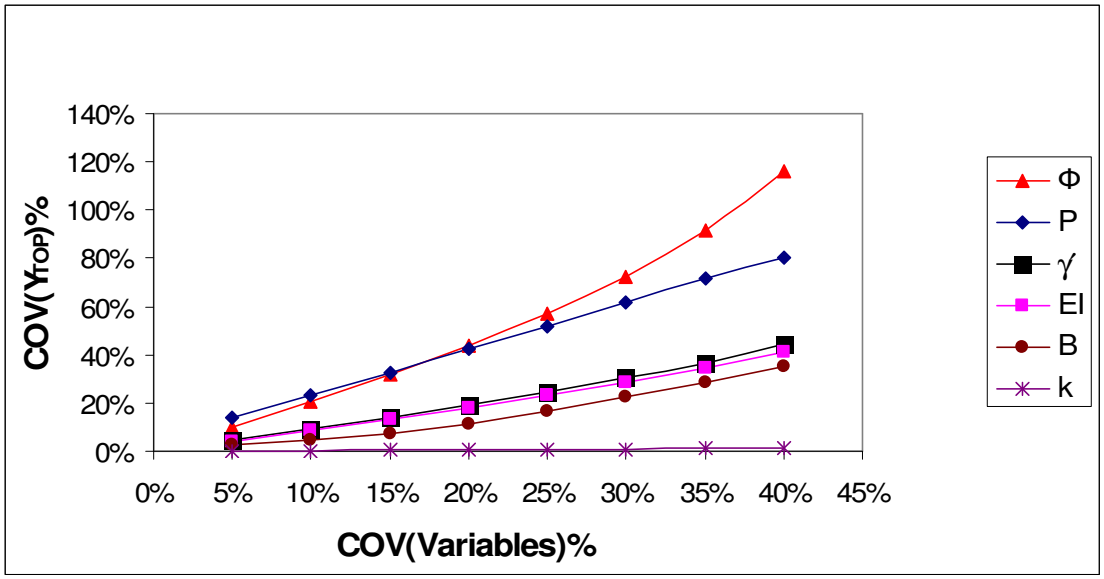


Fig. 5.13 Effect of different variables on COV(Y_{Top}) for hinged head long pile (10T) group with (3D) spacing at lateral load P=1025kN.

For the case COV(M_{max}), the random design variable 'P' is showing considerable influence (Fig. 5.14), then Φ, all the other variable γ' , B, EI, and k cause comparatively small change. COV(M_{max}) connected with COV(variables) for the hinged head group of piles (3D) spacing shows higher values than COV(M_{max}) connected with COV(variables) for free head single isolated pile (Fig. C.79 through C.114, Appendix C) with COV(k) has almost negligible effect.

In descending order, the variables affecting COV(M_{max}) are (P, Φ, γ',B, EI, and k).

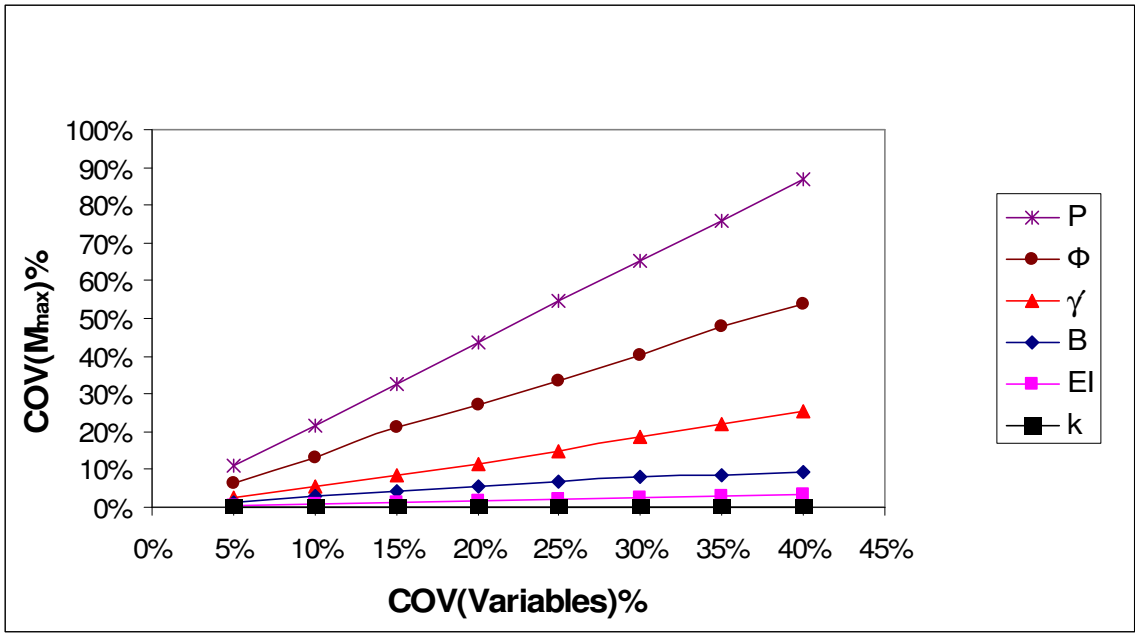


Fig. 5.14 Effect of different variables on COV(M_{max}) for hinged head long pile (10T) group with (3D) spacing at lateral load P=1025kN.

5.3.2 Discussion on the reliability analysis and probability of failure of hinged head long (10T) pile group with (3D) spacing

Reliability index (β_{YTop}) connected to (Y_{Top}) for hinged long pile group (3D) connected using pile cap (Fig.C.37 through C.72, Appendix C) is almost the same as (β_{YTop}) for free head single long pile (Section 5.2) with some slight differences in values. The reliability index connected with (Φ and P) shows that the reliability index (β_{YTop}) has value of more than two and the system is safe for the lateral load P of 250kN, 450kN and 650kN, and 950kN and (β_{YTop}) is less than two and the system fail under lateral load P of 1025kN. The results also show that the system is unsafe when COV(Φ) changed by more than 25% from it's mean value under lateral load 950kN. The results show that the group of piles is safe under all lateral loads for all other design variables. Results also indicates that variables P and Φ are showing noticeable effect on reliability index (β_{YTop}) as shown in Fig. 5.15 for lateral load P=1025kN. In descending order the effect of the design variables on the reliability index (β_{YTop}) are k, B, EI, γ', P, Φ.

The probability of failure increased when the reliability index decreased (Fig.C.73 through C.78, Appendix C).

From Fig. 5.16, we can determine that the angle of internal friction, Φ has significant influence on the probability of Failure of the pile with magnitude of about 0.1for lateral load P=1025kN, then the influence of the lateral load P comes in the second place, then γ' and EI, while B and k has the least effect on the probability of failure.

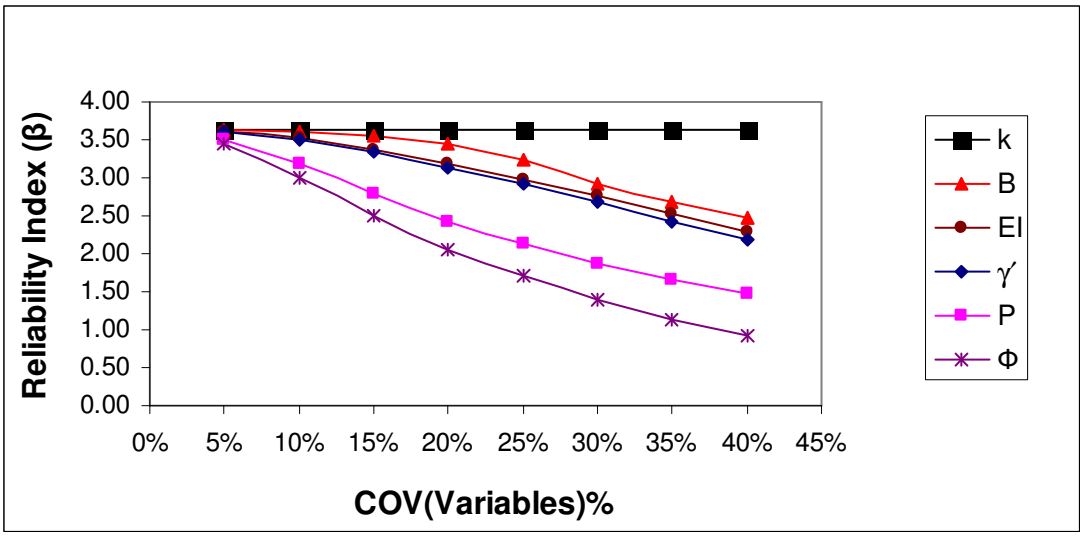


Fig. 5.15 Reliability Index (β_{YTop}) connected with Y_{Top} for hinged head long pile (10T) group with (3D) spacing at lateral load P=1025kN.

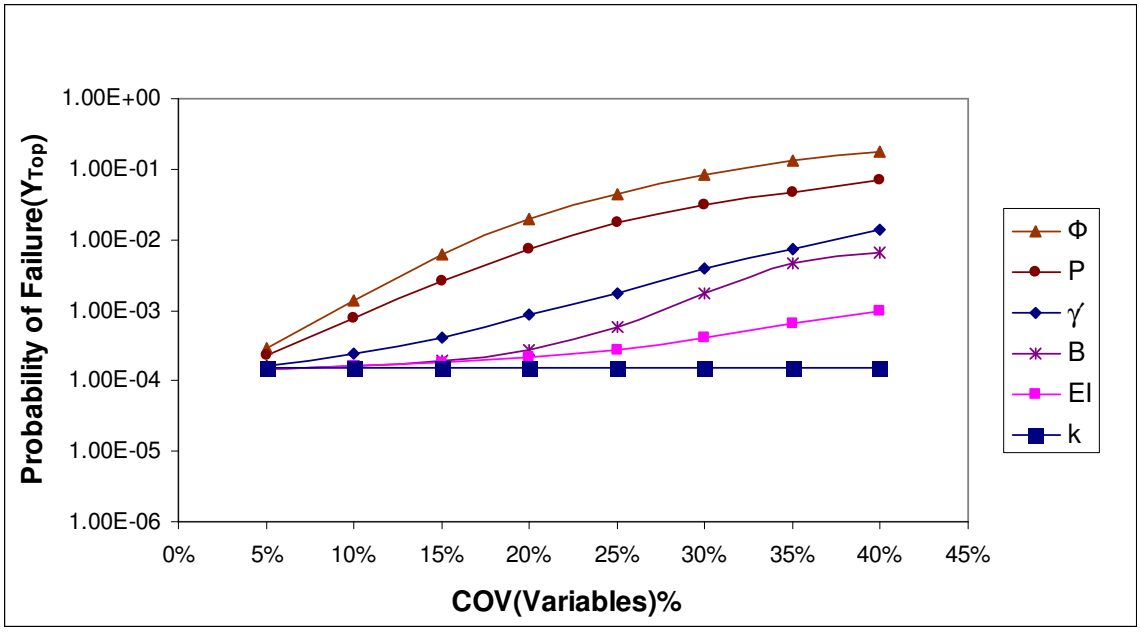


Fig. 5.16 Probability of Failure connected with Y_{Top} for hinged head long pile (10T) group with (3D) spacing at lateral load P=1025kN.

In case of reliability index (β_{Mmax}) connected to M_{max}, reliability index and probability of failure are more sensitive to lateral load, P, then to the angle of internal friction, Φ (Fig.5.17 and Fig.5.18). The reliability index (β) connected with all other design variables is > 3.7 for all lateral loads and the pile group are safe. For design variable (γ') at lateral load P=1025kN, the results shows that the pile fails under this load when (γ') increased more than 30% from its mean value (Fig.C.115 through C.156, Appendix C).

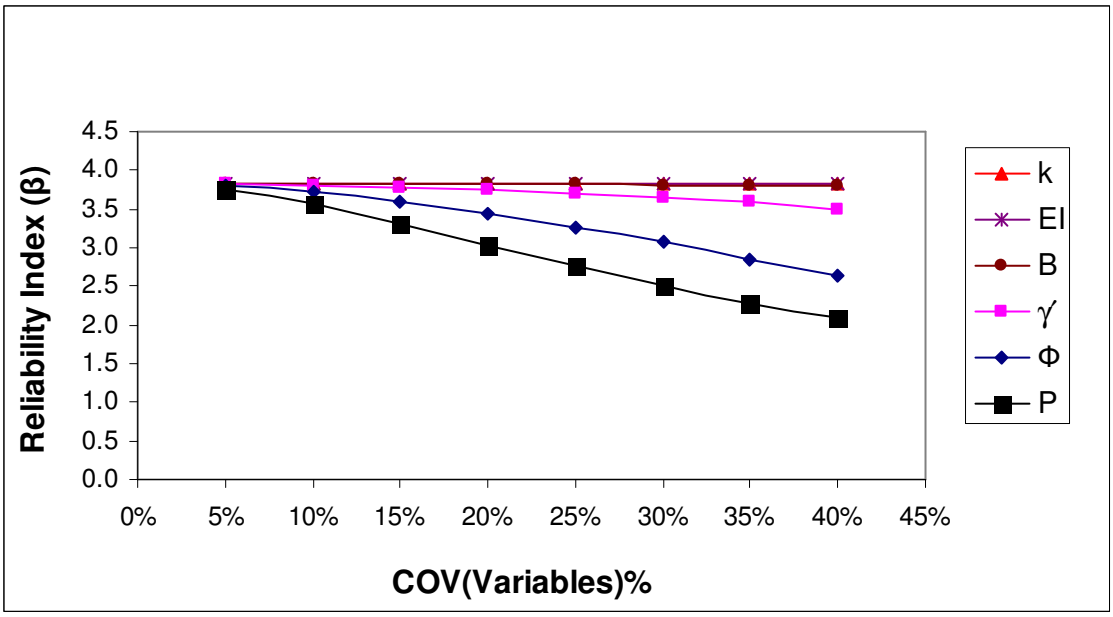


Fig. 5.17 Reliability Index (β_{Mmax}) connected with M_{max} for hinged head long pile (10T) group with (3D) spacing at lateral load P=1025kN.

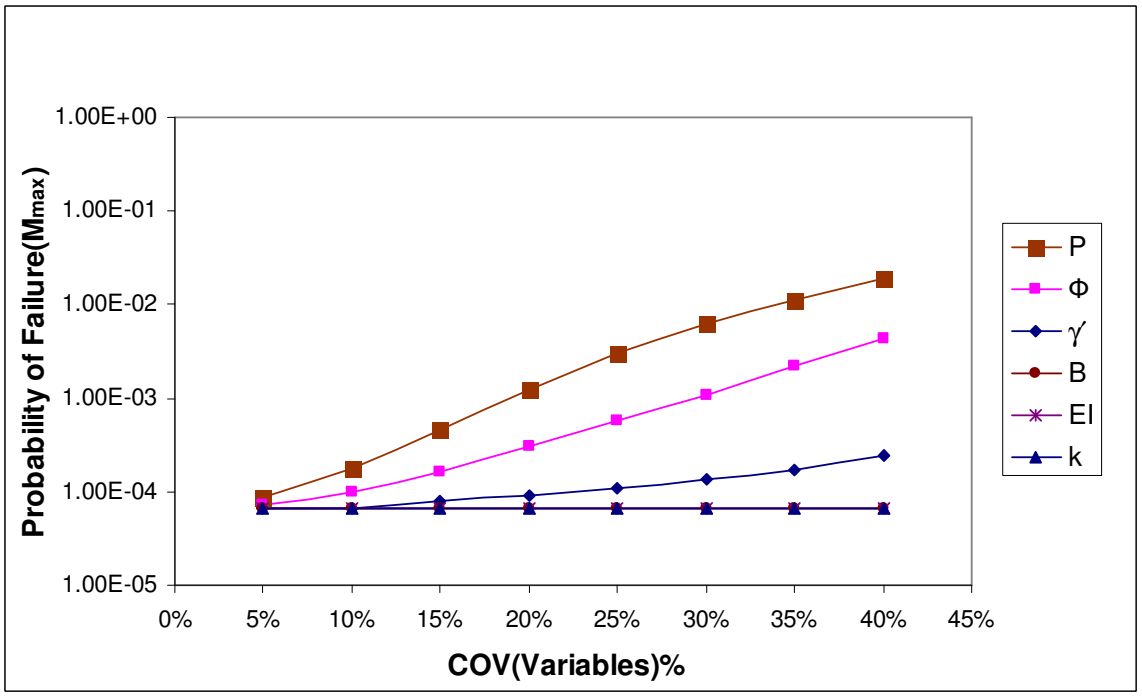


Fig. 5.18 Probability of Failure connected with M_{max} for hinged head long pile (10T) group with (3D) spacing at lateral load P=1025kN.

5.4 Discussion on the results of laterally loaded fixed head long (10T) pile group with (3D) spacing.

5.4.1 Discussion on the probabilistic modeling of fixed head long (10T) pile group with (3D) spacing

COV(Y_{Top}) connected to COV(B) for fixed head long pile group with (3D) spacing is different in curve pattern and with higher values from COV(Y_{Top}) connected to COV(B) for fixed head single long pile (refer to Fig. D.19 through D.24, Appendix D). For the case of COV(Φ) the results indicate that it has a great influence on the COV(Y_{TOP}) (refer Fig.D.1 through D.6, Appendix D). The curve between COV(EI) connected with COV(Y_{Top}) has slight difference in pattern and slightly higher value in the case of fixed head long pile group with (3D) spacing than the long single fixed head pile.

In descending order, the variables affecting COV(Y_{Top}) are (Φ, P, γ', EI, B and k)(Fig.5.19) for lateral load P=2500kN. In fact, variables k has smaller effect connected to Y_{Top}.

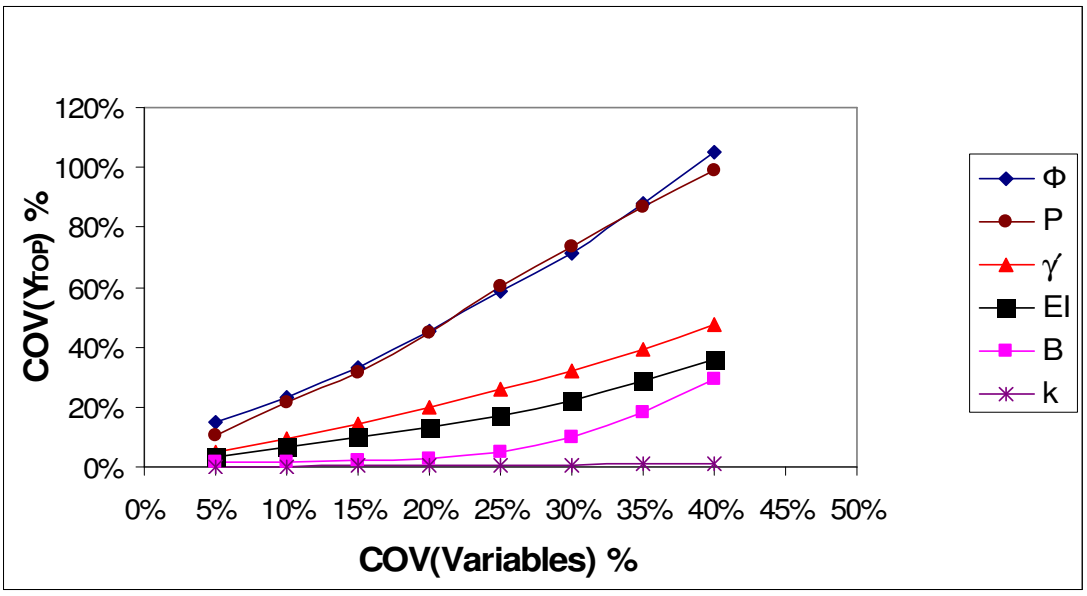


Fig. 5.19 Effect of different variables on COV(Y_{Top}) for fixed head long pile group with (3D) spacing at lateral load P=2500kN.

For the case COV(M_{max}), the random design variable 'P' is showing considerable influence (Fig. 5.20), then Φ, all the other variable B, EI, k, and γ' cause comparatively small change. In general COV(M_{max}) connected with COV(variables) for the fixed head group of piles (3D) spacing shows higher values than COV(M_{max}) connected with COV(variables) for fixed head single isolated pile (Fig. D.79 through D.114, Appendix D). COV(EI) shows lower value for the fixed head group of piles (3D) spacing than COV(M_{max}) connected with COV(variables) for fixed head single isolated pile and this is related to the spacing between piles. COV(k) has almost negligible effect.

In descending order, the variables affecting COV(M_{max}) are (P , Φ, γ', B, EI, and k).

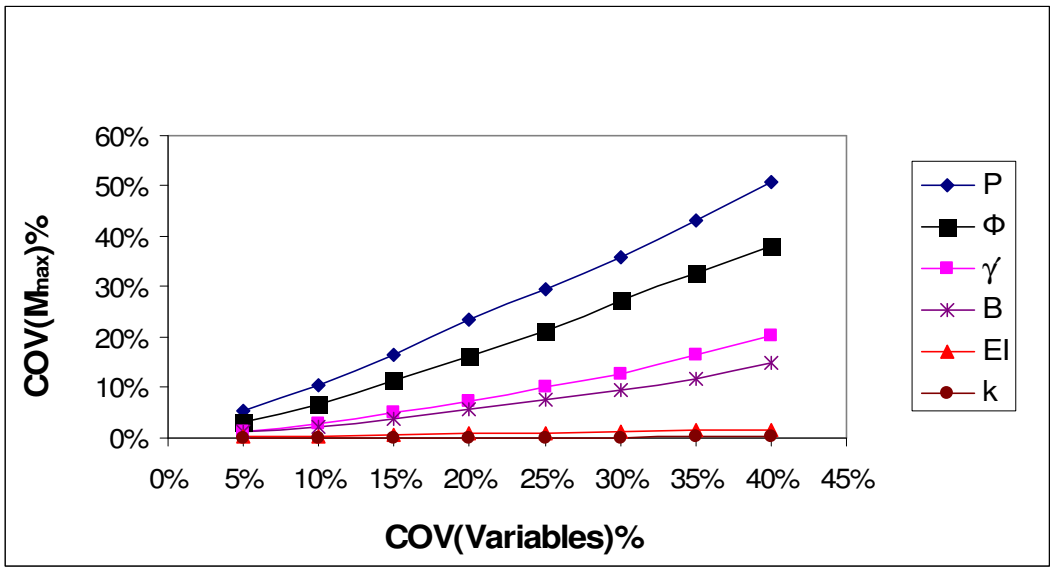


Fig. 5.20 Effect of different variables on COV(M_{max}) for fixed head long pile group with (3D) spacing at lateral load P=2500kN.

5.4.2 Discussion on the reliability analysis and probability of failure of fixed head long (10T) pile group with (3D) spacing

Reliability index (β_{YTOP}) connected to (Y_{Top}) for fixed head long pile group (3D) (Fig.D.37 through D.72, Appendix D) is has some differences than (β_{YTOP}) for fixed head long pile (Section 5.2) in values and slight differences in curve

pattern. The reliability index (β_{YTOP}) connected with (Φ and P) shows that the reliability index (β_{YTOP}) has value of more than two and the system is safe for the lateral load P of 1000kN, 1375kN and 1750kN, and (β_{YTOP}) is less than two and the system fail under lateral load P of 2150kN and 2500kN in case variable (Φ). For variable (P) results show that the pile group is unsafe for only lateral load P=2500kN. The results show that the group of piles is safe under all lateral loads for all other design variables. Results also indicates that variables P and Φ are showing noticeable effect on reliability index (β_{YTop}) as shown in Fig. 5.21 for lateral load P=2500 kN. In descending order the effect of the design variables on the reliability index (β_{YTop}) are k, B, EI, γ', P, Φ.

The probability of failure increased when the reliability index decreased (Fig.D.73 through D.78, Appendix D).

From Fig. 5.22, we can determine that the angle of internal friction, Φ has significant influence on the probability of failure of the pile with magnitude of about 0.1 for lateral load P=2500kN applied to the pile group cap. The influence of the lateral load P comes in the second place, γ' and EI, while B and k has the least effect on the probability of failure.

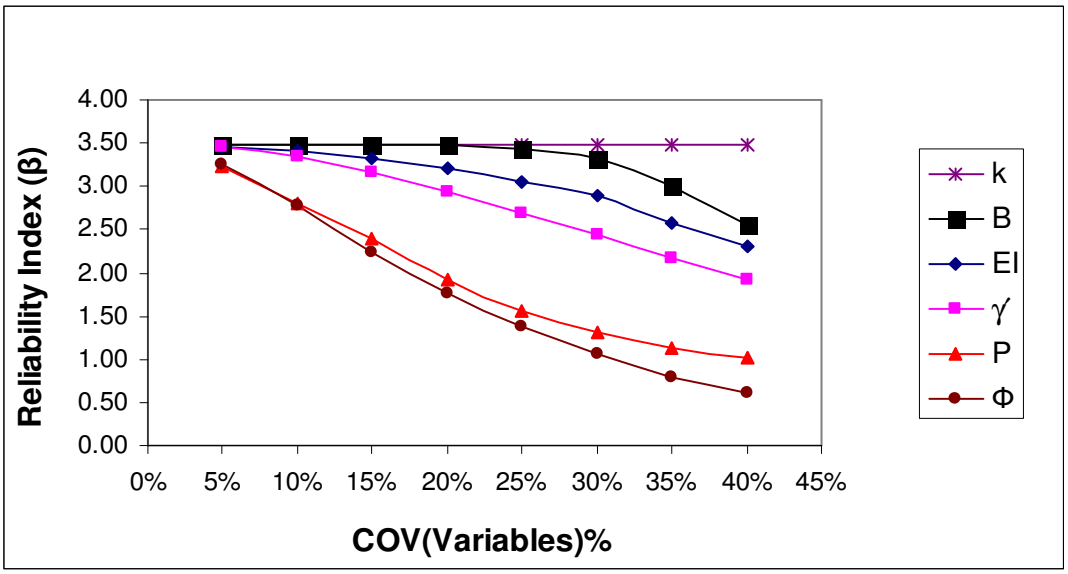


Fig. 5.21 Reliability Index (β_{YTOP}) connected with Y_{Top} for fixed head long pile group with (3D) spacing at lateral load P=2500kN.

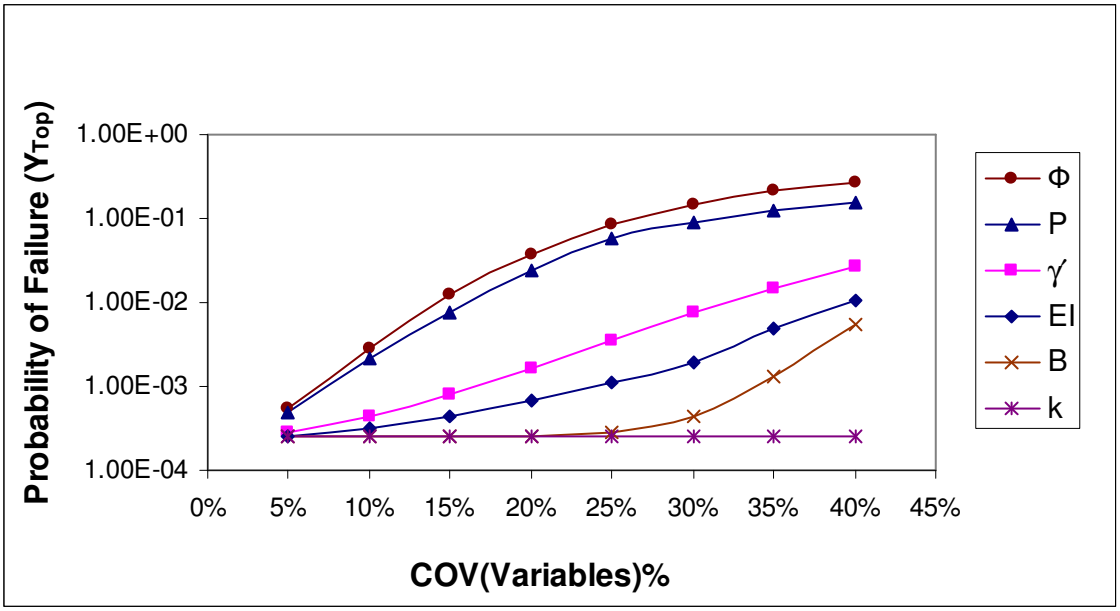


Fig. 5.22 Probability of Failure connected with Y_{Top} for fixed head long pile group (3D) with P=2500kN.

In case of reliability index (β_{Mmax}) connected to M_{max}, reliability index (β_{Mmax}) and probability of failure are more sensitive to lateral load, P, then the angle of internal friction, Φ (Fig.5.23 and Fig.5.24). The reliability index (β_{Mmax}) connected with all design variables is > 3.7 for lateral loads 1000kN, and 1375kN and the pile group are safe (Fig.D.115 through D.150, Appendix D). The system is fail under lateral loads 1750kN, 2150kN and 2500kN for random variables (γ', B, EI, and k. For random design variables (Φ, and P), the pile group is safe for lateral loads 1000kN and lateral load 1375kN is safe when COV(Φ) is less than 20% from its mean value. The system is unsafe for lateral loads (1750kN, 2125kN and 2500kN).

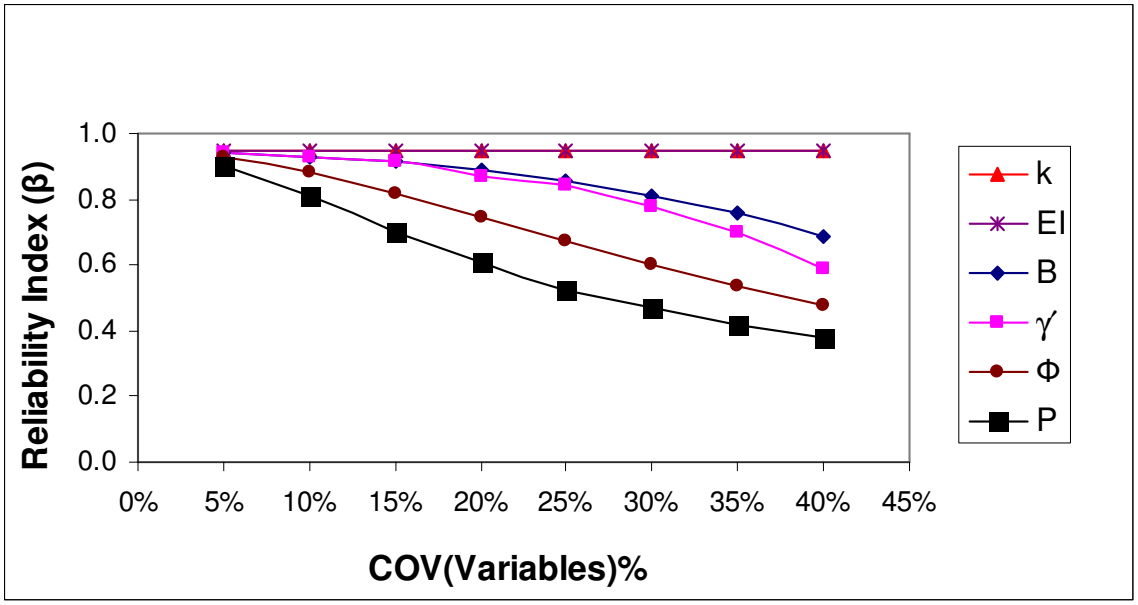


Fig. 5.23 Reliability Index (β_{Mmax}) connected with M_{max} for fixed head long pile group (10T) with (3D) spacing and lateral load P=2500kN.

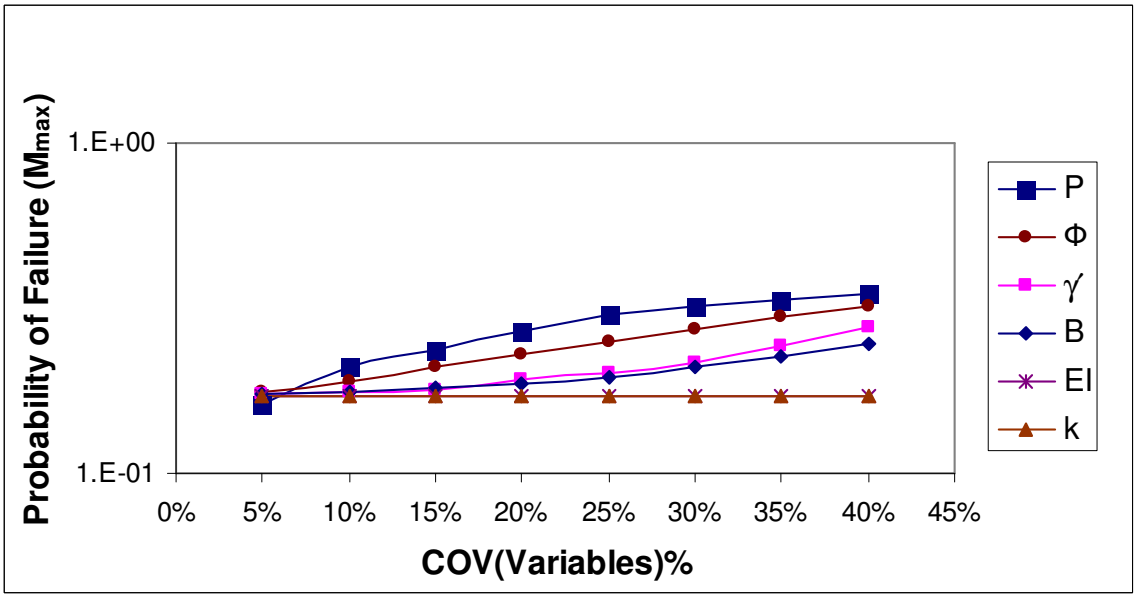


Fig. 5.24 Probability of Failure connected with M_{max} for fixed head long pile group (10T) with (3D) spacing and lateral load P=2500kN.

5.5 Discussion on the results of laterally loaded hinged head long (10T) pile group with (5D) spacing.

The behavior and response of laterally loaded pile spaced within group with (5D) spacing is almost similar to that of pile group with (3D) spacing.

5.5.1 Discussion on the probabilistic modeling of hinged head long (10T) pile group (5D) spacing

$COV(Y_{Top})$ connected to COV(variables) for hinged head long pile group with (5D) spacing (refer to Fig. E.1 through E.36, Appendix E) has slight differences in values and in curve pattern to $COV(Y_{Top})$ connected to COV(variables) for hinged head long pile group (3D)(Section 5.3.1 in this Chapter). In case In descending order, the variables affecting $COV(Y_{Top})$ are (Φ, P, γ′, EI, B, and k) (Fig.5.25). For design variables (B, and k), $COV(Y_{Top})$ in the case of (5D) spacing has lower values than $COV(Y_{Top})$ for the case of (5D) spacing. For all other design variables $COV(Y_{Top})$ in the case of (5D) spacing has higher values than the $COV(Y_{Top})$ for (3D) spacing.

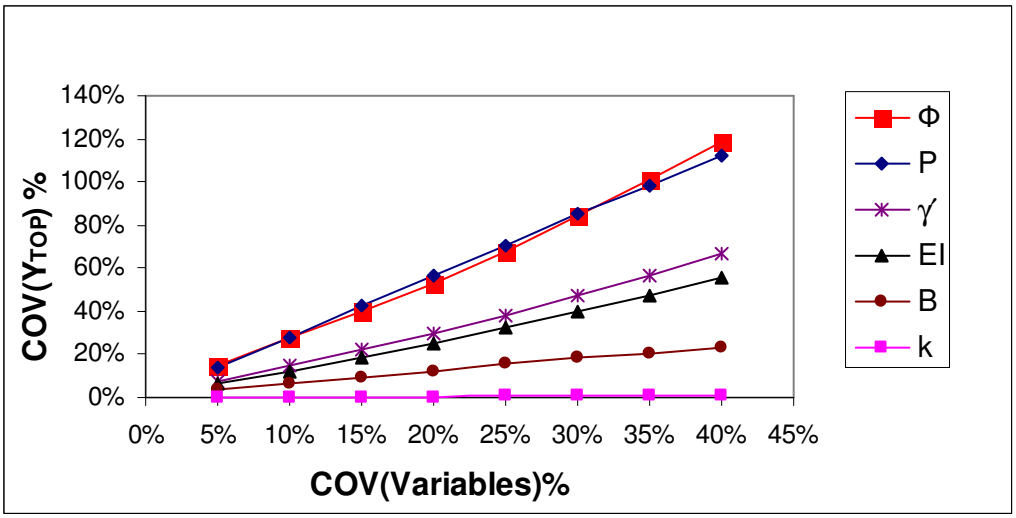


Fig. 5.25 Effect of different variables on $COV(Y_{Top})$ for hinged head long pile (10T) group with (5D) spacing at lateral load P=1300kN.

For the case $COV(M_{max})$, the random design variable 'P' is showing considerable influence (Fig. 5.26), then Φ, all the other variable B, EI, k, and γ'

cause comparatively small change. For variables (P, Φ, B, k, and γ'), COV(M_{max}) connected with COV(variables) for the hinged head group of piles (5D) spacing shows lower values than COV(M_{max}) connected with COV(variables) for hinged head pile group with (3D) spacing (Fig. E.79 through E.114, Appendix E) with COV(k) has almost negligible effect.

In descending order, the variables affecting COV(M_{max}) are (P, Φ, γ', B, EI, and k).

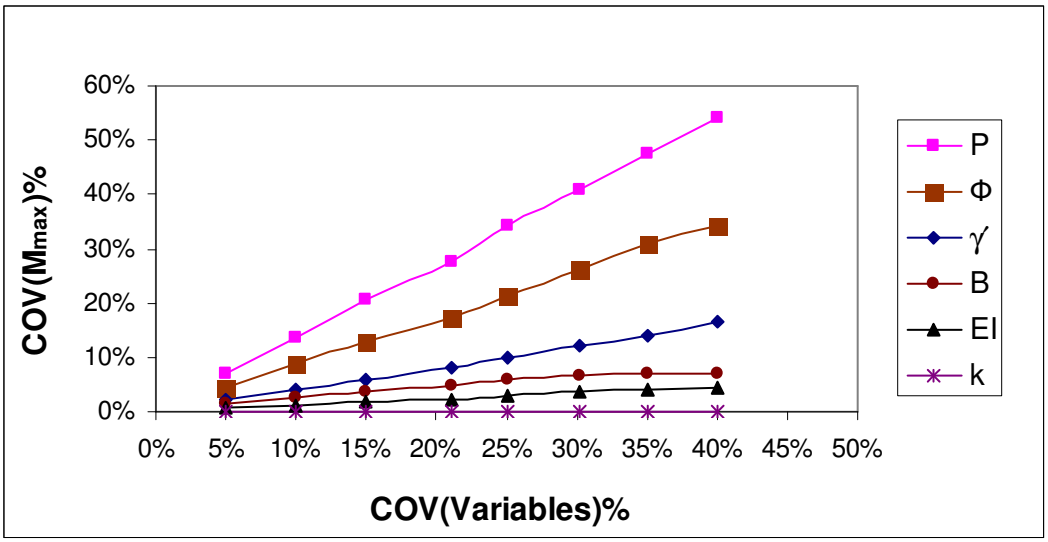


Fig. 5.26 Effect of different variables on COV(M_{max}) for hinged head long pile (10T) group with (5D) spacing at lateral load P=1300kN.

5.5.2 Discussion on the reliability analysis and probability of failure of hinged head long (10T) pile group with (5D) spacing

Reliability index (β_{YTOP}) connected to (Y_{Top}) for hinged long pile group (5D) (Fig.E.37 through E.72, Appendix E) is almost the same as (β_{YTOP}) for hinged head long pile group (3D) (section 5.3.2) in curve pattern but in general has higher values. The reliability index (β_{YTOP}) connected with (Φ and P) shows that the reliability index (β_{YTOP}) has value of more than two and the system is safe for the lateral load P of 285kN, 530kN 775kN and 1000kN, and (β_{YTOP}) is less than two and the system fails under lateral load P of 1300kN. The results show that the group of piles is safe under all lateral loads for all other design

variables (Fig.5.27). In descending order, the variables affecting the reliability index (β_{YTOP}) are (Φ, P, γ', EI, B, and k).

The probability of failure increased when the reliability index decreased (Fig.E.73 through E.78, Appendix E).

From Fig. 5.28, we can determine that the angle of internal friction, Φ has significant influence on the probability of Failure of the pile with magnitude of about 0.1 for lateral load P=1300kN, then the influence of the lateral load P comes in the second place, γ' and EI, while B and k has the least effect on the probability of failure.

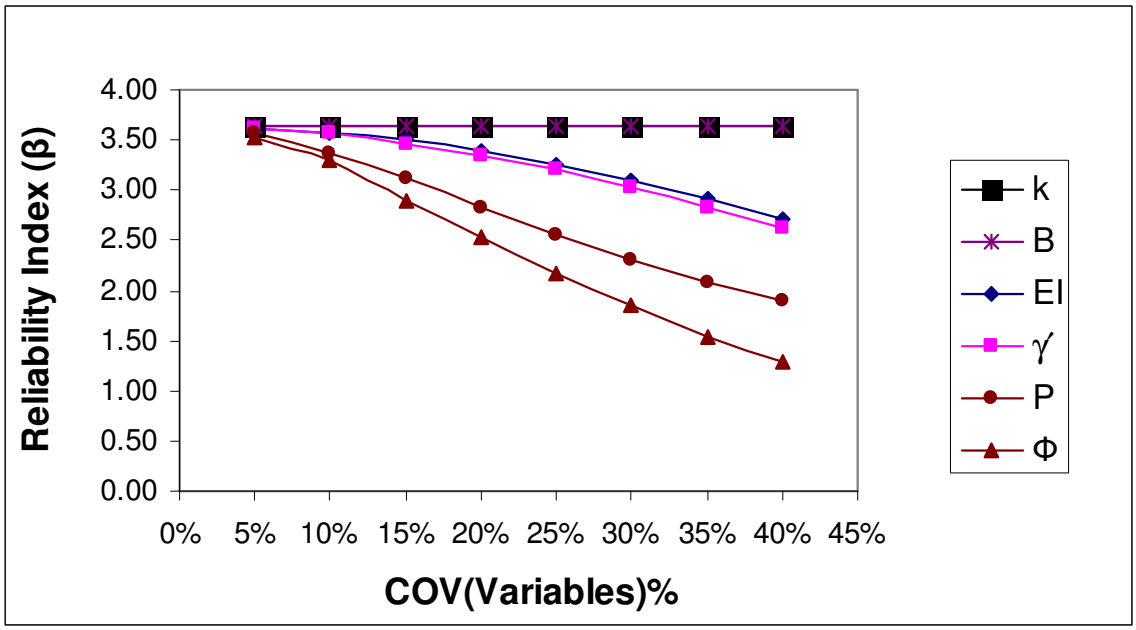


Fig. 5.27 Reliability Index (β_{YTOP}) connected with Y_{Top} for hinged head long pile (10T) group with (5D) spacing at lateral load P=1300kN.

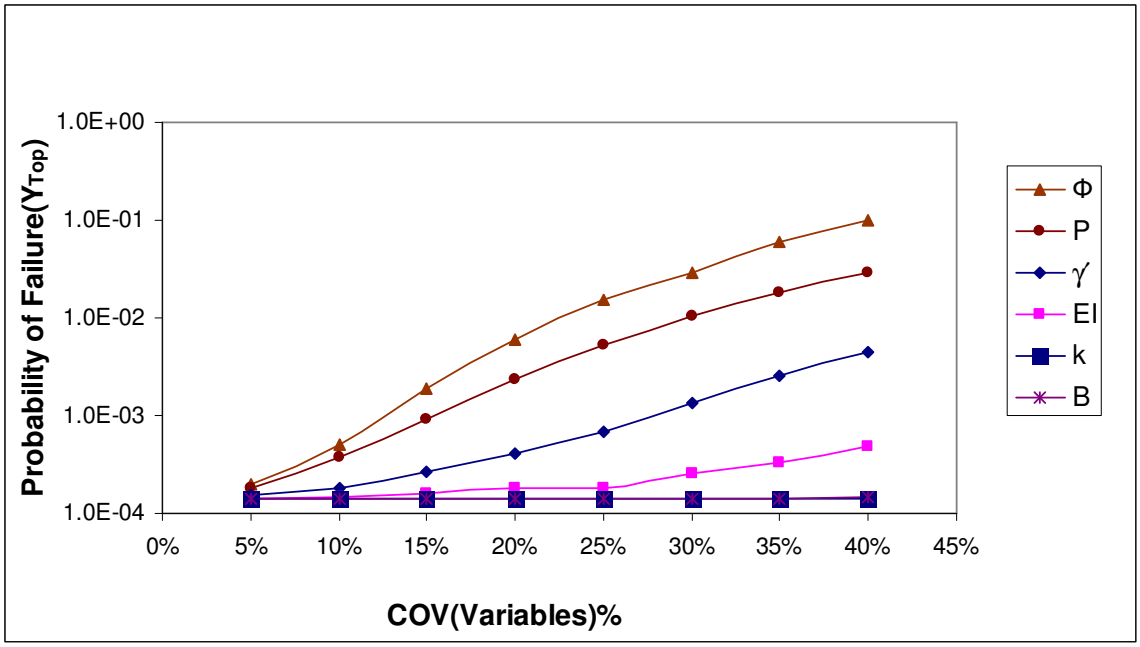


Fig. 5.28 Probability of Failure connected with Y_{Top} for hinged head long pile (10T) group with (5D) spacing at lateral load P=1300kN.

In case of reliability index (β_{Mmax}) connected to M_{max}, reliability index (β_{Mmax}) and probability of failure are more sensitive to lateral load, P, than the angle of internal friction, Φ (Fig.5.29 and Fig.5.30). The reliability index (β_{Mmax}) connected with all design variables is less than (3.7) for lateral load P=1300kN and the pile group is failing under this load, while (β_{Mmax}) >3.7 for all other lateral loads for all design variables and the pile is safe (Fig.E.115 through E.150, Appendix E). In descending order, the variables affecting the reliability index (β_{Mmax}) are (P, Φ, γ', EI, B, and k).

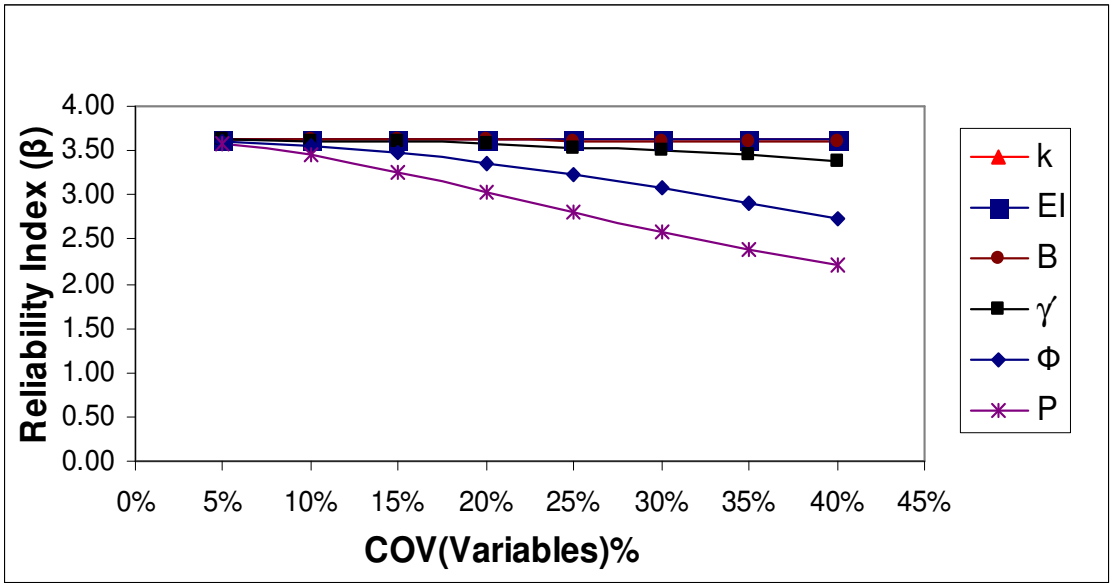


Fig. 5.29 Reliability Index (β_{Mmax}) connected with M_{max} for hinged head long pile (10T) group with (5D) spacing at lateral load P=1300kN.

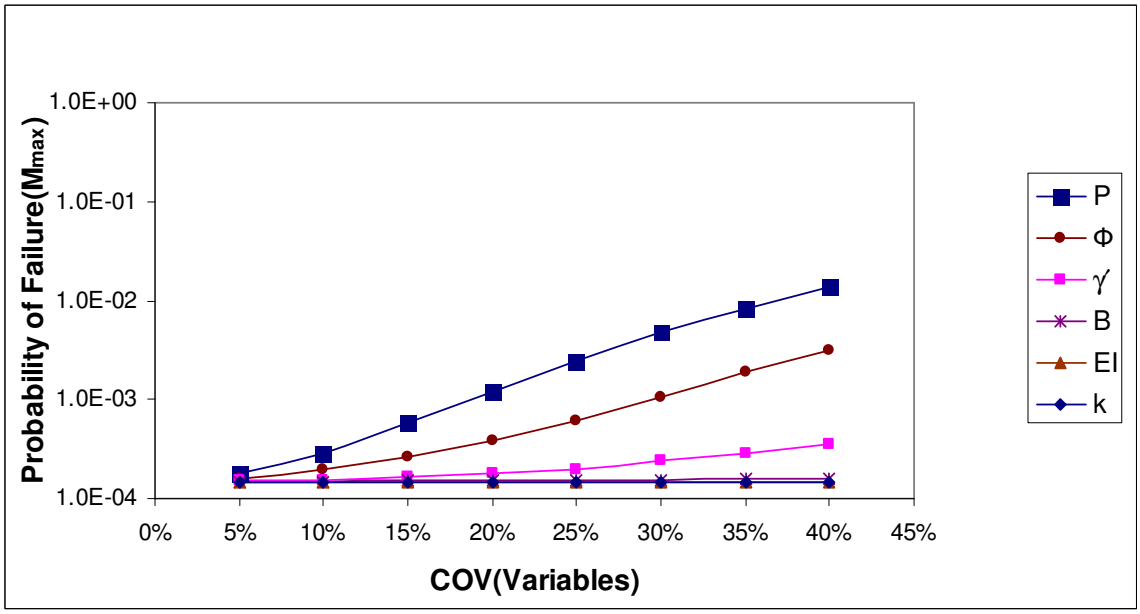


Fig. 5.30 Probability of Failure connected with M_{max} for hinged head long pile (10T) group with (5D) spacing at lateral load P=1300kN applied to the pile group.

5.6 Discussion on the results of laterally loaded fixed head long (10T) pile group with (5D) spacing.

5.6.1 Discussion on the probabilistic modeling of fixed head long (10T) pile group with (5D) spacing

For COV(Y_{Top}) connected with design variables (B and K) in fixed head long pile group with (5D) spacing is almost similar in value and curve pattern of COV(Y_{Top}) connected to all variables for fixed head long pile group with (3D) spacing (Section 5.4.1). The COV's of the design variables (Φ, P, γ', EI) for the fixed head group of piles with (5D) spacing have slightly higher values connected with COV(Y_{Top}) than there values connected with COV(Y_{Top}) for fixed head pile group with (3D) spacing (refer to Fig. F.1 through F.36, Appendix F).

In descending order, the variables affecting COV(Y_{Top}) are (Φ, P, γ', EI, B, and k) (Fig.5.31) for lateral load P=3300kN. In fact, variables k has negligible effect connected to COV(Y_{Top}).

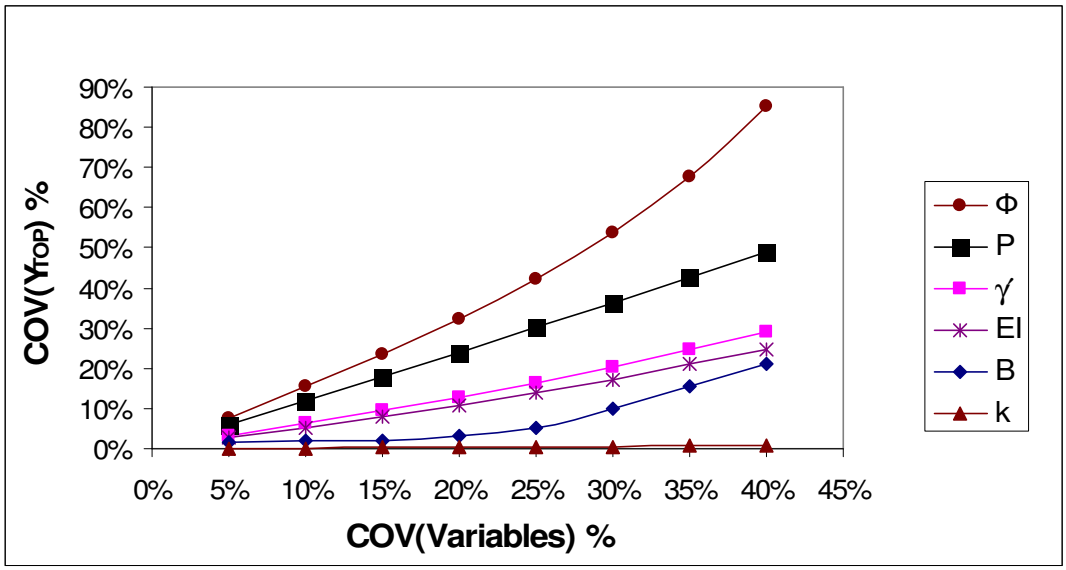


Fig.5.31 Effect of different variables on COV(Y_{Top}) for fixed head long pile group with (5D) spacing at lateral load P=3300kN.

For the case COV(M_{max}), the random design variable 'P' is showing considerable influence (Fig. 5.32), then Φ, all the other variable B, EI, k, and γ' cause comparatively small change. In general COV(M_{max}) connected with

COV(Φ, P, γ', B, and k) for the fixed head group of piles (5D) spacing shows lower values than COV(M_{max}) connected with COV(Φ, P, γ', B, and k) for fixed head pile group with (3D) spacing (Fig. F.79 through F.114, Appendix F) with COV(k) having almost negligible effect. COV(EI) for the fixed head group of piles (5D) spacing shows higher values than COV(M_{max}) connected with COV(EI) for fixed head pile group with (3D) spacing.

In descending order, the variables affecting COV(M_{max}) are (P , Φ, γ', B, EI, and k).

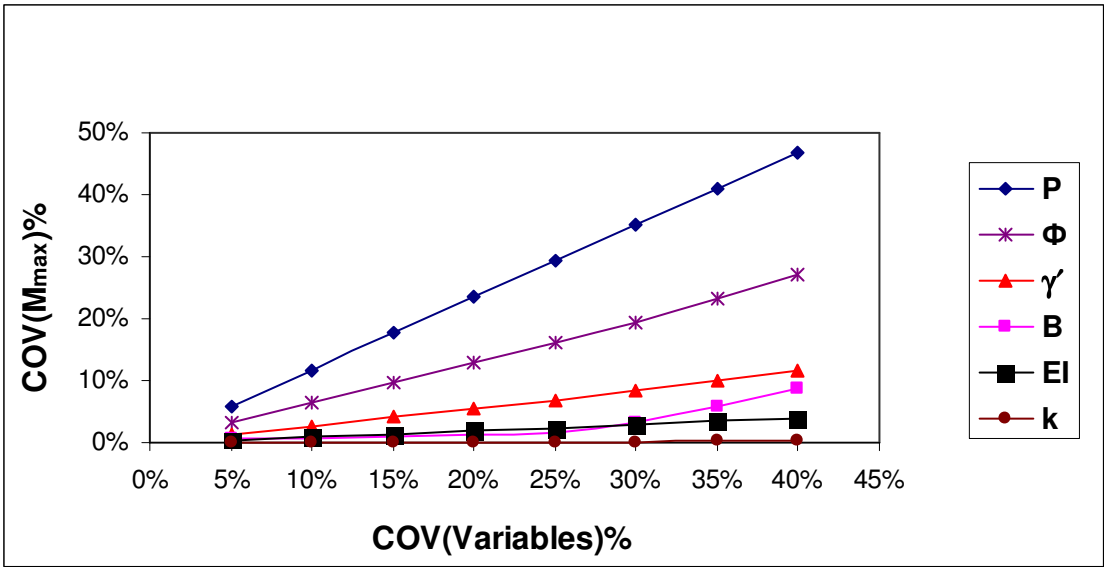


Fig. 5.32 Effect of different variables on COV(M_{max}) for fixed head long pile group with (5D) spacing at lateral load P=3300kN.

5.6.2 Discussion on the reliability analysis (and probability of failure of fixed head long (10T) pile group with (5D) spacing

Reliability index (β_{YTOP}) connected to (Y_{Top}) for fixed head long pile group with (5D) spacing (Fig.F.37 through F.72, Appendix F) has almost the same pattern as (β_{YTOP}) for fixed head long pile group with (3D) spacing (Section 5.4) but with higher value of reliability index. The reliability index (β_{YTOP}) connected with (Φ) shows that the reliability index (β_{YTOP}) has value of more than two and the system is safe for the lateral load P of 1000kN, 1550kN and 2100kN, and

2650kN, while (β_{YTOP}) is less than two and the system fail under lateral load P of 3300kN. The results show that the group of piles is safe under all lateral loads for all other design variables. Results also indicates that variable Φ is showing noticeable effect on reliability index (β_{YTop}) as shown in Fig. 5.33 for lateral load P=3300 kN. In descending order the effect of the design variables on the reliability index (β_{YTop}) are k, B, EI, γ', P, Φ.

The probability of failure increased when the reliability index (β_{YTOP}) decreased (Fig.F.73 through F.78, Appendix F).

From Fig. 5.34, we can determine that the angle of internal friction, Φ has significant influence on the probability of failure of the pile with magnitude of about 0.7 when its about 40% from its mean value for lateral load P=3300kN. Then the influence of the lateral load P comes in the second place, γ' and B, while EI and k has the least effect on the probability of failure.

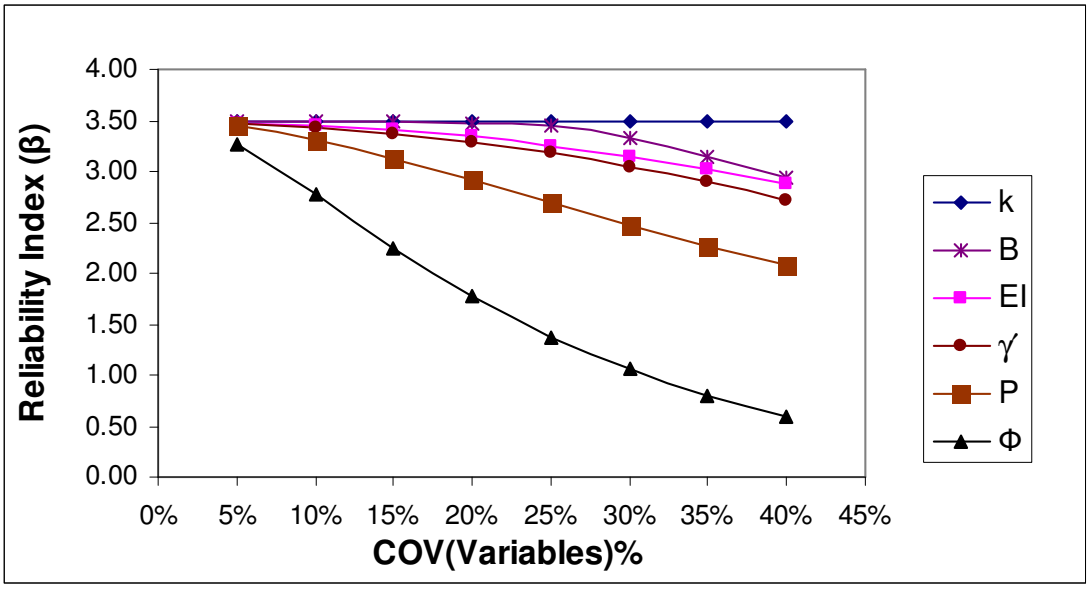


Fig. 5.33 Reliability Index (β_{YTOP}) connected with Y_{Top} for fixed head long pile group with (5D) spacing at lateral load P=3300kN.

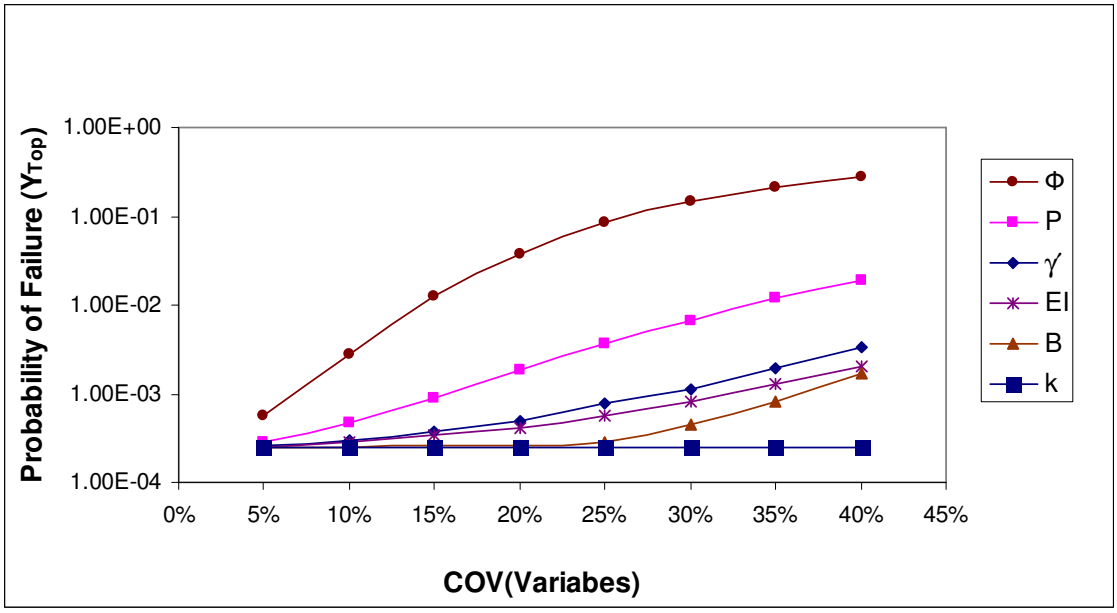


Fig. 5.34 Probability of Failure connected with Y_{Top} for fixed head long pile group (5D) with P=3300kN.

In case of reliability index (β_{Mmax}) connected to M_{max}, reliability index and probability of failure are more sensitive to lateral load, P, then the angle of internal friction, Φ (Fig.5.35 and Fig.5.36). The reliability index (β_{Mmax}) connected with all design variables is > 3.7 for lateral loads 1000kN, the system is unsafe and the group of pile is unsafe under all other lateral loads for all design variables (Fig.F.115 through F.150, Appendix F).

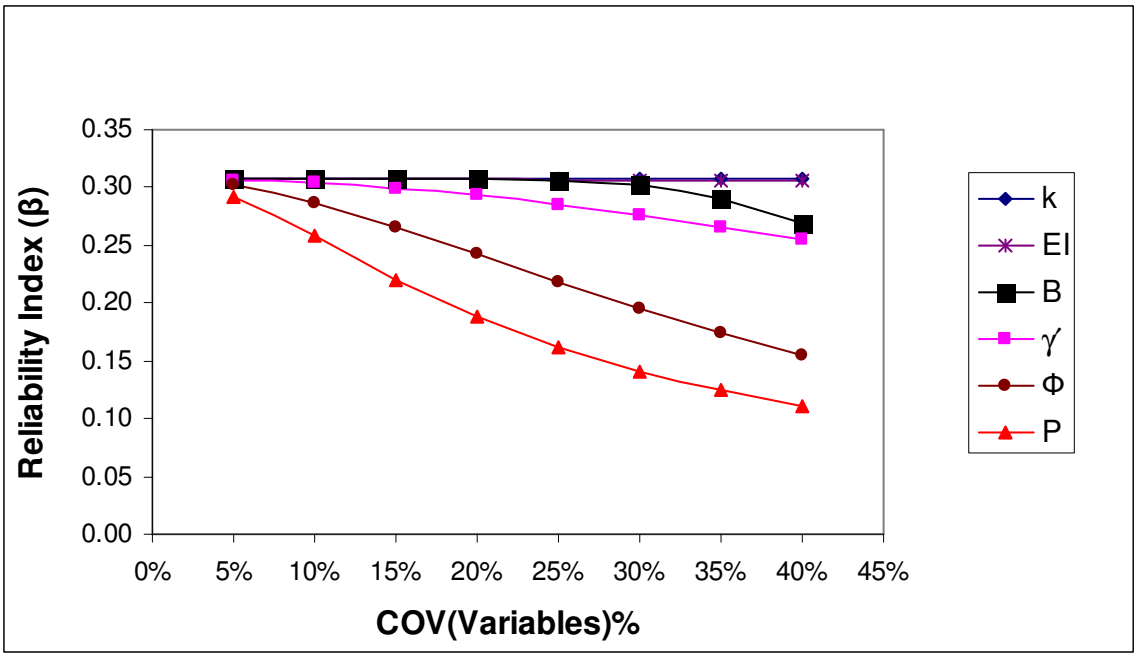


Fig. 5.35 Reliability Index (β_{Mmax}) connected with M_{max} for fixed head long pile group (10T) with (5D) spacing and lateral load P=3300kN.

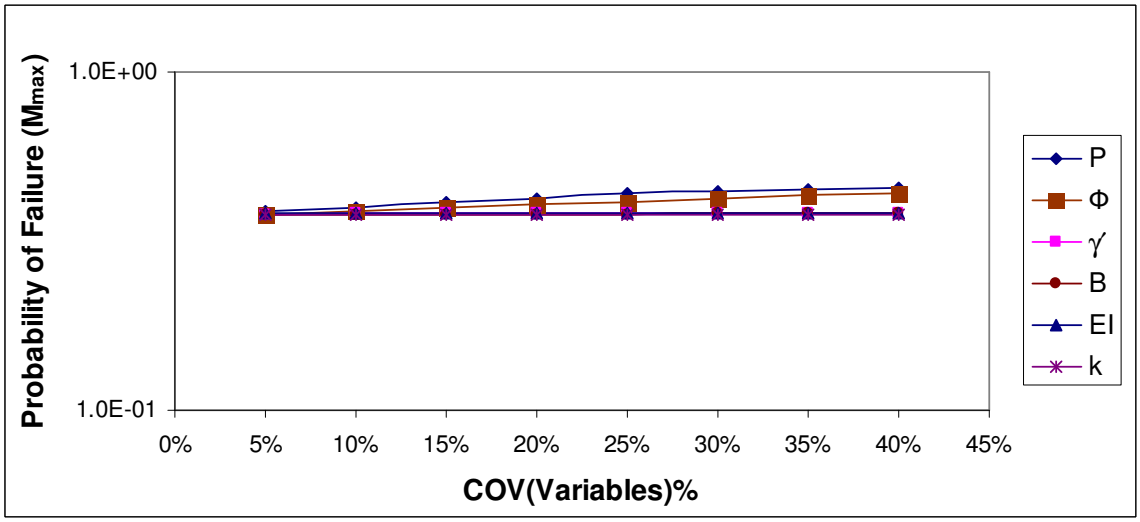


Fig. 5.36 Probability of Failure connected with M_{max} for fixed head long pile group (10T) with (5D) spacing and lateral load P=3300kN.

CHAPTER SIX
CONCLUSIONS

This study is conducted using probabilistic methods to evaluate performance of laterally loaded single pile and pile group embedded in sand using cyclic loading. The major sources of uncertainties connected with surrounding soil, pile material, applied loads affecting pile capacities and responses are identified. Their respective contributions to the overall reliability index and probability of failure are then analyzed and compared. For instance, besides the loading and the prediction model error, the type of soil sampling and test procedures used to select the design parameter (Φ) could play a significant role in the uncertainty level of the predicted laterally loaded pile capacity in sand. For group of piles the effect of center-to-center spacing between piles is analyzed and discussed.

An extensive discussion is carried out on the results of probabilistic modeling, reliability analysis and probability of failure to figure out the important aspects on the performance of laterally loaded single pile and pile group. The important points which came out of the discussion are inscribed in this chapter.

6.1 Conclusions on laterally loaded single pile

Following are the important points on the behavior of laterally loaded single pile:

1- The increase in pile length from short pile 3T to long pile 10T causes very small changes in pile head deflection at certain lateral load for both free and fixed head pile.

2- The pile boundary condition makes a large difference in deflection at pile head. To get the same pile head deflection as of free head pile, fixed head pile must be loaded laterally with more than 2 times the load. This is true for short (3T) as well as for long (10T) pile.

3- COV(Y_{Top}) is higher for higher lateral load for certain value of COV(Random variable), the only exception is the variable k.

4- COV(M_{max}) higher for higher lateral load for certain value of COV(Random variable), the only exception is the variable k.

5- In descending order, the variables affecting COV(Y_{Top}) in free and fixed head single pile are (Φ, P, γ', EI, B, k) . Affect of variable k on COV(Y_{Top}) is almost negligible. The COV(Y_{Top}) gets more sensitive to changes of Φ, when COV(Φ) crosses 30% mark.

6- For COV(M_{max}), random design variable 'P and Φ' is showing considerable influence. All other variables γ', B, EI, k cause comparatively smaller change. Especially, affect of random variable k is negligible. It means maximum bending moment of laterally loaded pile is not affected by variable k.

7- In descending order, the variables affecting COV(M_{max}) in free and fixed head single pile are (P, Φ , γ', B, EI, k). The COV(M_{max}) gets more sensitive to changes of variables P and Φ.

8- The increase of numerical value of COV(each design variable) connected with Y_{Top} decreases the reliability index β in the following order starting from most important to least important (Φ, P, γ', EI, B, k) refer to Fig.A.1 through A.72 .

9- For fixed head long pile COV(M_{max}) is showing the same pattern with COV(variables) as COV(Y_{Top}) but with lower values. Also in case of M_{max}, the design variable P has more effect than the design variable Φ.

10- The results show that the reliability index connected to Y_{Top} and M_{max} is very much dependent on the applied lateral load. As the load increases the reliability index is going down.

11- Results indicate that the reliability indices connected to Y_{Top} (β_{YTOP}) and M_{max} (β_{Mmax}) are very sensitive to the random variable 'Φ and P'. The

influence of other variables on β_{Mmax} is smaller. When COV(Φ and P) increased from their mean values, the reliability indices decreased.

12- In descending order, the variables affecting reliability index connected to Y_{Top} in free head long pile are (Φ, P, γ', EI, B, k) . For fixed head pile (Φ, P, γ', EI, B, k). In fact, variables k has very negligible effect on reliability index connected to Y_{Top}.

13- In descending order, random variables affecting (β_{Mmax}) in free and fixed head pile are (P, Φ , γ', B, EI, k) .

14- Fixed head long pile is safer than free head long pile under certain lateral load with higher reliability index (β_{YTOP}) more than 2, and lower probability of failure. For the free head single pile (β_{YTOP}) is more than 2 for all design variables under all lateral loads except for design variables (P and Φ) when subjected to lateral load P= 150kN.

15- Compared to free head long pile, fixed head long pile has lower values of reliability index (β_{Mmax}), and it is lower than 3.7 for all design variables under lateral loads (200kN, 250kN and 300kN) with higher probability of failure than free head single pile. The fixed head long pile is safe under lateral loads 100kN and 150kN for all design variables. Hence fixed head pile is more vulnerable to fail by bending moment (M_{max}) than free head.

6.2 Conclusions on laterally loaded pile group

Following are the characteristics of laterally loaded pile group:

1- The deflection and bending moment obtained in single isolated pile can be obtained in a pile of closely spaced pile group at lower lateral load per pile. It happens because of pile-soil-pile interaction, and lateral resistance provided by pile cap.

2- Also higher lateral load (for example 1000kN) needs to be applied to fixed head long pile group (3D) than hinged head long pile group (3D) (for example 250kN) to get the same deflection.

3- Spacing between the piles in pile group influence the lateral load applied at pile cap to get some specific pile head deflection. Results shows that higher lateral load (for example 1550kN) needs to be applied to pile cap in a pile group with pile spacing 5D than a pile group with pile spacing 3D (for example 1375kN) to get some specific pile head deflection (for example 0.016 m) (Tables D.1 through D.36, Appendix D & F.1 through F.36, Appendix F) for fixed head piles. Same conclusion is true for free head pile group 3D and 5D.

4- Variation of center-to-center pile spacing from 3D to 5D in a pile group, do not cause any significant change in COV(Y_{Top}) connected to all six random variables.

5- The pattern and values of curve for COV(Y_{Top}) connected to the COV of variables P, Φ, γ', EI, B, and k for fixed head long pile group with (3D) spacing is very close to COV(Y_{Top}) for fixed head single isolated long pile with the exception of design variable B. The COV(Y_{Top}) connected with design variable B in the case of fixed head pile group with (3D) spacing has higher value than the fixed head single pile.

6- Variation of pile spacing from 3D to 5D in a pile group has no effect on the reliability index connected to Y_{Top} (β_{YTOP}).

7- Reliability index connected to Y_{Top} (β_{YTOP}) for hinged long pile (10T) group with (3D) spacing is the same as (β_{YTOP}) for free head single isolated long pile (10T).

8- Reliability index connected to M_{max} (β_{Mmax}) for hinged head long pile group (3D) is the same as (β_{Mmax}) for free head single long pile.

9- In descending order, the variables affecting (β_{YTOP}) in hinged head long pile group are (Φ, P, γ', EI, B, k) .

10- In descending order, variables affecting (β_{YTOP}) in fixed head long pile group are (Φ, P, γ', EI, B, k) .

11- Reliability index (β_{YTOP}) is higher for the fixed head long pile group than the hinged head long pile group when subjected to specific load. This behavior is related to the lateral resistance of pile cap.

12- The fixed head long pile group is safe against Y_{Top} with (β_{YTOP})>2 for all random variables (γ', B, EI, and k) under all lateral loads. The pile group is unsafe for the design variables (Φ, and P) when the lateral load is 2500kN in case of pile group with (3D) spacing and 3300kN in case of pile group with (5D) spacing for design variable (Φ).

13- The hinged head long pile group is safe against M_{max} with (β_{Mmax}) >3.7 for the random variables (γ', Φ, P, EI) under all lateral loads except for lateral load P=1025kN for the pile group with (3D) spacing. For design variables (B and k) the system is safe under all lateral loads. While for the pile group with (5D) spacing, the piles are safe under all lateral load except when P=1300kN, then the system fails.

14- The fixed head long pile group are unsafe against M_{max} with (β_{Mmax}) <3.7 for all 6 random variables under most lateral loads for both (3D) and (5D) spacing.

6.3 Recommendations for future research

Reliability analysis provides a systemic account of the uncertainties and a rational procedure for design. Further studies on the following directions will certainly help in improving quality of reliability analysis.

Overall conservative assumptions adopted in some conventional deterministic design methods may be replaced with more objective reliability based design procedure.

Therefore the study can be further extended for:

1- Laterally loaded pile or pile group embedded in non-homogenous soil.
2- Collecting of detailed site explorations data to improve probabilistic modeling of soil properties.
3- Evaluation of damages associated with various failure modes, and their effect on overall system integrity.
4- Laterally loaded pile or pile group subjected to more complicated load such as dynamic load or seismic load.
5- Conducting reliability analysis connected to fatigue limit state on laterally loaded pile or pile group.
6- Analyzing the pile made of material other than steel under lateral load.

REFERENCES

ACI (1983). Building Code Requirement for Reinforced Concrete. ACI 318-83, American Concrete Institute, Detroit.

American Petroleum Institute, API, (1987). Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms. API Recommended Practice 2A (RP-2A), 17th Edition.

Ayyub, B. M. and Eloseily, K. H. (2002), Reliability Assessment of Pile Groups in Sands , Journal of Structural Engineering. ASCE. Vol. 128, No. 10, October 2002: 1346-1353.

Beacher, G. B., and Ingra, T. S. (1981). Stochastic FEM in Settlement Predictions. Journal of Geotechnical Engineering Division. ASCE. 107 (GT4): 449-463.

Brown, D. A., Morrison, C., and Reese, L. C. (1988). Lateral Load Behavior of a Pile Group in Sand. Journal of Geotechnical Engineering Division, ASCE 114(11):1261-1276.

Brown, D. A., and Reese, L. C. (1985). Behavior of Large-Scale Pile Group Subjected to Cyclic Lateral. Reports to the Mineral Management Services U.S. Dept. of Interior, Reston, VA; Dept. of Research, FHWA, Washington DC; U.S. Army Engineer Waterways Experiment Station, Vicksburg, Missisippi.

Brown, D. A., and Shie, C. F. (1991). Modification of p-y curves to Account for Group Effects on Laterally Loaded Piles. Geotechnical Engineering Congress, 1(G.S.PNo.27): 479-490.

BSI (1972). Code of Practice for Structural use of Concrete. CP110 (Pt.1), British Standard Institution, London.

B. K. Low and C. I. The. (1999). Probabilistic Analysis of Pile Deflection under Lateral Loads. International Conference on Application of Statistics and Probability (ICASP 8), A. A. Balkema, Rotterdam, The Netherlands, Vol. 1, 407-414.

Casagrande, A. (1965). Rule of the Calculated Risk in Earthwork and Foundation Engineering. Journal of Soil Mechanics and Foundation Engineering Division, ASCE 91(SM4), 1.

Christian, J.T., Ladd, C.C., and Baecher, G.B. (1994). Reliability Applied to Slope Stability Analysis. Journal of Geotechnical Engineering. Energy Citation Database. Dec. 1994, Vol. 120 (12): 2180–2207.

Cornell, C. A. (1969). A Probabilistic-Based Structural Code. Journal of the American Concrete Institute, 66 (12): 974-985.

Cox, W. R., Dixon, D. A., and Murphy, B. S. (1984). Lateral loaded tests on 25.4-mm diameter Piles in Very Soft Clay in Side-by-Side and in-Line Groups. Laterally Loaded Deep Foundations: Analysis and Performance, ASTM, STP 835, 122-139.

Duncan, J. M., Evans L.T.(1994). Lateral Load Analysis of Single Piles and Drilled Shafts. Journal of Geotechnical Engineering Division, ASCE 120(5): 1018-1033.

Ellingwood, B., MacGregor, J. G., Galambos, T. V. and Cornell, C. A. (1982). Probability Based Load Criteria: Load Factors and Load Combinations. Journal of the Structural Division (ASCE) 108, No. ST5, 978-997.

Evans, L. T. Jr. and Duncan, J.M. (1982). Simplified Analysis of Laterally Loaded Piles. Report No.UCB/GT/82-04, July 1982. University of California, Berkeley, CA.

Folse, M. D., (1989). Reliability Analysis for Laterally Loaded Piling, Journal of Structural Engineering. ASCE. Vol. 115, No. 5: 1011-1020.

Gazetas, G. and Mylonakis, G., (1988). Seismic Soil Structure Interaction: New Evidence and Emerging Issues. Geotechnical Earthquake Engineering and Soil Dynamics III. Dakoulas, P. Yegian. M, and Holtz, R.D. (eds). ASCE 2 (Geotechnical Special Publication 75), 1119-1174.

Hansen, P. F., Madsan, H. O., and Tjelta, T. I. (1995). Reliability Analysis of Pile Design. Marine Structures. Elsevir Science Ltd. 8:171-198.

Hetenyi, M. (1946), Beams on Elastic Foundation, Ann Arbor: The University of Michigan Press.

Matlock, H. and Reese, L.C., (1960). Generalized Solutions for Laterally Loaded Piles. Journal of Soil Mechanics and Foundations Division, ASCE. Vol. 86. No. SM5. Proc. Paper 2626. 63-91.

Matlock, J. (1970). Correlations for Design of Laterally Loaded Piles in Soft Clay. Proceeding of Second Annual Offshore Technology Conference, Huston, Texas, 577-594.

McClelland, B. and Focht, J. A. Jr. (1958). Soil Modulus for Laterally Loaded Piles. Transactions, ASCE 123, 1049-1086.

McVay, M., Casper, R., and Shang, T. (1995). Lateral Response of Three Row Groups in Loose to Dense Sands at 3D and 5D Pile Spacing. ASCE Journal of Geotechnical and Geoenvironmental Engineering. 121(5), 436-441.

McVay, M., Zhang, L., Molnit, T. and Lai, P. (1998). Centrifuge Testing of Large Laterally Loaded Pile Groups in and. ASCE Journal of Geotechnical and Geoenvironmental Engineering. 124(10), 1016-1206.

Melchers. (1999). Structural Reliability Analysis and Prediction. Journal of Structural and Multidisciplinary Optimization, Vol. 21, No. 4.

Mokwa, R. L., and Duncan, J. M. (2001a). Experimental Evaluation of Lateral Load Resistance of Pile Caps. ASCE Journal of Geotechnical and Geoenvironmental Engineering. 127(2), 185-192.

NKB (1978). Recommendations for Loading and Safety Regulation for Structural Design. Report 36,Nordic Committee on Building Regulation, Copenhagen.

Papoulis, A. and Unnikrishana, S. (2002). Probability Random Variables and Stochastic Processes, Fourth Edition. New York, McGraw-Hill.

Peter Friis Hansen , Henrik O. Madsen and Tor Inge Tjelta, (1995) . Reliability Analysis of a Pile Design . Elsevier Science Ltd.

Phoon, K.-K.and Kulhawy, F. H. (1999a). Characterization of Geotechnical Variability, Canadian Geotechnical Journal, 36:612-624.

Phoon, K.-K.and Kulhawy, F. H. (1999b). Evaluation of Geotechnical Property Variability. Canadian Geotechnical Journal, 36:625-639.

Phoon, Honjo and Gilber (eds), (2003). Why Consider Reliability Analysis for Geotechnical Limit State Design. International Workshop on Limit State Design in Geotechnical Engineering Practice. World Scientific Publishing Company.

Poulos, H. G. and Davis, E. H. (1980). Pile Foundation Analysis and Design. New York: Wiley.

Ramashaw C. L. Selby, A. R., and Bettess, P. (1988). Computed Ground Waves due to Piling. Geotechnical Earthquake Engineering and Soil Dynamics

III.Dakoulas, P. Yegian. M, and Holtz, R.D. (eds). ASCE 2 (Geotechnical Special Publication 75), 1484-1495.

Reese, L. C., Hudson, B. S., and Smith, R., E., (1970). Generalized Analysis of Pile Foundations., J. S. M. F. D. ASCE. Vol. 96, SM1:235.

Reese, L. C., Cox, W. R. and Coop, F. D. (1974). Analysis of Laterally Loaded Piles in Sand. Proceeding of Offshore Technical Conference, Huston, Texas, 473-483.

Reese, L. C., and Welch, R. C. (1975). Lateral Loading of Deep Foundations in Stiff Clay. Journal of Geotechnical Engineering Division. Proceedings of the American Society of Civil Engineers. Vol.101, No.GT7,1156, 633-649.

Reese, L. C., Wang, S. T. (1996). Technical Manual of Documentation of Computer Program GROUP 4.0 for Windows, Ensoft, Inc., Austin, Texas.

Rollins, K. P, Peterson, K. T. and Weaver, T. J. (1998). Lateral Load Behavior of Full-Scale Pile Group in Clay. ASCE Journal of Geotechnical and Geoenvironmental Engineering, 124(6), 468-478.

Ruesta, P. F. and Townsend, F. C. (1997). Evaluation of Laterally Loaded Pile Group. ASCE Journal of Geotechnical and Geoenvironmental Engineering, 123(12), 1153-1174.

Ruiz, S. E., (1984). Reliability Index for Offshore Piles subjected to bending., Structural Safety, 2. 83-90

Ruiz, S. E., (1986). Uncertainty About p-y Curves for Piles in Soft Clays, Journal of Geotechnical Engineering, ASCE. Vol. 112, No. 6, June 1986, 594-607.

Spry, M. J., Kulhawy, F. H., and Grigouriu, M. D. (1988) Reliability-based Foundation Design for Transmission Line Structures: Geotechnical Site Characterization Strategy. Electric Power Research Institute, Palo Alto, Calif., Report EL-5507(1).

Sundararajan, C. (1986). Probabilistic Assessment of Pressure Vessel and Piping Reliability. Journal of Pressure Vessel Technology, 108, 1-13.

Sundararajan (Raj), C. (1995). Probabilistic Structural Mechanics Handbook. Chapman and Hall, New York, ISBN 0-412-05481.

US Army Corps of Engineers (1997): "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies, Engineering and Design", Department of Army, Washington D. C, 20314-100.

Woods, R. D., and Stokoe II, K. H. (1985). Shallow Seismic Exploration in Soil Dynamics. Proceeding the Richart Commemorative Lectures, Geotechnical Engineering Division, ASCE:120-151.

VITA AUCTORIS

Ruoah Yousif was born in 1971 in Baghdad, Iraq. She graduated from University of Baghdad, college of Engineering where she obtained a B.Sc. in Civil Engineering in 1993. She is currently a candidate for the master degree in Civil Engineering at the University of Windsor and hopes to graduate in Fall 2009.

APPENDIX A

LATERALLY LOADED FREE HEAD SINGLE PILE (10T)

A-1 Deflection of free head single pile (Y_{Top}) and COV(Y_{Top}) vs. COV(Variables)

Table A.1 Probabilistic modeling of laterally loaded free head long pile 10T with varying (Φ) and load 30kN.

P=30kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	3.77E-03				
5%	30			2.25E+00	1.48E-07	4.13E-03	9.32%
		28.5	4.54E-03				
		33	3.44E-03				
10%	30			9.00E+00	6.08E-07	4.13E-03	18.89%
		27	5.00E-03				
		34.5	3.14E-03				
15%	30			2.03E+01	1.39E-06	4.13E-03	28.57%
		25.5	5.50E-03				
		36	3.01E-03				
20%	30			3.60E+01	2.40E-06	4.13E-03	37.53%
		24	6.11E-03				
		37.5	2.93E-03				
25%	30			5.63E+01	3.65E-06	4.13E-03	46.25%
		22.5	6.75E-03				
		39	2.88E-03				
30%	30			8.10E+01	5.27E-06	4.13E-03	55.57%
		21	7.47E-03				
		40.5	2.84E-03				
35%	30			1.10E+02	7.40E-06	4.13E-03	65.86%
		19.5	8.28E-03				
		42	2.80E-03				
40%	30			1.44E+02	1.03E-05	4.13E-03	77.72%
		18	9.22E-03				

Table A.2 Probabilistic modeling of laterally loaded free head long pile 10T with varying (Φ) and load 60kN.

P=60kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	1.08E-02				
5%	30			2.25E+00	1.10E-06	7.40E-03	8.90%
		28.5	1.29E-02				
		33	9.91E-03				
10%	30			9.00E+00	4.39E-06	7.40E-03	17.75%
		27	1.41E-02				
		34.5	9.07E-03				
15%	30			2.03E+01	1.03E-05	7.40E-03	27.25%
		25.5	1.55E-02				
		36	8.31E-03				
20%	30			3.60E+01	1.89E-05	7.40E-03	36.82%
		24	1.70E-02				
		37.5	7.64E-03				
25%	30			5.63E+01	3.00E-05	7.40E-03	46.44%
		22.5	1.86E-02				
		39	7.02E-03				
30%	30			8.10E+01	4.54E-05	7.40E-03	57.12%
		21	2.05E-02				
		40.5	6.44E-03				
35%	30			1.10E+02	6.53E-05	7.40E-03	68.47%
		19.5	2.26E-02				
		42	6.17E-03				
40%	30			1.44E+02	8.96E-05	7.40E-03	80.21%
		18	2.51E-02				

Table A.3 Probabilistic modeling of laterally loaded free head long pile 10T with varying (Φ) and load 90kN.

P=90kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	1.95E-02				
5%	30			2.25E+00	3.42E-06	1.63E-02	8.73%
		28.5	2.32E-02				
		33	1.79E-02				
10%	30			9.00E+00	1.41E-05	1.63E-02	17.69%
		27	2.54E-02				
		34.5	1.64E-02				
15%	30			2.03E+01	3.25E-05	1.63E-02	26.89%
		25.5	2.78E-02				
		36	1.51E-02				
20%	30			3.60E+01	5.93E-05	1.63E-02	36.32%
		24	3.05E-02				
		37.5	1.39E-02				
25%	30			5.63E+01	9.51E-05	1.63E-02	45.99%
		22.5	3.34E-02				
		39	1.28E-02				
30%	30			8.10E+01	1.49E-04	1.63E-02	57.55%
		21	3.72E-02				
		40.5	1.18E-02				
35%	30			1.10E+02	2.24E-04	1.63E-02	70.52%
		19.5	4.17E-02				
		42	1.09E-02				
40%	30			1.44E+02	3.29E-04	1.63E-02	85.61%
		18	4.72E-02				

Table A.4 Probabilistic modeling of laterally loaded free head long pile 10T with varying (Φ) and load 120kN.

P=120kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	2.95E-02				
5%	30			2.25E+00	8.70E-06	3.23E-02	9.13%
		28.5	3.54E-02				
		33	2.71E-02				
10%	30			9.00E+00	3.48E-05	3.23E-02	18.27%
		27	3.89E-02				
		34.5	2.48E-02				
15%	30			2.03E+01	8.19E-05	3.23E-02	28.02%
		25.5	4.29E-02				
		36	2.28E-02				
20%	30			3.60E+01	1.53E-04	3.23E-02	38.24%
		24	4.75E-02				
		37.5	2.10E-02				
25%	30			5.63E+01	2.56E-04	3.23E-02	49.54%
		22.5	5.30E-02				
		39	1.93E-02				
30%	30			8.10E+01	4.08E-04	3.23E-02	62.54%
		21	5.97E-02				
		40.5	1.78E-02				
35%	30			1.10E+02	6.28E-04	3.23E-02	77.55%
		19.5	6.79E-02				
		42	1.64E-02				
40%	30			1.44E+02	9.55E-04	3.23E-02	95.67%
		18	7.82E-02				

Table A.5 Probabilistic modeling of laterally loaded free head long pile 10T with varying (Φ) and load 150kN.

P=150kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	4.14E-02				
5%	30			2.25E+00	1.94E-05	4.55E-02	9.67%
		28.5	5.02E-02				
		33	3.77E-02				
10%	30			9.00E+00	8.01E-05	4.55E-02	19.67%
		27	5.56E-02				
		34.5	3.44E-02				
15%	30			2.03E+01	1.89E-04	4.55E-02	30.22%
		25.5	6.19E-02				
		36	3.16E-02				
20%	30			3.60E+01	3.53E-04	4.55E-02	41.32%
		24	6.92E-02				
		37.5	2.89E-02				
25%	30			5.63E+01	6.00E-04	4.55E-02	53.85%
		22.5	7.79E-02				
		39	2.66E-02				
30%	30			8.10E+01	9.61E-04	4.55E-02	68.13%
		21	8.86E-02				
		40.5	2.44E-02				
35%	30			1.10E+02	1.51E-03	4.55E-02	85.27%
		19.5	1.02E-01				
		42	2.25E-02				
40%	30			1.44E+02	2.38E-03	4.55E-02	107.14%
		18	1.20E-01				

Table A.6 Value of COV (Y_{TOP}) for free head long pile with varying COV(Φ) and lateral load 30kN.

P=30kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	1.48E-07	9.32%
10%	9.00E+00	6.08E-07	18.89%
15%	2.03E+01	1.39E-06	28.57%
20%	3.60E+01	2.40E-06	37.53%
25%	5.63E+01	3.65E-06	46.25%
30%	8.10E+01	5.27E-06	55.57%
35%	1.10E+02	7.40E-06	65.86%
40%	1.44E+02	1.03E-05	77.72%

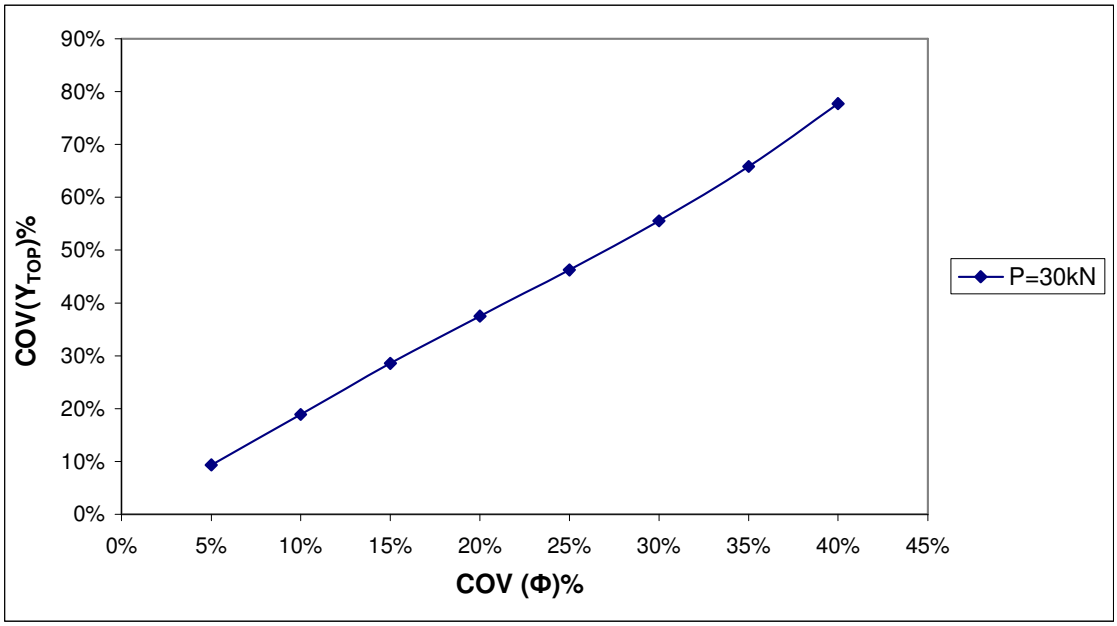


Fig. A.1 Variability of COV (Y_{TOP}) vs. COV(Φ) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.7 Value of COV (Y_{TOP}) for free head long pile with varying COV(Φ) and lateral load 60kN.

P=60kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	1.10E-06	8.90%
10%	9.00E+00	4.39E-06	17.75%
15%	2.03E+01	1.03E-05	27.25%
20%	3.60E+01	1.89E-05	36.82%
25%	5.63E+01	3.00E-05	46.44%
30%	8.10E+01	4.54E-05	57.12%
35%	1.10E+02	6.53E-05	68.47%
40%	1.44E+02	8.96E-05	80.21%

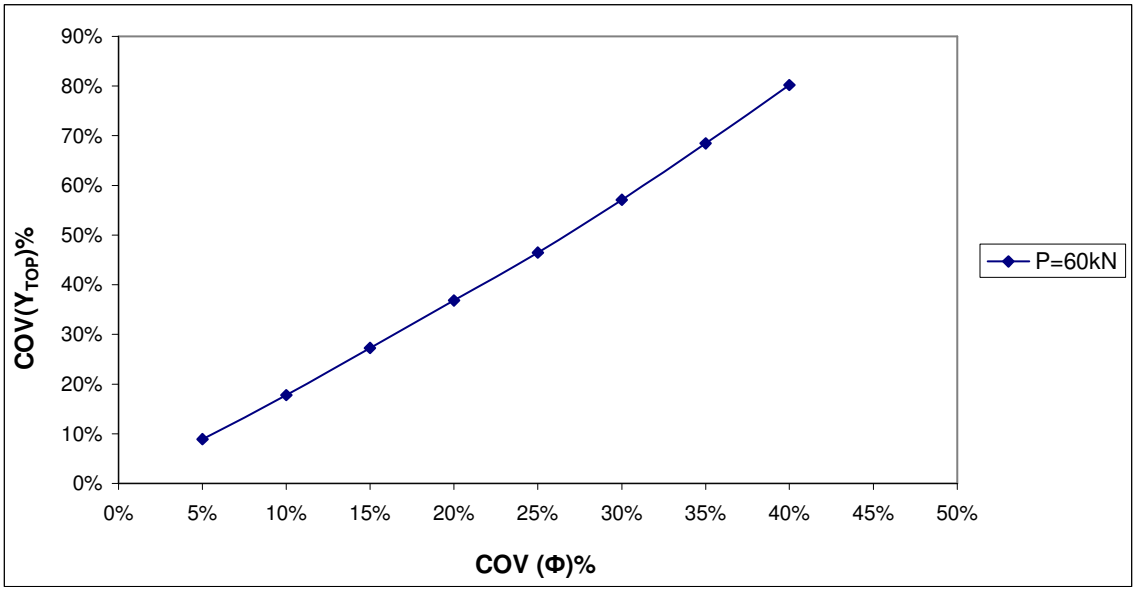


Fig. A.2 Variability of COV (Y_{TOP}) vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.8 Value of COV (Y_{TOP}) for free head long pile with varying COV(Φ) and lateral load 90kN.

P=90kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	3.42E-06	8.73%
10%	9.00E+00	1.41E-05	17.69%
15%	2.03E+01	3.25E-05	26.89%
20%	3.60E+01	5.93E-05	36.32%
25%	5.63E+01	9.51E-05	45.99%
30%	8.10E+01	1.49E-04	57.55%
35%	1.10E+02	2.24E-04	70.52%
40%	1.44E+02	3.29E-04	85.61%

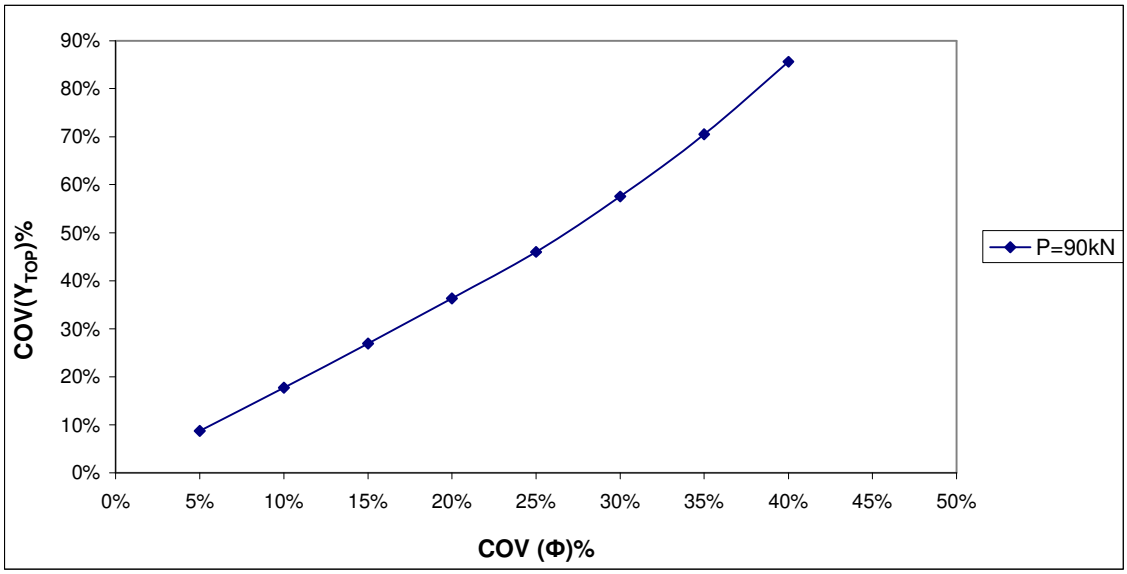


Fig. A.3 Variability of COV (Y_{TOP}) vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.9 Value of COV (Y_{TOP}) for free head long pile with varying COV(Φ) and lateral load 120kN.

P=120kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	8.70E-06	9.13%
10%	9.00E+00	3.48E-05	18.27%
15%	2.03E+01	8.19E-05	28.02%
20%	3.60E+01	1.53E-04	38.24%
25%	5.63E+01	2.56E-04	49.54%
30%	8.10E+01	4.08E-04	62.54%
35%	1.10E+02	6.28E-04	77.55%
40%	1.44E+02	9.55E-04	95.67%

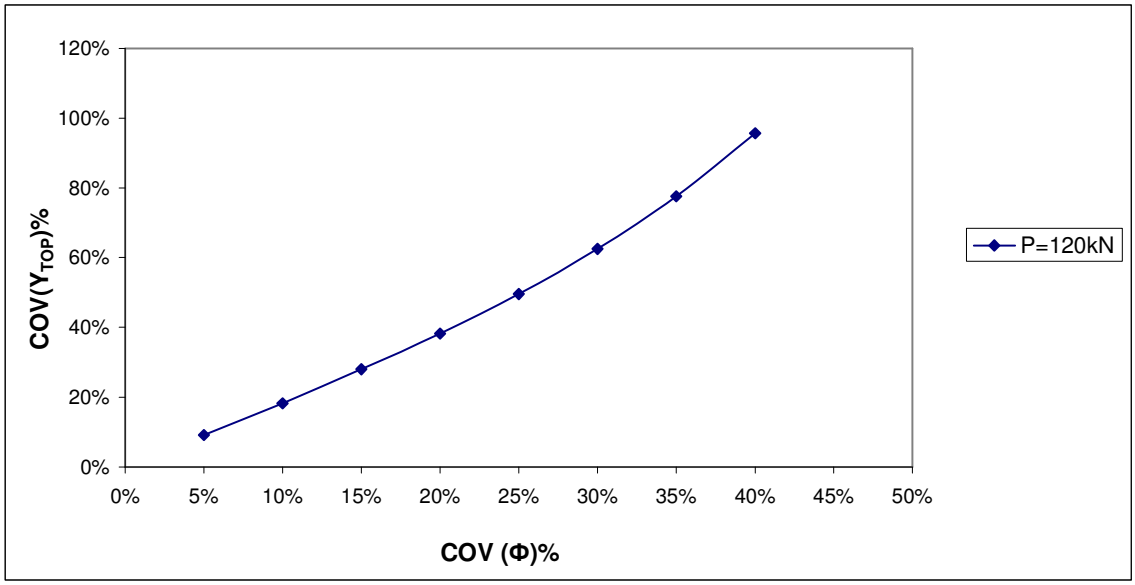


Fig. A.4 Variability of COV (Y_{TOP}) vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.10 Value of COV (Y_{TOP}) for free head long pile with varying COV(Φ) and lateral load 150kN.

P=150kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	1.94E-05	9.67%
10%	9.00E+00	8.01E-05	19.67%
15%	2.03E+01	1.89E-04	30.22%
20%	3.60E+01	3.53E-04	41.32%
25%	5.63E+01	6.00E-04	53.85%
30%	8.10E+01	9.61E-04	68.13%
35%	1.10E+02	1.51E-03	85.27%
40%	1.44E+02	2.38E-03	107.14%

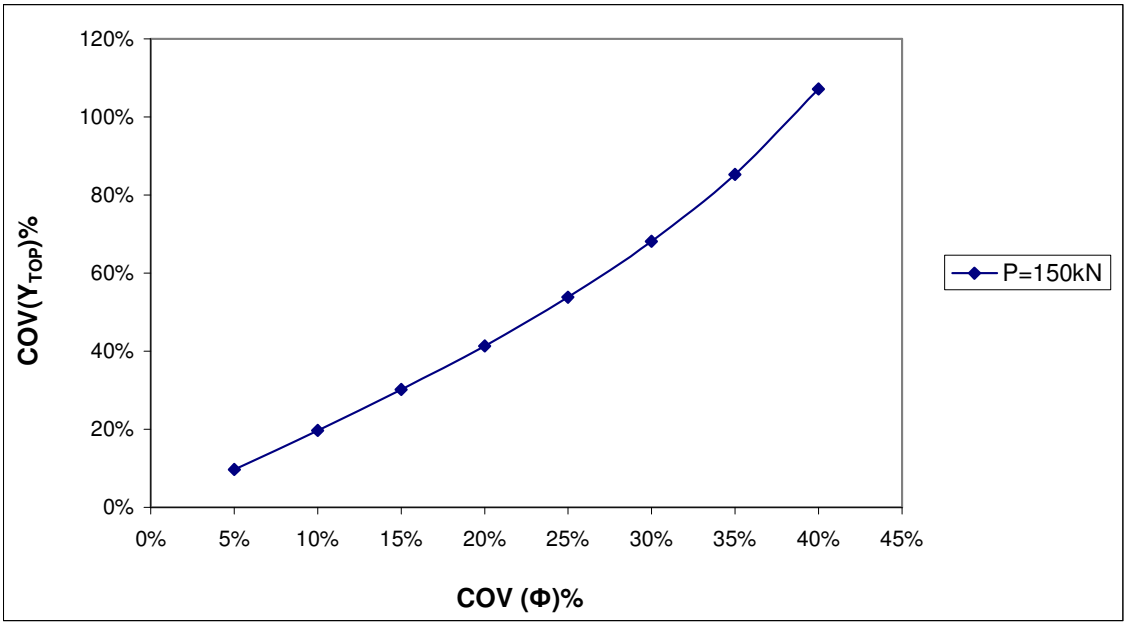


Fig. A.5 Variability of COV (Y_{TOP}) vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 150kN.

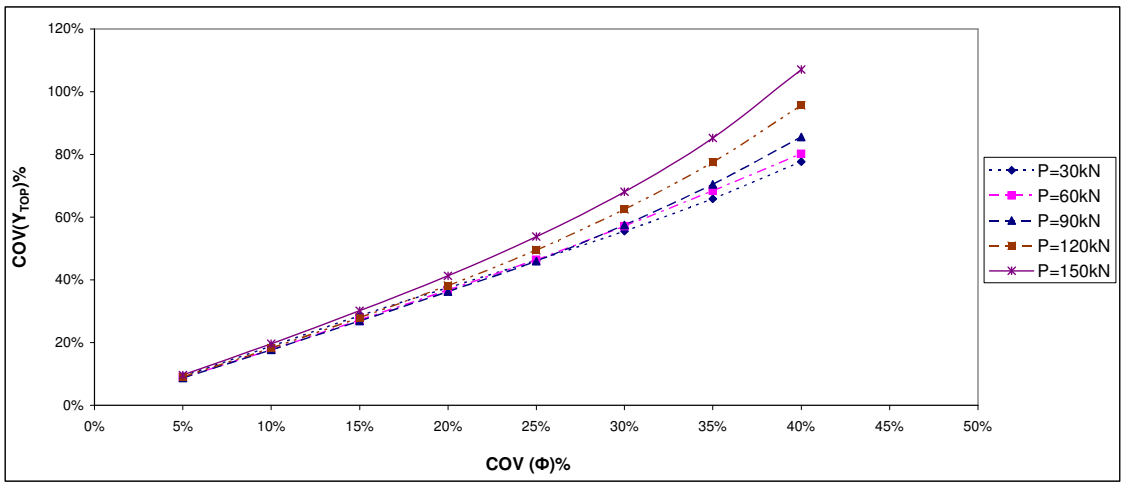


Fig. A.6 Variability of COV (Y_{TOP}) vs. COV (Φ) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.11 Probabilistic modeling of laterally loaded free head long pile 10T with varying (γ) and load 30kN.

P=30kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^o (m)	COV(Y_{TOP}) (%)
		11.025	3.97E-03				
5%	10.5			2.76E-01	6.40E-07	4.13E-03	3.77%
		9.975	4.31E-03				
		11.55	3.82E-03				
10%	10.5			1.10E+00	2.56E-06	4.13E-03	7.55%
		9.45	4.51E-03				
		12.075	3.69E-03				
15%	10.5			2.48E+00	6.00E-06	4.13E-03	11.56%
		8.925	4.73E-03				
		12.6	3.56E-03				
20%	10.5			4.41E+00	1.06E-05	4.13E-03	15.33%
		8.4	4.97E-03				
		13.125	3.44E-03				
25%	10.5			6.89E+00	1.72E-05	4.13E-03	19.58%
		7.875	5.24E-03				
		13.65	3.33E-03				
30%	10.5			9.92E+00	2.60E-05	4.13E-03	24.06%
		7.35	5.58E-03				
		14.175	3.23E-03				
35%	10.5			1.35E+01	3.78E-05	4.13E-03	29.01%
		6.825	5.93E-03				
		14.7	3.14E-03				
40%	10.5			1.76E+01	5.18E-05	4.13E-03	33.96%
		6.3	6.33E-03				

Table A.12 Probabilistic modeling of laterally loaded free head long pile 10T with varying (γ) and load 60kN.

P=60kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^o (m)	COV(Y_{TOP}) (%)
		11.025	1.14E-02				
5%	10.5			2.76E-01	2.03E-07	7.40E-03	3.81%
		9.975	1.23E-02				
		11.55	1.10E-02				
10%	10.5			1.10E+00	8.10E-07	7.40E-03	7.63%
		9.45	1.28E-02				
		12.075	1.06E-02				
15%	10.5			2.48E+00	1.96E-06	7.40E-03	11.86%
		8.925	1.34E-02				
		12.6	1.03E-02				
20%	10.5			4.41E+00	3.42E-06	7.40E-03	15.88%
		8.4	1.40E-02				
		13.125	9.95E-03				
25%	10.5			6.89E+00	5.88E-06	7.40E-03	20.55%
		7.875	1.48E-02				
		13.65	9.66E-03				
30%	10.5			9.92E+00	8.82E-06	7.40E-03	25.17%
		7.35	1.56E-02				
		14.175	9.38E-03				
35%	10.5			1.35E+01	1.23E-05	7.40E-03	29.75%
		6.825	1.64E-02				
		14.7	9.11E-03				
40%	10.5			1.76E+01	1.72E-05	7.40E-03	35.13%
		6.3	1.74E-02				

Table A.13 Probabilistic modeling of laterally loaded free head long pile 10T with varying (γ) and load 90kN.

P=90kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^{o} (m)	COV(Y_{TOP}) (%)
		11.025	2.05E-02				
5%	10.5			2.76E-01	1.56E-06	1.63E-02	3.87%
		9.975	2.21E-02				
		11.55	1.98E-02				
10%	10.5			1.10E+00	6.25E-06	1.63E-02	7.74%
		9.45	2.30E-02				
		12.075	1.91E-02				
15%	10.5			2.48E+00	1.44E-05	1.63E-02	11.76%
		8.925	2.40E-02				
		12.6	1.86E-02				
20%	10.5			4.41E+00	2.65E-05	1.63E-02	15.94%
		8.4	2.51E-02				
		13.125	1.80E-02				
25%	10.5			6.89E+00	4.29E-05	1.63E-02	20.28%
		7.875	2.63E-02				
		13.65	1.75E-02				
30%	10.5			9.92E+00	6.56E-05	1.63E-02	25.08%
		7.35	2.77E-02				
		14.175	1.70E-02				
35%	10.5			1.35E+01	9.60E-05	1.63E-02	30.34%
		6.825	2.93E-02				
		14.7	1.66E-02				
40%	10.5			1.76E+01	1.38E-04	1.63E-02	36.38%
		6.3	3.10E-02				

Table A.14 Probabilistic modeling of laterally loaded free head long pile 10T with varying (γ') and load 120kN.

P=120kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^{o} (m)	COV(Y_{TOP}) (%)
		11.025	3.11E-02				
5%	10.5			2.76E-01	2.89E-08	3.23E-02	4.12%
		9.975	3.36E-02				
		11.55	3.00E-02				
10%	10.5			1.10E+00	1.19E-07	3.23E-02	8.35%
		9.45	3.50E-02				
		12.075	2.90E-02				
15%	10.5			2.48E+00	2.70E-07	3.23E-02	12.59%
		8.925	3.66E-02				
		12.6	2.81E-02				
20%	10.5			4.41E+00	4.97E-07	3.23E-02	17.07%
		8.4	3.84E-02				
		13.125	2.73E-02				
25%	10.5			6.89E+00	8.10E-07	3.23E-02	21.79%
		7.875	4.04E-02				
		13.65	2.65E-02				
30%	10.5			9.92E+00	1.27E-06	3.23E-02	27.24%
		7.35	4.27E-02				
		14.175	2.58E-02				
35%	10.5			1.35E+01	1.82E-06	3.23E-02	32.69%
		6.825	4.54E-02				
		14.7	2.51E-02				
40%	10.5			1.76E+01	2.54E-06	3.23E-02	38.62%
		6.3	4.86E-02				

Table A.15 Probabilistic modeling of laterally loaded free head long pile 10T with varying (γ) and load 150kN.

P=150kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.025	4.38E-02				
5%	10.5			2.76E-01	3.42E-06	4.55E-02	4.07%
		9.975	4.75E-02				
		11.55	4.22E-02				
10%	10.5			1.10E+00	1.37E-05	4.55E-02	8.13%
		9.45	4.96E-02				
		12.075	4.07E-02				
15%	10.5			2.48E+00	3.25E-05	4.55E-02	12.53%
		8.925	5.21E-02				
		12.6	3.93E-02				
20%	10.5			4.41E+00	6.08E-05	4.55E-02	17.14%
		8.4	5.49E-02				
		13.125	3.80E-02				
25%	10.5			6.89E+00	1.00E-04	4.55E-02	21.98%
		7.875	5.80E-02				
		13.65	3.69E-02				
30%	10.5			9.92E+00	1.53E-04	4.55E-02	27.14%
		7.35	6.16E-02				
		14.175	3.59E-02				
35%	10.5			1.35E+01	2.22E-04	4.55E-02	32.75%
		6.825	6.57E-02				
		14.7	3.49E-02				
40%	10.5			1.76E+01	3.17E-04	4.55E-02	39.12%
		6.3	7.05E-02				

Table A.16 Value of COV (Y_{TOP}) for free head long pile with varying COV(γ) and lateral load 30kN.

P=30kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	6.40E-07	3.77%
10%	1.10E+00	2.56E-06	7.55%
15%	2.48E+00	6.00E-06	11.56%
20%	4.41E+00	1.06E-05	15.33%
25%	6.89E+00	1.72E-05	19.58%
30%	9.92E+00	2.60E-05	24.06%
35%	1.35E+01	3.78E-05	29.01%
40%	1.76E+01	5.18E-05	33.96%

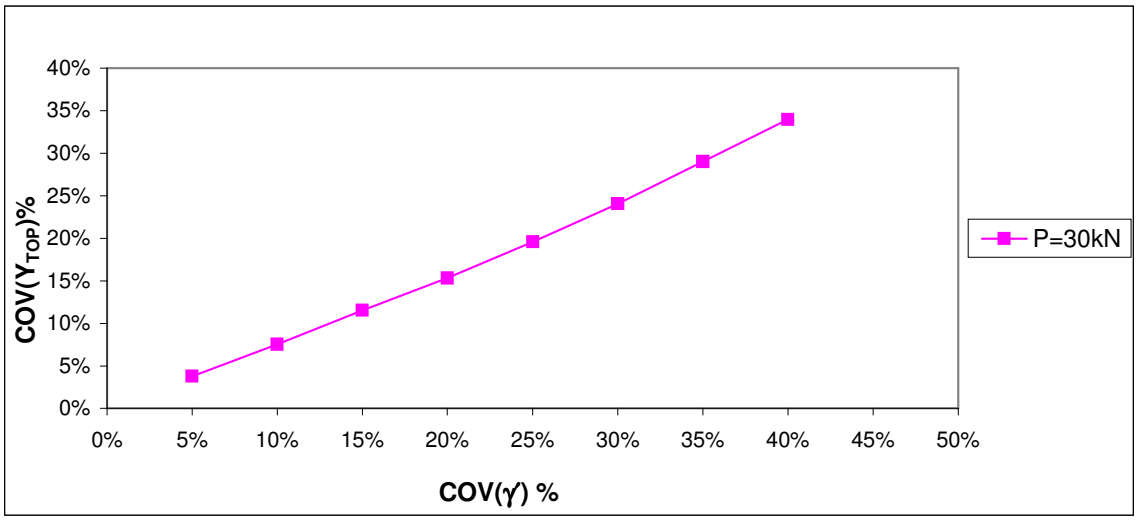


Fig. A.7 Variability of COV (Y_{TOP}) vs. COV (γ) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.17 Value of COV (Y_{TOP}) for free head long pile with varying COV(γ) and lateral load 60kN.

P=60kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	2.03E-07	3.81%
10%	1.10E+00	8.10E-07	7.63%
15%	2.48E+00	1.96E-06	11.86%
20%	4.41E+00	3.42E-06	15.88%
25%	6.89E+00	5.88E-06	20.55%
30%	9.92E+00	8.82E-06	25.17%
35%	1.35E+01	1.23E-05	29.75%
40%	1.76E+01	1.72E-05	35.13%

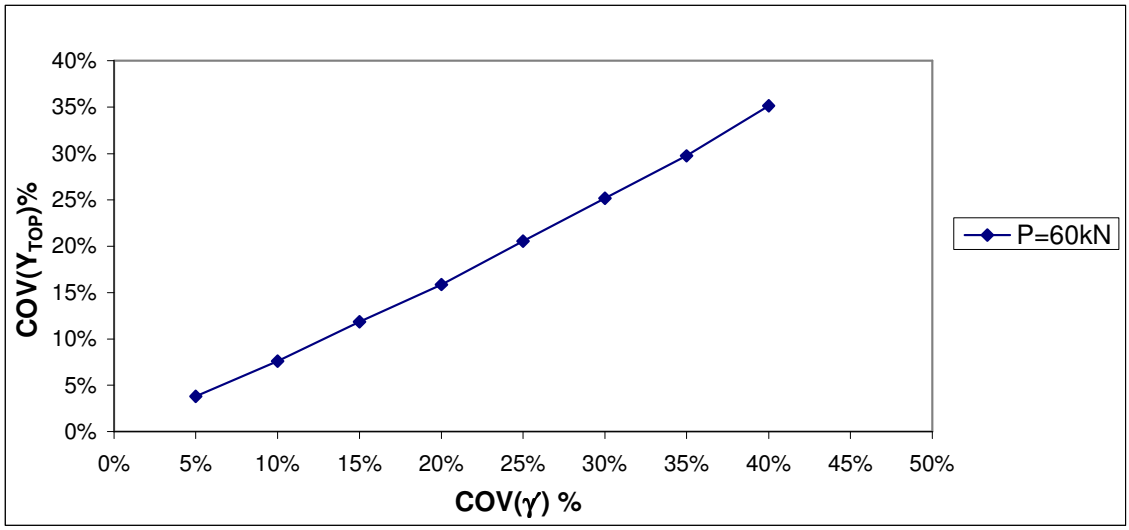


Fig. A.8 Variability of COV (Y_{TOP}) vs. COV (γ) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.18 Value of COV(Y_{TOP}) for free head long pile with varying COV(γ) and lateral load 90kN.

P=90kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	1.56E-06	3.87%
10%	1.10E+00	6.25E-06	7.74%
15%	2.48E+00	1.44E-05	11.76%
20%	4.41E+00	2.65E-05	15.94%
25%	6.89E+00	4.29E-05	20.28%
30%	9.92E+00	6.56E-05	25.08%
35%	1.35E+01	9.60E-05	30.34%
40%	1.76E+01	1.38E-04	36.38%

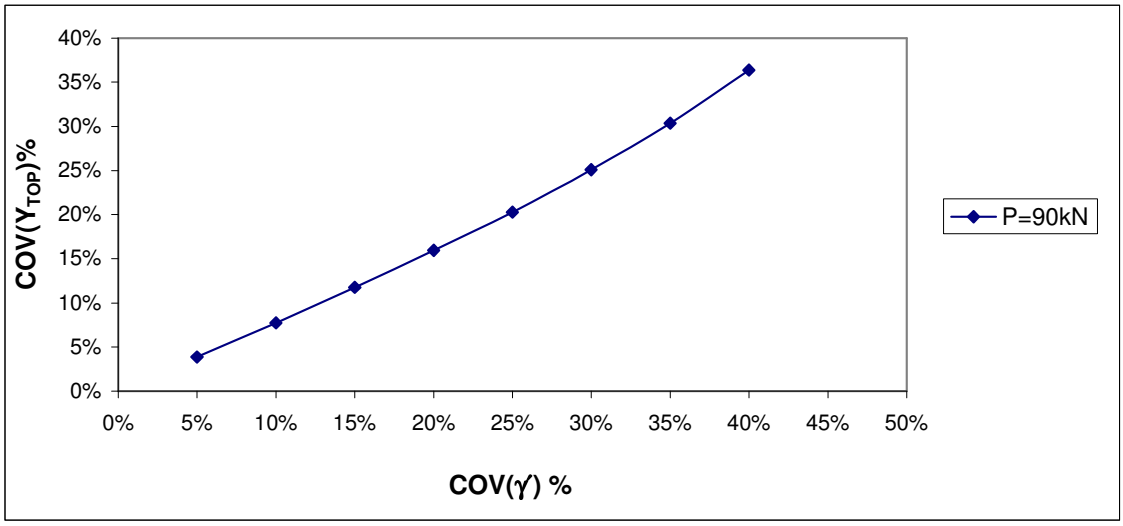


Fig. A.9 Variability of COV (Y_{TOP}) vs. COV (γ) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.19 Value of COV(Y_{TOP}) for free head long pile with varying COV(γ) and lateral load 120kN.

P=120kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	2.89E-08	4.12%
10%	1.10E+00	1.19E-07	8.35%
15%	2.48E+00	2.70E-07	12.59%
20%	4.41E+00	4.97E-07	17.07%
25%	6.89E+00	8.10E-07	21.79%
30%	9.92E+00	1.27E-06	27.24%
35%	1.35E+01	1.82E-06	32.69%
40%	1.76E+01	2.54E-06	38.62%

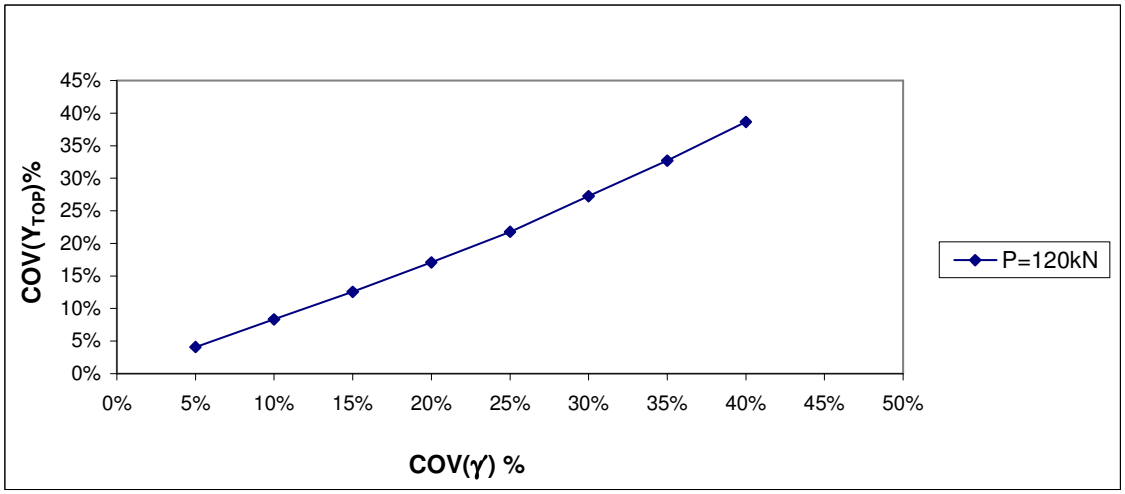


Fig. A.10 Variability of COV (Y_{TOP}) vs. COV (γ) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.20 Value of COV(Y_{TOP}) for free head long pile with varying COV(γ) and lateral load 150kN.

P=150kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	3.42E-06	4.07%
10%	1.10E+00	1.37E-05	8.13%
15%	2.48E+00	3.25E-05	12.53%
20%	4.41E+00	6.08E-05	17.14%
25%	6.89E+00	1.00E-04	21.98%
30%	9.92E+00	1.53E-04	27.14%
35%	1.35E+01	2.22E-04	32.75%
40%	1.76E+01	3.17E-04	39.12%

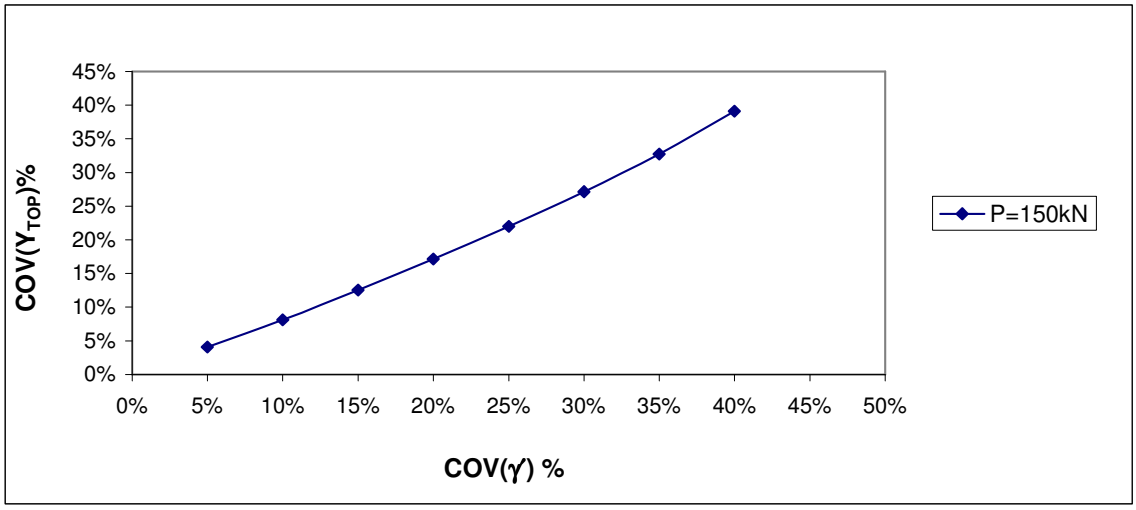


Fig. A.11 Variability of COV(Y_{TOP}) vs. COV(γ) for single free head long pile (10T) subjected to lateral force 150kN.

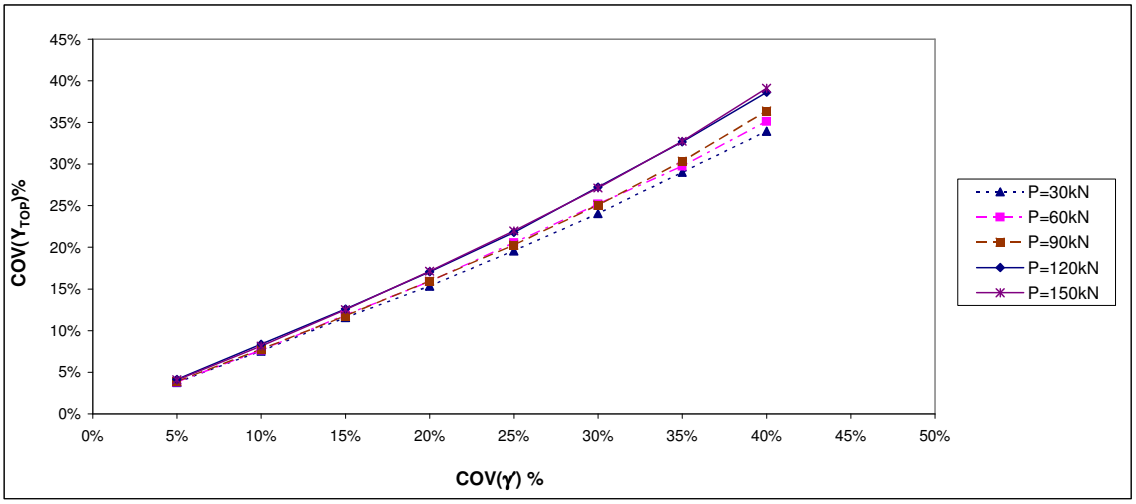


Fig. A.12 Variability of COV(Y_{TOP}) vs. COV(γ) for single free head long pile (10T) subjected to lateral force of discrete variability .

Table A.21 Probabilistic modeling of laterally loaded free head long pile 10T with varying (k) and load 30kN.

P=30kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	4.12E-03				
5%	16300			6.64E+05	1.00E-08	4.13E-03	2.42%
		15485	4.16E-03				
		17930	4.10E-03				
10%	16300			2.66E+06	4.00E-08	4.13E-03	4.84%
		14670	4.18E-03				
		18745	4.08E-03				
15%	16300			5.98E+06	8.50E-08	4.13E-03	7.06%
		13855	4.20E-03				
		19560	4.08E-03				
20%	16300			1.06E+07	9.00E-08	4.13E-03	1.99%
		13040	4.23E-03				
		20375	4.06E-03				
25%	16300			1.66E+07	1.60E-07	4.13E-03	9.69%
		12225	4.27E-03				
		21190	4.06E-03				
30%	16300			2.39E+07	1.82E-07	4.13E-03	10.34%
		11410	4.31E-03				
		22005	4.05E-03				
35%	16300			3.25E+07	2.50E-07	4.13E-03	12.11%
		10595	4.36E-03				
		22820	4.04E-03				
40%	16300			4.25E+07	3.60E-07	4.13E-03	14.53%
		9780	4.42E-03				

Table A.22 Probabilistic modeling of laterally loaded free head long pile 10T with varying (k) and load 60kN.

P=60kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	1.18E-02				
5%	16300			6.64E+05	2.50E-09	7.40E-03	0.30%
		15485	1.19E-02				
		17930	1.18E-02				
10%	16300			2.66E+06	2.60E-09	7.40E-03	0.57%
		14670	1.19E-02				
		18745	1.18E-02				
15%	16300			5.98E+06	2.00E-08	7.40E-03	0.84%
		13855	1.19E-02				
		19560	1.17E-02				
20%	16300			1.06E+07	2.25E-08	7.40E-03	1.13%
		13040	1.20E-02				
		20375	1.17E-02				
25%	16300			1.66E+07	3.65E-08	7.40E-03	1.43%
		12225	1.20E-02				
		21190	1.17E-02				
30%	16300			2.39E+07	4.00E-08	7.40E-03	1.73%
		11410	1.21E-02				
		22005	1.17E-02				
35%	16300			3.25E+07	6.25E-08	7.40E-03	3.38%
		10595	1.22E-02				
		22820	1.17E-02				
40%	16300			4.25E+07	9.00E-08	7.40E-03	4.05%
		9780	1.23E-02				

Table A.23 Probabilistic modeling of laterally loaded free head long pile 10T with varying (k) and load 90kN.

P=90kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	2.12E-02				
5%	16300			6.64E+05	2.50E-09	1.63E-02	0.08%
		15485	2.13E-02				
		17930	2.12E-02				
10%	16300			2.66E+06	2.57E-09	1.63E-02	0.31%
		14670	2.13E-02				
		18745	2.11E-02				
15%	16300			5.98E+06	1.86E-08	1.63E-02	0.47%
		13855	2.14E-02				
		19560	2.11E-02				
20%	16300			1.06E+07	2.20E-08	1.63E-02	0.71%
		13040	2.14E-02				
		20375	2.11E-02				
25%	16300			1.66E+07	3.23E-08	1.63E-02	0.94%
		12225	2.15E-02				
		21190	2.11E-02				
30%	16300			2.39E+07	3.97E-08	1.63E-02	1.18%
		11410	2.16E-02				
		22005	2.11E-02				
35%	16300			3.25E+07	6.21E-08	1.63E-02	1.56%
		10595	2.16E-02				
		22820	2.11E-02				
40%	16300			4.25E+07	8.69E-08	1.63E-02	2.01%
		9780	2.17E-02				

Table A.24 Probabilistic modeling of laterally loaded free head long pile 10T with varying (k) and load 120kN.

P=120kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	3.22E-02				
5%	16300	815		6.64E+05	2.42E-09	3.23E-02	0.13%
		15485	3.23E-02				
		17930	3.22E-02				
10%	16300			2.66E+06	2.69E-09	3.23E-02	0.21%
		14670	3.24E-02				
		18745	3.22E-02				
15%	16300			5.98E+06	1.00E-08	3.23E-02	0.31%
		13855	3.24E-02				
		19560	3.22E-02				
20%	16300			1.06E+07	1.56E-08	3.23E-02	0.46%
		13040	3.25E-02				
		20375	3.21E-02				
25%	16300			1.66E+07	3.00E-08	3.23E-02	0.65%
		12225	3.26E-02				
		21190	3.21E-02				
30%	16300			2.39E+07	3.67E-08	3.23E-02	0.86%
		11410	3.27E-02				
		22005	3.21E-02				
35%	16300			3.25E+07	6.14E-08	3.23E-02	1.08%
		10595	3.28E-02				
		22820	3.20E-02				
40%	16300			4.25E+07	7.79E-08	3.23E-02	1.39%
		9780	3.29E-02				

Table A.25 Probabilistic modeling of laterally loaded free head long pile 10T with varying (k) and load 150kN.

P=150kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	4.54E-02				
5%	16300			6.64E+05	1.00E-09	4.55E-02	0.04%
		15485	4.56E-02				
		17930	4.53E-02				
10%	16300			2.66E+06	1.60E-09	4.55E-02	0.16%
		14670	4.57E-02				
		18745	4.52E-02				
15%	16300			5.98E+06	2.70E-09	4.55E-02	0.30%
		13855	4.58E-02				
		19560	4.53E-02				
20%	16300			1.06E+07	5.63E-09	4.55E-02	0.45%
		13040	4.59E-02				
		20375	4.52E-02				
25%	16300			1.66E+07	1.10E-08	4.55E-02	0.65%
		12225	4.60E-02				
		21190	4.53E-02				
30%	16300			2.39E+07	1.56E-08	4.55E-02	0.88%
		11410	4.61E-02				
		22005	4.52E-02				
35%	16300			3.25E+07	2.40E-08	4.55E-02	1.10%
		10595	4.62E-02				
		22820	4.52E-02				
40%	16300			4.25E+07	3.61E-08	4.55E-02	1.36%
		9780	4.64E-02				

Table A.26 Value of COV(Y_{TOP}) for free head long pile with varying COV(k) and lateral load 30kN.

P=30kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	1.00E-08	0.48%
10%	2.66E+06	4.00E-08	0.97%
15%	5.98E+06	8.50E-08	1.45%
20%	1.06E+07	9.00E-08	1.99%
25%	1.66E+07	1.60E-07	2.54%
30%	2.39E+07	1.82E-07	3.03%
35%	3.25E+07	2.50E-07	3.75%
40%	4.25E+07	3.60E-07	4.60%

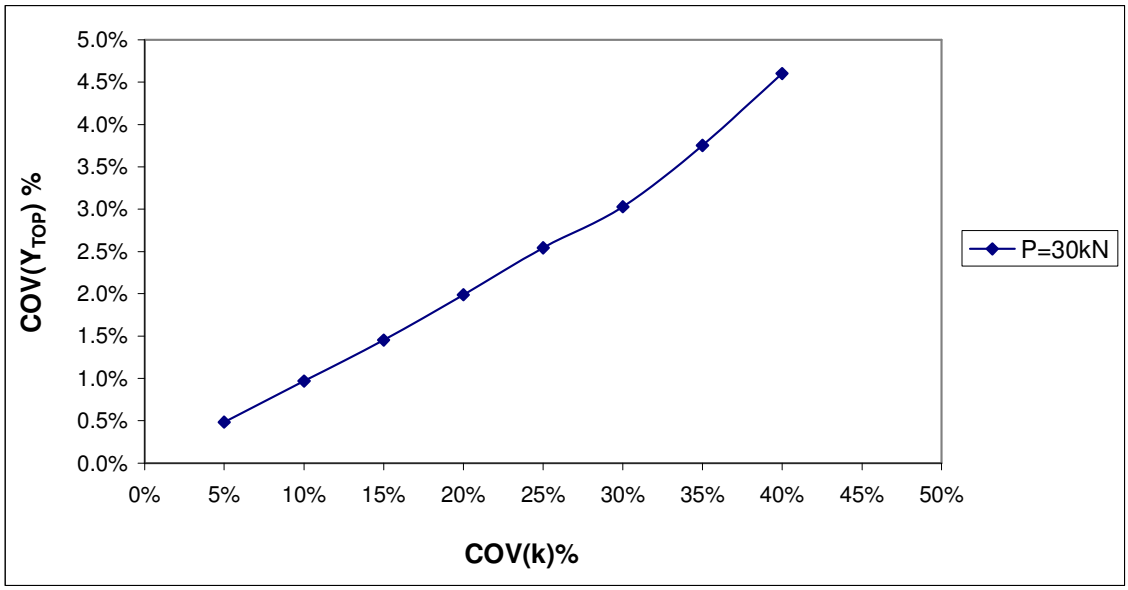


Fig. A.13 Variability of COV(Y_{TOP}) vs. COV(k) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.27 Value of COV (Y_{TOP}) for free head long pile with varying COV(k) and lateral load 60kN.

P=60kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	2.50E-09	0.30%
10%	2.66E+06	2.60E-09	0.57%
15%	5.98E+06	2.00E-08	0.84%
20%	1.06E+07	2.25E-08	1.13%
25%	1.66E+07	3.65E-08	1.43%
30%	2.39E+07	4.00E-08	1.73%
35%	3.25E+07	6.25E-08	2.12%
40%	4.25E+07	9.00E-08	2.54%

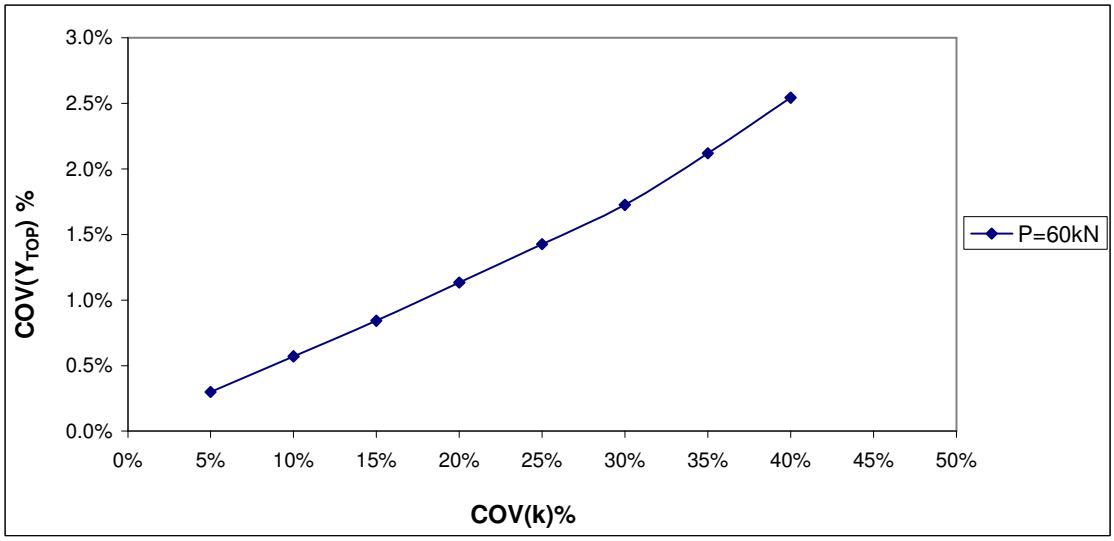


Fig. A.14 Variability of COV (Y_{TOP}) vs. COV (k) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.28 Value of COV(Y_{TOP}) for free head long pile with varying COV(k) and lateral load 90kN.

P=90kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	2.50E-09	0.08%
10%	2.66E+06	2.57E-09	0.24%
15%	5.98E+06	1.86E-08	0.47%
20%	1.06E+07	2.20E-08	0.71%
25%	1.66E+07	3.23E-08	0.94%
30%	2.39E+07	3.97E-08	1.18%
35%	3.25E+07	6.21E-08	1.56%
40%	4.25E+07	8.69E-08	2.01%

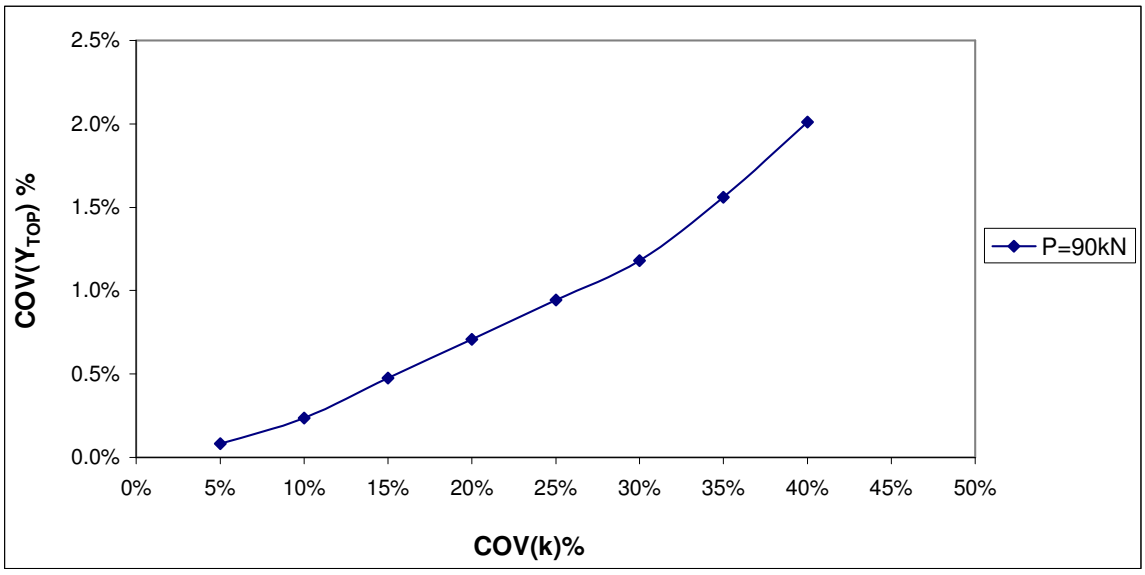


Fig. A.15 Variability of COV(Y_{TOP}) vs. COV(k) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.29 Value of COV(Y_{TOP}) for free head long pile with varying COV(k) and lateral load 120kN.

P=120kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	2.42E-09	0.13%
10%	2.66E+06	2.69E-09	0.21%
15%	5.98E+06	1.00E-08	0.31%
20%	1.06E+07	1.56E-08	0.46%
25%	1.66E+07	3.00E-08	0.65%
30%	2.39E+07	3.67E-08	0.86%
35%	3.25E+07	6.14E-08	1.08%
40%	4.25E+07	7.79E-08	1.39%

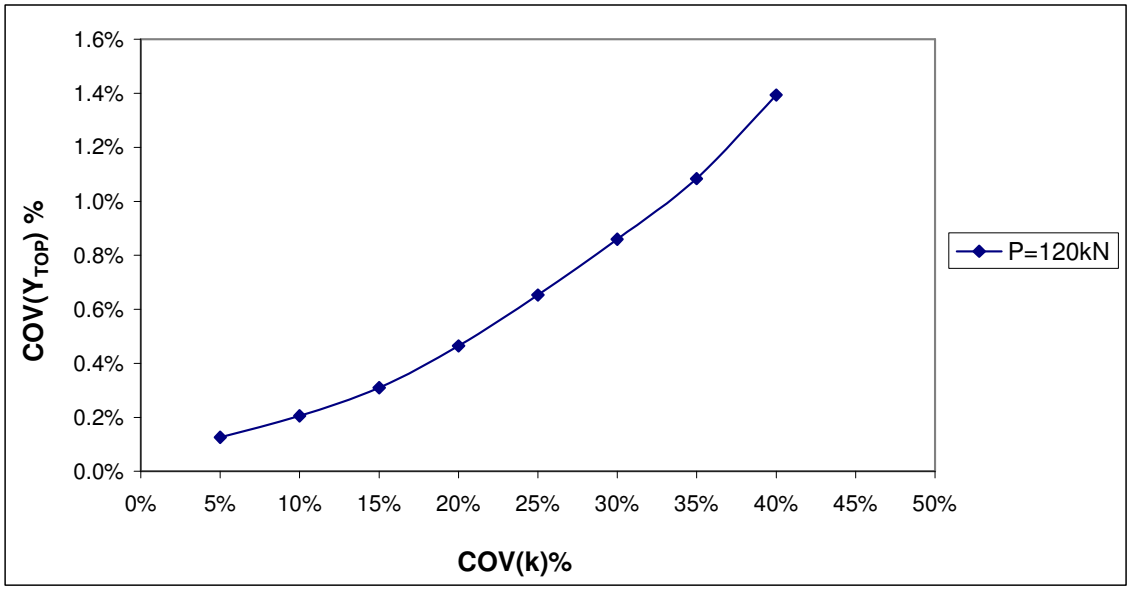


Fig. A.16 Variability of COV (Y_{TOP}) vs. COV (k) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.30 Value of COV(Y_{TOP}) for free head long pile with varying COV(k) and lateral load 150kN.

P=150kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	1.00E-09	0.04%
10%	2.66E+06	1.60E-09	0.16%
15%	5.98E+06	2.70E-09	0.30%
20%	1.06E+07	5.63E-09	0.45%
25%	1.66E+07	1.10E-08	0.65%
30%	2.39E+07	1.56E-08	0.88%
35%	3.25E+07	2.40E-08	1.10%
40%	4.25E+07	3.61E-08	1.36%

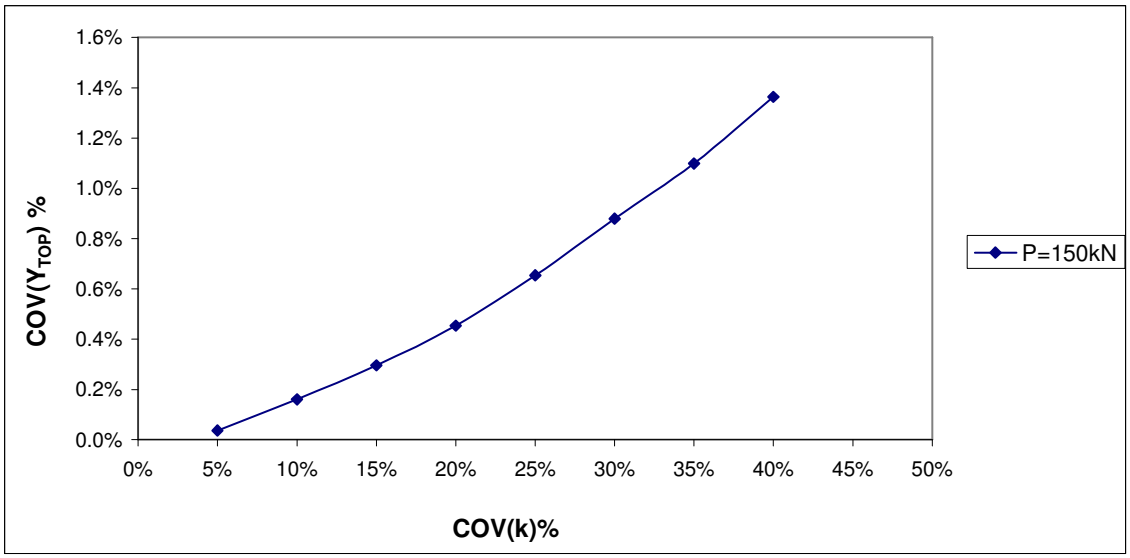


Fig. A.17 Variability of COV (Y_{TOP}) vs. COV (k) for single free head long pile (10T) subjected to lateral force 150kN.

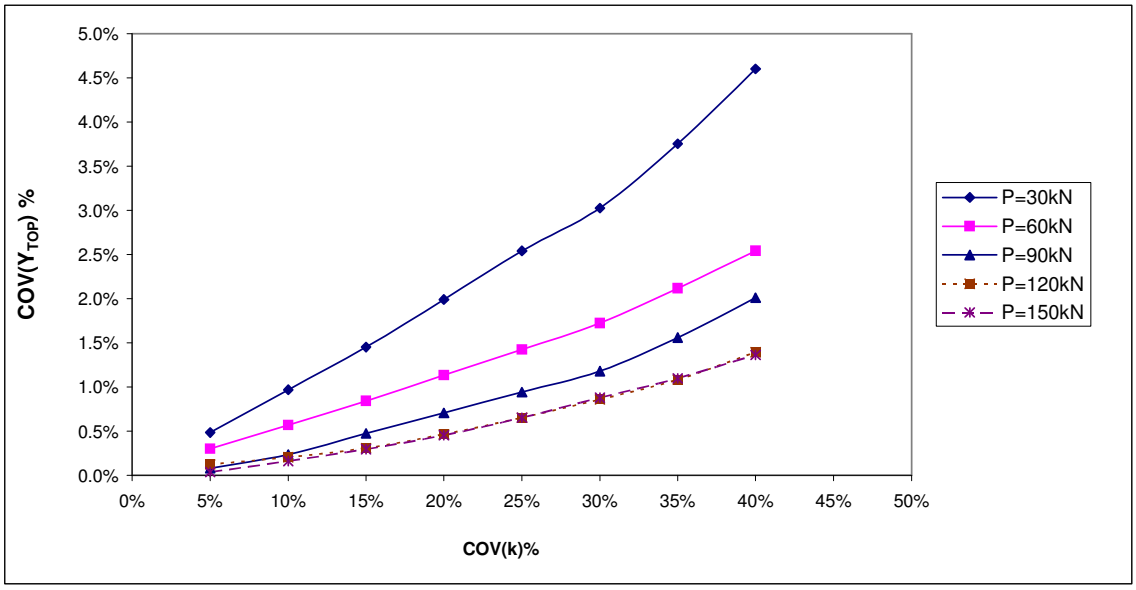


Fig. A.18 Variability of COV (Y_{TOP}) vs. COV (k) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.31 Probabilistic modeling of laterally loaded free head long pile 10T with varying (B) and load 30kN.

P=30kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}^o (m)	COV(Y_{TOP}) (%)
		0.4263	4.05E-03				
5%	0.406			4.12E-04	2.50E-09	4.13E-03	0.09%
		0.3857	4.23E-03				
		0.4466	3.93E-03				
10%	0.406			1.65E-03	1.00E-08	4.13E-03	0.34%
		0.3654	4.38E-03				
		0.4669	3.81E-03				
15%	0.406			3.71E-03	1.96E-09	4.13E-03	0.54%
		0.3451	4.43E-03				
		0.4872	3.69E-03				
20%	0.406			6.59E-03	2.25E-08	4.13E-03	0.76%
		0.3248	4.48E-03				
		0.5075	3.58E-03				
25%	0.406			1.03E-02	4.00E-08	4.13E-03	1.00%
		0.3045	4.55E-03				
		0.5278	3.47E-03				
30%	0.406			1.48E-02	9.00E-08	4.13E-03	1.25%
		0.2842	4.57E-03				
		0.5472	3.41E-03				
35%	0.406			2.02E-02	1.62E-07	4.13E-03	1.41%
		0.2648	4.59E-03				
		0.5684	3.37E-03				
40%	0.406			2.64E-02	1.60E-07	4.13E-03	1.48%
		0.2436	4.60E-03				

Table A.32 Probabilistic modeling of laterally loaded free head long pile 10T with varying (B) and load 60kN.

P=60kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}^o (m)	COV(Y_{TOP}) (%)
		0.4263	1.17E-02				
5%	0.406			4.12E-04	1.00E-08	7.40E-03	0.16%
		0.3857	1.19E-02				
		0.4466	1.16E-02				
10%	0.406			1.65E-03	2.25E-08	7.40E-03	0.46%
		0.3654	1.20E-02				
		0.4669	1.14E-02				
15%	0.406			3.71E-03	4.00E-08	7.40E-03	0.70%
		0.3451	1.20E-02				
		0.4872	1.13E-02				
20%	0.406			6.59E-03	1.23E-07	7.40E-03	0.93%
		0.3248	1.20E-02				
		0.5075	1.11E-02				
25%	0.406			1.03E-02	2.03E-07	7.40E-03	1.15%
		0.3045	1.20E-02				
		0.5278	1.09E-02				
30%	0.406			1.48E-02	2.50E-07	7.40E-03	1.39%
		0.2842	1.19E-02				
		0.5472	1.07E-02				
35%	0.406			2.02E-02	4.28E-07	7.40E-03	1.65%
		0.2648	1.18E-02				
		0.5684	1.04E-02				
40%	0.406			2.64E-02	7.23E-07	7.40E-03	1.87%
		0.2436	1.17E-02				

Table A.33 Probabilistic modeling of laterally loaded free head long pile 10T with varying (B) and load 90kN.

P=90kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}^o (m)	COV(Y_{TOP}) (%)
		0.4263	2.10E-02				
5%	0.406			4.12E-04	1.00E-08	1.63E-02	0.33%
		0.3857	2.12E-02				
		0.4466	2.10E-02				
10%	0.406			1.65E-03	1.56E-08	1.63E-02	0.75%
		0.3654	2.13E-02				
		0.4669	2.10E-02				
15%	0.406			3.71E-03	2.25E-08	1.63E-02	1.16%
		0.3451	2.13E-02				
		0.4872	2.09E-02				
20%	0.406			6.59E-03	4.00E-08	1.63E-02	1.60%
		0.3248	2.13E-02				
		0.5075	2.08E-02				
25%	0.406			1.03E-02	6.25E-08	1.63E-02	1.96%
		0.3045	2.13E-02				
		0.5278	2.06E-02				
30%	0.406			1.48E-02	1.23E-07	1.63E-02	2.32%
		0.2842	2.13E-02				
		0.5472	2.04E-02				
35%	0.406			2.02E-02	2.53E-07	1.63E-02	2.64%
		0.2648	2.14E-02				
		0.5684	2.01E-02				
40%	0.406			2.64E-02	4.23E-07	1.63E-02	2.90%
		0.2436	2.14E-02				

Table A.34 Probabilistic modeling of laterally loaded free head long pile 10T with varying (B) and load 120kN.

P=120kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}^o (m)	COV(Y_{TOP}) (%)
		0.4263	0.0322				
5%	0.406			4.12E-04	1.00E-08	3.23E-02	0.85%
		0.3857	0.0323				
		0.4466	0.0322				
10%	0.406			1.65E-03	4.00E-08	3.23E-02	1.69%
		0.3654	0.0324				
		0.4669	0.0322				
15%	0.406			3.71E-03	9.00E-08	3.23E-02	2.54%
		0.3451	0.0324				
		0.4872	0.0321				
20%	0.406			6.59E-03	1.23E-07	3.23E-02	2.97%
		0.3248	0.0324				
		0.5075	0.032				
25%	0.406			1.03E-02	2.03E-07	3.23E-02	3.81%
		0.3045	0.0324				
		0.5278	0.0318				
30%	0.406			1.48E-02	2.50E-07	3.23E-02	4.24%
		0.2842	0.0324				
		0.5472	0.0317				
35%	0.406			2.02E-02	3.06E-07	3.23E-02	4.69%
		0.2648	0.0325				
		0.5684	0.0317				
40%	0.406			2.64E-02	4.23E-07	3.23E-02	5.51%
		0.2436	0.0325				

Table A.35 Probabilistic modeling of laterally loaded free head long pile 10T with varying (B) and load 150kN.

P150=kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	4.54E-02				
5%	0.406			4.12E-04	8.10E-09	4.55E-02	1.18%
		0.3857	4.56E-02				
		0.4466	4.53E-02				
10%	0.406			1.65E-03	5.06E-08	4.55E-02	4.87%
		0.3654	4.56E-02				
		0.4669	4.52E-02				
15%	0.406			3.71E-03	9.61E-08	4.55E-02	0.68%
		0.3451	4.56E-02				
		0.4872	4.51E-02				
20%	0.406			6.59E-03	1.56E-07	4.55E-02	9.87%
		0.3248	4.58E-02				
		0.5075	4.50E-02				
25%	0.406			1.03E-02	2.35E-07	4.55E-02	1.07%
		0.3045	4.59E-02				
		0.5278	4.49E-02				
30%	0.406			1.48E-02	3.03E-07	4.55E-02	1.21%
		0.2842	4.59E-02				
		0.5472	4.47E-02				
35%	0.406			2.02E-02	3.53E-07	4.55E-02	1.30%
		0.2648	4.60E-02				
		0.5684	4.45E-02				
40%	0.406			2.64E-02	3.78E-07	4.55E-02	14.99%
		0.2436	4.62E-02				

Table A.36 Value of COV (Y_{TOP}) for free head long pile with varying COV(B) and lateral load 30kN.

P=30kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	2.50E-09	0.09%
10%	1.65E-03	1.00E-08	0.34%
15%	3.71E-03	1.96E-09	0.54%
20%	6.59E-03	2.25E-08	0.76%
25%	1.03E-02	4.00E-08	1.00%
30%	1.48E-02	9.00E-08	1.25%
35%	2.02E-02	1.62E-07	1.41%
40%	2.64E-02	1.60E-07	1.48%

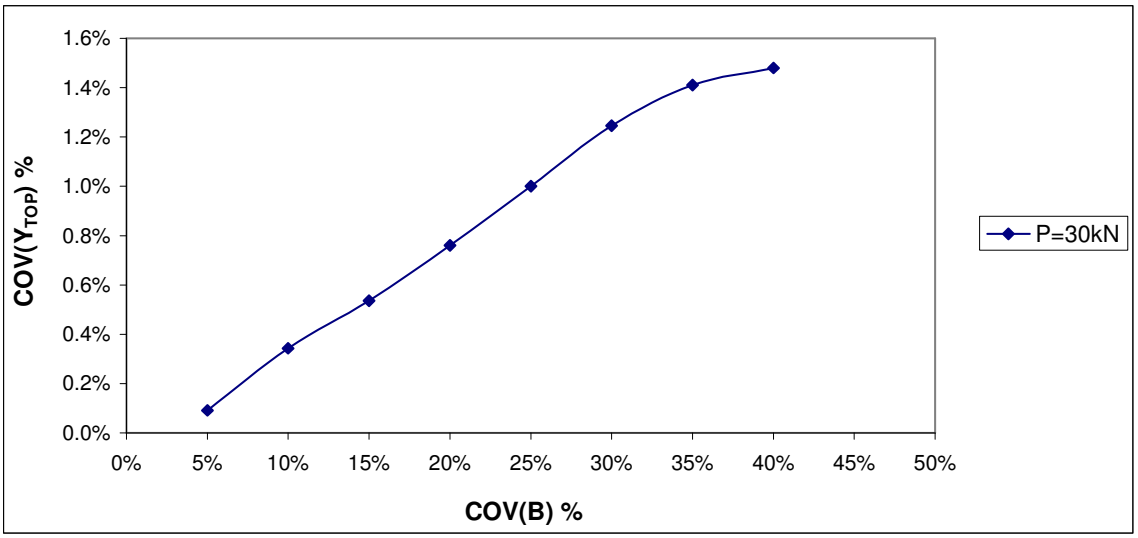


Fig. A.19 Variability of COV(Y_{TOP}) vs. COV(B) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.37 Value of COV(Y_{TOP}) for free head long pile with varying COV(B) and lateral load 60kN.

P=60kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.00E-08	0.16%
10%	1.65E-03	2.25E-08	0.46%
15%	3.71E-03	4.00E-08	0.70%
20%	6.59E-03	1.23E-07	0.93%
25%	1.03E-02	2.03E-07	1.15%
30%	1.48E-02	2.50E-07	1.39%
35%	2.02E-02	4.28E-07	1.65%
40%	2.64E-02	7.23E-07	1.87%

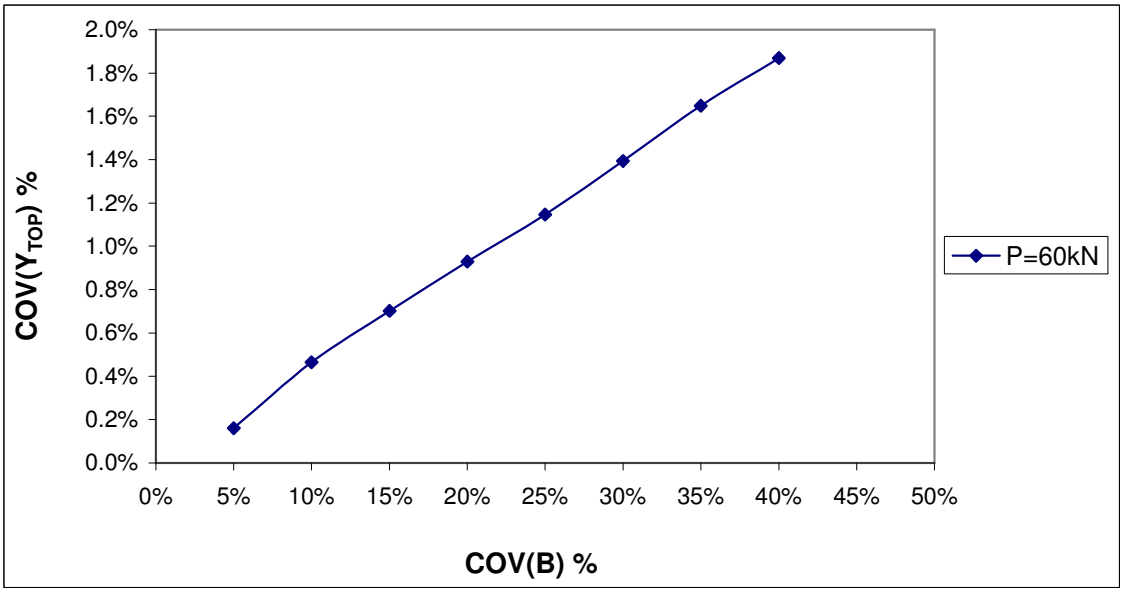


Fig. A.20 Variability of COV (Y_{TOP}) vs. COV(B) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.38 Value of COV(Y_{TOP}) for free head long pile with varying COV(B) and lateral load 90kN.

P=90kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.00E-08	0.33%
10%	1.65E-03	1.56E-08	0.75%
15%	3.71E-03	2.25E-08	1.16%
20%	6.59E-03	4.00E-08	1.60%
25%	1.03E-02	6.25E-08	1.96%
30%	1.48E-02	1.23E-07	2.32%
35%	2.02E-02	2.53E-07	2.64%
40%	2.64E-02	4.23E-07	2.90%

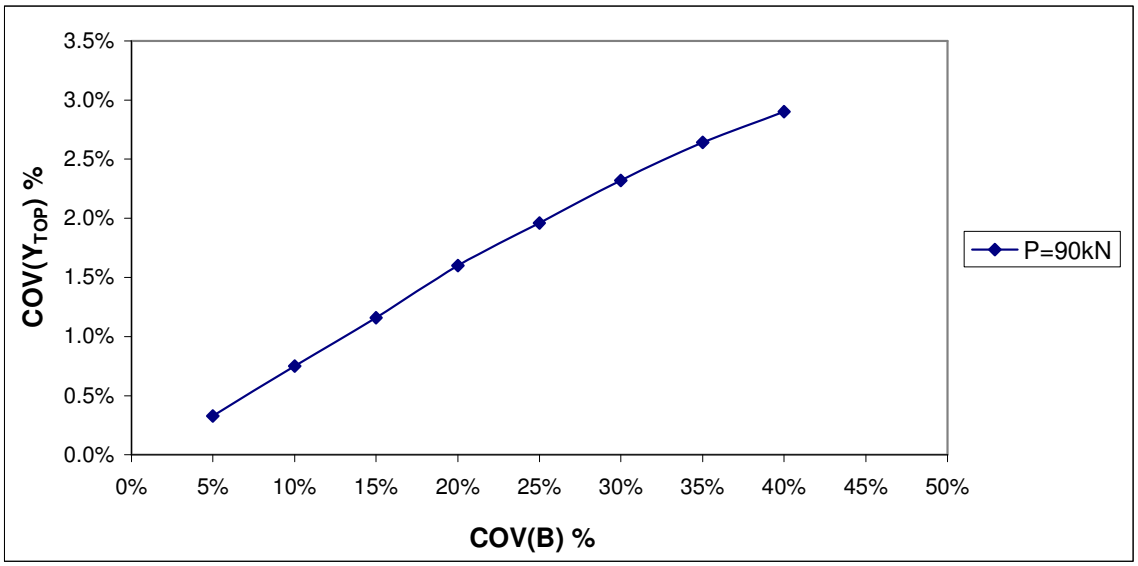


Fig. A.21 Variability of COV (Y_{TOP}) vs. COV(B) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.39 Value of COV(Y_{TOP}) for free head long pile with varying COV(B) and lateral load 120kN.

P=120kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.00E-08	0.85%
10%	1.65E-03	4.00E-08	1.69%
15%	3.71E-03	9.00E-08	2.54%
20%	6.59E-03	1.23E-07	3.16%
25%	1.03E-02	2.03E-07	3.81%
30%	1.48E-02	2.50E-07	4.40%
35%	2.02E-02	3.06E-07	4.98%
40%	2.64E-02	4.23E-07	5.51%

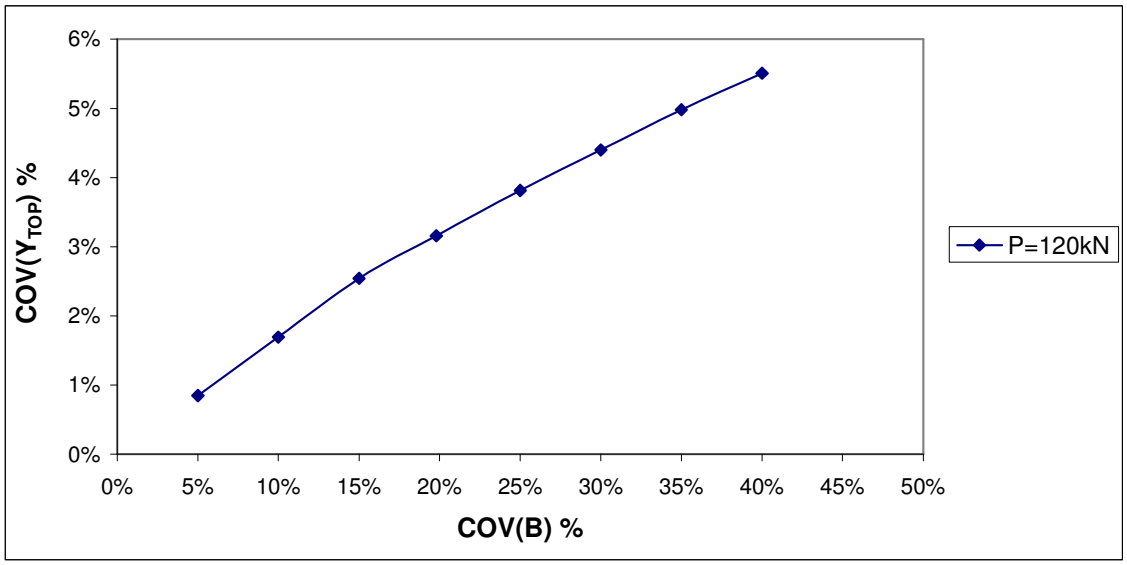


Fig. A.22 Variability of COV (Y_{TOP}) vs. COV (B) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.40 Value of COV (Y_{TOP}) for free head long pile with varying COV(B) and lateral load 150kN.

P=150kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	8.10E-09	1.18%
10%	1.65E-03	5.06E-08	4.87%
15%	3.71E-03	9.61E-08	7.51%
20%	6.59E-03	1.56E-07	9.87%
25%	1.03E-02	2.35E-07	11.74%
30%	1.48E-02	3.03E-07	13.32%
35%	2.02E-02	3.53E-07	14.38%
40%	2.64E-02	3.78E-07	14.99%

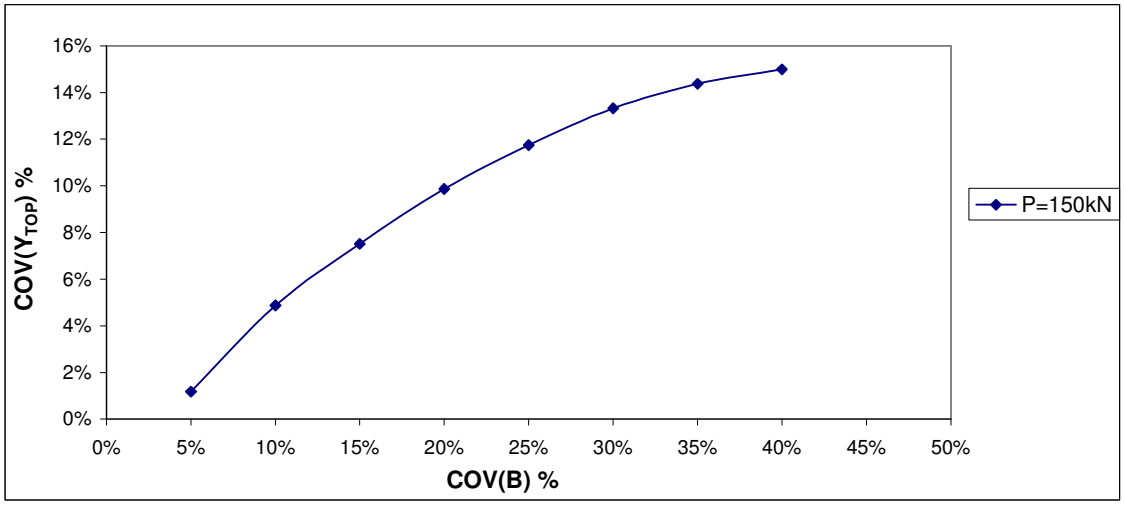


Fig. A.23 Variability of COV (Y_{TOP}) vs. COV (B) for single free head long pile (10T) subjected to lateral force 150kN.

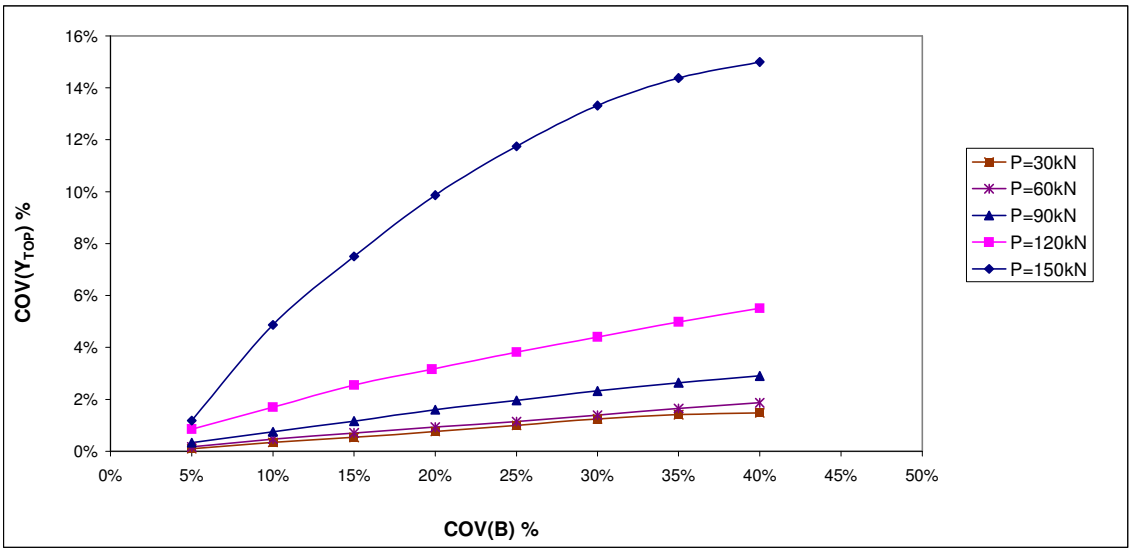


Fig. A.24 Variability of COV (Y_{TOP}) vs. COV(B) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.41 Probabilistic modeling of laterally loaded free head long pile 10T with varying

(EI) and load 30kN.

P=30kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	4.01E-03				
5%	61000			9.30E+06	4.23E-09	4.13E-03	1.57%
		57950	4.27E-03				
		67100	3.89E-03				
10%	61000			3.72E+07	1.76E-08	4.13E-03	3.56%
		54900	4.42E-03				
		70150	3.19E-03				
15%	61000			8.37E+07	1.23E-07	4.13E-03	8.48%
		51850	4.59E-03				
		73200	3.11E-03				
20%	61000			1.49E+08	6.05E-07	4.13E-03	13.10%
		48800	6.22E-03				
		76250	3.03E-03				
25%	61000			2.33E+08	3.30E-07	4.13E-03	19.37%
		45750	6.49E-03				
		79300	2.95E-03				
30%	61000			3.35E+08	9.26E-07	4.13E-03	23.31%
		42700	6.80E-03				
		82350	2.89E-03				
35%	61000			4.56E+08	1.13E-06	4.13E-03	25.72%
		39650	7.14E-03				
		85400	2.82E-03				
40%	61000			5.95E+08	1.36E-06	4.13E-03	28.27%
		36600	7.49E-03				

Table A.42 Probabilistic modeling of laterally loaded free head long pile 10T with varying (EI) and load 60kN.

P=60kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	1.15E-02				
5%	61000			9.30E+06	3.06E-08	7.40E-03	1.48%
		57950	1.22E-02				
		67100	1.11E-02				
10%	61000			3.72E+07	1.60E-07	7.40E-03	3.39%
		54900	1.27E-02				
		70150	8.94E-03				
15%	61000			8.37E+07	1.13E-06	7.40E-03	9.03%
		51850	1.32E-02				
		73200	8.69E-03				
20%	61000			1.49E+08	5.30E-06	7.40E-03	15.83%
		48800	1.79E-02				
		76250	8.47E-03				
25%	61000			2.33E+08	2.88E-06	7.40E-03	20.53%
		45750	1.87E-02				
		79300	8.25E-03				
30%	61000			3.35E+08	7.91E-06	7.40E-03	23.83%
		42700	1.95E-02				
		82350	8.09E-03				
35%	61000			4.56E+08	9.62E-06	7.40E-03	26.29%
		39650	2.05E-02				
		85400	7.90E-03				
40%	61000			5.95E+08	1.17E-05	7.40E-03	29.03%
		36600	2.16E-02				

Table A.43 Probabilistic modeling of laterally loaded free head long pile 10T with varying

(EI) and load 90kN.

P=90kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	2.16E-02				
5%	61000			9.30E+06	1.00E-08	1.63E-02	1.23%
		57950	2.20E-02				
		67100	2.28E-02				
10%	61000			3.72E+07	2.10E-07	1.63E-02	3.98%
		54900	2.32E-02				
		70150	3.30E-02				
15%	61000			8.37E+07	2.25E-07	1.63E-02	9.73%
		51850	3.90E-02				
		73200	1.57E-02				
20%	61000			1.49E+08	1.79E-06	1.63E-02	16.52%
		48800	3.26E-02				
		76250	1.53E-02				
25%	61000			2.33E+08	9.73E-06	1.63E-02	21.35%
		45750	3.41E-02				
		79300	1.49E-02				
30%	61000			3.35E+08	2.73E-05	1.63E-02	24.65%
		42700	3.58E-02				
		82350	1.45E-02				
35%	61000			4.56E+08	3.39E-05	1.63E-02	27.47%
		39650	3.78E-02				
		85400	1.42E-02				
40%	61000			5.95E+08	4.19E-05	1.63E-02	30.54%
		36600	4.01E-02				

Table A.44 Probabilistic modeling of laterally loaded free head long pile 10T with varying (EI) and load 120kN.

P=120kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	3.12E-02				
5%	61000			9.30E+06	3.31E-07	3.23E-02	1.78%
		57950	3.35E-02				
		67100	3.02E-02				
10%	61000			3.72E+07	1.32E-06	3.23E-02	3.56%
		54900	3.48E-02				
		70150	2.42E-02				
15%	61000			8.37E+07	9.00E-06	3.23E-02	12.35%
		51850	3.62E-02				
		73200	2.35E-02				
20%	61000			1.49E+08	4.76E-05	3.23E-02	18.73%
		48800	5.11E-02				
		76250	2.29E-02				
25%	61000			2.33E+08	2.63E-05	3.23E-02	23.43%
		45750	5.38E-02				
		79300	2.23E-02				
30%	61000			3.35E+08	7.44E-05	3.23E-02	26.70%
		42700	5.68E-02				
		82350	2.17E-02				
35%	61000			4.56E+08	9.26E-05	3.23E-02	29.79%
		39650	6.02E-02				
		85400	2.12E-02				
40%	61000			5.95E+08	1.16E-04	3.23E-02	33.28%
		36600	6.42E-02				

Table A.45 Probabilistic modeling of laterally loaded free head long pile 10T with varying (EI) and load 150kN.

P=150kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	4.39E-02				
5%	61000			9.30E+06	6.81E-07	4.55E-02	1.81%
		57950	4.72E-02				
		67100	4.24E-02				
10%	61000			3.72E+07	2.98E-06	4.55E-02	4.75%
		54900	4.93E-02				
		70150	3.34E-02				
15%	61000			8.37E+07	2.05E-05	4.55E-02	12.32%
		51850	5.15E-02				
		73200	3.24E-02				
20%	61000			1.49E+08	1.12E-04	4.55E-02	20.32%
		48800	7.47E-02				
		76250	3.15E-02				
25%	61000			2.33E+08	6.19E-05	4.55E-02	25.46%
		45750	7.89E-02				
		79300	3.07E-02				
30%	61000			3.35E+08	1.76E-04	4.55E-02	29.12%
		42700	8.37E-02				
		82350	2.99E-02				
35%	61000			4.56E+08	2.19E-04	4.55E-02	32.52%
		39650	8.91E-02				
		85400	2.91E-02				
40%	61000			5.95E+08	2.74E-04	4.55E-02	36.37%
		36600	9.53E-02				

Table A.46 Value of COV(Y_{TOP}) for free head long pile with varying COV(EI) and lateral load 30kN.

P=30kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	4.23E-09	1.57%
10%	3.72E+07	1.76E-08	3.56%
15%	8.37E+07	1.23E-07	8.48%
20%	1.49E+08	6.05E-07	13.10%
25%	2.33E+08	3.30E-07	19.37%
30%	3.35E+08	9.26E-07	23.31%
35%	4.56E+08	1.13E-06	25.72%
40%	5.95E+08	1.36E-06	28.27%

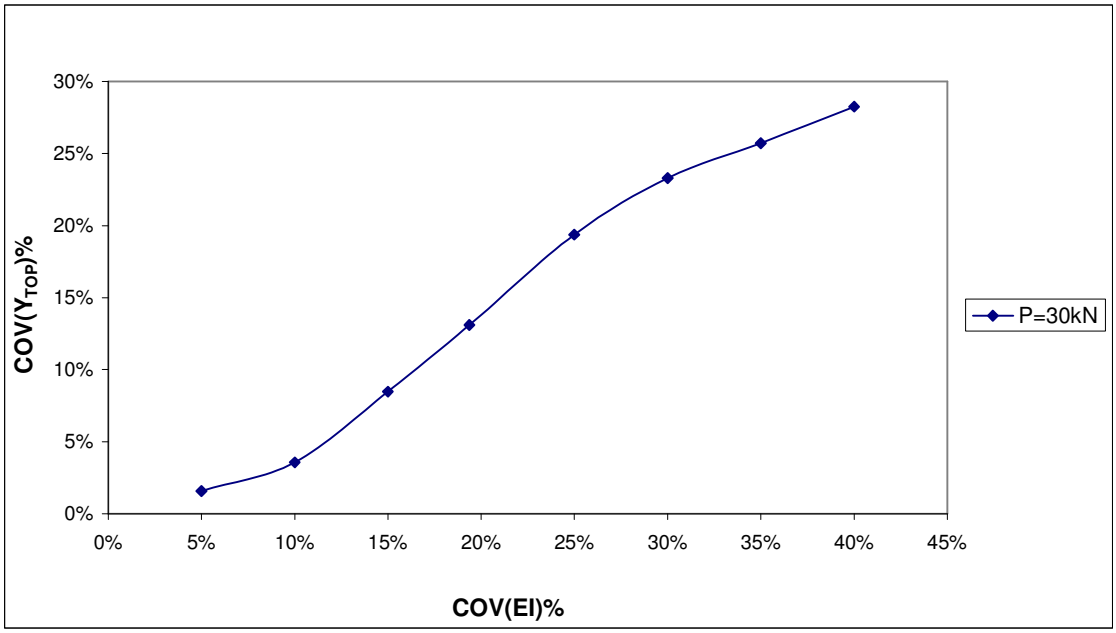


Fig. A.25 Variability of COV (Y_{TOP}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.47 Value of COV (Y_{TOP}) for free head long pile with varying COV(EI) and lateral load 60kN.

P=60kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	3.06E-08	1.48%
10%	3.72E+07	1.60E-07	3.39%
15%	8.37E+07	1.13E-06	9.03%
20%	1.49E+08	5.30E-06	15.83%
25%	2.33E+08	2.88E-06	20.53%
30%	3.35E+08	7.91E-06	23.83%
35%	4.56E+08	9.62E-06	26.29%
40%	5.95E+08	1.17E-05	29.03%

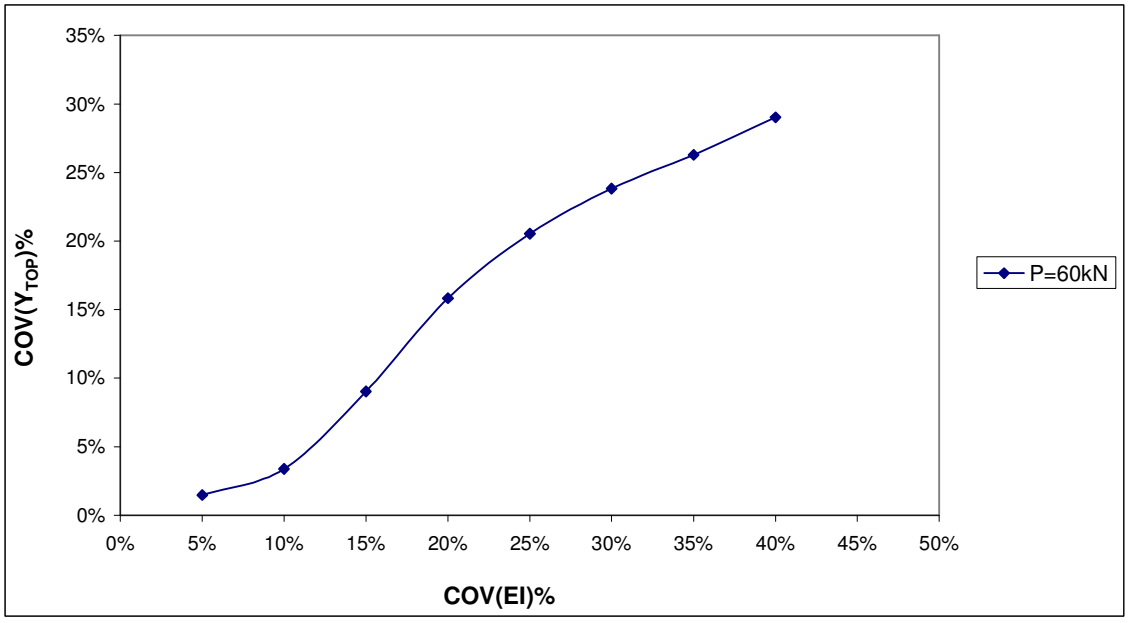


Fig. A.26 Variability of COV (Y_{TOP}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.48 Value of COV(Y_{TOP}) for free head long pile with varying COV(EI) and lateral load 90kN.

P=90kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	1.00E-08	1.23%
10%	3.72E+07	2.10E-07	3.98%
15%	8.37E+07	2.25E-07	9.73%
20%	1.49E+08	1.79E-06	16.52%
25%	2.33E+08	9.73E-06	21.35%
30%	3.35E+08	2.73E-05	24.65%
35%	4.56E+08	3.39E-05	27.47%
40%	5.95E+08	4.19E-05	30.54%

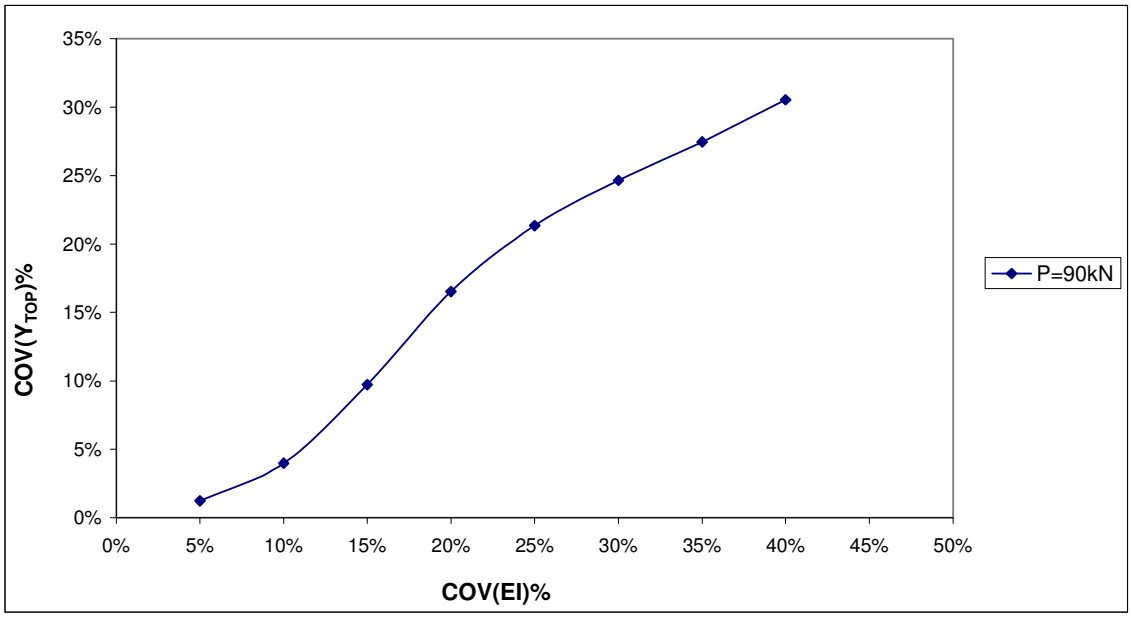


Fig. A.27 Variability of COV (Y_{TOP}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.49 Value of COV (Y_{TOP}) for free head long pile with varying COV(EI) and lateral load 120kN.

P=120kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	3.31E-07	1.78%
10%	3.72E+07	1.32E-06	3.56%
15%	8.37E+07	9.00E-06	12.35%
20%	1.49E+08	4.76E-05	18.73%
25%	2.33E+08	2.63E-05	23.43%
30%	3.35E+08	7.44E-05	26.70%
35%	4.56E+08	9.26E-05	29.79%
40%	5.95E+08	1.16E-04	33.28%

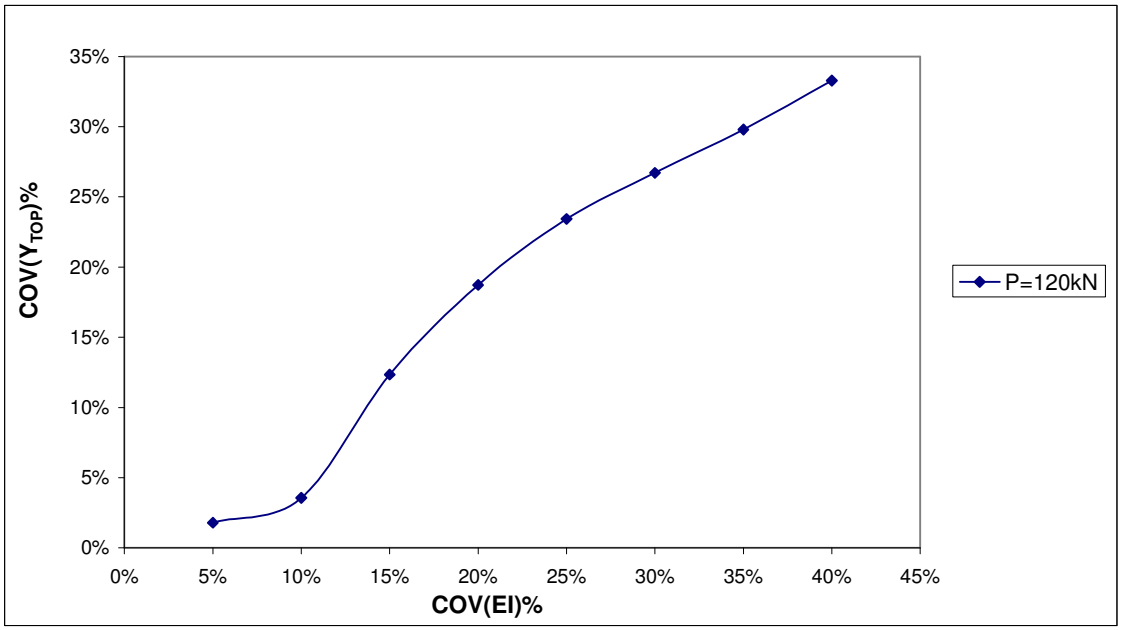


Fig. A.28 Variability of COV (Y_{TOP}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.50 Value of COV (Y_{TOP}) for free head long pile with varying COV(EI) and lateral load 150kN.

P=150kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	6.81E-07	1.81%
10%	3.72E+07	2.98E-06	4.75%
15%	8.37E+07	2.05E-05	12.32%
20%	1.49E+08	1.12E-04	20.32%
25%	2.33E+08	6.19E-05	25.46%
30%	3.35E+08	1.76E-04	29.12%
35%	4.56E+08	2.19E-04	32.52%
40%	5.95E+08	2.74E-04	36.37%

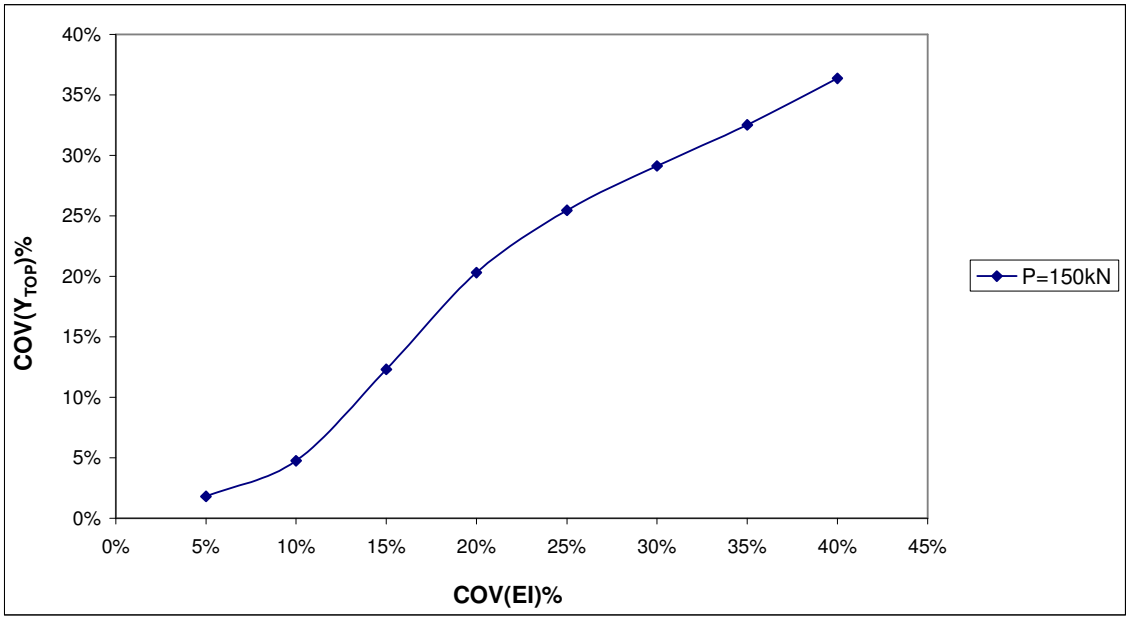


Fig. A.29 Variability of COV (Y_{TOP}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force 150kN.

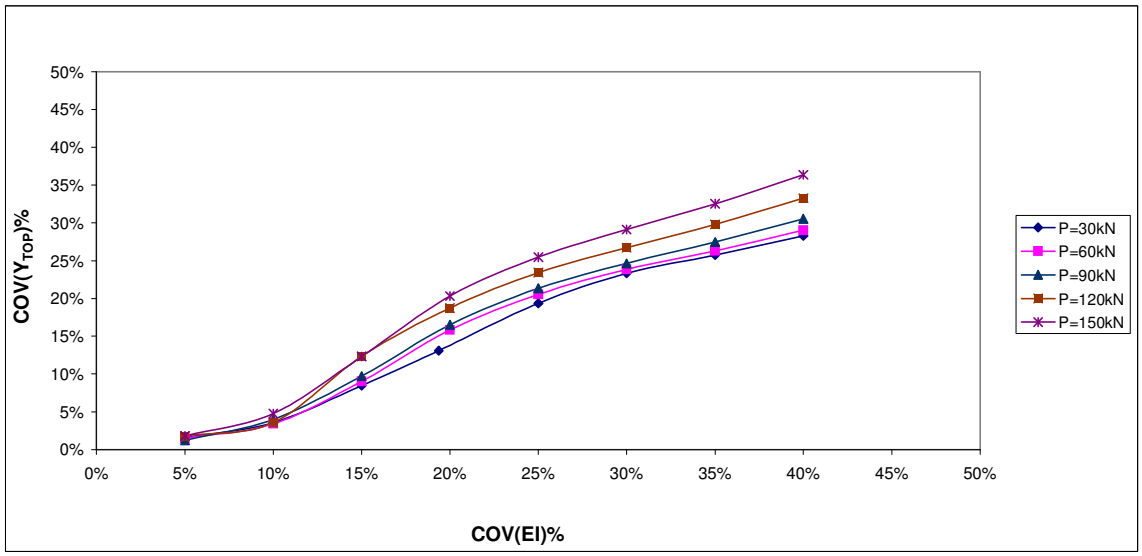


Fig. A.30 Variability of COV (Y_{TOP}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.51 Probabilistic modeling of laterally loaded free head long pile 10T with varying

(P) and load 30kN.

P=30kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		31.5	4.46E-03				
5%	30			2.25E+00	1.02E-07	4.13E-03	7.31%
		28.5	3.82E-03				
		33	4.79E-03				
10%	30			9.00E+00	4.10E-07	4.13E-03	14.39%
		27	3.51E-03				
		34.5	5.13E-03				
15%	30			2.03E+01	9.31E-07	4.13E-03	21.70%
		25.5	3.20E-03				
		36	5.48E-03				
20%	30			3.60E+01	1.64E-06	4.13E-03	28.77%
		24	2.92E-03				
		37.5	5.83E-03				
25%	30			5.63E+01	2.50E-06	4.13E-03	36.08%
		22.5	2.67E-03				
		39	6.19E-03				
30%	30			8.10E+01	3.59E-06	4.13E-03	43.40%
		21	2.40E-03				
		40.5	6.56E-03				
35%	30			1.10E+02	4.91E-06	4.13E-03	50.71%
		19.5	2.13E-03				
		42	6.93E-03				
40%	30			1.44E+02	6.38E-06	4.13E-03	58.02%
		18	1.88E-03				

Table A.52 Probabilistic modeling of laterally loaded free head long pile 10T with varying (P) and load 60kN.

P=60kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		63	1.27E-02				
5%	60			9.00E+00	7.23E-07	7.40E-03	7.20%
		57	1.10E-02				
		66	1.36E-02				
10%	60			3.60E+01	3.06E-06	7.40E-03	14.83%
		54	1.01E-02				
		69	1.45E-02				
15%	60			8.10E+01	6.79E-06	7.40E-03	22.08%
		51	9.29E-03				
		72	1.54E-02				
20%	60			1.44E+02	1.20E-05	7.40E-03	29.32%
		48	8.48E-03				
		75	1.64E-02				
25%	60			2.25E+02	1.90E-05	7.40E-03	36.91%
		45	7.69E-03				
		78	1.73E-02				
30%	60			3.24E+02	2.69E-05	7.40E-03	43.94%
		42	6.93E-03				
		81	1.83E-02				
35%	60			4.41E+02	3.67E-05	7.40E-03	51.31%
		39	6.19E-03				
		84	1.92E-02				
40%	60			5.76E+02	4.71E-05	7.40E-03	58.14%
		36	5.48E-03				

Table A.53 Probabilistic modeling of laterally loaded free head long pile 10T with varying

(P) and load 90kN.

P=90kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		94.5	2.28E-02				
5%	90			2.03E+01	2.40E-06	1.63E-02	7.43%
		85.5	1.97E-02				
		99	2.44E-02				
10%	90			8.10E+01	9.30E-06	1.63E-02	15.02%
		81	1.83E-02				
		103.5	2.60E-02				
15%	90			1.82E+02	2.12E-05	1.63E-02	22.60%
		76.5	1.68E-02				
		108	2.76E-02				
20%	90			3.24E+02	3.72E-05	1.63E-02	30.03%
		72	1.54E-02				
		112.5	2.94E-02				
25%	90			5.06E+02	5.85E-05	1.63E-02	37.62%
		67.5	1.41E-02				
		117	3.11E-02				
30%	90			7.29E+02	8.46E-05	1.63E-02	45.36%
		63	1.27E-02				
		121.5	3.29E-02				
35%	90			9.92E+02	1.16E-04	1.63E-02	52.94%
		58.5	1.14E-02				
		126	3.47E-02				
40%	90			1.30E+03	1.51E-04	1.63E-02	60.99%
		54	1.01E-02				

Table A.54 Probabilistic modeling of laterally loaded free head long pile 10T with varying (P) and load 120kN.

P=120kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		126	3.47E-02				
5%	120			3.60E+01	5.76E-06	3.23E-02	7.75%
		114	2.99E-02				
		132	3.73E-02				
10%	120			1.44E+02	2.35E-05	3.23E-02	15.50%
		108	2.76E-02				
		138	4.00E-02				
15%	120			3.24E+02	5.33E-05	3.23E-02	23.37%
		102	2.54E-02				
		144	4.27E-02				
20%	120			5.76E+02	9.41E-05	3.23E-02	30.99%
		96	2.33E-02				
		150	4.55E-02				
25%	120			9.00E+02	1.48E-04	3.23E-02	38.26%
		90	2.12E-02				
		156	4.85E-02				
30%	120			1.30E+03	2.15E-04	3.23E-02	45.88%
		84	1.92E-02				
		162	5.15E-02				
35%	120			1.76E+03	2.92E-04	3.23E-02	53.63%
		78	1.73E-02				
		168	5.48E-02				
40%	120			2.30E+03	3.88E-04	3.23E-02	61.14%
		72	1.54E-02				

Table A.55 Probabilistic modeling of laterally loaded free head long pile 10T with varying (P) and load 150kN.

P=150kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		157.5	4.92E-02				
5%	150			5.63E+01	1.30E-05	4.55E-02	7.91%
		142.5	4.20E-02				
		165	5.31E-02				
10%	150			2.25E+02	5.26E-05	4.55E-02	15.93%
		135	3.86E-02				
		172.5	5.72E-02				
15%	150			5.06E+02	1.19E-04	4.55E-02	23.96%
		127.5	3.54E-02				
		180	6.14E-02				
20%	150			9.00E+02	2.12E-04	4.55E-02	31.98%
		120	3.23E-02				
		187.5	6.59E-02				
25%	150			1.41E+03	3.33E-04	4.55E-02	40.11%
		112.5	2.94E-02				
		195	7.03E-02				
30%	150			2.03E+03	4.80E-04	4.55E-02	48.13%
		105	2.65E-02				
		202.5	7.52E-02				
35%	150			2.76E+03	6.60E-04	4.55E-02	56.48%
		97.5	2.38E-02				
		210	8.01E-02				
40%	150			3.60E+03	8.67E-04	4.55E-02	64.73%
		90	2.12E-02				

Table A.56 Value of COV (Y_{TOP}) for free head long pile with varying COV(P) and lateral load 30kN.

P=30kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	1.02E-07	7.31%
10%	9.00E+00	4.10E-07	14.39%
15%	2.03E+01	9.31E-07	21.70%
20%	3.60E+01	1.64E-06	28.77%
25%	5.63E+01	2.50E-06	36.08%
30%	8.10E+01	3.59E-06	43.40%
35%	1.10E+02	4.91E-06	50.71%
40%	1.44E+02	6.38E-06	58.02%

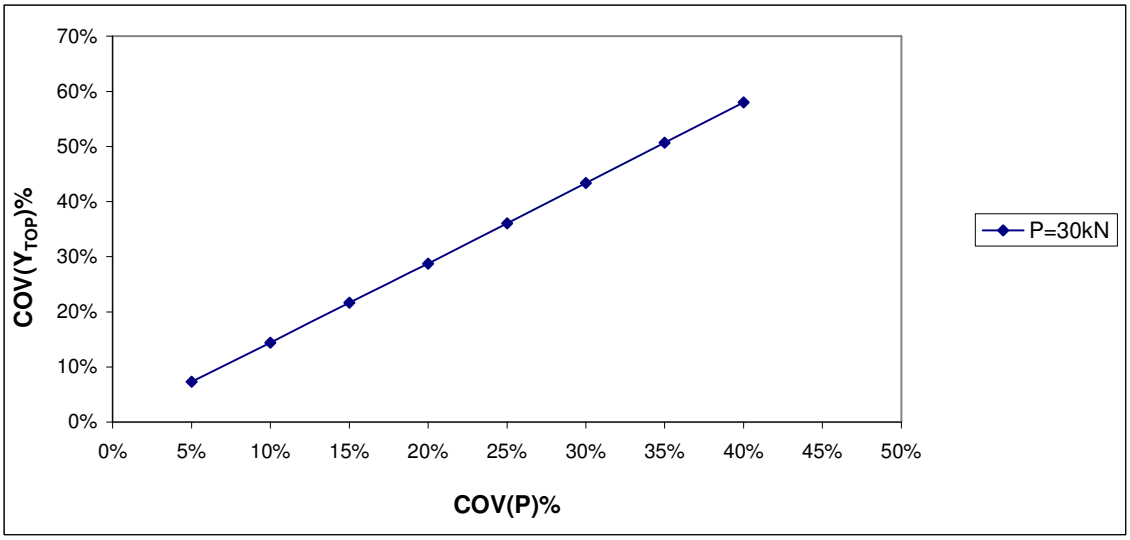


Fig. A.31 Variability of COV (Y_{TOP}) vs. COV (P) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.57 Value of COV (Y_{TOP}) for free head long pile with varying COV(P) and lateral load 60kN.

P=60kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.00E+00	7.23E-07	7.20%
10%	3.60E+01	3.06E-06	14.83%
15%	8.10E+01	6.79E-06	22.08%
20%	1.44E+02	1.20E-05	29.32%
25%	2.25E+02	1.90E-05	36.91%
30%	3.24E+02	2.69E-05	43.94%
35%	4.41E+02	3.67E-05	51.31%
40%	5.76E+02	4.71E-05	58.14%

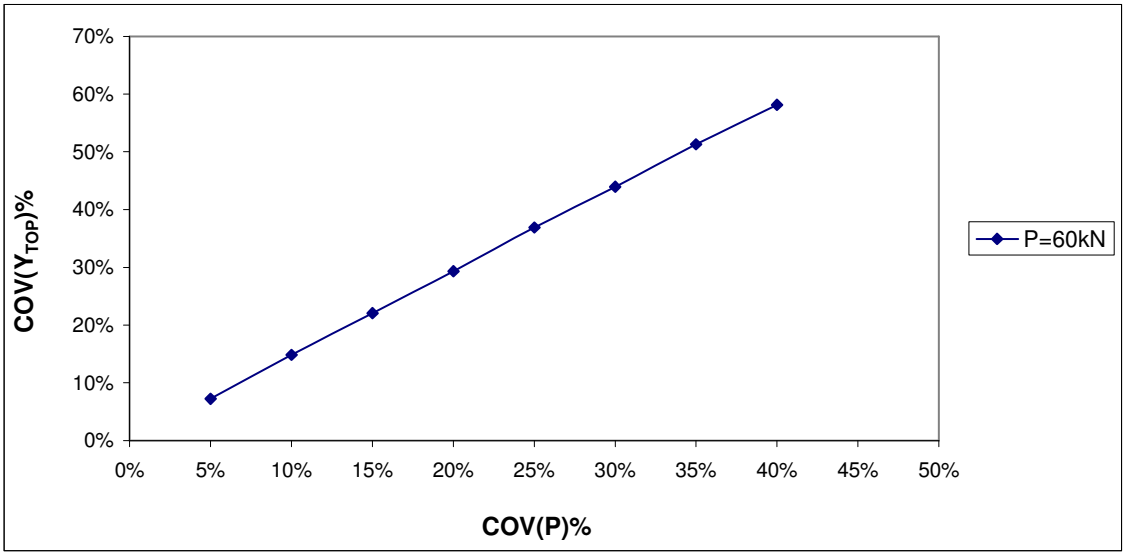


Fig. A.32 Variability of COV (Y_{TOP}) vs. COV (P) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.58 Value of COV (Y_{TOP}) for free head long pile with varying COV(P) and lateral load 90kN.

P=90kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.03E+01	2.40E-06	7.43%
10%	8.10E+01	9.30E-06	15.02%
15%	1.82E+02	2.12E-05	22.60%
20%	3.24E+02	3.72E-05	30.03%
25%	5.06E+02	5.85E-05	37.62%
30%	7.29E+02	8.46E-05	45.36%
35%	9.92E+02	1.16E-04	52.94%
40%	1.30E+03	1.51E-04	60.99%

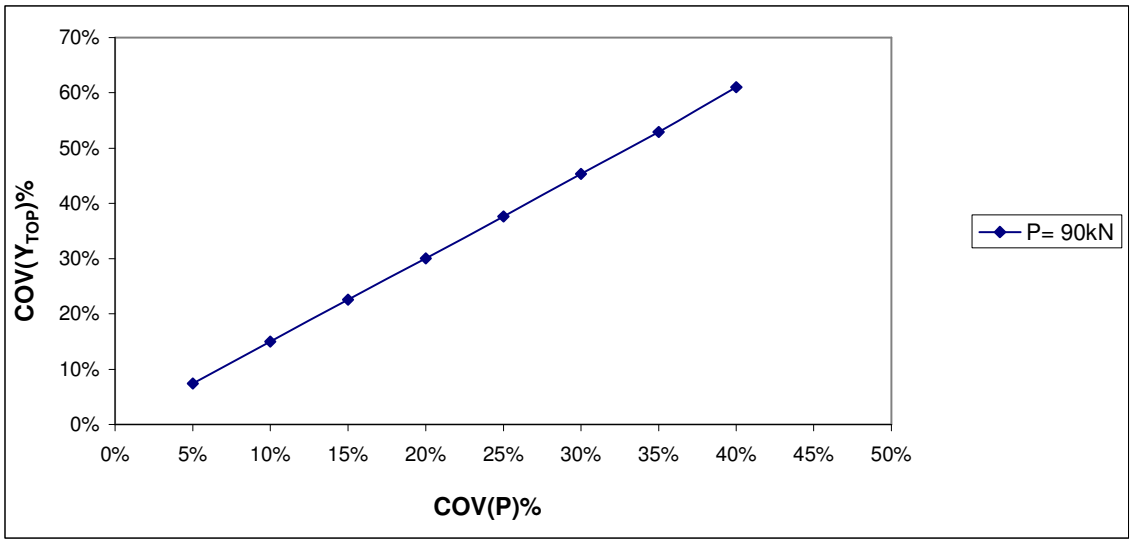


Fig. A.33 Variability of COV (Y_{TOP}) vs. COV (P) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.59 Value of COV (Y_{TOP}) for free head long pile with varying COV(P) and lateral load 120kN.

P=120kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	3.60E+01	5.76E-06	7.75%
10%	1.44E+02	2.35E-05	15.50%
15%	3.24E+02	5.33E-05	23.37%
20%	5.76E+02	9.41E-05	30.99%
25%	9.00E+02	1.48E-04	38.26%
30%	1.30E+03	2.15E-04	45.88%
35%	1.76E+03	2.92E-04	53.63%
40%	2.30E+03	3.88E-04	61.14%

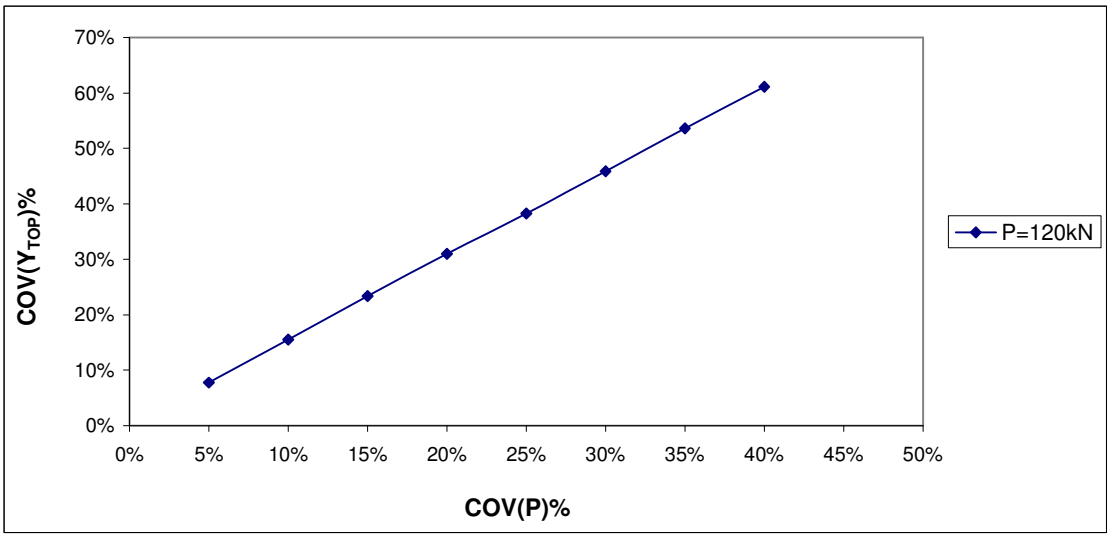


Fig. A.34 Variability of COV (Y_{TOP}) vs. COV (P) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.60 Value of COV (Y_{TOP}) for free head long pile with varying COV(P) and lateral load 150kN.

P=150kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	5.63E+01	1.30E-05	7.91%
10%	2.25E+02	5.26E-05	15.93%
15%	5.06E+02	1.19E-04	23.96%
20%	9.00E+02	2.12E-04	31.98%
25%	1.41E+03	3.33E-04	40.11%
30%	2.03E+03	4.80E-04	48.13%
35%	2.76E+03	6.60E-04	56.48%
40%	3.60E+03	8.67E-04	64.73%

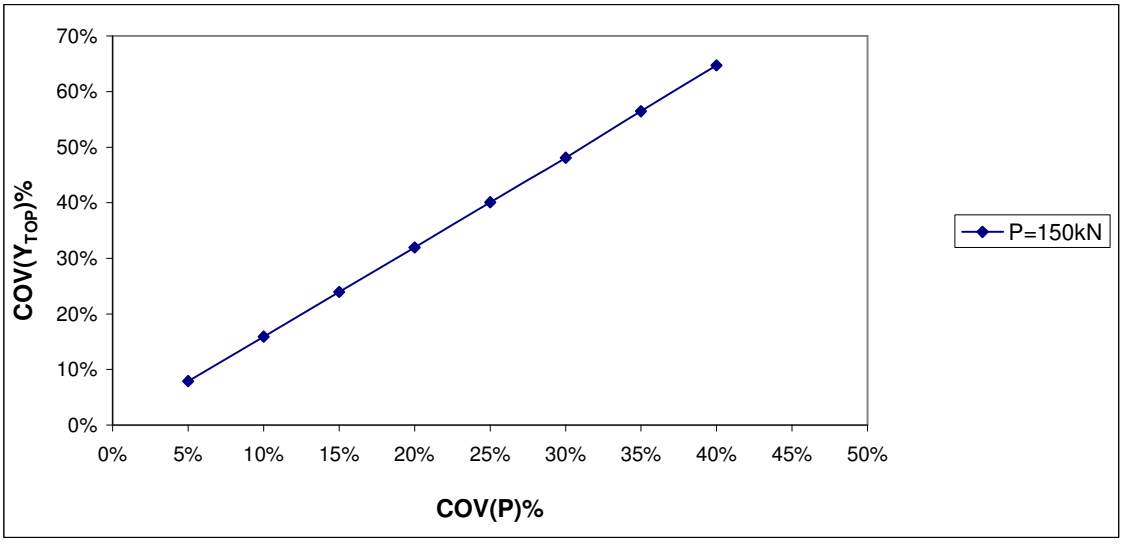


Fig. A.35 Variability of COV (Y_{TOP}) vs. COV (P) for single free head long pile (10T) subjected to lateral force 150kN.

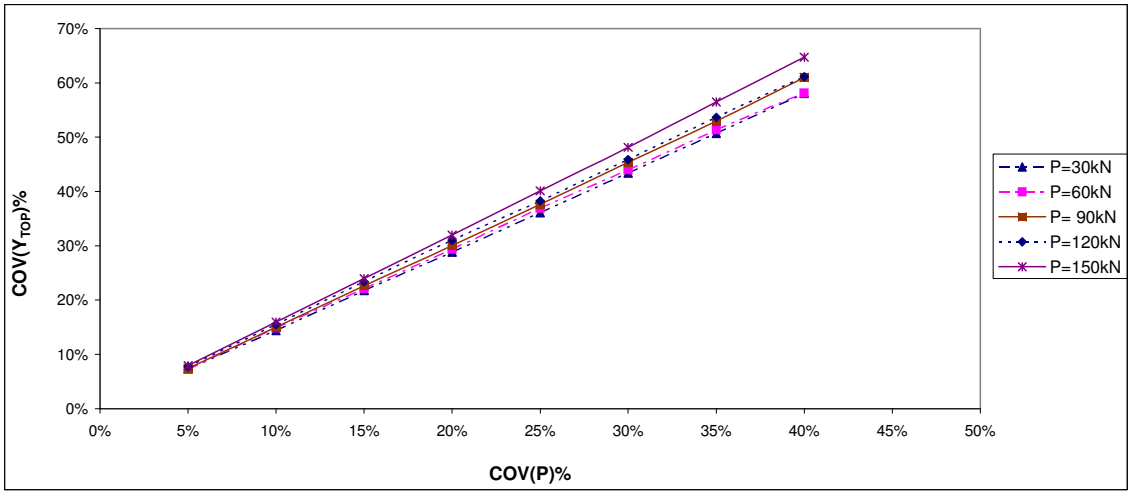


Fig. A.36 Variability of COV (Y_{TOP}) vs. COV (P) for single free head long pile (10T) subjected to lateral force of discrete variability.

A-2 Reliability Index (β) of top deflection vs. COV(Variables)

Table A.61 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'Φ' subjected to lateral load 30kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.48E-07	0.000225	5%	0.0150	6.3892
6.08E-07	0.000225	10%	0.0150	6.3827
1.39E-06	0.000225	15%	0.0150	6.3716
2.40E-06	0.000225	20%	0.0151	6.3575
3.65E-06	0.000225	25%	0.0151	6.3401
5.27E-06	0.000225	30%	0.0152	6.3178
7.40E-06	0.000225	35%	0.0152	6.2888
1.03E-05	0.000225	40%	0.0153	6.2498

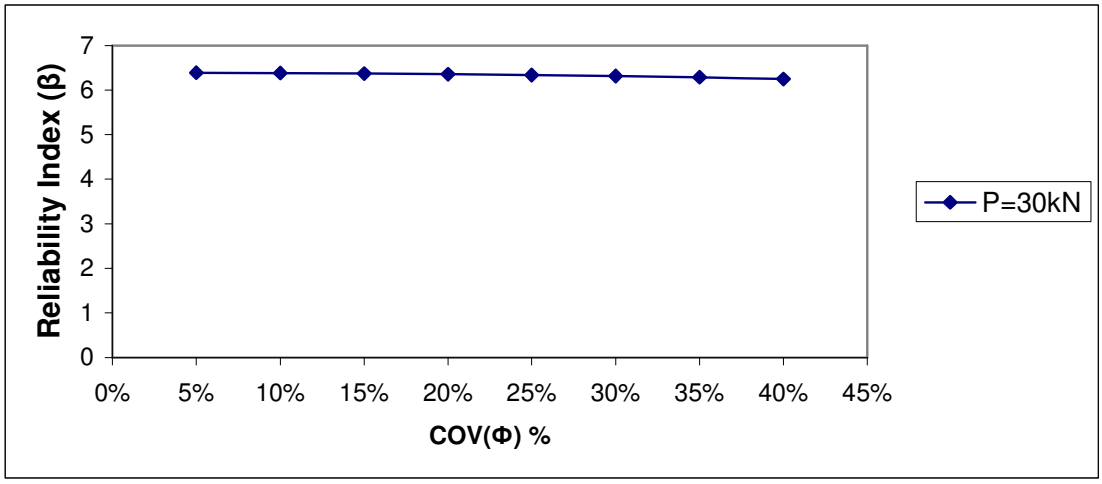


Fig. A.37 Reliability Index (β) of Y_{Top} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.62 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'Φ' subjected to lateral load 60kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.10E-06	0.000225	5%	0.0150	5.8656
4.39E-06	0.000225	10%	0.0151	5.8235
1.03E-05	0.000225	15%	0.0153	5.7494
1.89E-05	0.000225	20%	0.0156	5.6478
3.00E-05	0.000225	25%	0.0160	5.5230
4.54E-05	0.000225	30%	0.0164	5.3634
6.53E-05	0.000225	35%	0.0170	5.1767
8.96E-05	0.000225	40%	0.0177	4.9728

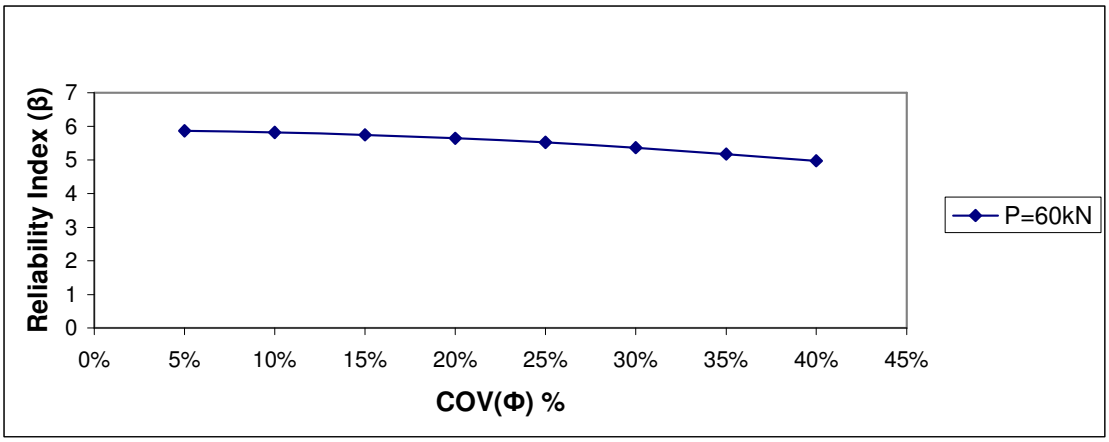


Fig. A. 38 Reliability Index (β) of Y_{Top} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.63 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'Φ' subjected to lateral load 90kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.42E-06	0.000225	5%	0.0151	5.2138
1.41E-05	0.000225	10%	0.0155	5.0965
3.25E-05	0.000225	15%	0.0160	4.9107
5.93E-05	0.000225	20%	0.0169	4.6735
9.51E-05	0.000225	25%	0.0179	4.4046
1.49E-04	0.000225	30%	0.0193	4.0755
2.24E-04	0.000225	35%	0.0212	3.7209
3.29E-04	0.000225	40%	0.0235	3.3466

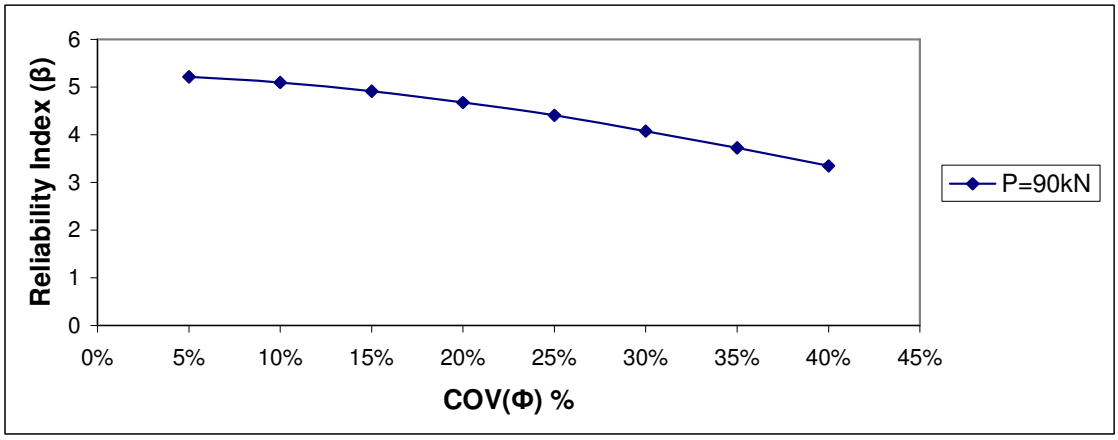


Fig. A.39 Reliability Index (β) of Y_{Top} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.64 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'Φ' subjected to lateral load 120kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
8.70E-06	0.000225	5%	0.0153	4.4285
3.48E-05	0.000225	10%	0.0161	4.2001
8.19E-05	0.000225	15%	0.0175	3.8645
1.53E-04	0.000225	20%	0.0194	3.4843
2.56E-04	0.000225	25%	0.0219	3.0869
4.08E-04	0.000225	30%	0.0252	2.6907
6.28E-04	0.000225	35%	0.0292	2.3187
9.55E-04	0.000225	40%	0.0343	1.9710

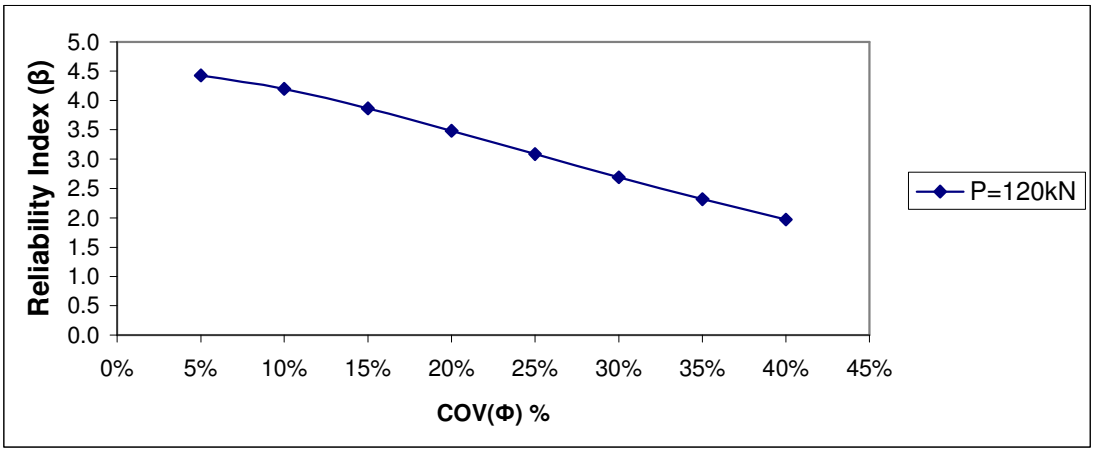


Fig. A.40 Reliability Index (β) of Y_{Top} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.65 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'Φ' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.94E-05	0.000225	5%	0.0156	3.4864
8.01E-05	0.000225	10%	0.0175	3.1201
1.89E-04	0.000225	15%	0.0203	2.6783
3.53E-04	0.000225	20%	0.0241	2.2660
6.00E-04	0.000225	25%	0.0287	1.8972
9.61E-04	0.000225	30%	0.0344	1.5825
1.51E-03	0.000225	35%	0.0416	1.3101
2.38E-03	0.000225	40%	0.0510	1.0685

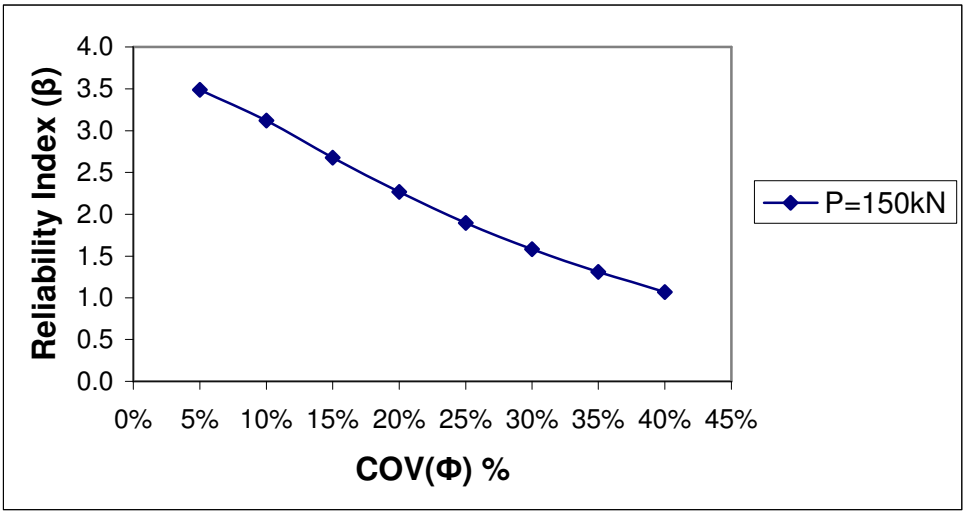


Fig. A.41 Reliability Index (β) of Y_{Top} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 150kN.

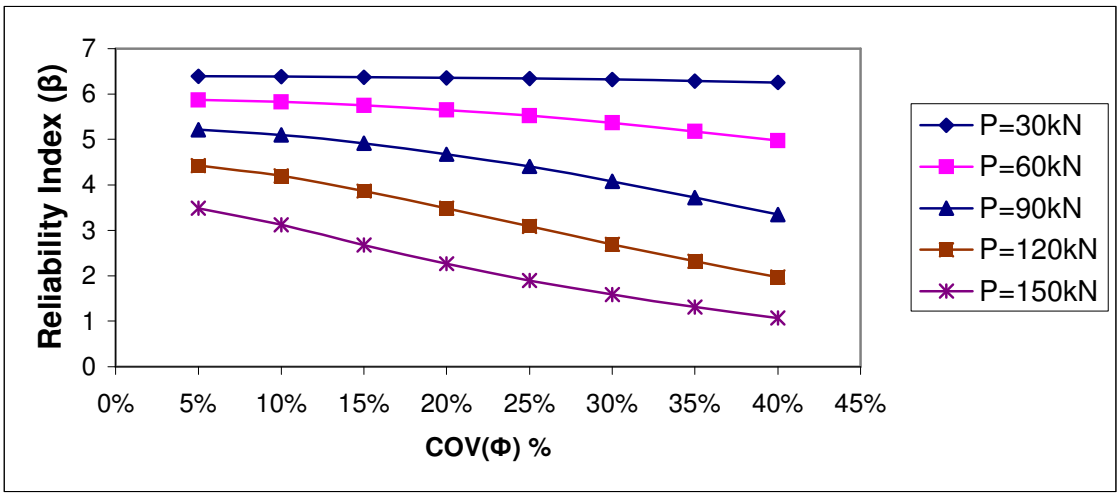


Fig. A.42 Reliability Index (β) of Y_{Top} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force of discrete variability

Table A.66 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'γ' subjected to lateral load 30kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ') (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.40E-07	0.000225	5%	0.0150	6.3823
2.56E-06	0.000225	10%	0.0151	6.3553
6.00E-06	0.000225	15%	0.0152	6.3077
1.06E-05	0.000225	20%	0.0153	6.2464
1.72E-05	0.000225	25%	0.0156	6.1599
2.60E-05	0.000225	30%	0.0158	6.0511
3.78E-05	0.000225	35%	0.0162	5.9136
5.18E-05	0.000225	40%	0.0166	5.7619

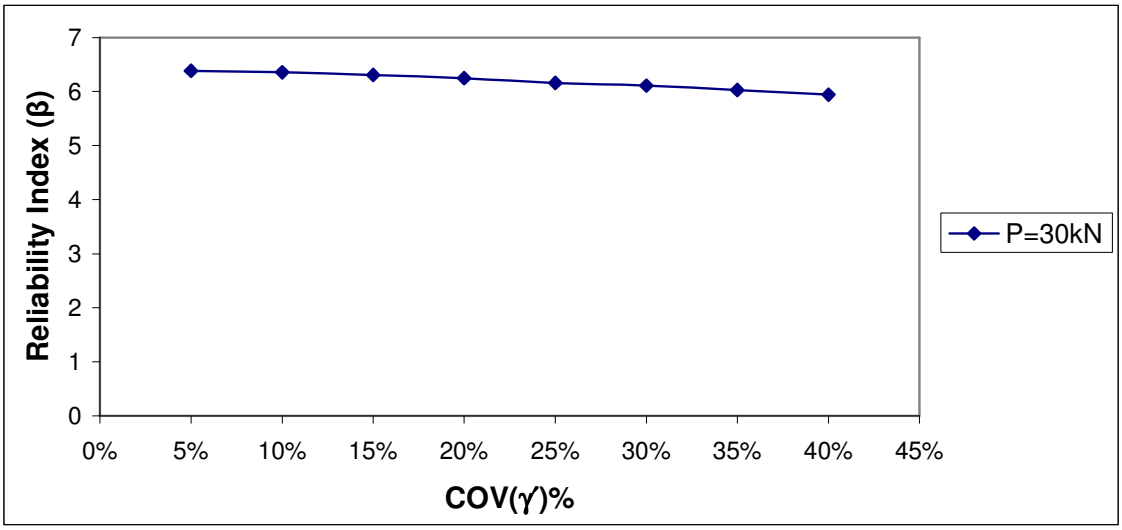


Fig. A.43 Reliability Index (β) of Y_{Top} vs. COV (γ') for single free head long pile (10T) subjected to lateral force 30kN.

Table A.67 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'γ' subjected to lateral load 60kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ') (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.03E-07	0.000225	5%	0.0150	5.8774
8.10E-07	0.000225	10%	0.0150	5.8694
1.96E-06	0.000225	15%	0.0151	5.8546
3.42E-06	0.000225	20%	0.0151	5.8358
5.88E-06	0.000225	25%	0.0152	5.8046
8.82E-06	0.000225	30%	0.0153	5.7680
1.23E-05	0.000225	35%	0.0154	5.7253
1.72E-05	0.000225	40%	0.0156	5.6676

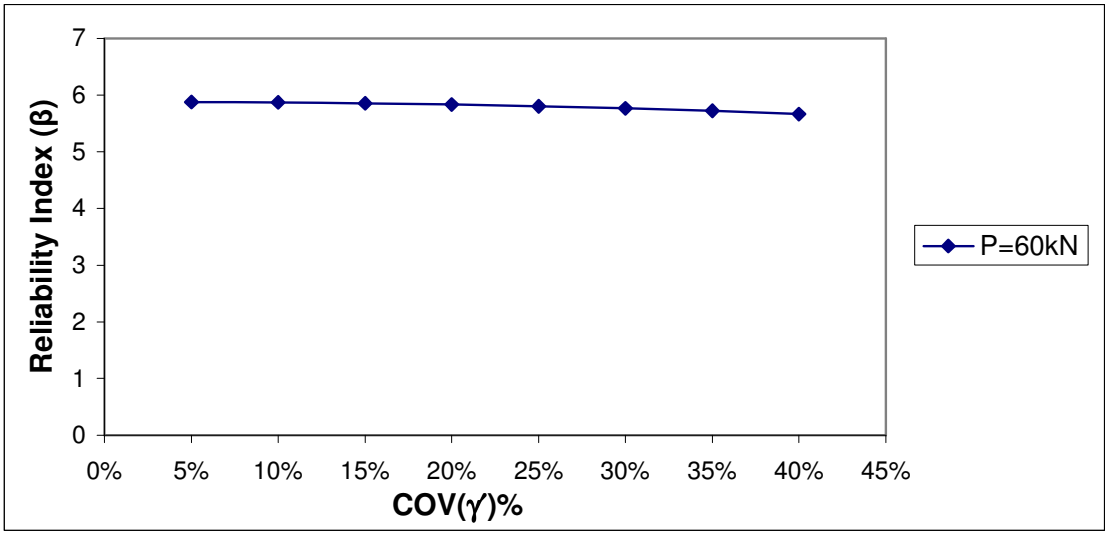


Fig. A.44 Reliability Index (β) of Y_{Top} vs. COV (γ') for single free head long pile (10T) subjected to lateral force 60kN.

Table A.68 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'γ' subjected to lateral load 90kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ') (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.56E-06	0.000225	5%	0.0151	5.2352
6.25E-06	0.000225	10%	0.0152	5.1819
1.44E-05	0.000225	15%	0.0155	5.0925
2.65E-05	0.000225	20%	0.0159	4.9686
4.29E-05	0.000225	25%	0.0164	4.8144
6.56E-05	0.000225	30%	0.0170	4.6224
9.60E-05	0.000225	35%	0.0179	4.3979
1.38E-04	0.000225	40%	0.0191	4.1356

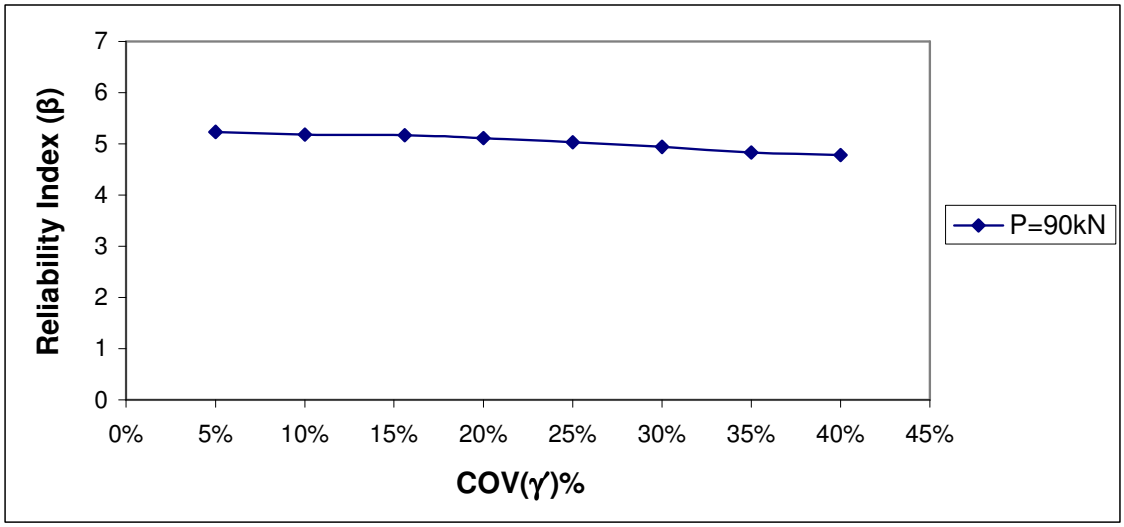


Fig. A.45 Reliability Index (β) of Y_{Top} vs. COV (γ') for single free head long pile (10T) subjected to lateral force 90kN.

Table A.69 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'γ' subjected to lateral load 120kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ') (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.89E-08	0.000225	5%	0.0150	4.6500
1.19E-07	0.000225	10%	0.0150	4.5500
2.70E-07	0.000225	15%	0.0150	4.4000
4.97E-07	0.000225	20%	0.0150	4.2000
8.10E-07	0.000225	25%	0.0150	3.9870
1.27E-06	0.000225	30%	0.0150	3.7680
1.82E-06	0.000225	35%	0.0151	3.4320
2.54E-06	0.000225	40%	0.0151	3.0870

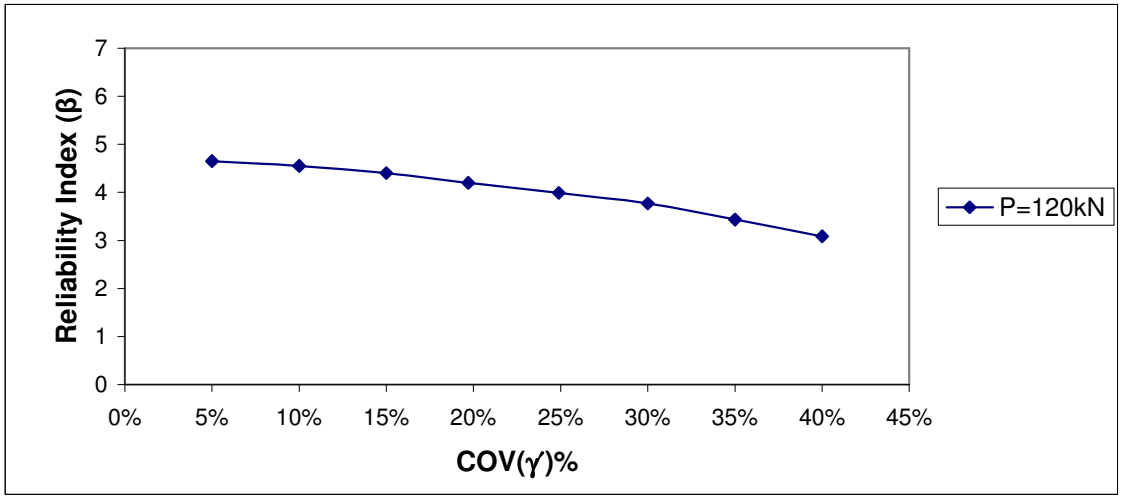


Fig. A.46 Reliability Index (β) of Y_{Top} vs. COV (γ') for single free head long pile (10T) subjected to lateral force 120kN.

Table A.70 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'γ' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ') (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.42E-06	0.000225	5%	0.0151	3.6060
1.37E-05	0.000225	10%	0.0154	3.5276
3.25E-05	0.000225	15%	0.0160	3.3964
6.08E-05	0.000225	20%	0.0169	3.2236
1.00E-04	0.000225	25%	0.0180	3.0231
1.53E-04	0.000225	30%	0.0194	2.8049
2.22E-04	0.000225	35%	0.0211	2.5777
3.17E-04	0.000225	40%	0.0233	2.3413

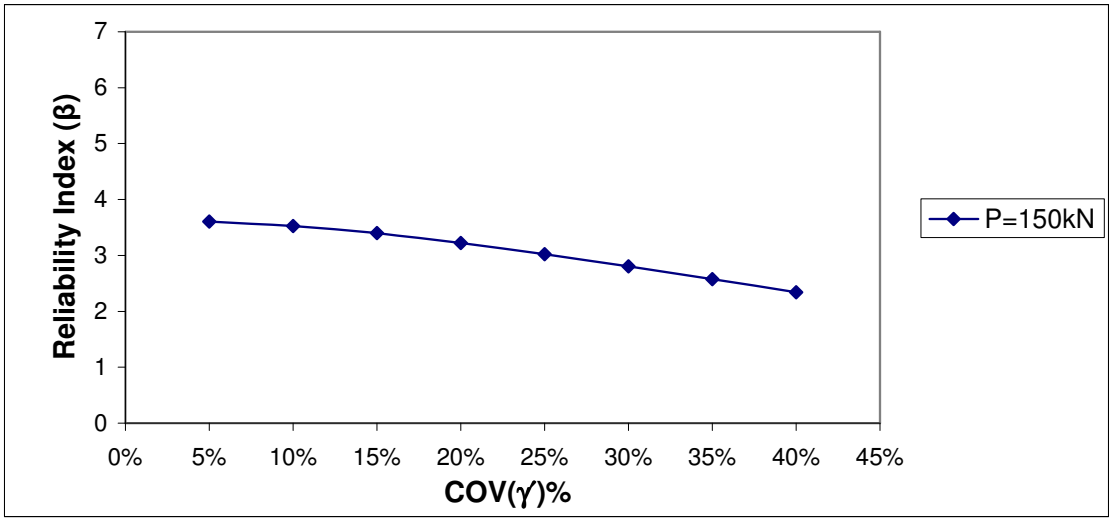


Fig. A.47 Reliability Index (β) of Y_{Top} vs. COV (γ') for single free head long pile (10T) subjected to lateral force 150kN.

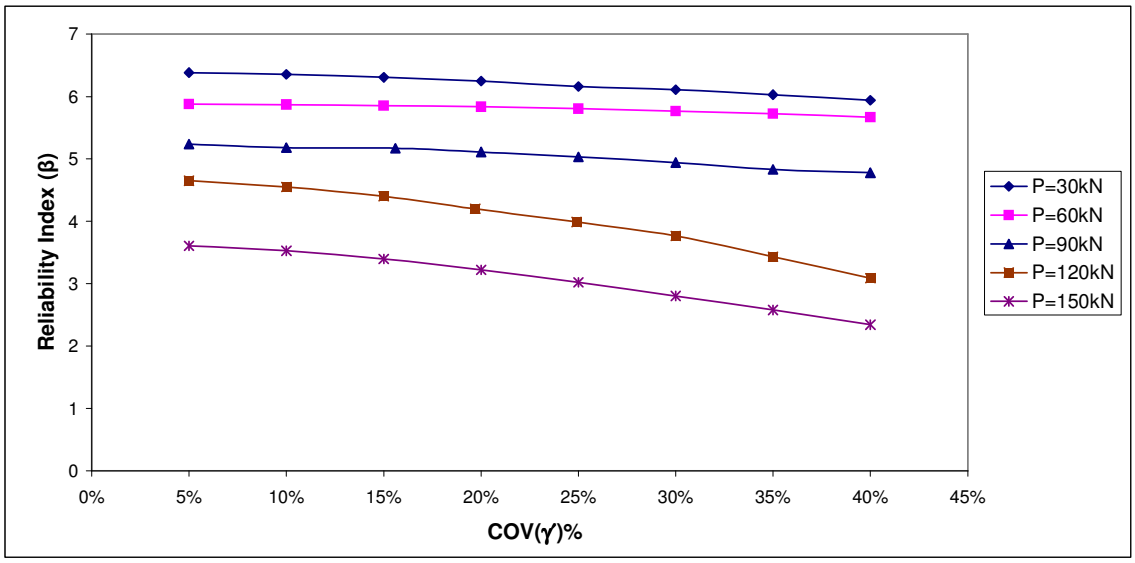


Fig. A.48 Reliability Index (β) of Y_{Top} vs. COV (γ) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.71 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'k' subjected to lateral load 30kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.00E-08	0.000225	5%	0.0150	6.3912
4.00E-08	0.000225	10%	0.0150	6.3908
8.50E-08	0.000225	15%	0.0150	6.3901
9.00E-08	0.000225	20%	0.0150	6.3901
1.60E-07	0.000225	25%	0.0150	6.3891
1.82E-07	0.000225	30%	0.0150	6.3887
2.50E-07	0.000225	35%	0.0150	6.3878
3.60E-07	0.000225	40%	0.0150	6.3862

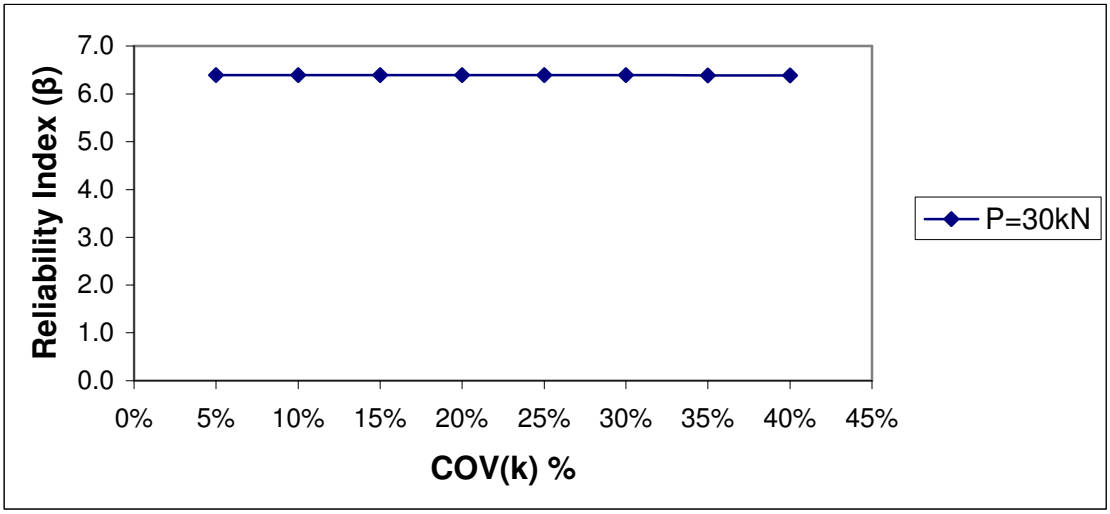


Fig. A.49 Reliability Index (β) of Y_{Top} vs. COV (k) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.72 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'k' subjected to lateral load 60kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.50E-09	0.000225	5%	0.0150	5.8800
2.60E-09	0.000225	10%	0.0150	5.8800
2.00E-08	0.000225	15%	0.0150	5.8797
2.25E-08	0.000225	20%	0.0150	5.8797
3.65E-08	0.000225	25%	0.0150	5.8795
4.00E-08	0.000225	30%	0.0150	5.8795
6.25E-08	0.000225	35%	0.0150	5.8792
9.00E-08	0.000225	40%	0.0150	5.8788

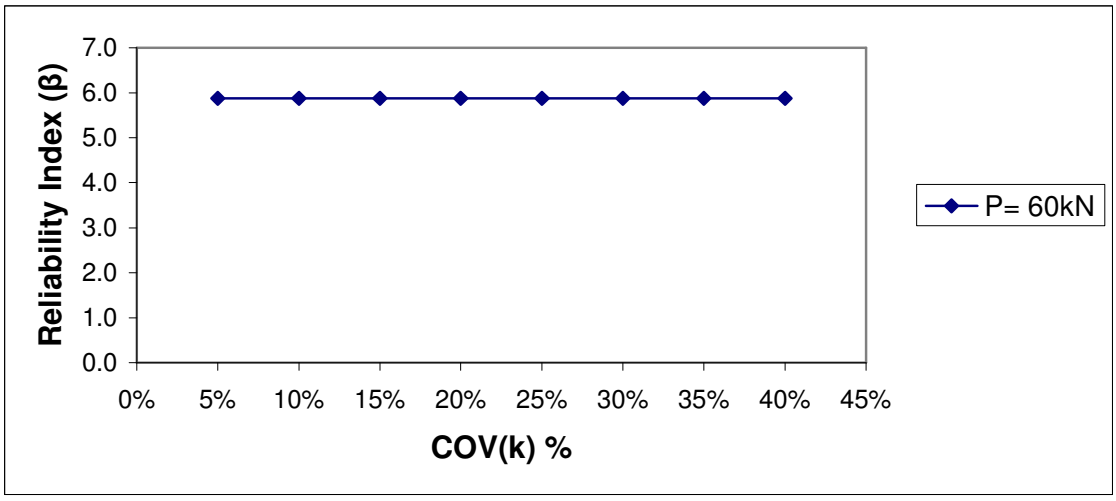


Fig. A.50 Reliability Index (β) of Y_{Top} vs. COV (k) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.73 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'k' subjected to lateral load 90kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.50E-09	0.000225	5%	0.0150	5.2533
2.57E-09	0.000225	10%	0.0150	5.2533
1.86E-08	0.000225	15%	0.0150	5.2531
2.20E-08	0.000225	20%	0.0150	5.2531
3.23E-08	0.000225	25%	0.0150	5.2530
3.97E-08	0.000225	30%	0.0150	5.2529
6.21E-08	0.000225	35%	0.0150	5.2526
8.69E-08	0.000225	40%	0.0150	5.2523

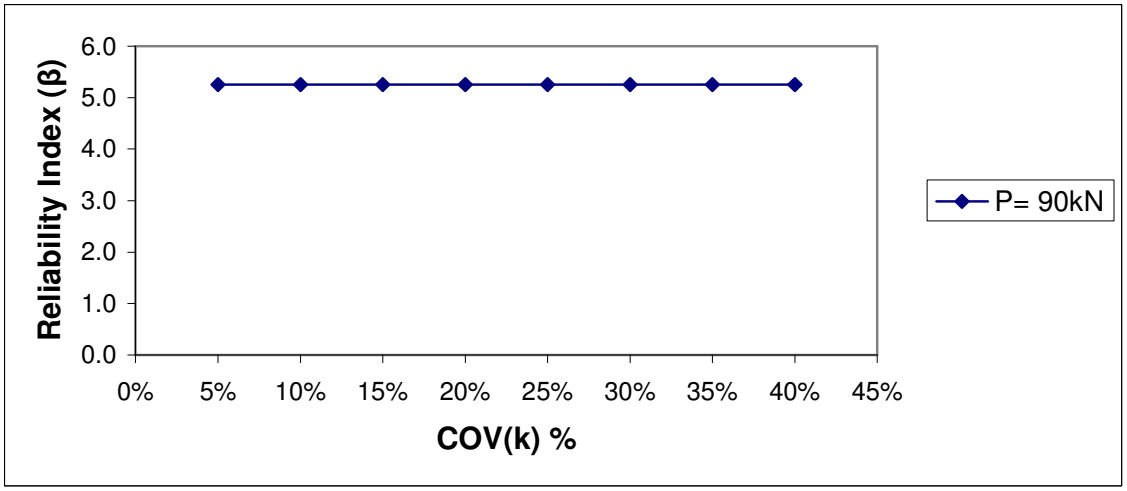


Fig. A.51 Reliability Index (β) of Y_{Top} vs. COV (k) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.74 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'k' subjected to lateral load 120kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.42E-09	0.000225	5%	0.0150	4.5133
2.69E-09	0.000225	10%	0.0150	4.5133
1.00E-08	0.000225	15%	0.0150	4.5132
1.56E-08	0.000225	20%	0.0150	4.5132
3.00E-08	0.000225	25%	0.0150	4.5130
3.67E-08	0.000225	30%	0.0150	4.5130
6.14E-08	0.000225	35%	0.0150	4.5127
7.79E-08	0.000225	40%	0.0150	4.5126

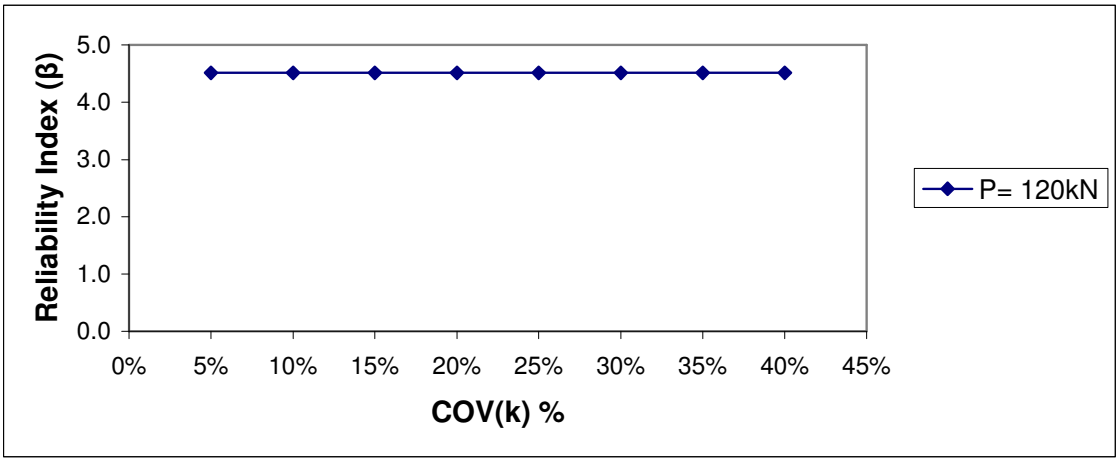


Fig. A.52 Reliability Index (β) of Y_{Top} vs. COV (k) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.75 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'k' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.00E-09	0.000225	5%	0.0150	3.6333
1.60E-09	0.000225	10%	0.0150	3.6333
2.70E-09	0.000225	15%	0.0150	3.6333
5.63E-09	0.000225	20%	0.0150	3.6333
1.10E-08	0.000225	25%	0.0150	3.6332
1.56E-08	0.000225	30%	0.0150	3.6332
2.40E-08	0.000225	35%	0.0150	3.6331
3.61E-08	0.000225	40%	0.0150	3.6330

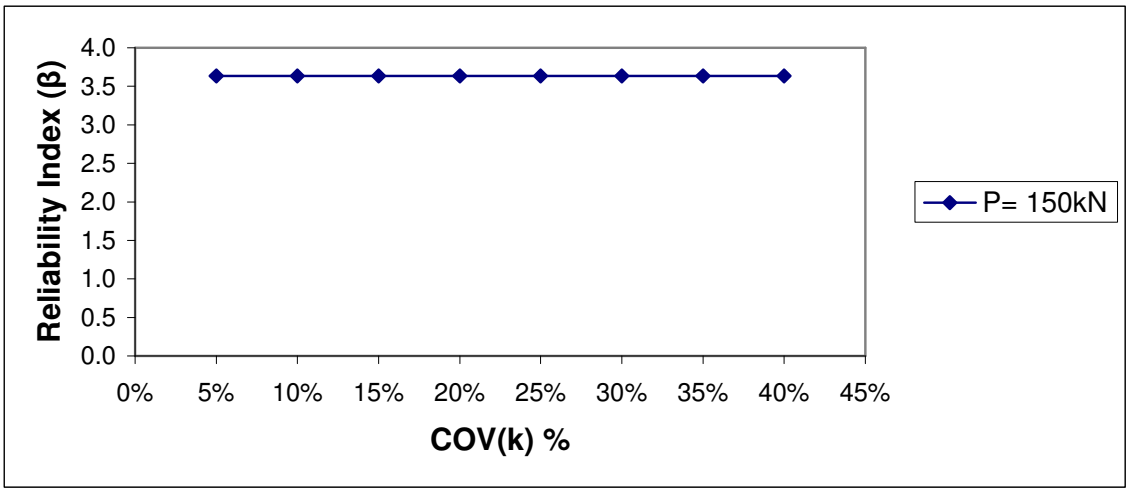


Fig. A.53 Reliability Index (β) of Y_{Top} vs. COV (k) for single free head long pile (10T) subjected to lateral force 150kN.

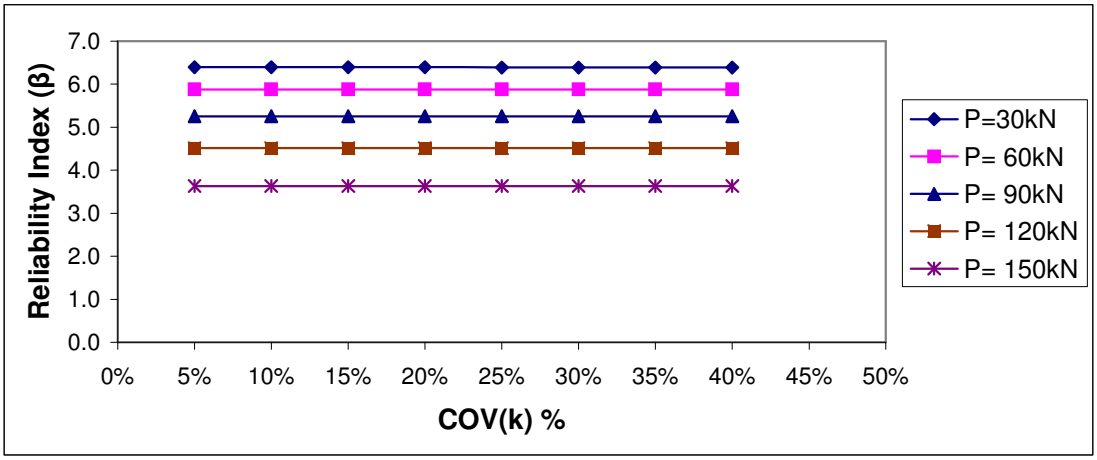


Fig. A.54 Reliability Index (β) of Y_{Top} vs. COV (k) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.76 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'B' subjected to lateral load 30kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.50E-09	0.000225	5%	0.0150	6.3913
1.00E-08	0.000225	10%	0.0150	6.3912
1.96E-09	0.000225	15%	0.0150	6.3913
2.25E-08	0.000225	20%	0.0150	6.3910
4.00E-08	0.000225	25%	0.0150	6.3908
9.00E-08	0.000225	30%	0.0150	6.3901
1.62E-07	0.000225	35%	0.0150	6.3890
1.60E-07	0.000225	40%	0.0150	6.3891

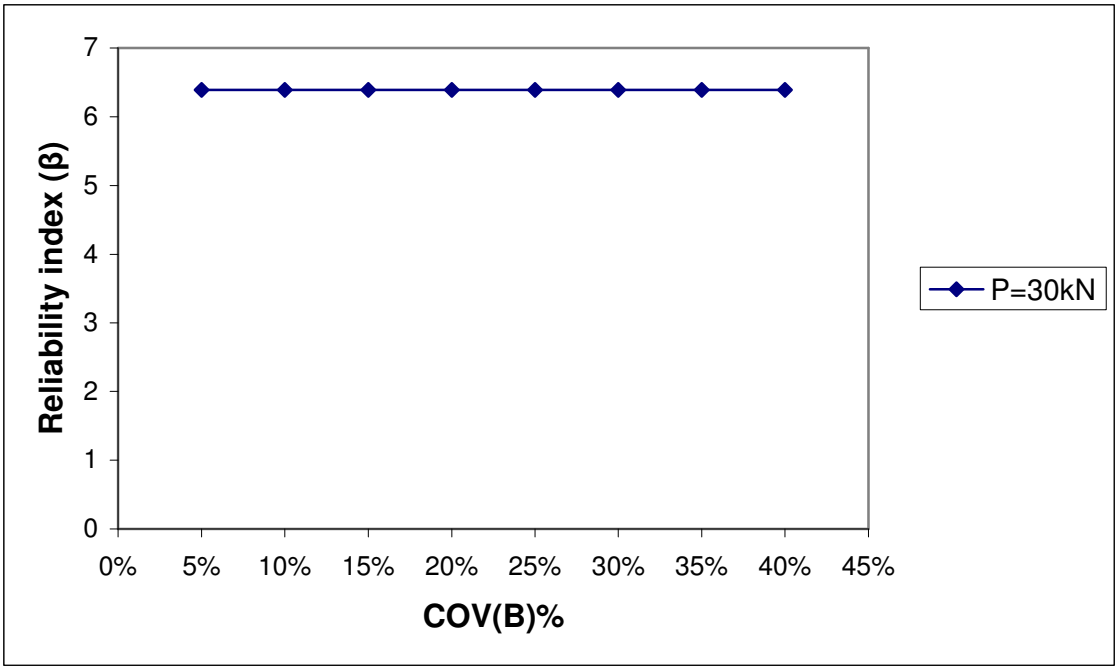


Fig. A.55 Reliability Index (β) of Y_{Top} vs. COV (B) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.77 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'B' subjected to lateral load 60kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.00E-08	0.000225	5%	0.0150	5.8799
2.25E-08	0.000225	10%	0.0150	5.8797
4.00E-08	0.000225	15%	0.0150	5.8795
1.23E-07	0.000225	20%	0.0150	5.8784
2.03E-07	0.000225	25%	0.0150	5.8774
2.50E-07	0.000225	30%	0.0150	5.8767
4.28E-07	0.000225	35%	0.0150	5.8744
7.23E-07	0.000225	40%	0.0150	5.8706

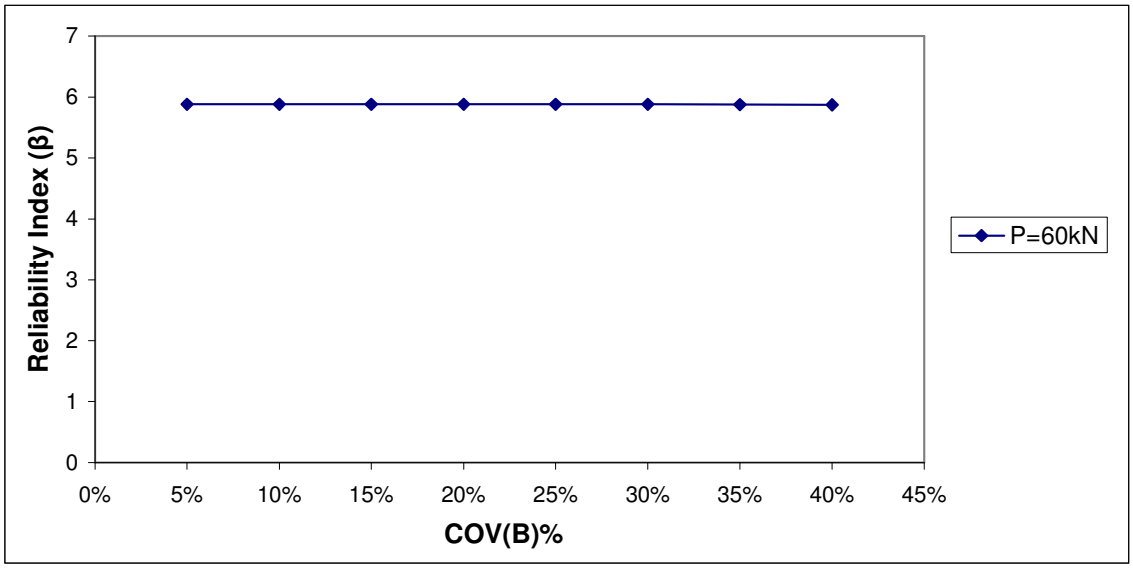


Fig. A.56 Reliability Index (β) of Y_{Top} vs. COV (B) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.78 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'B' subjected to lateral load 90kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.00E-08	0.000225	5%	0.0150	5.2532
1.56E-08	0.000225	10%	0.0150	5.2532
2.25E-08	0.000225	15%	0.0150	5.2531
4.00E-08	0.000225	20%	0.0150	5.2529
6.25E-08	0.000225	25%	0.0150	5.2526
1.23E-07	0.000225	30%	0.0150	5.2519
2.53E-07	0.000225	35%	0.0150	5.2504
4.23E-07	0.000225	40%	0.0150	5.2484

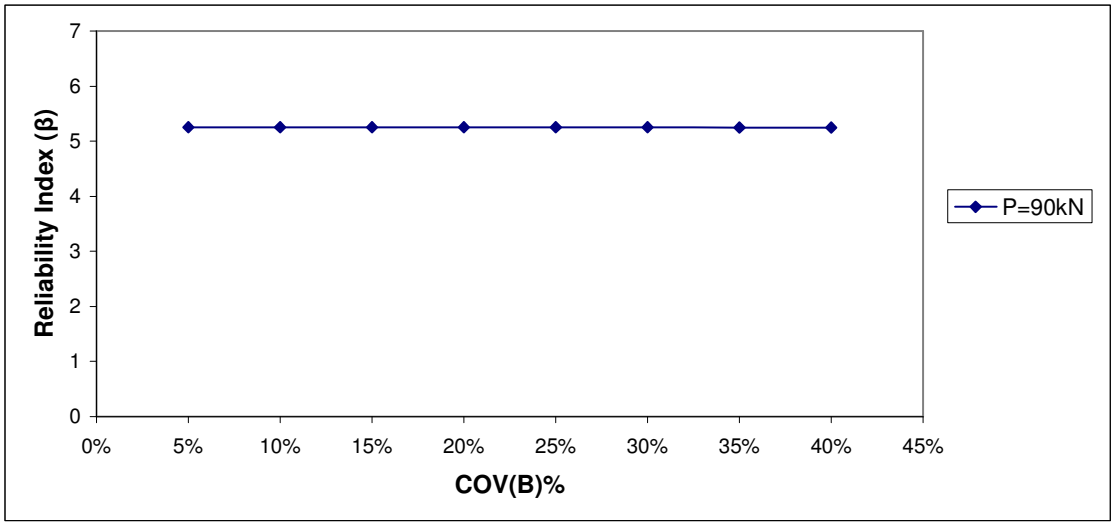


Fig. A.57 Reliability Index (β) of Y_{Top} vs. COV (B) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.79 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'B' subjected to lateral load 120kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.00E-08	0.000225	5%	0.01500	4.51323
4.00E-08	0.000225	10%	0.01500	4.51293
9.00E-08	0.000225	15%	0.01500	4.51243
1.23E-07	0.000225	20%	0.01500	4.51211
2.03E-07	0.000225	25%	0.01501	4.51130
2.50E-07	0.000225	30%	0.01501	4.51083
3.06E-07	0.000225	35%	0.01501	4.51026
4.23E-07	0.000225	40%	0.01501	4.50910

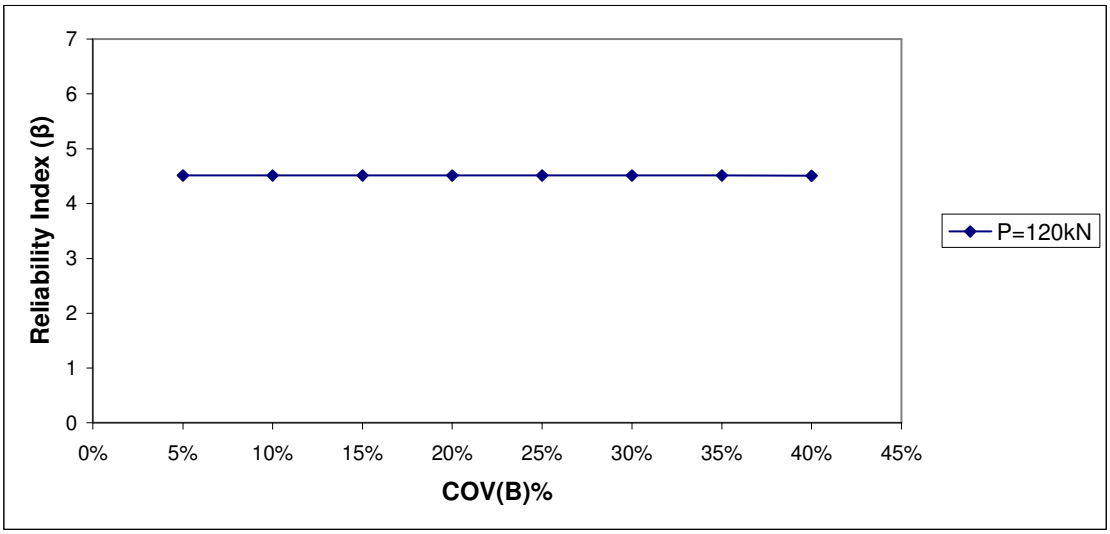


Fig. A.58 Reliability Index (β) of Y_{Top} vs. COV (B) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.80 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'B' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
8.10E-09	0.000225	5%	0.0150	3.6333
5.06E-08	0.000225	10%	0.0150	3.6329
9.61E-08	0.000225	15%	0.0150	3.6326
1.56E-07	0.000225	20%	0.0150	3.6321
2.35E-07	0.000225	25%	0.0150	3.6314
3.03E-07	0.000225	30%	0.0150	3.6309
3.53E-07	0.000225	35%	0.0150	3.6305
3.78E-07	0.000225	40%	0.0150	3.6303

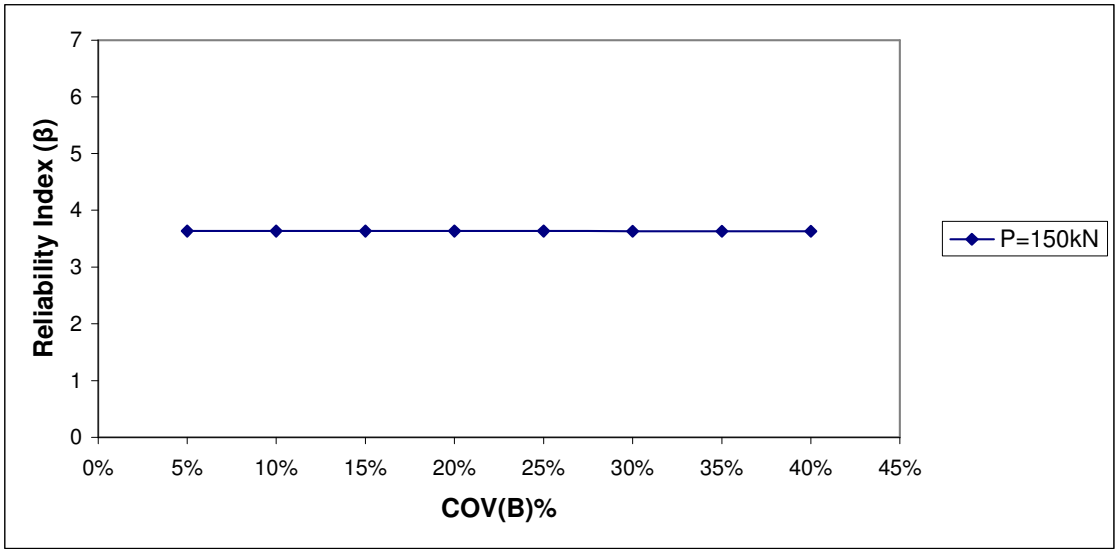


Fig. A.59 Reliability Index (β) of Y_{Top} vs. COV (B) for single free head long pile (10T) subjected to lateral force 150kN.

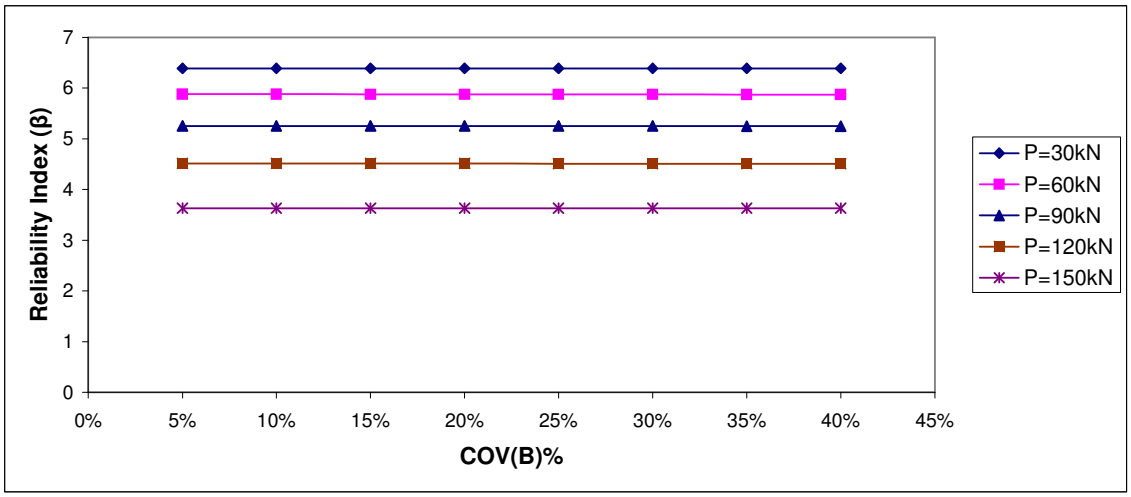


Fig. A.60 Reliability Index (β) of Y_{Top} vs. COV (B) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.81 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'EI' subjected to lateral load 30kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.23E-09	0.000225	5%	0.0150	6.3913
1.76E-08	0.000225	10%	0.0150	6.3911
1.23E-07	0.000225	15%	0.0150	6.3896
6.05E-07	0.000225	20%	0.0150	6.3828
3.30E-07	0.000225	25%	0.0150	6.3867
9.26E-07	0.000225	30%	0.0150	6.3782
1.13E-06	0.000225	35%	0.0150	6.3754
1.36E-06	0.000225	40%	0.0150	6.3721

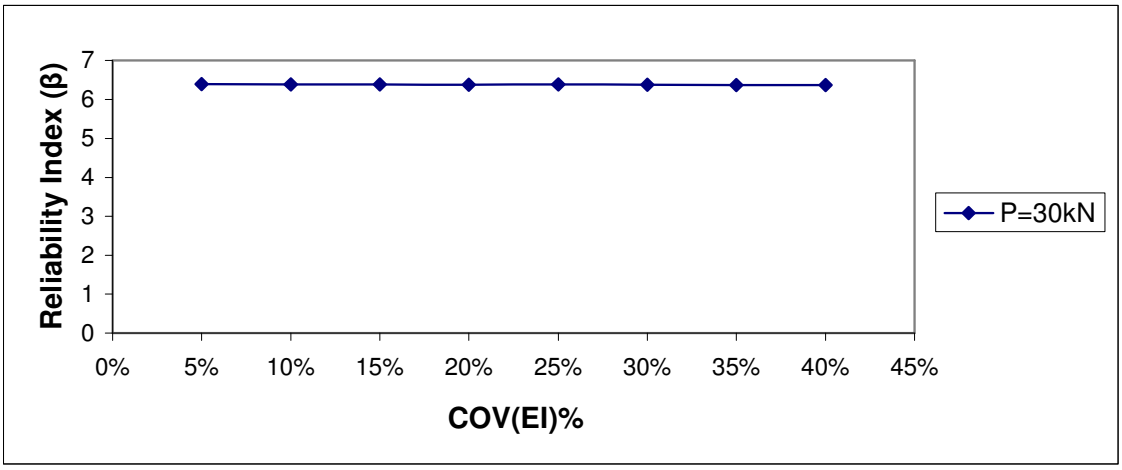


Fig. A.61 Reliability Index (β) of Y_{Top} vs. COV (EI) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.82 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'EI' subjected to lateral load 60kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.06E-08	0.000225	5%	0.0150	5.8796
1.60E-07	0.000225	10%	0.0150	5.8779
1.13E-06	0.000225	15%	0.0150	5.8652
5.30E-06	0.000225	20%	0.0152	5.8119
2.88E-06	0.000225	25%	0.0151	5.7800
7.91E-06	0.000225	30%	0.0153	5.7793
9.62E-06	0.000225	35%	0.0153	5.7582
1.17E-05	0.000225	40%	0.0154	5.7325

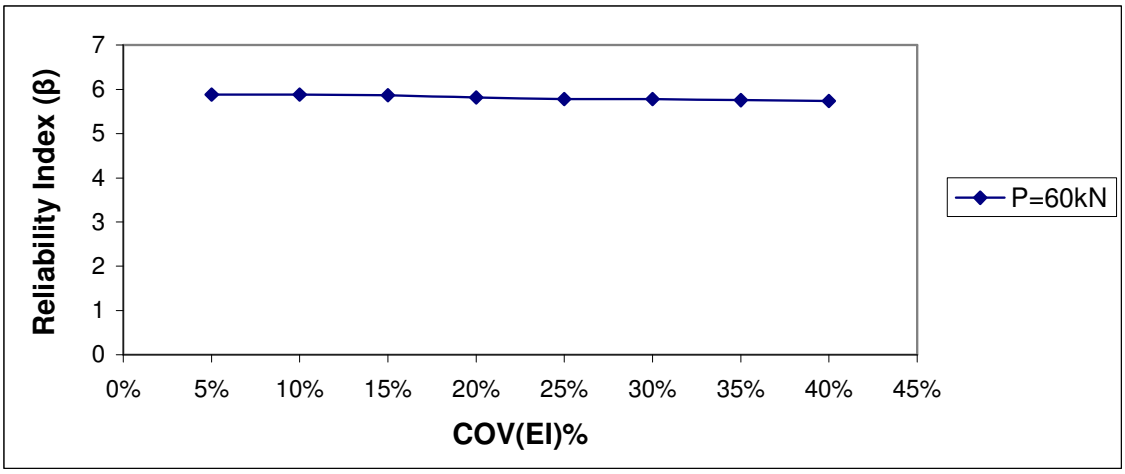


Fig. A.62 Reliability Index (β) of Y_{Top} vs. COV (EI) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.83 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'EI' subjected to lateral load 90kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.00E-08	0.000225	5%	0.0150	5.2532
2.10E-07	0.000225	10%	0.0150	5.2509
2.25E-07	0.000225	15%	0.0150	5.2507
1.79E-06	0.000225	20%	0.0151	5.2326
9.73E-06	0.000225	25%	0.0153	5.1433
2.73E-05	0.000225	30%	0.0159	4.9610
3.39E-05	0.000225	35%	0.0161	4.8972
4.19E-05	0.000225	40%	0.0163	4.8232

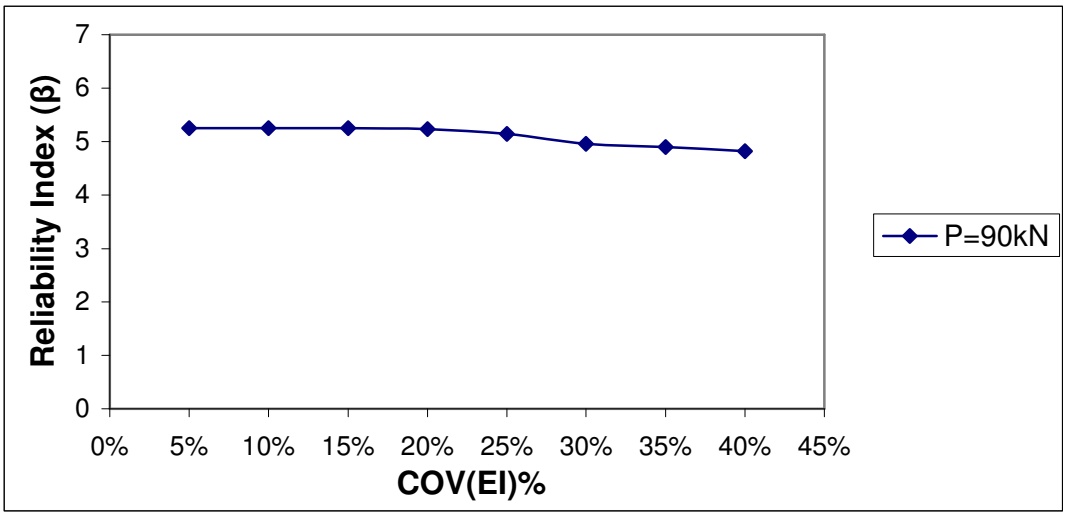


Fig. A.63 Reliability Index (β) of Y_{Top} vs. COV (EI) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.84 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'EI' subjected to lateral load 120kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.31E-07	0.000225	5%	0.0150	4.5100
1.32E-06	0.000225	10%	0.0150	4.5001
9.00E-06	0.000225	15%	0.0153	4.4256
4.76E-05	0.000225	20%	0.0165	4.2500
2.63E-05	0.000225	25%	0.0159	4.0600
7.44E-05	0.000225	30%	0.0173	3.9126
9.26E-05	0.000225	35%	0.0178	3.7988
1.16E-04	0.000225	40%	0.0185	3.6685

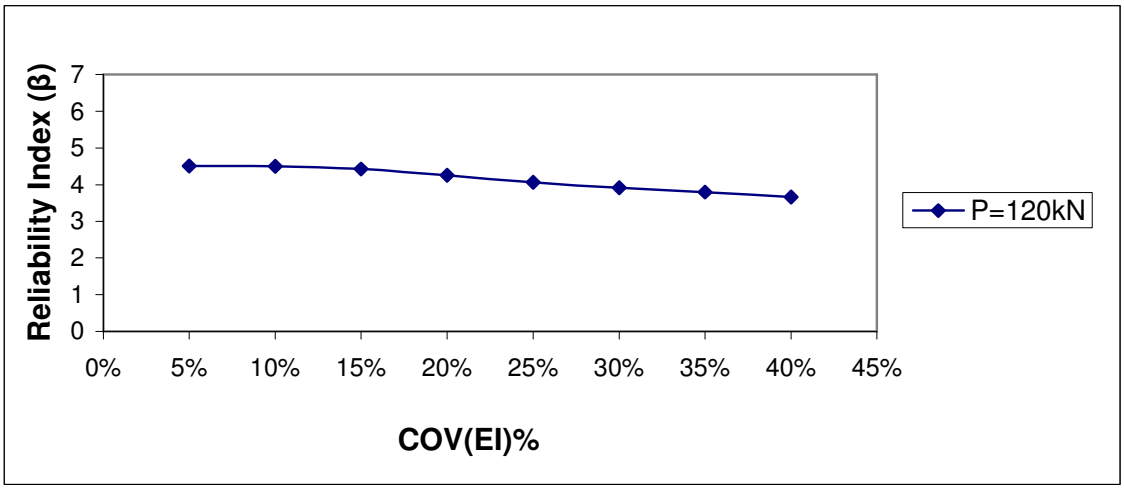


Fig. A.64 Reliability Index (β) of Y_{Top} vs. COV (EI) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.85 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'EI' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.81E-07	0.000225	5%	0.0150	3.6279
2.98E-06	0.000225	10%	0.0151	3.6095
2.05E-05	0.000225	15%	0.0157	3.4784
1.12E-04	0.000225	20%	0.0184	3.2200
6.19E-05	0.000225	25%	0.0169	2.9800
1.76E-04	0.000225	30%	0.0200	2.7231
2.19E-04	0.000225	35%	0.0211	2.5866
2.74E-04	0.000225	40%	0.0223	2.4400

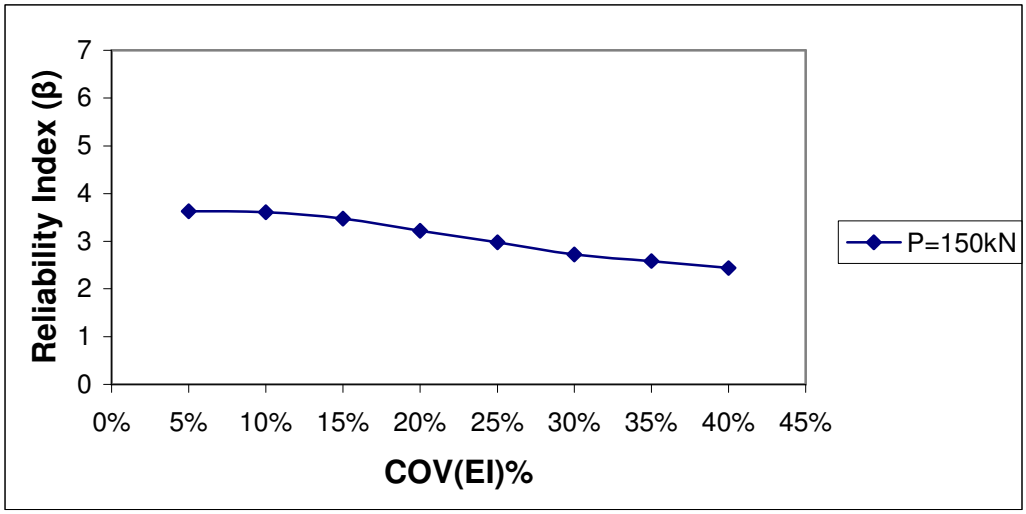


Fig. A.65 Reliability Index (β) of Y_{Top} vs. COV (EI) for single free head long pile (10T) subjected to lateral force 150kN.

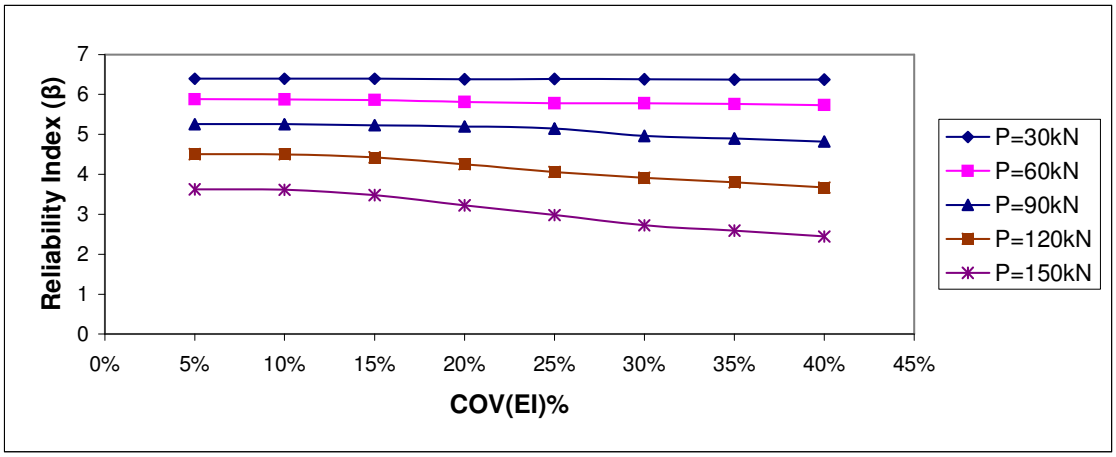


Fig. A.66 Reliability Index (β) of Y_{Top} vs. COV (EI) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.86 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'P' subjected to lateral load 30kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.02E-07	0.000225	5%	0.0150	6.3899
4.10E-07	0.000225	10%	0.0150	6.3855
9.31E-07	0.000225	15%	0.0150	6.3781
1.64E-06	0.000225	20%	0.0151	6.3682
2.50E-06	0.000225	25%	0.0151	6.3562
3.59E-06	0.000225	30%	0.0151	6.3409
4.91E-06	0.000225	35%	0.0152	6.3228
6.38E-06	0.000225	40%	0.0152	6.3027

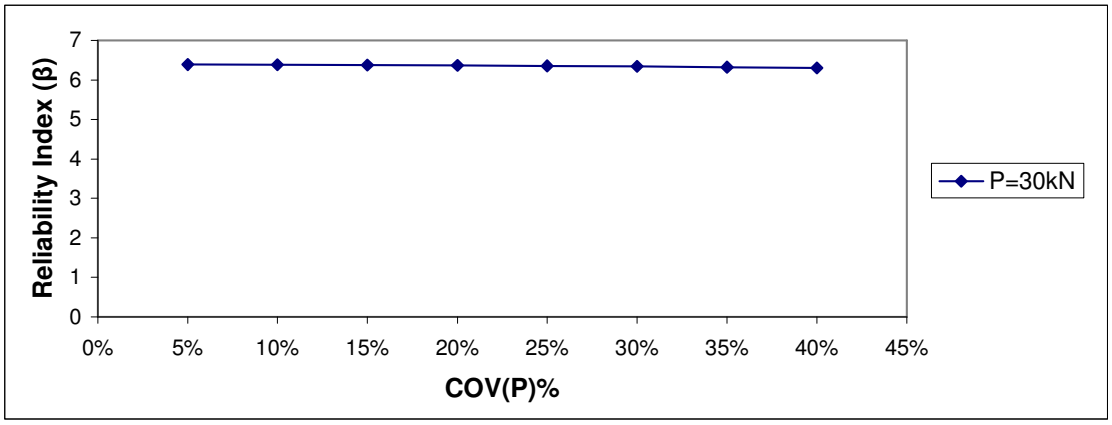


Fig. A.67 Reliability Index (β) of Y_{Top} vs. COV (P) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.87 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'P' subjected to lateral load 60kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
7.23E-07	0.000225	5%	0.0150	5.8706
3.06E-06	0.000225	10%	0.0151	5.8404
6.79E-06	0.000225	15%	0.0152	5.7933
1.20E-05	0.000225	20%	0.0154	5.7295
1.90E-05	0.000225	25%	0.0156	5.6468
2.69E-05	0.000225	30%	0.0159	5.5574
3.67E-05	0.000225	35%	0.0162	5.4525
4.71E-05	0.000225	40%	0.0165	5.3473

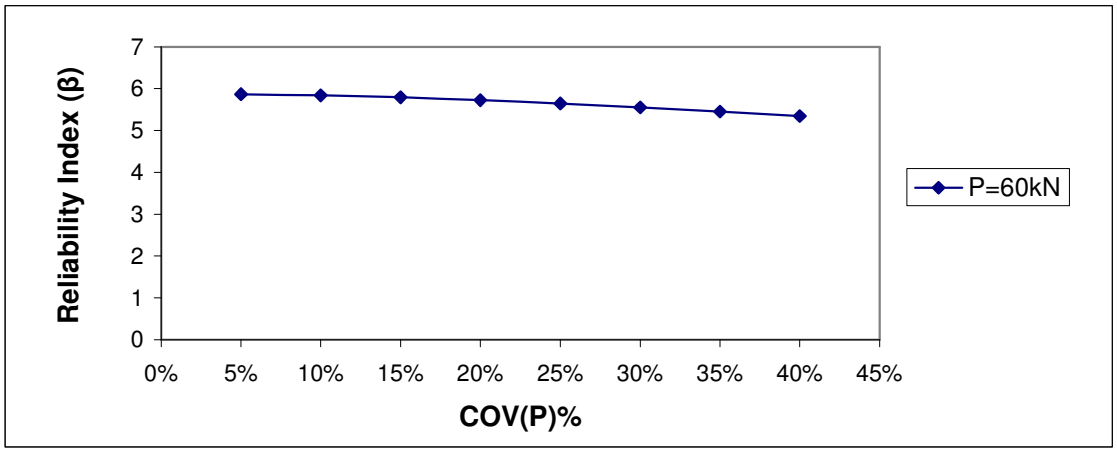


Fig. A.68 Reliability Index (β) of Y_{Top} vs. COV (P) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.88 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'P' subjected to lateral load 90kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.40E-06	0.000225	5%	0.0151	5.2255
9.30E-06	0.000225	10%	0.0153	5.1480
2.12E-05	0.000225	15%	0.0157	5.0225
3.72E-05	0.000225	20%	0.0162	4.8663
5.85E-05	0.000225	25%	0.0168	4.6799
8.46E-05	0.000225	30%	0.0176	4.4781
1.16E-04	0.000225	35%	0.0185	4.2700
1.51E-04	0.000225	40%	0.0194	4.0622

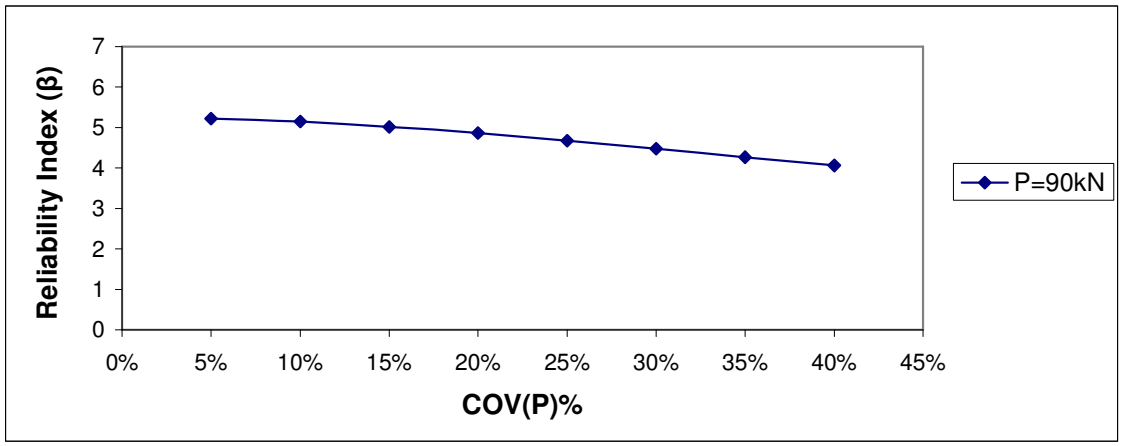


Fig. A.69 Reliability Index (β) of Y_{Top} vs. COV (P) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.89 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'P' subjected to lateral load 120kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.76E-06	0.000225	5%	0.0152	4.4566
2.35E-05	0.000225	10%	0.0158	4.2944
5.33E-05	0.000225	15%	0.0167	4.0583
9.41E-05	0.000225	20%	0.0179	3.7899
1.48E-04	0.000225	25%	0.0193	3.5071
2.15E-04	0.000225	30%	0.0210	3.2289
2.92E-04	0.000225	35%	0.0227	2.9763
3.88E-04	0.000225	40%	0.0248	2.7342

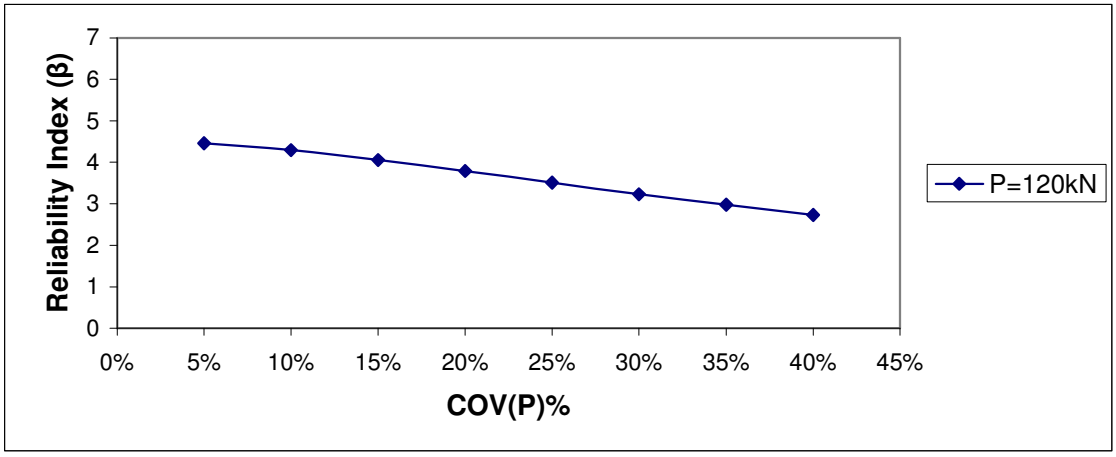


Fig. A.70 Reliability Index (β) of Y_{Top} vs. COV (P) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.90 Reliability Index (β) connected to Y_{Top} for free head single long (10T) pile with varying 'P' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.30E-05	0.000225	5%	0.0154	3.5330
5.26E-05	0.000225	10%	0.0167	3.2713
1.19E-04	0.000225	15%	0.0185	2.9393
2.12E-04	0.000225	20%	0.0209	2.6080
3.33E-04	0.000225	25%	0.0236	2.3070
4.80E-04	0.000225	30%	0.0265	2.0532
6.60E-04	0.000225	35%	0.0298	1.8315
8.67E-04	0.000225	40%	0.0331	1.6490

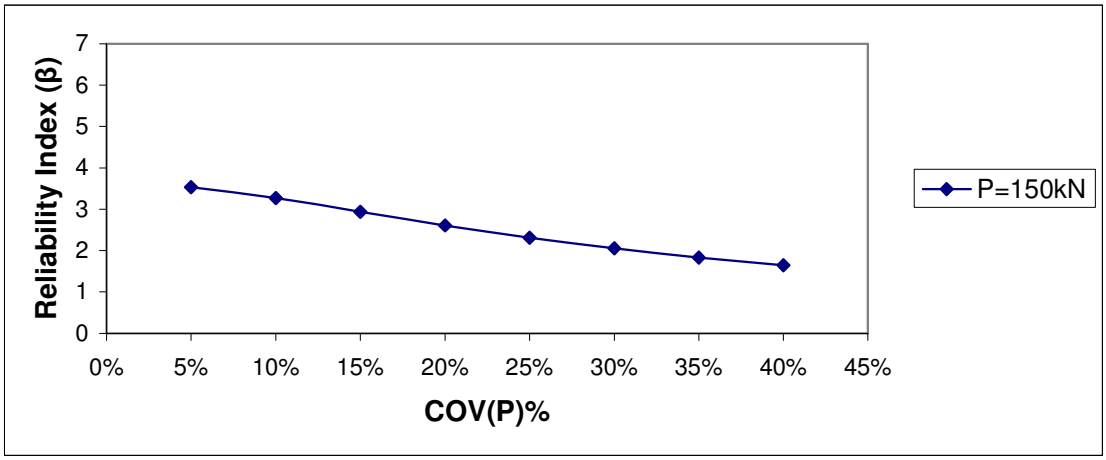


Fig. A.71 Reliability Index (β) of Y_{Top} vs. COV (P) for single free head long pile (10T) subjected to lateral force 150kN.

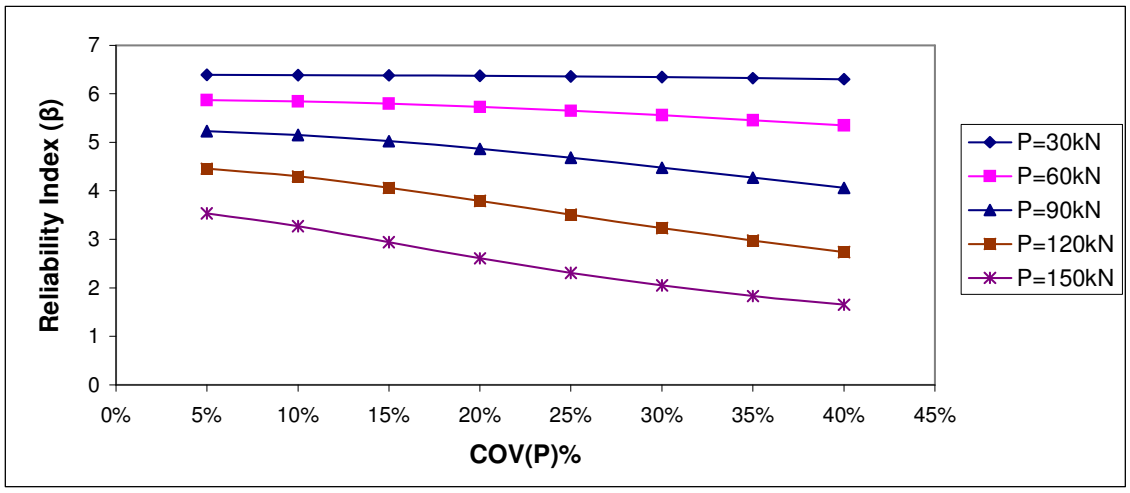


Fig. A.72 Reliability Index (β) of Y_{Top} vs. COV (P) for single free head long pile (10T) subjected to lateral force of discrete variability.

A.3 Probability of failure, $p_f(Y_{Top})$ of top deflection Y_{Top} vs. COV (Variables).

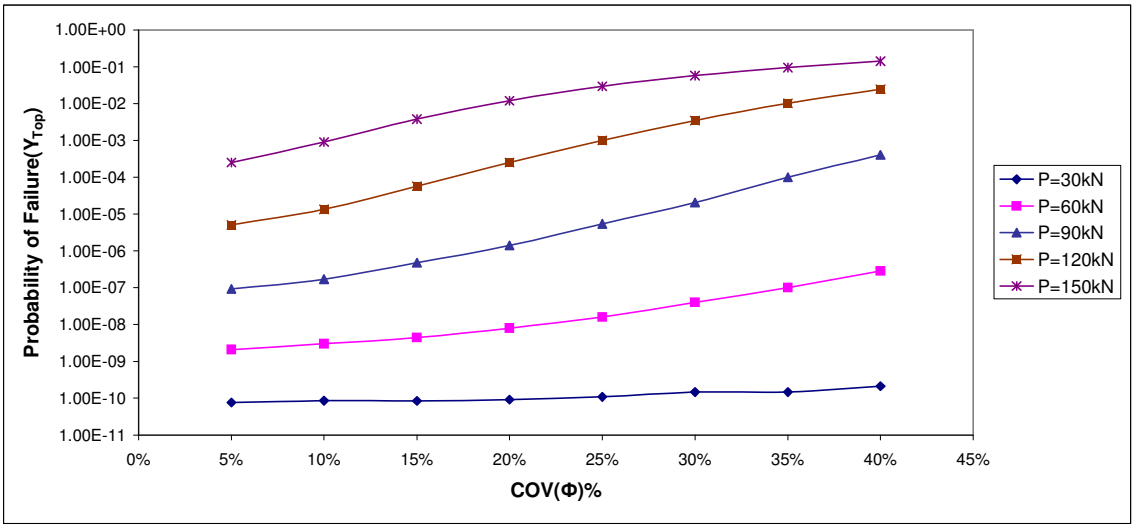


Fig. A.73 Probability of failure of top deflection $p_f(Y_{Top})$ vs. COV(Φ) for single free head long pile of length 10T.

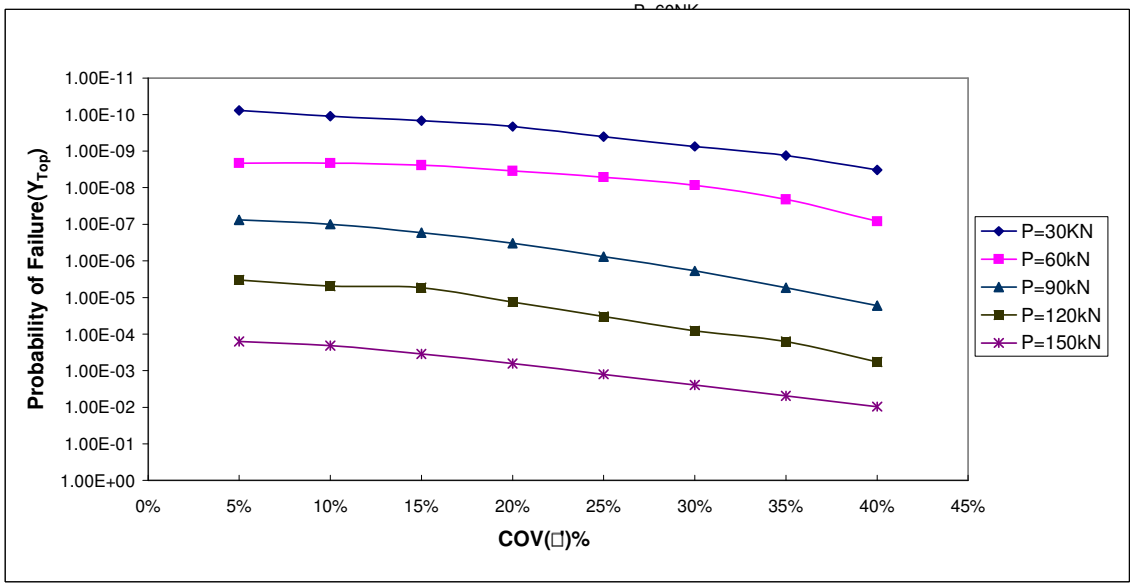


Fig. A.74 Probability of failure of top deflection $p_f(Y_{Top})$ vs. COV(γ) for single free head . long pile of length 10T.

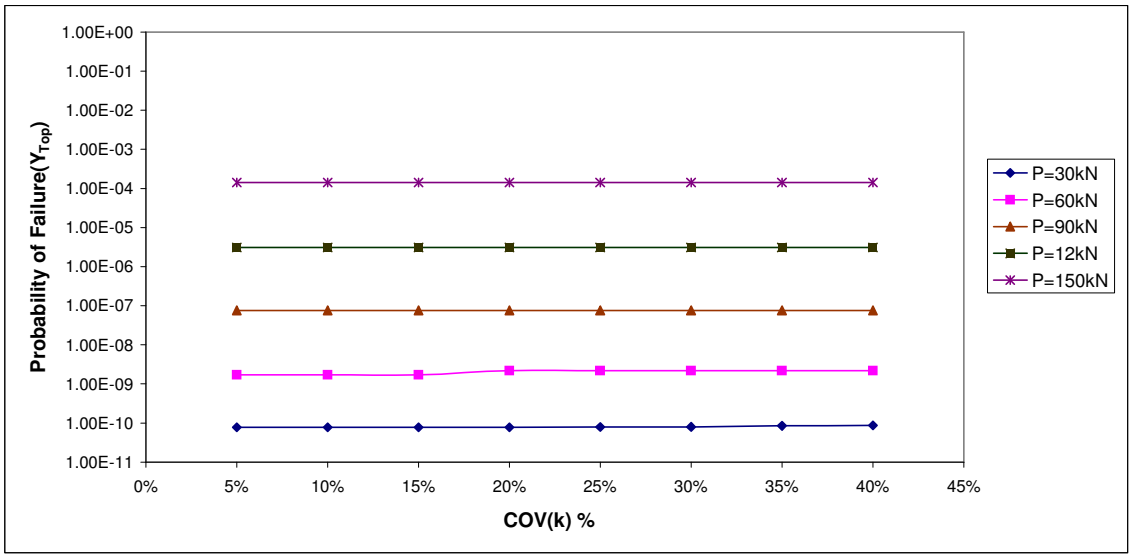


Fig. A.75 74 Probability of failure of top deflection $p_f(Y_{Top})$ vs. COV (k) for single free head long pile of length 10T.

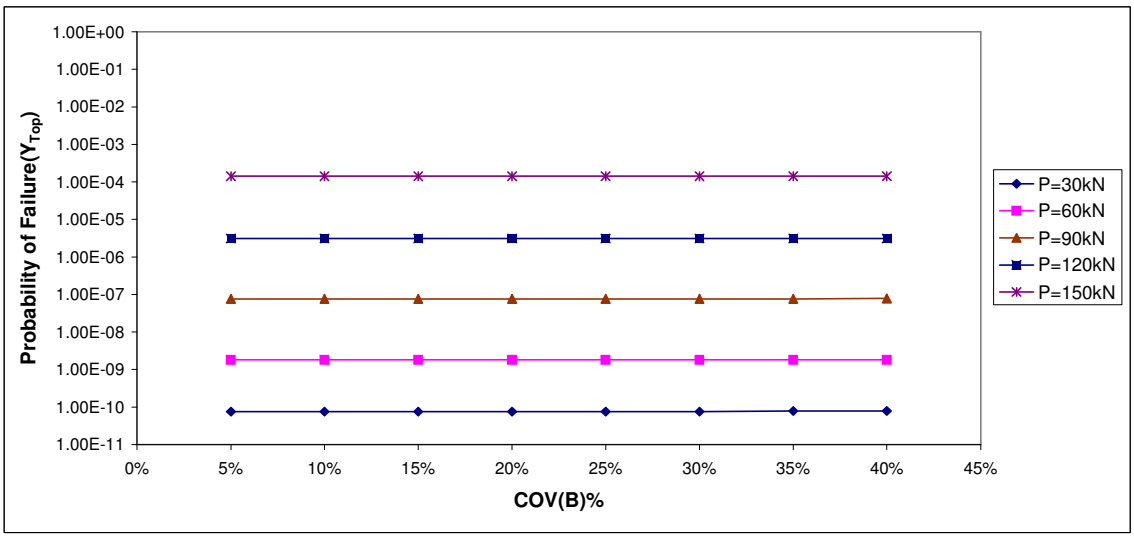


Fig. A.76 Probability of failure of top deflection $p_f(Y_{Top})$ vs. COV (B) for single free head long pile of length 10T.

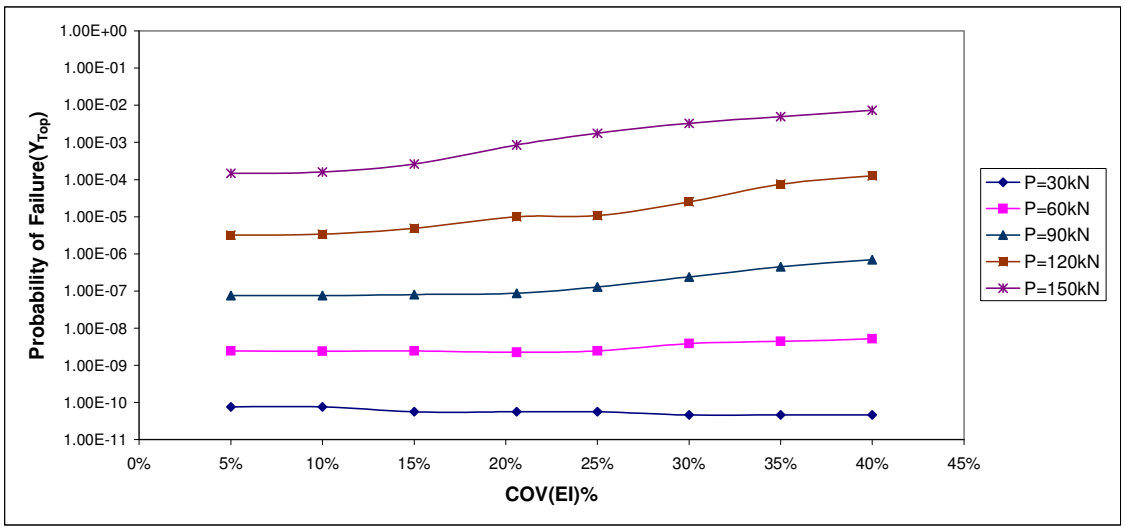


Fig. A.77 Probability of failure of top deflection $p_f(Y_{Top})$ vs. COV (EI) for single free head long pile of length 10T.

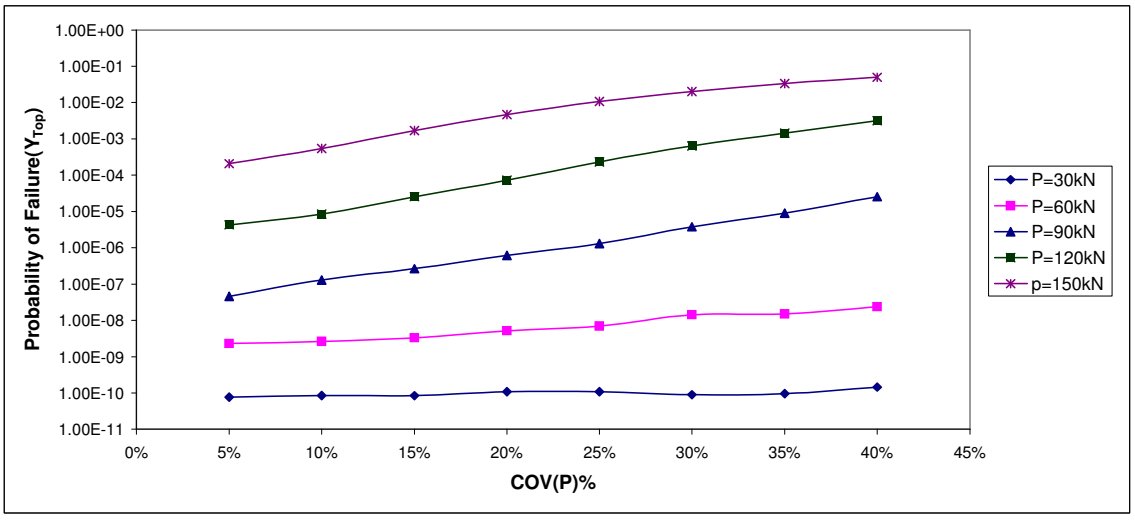


Fig. A.78 Probability of failure of top deflection $p_f(Y_{Top})$ vs. COV (P) for single free head long pile of length 10T.

A.4 Moment of free head single long pile and coefficient of (M_{max}) vs. COV (Variables).

Table A.91 Probabilistic modeling of laterally loaded free head long pile 10T with varying (Φ) and load 30kN.

P=30kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	3.77E+01				
5%	30			2.25E+00	2.50E+01	3.94E+01	3.23%
		28.5	4.13E+01				
		33	3.61E+01				
10%	30			9.00E+00	1.10E+02	3.94E+01	6.77%
		27	4.31E+01				
		34.5	3.44E+01				
15%	30			2.03E+01	2.56E+02	3.94E+01	10.32%
		25.5	4.49E+01				
		36	3.36E+01				
20%	30			3.60E+01	4.84E+02	3.94E+01	14.19%
		24	4.70E+01				
		37.5	3.29E+01				
25%	30			5.63E+01	7.56E+02	3.94E+01	17.96%
		22.5	4.88E+01				
		39	3.24E+01				
30%	30			8.10E+01	1.16E+03	3.94E+01	21.94%
		21	5.10E+01				
		40.5	3.20E+01				
35%	30			1.10E+02	1.64E+03	3.94E+01	26.13%
		19.5	5.31E+01				
		42	3.15E+01				
40%	30			1.44E+02	2.26E+03	3.94E+01	30.65%
		18	5.53E+01				

Table A.92 Probabilistic modeling of laterally loaded free head long pile 10T with varying (Φ) and load 60kN.

P=60kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	9.13E+01				
5%	30			2.25E+00	1.30E+01	9.51E+01	3.79%
		28.5	9.85E+01				
		33	8.79E+01				
10%	30			9.00E+00	4.97E+01	9.51E+01	7.41%
		27	1.02E+02				
		34.5	8.45E+01				
15%	30			2.03E+01	1.16E+02	9.51E+01	11.30%
		25.5	1.06E+02				
		36	8.08E+01				
20%	30			3.60E+01	1.99E+02	9.51E+01	14.83%
		24	1.09E+02				
		37.5	7.75E+01				
25%	30			5.63E+01	3.15E+02	9.51E+01	18.66%
		22.5	1.13E+02				
		39	7.41E+01				
30%	30			8.10E+01	4.60E+02	9.51E+01	22.56%
		21	1.17E+02				
		40.5	7.06E+01				
35%	30			1.10E+02	6.35E+02	9.51E+01	27.00%
		19.5	1.21E+02				
		42	6.85E+01				
40%	30			1.44E+02	8.27E+02	9.51E+01	31.17%
		18	1.26E+02				

Table A.93 Probabilistic modeling of laterally loaded free head long pile 10T with varying

(Φ) and load 90kN.

P=90kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	1.50E+02				
5%	30			2.25E+00	5.63E+01	1.55E+02	3.41%
		28.5	1.60E+02				
		33	1.45E+02				
10%	30			9.00E+00	2.56E+02	1.55E+02	7.27%
		27	1.66E+02				
		34.5	1.39E+02				
15%	30			2.03E+01	5.76E+02	1.55E+02	10.91%
		25.5	1.71E+02				
		36	1.34E+02				
20%	30			3.60E+01	1.09E+03	1.55E+02	15.00%
		24	1.78E+02				
		37.5	1.29E+02				
25%	30			5.63E+01	1.81E+03	1.55E+02	19.32%
		22.5	1.84E+02				
		39	1.24E+02				
30%	30			8.10E+01	2.65E+03	1.55E+02	23.41%
		21	1.92E+02				
		40.5	1.19E+02				
35%	30			1.10E+02	3.84E+03	1.55E+02	28.18%
		19.5	2.00E+02				
		42	1.14E+02				
40%	30			1.44E+02	5.33E+03	1.55E+02	33.18%
		18	2.09E+02				

Table A.94 Probabilistic modeling of laterally loaded free head long pile 10T with varying (Φ) and load 120kN.

P=120kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	2.12E+02				
5%	30			2.25E+00	3.24E+00	2.20E+02	3.80%
		28.5	2.27E+02				
		33	2.04E+02				
10%	30			9.00E+00	1.23E+01	2.20E+02	8.10%
		27	2.36E+02				
		34.5	1.98E+02				
15%	30			2.03E+01	2.76E+01	2.20E+02	11.73%
		25.5	2.46E+02				
		36	1.90E+02				
20%	30			3.60E+01	4.49E+01	2.20E+02	15.80%
		24	2.56E+02				
		37.5	1.83E+02				
25%	30			5.63E+01	6.32E+01	2.20E+02	20.18%
		22.5	2.68E+02				
		39	1.77E+02				
30%	30			8.10E+01	8.65E+01	2.20E+02	24.42%
		21	2.80E+02				
		40.5	1.70E+02				
35%	30			1.10E+02	1.11E+02	2.20E+02	27.24%
		19.5	2.94E+02				
		42	1.63E+02				
40%	30			1.44E+02	1.42E+02	2.20E+02	33.62%
		18	3.09E+02				

Table A.95 Probabilistic modeling of laterally loaded free head long pile 10T with varying (Φ) and load 150kN.

P=150kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	2.81E+02				
5%	30			2.25E+00	1.32E+02	2.91E+02	3.95%
		28.5	3.04E+02				
		33	2.70E+02				
10%	30			9.00E+00	5.29E+02	2.91E+02	8.39%
		27	3.16E+02				
		34.5	2.60E+02				
15%	30			2.03E+01	1.26E+03	2.91E+02	12.17%
		25.5	3.31E+02				
		36	2.51E+02				
20%	30			3.60E+01	2.26E+03	2.91E+02	16.32%
		24	3.46E+02				
		37.5	2.41E+02				
25%	30			5.63E+01	3.66E+03	2.91E+02	20.79%
		22.5	3.62E+02				
		39	2.32E+02				
30%	30			8.10E+01	5.48E+03	2.91E+02	25.43%
		21	3.80E+02				
		40.5	2.24E+02				
35%	30			1.10E+02	7.66E+03	2.91E+02	30.07%
		19.5	3.99E+02				
		42	2.15E+02				
40%	30			1.44E+02	1.06E+04	2.91E+02	35.40%
		18	4.21E+02				

Table A.96 Value of COV (M_{max}) for free head long pile with varying COV(Φ) and lateral load 30kN.

P=30kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) (kN-m)2	COV (M_{max}) (%)
5%	2.25E+00	2.50E+01	3.23%
10%	9.00E+00	1.10E+02	6.77%
15%	2.03E+01	2.56E+02	10.32%
20%	3.60E+01	4.84E+02	14.19%
25%	5.63E+01	7.56E+02	17.96%
30%	8.10E+01	1.16E+03	21.94%
35%	1.10E+02	1.64E+03	26.13%
40%	1.44E+02	2.26E+03	30.65%

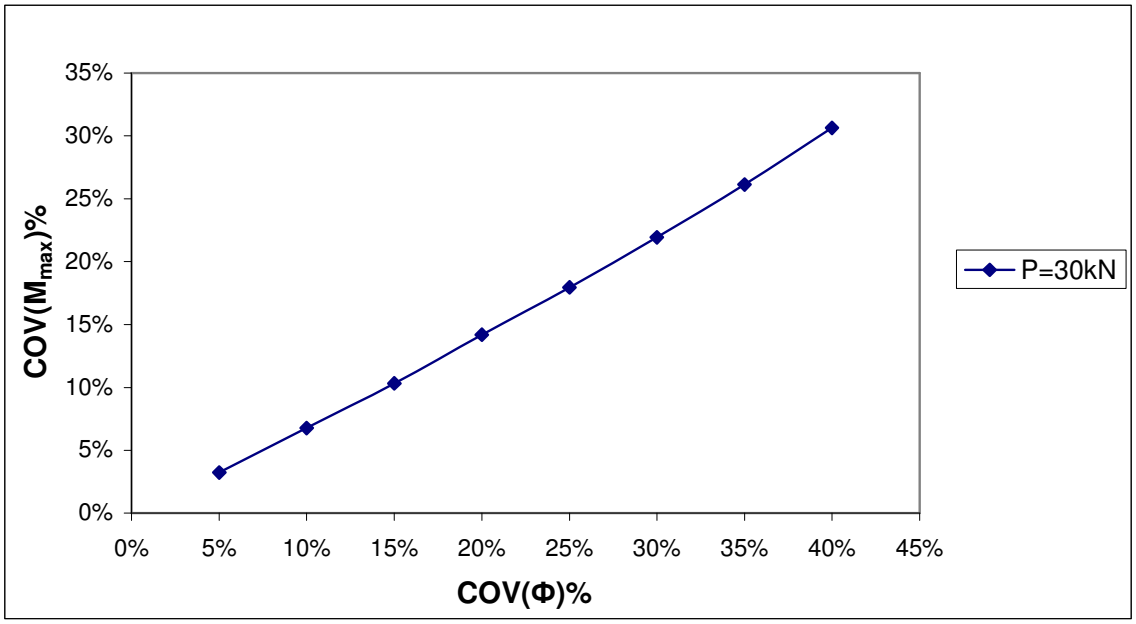


Fig. A.79 Variability of COV(M_{max}) vs. COV(Φ) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.97 Value of COV (M_{max}) for free head long pile with varying COV(Φ) and lateral load 60kN.

P=60kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) (kN-m)2	COV (M_{max}) (%)
5%	2.25E+00	1.30E+01	3.79%
10%	9.00E+00	4.97E+01	7.41%
15%	2.03E+01	1.16E+02	11.30%
20%	3.60E+01	1.99E+02	14.83%
25%	5.63E+01	3.15E+02	18.66%
30%	8.10E+01	4.60E+02	22.56%
35%	1.10E+02	6.35E+02	27.00%
40%	1.44E+02	8.27E+02	31.17%

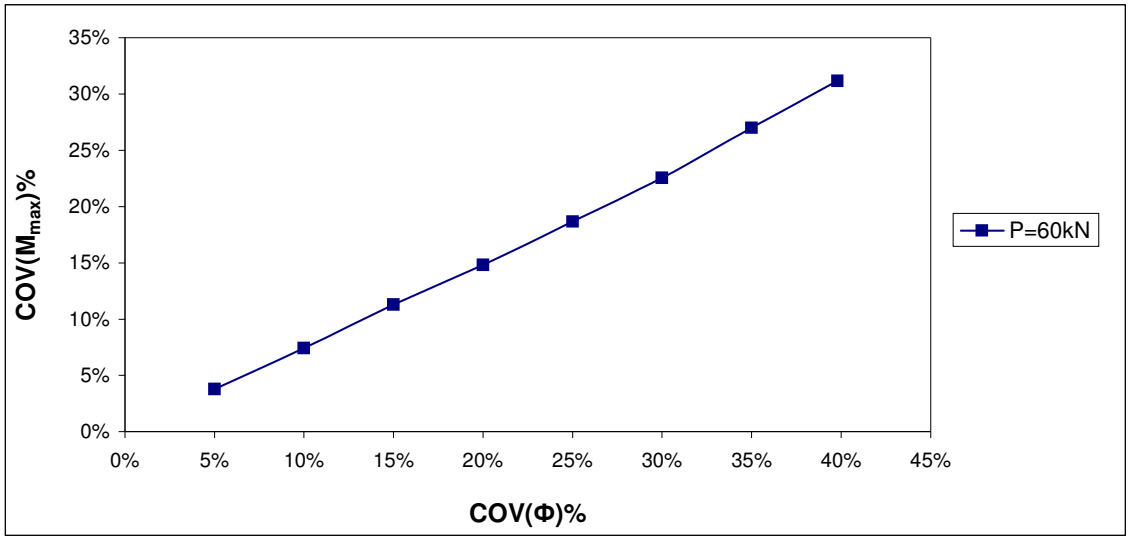


Fig. A.80 Variability of COV(M_{max}) vs. COV(Φ) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.98 Value of COV (M_{max}) for free head long pile with varying COV(Φ) and lateral load 90kN.

P=90kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) (kN-m)2	COV (M_{max}) (%)
5%	2.25E+00	5.63E+01	3.41%
10%	9.00E+00	2.56E+02	7.27%
15%	2.03E+01	5.76E+02	10.91%
20%	3.60E+01	1.09E+03	15.00%
25%	5.63E+01	1.81E+03	19.32%
30%	8.10E+01	2.65E+03	23.41%
35%	1.10E+02	3.84E+03	28.18%
40%	1.44E+02	5.33E+03	33.18%

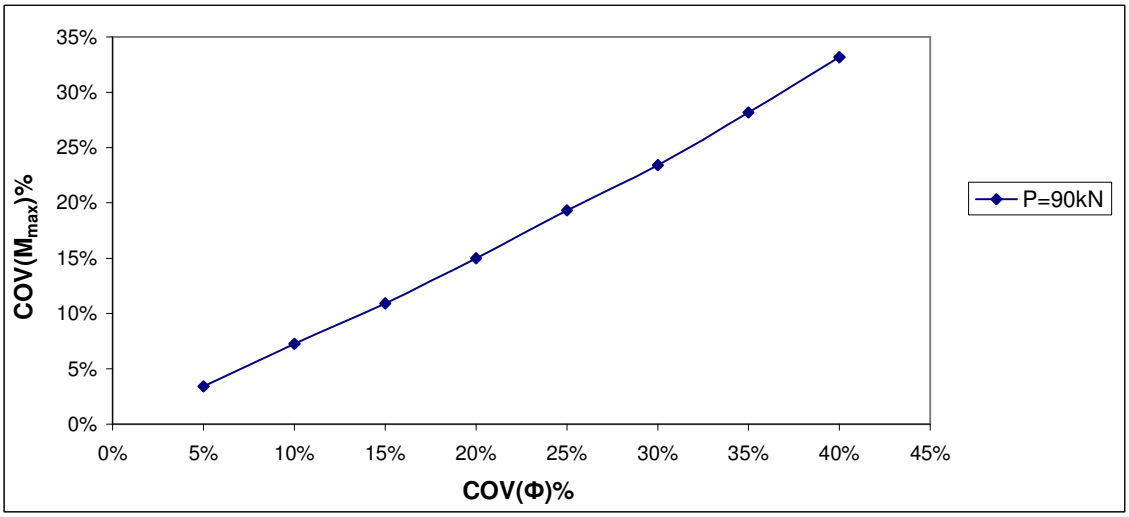


Fig. A.81 Variability of COV(M_{max}) vs. COV(Φ) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.99 Value of COV(M_{max}) for free head long pile with varying COV(Φ) and lateral load 120kN.

P=120kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) (kN-m)2	COV (M_{max}) (%)
5%	2.25E+00	3.24E+00	3.80%
10%	9.00E+00	1.23E+01	8.10%
15%	2.03E+01	2.76E+01	11.73%
20%	3.60E+01	4.49E+01	15.80%
25%	5.63E+01	6.32E+01	20.18%
30%	8.10E+01	8.65E+01	24.42%
35%	1.10E+02	1.11E+02	27.24%
40%	1.44E+02	1.42E+02	33.62%

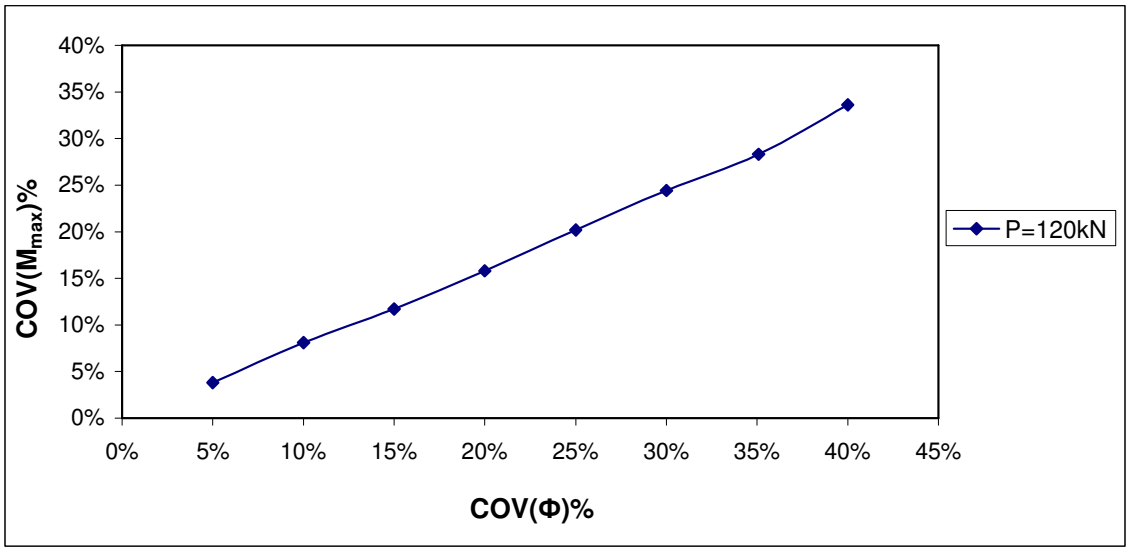


Fig. A.82 Variability of COV(M_{max}) vs. COV(Φ) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.100 Value of COV(M_{max}) for free head long pile with varying COV(Φ) and lateral load 150kN.

P=150kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) (kN-m)2	COV (M_{max}) (%)
5%	2.25E+00	1.32E+02	3.95%
10%	9.00E+00	5.29E+02	8.39%
15%	2.03E+01	1.26E+03	12.17%
20%	3.60E+01	2.26E+03	16.32%
25%	5.63E+01	3.66E+03	20.79%
30%	8.10E+01	5.48E+03	25.43%
35%	1.10E+02	7.66E+03	30.07%
40%	1.44E+02	1.06E+04	35.40%

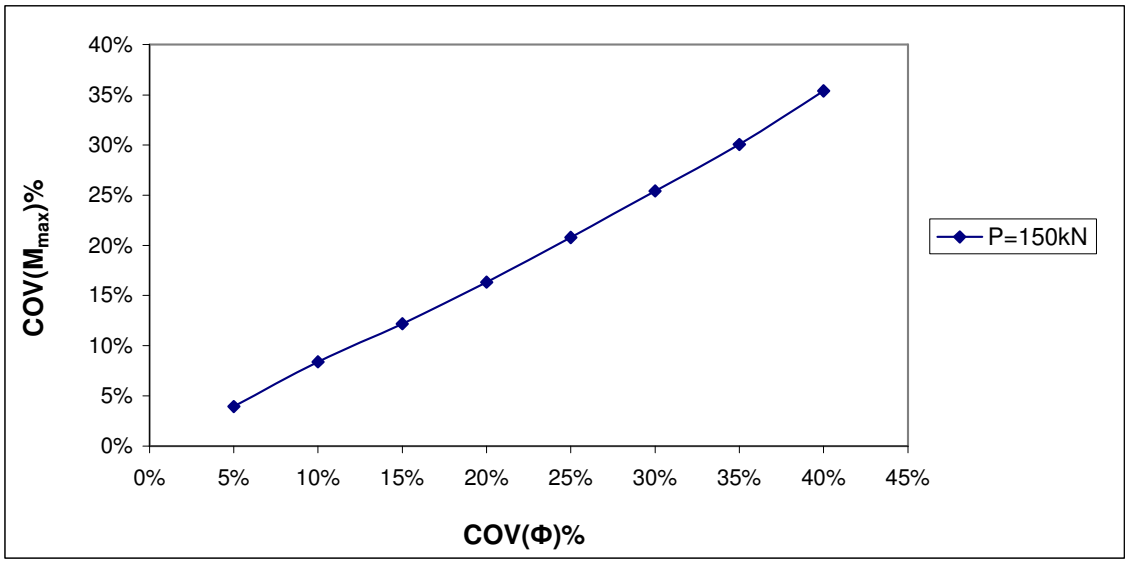


Fig. A.83 Variability of COV(M_{max}) vs. COV(Φ) for single free head long pile (10T) subjected to lateral force 150kN.

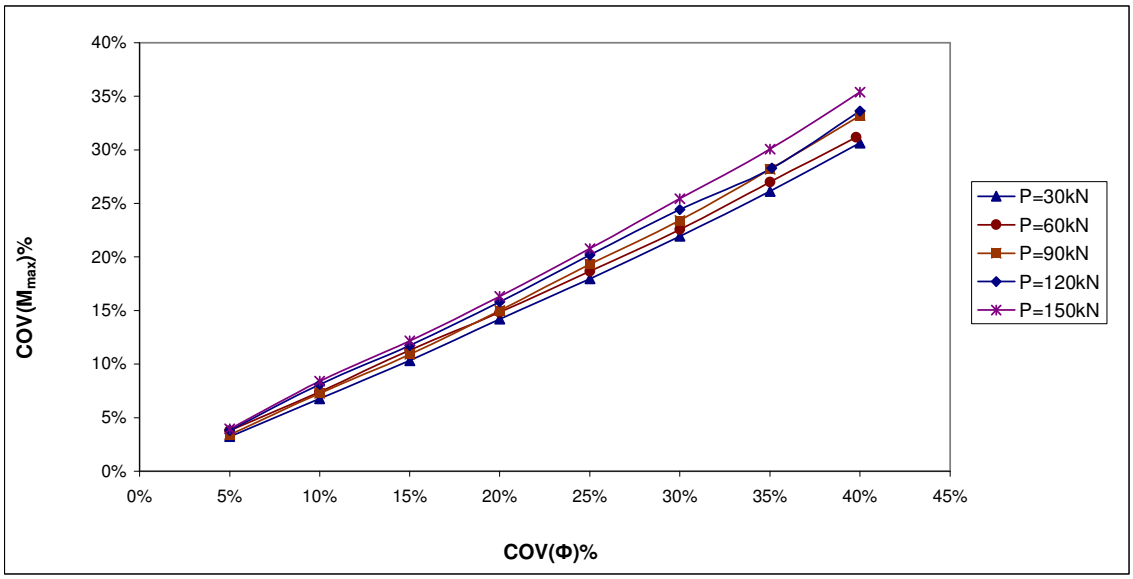


Fig. A.84 Variability of COV (M_{max}) vs. COV(Φ) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.101 Probabilistic modeling of laterally loaded free head long pile 10T with varying (γ) and load 30kN.

P=30kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}° (kN-m)	COV(M_{max}) (%)
		11.025	3.86E+01				
5%	10.5			2.76E-01	6.25E+00	3.94E+01	1.34%
		9.975	4.03E+01				
		11.55	3.80E+01				
10%	10.5			1.10E+00	2.50E+01	3.94E+01	2.76%
		9.45	4.12E+01				
		12.075	3.73E+01				
15%	10.5			2.48E+00	5.63E+01	3.94E+01	4.32%
		8.925	4.21E+01				
		12.6	3.67E+01				
20%	10.5			4.41E+00	1.00E+02	3.94E+01	5.96%
		8.4	4.31E+01				
		13.125	3.60E+01				
25%	10.5			6.89E+00	1.32E+02	3.94E+01	7.42%
		7.875	4.40E+01				
		13.65	3.54E+01				
30%	10.5			9.92E+00	2.10E+02	3.94E+01	9.35%
		7.35	4.55E+01				
		14.175	3.48E+01				
35%	10.5			1.35E+01	3.06E+02	3.94E+01	11.29%
		6.825	4.67E+01				
		14.7	3.42E+01				
40%	10.5			1.76E+01	4.20E+02	3.94E+01	13.23%
		6.3	4.80E+01				

Table A.102 Probabilistic modeling of laterally loaded free head long pile 10T with varying (γ) and load 60kN.

P=60kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}° (kN-m)	COV(M_{max}) (%)
		11.025	9.35E+01				
5%	10.5			2.76E-01	1.23E+01	9.51E+01	1.59%
		9.975	9.67E+01				
		11.55	9.18E+01				
10%	10.5			1.10E+00	4.90E+01	9.51E+01	3.18%
		9.45	9.84E+01				
		12.075	9.03E+01				
15%	10.5			2.48E+00	1.10E+02	9.51E+01	4.77%
		8.925	1.00E+02				
		12.6	8.91E+01				
20%	10.5			4.41E+00	2.10E+02	9.51E+01	6.59%
		8.4	1.02E+02				
		13.125	8.79E+01				
25%	10.5			6.89E+00	3.42E+02	9.51E+01	8.41%
		7.875	1.04E+02				
		13.65	8.67E+01				
30%	10.5			9.92E+00	4.84E+02	9.51E+01	10.00%
		7.35	1.06E+02				
		14.175	8.56E+01				
35%	10.5			1.35E+01	6.76E+02	9.51E+01	11.82%
		6.825	1.09E+02				
		14.7	8.44E+01				
40%	10.5			1.76E+01	9.61E+02	9.51E+01	13.70%
		6.3	1.11E+02				

Table A.103 Probabilistic modeling of laterally loaded free head long pile 10T with varying (γ) and load 90kN.

P=90kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		11.025	1.52E+02				
5%	10.5			2.76E-01	2.56E+00	1.55E+02	1.68%
		9.975	1.57E+02				
		11.55	1.50E+02				
10%	10.5			1.10E+00	1.09E+01	1.55E+02	3.47%
		9.45	1.60E+02				
		12.075	1.48E+02				
15%	10.5			2.48E+00	2.35E+01	1.55E+02	5.10%
		8.925	1.63E+02				
		12.6	1.46E+02				
20%	10.5			4.41E+00	4.16E+01	1.55E+02	6.78%
		8.4	1.66E+02				
		13.125	1.45E+02				
25%	10.5			6.89E+00	6.48E+01	1.55E+02	8.46%
		7.875	1.68E+02				
		13.65	1.43E+02				
30%	10.5			9.92E+00	9.31E+01	1.55E+02	10.15%
		7.35	1.72E+02				
		14.175	1.41E+02				
35%	10.5			1.35E+01	1.37E+02	1.55E+02	12.30%
		6.825	1.76E+02				
		14.7	1.39E+02				
40%	10.5			1.76E+01	1.77E+02	1.55E+02	13.99%
		6.3	1.80E+02				

Table A.104 Probabilistic modeling of laterally loaded free head long pile 10T with varying (γ) and load 120kN.

P=120kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		11.025	2.16E+02				
5%	10.5			2.76E-01	2.50E+01	2.20E+02	1.72%
		9.975	2.23E+02				
		11.55	2.13E+02				
10%	10.5			1.10E+00	1.00E+02	2.20E+02	3.44%
		9.45	2.27E+02				
		12.075	2.10E+02				
15%	10.5			2.48E+00	2.40E+02	2.20E+02	5.33%
		8.925	2.31E+02				
		12.6	2.07E+02				
20%	10.5			4.41E+00	4.20E+02	2.20E+02	7.04%
		8.4	2.36E+02				
		13.125	2.04E+02				
25%	10.5			6.89E+00	6.76E+02	2.20E+02	8.93%
		7.875	2.41E+02				
		13.65	2.02E+02				
30%	10.5			9.92E+00	1.02E+03	2.20E+02	11.00%
		7.35	2.46E+02				
		14.175	2.00E+02				
35%	10.5			1.35E+01	1.48E+03	2.20E+02	13.23%
		6.825	2.52E+02				
		14.7	1.98E+02				
40%	10.5			1.76E+01	2.03E+03	2.20E+02	15.46%
		6.3	2.60E+02				

Table A.105 Probabilistic modeling of laterally loaded free head long pile 10T with varying (γ') and load 150kN.

P=150kN							
COV(γ') (%)	γ'o (kN/m^3)	γ'(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ') (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		11.025	2.87E+02				
5%	10.5			2.76E-01	7.22E-01	2.91E+02	2.16%
		9.975	2.97E+02				
		11.55	2.82E+02				
10%	10.5			1.10E+00	2.56E+00	2.91E+02	4.06%
		9.45	3.02E+02				
		12.075	2.78E+02				
15%	10.5			2.48E+00	5.76E+00	2.91E+02	6.09%
		8.925	3.09E+02				
		12.6	2.74E+02				
20%	10.5			4.41E+00	1.02E+01	2.91E+02	8.12%
		8.4	3.15E+02				
		13.125	2.70E+02				
25%	10.5			6.89E+00	1.60E+01	2.91E+02	10.15%
		7.875	3.22E+02				
		13.65	2.67E+02				
30%	10.5			9.92E+00	2.55E+01	2.91E+02	12.82%
		7.35	3.31E+02				
		14.175	2.63E+02				
35%	10.5			1.35E+01	3.54E+01	2.91E+02	15.10%
		6.825	3.40E+02				
		14.7	2.60E+02				
40%	10.5			1.76E+01	4.76E+01	2.91E+02	17.51%
		6.3	3.50E+02				

Table A.106 Value of COV (M_{max}) for free head long pile with varying COV(γ) and lateral load 30kN.

P=30kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	6.25E+00	1.34%
10%	2.66E+06	2.50E+01	2.76%
15%	5.98E+06	5.63E+01	4.32%
20%	1.06E+07	1.00E+02	5.96%
25%	1.66E+07	1.32E+02	7.42%
30%	2.39E+07	2.10E+02	9.35%
35%	3.25E+07	3.06E+02	11.29%
40%	4.25E+07	4.20E+02	13.23%

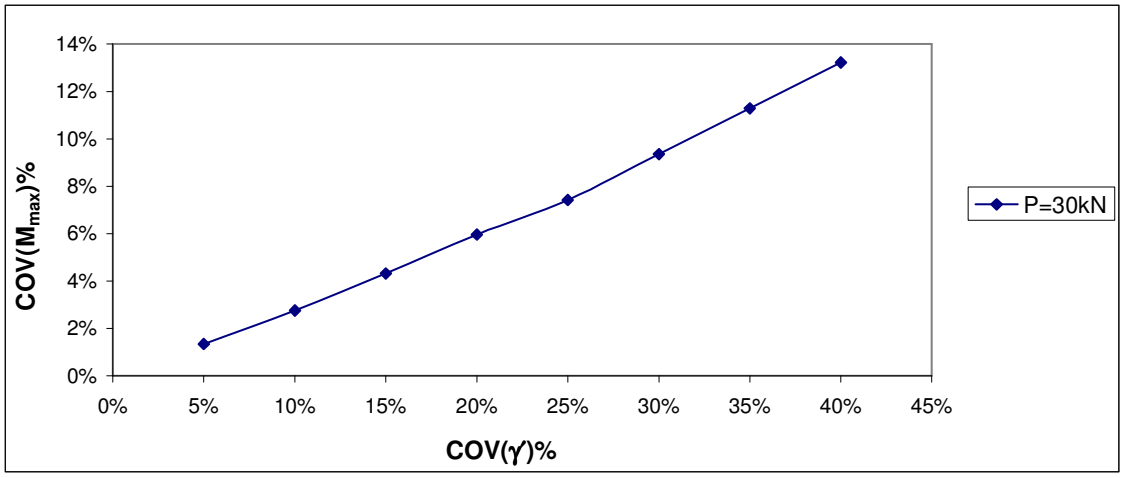


Fig. A.85 Variability of COV (M_{max}) vs. COV (γ) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.107 Value of COV (M_{max}) for free head long pile with varying COV(γ) and lateral load 60kN.

P=60kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.23E+01	1.59%
10%	2.66E+06	4.90E+01	3.18%
15%	5.98E+06	1.10E+02	4.77%
20%	1.06E+07	2.10E+02	6.59%
25%	1.66E+07	3.42E+02	8.41%
30%	2.39E+07	4.84E+02	10.00%
35%	3.25E+07	6.76E+02	11.82%
40%	4.25E+07	9.61E+02	13.70%

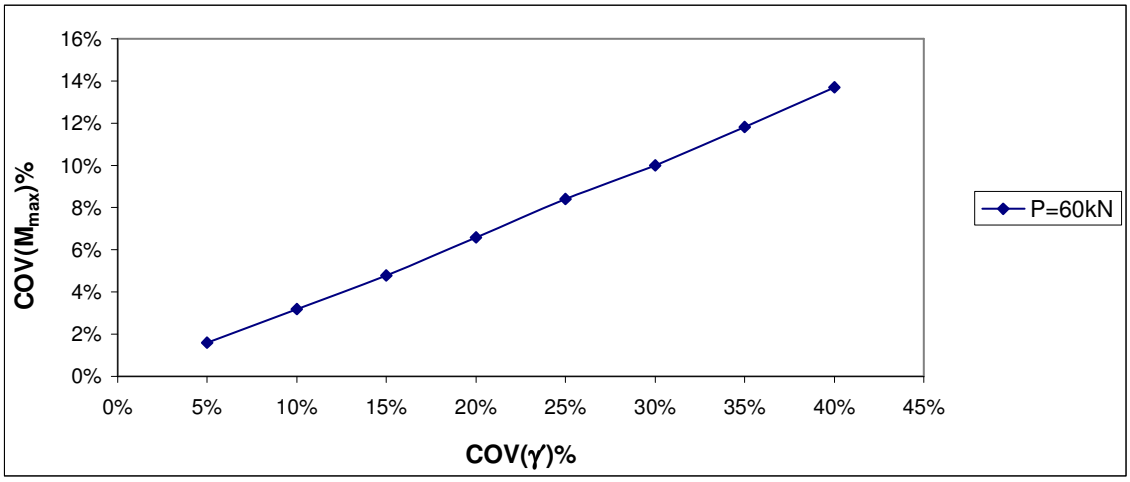


Fig. A.86 Variability of COV (M_{max}) vs. COV (γ) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.108 Value of COV (M_{max}) for free head long pile with varying COV(γ) and lateral load 90kN.

P=90kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	2.56E+00	1.68%
10%	1.10E+00	1.09E+01	3.47%
15%	2.48E+00	2.35E+01	5.10%
20%	4.41E+00	4.16E+01	6.78%
25%	6.89E+00	6.48E+01	8.46%
30%	9.92E+00	9.31E+01	10.15%
35%	1.35E+01	1.37E+02	12.30%
40%	1.76E+01	1.77E+02	13.99%

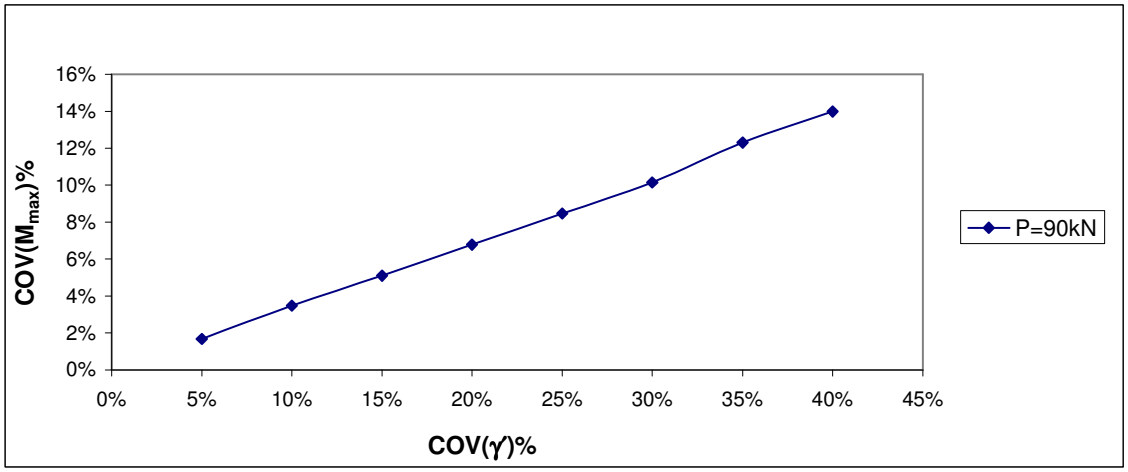


Fig. A.87 Variability of COV (M_{max}) vs. COV (γ) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.109 Value of COV (M_{max}) for free head long pile with varying COV(γ) and lateral load 120kN.

P=120kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.50E+01	1.72%
10%	2.66E+06	1.00E+02	3.44%
15%	5.98E+06	2.40E+02	5.33%
20%	1.06E+07	4.20E+02	7.04%
25%	1.66E+07	6.76E+02	8.93%
30%	2.39E+07	1.02E+03	11.00%
35%	3.25E+07	1.48E+03	13.23%
40%	4.25E+07	2.03E+03	15.46%

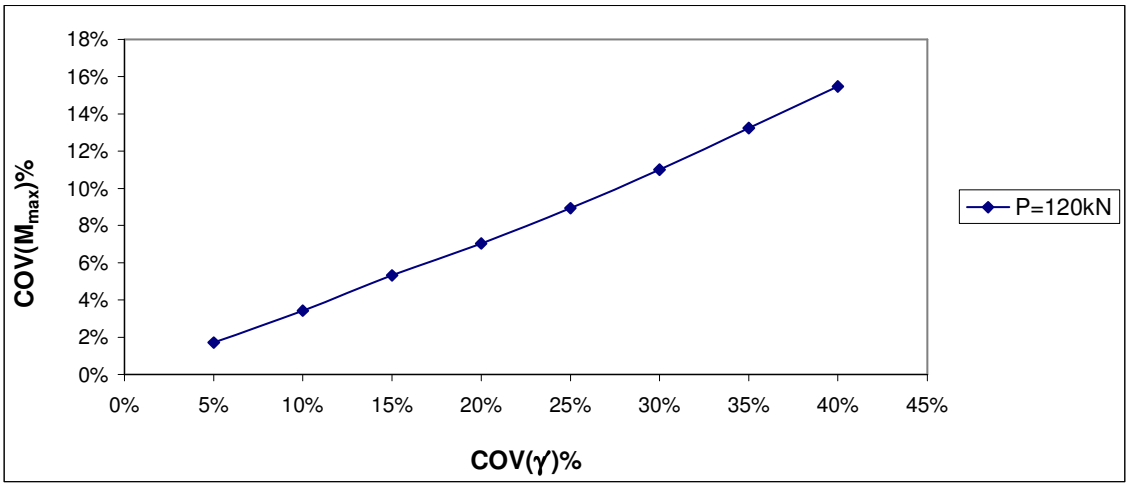


Fig. A.88 Variability of COV (M_{max}) vs. COV (γ) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.110 Value of COV (M_{max}) for free head long pile with varying COV(γ) and lateral load 150kN.

P=150kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	7.22E-01	2.16%
10%	1.10E+00	2.56E+00	4.06%
15%	2.48E+00	5.76E+00	6.09%
20%	4.41E+00	1.02E+01	8.12%
25%	6.89E+00	1.60E+01	10.15%
30%	9.92E+00	2.55E+01	12.82%
35%	1.35E+01	3.54E+01	15.10%
40%	1.76E+01	4.76E+01	17.51%

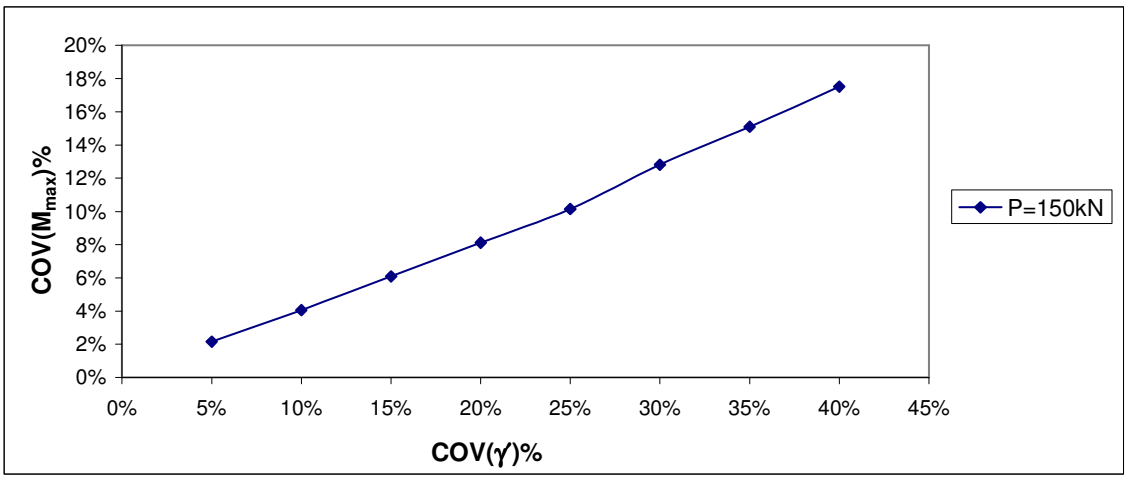


Fig. A.89 Variability of COV (M_{max}) vs. COV (γ) for single free head long pile (10T) subjected to lateral force 150kN.

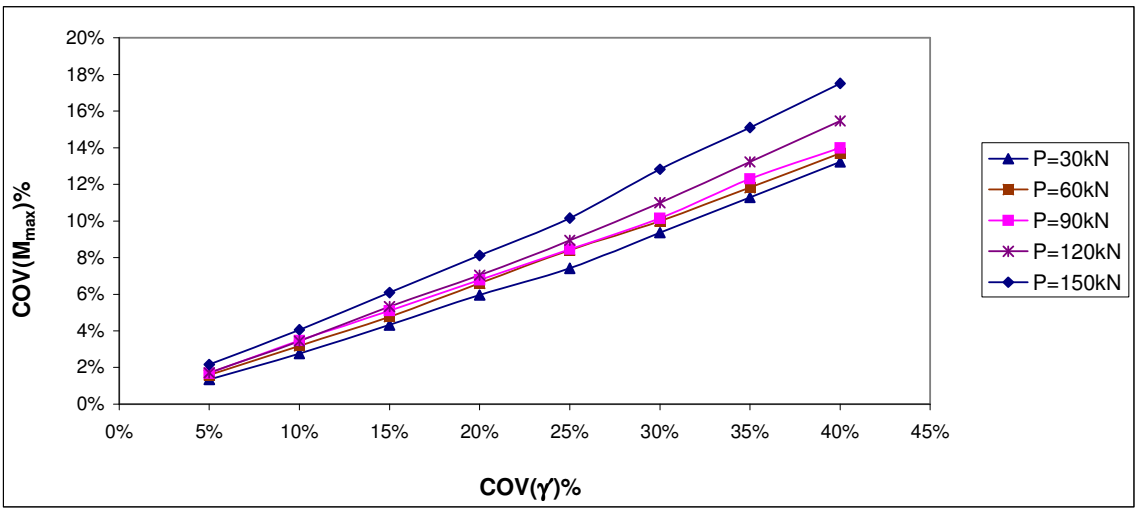


Fig. A.90 Variability of COV(M_{max}) vs. COV(γ) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.111 Probabilistic modeling of laterally loaded free head long pile 10T with varying (k) and load 30kN.

P=30kN							
COV(k) (%)	k° (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		17115	3.95E+01				
5%	16300			6.64E+05	1.00E-02	3.94E+01	0.15%
		15485	3.93E+01				
		17930	3.95E+01				
10%	16300			2.66E+06	1.65E-02	3.94E+01	0.25%
		14670	3.93E+01				
		18745	3.96E+01				
15%	16300			5.98E+06	4.00E-02	3.94E+01	0.36%
		13855	3.92E+01				
		19560	3.96E+01				
20%	16300			1.06E+07	6.25E-02	3.94E+01	0.50%
		13040	3.91E+01				
		20375	3.96E+01				
25%	16300			1.66E+07	9.00E-02	3.94E+01	0.68%
		12225	3.90E+01				
		21190	3.96E+01				
30%	16300			2.39E+07	1.23E-01	3.94E+01	0.84%
		11410	3.89E+01				
		22005	3.97E+01				
35%	16300			3.25E+07	1.60E-01	3.94E+01	1.02%
		10595	3.89E+01				
		22820	3.97E+01				
40%	16300			4.25E+07	2.50E-01	3.94E+01	1.27%
		9780	3.87E+01				

Table A.112 Probabilistic modeling of laterally loaded free head long pile 10T with varying (k) and load 60kN.

P=60kN							
COV(k) (%)	k° (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		17115	9.51E+01				
5%	16300			6.64E+05	2.50E-03	9.51E+01	0.05%
		15485	9.50E+01				
		17930	9.51E+01				
10%	16300			2.66E+06	1.00E-02	9.51E+01	0.11%
		14670	9.49E+01				
		18745	9.52E+01				
15%	16300			5.98E+06	4.00E-02	9.51E+01	0.18%
		13855	9.48E+01				
		19560	9.52E+01				
20%	16300			1.06E+07	6.25E-02	9.51E+01	0.26%
		13040	9.47E+01				
		20375	9.53E+01				
25%	16300			1.66E+07	1.23E-01	9.51E+01	0.34%
		12225	9.46E+01				
		21190	9.53E+01				
30%	16300			2.39E+07	1.60E-01	9.51E+01	0.44%
		11410	9.45E+01				
		22005	9.53E+01				
35%	16300			3.25E+07	2.50E-01	9.51E+01	0.55%
		10595	9.43E+01				
		22820	9.54E+01				
40%	16300			4.25E+07	4.23E-01	9.51E+01	0.68%
		9780	9.41E+01				

Table A.113 Probabilistic modeling of laterally loaded free head long pile 10T with varying (k) and load 90kN.

P=90kN

COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	1.55E+02				
5%	16300			6.64E+05	2.50E-01	1.55E+02	0.02%
		15485	1.55E+02				
		17930	1.55E+02				
10%	16300			2.66E+06	2.53E-01	1.55E+02	0.03%
		14670	1.55E+02				
		18745	1.54E+02				
15%	16300			5.98E+06	2.56E-01	1.55E+02	0.04%
		13855	1.54E+02				
		19560	1.54E+02				
20%	16300			1.06E+07	2.57E-01	1.55E+02	0.06%
		13040	1.54E+02				
		20375	1.54E+02				
25%	16300			1.66E+07	2.59E-01	1.55E+02	0.10%
		12225	1.54E+02				
		21190	1.54E+02				
30%	16300			2.39E+07	2.60E-01	1.55E+02	0.15%
		11410	1.54E+02				
		22005	1.54E+02				
35%	16300			3.25E+07	2.62E-01	1.55E+02	0.22%
		10595	1.54E+02				
		22820	1.55E+02				
40%	16300			4.25E+07	1.00E+00	1.55E+02	0.32%
		9780	1.54E+02				

Table A.114 Probabilistic modeling of laterally loaded free head long pile 10T with varying (k) and load 120kN.

P=120kN

COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	2.19E+02				
5%	16300			6.64E+05	8.60E-03	2.20E+02	0.00%
		15485	2.19E+02				
		17930	2.20E+02				
10%	16300			2.66E+06	9.50E-03	2.20E+02	0.01%
		14670	2.20E+02				
		18745	2.20E+02				
15%	16300			5.98E+06	9.52E-03	2.20E+02	0.01%
		13855	2.20E+02				
		19560	2.20E+02				
20%	16300			1.06E+07	3.00E-02	2.20E+02	0.03%
		13040	2.20E+02				
		20375	2.20E+02				
25%	16300			1.66E+07	4.20E-02	2.20E+02	0.04%
		12225	2.20E+02				
		21190	2.20E+02				
30%	16300			2.39E+07	6.23E-02	2.20E+02	0.06%
		11410	2.20E+02				
		22005	2.20E+02				
35%	16300			3.25E+07	6.85E-02	2.20E+02	0.10%
		10595	2.20E+02				
		22820	2.20E+02				
40%	16300			4.25E+07	2.50E-01	2.20E+02	0.16%
		9780	2.19E+02				

Table A.115 Probabilistic modeling of laterally loaded free head long pile 10T with varying (k) and load 150kN.

P=150kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		17115	2.91E+02				
5%	16300			6.64E+05	0.00E+00	2.91E+02	0.00%
		15485	2.91E+02				
		17930	2.91E+02				
10%	16300			2.66E+06	0.00E+00	2.91E+02	0.00%
		14670	2.91E+02				
		18745	2.91E+02				
15%	16300			5.98E+06	0.00E+00	2.91E+02	0.00%
		13855	2.91E+02				
		19560	2.91E+02				
20%	16300			1.06E+07	0.00E+00	2.91E+02	0.00%
		13040	2.91E+02				
		20375	2.91E+02				
25%	16300			1.66E+07	0.00E+00	2.91E+02	0.00%
		12225	2.91E+02				
		21190	2.91E+02				
30%	16300			2.39E+07	0.00E+00	2.91E+02	0.00%
		11410	2.91E+02				
		22005	2.91E+02				
35%	16300			3.25E+07	2.50E-02	2.91E+02	0.01%
		10595	2.91E+02				
		22820	2.91E+02				
40%	16300			4.25E+07	2.73E-02	2.91E+02	0.03%
		9780	2.91E+02				

Table A.116 Value of COV(M_{max}) for free head long pile with varying COV(k) and lateral load 30kN.

P=30kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.00E-02	0.15%
10%	2.66E+06	1.65E-02	0.25%
15%	5.98E+06	4.00E-02	0.36%
20%	1.06E+07	6.25E-02	0.50%
25%	1.66E+07	9.00E-02	0.68%
30%	2.39E+07	1.23E-01	0.84%
35%	3.25E+07	1.60E-01	1.02%
40%	4.25E+07	2.50E-01	1.27%

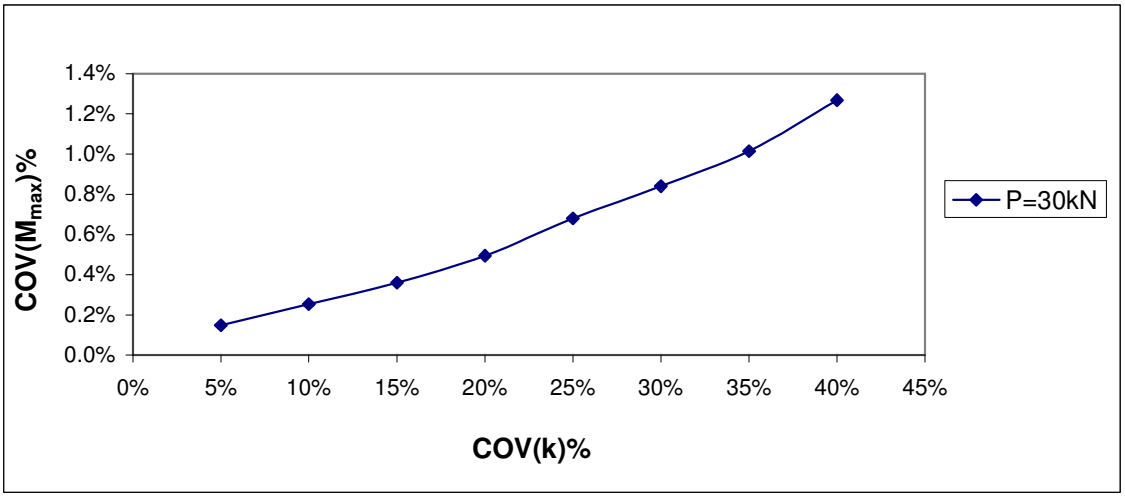


Fig. A.91 Variability of COV(M_{max}) vs. COV(k) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.117 Value of COV(M_{max}) for free head long pile with varying COV(k) and lateral load 60kN.

P=60kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.50E-03	0.05%
10%	2.66E+06	1.00E-02	0.11%
15%	5.98E+06	4.00E-02	0.18%
20%	1.06E+07	6.25E-02	0.26%
25%	1.66E+07	1.23E-01	0.34%
30%	2.39E+07	1.60E-01	0.44%
35%	3.25E+07	2.50E-01	0.55%
40%	4.25E+07	4.23E-01	0.68%

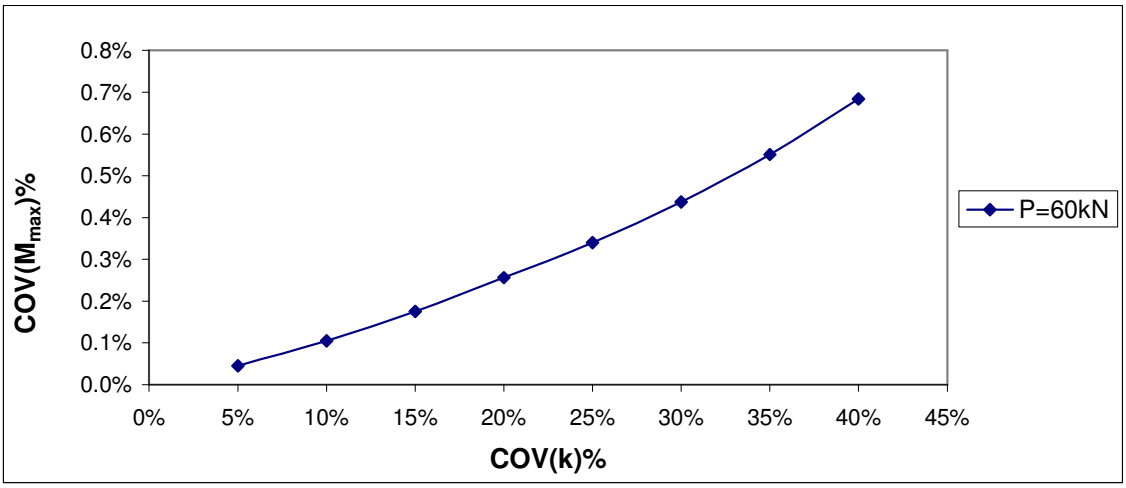


Fig. A.92 Variability of COV (M_{max}) vs. COV (k) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.118 Value of COV (M_{max}) for free head long pile with varying COV(k) and lateral load 90kN.

P=90kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.50E-01	0.02%
10%	2.66E+06	2.53E-01	0.03%
15%	5.98E+06	2.56E-01	0.04%
20%	1.06E+07	2.57E-01	0.06%
25%	1.66E+07	2.59E-01	0.10%
30%	2.39E+07	2.60E-01	0.15%
35%	3.25E+07	2.62E-01	0.22%
40%	4.25E+07	1.00E+00	0.32%

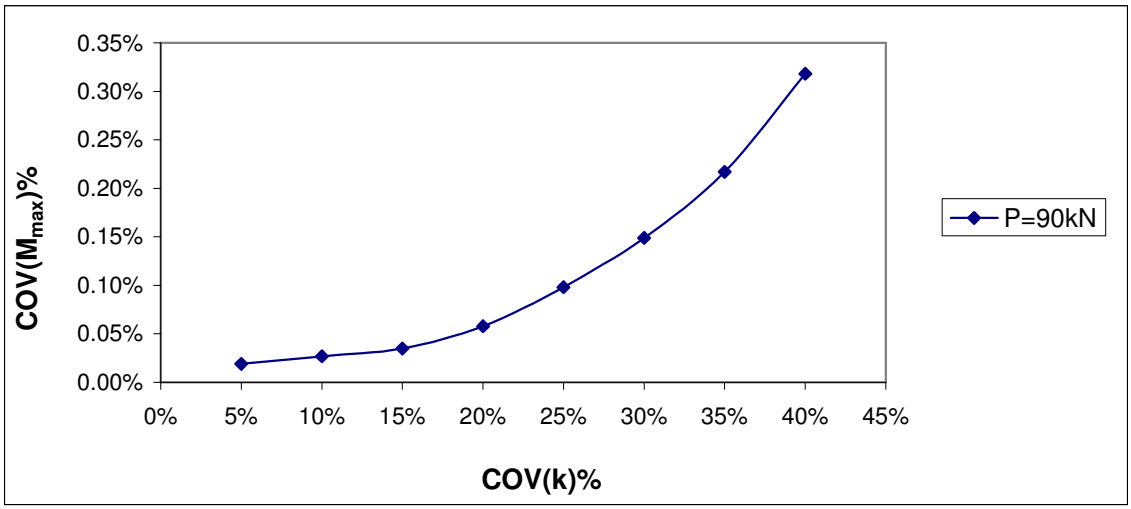


Fig. A.93 Variability of COV (M_{max}) vs. COV (k) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.119 Value of COV (M_{max}) for free head long pile with varying COV(k) and lateral load 120kN.

P=120kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	8.60E-03	0.00%
10%	2.66E+06	9.50E-03	0.01%
15%	5.98E+06	9.52E-03	0.01%
20%	1.06E+07	3.00E-02	0.03%
25%	1.66E+07	4.20E-02	0.04%
30%	2.39E+07	6.23E-02	0.06%
35%	3.25E+07	6.85E-02	0.10%
40%	4.25E+07	2.50E-01	0.16%

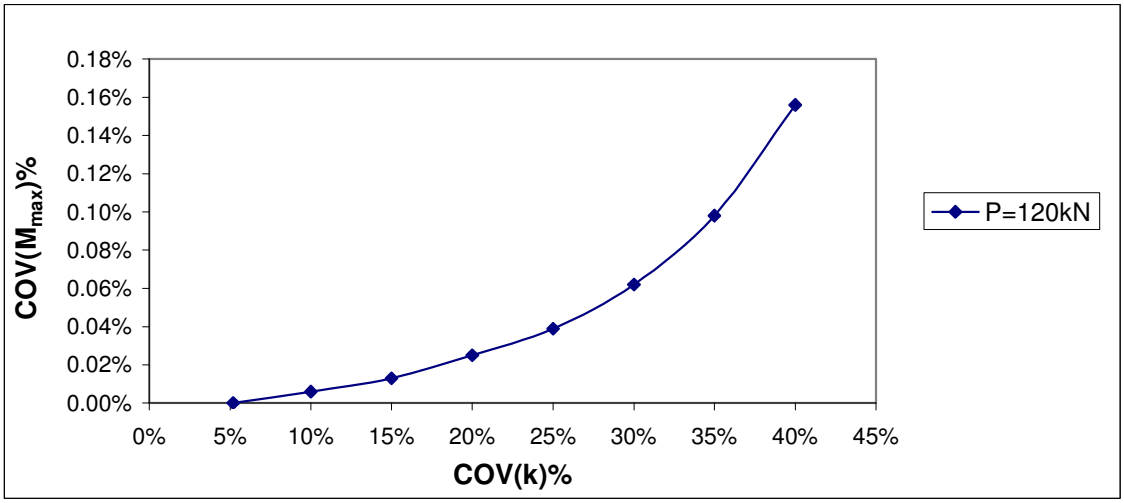


Fig. A.94 Variability of COV (M_{max}) vs. COV (k) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.120 Value of COV(M_{max}) for free head long pile with varying COV(k) and lateral load 150kN.

P=150kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	0.00E+00	0.00%
10%	2.66E+06	0.00E+00	0.00%
15%	5.98E+06	0.00E+00	0.00%
20%	1.06E+07	0.00E+00	0.00%
25%	1.66E+07	0.00E+00	0.00%
30%	2.39E+07	0.00E+00	0.00%
35%	3.25E+07	2.50E-02	0.01%
40%	4.25E+07	2.73E-02	0.03%

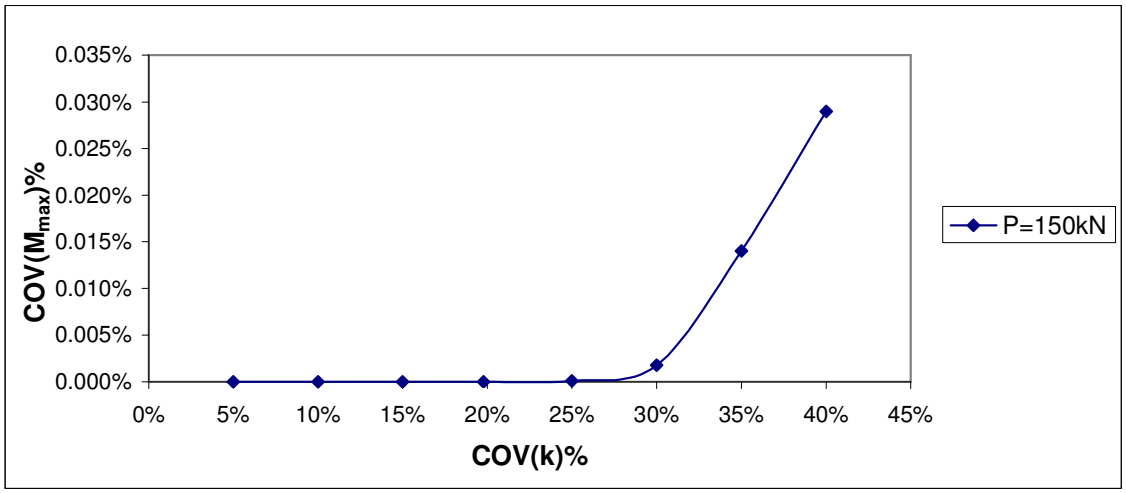


Fig. A.95 Variability of COV (M_{max}) vs. COV (k) for single free head long pile (10T) subjected to lateral force 150kN.

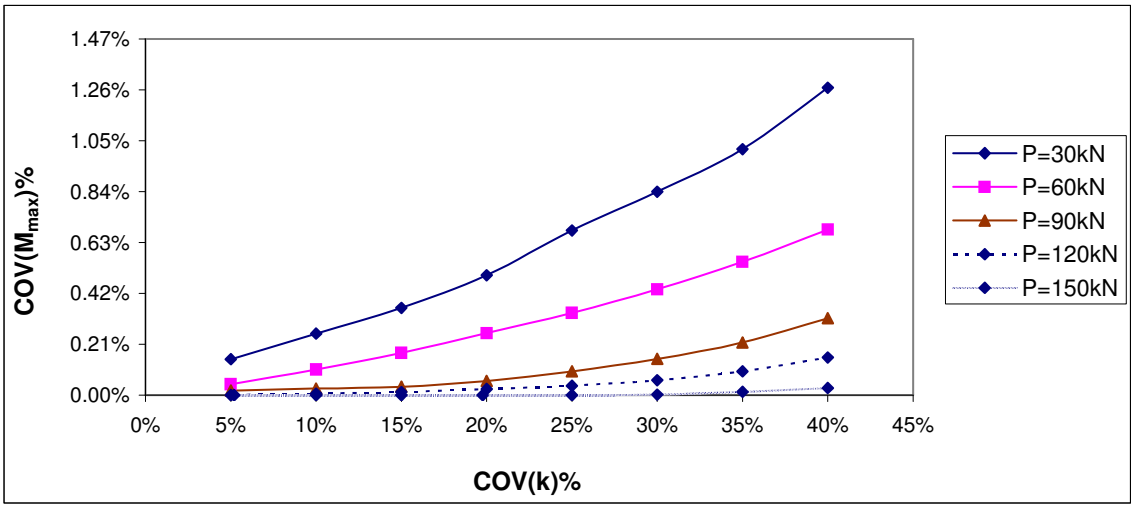


Fig. A.96 Variability of COV (M_{max}) vs. COV (k) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.121 Probabilistic modeling of laterally loaded free head long pile 10T with varying (B) and load 30kN.

P=30kN							
COV(B) (%)	B° (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	3.88E+01				
5%	0.406			4.12E-04	2.50E-01	3.94E+01	0.24%
		0.3857	4.01E+01				
		0.4466	3.83E+01				
10%	0.406			1.65E-03	1.00E+00	3.94E+01	0.65%
		0.3654	4.10E+01				
		0.4669	3.78E+01				
15%	0.406			3.71E-03	4.00E+00	3.94E+01	1.12%
		0.3451	4.15E+01				
		0.4872	3.73E+01				
20%	0.406			6.59E-03	6.25E+00	3.94E+01	1.65%
		0.3248	4.20E+01				
		0.5075	3.71E+01				
25%	0.406			1.03E-02	9.00E+00	3.94E+01	2.20%
		0.3045	4.26E+01				
		0.5278	3.69E+01				
30%	0.406			1.48E-02	1.60E+01	3.94E+01	2.63%
		0.2842	4.29E+01				
		0.5472	3.67E+01				
35%	0.406			2.02E-02	2.05E+01	3.94E+01	2.92%
		0.2648	4.32E+01				
		0.5684	3.65E+01				
40%	0.406			2.64E-02	2.50E+01	3.94E+01	3.23%
		0.2436	4.36E+01				

Table A.122 Probabilistic modeling of laterally loaded free head long pile 10T with varying (B) and load 60kN.

P=60kN							
COV(B) (%)	B° (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	9.43E+01				
5%	0.406			4.12E-04	2.50E-01	9.51E+01	0.23%
		0.3857	9.58E+01				
		0.4466	9.33E+01				
10%	0.406			1.65E-03	2.25E+00	9.51E+01	0.83%
		0.3654	9.65E+01				
		0.4669	9.23E+01				
15%	0.406			3.71E-03	6.25E+00	9.51E+01	1.42%
		0.3451	9.70E+01				
		0.4872	9.13E+01				
20%	0.406			6.59E-03	1.23E+01	9.51E+01	2.06%
		0.3248	9.73E+01				
		0.5075	9.04E+01				
25%	0.406			1.03E-02	2.03E+01	9.51E+01	2.60%
		0.3045	9.78E+01				
		0.5278	8.93E+01				
30%	0.406			1.48E-02	3.60E+01	9.51E+01	3.13%
		0.2842	9.78E+01				
		0.5472	8.86E+01				
35%	0.406			2.02E-02	5.70E+01	9.51E+01	3.54%
		0.2648	9.78E+01				
		0.5684	8.80E+01				
40%	0.406			2.64E-02	7.23E+01	9.51E+01	3.86%
		0.2436	9.77E+01				

Table A.123 Probabilistic modeling of laterally loaded free head long pile 10T with varying (B) and load 90kN.

P=90kN							
COV(B) (%)	B° (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	1.54E+02				
5%	0.406			4.12E-04	4.00E+00	1.55E+02	0.56%
		0.3857	1.55E+02				
		0.4466	1.53E+02				
10%	0.406			1.65E-03	9.00E+00	1.55E+02	1.15%
		0.3654	1.55E+02				
		0.4669	1.52E+02				
15%	0.406			3.71E-03	2.03E+01	1.55E+02	1.86%
		0.3451	1.56E+02				
		0.4872	1.51E+02				
20%	0.406			6.59E-03	4.23E+01	1.55E+02	2.54%
		0.3248	1.56E+02				
		0.5075	1.50E+02				
25%	0.406			1.03E-02	6.40E+01	1.55E+02	3.13%
		0.3045	1.56E+02				
		0.5278	1.49E+02				
30%	0.406			1.48E-02	9.03E+01	1.55E+02	3.78%
		0.2842	1.57E+02				
		0.5472	1.48E+02				
35%	0.406			2.02E-02	1.34E+02	1.55E+02	4.28%
		0.2648	1.57E+02				
		0.5684	1.47E+02				
40%	0.406			2.64E-02	1.82E+02	1.55E+02	4.64%
		0.2436	1.57E+02				

Table A.124 Probabilistic modeling of laterally loaded free head long pile 10T with varying (B) and load 120kN.

P=120kN							
COV(B) (%)	B° (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	2.19E+02				
5%	0.406			4.12E-04	5.62E-01	2.20E+02	0.79%
		0.3857	2.20E+02				
		0.4466	2.18E+02				
10%	0.406			1.65E-03	2.56E+00	2.20E+02	1.68%
		0.3654	2.21E+02				
		0.4669	2.17E+02				
15%	0.406			3.71E-03	5.52E+00	2.20E+02	2.47%
		0.3451	2.22E+02				
		0.4872	2.16E+02				
20%	0.406			6.59E-03	9.00E+00	2.20E+02	3.15%
		0.3248	2.23E+02				
		0.5075	2.15E+02				
25%	0.406			1.03E-02	1.37E+01	2.20E+02	3.89%
		0.3045	2.24E+02				
		0.5278	2.13E+02				
30%	0.406			1.48E-02	1.81E+01	2.20E+02	4.47%
		0.2842	2.25E+02				
		0.5472	2.12E+02				
35%	0.406			2.02E-02	2.14E+01	2.20E+02	4.87%
		0.2648	2.27E+02				
		0.5684	2.11E+02				
40%	0.406			2.64E-02	2.35E+01	2.20E+02	5.10%
		0.2436	2.28E+02				

Table A.125 Probabilistic modeling of laterally loaded free head long pile 10T with varying (B) and load 150kN.

P=150kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	2.89E+02				
5%	0.406			4.12E-04	4.23E-01	2.91E+02	0.82%
		0.3857	2.93E+02				
		0.4466	2.88E+02				
10%	0.406			1.65E-03	1.82E+00	2.91E+02	1.83%
		0.3654	2.94E+02				
		0.4669	2.87E+02				
15%	0.406			3.71E-03	3.42E+00	2.91E+02	2.94%
		0.3451	2.96E+02				
		0.4872	2.85E+02				
20%	0.406			6.59E-03	5.52E+00	2.91E+02	3.87%
		0.3248	2.98E+02				
		0.5075	2.84E+02				
25%	0.406			1.03E-02	7.56E+00	2.91E+02	4.79%
		0.3045	3.00E+02				
		0.5278	2.82E+02				
30%	0.406			1.48E-02	9.00E+00	2.91E+02	5.49%
		0.2842	3.01E+02				
		0.5472	2.81E+02				
35%	0.406			2.02E-02	1.07E+01	2.91E+02	6.10%
		0.2648	3.04E+02				
		0.5684	2.79E+02				
40%	0.406			2.64E-02	1.26E+01	2.91E+02	6.48%
		0.2436	3.06E+02				

Table A.126 Value of COV (M_{max}) for free head long pile with varying COV(B) and lateral load 30kN.

P=30kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	2.50E-01	0.24%
10%	1.65E-03	1.00E+00	0.65%
15%	3.71E-03	4.00E+00	1.12%
20%	6.59E-03	6.25E+00	1.65%
25%	1.03E-02	9.00E+00	2.20%
30%	1.48E-02	1.60E+01	2.63%
35%	2.02E-02	2.05E+01	2.92%
40%	2.64E-02	2.50E+01	3.23%

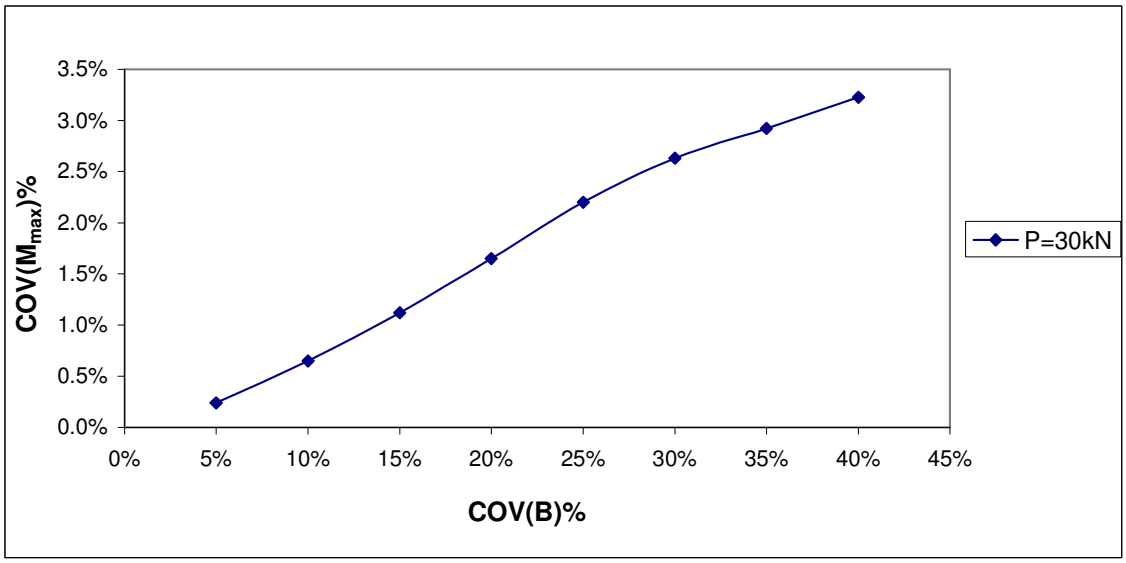


Fig. A.97 Variability of COV (M_{max}) vs. COV (B) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.127 Value of COV (M_{max}) for free head long pile with varying COV(B) and lateral load 60kN.

P=60kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	2.50E-01	0.23%
10%	1.65E-03	2.25E+00	0.83%
15%	3.71E-03	6.25E+00	1.42%
20%	6.59E-03	1.23E+01	2.06%
25%	1.03E-02	2.03E+01	2.60%
30%	1.48E-02	3.60E+01	3.13%
35%	2.02E-02	5.70E+01	3.54%
40%	2.64E-02	7.23E+01	3.86%

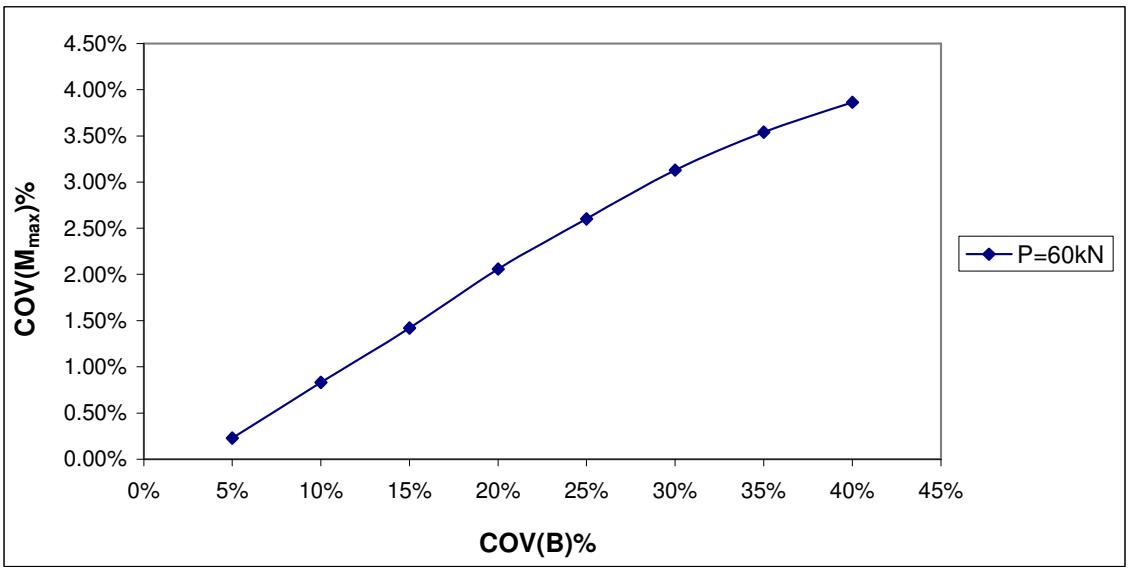


Fig. A.98 Variability of COV (M_{max}) vs. COV (B) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.128 Value of COV (M_{max}) for free head long pile with varying COV(B) and lateral load 90kN.

P=90kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	4.00E+00	0.56%
10%	1.65E-03	9.00E+00	1.15%
15%	3.71E-03	2.03E+01	1.86%
20%	6.59E-03	4.23E+01	2.54%
25%	1.03E-02	6.40E+01	3.13%
30%	1.48E-02	9.03E+01	3.78%
35%	2.02E-02	1.34E+02	4.28%
40%	2.64E-02	1.82E+02	4.64%

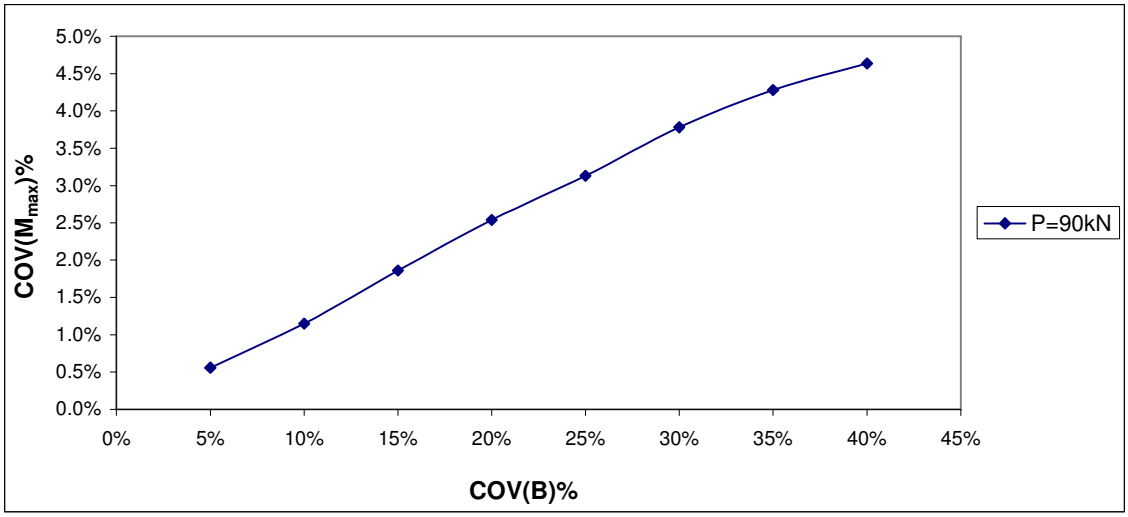


Fig. A.99 Variability of COV (M_{max}) vs. COV (B) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.129 Value of COV (M_{max}) for free head long pile with varying COV(B) and lateral load 120kN.

P=120kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	5.62E-01	0.79%
10%	1.65E-03	2.56E+00	1.68%
15%	3.71E-03	5.52E+00	2.47%
20%	6.59E-03	9.00E+00	3.15%
25%	1.03E-02	1.37E+01	3.89%
30%	1.48E-02	1.81E+01	4.47%
35%	2.02E-02	2.14E+01	4.87%
40%	2.64E-02	2.35E+01	5.10%

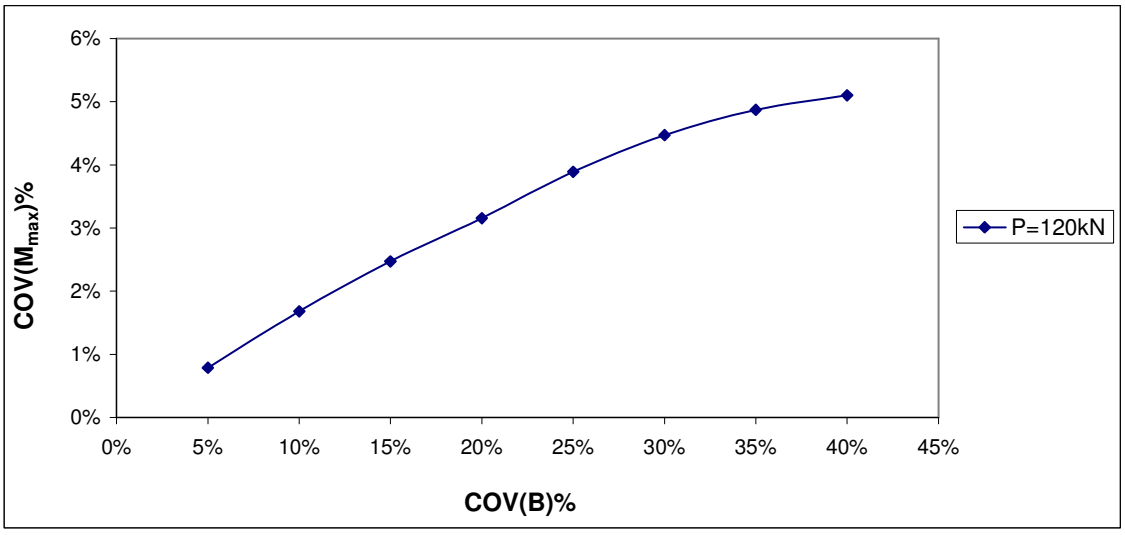


Fig. A.100 Variability of COV (M_{max}) vs. COV (B) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.130 Value of COV (M_{max}) for free head long pile with varying COV(B) and lateral load 150kN.

P=150kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	4.23E-01	0.82%
10%	1.65E-03	1.82E+00	1.83%
15%	3.71E-03	3.42E+00	2.94%
20%	6.59E-03	5.52E+00	3.87%
25%	1.03E-02	7.56E+00	4.79%
30%	1.48E-02	9.00E+00	5.49%
35%	2.02E-02	1.07E+01	6.10%
40%	2.64E-02	1.26E+01	6.48%

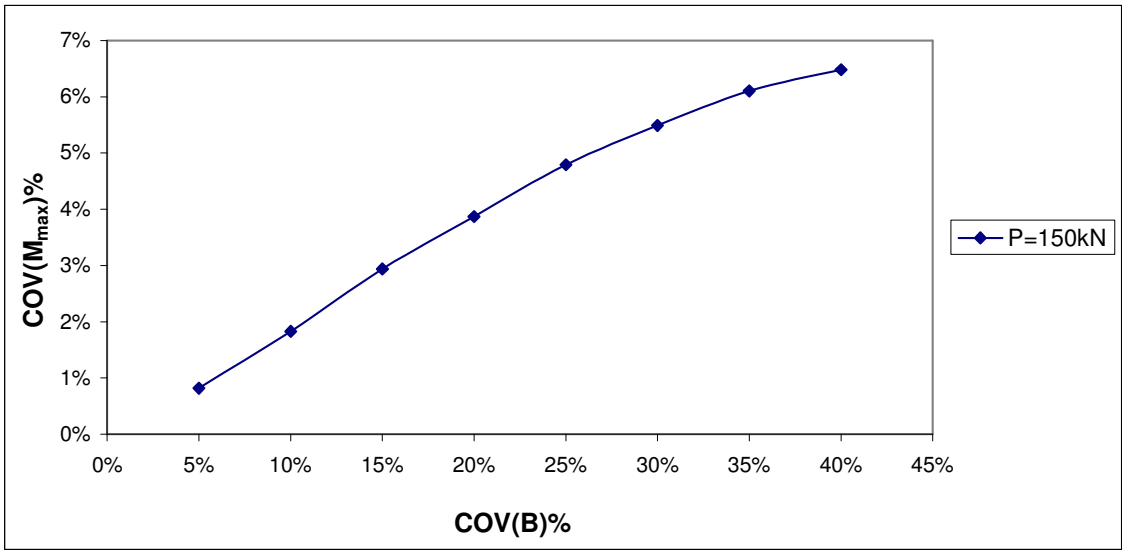


Fig. A.101 Variability of COV (M_{max}) vs. COV (B) for single free head long pile (10T) subjected to lateral force 150kN.

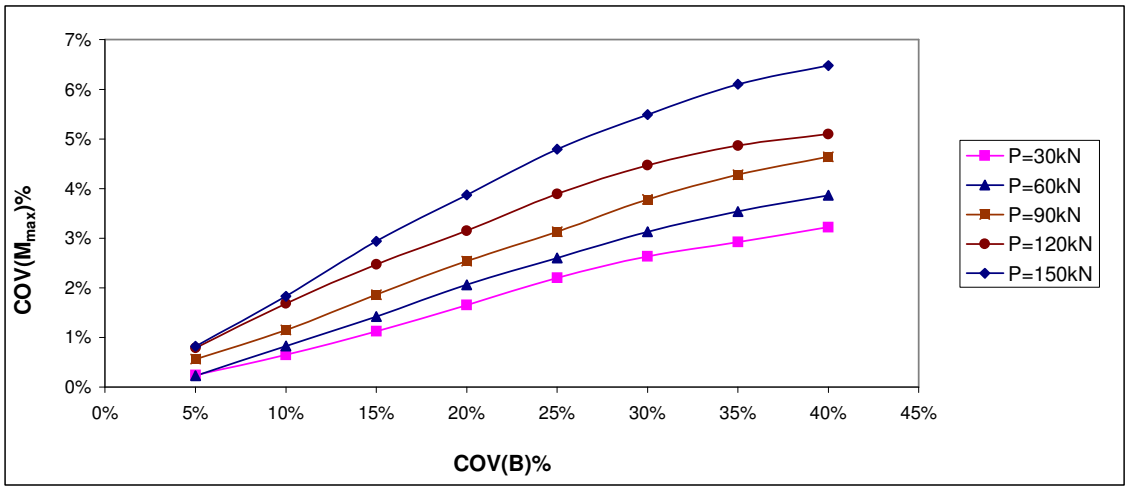


Fig. A.102 Variability of COV (M_{max}) vs. COV (B) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.131 Probabilistic modeling of laterally loaded free head long pile 10T with varying (EI) and load 30kN.

P=30kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN-m^2)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		64050	3.96E+01				
5%	61000			9.30E+06	4.00E-02	3.94E+01	0.09%
		57950	3.92E+01				
		67100	3.98E+01				
10%	61000			3.72E+07	1.60E-01	3.94E+01	0.55%
		54900	3.90E+01				
		70150	4.12E+01				
15%	61000			8.37E+07	1.44E+00	3.94E+01	1.02%
		51850	3.88E+01				
		73200	4.13E+01				
20%	61000			1.49E+08	3.61E+00	3.94E+01	1.43%
		48800	3.75E+01				
		76250	4.14E+01				
25%	61000			2.33E+08	4.20E+00	3.94E+01	1.73%
		45750	3.73E+01				
		79300	4.16E+01				
30%	61000			3.35E+08	5.06E+00	3.94E+01	1.93%
		42700	3.71E+01				
		82350	4.17E+01				
35%	61000			4.56E+08	5.76E+00	3.94E+01	2.02%
		39650	3.69E+01				
		85400	4.18E+01				
40%	61000			5.95E+08	7.02E+00	3.94E+01	2.08%
		36600	3.65E+01				

Table A.132 Probabilistic modeling of laterally loaded free head long pile 10T with varying (EI) and load 60kN.

P=60kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN-m^2)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		64050	9.55E+01				
5%	61000			9.30E+06	2.03E-01	9.51E+01	0.11%
		57950	9.46E+01				
		67100	9.59E+01				
10%	61000			3.72E+07	8.10E-01	9.51E+01	0.66%
		54900	9.41E+01				
		70150	9.87E+01				
15%	61000			8.37E+07	6.76E+00	9.51E+01	1.22%
		51850	9.35E+01				
		73200	9.90E+01				
20%	61000			1.49E+08	2.35E+01	9.51E+01	1.70%
		48800	8.93E+01				
		76250	9.94E+01				
25%	61000			2.33E+08	2.81E+01	9.51E+01	1.99%
		45750	8.88E+01				
		79300	9.97E+01				
30%	61000			3.35E+08	3.31E+01	9.51E+01	2.20%
		42700	8.82E+01				
		82350	1.00E+02				
35%	61000			4.56E+08	3.78E+01	9.51E+01	2.29%
		39650	8.77E+01				
		85400	1.01E+02				
40%	61000			5.95E+08	4.90E+01	9.51E+01	2.38%
		36600	8.70E+01				

Table A.133 Probabilistic modeling of laterally loaded free head long pile 10T with varying (EI) and load 90kN.

P=90kN							
COV(EI) (%)	EI^{o} ($kN\text{-}m^{2}$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^{2})^{2}$	VAR (M_{max}) $(kN\text{-}m)^{2}$	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		64050	1.55E+02				
5%	61000			9.30E+06	2.50E-01	1.55E+02	0.21%
		57950	1.54E+02				
		67100	1.57E+02				
10%	61000			3.72E+07	1.00E+00	1.55E+02	0.85%
		54900	1.53E+02				
		70150	1.59E+02				
15%	61000			8.37E+07	1.60E+01	1.55E+02	1.40%
		51850	1.50E+02				
		73200	1.63E+02				
20%	61000			1.49E+08	3.03E+01	1.55E+02	1.98%
		48800	1.47E+02				
		76250	1.63E+02				
25%	61000			2.33E+08	3.60E+01	1.55E+02	2.49%
		45750	1.46E+02				
		79300	1.64E+02				
30%	61000			3.35E+08	4.23E+01	1.55E+02	2.86%
		42700	1.46E+02				
		82350	1.64E+02				
35%	61000			4.56E+08	4.90E+01	1.55E+02	3.08%
		39650	1.45E+02				
		85400	1.65E+02				
40%	61000			5.95E+08	5.63E+01	1.55E+02	3.25%
		36600	1.44E+02				

Table A.134 Probabilistic modeling of laterally loaded free head long pile 10T with varying (EI) and load 120kN.

P=120kN							
COV(EI) (%)	EI^{o} ($kN\text{-}m^{2}$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^{2})^{2}$	VAR (M_{max}) $(kN\text{-}m)^{2}$	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		64050	2.20E+02				
5%	61000			9.30E+06	2.50E-01	2.20E+02	0.16%
		57950	2.19E+02				
		67100	2.21E+02				
10%	61000			3.72E+07	2.25E+00	2.20E+02	0.87%
		54900	2.18E+02				
		70150	2.27E+02				
15%	61000			8.37E+07	2.50E+01	2.20E+02	1.58%
		51850	2.17E+02				
		73200	2.28E+02				
20%	61000			1.49E+08	5.63E+01	2.20E+02	2.18%
		48800	2.13E+02				
		76250	2.29E+02				
25%	61000			2.33E+08	7.23E+01	2.20E+02	2.65%
		45750	2.12E+02				
		79300	2.30E+02				
30%	61000			3.35E+08	8.10E+01	2.20E+02	3.01%
		42700	2.12E+02				
		82350	2.31E+02				
35%	61000			4.56E+08	9.03E+01	2.20E+02	3.28%
		39650	2.12E+02				
		85400	2.32E+02				
40%	61000			5.95E+08	1.00E+02	2.20E+02	3.43%
		36600	2.12E+02				

Table A.135 Probabilistic modeling of laterally loaded free head long pile 10T with varying (EI) and load 150kN.

P=150kN							
COV(EI) (%)	EI^o (kN-m^2)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) (kN-m^2)^2	VAR (M_{max}) (kN-m)^2	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		64050	2.92E+02				
5%	61000			9.30E+06	2.50E-01	2.91E+02	0.24%
		57950	2.91E+02				
		67100	2.92E+02				
10%	61000			3.72E+07	4.00E+00	2.91E+02	0.96%
		54900	2.90E+02				
		70150	2.98E+02				
15%	61000			8.37E+07	2.03E+01	2.91E+02	1.63%
		51850	2.90E+02				
		73200	2.99E+02				
20%	61000			1.49E+08	6.40E+01	2.91E+02	2.30%
		48800	2.88E+02				
		76250	3.00E+02				
25%	61000			2.33E+08	7.23E+01	2.91E+02	2.72%
		45750	2.88E+02				
		79300	3.01E+02				
30%	61000			3.35E+08	8.10E+01	2.91E+02	3.08%
		42700	2.88E+02				
		82350	3.02E+02				
35%	61000			4.56E+08	9.03E+01	2.91E+02	3.33%
		39650	2.88E+02				
		85400	3.03E+02				
40%	61000			5.95E+08	1.10E+02	2.91E+02	3.53%
		36600	2.88E+02				

Table A.136 Value of COV (M_{max}) for free head long pile with varying COV(EI) and lateral load 30kN.

P=30kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	4.00E-02	0.09%
10%	3.72E+07	1.60E-01	0.55%
15%	8.37E+07	1.44E+00	1.02%
20%	1.49E+08	3.61E+00	1.43%
25%	2.33E+08	4.20E+00	1.73%
30%	3.35E+08	5.06E+00	1.93%
35%	4.56E+08	5.76E+00	2.02%
40%	5.95E+08	7.02E+00	2.08%

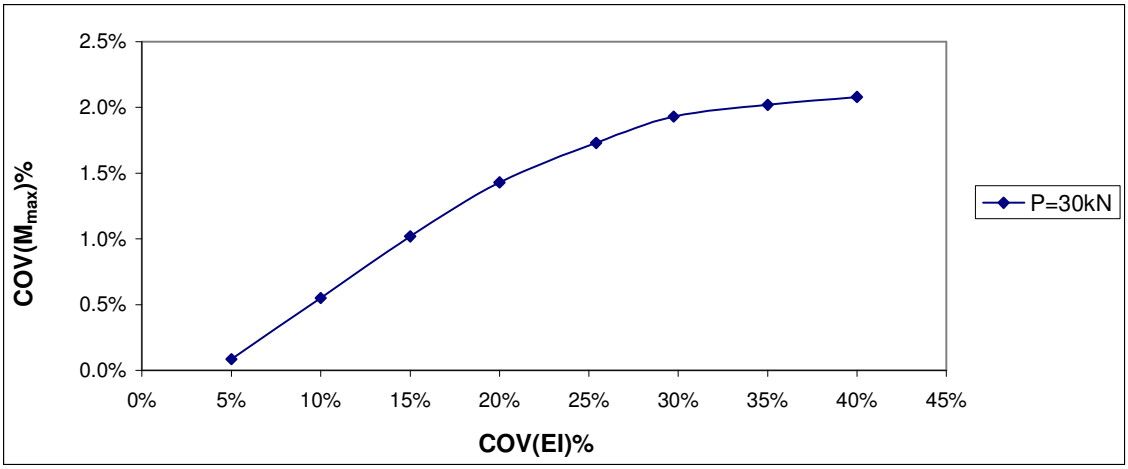


Fig. A.103 Variability of COV (M_{max}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.137 Value of COV (M_{max}) for free head long pile with varying COV(EI) and lateral load 60kN.

P=60kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	2.03E-01	0.11%
10%	3.72E+07	8.10E-01	0.66%
15%	8.37E+07	6.76E+00	1.22%
20%	1.49E+08	2.35E+01	1.70%
25%	2.33E+08	2.81E+01	1.99%
30%	3.35E+08	3.31E+01	2.20%
35%	4.56E+08	3.78E+01	2.29%
40%	5.95E+08	4.90E+01	2.38%

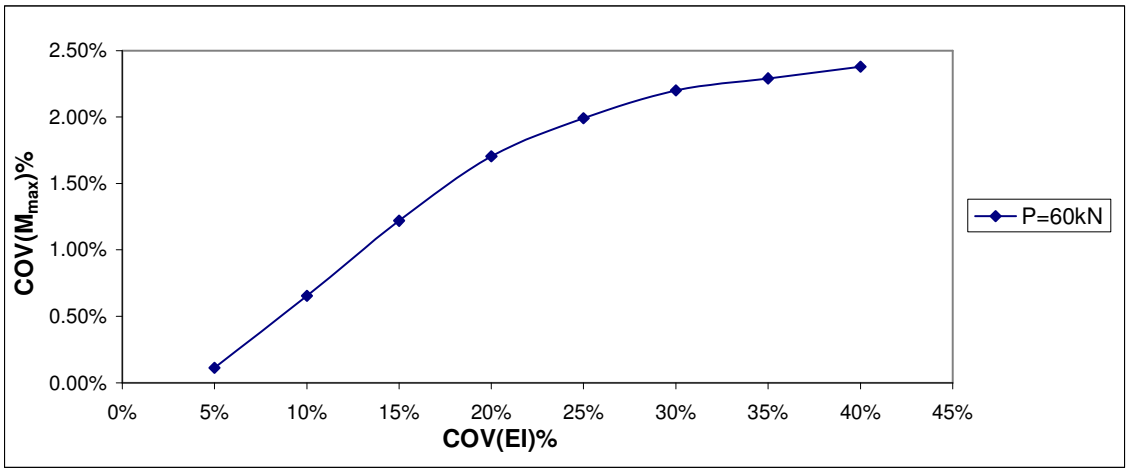


Fig. A.104 Variability of COV (M_{max}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.138 Value of COV(M_{max}) for free head long pile with varying COV(EI) and lateral load 90kN.

P=90kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	2.50E-01	0.21%
10%	3.72E+07	1.00E+00	0.85%
15%	8.37E+07	1.60E+01	1.40%
20%	1.49E+08	3.03E+01	1.98%
25%	2.33E+08	3.60E+01	2.49%
30%	3.35E+08	4.23E+01	2.86%
35%	4.56E+08	4.90E+01	3.08%
40%	5.95E+08	5.63E+01	3.25%

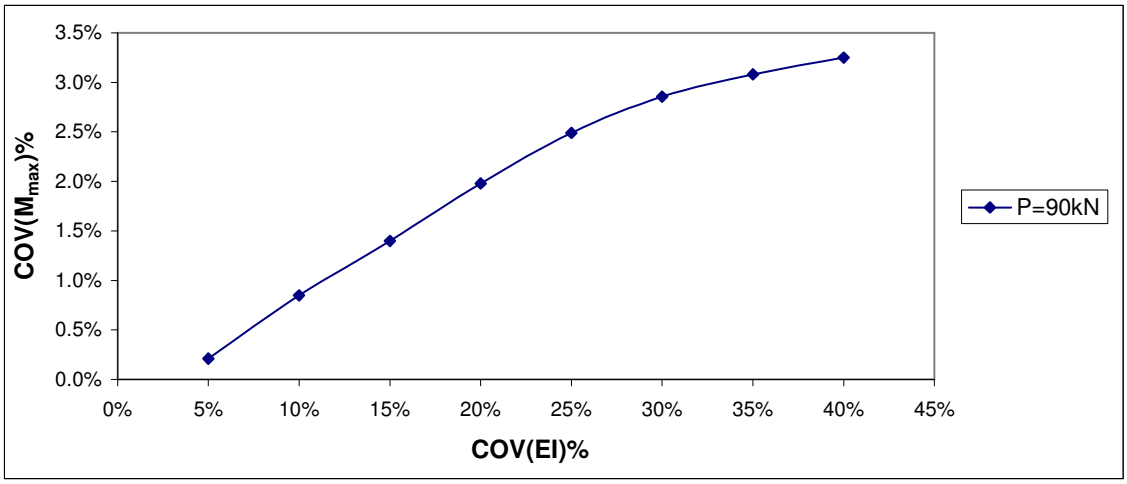


Fig. A.105 Variability of COV (M_{max}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.139 Value of COV(M_{max}) for free head long pile with varying COV(EI) and lateral load 120kN.

P=120kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	2.50E-01	0.16%
10%	3.72E+07	2.25E+00	0.87%
15%	8.37E+07	2.50E+01	1.58%
20%	1.49E+08	5.63E+01	2.18%
25%	2.33E+08	7.23E+01	2.65%
30%	3.35E+08	8.10E+01	3.01%
35%	4.56E+08	9.03E+01	3.28%
40%	5.95E+08	1.00E+02	3.43%

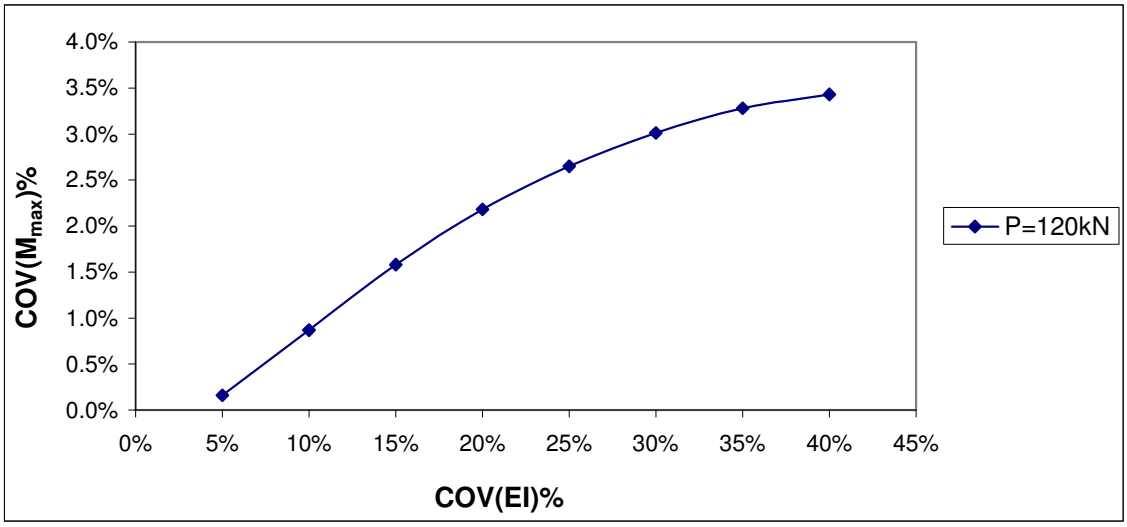


Fig. A.106 Variability of COV (M_{max}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.140 Value of COV(M_{max}) for free head long pile with varying COV(EI) and lateral load 150kN.

P=150kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	2.50E-01	0.24%
10%	3.72E+07	4.00E+00	0.96%
15%	8.37E+07	2.03E+01	1.63%
20%	1.49E+08	6.40E+01	2.30%
25%	2.33E+08	7.23E+01	2.72%
30%	3.35E+08	8.10E+01	3.08%
35%	4.56E+08	9.03E+01	3.33%
40%	5.95E+08	1.10E+02	3.53%

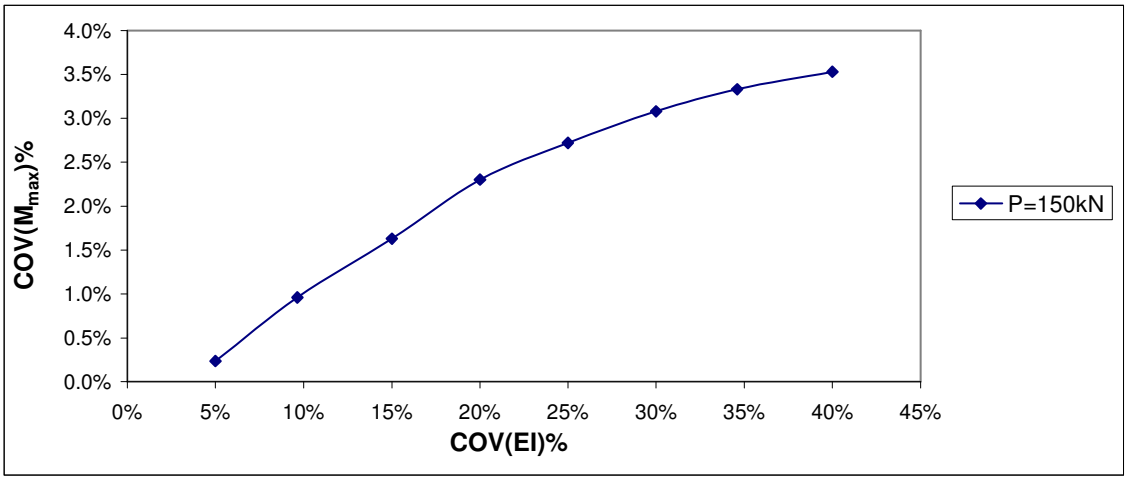


Fig. A.107 Variability of COV (M_{max}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force 150kN.

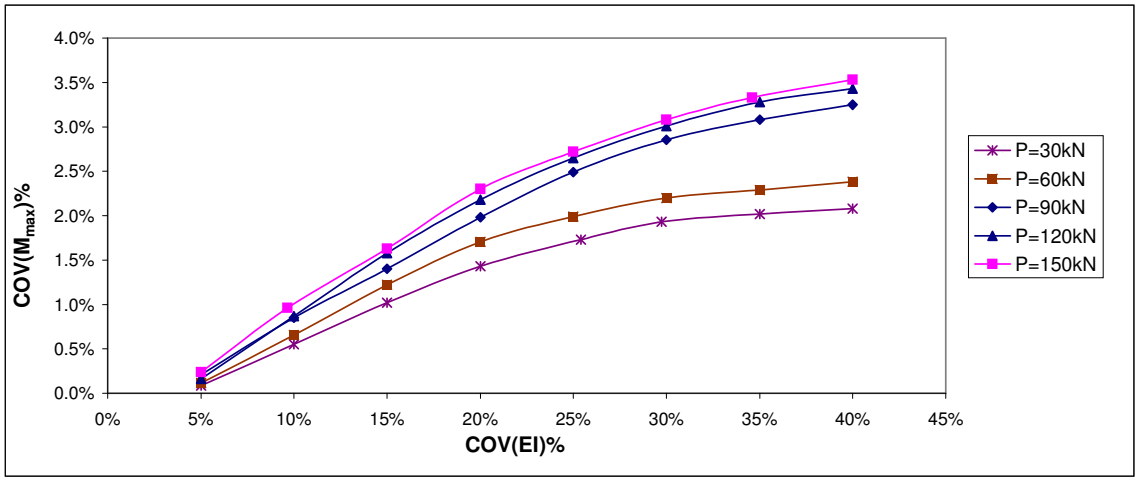


Fig. A108 Variability of COV (M_{max}) vs. COV (EI) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.141 Probabilistic modeling of laterally loaded free head long pile 10T with varying (P) and load 30kN.

P=30kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	4.20E+01				
5%	30			2.25E+00	6.76E+00	3.94E+01	6.13%
		28.5	3.68E+01				
		33	4.47E+01				
10%	30			9.00E+00	2.65E+01	3.94E+01	12.26%
		27	3.44E+01				
		34.5	4.73E+01				
15%	30			2.03E+01	5.93E+01	3.94E+01	18.06%
		25.5	3.19E+01				
		36	5.00E+01				
20%	30			3.60E+01	1.05E+02	3.94E+01	23.87%
		24	2.95E+01				
		37.5	5.27E+01				
25%	30			5.63E+01	1.61E+02	3.94E+01	30.00%
		22.5	2.73E+01				
		39	5.54E+01				
30%	30			8.10E+01	2.31E+02	3.94E+01	36.13%
		21	2.50E+01				
		40.5	5.81E+01				
35%	30			1.10E+02	3.15E+02	3.94E+01	42.23%
		19.5	2.26E+01				
		42	6.08E+01				
40%	30			1.44E+02	4.10E+02	3.94E+01	48.26%
		18	2.03E+01				

Table A.142 Probabilistic modeling of laterally loaded free head long pile 10T with varying (P) and load 60kN.

P=60kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		63	1.01E+02				
5%	60			9.00E+00	3.48E+01	9.51E+01	6.20%
		57	8.92E+01				
		66	1.07E+02				
10%	60			3.60E+01	1.39E+02	9.51E+01	12.41%
		54	8.34E+01				
		69	1.13E+02				
15%	60			8.10E+01	3.15E+02	9.51E+01	18.66%
		51	7.75E+01				
		72	1.19E+02				
20%	60			1.44E+02	5.57E+02	9.51E+01	24.82%
		48	7.18E+01				
		75	1.24E+02				
25%	60			2.25E+02	8.32E+02	9.51E+01	30.34%
		45	6.63E+01				
		78	1.30E+02				
30%	60			3.24E+02	1.20E+03	9.51E+01	36.38%
		42	6.08E+01				
		81	1.36E+02				
35%	60			4.41E+02	1.62E+03	9.51E+01	42.38%
		39	5.54E+01				
		84	1.42E+02				
40%	60			5.76E+02	2.12E+03	9.51E+01	48.37%
		36	5.00E+01				

Table A.143 Probabilistic modeling of laterally loaded free head long pile 10T with varying (P) and load 90kN.

P=90kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		94.5	1.64E+02				
5%	90			2.03E+01	9.03E+01	1.55E+02	6.14%
		85.5	1.45E+02				
		99	1.74E+02				
10%	90			8.10E+01	3.61E+02	1.55E+02	12.27%
		81	1.36E+02				
		103.5	1.83E+02				
15%	90			1.82E+02	7.84E+02	1.55E+02	18.64%
		76.5	1.27E+02				
		108	1.93E+02				
20%	90			3.24E+02	1.37E+03	1.55E+02	24.77%
		72	1.19E+02				
		112.5	2.03E+02				
25%	90			5.06E+02	2.16E+03	1.55E+02	30.91%
		67.5	1.10E+02				
		117	2.13E+02				
30%	90			7.29E+02	3.14E+03	1.55E+02	37.50%
		63	1.01E+02				
		121.5	2.23E+02				
35%	90			9.92E+02	4.28E+03	1.55E+02	43.64%
		58.5	9.21E+01				
		126	2.33E+02				
40%	90			1.30E+03	5.60E+03	1.55E+02	50.00%
		54	8.34E+01				

Table A.144 Probabilistic modeling of laterally loaded free head long pile 10T with varying (P) and load 120kN.

P=120kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		126	2.33E+02				
5%	120			3.60E+01	1.82E+02	2.20E+02	6.60%
		114	2.06E+02				
		132	2.47E+02				
10%	120			1.44E+02	7.29E+02	2.20E+02	13.07%
		108	1.93E+02				
		138	2.62E+02				
15%	120			3.24E+02	1.68E+03	2.20E+02	19.54%
		102	1.80E+02				
		144	2.76E+02				
20%	120			5.76E+02	2.97E+03	2.20E+02	26.02%
		96	1.67E+02				
		150	2.91E+02				
25%	120			9.00E+02	4.62E+03	2.20E+02	32.23%
		90	1.55E+02				
		156	3.07E+02				
30%	120			1.30E+03	6.81E+03	2.20E+02	38.58%
		84	1.42E+02				
		162	3.22E+02				
35%	120			1.76E+03	9.22E+03	2.20E+02	45.05%
		78	1.30E+02				
		168	3.39E+02				
40%	120			2.30E+03	1.21E+04	2.20E+02	51.40%
		72	1.19E+02				

Table A.145 Probabilistic modeling of laterally loaded free head long pile 10T with varying (P) and load 150kN.

P=150kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		157.5	3.11E+02				
5%	150			5.63E+01	3.61E+02	2.91E+02	6.53%
		142.5	2.73E+02				
		165	3.31E+02				
10%	150			2.25E+02	1.44E+03	2.91E+02	13.06%
		135	2.55E+02				
		172.5	3.51E+02				
15%	150			5.06E+02	3.25E+03	2.91E+02	19.59%
		127.5	2.37E+02				
		180	3.72E+02				
20%	150			9.00E+02	5.78E+03	2.91E+02	26.12%
		120	2.20E+02				
		187.5	3.93E+02				
25%	150			1.41E+03	9.03E+03	2.91E+02	32.65%
		112.5	2.03E+02				
		195	4.15E+02				
30%	150			2.03E+03	1.31E+04	2.91E+02	39.35%
		105	1.86E+02				
		202.5	4.36E+02				
35%	150			2.76E+03	1.77E+04	2.91E+02	45.70%
		97.5	1.70E+02				
		210	4.58E+02				
40%	150			3.60E+03	2.30E+04	2.91E+02	52.06%
		90	1.55E+02				

Table A.146 Value of COV (M_{max}) for free head long pile with varying COV(P) and lateral load 30kN.

P=30kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	6.76E+00	6.13%
10%	9.00E+00	2.10E+00	12.26%
15%	2.03E+01	5.93E+01	18.06%
20%	3.60E+01	1.05E+02	23.87%
25%	5.63E+01	1.61E+02	30.00%
30%	8.10E+01	2.31E+02	36.13%
35%	1.10E+02	3.15E+02	42.23%
40%	1.44E+02	4.10E+02	48.26%

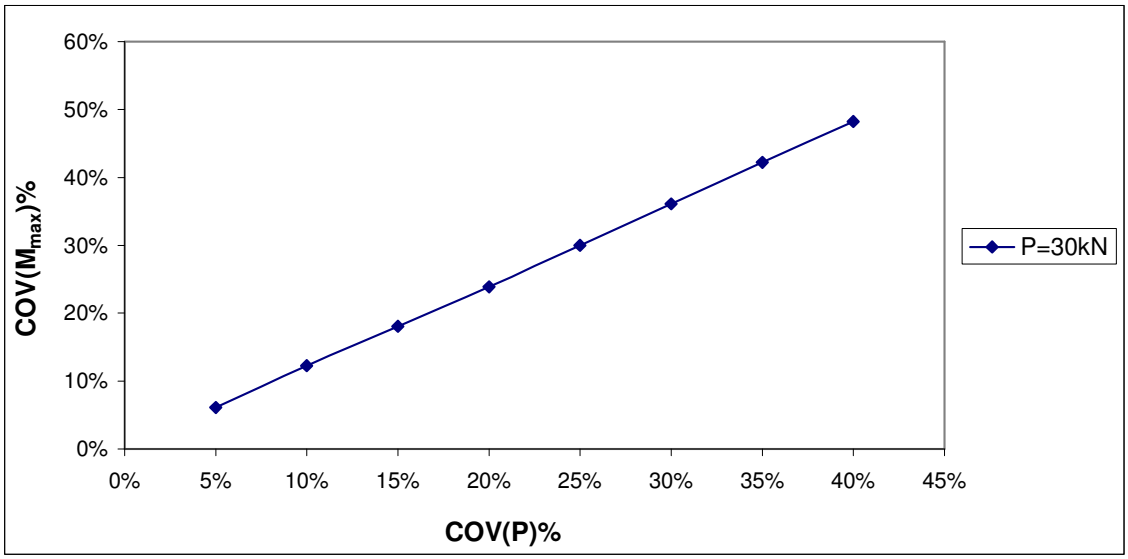


Fig. A.109 Variability of COV (M_{max}) vs. COV (P) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.147 Value of COV (M_{max}) for free head long pile with varying COV(P) and lateral load 60kN.

P=60kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.00E+00	3.48E+01	6.20%
10%	3.60E+01	1.39E+02	12.41%
15%	8.10E+01	3.15E+02	18.66%
20%	1.44E+02	5.57E+02	24.82%
25%	2.25E+02	8.32E+02	30.34%
30%	3.24E+02	1.20E+03	36.38%
35%	4.41E+02	1.62E+03	42.38%
40%	5.76E+02	2.12E+03	48.37%

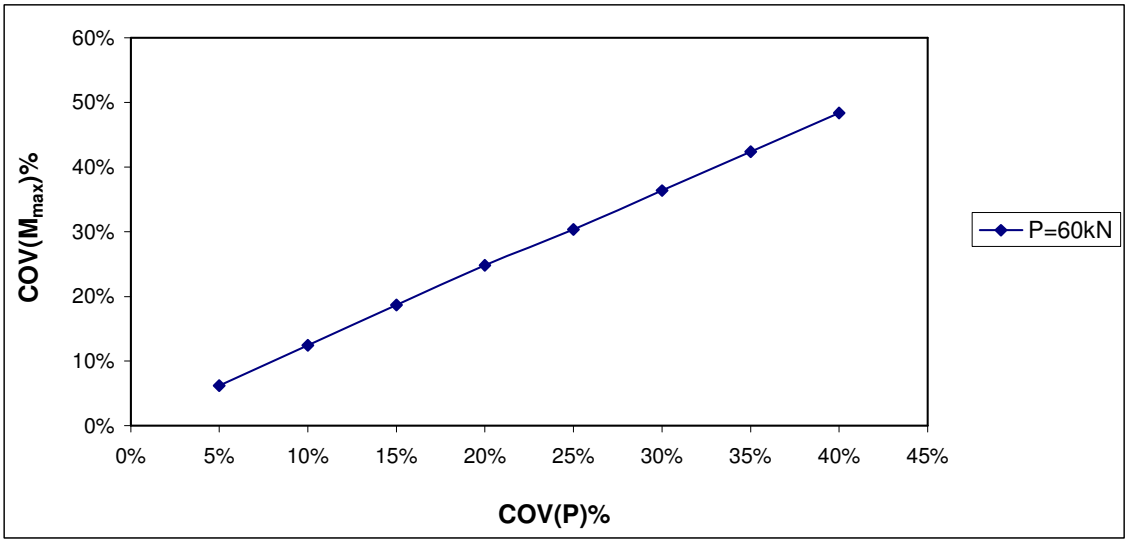


Fig. A.110 Variability of COV (M_{max}) vs. COV (P) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.148 Value of COV (M_{max}) for free head long pile with varying COV(P) and lateral load 90kN.

P=90kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.03E+01	9.03E+01	6.14%
10%	8.10E+01	3.61E+02	12.27%
15%	1.82E+02	7.84E+02	18.64%
20%	3.24E+02	1.37E+03	24.77%
25%	5.06E+02	2.16E+03	30.91%
30%	7.29E+02	3.14E+03	37.50%
35%	9.92E+02	4.28E+03	43.64%
40%	1.30E+03	5.60E+03	50.00%

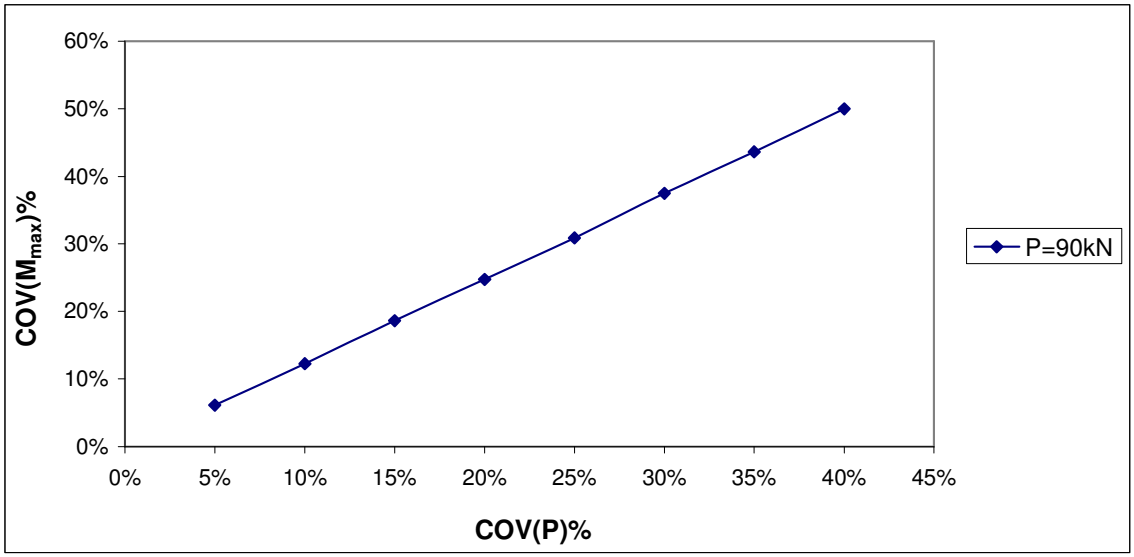


Fig. A.111 Variability of COV (M_{max}) vs. COV (P) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.149 Value of COV (M_{max}) for free head long pile with varying COV(P) and lateral load 120kN.

P=120kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	3.60E+01	1.82E+02	6.60%
10%	1.44E+02	7.29E+02	13.07%
15%	3.24E+02	1.68E+03	19.54%
20%	5.76E+02	2.97E+03	26.02%
25%	9.00E+02	4.62E+03	32.23%
30%	1.30E+03	6.81E+03	38.58%
35%	1.76E+03	9.22E+03	45.05%
40%	2.30E+03	1.21E+04	51.40%

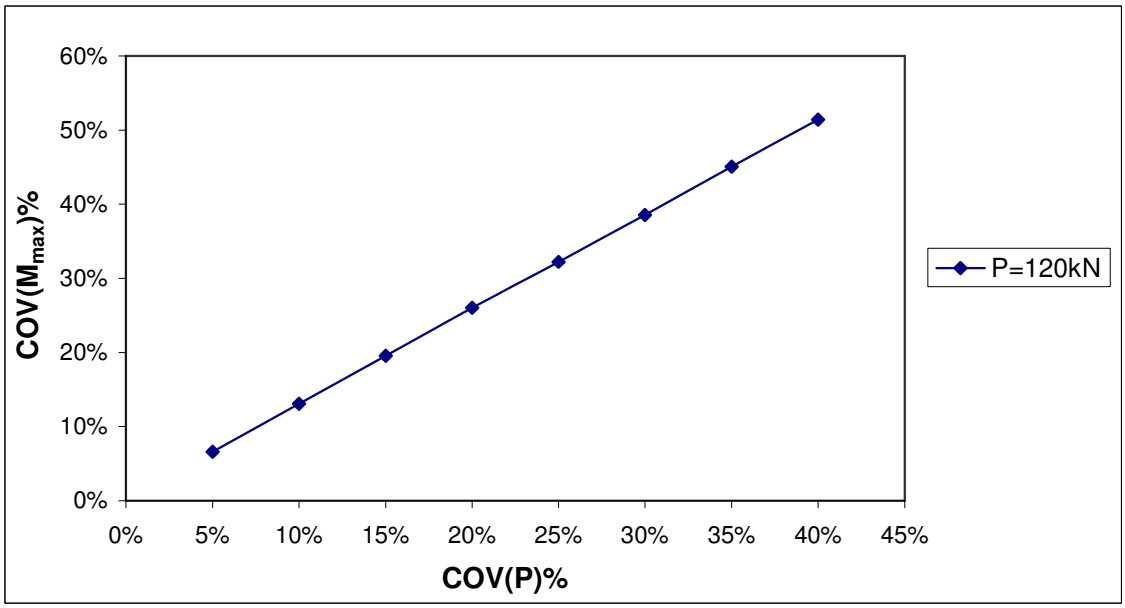


Fig. A.112 Variability of COV (M_{max}) vs. COV (P) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.150 Value of COV (M_{max}) for free head long pile with varying COV(P) and lateral load 150kN.

P=150kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	5.63E+01	3.61E+02	6.53%
10%	2.25E+02	1.44E+03	13.06%
15%	5.06E+02	3.25E+03	19.59%
20%	9.00E+02	5.78E+03	26.12%
25%	1.41E+03	9.03E+03	32.65%
30%	2.03E+03	1.31E+04	39.35%
35%	2.76E+03	1.77E+04	45.70%
40%	3.60E+03	2.30E+04	52.06%

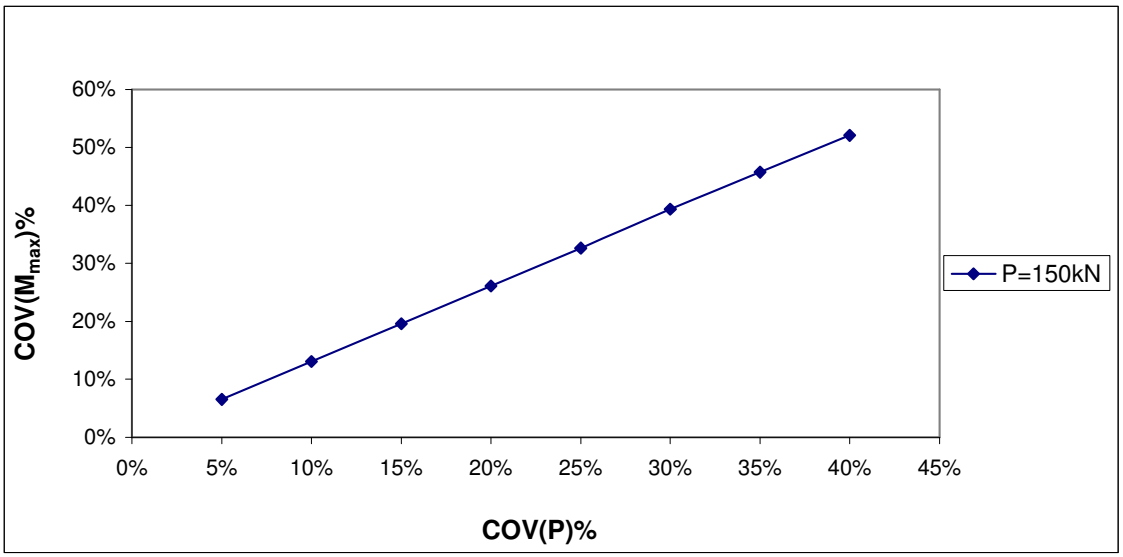


Fig. A.113 Variability of COV (M_{max}) vs. COV (P) for single free head long pile (10T) subjected to lateral force 150kN.

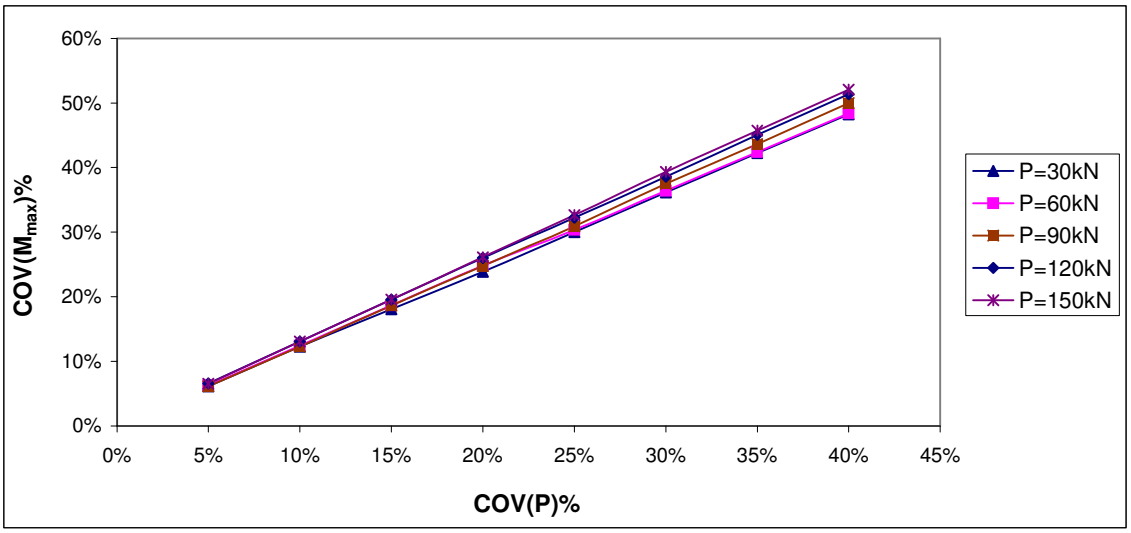


Fig. A.114 Variability of COV (M_{max}) vs. COV (P) for single free head long pile (10T) subjected to lateral force of discrete variability.

A.5 Reliability Index (β) of bending moment vs. COV (Variables)

Table A.151 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'Φ' subjected to lateral load 30kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E+01	10696.73	5%	103.5458	6.2784
1.10E+02	10696.73	10%	103.9566	6.2536
2.56E+02	10696.73	15%	104.6553	6.2118
4.84E+02	10696.73	20%	105.7390	6.1482
7.56E+02	10696.73	25%	107.0186	6.1600
1.16E+03	10696.73	30%	108.8702	6.1100
1.64E+03	10696.73	35%	111.0720	6.0200
2.26E+03	10696.73	40%	113.8112	6.0000

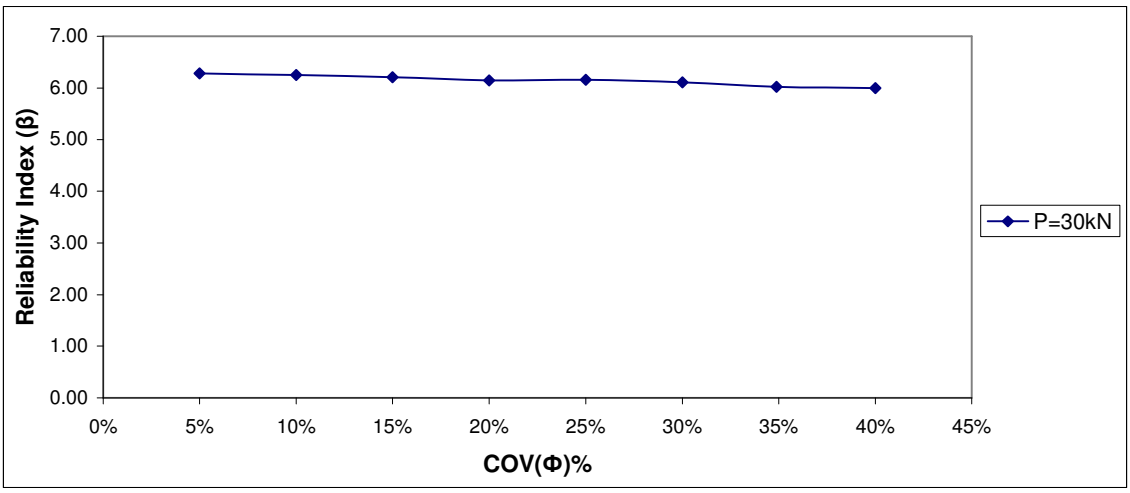


Fig. A.115 Reliability Index (β) of M_{max} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.152 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'Φ' subjected to lateral load 60kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.30E+01	10696.73	5%	103.4876	5.7437
4.97E+01	10696.73	10%	103.6650	5.7339
1.16E+02	10696.73	15%	103.9822	5.7164
1.99E+02	10696.73	20%	104.3817	5.6945
3.15E+02	10696.73	25%	104.9371	5.6643
4.60E+02	10696.73	30%	105.6259	5.6274
6.35E+02	10696.73	35%	106.4508	5.5838
8.27E+02	10696.73	40%	107.3466	5.5372

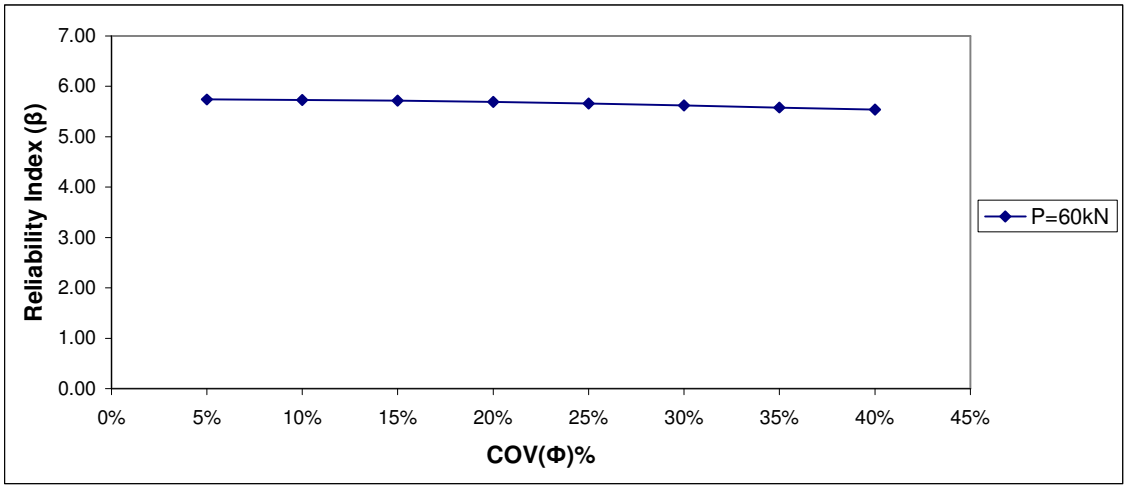


Fig. A.116 Reliability Index (β) of M_{max} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.153 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'Φ' subjected to lateral load 90kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
5.63E+01	10696.73	5%	103.6966	5.1545
2.56E+02	10696.73	10%	104.6553	5.1072
5.76E+02	10696.73	15%	106.1731	5.0342
1.09E+03	10696.73	20%	108.5621	4.9234
1.81E+03	10696.73	25%	111.8167	4.7801
2.65E+03	10696.73	30%	115.5378	4.6262
3.84E+03	10696.73	35%	120.5850	4.4326
5.33E+03	10696.73	40%	126.5928	4.2222

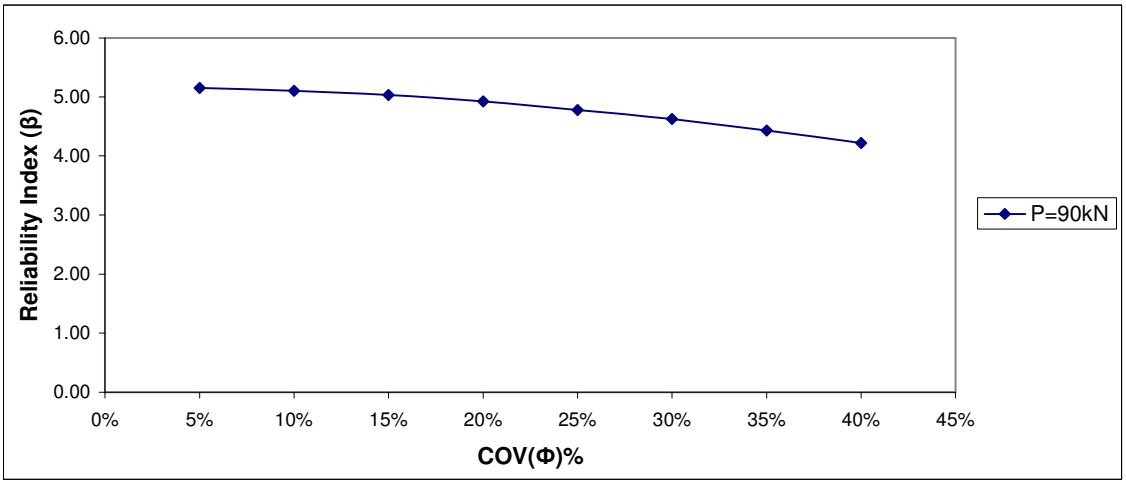


Fig. A.117 Reliability Index (β) of M_{max} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.154 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'Φ' subjected to lateral load 120kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.24E+00	10696.73	5%	103.4407	4.5388
1.23E+01	10696.73	10%	103.4842	4.5369
2.76E+01	10696.73	15%	103.5582	4.4900
4.49E+01	10696.73	20%	103.6418	4.4000
6.32E+01	10696.73	25%	103.7301	4.2700
8.65E+01	10696.73	30%	103.8423	4.0700
1.11E+02	10696.73	35%	103.9617	3.8400
1.42E+02	10696.73	40%	104.1074	3.5800

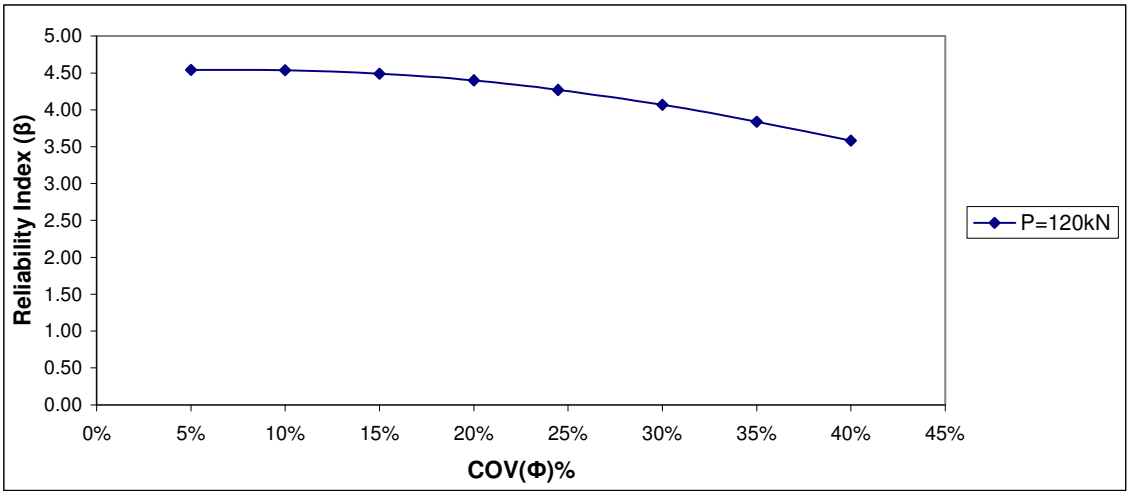


Fig. A.118 Reliability Index (β) of M_{max} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.155 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'Φ' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.32E+02	10696.73	5%	104.0624	3.8294
5.29E+02	10696.73	10%	105.9515	3.7612
1.26E+03	10696.73	15%	109.3480	3.6443
2.26E+03	10696.73	20%	113.8112	3.5014
3.66E+03	10696.73	25%	119.8206	3.3258
5.48E+03	10696.73	30%	127.1721	3.1336
7.66E+03	10696.73	35%	135.4732	2.9415
1.06E+04	10696.73	40%	145.9648	2.7301

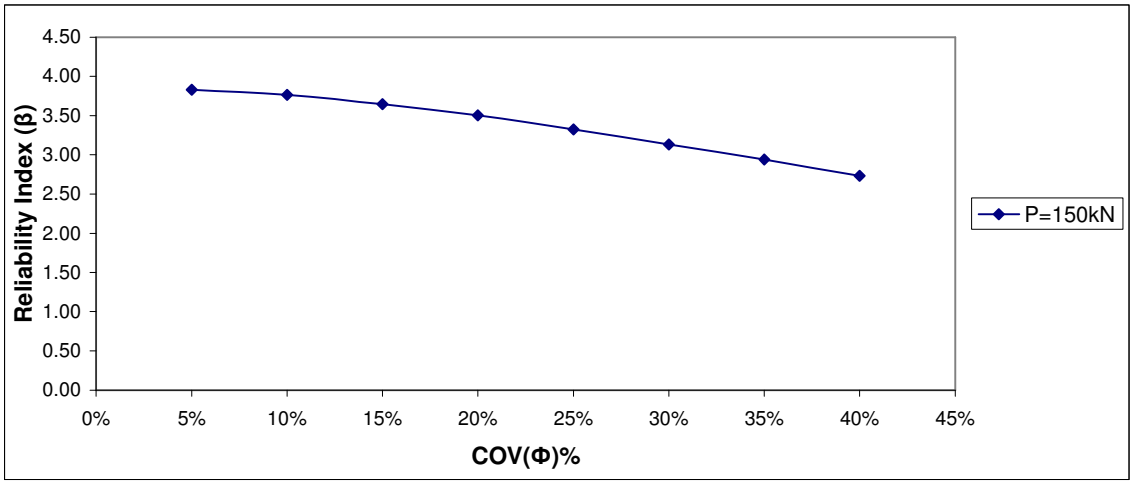


Fig. A.119 Reliability Index (β) of M_{max} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force 150kN.

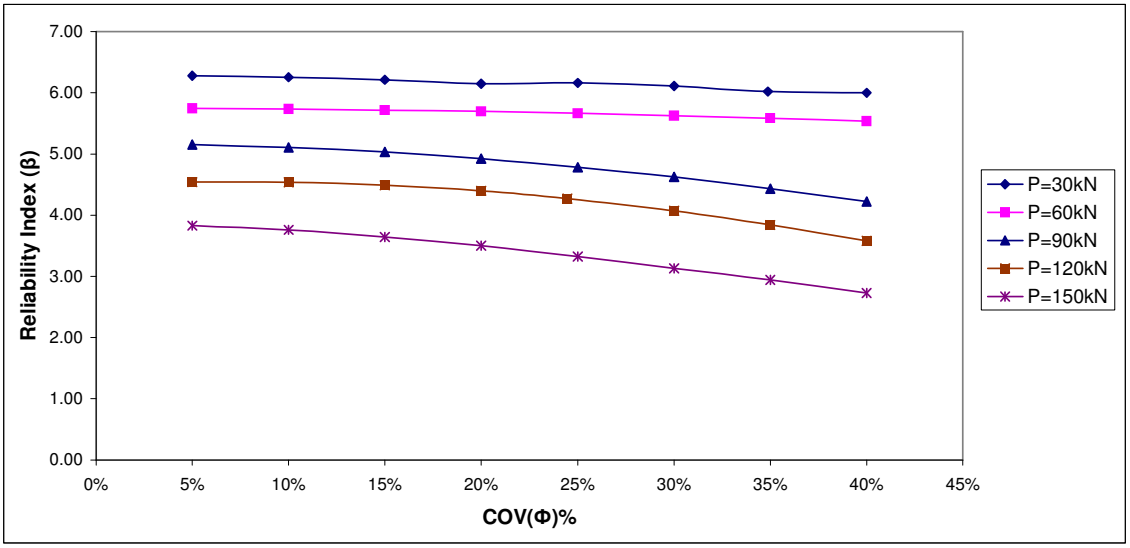


Fig. A.120 Reliability Index (β) of M_{max} vs. COV (Φ) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.156 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'γ' subjected to lateral load 30kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
6.25E+00	10696.73	5%	103.4552	6.2839
2.50E+01	10696.73	10%	103.5458	6.2784
5.63E+01	10696.73	15%	103.6966	6.2693
1.00E+02	10696.73	20%	103.9073	6.2565
1.32E+02	10696.73	25%	104.0624	6.2472
2.10E+02	10696.73	30%	104.4365	6.2248
3.06E+02	10696.73	35%	104.8951	6.1976
4.20E+02	10696.73	40%	105.4371	6.1658

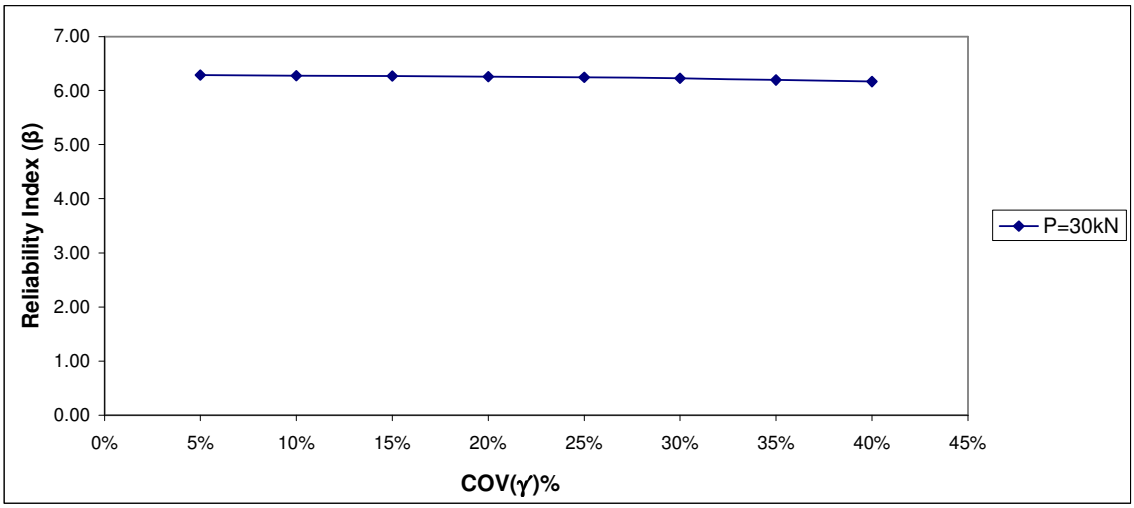


Fig. A.121 Reliability Index (β) of M_{max} vs. COV (γ) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.157 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'γ' subjected to lateral load 60kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.23E+01	10696.73	5%	103.4842	5.7439
4.90E+01	10696.73	10%	103.6616	5.7340
1.10E+02	10696.73	15%	103.9566	5.7178
2.10E+02	10696.73	20%	104.4365	5.6915
3.42E+02	10696.73	25%	105.0666	5.6574
4.84E+02	10696.73	30%	105.7390	5.6214
6.76E+02	10696.73	35%	106.6430	5.5737
9.61E+02	10696.73	40%	107.9710	5.5052

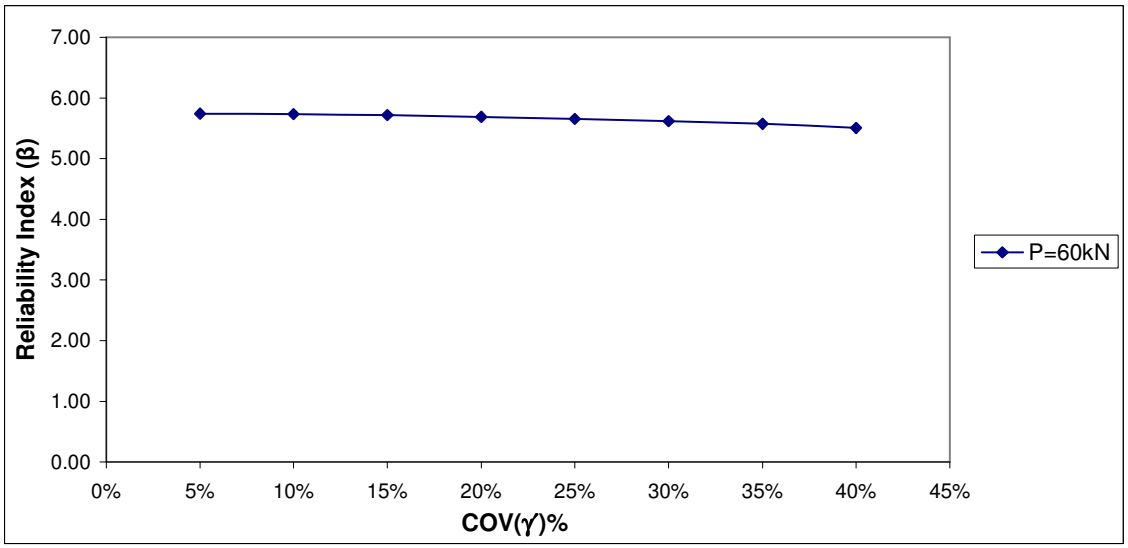


Fig. A.122 Reliability Index (β) of M_{max} vs. COV (γ) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.158 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'γ' subjected to lateral load 90kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
2.56E+00	10696.73	5%	103.4374	5.1674
1.09E+01	10696.73	10%	103.4776	5.1654
2.35E+01	10696.73	15%	103.5387	5.1623
4.16E+01	10696.73	20%	103.6259	5.1580
6.48E+01	10696.73	25%	103.7378	5.1524
9.31E+01	10696.73	30%	103.8742	5.1456
1.37E+02	10696.73	35%	104.0847	5.1352
1.77E+02	10696.73	40%	104.2767	5.1258

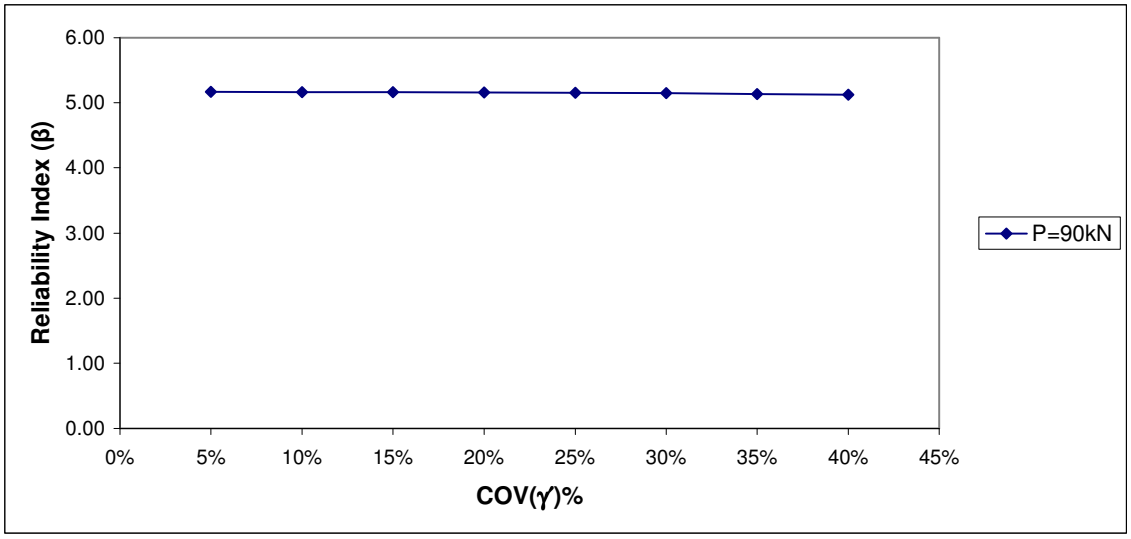


Fig. A.123 Reliability Index (β) of M_{max} vs. COV (γ) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.159 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'γ' subjected to lateral load 120kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
2.50E+01	10696.73	5%	103.5458	4.5342
1.00E+02	10696.73	10%	103.9073	4.5184
2.40E+02	10696.73	15%	104.5800	4.4894
4.20E+02	10696.73	20%	105.4371	4.4529
6.76E+02	10696.73	25%	106.6430	4.4025
1.02E+03	10696.73	30%	108.2623	4.3367
1.48E+03	10696.73	35%	110.3584	4.2543
2.03E+03	10696.73	40%	112.7906	4.1626

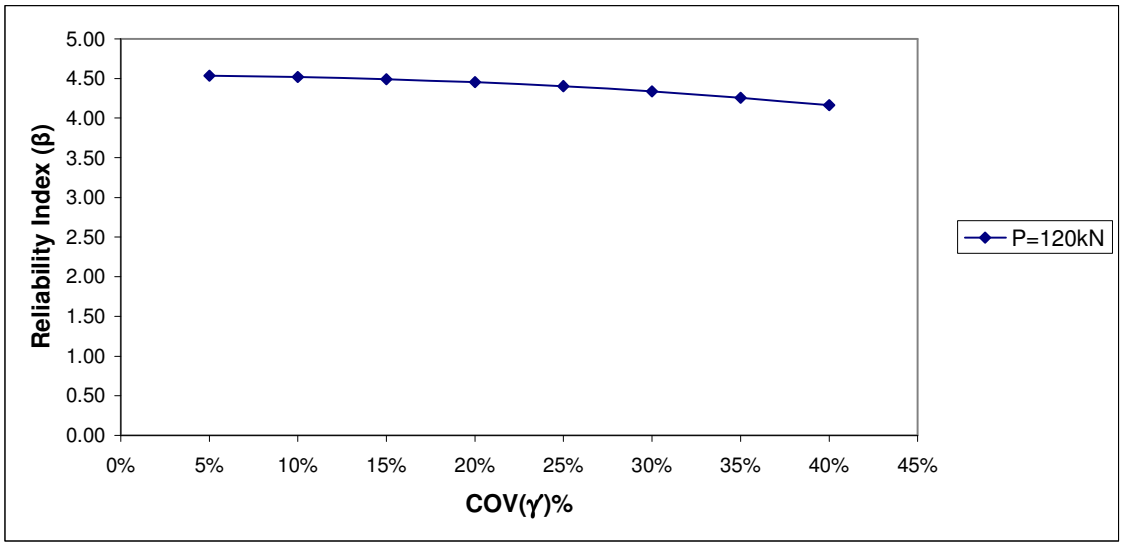


Fig. A.124 Reliability Index (β) of M_{max} vs. COV (γ) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.160 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'γ' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
7.22E-01	10696.73	5%	103.4285	3.8529
2.56E+00	10696.73	10%	103.4374	3.8526
5.76E+00	10696.73	15%	103.4528	3.8520
1.02E+01	10696.73	20%	103.4745	3.8512
1.60E+01	10696.73	25%	103.5023	3.8502
2.55E+01	10696.73	30%	103.5482	3.8100
3.54E+01	10696.73	35%	103.5960	3.8000
4.76E+01	10696.73	40%	103.6549	3.7300

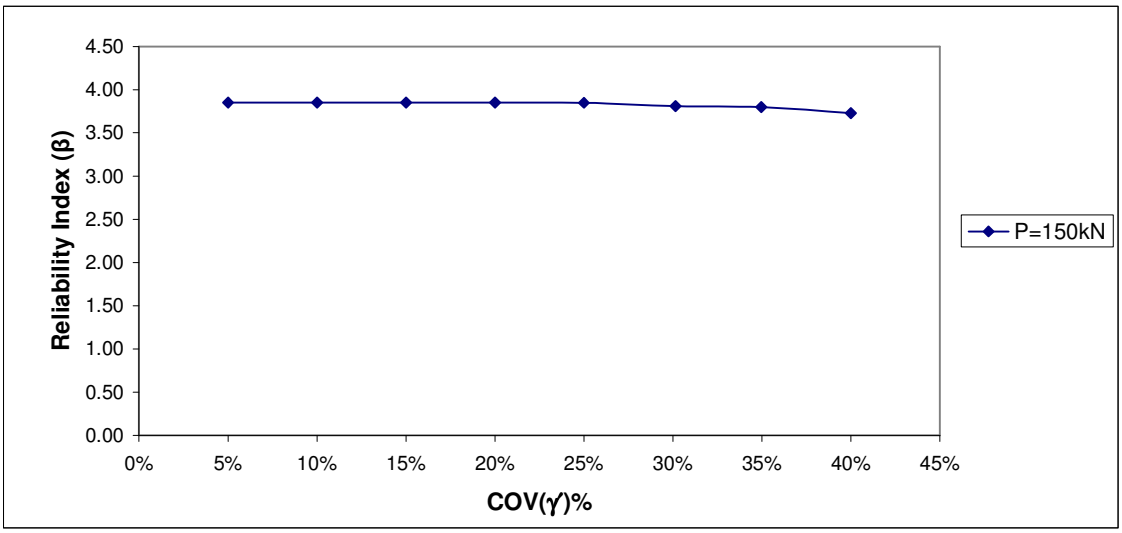


Fig. A.125 Reliability Index (β) of M_{max} vs. COV (γ) for single free head long pile (10T) subjected to lateral force 150kN.

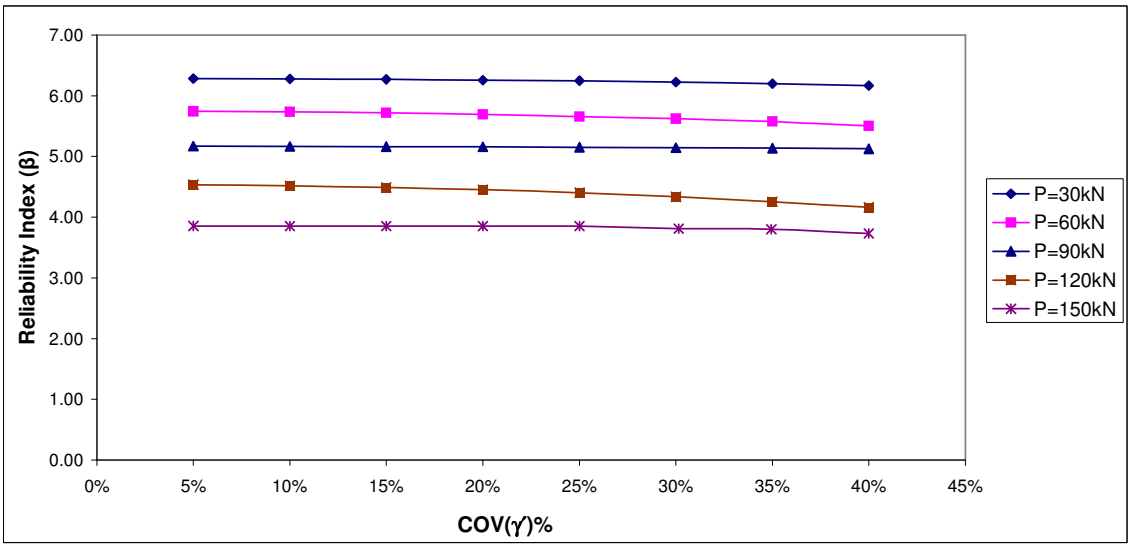


Fig. A.126 Reliability Index (β) of M_{max} vs. COV (γ) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.161 Reliability Index (β) connected to M_{max} for free head single pile (10T) with

varying 'k' subjected to lateral load 30kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E-02	10696.73	5%	103.4250	6.2857
1.65E-02	10696.73	10%	103.4251	6.2857
4.00E-02	10696.73	15%	103.4252	6.2857
6.25E-02	10696.73	20%	103.4253	6.2857
9.00E-02	10696.73	25%	103.4254	6.2857
1.23E-01	10696.73	30%	103.4256	6.2857
1.60E-01	10696.73	35%	103.4258	6.2857
2.50E-01	10696.73	40%	103.4262	6.2856

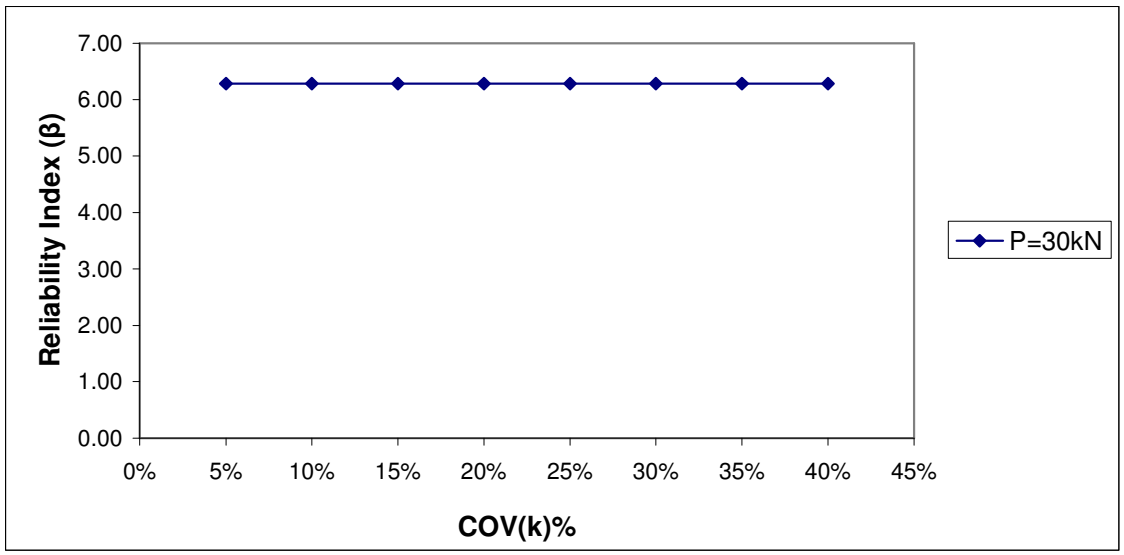


Fig. A.127 Reliability Index (β) of M_{max} vs. COV (k) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.162 Reliability Index (β) connected to M_{max} for free head single pile (10T) with

varying 'k' subjected to lateral load 60kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-03	10696.73	5%	103.4250	5.7472
1.00E-02	10696.73	10%	103.4250	5.7472
4.00E-02	10696.73	15%	103.4252	5.7471
6.25E-02	10696.73	20%	103.4253	5.7471
1.23E-01	10696.73	25%	103.4256	5.7471
1.60E-01	10696.73	30%	103.4258	5.7471
2.50E-01	10696.73	35%	103.4262	5.7471
4.23E-01	10696.73	40%	103.4270	5.7470

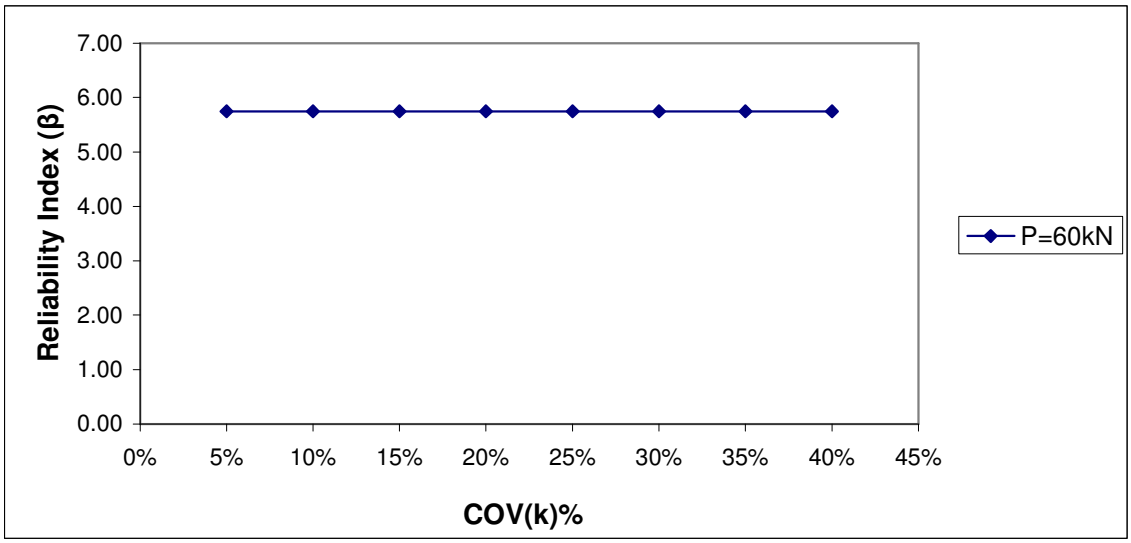


Fig. A.128 Reliability Index (β) of M_{max} vs. COV (k) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.163 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'k' subjected to lateral load 90kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-01	10696.73	5%	103.4262	5.1679
2.53E-01	10696.73	10%	103.4262	5.1679
2.56E-01	10696.73	15%	103.4262	5.1679
2.57E-01	10696.73	20%	103.4262	5.1679
2.59E-01	10696.73	25%	103.4263	5.1679
2.60E-01	10696.73	30%	103.4263	5.1679
2.62E-01	10696.73	35%	103.4263	5.1679
1.00E+00	10696.73	40%	103.4298	5.1678

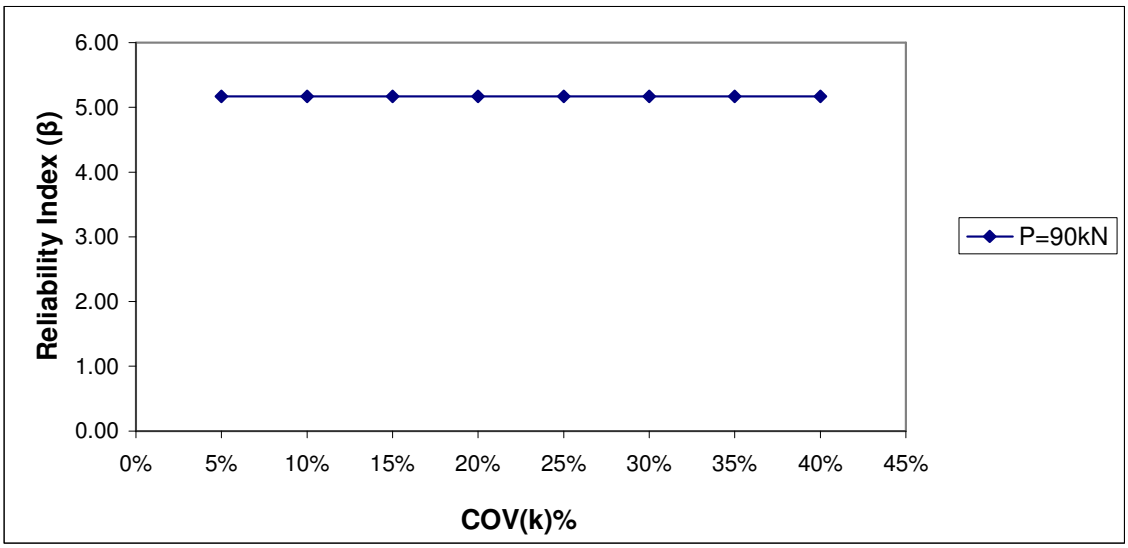


Fig. A.129 Reliability Index (β) of M_{max} vs. COV (k) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.164 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'k' subjected to lateral load 120kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M_l})$ (kN-m)	Reliability Index (β)
8.60E-03	10696.73	5%	103.4250	4.5395
9.50E-03	10696.73	10%	103.4250	4.5395
9.52E-03	10696.73	15%	103.4250	4.5395
3.00E-02	10696.73	20%	103.4251	4.5395
4.20E-02	10696.73	25%	103.4252	4.5395
6.23E-02	10696.73	30%	103.4253	4.5395
6.85E-02	10696.73	35%	103.4253	4.5395
2.50E-01	10696.73	40%	103.4262	4.5395

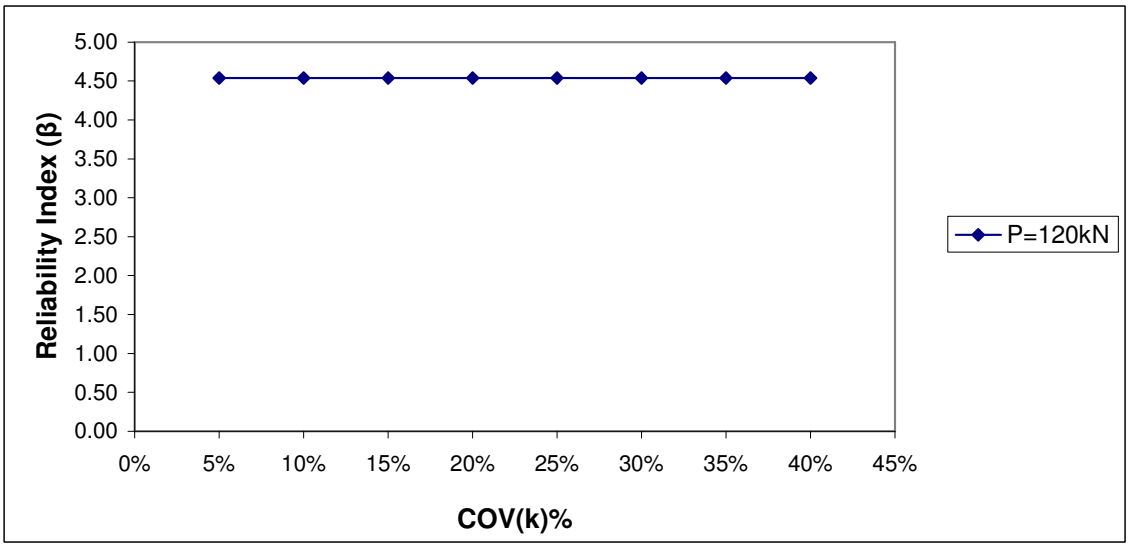


Fig. A.130 Reliability Index (β) of M_{max} vs. COV (k) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.165 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'k' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
0.00E+00	10696.73	5%	103.4250	3.8530
0.00E+00	10696.73	10%	103.4250	3.8530
0.00E+00	10696.73	15%	103.4250	3.8530
0.00E+00	10696.73	20%	103.4250	3.8530
0.00E+00	10696.73	25%	103.4250	3.8530
0.00E+00	10696.73	30%	103.4250	3.8530
2.50E-02	10696.73	35%	103.4251	3.8530
2.73E-02	10696.73	40%	103.4251	3.8530

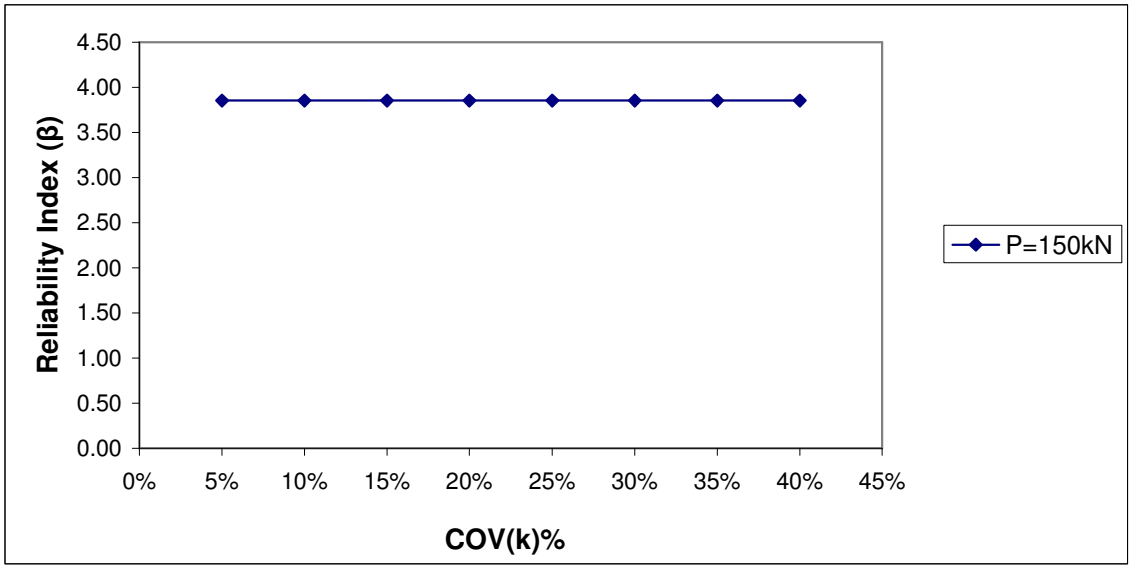


Fig. A.131 Reliability Index (β) of M_{max} vs. COV (k) for single free head long pile (10T) subjected to lateral force 150kN.

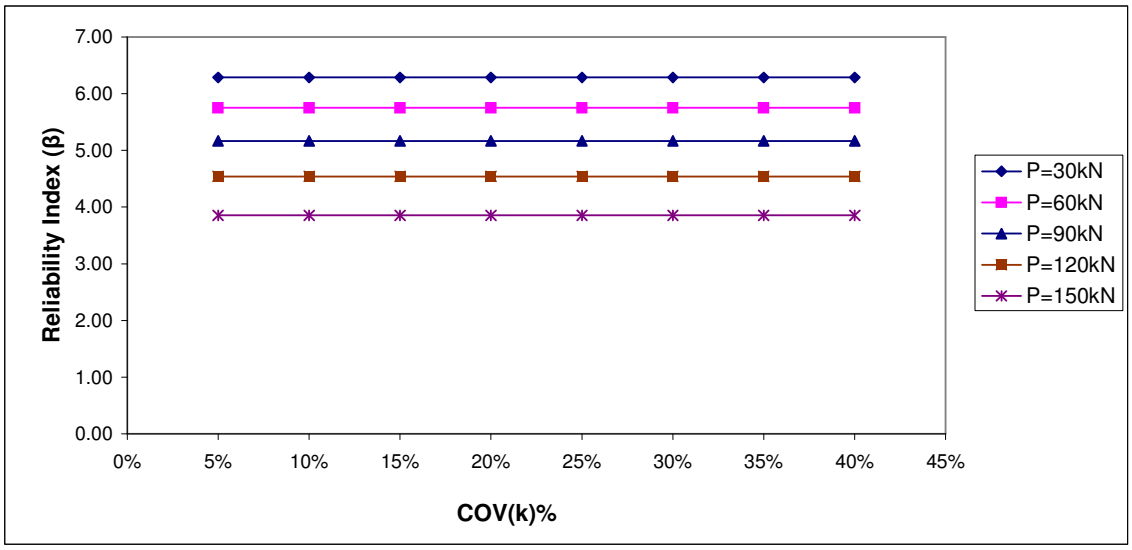


Fig. A.132 Reliability Index (β) of M_{max} vs. COV (k) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.166 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'B' subjected to lateral load 30kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-01	10696.73	5%	103.4262	6.2856
1.00E+00	10696.73	10%	103.4298	6.2854
4.00E+00	10696.73	15%	103.4443	6.2845
6.25E+00	10696.73	20%	103.4552	6.2839
9.00E+00	10696.73	25%	103.4685	6.2831
1.60E+01	10696.73	30%	103.5023	6.2810
2.05E+01	10696.73	35%	103.5241	6.2797
2.50E+01	10696.73	40%	103.5458	6.2784

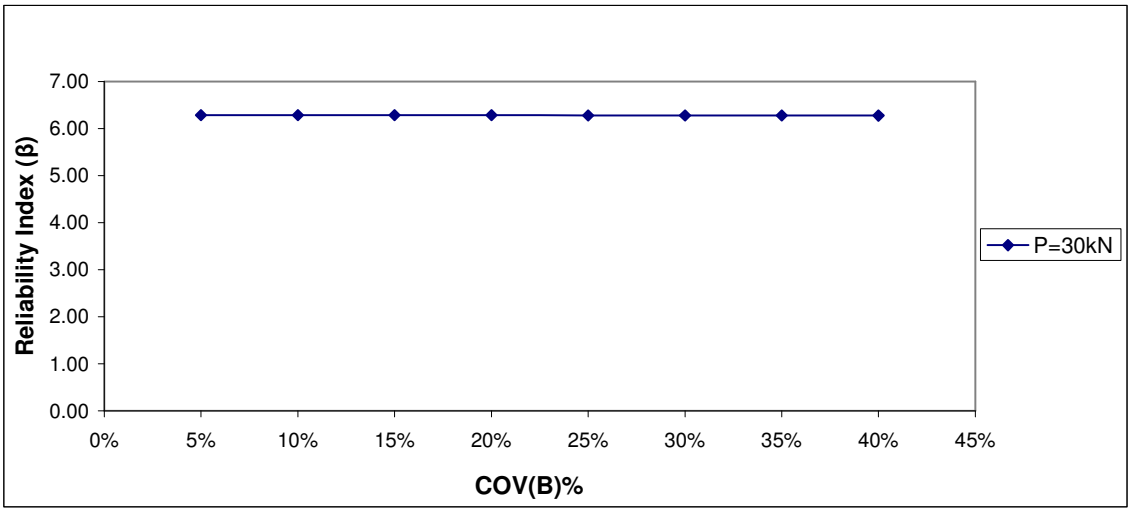


Fig. A.133 Reliability Index (β) of M_{max} vs. COV (B) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.167 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'B' subjected to lateral load 60kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-01	10696.73	5%	103.4262	5.7471
2.25E+00	10696.73	10%	103.4359	5.7466
6.25E+00	10696.73	15%	103.4552	5.7455
1.23E+01	10696.73	20%	103.4842	5.7439
2.03E+01	10696.73	25%	103.5229	5.7417
3.60E+01	10696.73	30%	103.5989	5.7375
5.70E+01	10696.73	35%	103.7000	5.7319
7.23E+01	10696.73	40%	103.7737	5.7278

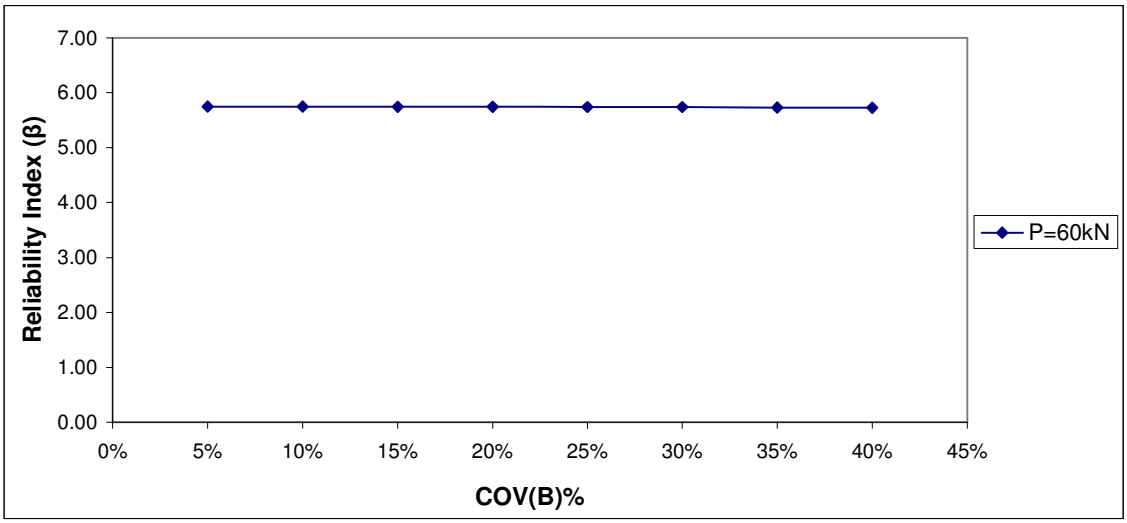


Fig. A.134 Reliability Index (β) of M_{max} vs. COV (B) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.168 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'B' subjected to lateral load 90kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.00E+00	10696.73	5%	103.4443	5.1670
9.00E+00	10696.73	10%	103.4685	5.1658
2.03E+01	10696.73	15%	103.5229	5.1631
4.23E+01	10696.73	20%	103.6291	5.1578
6.40E+01	10696.73	25%	103.7339	5.1526
9.03E+01	10696.73	30%	103.8604	5.1463
1.34E+02	10696.73	35%	104.0705	5.1359
1.82E+02	10696.73	40%	104.3024	5.1245

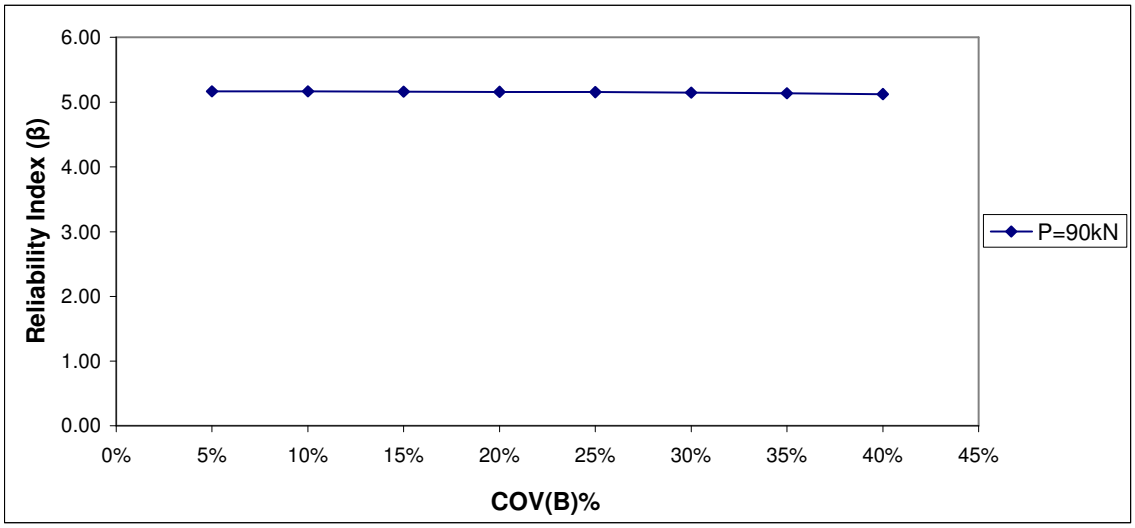


Fig. A.135 Reliability Index (β) of M_{max} vs. COV (B) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.169 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'B' subjected to lateral load 120kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
5.62E-01	10696.73	5%	103.4277	4.5394
2.56E+00	10696.73	10%	103.4374	4.5390
5.52E+00	10696.73	15%	103.4517	4.5384
9.00E+00	10696.73	20%	103.4685	4.5376
1.37E+01	10696.73	25%	103.4912	4.5366
1.81E+01	10696.73	30%	103.5123	4.5357
2.14E+01	10696.73	35%	103.5286	4.5350
2.35E+01	10696.73	40%	103.5387	4.5345

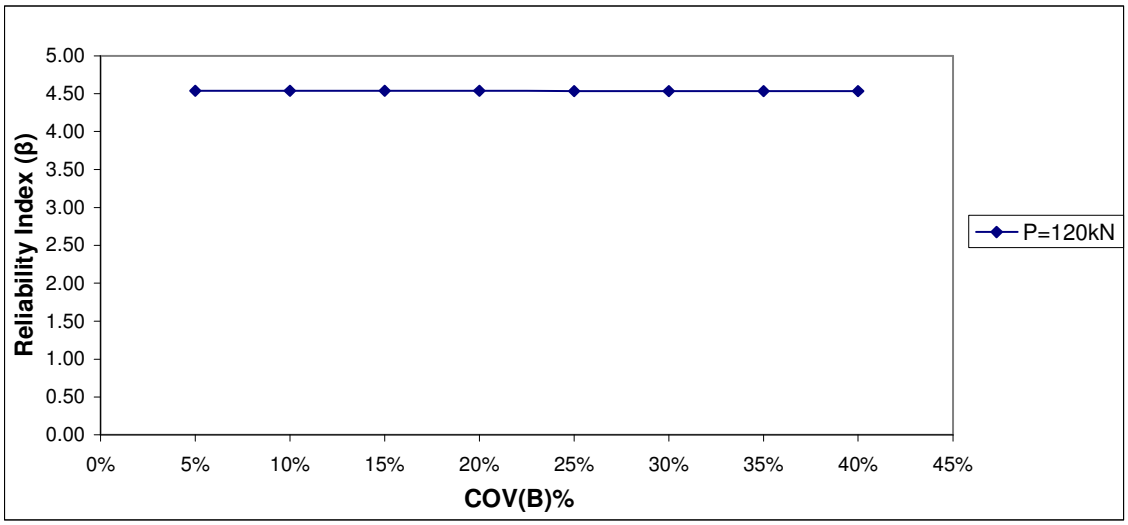


Fig. A.136 Reliability Index (β) of M_{max} vs. COV (B) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.170 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'B' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.23E-01	10696.73	5%	103.4270	3.8530
1.82E+00	10696.73	10%	103.4338	3.8527
3.42E+00	10696.73	15%	103.4415	3.8524
5.52E+00	10696.73	20%	103.4517	3.8520
7.56E+00	10696.73	25%	103.4616	3.8517
9.00E+00	10696.73	30%	103.4685	3.8514
1.07E+01	10696.73	35%	103.4767	3.8511
1.26E+01	10696.73	40%	103.4859	3.8508

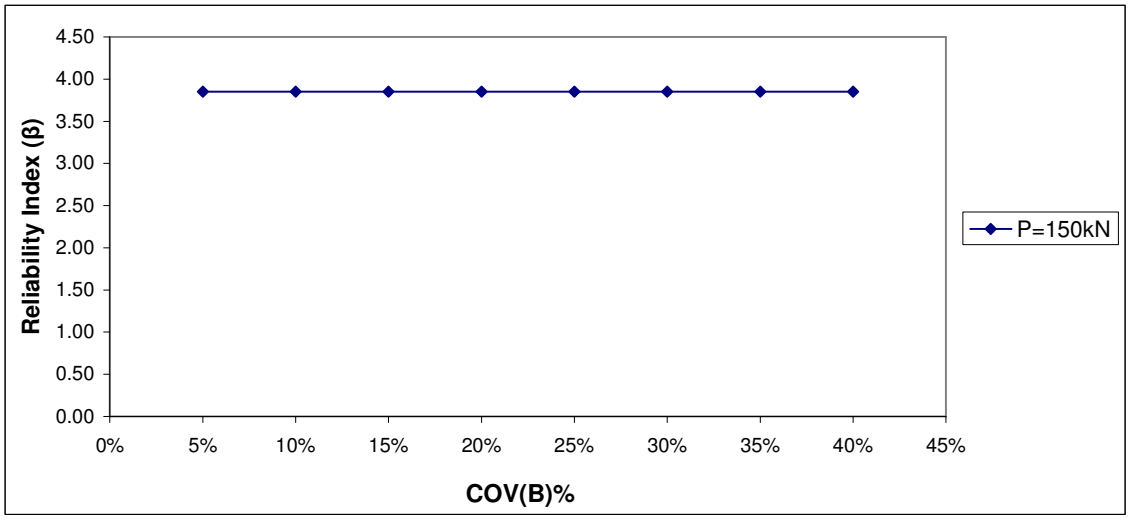


Fig. A.137 Reliability Index (β) of M_{max} vs. COV (B) for single free head long pile (10T) subjected to lateral force 150kN.

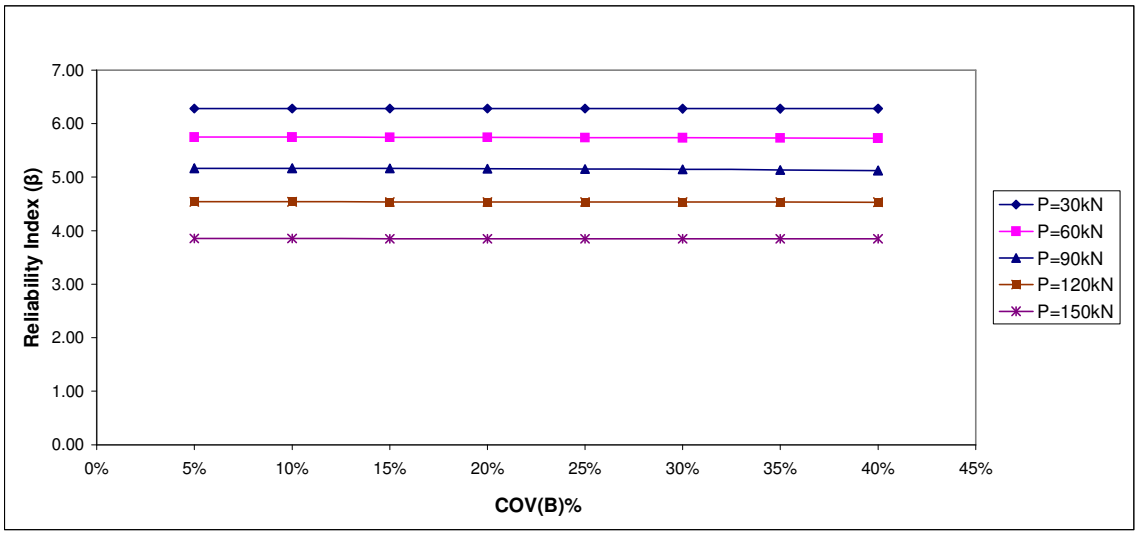


Fig. A.138 Reliability Index (β) of M_{max} vs. COV (B) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.171 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'EI' subjected to lateral load 30kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.00E-02	10696.73	5%	103.4252	6.2857
1.60E-01	10696.73	10%	103.4258	6.2857
1.44E+00	10696.73	15%	103.4320	6.2853
3.61E+00	10696.73	20%	103.4425	6.2847
4.20E+00	10696.73	25%	103.4453	6.2845
5.06E+00	10696.73	30%	103.4495	6.2842
5.76E+00	10696.73	35%	103.4528	6.2840
7.02E+00	10696.73	40%	103.4589	6.2837

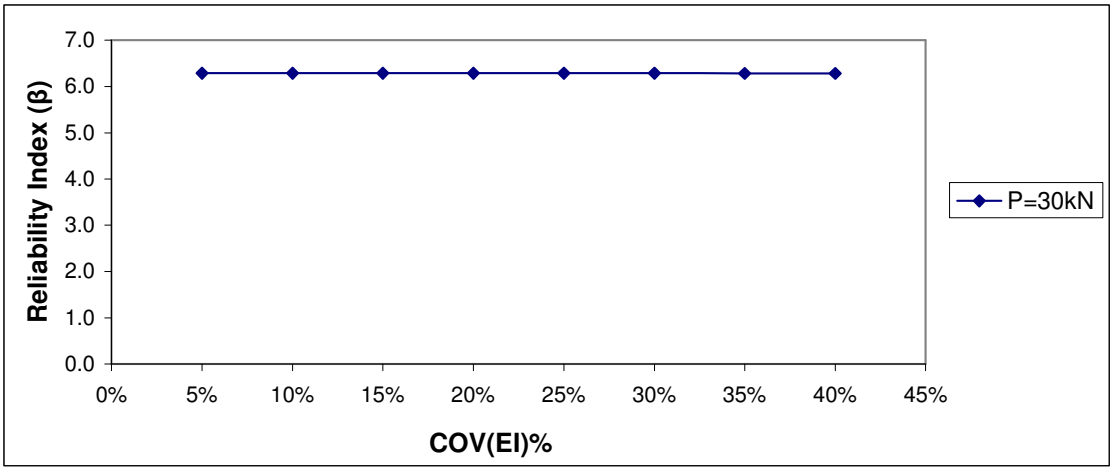


Fig. A139 Reliability Index (β) of M_{max} vs. COV (EI) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.172 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'EI' subjected to lateral load 60kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.03E-01	10696.73	5%	103.4260	5.7471
8.10E-01	10696.73	10%	103.4289	5.7470
6.76E+00	10696.73	15%	103.4577	5.7455
2.35E+01	10696.73	20%	103.5387	5.7434
2.81E+01	10696.73	25%	103.5607	5.7450
3.31E+01	10696.73	30%	103.5847	5.7417
3.78E+01	10696.73	35%	103.6077	5.7411
4.90E+01	10696.73	40%	103.6616	5.7405

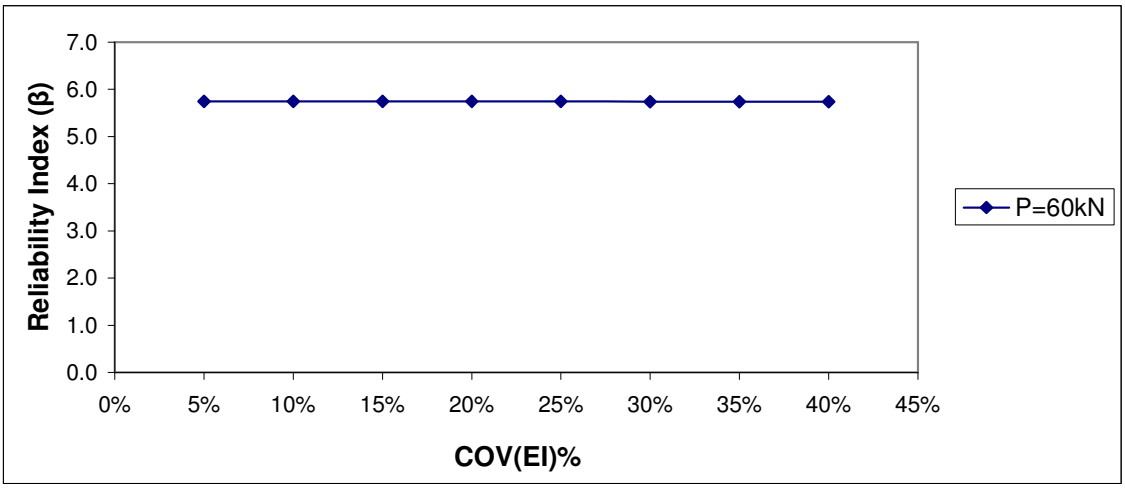


Fig. A140 Reliability Index (β) of M_{max} vs. COV (EI) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.173 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'EI' subjected to lateral load 90kN.

VAR (M_{max}) $(kN\text{-}m)^2$	(M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-01	10696.73	5%	103.4262	5.1680
1.00E+00	10696.73	10%	103.4298	5.1680
1.60E+01	10696.73	15%	103.5023	5.1679
3.03E+01	10696.73	20%	103.5711	5.1678
3.60E+01	10696.73	25%	103.5989	5.1679
4.23E+01	10696.73	30%	103.6291	5.1677
4.90E+01	10696.73	35%	103.6616	5.1676
5.63E+01	10696.73	40%	103.6966	5.1676

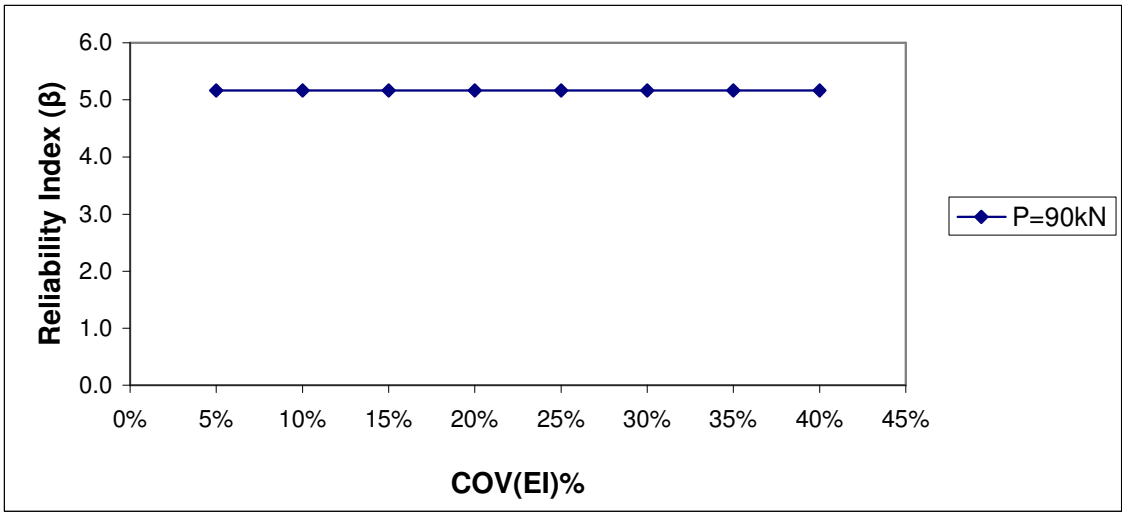


Fig. A141 Reliability Index (β) of M_{max} vs. COV (EI) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.174 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'EI' subjected to lateral load 120kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-01	10696.73	5%	103.4262	4.5395
2.25E+00	10696.73	10%	103.4359	4.5395
2.50E+01	10696.73	15%	103.5458	4.5395
5.63E+01	10696.73	20%	103.6966	4.5361
7.23E+01	10696.73	25%	103.7737	4.5378
8.10E+01	10696.73	30%	103.8158	4.5352
9.03E+01	10696.73	35%	103.8604	4.5347
1.00E+02	10696.73	40%	103.9073	4.5337

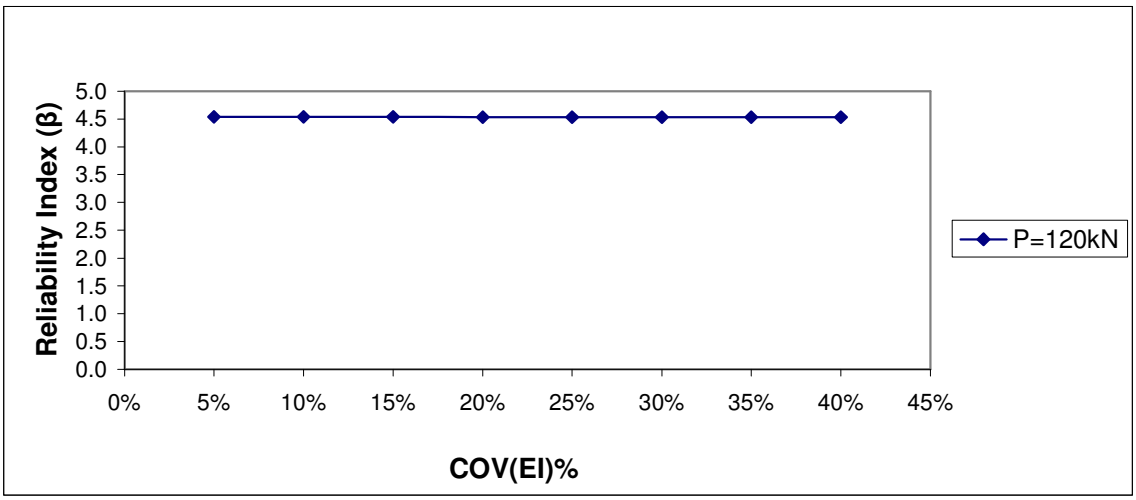


Fig. A142 Reliability Index (β) of M_{max} vs. COV (EI) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.175 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'EI' subjected to lateral load 150kN.

VAR (M_{max}) (kN-m)^2	VAR (M_{max}^{max}) (kN-m)^2	COV(EI) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
5.06E-02	10696.73	5%	103.4252	3.8530
2.03E-01	10696.73	10%	103.4260	3.8530
1.69E+00	10696.73	15%	103.4332	3.8527
5.88E+00	10696.73	20%	103.4534	3.8520
3.09E+00	10696.73	25%	103.4400	3.8525
8.27E+00	10696.73	30%	103.4650	3.8515
9.45E+00	10696.73	35%	103.4707	3.8513
1.23E+01	10696.73	40%	103.4842	3.8508

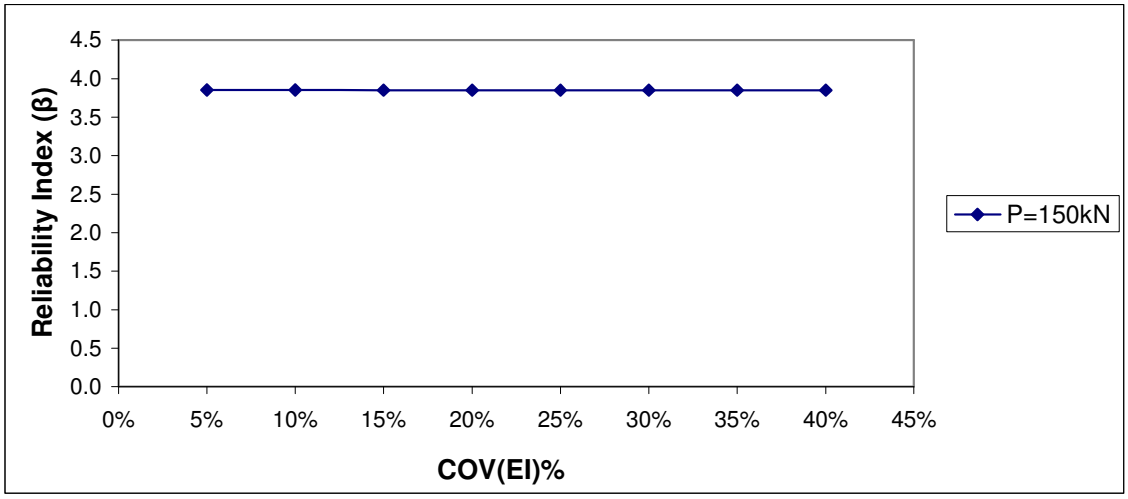


Fig. A143 Reliability Index (β) of M_{max} vs. COV (EI) for single free head long pile (10T) subjected to lateral force 150kN.

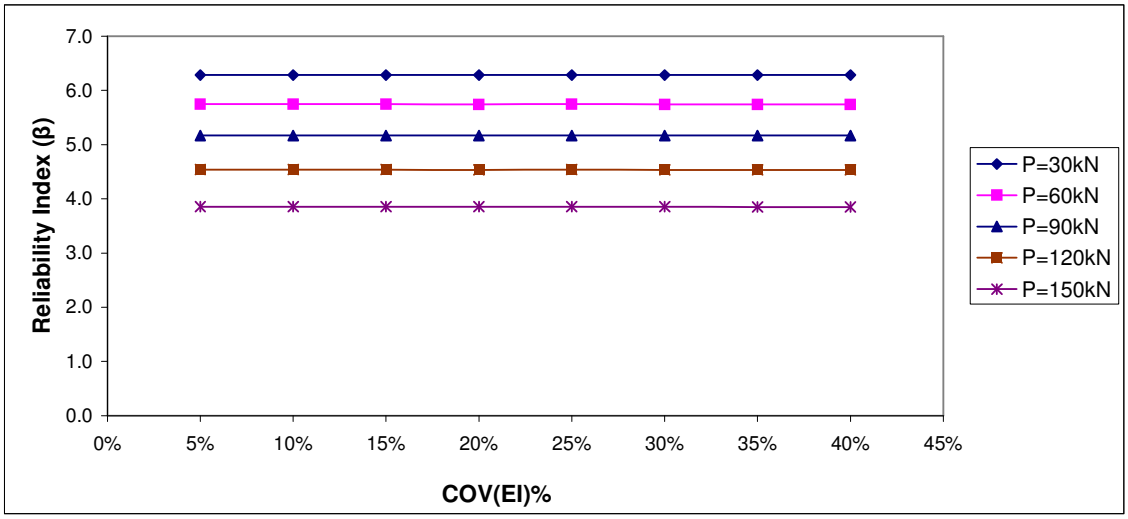


Fig.A.144 Reliability Index (β) of M_{max} vs. COV (EI) for single free head long pile (10T) subjected to lateral force of discrete variability.

Table A.176 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'P' subjected to lateral load 30kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
6.76E+00	10696.73	5%	103.4577	6.2837
2.10E+00	10696.73	10%	103.4352	6.2851
5.93E+01	10696.73	15%	103.7112	6.2684
1.05E+02	10696.73	20%	103.9317	6.2551
1.61E+02	10696.73	25%	104.2018	6.2389
2.31E+02	10696.73	30%	104.5360	6.2189
3.15E+02	10696.73	35%	104.9371	6.1951
4.10E+02	10696.73	40%	105.3888	6.1686

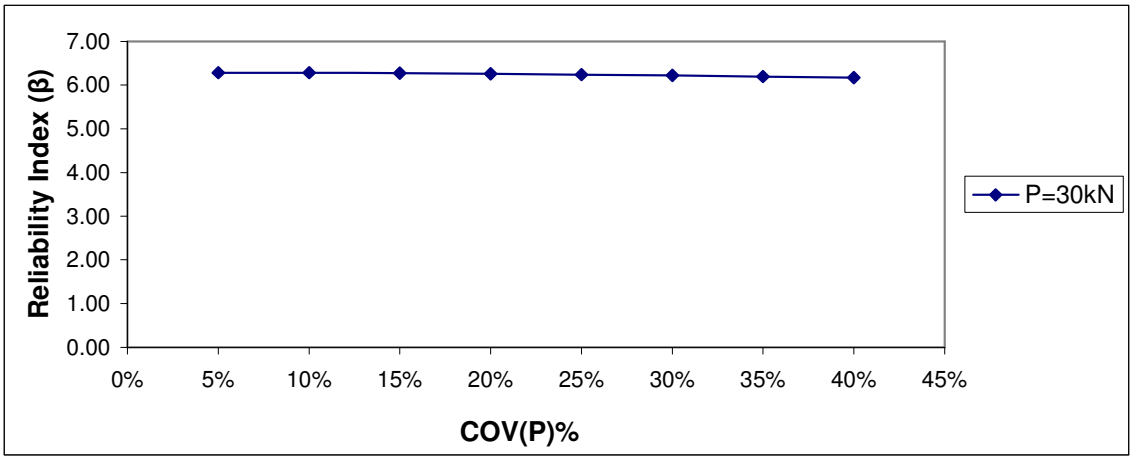


Fig.A.145 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force 30kN.

Table A.177 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'P' subjected to lateral load 60kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.48E+01	10696.73	5%	103.5931	5.7378
1.39E+02	10696.73	10%	104.0960	5.7101
3.15E+02	10696.73	15%	104.9371	5.6643
5.57E+02	10696.73	20%	106.0834	5.6031
8.32E+02	10696.73	25%	107.3734	5.4600
1.20E+03	10696.73	30%	109.0591	5.3400
1.62E+03	10696.73	35%	110.9992	5.1300
2.12E+03	10696.73	40%	113.1933	4.9200

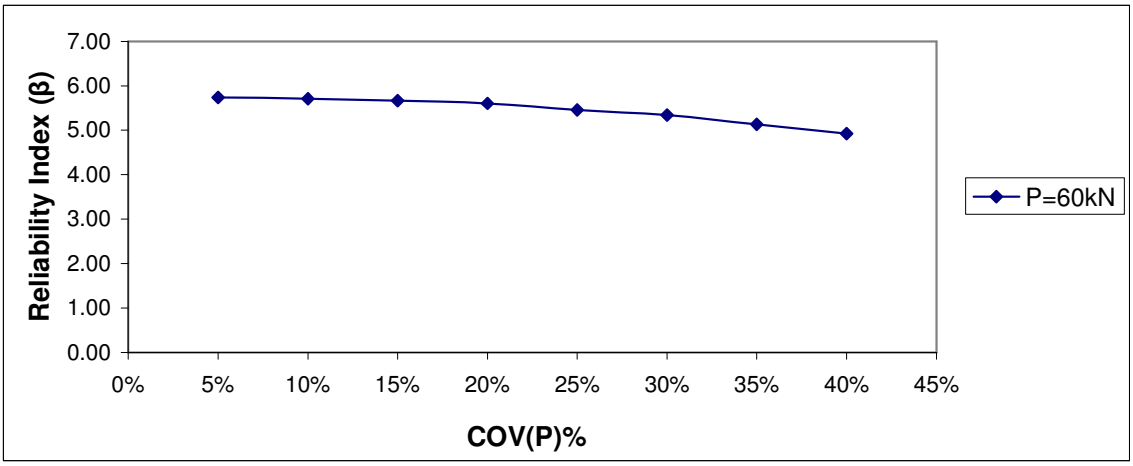


Fig.A.146 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force 60kN.

Table A.178 Reliability Index (β) connected to M_{max} for free head single pile (10T) with

varying 'P' subjected to lateral load 90kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
9.03E+01	10696.73	5%	103.8604	5.1463
3.61E+02	10696.73	10%	105.1557	5.0829
7.84E+02	10696.73	15%	107.1482	4.9884
1.37E+03	10696.73	20%	109.8441	4.8660
2.16E+03	10696.73	25%	113.3974	4.7135
3.14E+03	10696.73	30%	117.6126	4.5446
4.28E+03	10696.73	35%	122.3946	4.3670
5.60E+03	10696.73	40%	127.6392	4.1876

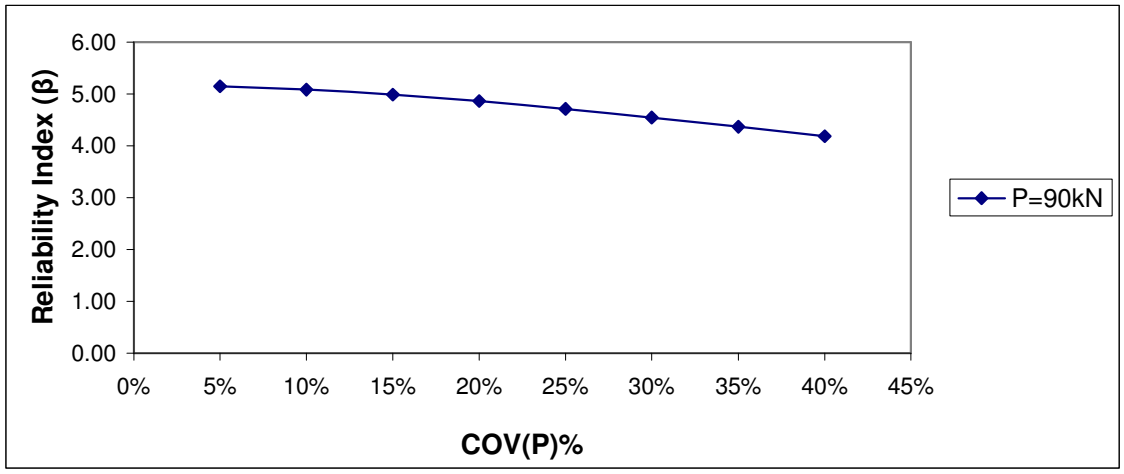


Fig.A.147 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force 90kN.

Table A.179 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'P' subjected to lateral load 120kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.82E+02	10696.73	5%	104.3024	4.5013
7.29E+02	10696.73	10%	106.8912	4.3923
1.68E+03	10696.73	15%	111.2552	4.2200
2.97E+03	10696.73	20%	116.9059	4.0161
4.62E+03	10696.73	25%	123.7769	3.7931
6.81E+03	10696.73	30%	132.2988	3.5488
9.22E+03	10696.73	35%	141.1125	3.3271
1.21E+04	10696.73	40%	150.9859	3.1096

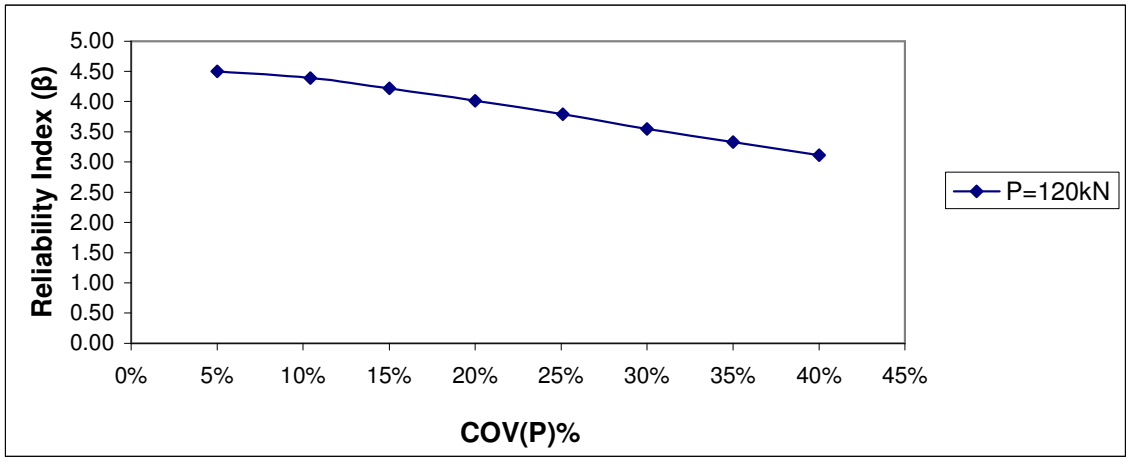


Fig.A.148 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force 120kN.

Table A.180 Reliability Index (β) connected to M_{max} for free head single pile (10T) with varying 'P' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.61E+02	10696.73	5%	105.1557	3.7896
1.44E+03	10696.73	10%	110.1850	3.6166
3.25E+03	10696.73	15%	118.0920	3.3745
5.78E+03	10696.73	20%	128.3461	3.1049
9.03E+03	10696.73	25%	140.4341	2.8376
1.31E+04	10696.73	30%	154.2951	2.5827
1.77E+04	10696.73	35%	168.4807	2.3653
2.30E+04	10696.73	40%	183.4366	2.1724

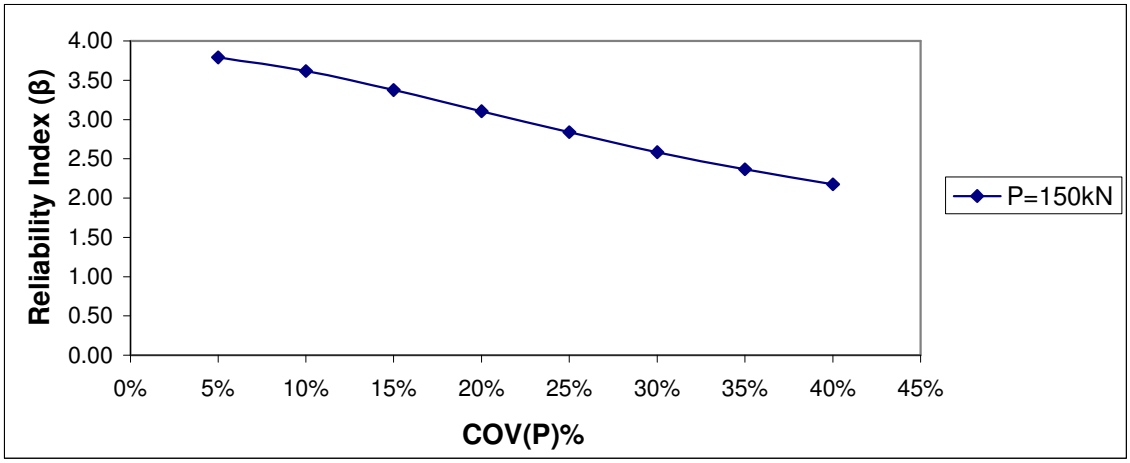


Fig.A.149 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force 150kN.

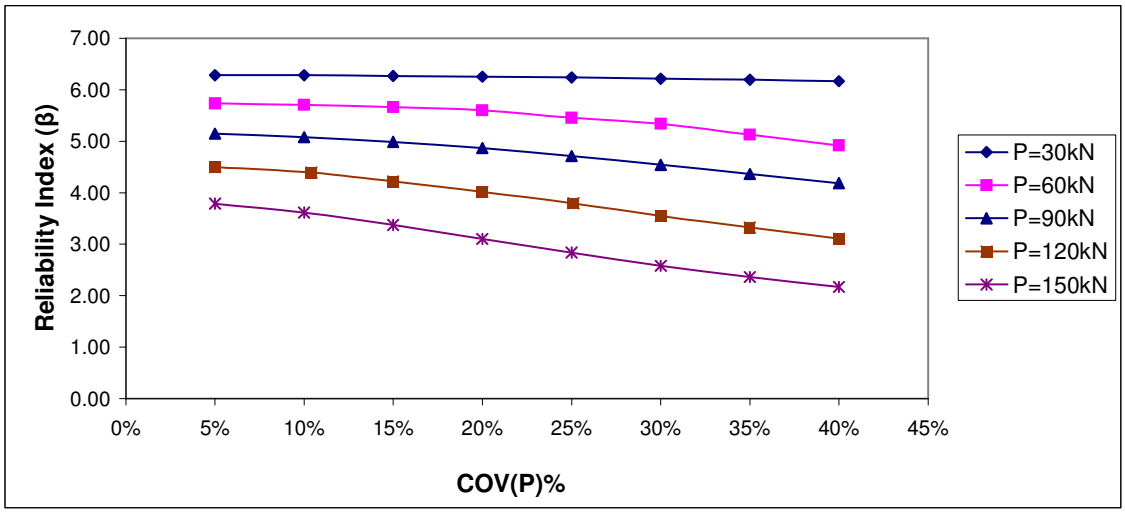


Fig.A.150 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force of discrete variability.

A.6 Probability of failure, p_f .of bending moment p_f (M_{max}) vs. COV (Variables)

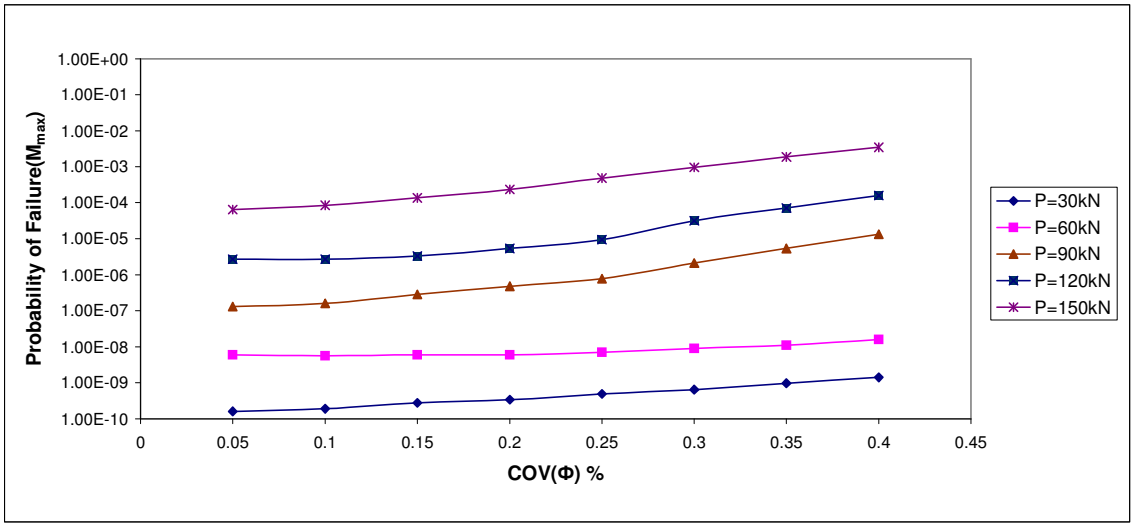


Fig. A.151 Probability of failure of bending moment p_f (M_{max}) vs. COV (Φ) for single free head long pile of length 10T.

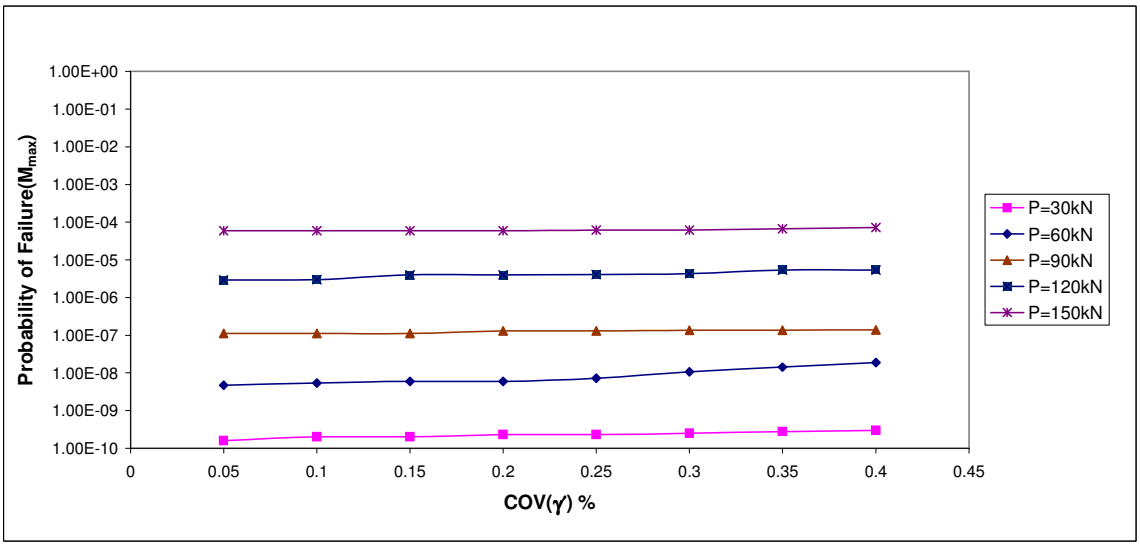


Fig. A.152 Probability of failure of bending moment p_f (M_{max}) vs. COV (γ') for single free head long pile of length 10T.

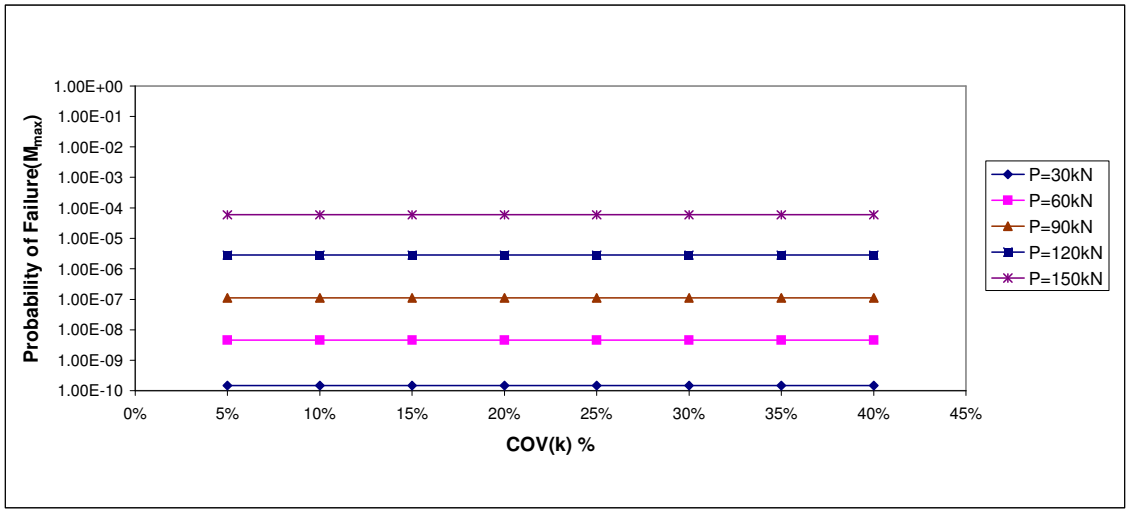


Fig. A.153 Probability of failure of bending moment p_f (M_{max}) vs. COV (k) for single free head long pile of length 10T.

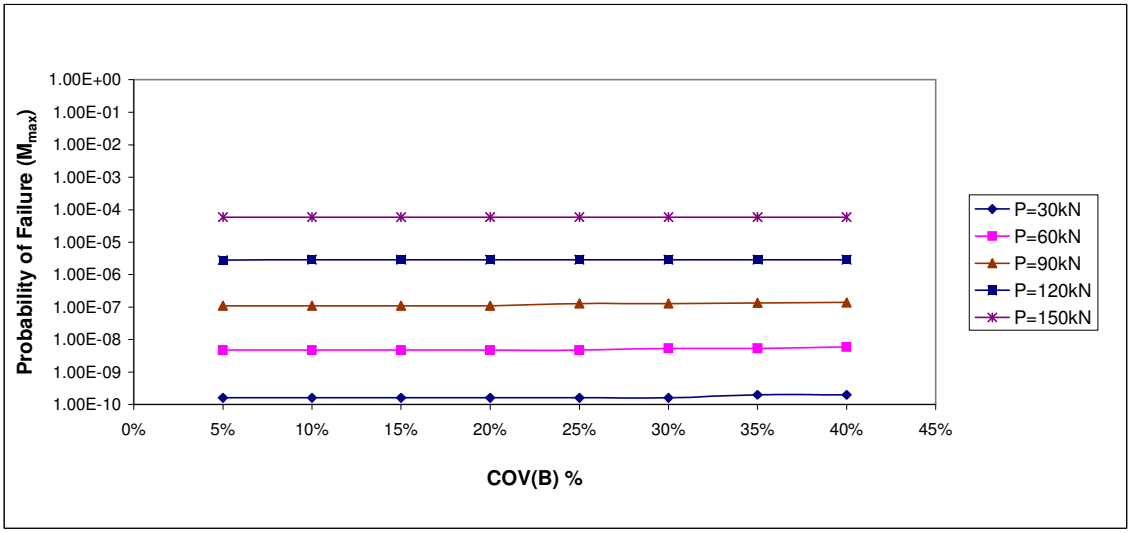


Fig. A.154 Probability of failure of bending moment p_f (M_{max}) vs. COV (B) for single free head long pile of length 10T.

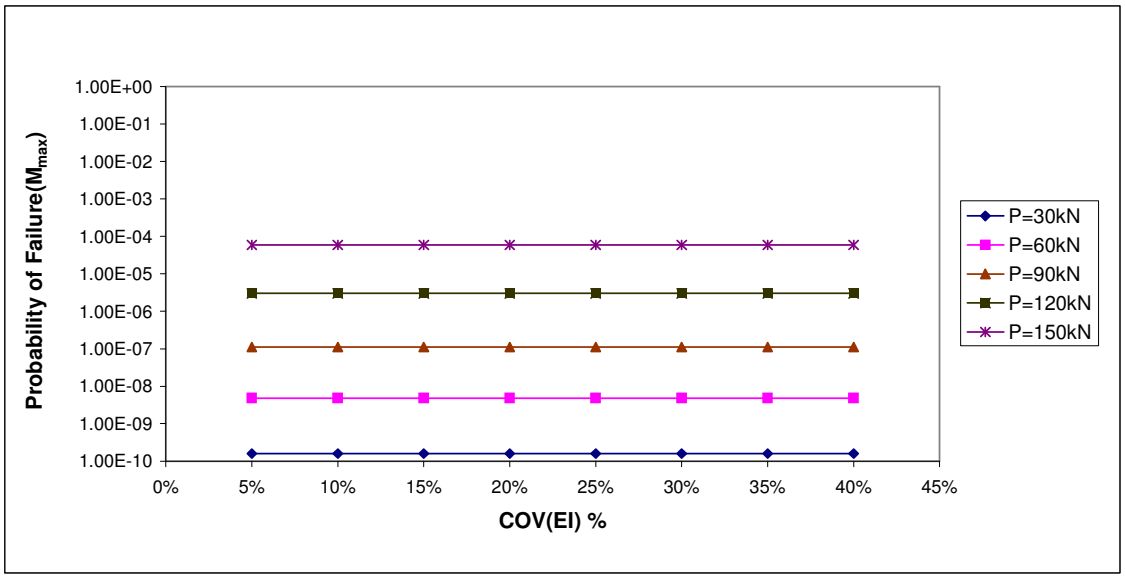


Fig. A.155 Probability of failure of bending moment p_f (M_{max}) vs. COV (EI) for single free head long pile of length 10T.

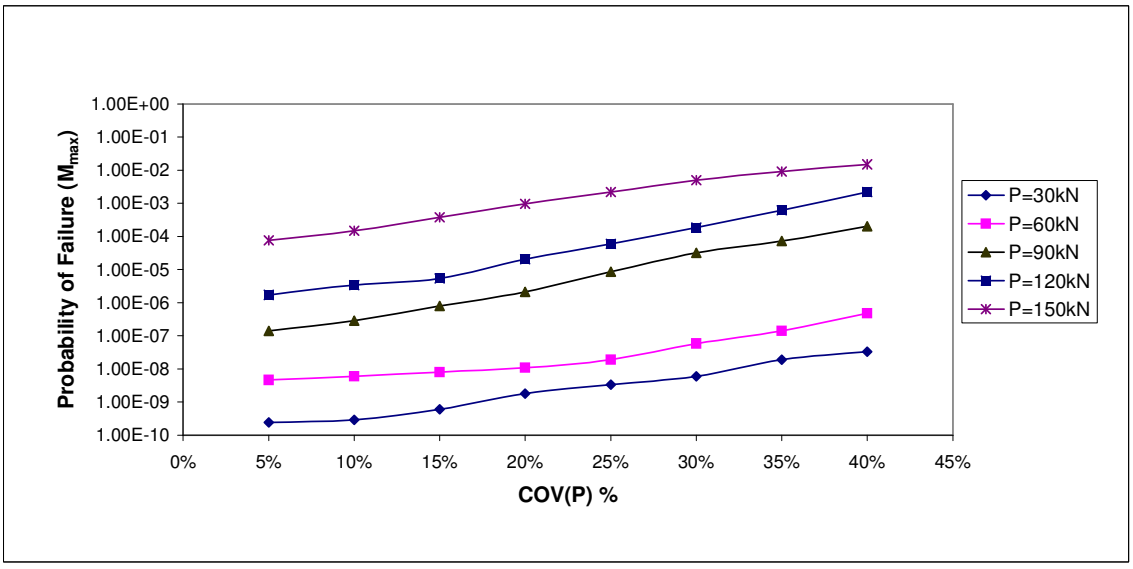


Fig. A.156 Probability of failure of bending moment p_f (M_{max}) vs. COV (P) for single free head long pile of length 10T.

APENDIX B

LATERALLY LOADED FIXED HEAD SINGLE PILE (10T)

B-1 Deflection of fixed head single pile (Y_{Top}) and COV (Y_{Top}) vs. COV (Variables).

Table B.1 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (Φ) and load 100kN.

P=100kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	5.69E-03				
5%	30			2.25E+00	4.84E-08	6.22E-03	3.54%
		28.5	5.25E-03				
		33	5.25E-03				
10%	30			9.00E+00	1.16E-06	6.22E-03	17.28%
		27	7.40E-03				
		34.5	4.85E-03				
15%	30			2.03E+01	2.62E-06	6.22E-03	26.05%
		25.5	8.09E-03				
		36	4.47E-03				
20%	30			3.60E+01	4.93E-06	6.22E-03	35.69%
		24	8.91E-03				
		37.5	4.16E-03				
25%	30			5.63E+01	7.90E-06	6.22E-03	45.18%
		22.5	9.78E-03				
		39	3.88E-03				
30%	30			8.10E+01	1.20E-05	6.22E-03	55.63%
		21	1.08E-02				
		40.5	3.65E-03				
35%	30			1.10E+02	1.70E-05	6.22E-03	66.32%
		19.5	1.19E-02				
		42	3.57E-03				
40%	30			1.44E+02	2.37E-05	6.22E-03	78.22%
		18	1.33E-02				

Table B.2 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (Φ) and load 150kN.

P=150kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	1.03E-02				
5%	30			2.25E+00	9.03E-07	7.40E-03	8.48%
		28.5	1.22E-02				
		33	9.48E-03				
10%	30			9.00E+00	3.65E-06	7.40E-03	17.05%
		27	1.33E-02				
		34.5	8.73E-03				
15%	30			2.03E+01	8.32E-06	7.40E-03	25.76%
		25.5	1.45E-02				
		36	8.06E-03				
20%	30			3.60E+01	1.50E-05	7.40E-03	34.55%
		24	1.58E-02				
		37.5	7.45E-03				
25%	30			5.63E+01	2.43E-05	7.40E-03	43.97%
		22.5	1.73E-02				
		39	6.92E-03				
30%	30			8.10E+01	3.65E-05	7.40E-03	53.93%
		21	1.90E-02				
		40.5	6.44E-03				
35%	30			1.10E+02	5.37E-05	7.40E-03	65.45%
		19.5	2.11E-02				
		42	6.02E-03				
40%	30			1.44E+02	7.90E-05	7.40E-03	79.38%
		18	2.38E-02				

Table B.3 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (Φ) and load 200kN.

P=200kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	1.52E-02				
5%	30			2.25E+00	3.60E-07	1.65E-02	3.64%
		28.5	1.40E-02				
		33	1.40E-02				
10%	30			9.00E+00	7.84E-06	1.65E-02	16.97%
		27	1.96E-02				
		34.5	1.29E-02				
15%	30			2.03E+01	1.85E-05	1.65E-02	26.06%
		25.5	2.15E-02				
		36	1.19E-02				
20%	30			3.60E+01	3.42E-05	1.65E-02	35.45%
		24	2.36E-02				
		37.5	1.10E-02				
25%	30			5.63E+01	5.70E-05	1.65E-02	45.76%
		22.5	2.61E-02				
		39	1.02E-02				
30%	30			8.10E+01	9.03E-05	1.65E-02	57.58%
		21	2.92E-02				
		40.5	9.49E-03				
35%	30			1.10E+02	1.38E-04	1.65E-02	71.24%
		19.5	3.30E-02				
		42	8.84E-03				
40%	30			1.44E+02	2.11E-04	1.65E-02	88.06%
		18	3.79E-02				

Table B.4 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (Φ) and load 250kN.

P=250kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	2.08E-02				
5%	30			2.25E+00	4.20E-06	2.98E-02	9.03%
		28.5	2.49E-02				
		33	1.92E-02				
10%	30			9.00E+00	1.60E-05	2.98E-02	17.62%
		27	2.72E-02				
		34.5	1.77E-02				
15%	30			2.03E+01	3.84E-05	2.98E-02	27.31%
		25.5	3.01E-02				
		36	1.63E-02				
20%	30			3.60E+01	7.31E-05	2.98E-02	37.67%
		24	3.34E-02				
		37.5	1.51E-02				
25%	30			5.63E+01	1.23E-04	2.98E-02	48.90%
		22.5	3.73E-02				
		39	1.40E-02				
30%	30			8.10E+01	2.00E-04	2.98E-02	62.33%
		21	4.23E-02				
		40.5	1.30E-02				
35%	30			1.10E+02	3.12E-04	2.98E-02	77.75%
		19.5	4.83E-02				
		42	1.21E-02				
40%	30			1.44E+02	5.02E-04	2.98E-02	98.68%
		18	5.69E-02				

Table B.5 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (Φ) and load 300kN.

P=300kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	2.71E-02				
5%	30			2.25E+00	1.44E-06	4.77E-02	4.03%
		28.5	2.47E-02				
		33	2.47E-02				
10%	30			9.00E+00	3.36E-05	4.77E-02	19.46%
		27	3.63E-02				
		34.5	2.26E-02				
15%	30			2.03E+01	7.83E-05	4.77E-02	29.70%
		25.5	4.03E-02				
		36	2.08E-02				
20%	30			3.60E+01	1.49E-04	4.77E-02	40.94%
		24	4.52E-02				
		37.5	1.92E-02				
25%	30			5.63E+01	2.54E-04	4.77E-02	53.52%
		22.5	5.11E-02				
		39	1.77E-02				
30%	30			8.10E+01	4.18E-04	4.77E-02	68.62%
		21	5.86E-02				
		40.5	1.64E-02				
35%	30			1.10E+02	6.76E-04	4.77E-02	87.25%
		19.5	6.84E-02				
		42	1.53E-02				
40%	30			1.44E+02	1.09E-03	4.77E-02	110.91%
		18	8.14E-02				

Table B.6 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(Φ) and lateral load 100kN.

P=100kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	4.84E-08	3.54%
10%	9.00E+00	1.16E-06	17.28%
15%	2.03E+01	2.62E-06	26.05%
20%	3.60E+01	4.93E-06	35.69%
25%	5.63E+01	7.90E-06	45.18%
30%	8.10E+01	1.20E-05	55.63%
35%	1.10E+02	1.70E-05	66.32%
40%	1.44E+02	2.37E-05	78.22%

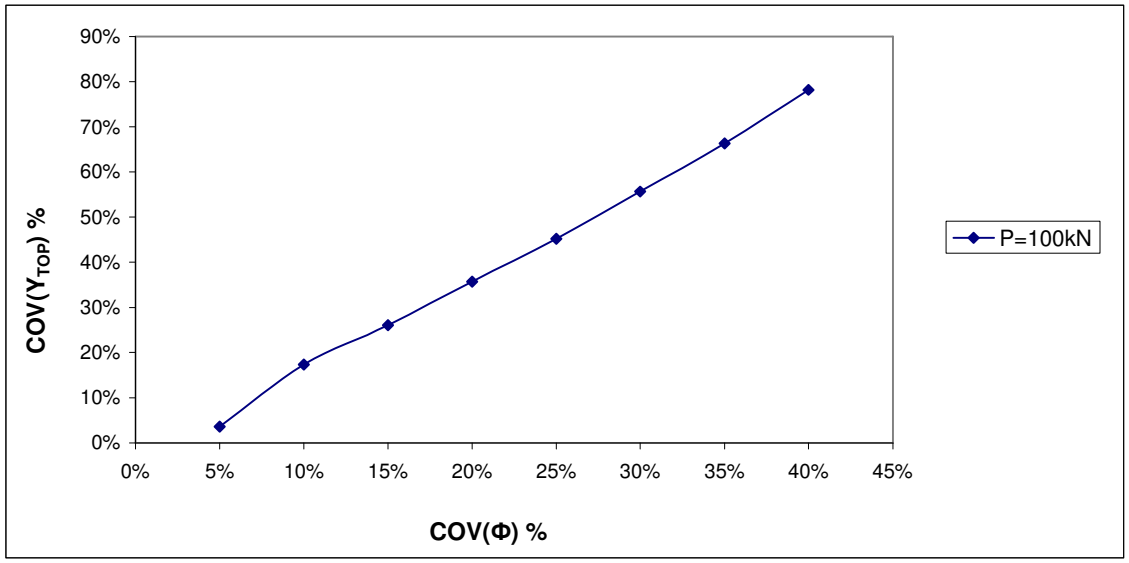


Fig. B.1 Variability of COV (Y_{TOP}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.7 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(Φ) and lateral load 150kN.

P=150kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	9.03E-07	8.48%
10%	9.00E+00	3.65E-06	17.05%
15%	2.03E+01	8.32E-06	25.76%
20%	3.60E+01	1.50E-05	34.55%
25%	5.63E+01	2.43E-05	43.97%
30%	8.10E+01	3.65E-05	53.93%
35%	1.10E+02	5.37E-05	65.45%
40%	1.44E+02	7.90E-05	79.38%

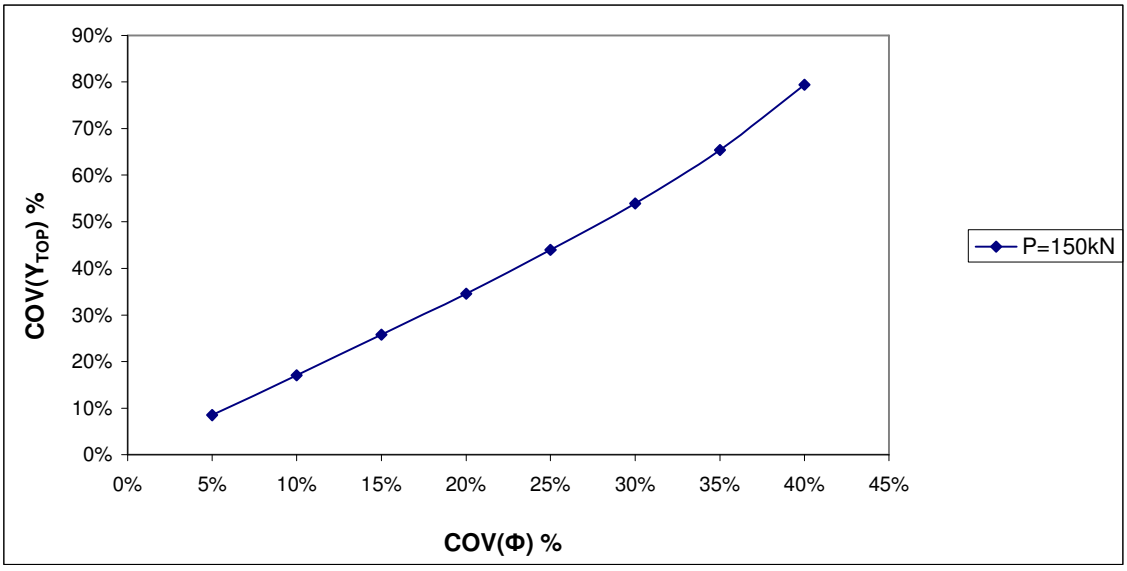


Fig. B.2 Variability of COV (Y_{TOP}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.8 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(Φ) and lateral load 200kN.

P=200kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	3.60E-07	3.64%
10%	9.00E+00	7.84E-06	16.97%
15%	2.03E+01	1.85E-05	26.06%
20%	3.60E+01	3.42E-05	35.45%
25%	5.63E+01	5.70E-05	45.76%
30%	8.10E+01	9.03E-05	57.58%
35%	1.10E+02	1.38E-04	71.24%
40%	1.44E+02	2.11E-04	88.06%

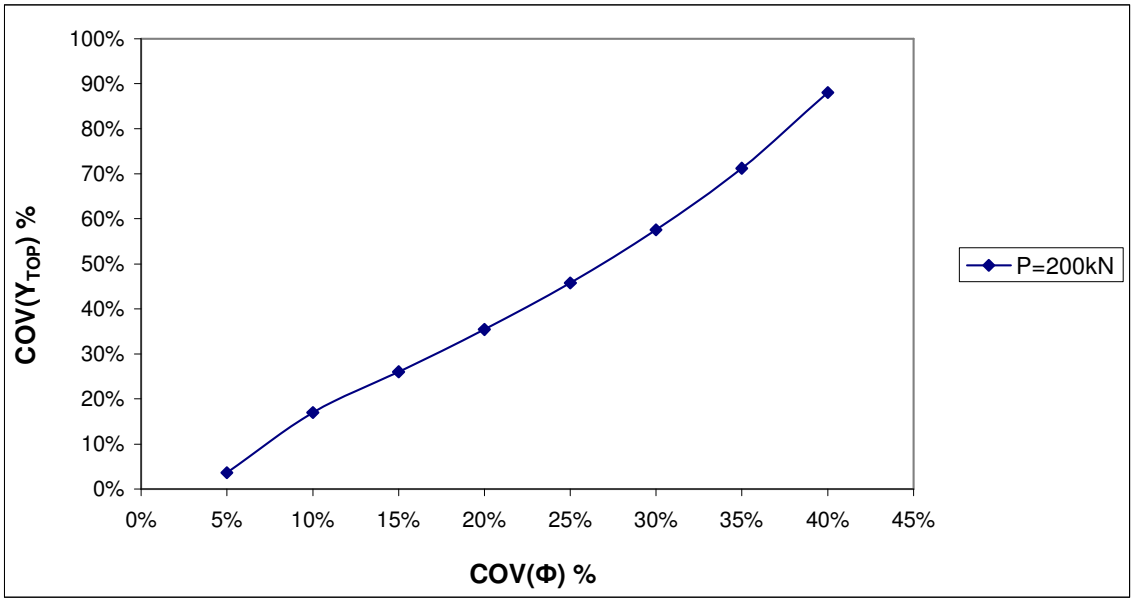


Fig. B.3 Variability of COV (Y_{TOP}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.9 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(Φ) and lateral load 250kN.

P=250kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	4.20E-06	9.03%
10%	9.00E+00	1.60E-05	17.62%
15%	2.03E+01	3.84E-05	27.31%
20%	3.60E+01	7.31E-05	37.67%
25%	5.63E+01	1.23E-04	48.90%
30%	8.10E+01	2.00E-04	62.33%
35%	1.10E+02	3.12E-04	77.75%
40%	1.44E+02	5.02E-04	98.68%

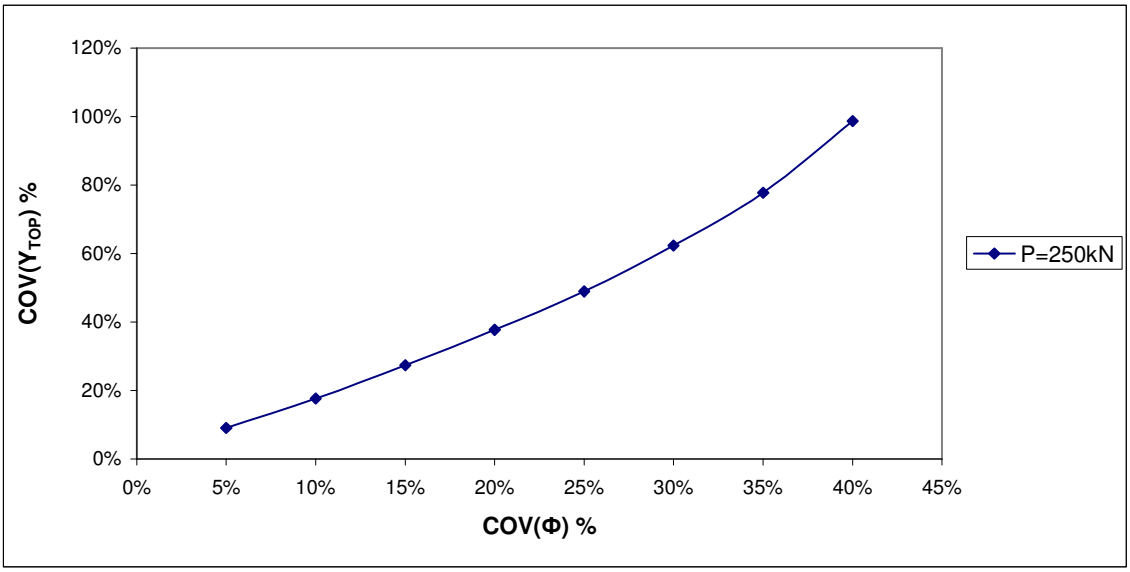


Fig. B.4 Variability of COV (Y_{TOP}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.10 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(Φ) and lateral load 300kN.

P=300kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	1.44E-06	4.03%
10%	9.00E+00	3.36E-05	19.46%
15%	2.03E+01	7.83E-05	29.70%
20%	3.60E+01	1.49E-04	40.94%
25%	5.63E+01	2.54E-04	53.52%
30%	8.10E+01	4.18E-04	68.62%
35%	1.10E+02	6.76E-04	87.25%
40%	1.44E+02	1.09E-03	110.91%

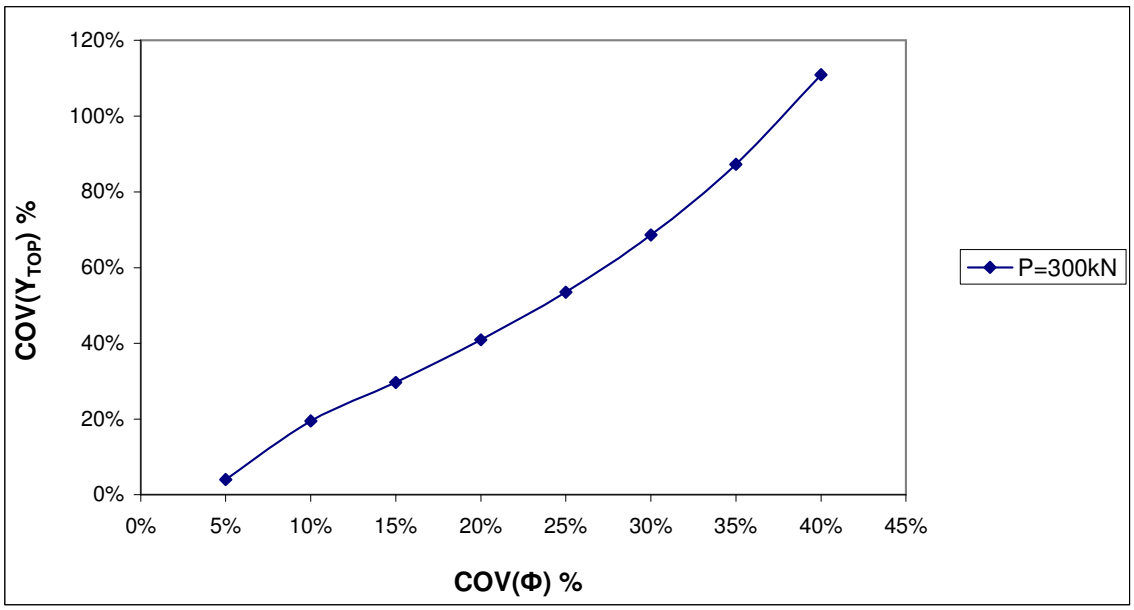


Fig. B.5 Variability of COV (Y_{TOP}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 300kN.

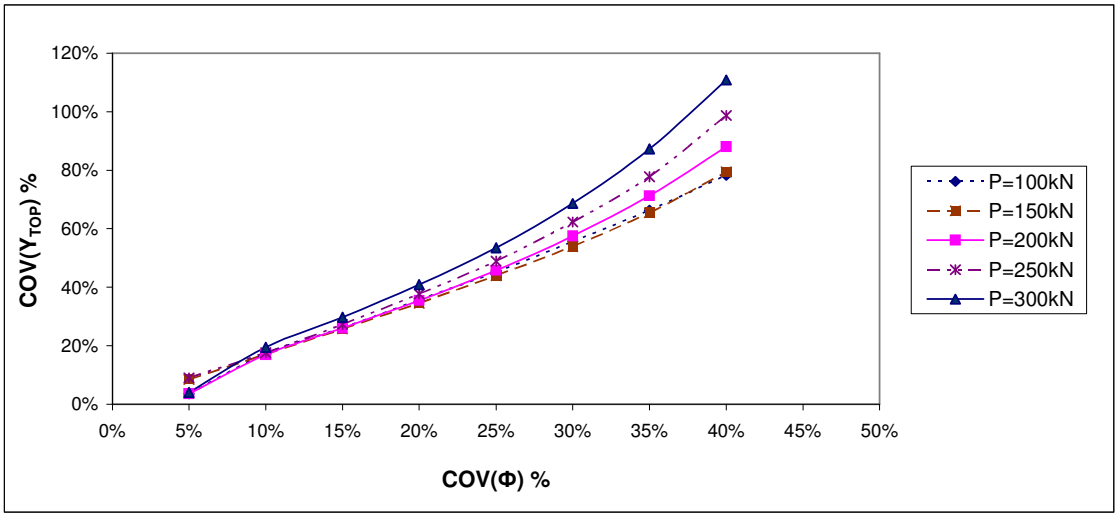


Fig. B.6 Variability of COV (Y_{TOP}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.11 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying

(γ) and load 100kN.

P=100kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.025	1.08E-02				
5%	10.5			2.76E-01	1.60E-07	6.22E-03	3.57%
		9.975	1.16E-02				
		11.55	1.05E-02				
10%	10.5			1.10E+00	6.40E-07	6.22E-03	7.14%
		9.45	1.21E-02				
		12.075	1.01E-02				
15%	10.5			2.48E+00	1.56E-06	6.22E-03	11.16%
		8.925	1.26E-02				
		12.6	9.84E-03				
20%	10.5			4.41E+00	2.66E-06	6.22E-03	14.55%
		8.4	1.31E-02				
		13.125	9.56E-03				
25%	10.5			6.89E+00	4.49E-06	6.22E-03	18.93%
		7.875	1.38E-02				
		13.65	9.30E-03				
30%	10.5			9.92E+00	6.50E-06	6.22E-03	22.77%
		7.35	1.44E-02				
		14.175	9.05E-03				
35%	10.5			1.35E+01	9.46E-06	6.22E-03	27.46%
		6.825	1.52E-02				
		14.7	8.82E-03				
40%	10.5			1.76E+01	1.29E-05	6.22E-03	32.05%
		6.3	1.60E-02				

Table B.12 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (γ) and load 150kN.

P=150kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.025	1.60E-02				
5%	10.5			2.76E-01	3.03E-07	7.40E-03	3.33%
		9.975	1.71E-02				
		11.55	1.55E-02				
10%	10.5			1.10E+00	1.32E-06	7.40E-03	6.97%
		9.45	1.78E-02				
		12.075	1.50E-02				
15%	10.5			2.48E+00	3.06E-06	7.40E-03	10.61%
		8.925	1.85E-02				
		12.6	1.46E-02				
20%	10.5			4.41E+00	5.76E-06	7.40E-03	14.55%
		8.4	1.94E-02				
		13.125	1.41E-02				
25%	10.5			6.89E+00	9.61E-06	7.40E-03	18.79%
		7.875	2.03E-02				
		13.65	1.38E-02				
30%	10.5			9.92E+00	1.44E-05	7.40E-03	23.03%
		7.35	2.14E-02				
		14.175	1.34E-02				
35%	10.5			1.35E+01	2.12E-05	7.40E-03	27.88%
		6.825	2.26E-02				
		14.7	1.31E-02				
40%	10.5			1.76E+01	2.92E-05	7.40E-03	32.73%
		6.3	2.39E-02				

Table B.13 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (γ) and load 200kN.

P=200kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.025	5.97E-03				
5%	10.5			2.76E-01	6.00E-08	1.65E-02	3.94%
		9.975	6.46E-03				
		11.55	5.77E-03				
10%	10.5			1.10E+00	2.26E-07	1.65E-02	7.64%
		9.45	6.72E-03				
		12.075	5.60E-03				
15%	10.5			2.48E+00	4.97E-07	1.65E-02	11.33%
		8.925	7.01E-03				
		12.6	5.43E-03				
20%	10.5			4.41E+00	8.93E-07	1.65E-02	15.19%
		8.4	7.32E-03				
		13.125	5.28E-03				
25%	10.5			6.89E+00	1.44E-06	1.65E-02	19.29%
		7.875	7.68E-03				
		13.65	5.14E-03				
30%	10.5			9.92E+00	2.16E-06	1.65E-02	23.63%
		7.35	8.08E-03				
		14.175	5.01E-03				
35%	10.5			1.35E+01	3.17E-06	1.65E-02	28.62%
		6.825	8.57E-03				
		14.7	4.88E-03				
40%	10.5			1.76E+01	4.43E-06	1.65E-02	33.84%
		6.3	9.09E-03				

Table B.14 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (γ) and load 250kN.

P=250kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.025	2.19E-02				
5%	10.5			2.76E-01	7.22E-07	2.98E-02	3.74%
		9.975	2.36E-02				
		11.55	2.12E-02				
10%	10.5			1.10E+00	2.89E-06	2.98E-02	7.49%
		9.45	2.46E-02				
		12.075	2.05E-02				
15%	10.5			2.48E+00	6.76E-06	2.98E-02	11.45%
		8.925	2.57E-02				
		12.6	1.99E-02				
20%	10.5			4.41E+00	1.19E-05	2.98E-02	15.20%
		8.4	2.68E-02				
		13.125	1.94E-02				
25%	10.5			6.89E+00	1.94E-05	2.98E-02	19.38%
		7.875	2.82E-02				
		13.65	1.88E-02				
30%	10.5			9.92E+00	3.03E-05	2.98E-02	24.23%
		7.35	2.98E-02				
		14.175	1.84E-02				
35%	10.5			1.35E+01	4.42E-05	2.98E-02	29.30%
		6.825	3.17E-02				
		14.7	1.79E-02				
40%	10.5			1.76E+01	6.32E-05	2.98E-02	35.02%
		6.3	3.38E-02				

Table B.15 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (γ) and load 300kN.

P=300kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.025	2.86E-02				
5%	10.5			2.76E-01	1.44E-06	4.77E-02	4.03%
		9.975	3.10E-02				
		11.55	2.76E-02				
10%	10.5			1.10E+00	5.76E-06	4.77E-02	8.05%
		9.45	3.24E-02				
		12.075	2.67E-02				
15%	10.5			2.48E+00	1.30E-05	4.77E-02	12.08%
		8.925	3.39E-02				
		12.6	2.58E-02				
20%	10.5			4.41E+00	2.45E-05	4.77E-02	16.61%
		8.4	3.57E-02				
		13.125	2.50E-02				
25%	10.5			6.89E+00	4.03E-05	4.77E-02	21.31%
		7.875	3.77E-02				
		13.65	2.43E-02				
30%	10.5			9.92E+00	6.08E-05	4.77E-02	26.17%
		7.35	3.99E-02				
		14.175	2.36E-02				
35%	10.5			1.35E+01	8.93E-05	4.77E-02	31.71%
		6.825	4.25E-02				
		14.7	2.30E-02				
40%	10.5			1.76E+01	1.28E-04	4.77E-02	37.92%
		6.3	4.56E-02				

Table B.16 Value of COV(Y_{TOP}) for fixed head long pile with varying COV(γ) and lateral load 100kN.

P=100kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	1.60E-07	3.57%
10%	1.10E+00	6.40E-07	7.14%
15%	2.48E+00	1.56E-06	11.16%
20%	4.41E+00	2.66E-06	14.55%
25%	6.89E+00	4.49E-06	18.93%
30%	9.92E+00	6.50E-06	22.77%
35%	1.35E+01	9.46E-06	27.46%
40%	1.76E+01	1.29E-05	32.05%

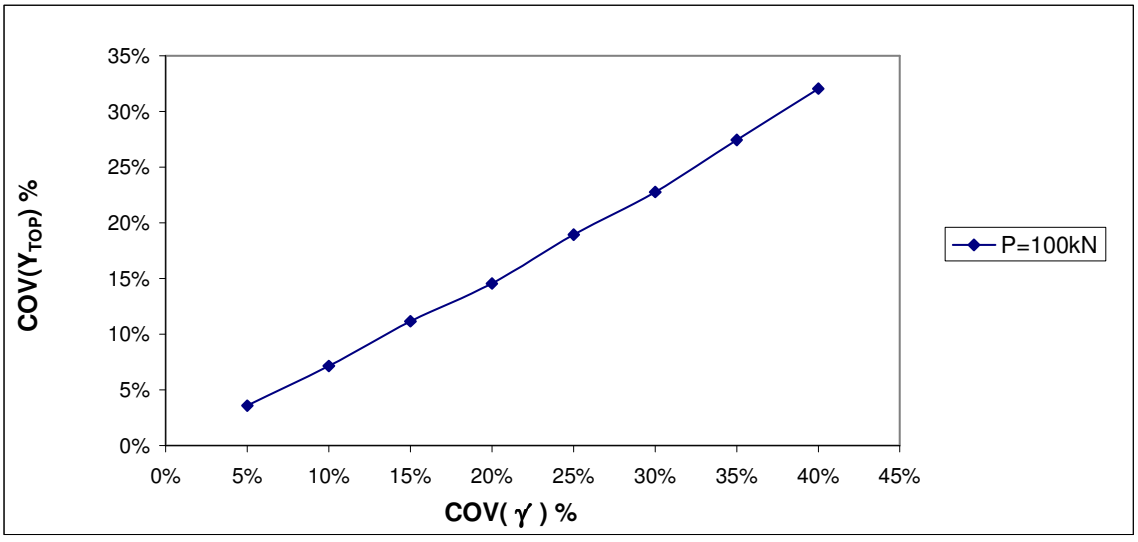


Fig. B.7 Variability of COV (Y_{TOP}) vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.17 Value of COV(Y_{TOP}) for fixed head long pile with varying COV(γ) and lateral load 150kN.

P=150kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	3.03E-07	3.33%
10%	1.10E+00	1.32E-06	6.97%
15%	2.48E+00	3.06E-06	10.61%
20%	4.41E+00	5.76E-06	14.55%
25%	6.89E+00	9.61E-06	18.79%
30%	9.92E+00	1.44E-05	23.03%
35%	1.35E+01	2.12E-05	27.88%
40%	1.76E+01	2.92E-05	32.73%

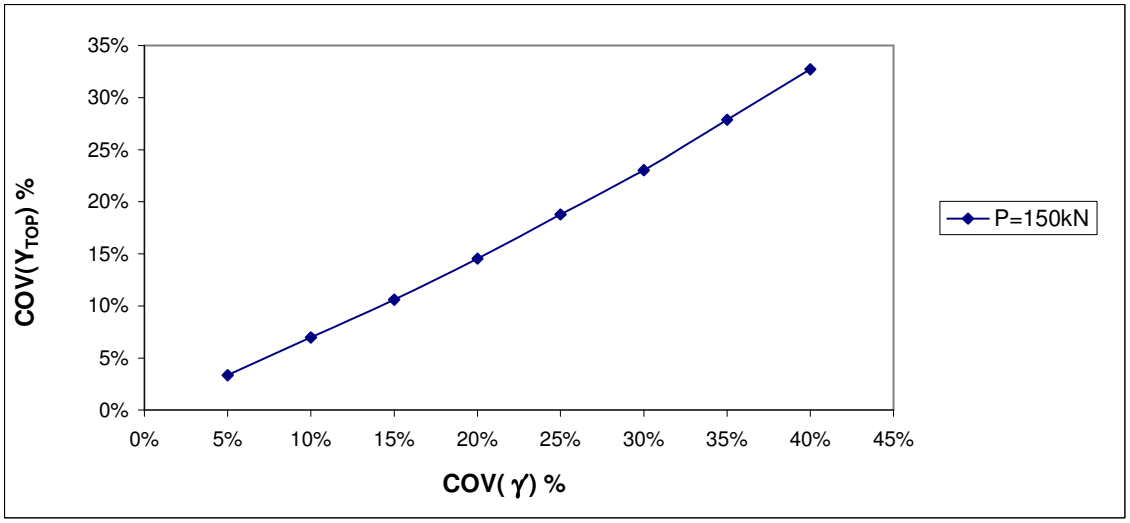


Fig. B.8 Variability of COV (Y_{TOP}) vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.18 Value of COV(Y_{TOP}) for fixed head long pile with varying COV(γ') and lateral load 200kN.

P=200kN			
COV(γ') (%)	VAR(γ') $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	6.00E-08	3.94%
10%	1.10E+00	2.26E-07	7.64%
15%	2.48E+00	4.97E-07	11.33%
20%	4.41E+00	8.93E-07	15.19%
25%	6.89E+00	1.44E-06	19.29%
30%	9.92E+00	2.16E-06	23.63%
35%	1.35E+01	3.17E-06	28.62%
40%	1.76E+01	4.43E-06	33.84%

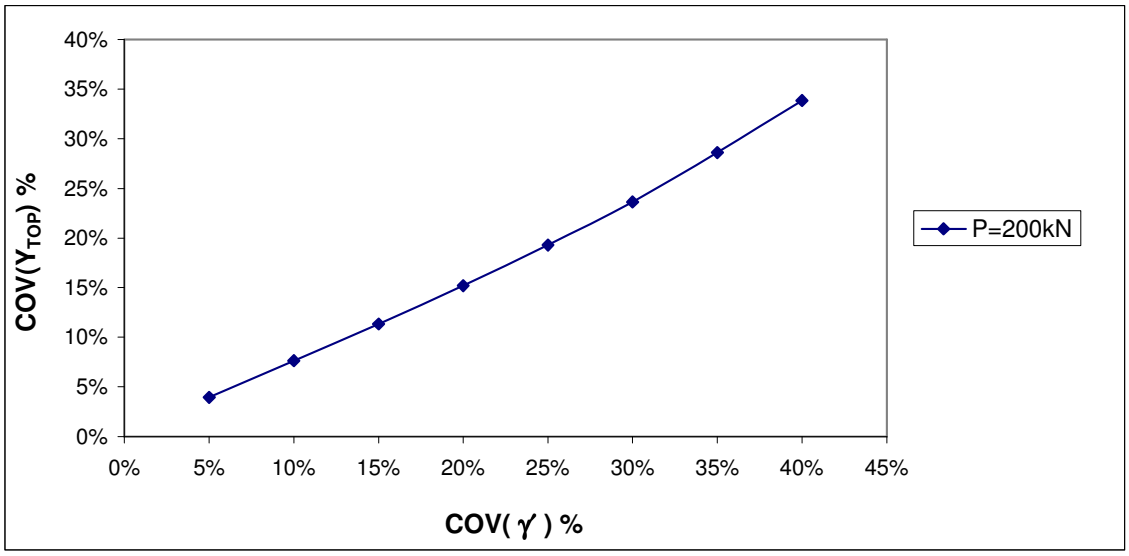


Fig. B.9 Variability of COV (Y_{TOP}) vs. COV (γ') for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.19 Value of COV(Y_{TOP}) for fixed head long pile with varying COV(γ') and lateral load 250kN.

P=250kN			
COV(γ') (%)	VAR(γ') $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	7.22E-07	3.74%
10%	1.10E+00	2.89E-06	7.49%
15%	2.48E+00	6.76E-06	11.45%
20%	4.41E+00	1.19E-05	15.20%
25%	6.89E+00	1.94E-05	19.38%
30%	9.92E+00	3.03E-05	24.23%
35%	1.35E+01	4.42E-05	29.30%
40%	1.76E+01	6.32E-05	35.02%

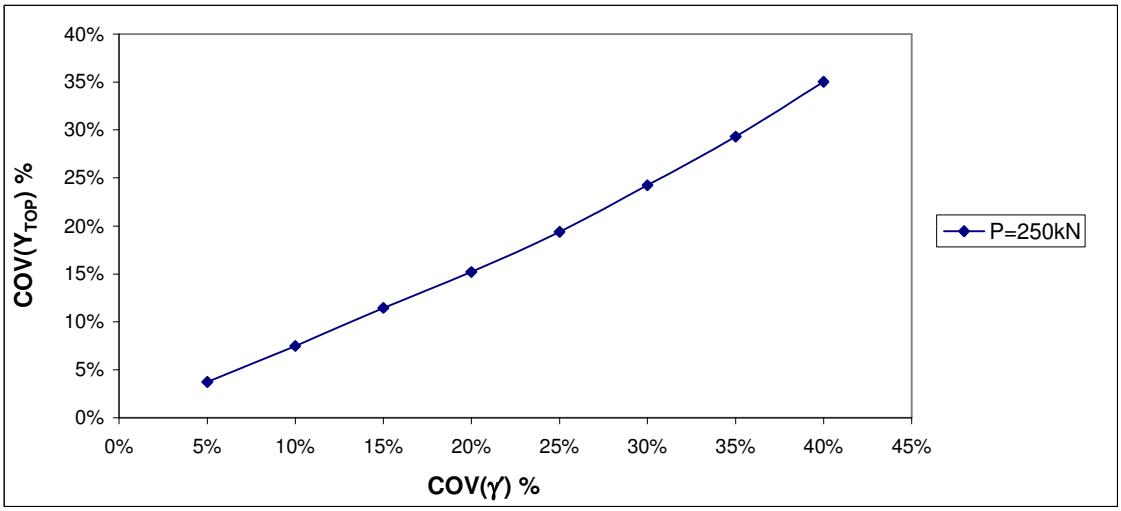


Fig. B.10 Variability of COV (Y_{TOP}) vs. COV (γ') for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.20 Value of COV(Y_{TOP}) for fixed head long pile with varying COV(γ') and lateral load 300kN.

P=300kN			
COV(γ') (%)	VAR(γ') $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	1.44E-06	4.03%
10%	1.10E+00	5.76E-06	8.05%
15%	2.48E+00	1.30E-05	12.08%
20%	4.41E+00	2.45E-05	16.61%
25%	6.89E+00	4.03E-05	21.31%
30%	9.92E+00	6.08E-05	26.17%
35%	1.35E+01	8.93E-05	31.71%
40%	1.76E+01	1.28E-04	37.92%

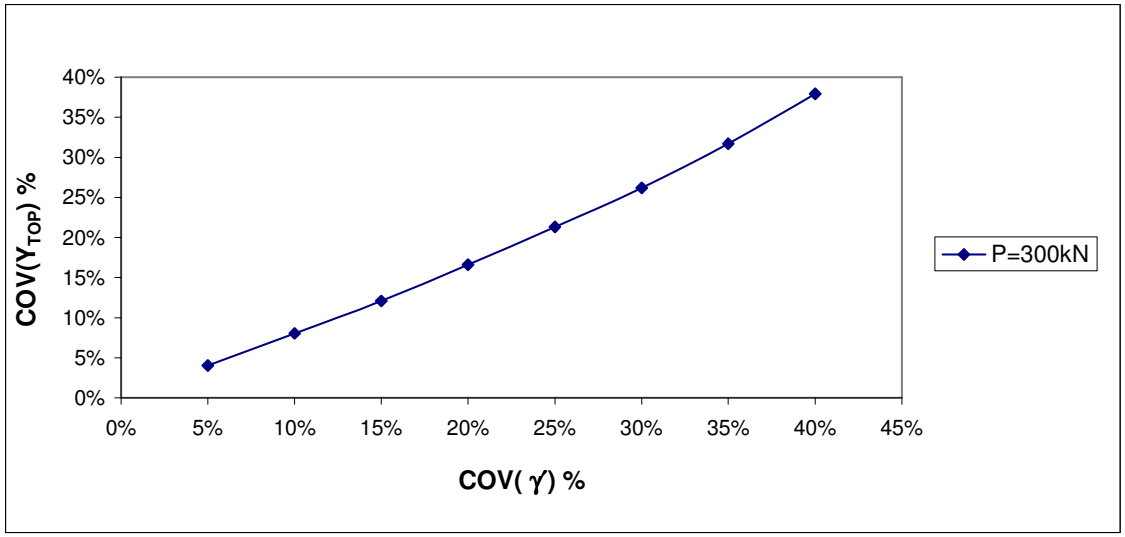


Fig. B.11 Variability of COV (Y_{TOP}) vs. COV (γ') for single fixed head long pile (10T) subjected to lateral force 300kN.

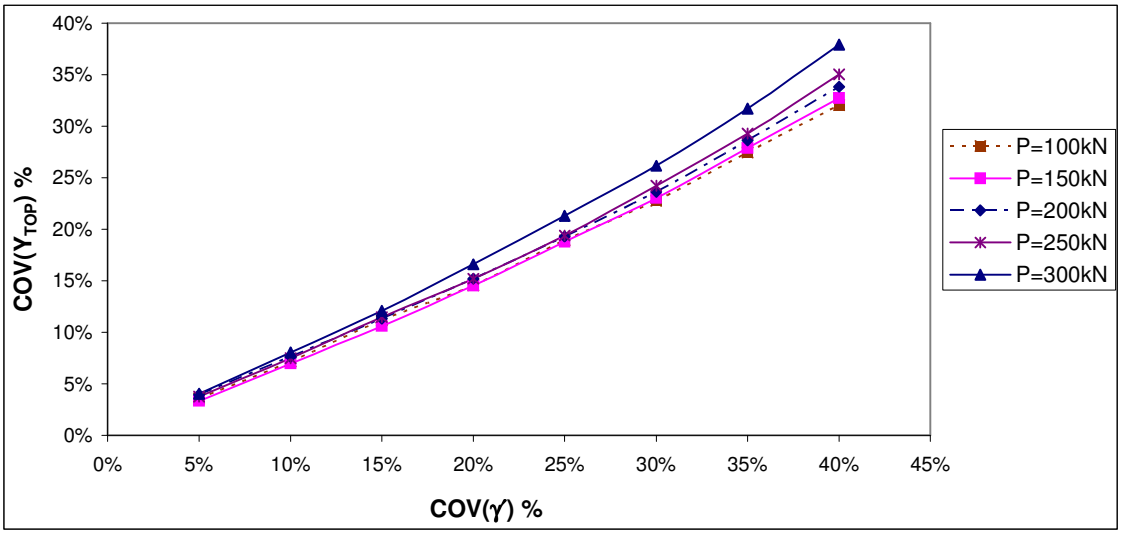


Fig. B.12 Variability of COV(Y_{TOP}) vs. COV(γ) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.21 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying

(k) and load 100kN.

P=100kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	6.20E-03				
5%	16300			6.64E+05	6.25E-10	6.22E-03	0.24%
		15485	6.25E-03				
		17930	6.19E-03				
10%	16300			2.66E+06	6.56E-10	6.22E-03	0.44%
		14670	6.24E-03				
		18745	6.17E-03				
15%	16300			5.98E+06	2.50E-09	6.22E-03	0.74%
		13855	6.27E-03				
		19560	6.15E-03				
20%	16300			1.06E+07	6.40E-09	6.22E-03	1.14%
		13040	6.31E-03				
		20375	6.14E-03				
25%	16300			1.66E+07	1.21E-08	6.22E-03	1.63%
		12225	6.36E-03				
		21190	6.13E-03				
30%	16300			2.39E+07	1.96E-08	6.22E-03	2.14%
		11410	6.41E-03				
		22005	6.12E-03				
35%	16300			3.25E+07	3.06E-08	6.22E-03	2.71%
		10595	6.47E-03				
		22820	6.11E-03				
40%	16300			4.25E+07	5.06E-08	6.22E-03	3.38%
		9780	6.56E-03				

Table B.22 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (k) and load 150kN.

P=150kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	1.12E-02				
5%	16300			6.64E+05	2.50E-09	7.40E-03	0.22%
		15485	1.13E-02				
		17930	1.12E-02				
10%	16300			2.66E+06	2.63E-09	7.40E-03	0.38%
		14670	1.13E-02				
		18745	1.11E-02				
15%	16300			5.98E+06	1.00E-08	7.40E-03	0.62%
		13855	1.13E-02				
		19560	1.11E-02				
20%	16300			1.06E+07	1.70E-09	7.40E-03	0.89%
		13040	1.13E-02				
		20375	1.11E-02				
25%	16300			1.66E+07	2.25E-08	7.40E-03	1.19%
		12225	1.14E-02				
		21190	1.11E-02				
30%	16300			2.39E+07	2.43E-08	7.40E-03	1.45%
		11410	1.14E-02				
		22005	1.11E-02				
35%	16300			3.25E+07	4.00E-08	7.40E-03	1.79%
		10595	1.15E-02				
		22820	1.11E-02				
40%	16300			4.25E+07	6.25E-08	7.40E-03	2.23%
		9780	1.16E-02				

Table B.23 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying

(k) and load 200kN.

P=200kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	2.27E-02				
5%	16300			6.64E+05	2.33E-09	1.65E-02	0.22%
		15485	2.28E-02				
		17930	2.27E-02				
10%	16300			2.66E+06	2.47E-09	1.65E-02	0.30%
		14670	2.28E-02				
		18745	2.27E-02				
15%	16300			5.98E+06	2.54E-09	1.65E-02	0.44%
		13855	2.28E-02				
		19560	2.26E-02				
20%	16300			1.06E+07	1.00E-08	1.65E-02	0.61%
		13040	2.29E-02				
		20375	2.26E-02				
25%	16300			1.66E+07	2.25E-08	1.65E-02	0.84%
		12225	2.29E-02				
		21190	2.26E-02				
30%	16300			2.39E+07	4.00E-08	1.65E-02	1.10%
		11410	2.30E-02				
		22005	2.26E-02				
35%	16300			3.25E+07	4.30E-08	1.65E-02	1.28%
		10595	2.31E-02				
		22820	2.26E-02				
40%	16300			4.25E+07	6.25E-08	1.65E-02	1.52%
		9780	2.32E-02				

Table B.24 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (k) and load 250kN.

P=250kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	2.97E-02				
5%	16300			6.64E+05	2.50E-09	2.98E-02	0.18%
		15485	2.98E-02				
		17930	2.97E-02				
10%	16300			2.66E+06	2.53E-09	2.98E-02	0.22%
		14670	2.98E-02				
		18745	2.97E-02				
15%	16300			5.98E+06	2.57E-09	2.98E-02	0.32%
		13855	2.98E-02				
		19560	2.97E-02				
20%	16300			1.06E+07	2.25E-08	2.98E-02	0.47%
		13040	2.99E-02				
		20375	2.96E-02				
25%	16300			1.66E+07	2.46E-08	2.98E-02	0.66%
		12225	3.00E-02				
		21190	2.96E-02				
30%	16300			2.39E+07	4.00E-08	2.98E-02	0.88%
		11410	3.00E-02				
		22005	2.96E-02				
35%	16300			3.25E+07	6.25E-08	2.98E-02	1.10%
		10595	3.01E-02				
		22820	2.96E-02				
40%	16300			4.25E+07	9.00E-08	2.98E-02	1.32%
		9780	3.03E-02				

Table B.25 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (k) and load 300kN.

P=300kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	4.77E-02				
5%	16300			6.64E+05	2.30E-09	4.77E-02	0.11%
		15485	4.77E-02				
		17930	4.74E-02				
10%	16300			2.66E+06	2.43E-09	4.77E-02	0.13%
		14670	4.78E-02				
		18745	4.73E-02				
15%	16300			5.98E+06	2.50E-09	4.77E-02	0.20%
		13855	4.80E-02				
		19560	4.72E-02				
20%	16300			1.06E+07	1.00E-08	4.77E-02	0.34%
		13040	4.81E-02				
		20375	4.70E-02				
25%	16300			1.66E+07	4.00E-08	4.77E-02	0.52%
		12225	4.82E-02				
		21190	4.69E-02				
30%	16300			2.39E+07	4.10E-08	4.77E-02	0.67%
		11410	4.86E-02				
		22005	4.68E-02				
35%	16300			3.25E+07	6.25E-08	4.77E-02	0.87%
		10595	4.91E-02				
		22820	4.66E-02				
40%	16300			4.25E+07	1.23E-07	4.77E-02	1.13%
		9780	5.01E-02				

Table B.26 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(k) and lateral load 100kN.

P=100kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	6.25E-10	0.24%
10%	2.66E+06	6.56E-10	0.44%
15%	5.98E+06	2.50E-09	0.74%
20%	1.06E+07	6.40E-09	1.14%
25%	1.66E+07	1.21E-08	1.63%
30%	2.39E+07	1.96E-08	2.14%
35%	3.25E+07	3.06E-08	2.71%
40%	4.25E+07	5.06E-08	3.38%

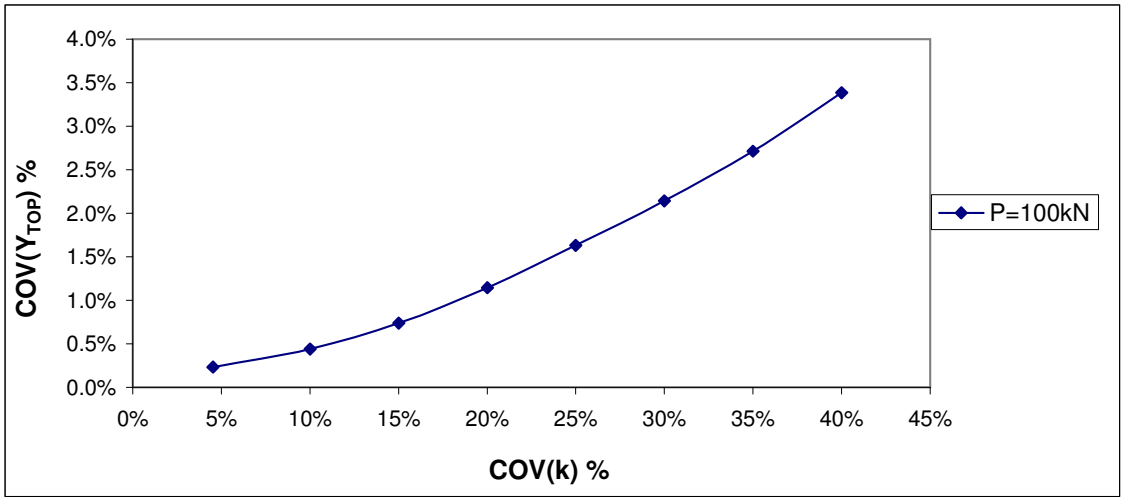


Fig. B.13 Variability of COV (Y_{TOP}) vs. COV(k) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.27 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(k) and lateral load 150kN.

P=150kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	2.50E-09	0.22%
10%	2.66E+06	2.63E-09	0.38%
15%	5.98E+06	1.00E-08	0.62%
20%	1.06E+07	1.70E-09	0.89%
25%	1.66E+07	2.25E-08	1.19%
30%	2.39E+07	2.43E-08	1.45%
35%	3.25E+07	4.00E-08	1.79%
40%	4.25E+07	6.25E-08	2.23%

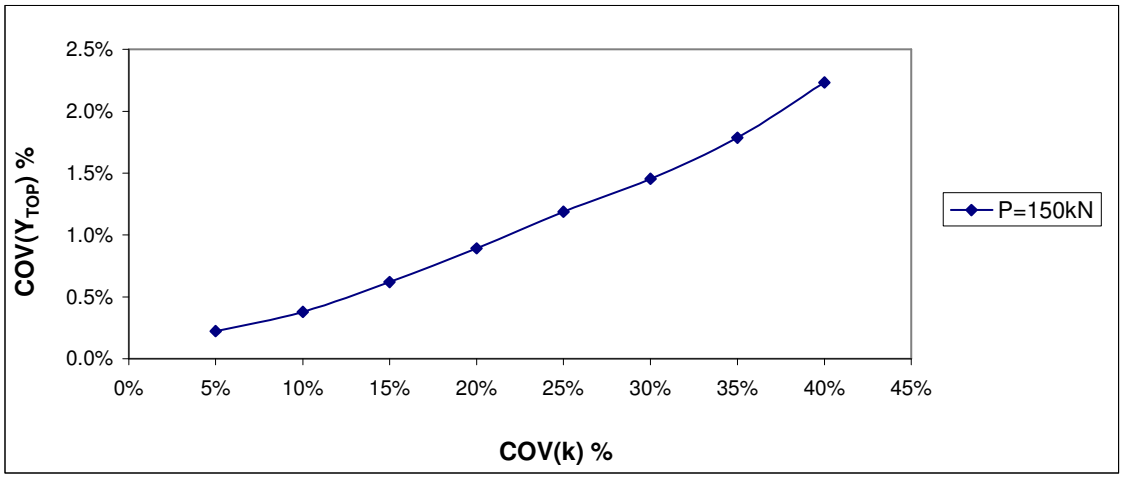


Fig. B.14 Variability of COV (Y_{TOP}) vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.28 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(k) and lateral load 200kN.

P=200kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	2.33E-09	0.22%
10%	2.66E+06	2.47E-09	0.30%
15%	5.98E+06	2.54E-09	0.44%
20%	1.06E+07	1.00E-08	0.61%
25%	1.66E+07	2.25E-08	0.84%
30%	2.39E+07	4.00E-08	1.10%
35%	3.25E+07	4.30E-08	1.28%
40%	4.25E+07	6.25E-08	1.52%

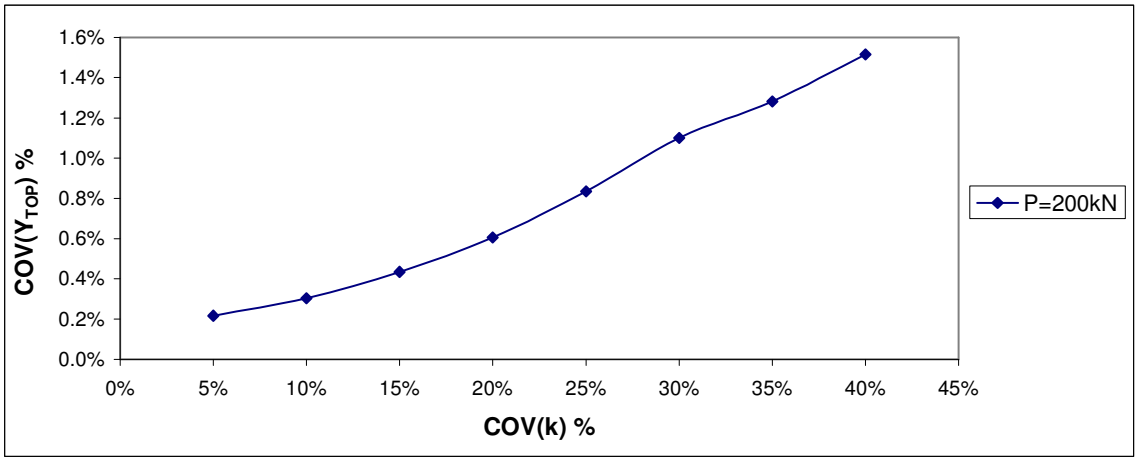


Fig. B.15 Variability of COV (Y_{TOP}) vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.29 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(k) and lateral load 250kN.

P=250kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	2.50E-09	0.18%
10%	2.66E+06	2.53E-09	0.22%
15%	5.98E+06	2.57E-09	0.32%
20%	1.06E+07	2.25E-08	0.47%
25%	1.66E+07	2.46E-08	0.66%
30%	2.39E+07	4.00E-08	0.88%
35%	3.25E+07	6.25E-08	1.10%
40%	4.25E+07	9.00E-08	1.32%

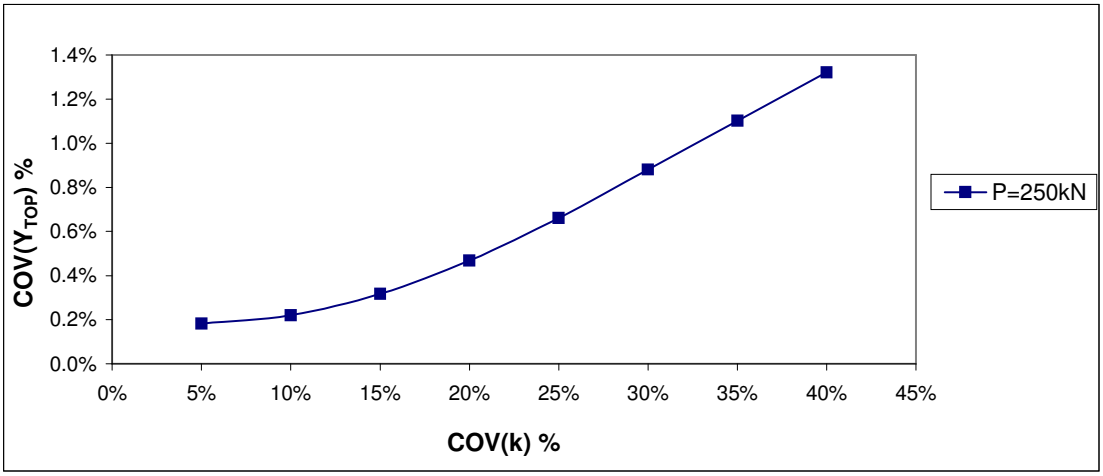


Fig. B.16 Variability of COV (Y_{TOP}) vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.30 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(k) and lateral load 300kN.

P=300kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	2.30E-09	0.11%
10%	2.66E+06	2.43E-09	0.13%
15%	5.98E+06	2.50E-09	0.20%
20%	1.06E+07	1.00E-08	0.34%
25%	1.66E+07	4.00E-08	0.52%
30%	2.39E+07	4.10E-08	0.67%
35%	3.25E+07	6.25E-08	0.87%
40%	4.25E+07	1.23E-07	1.13%

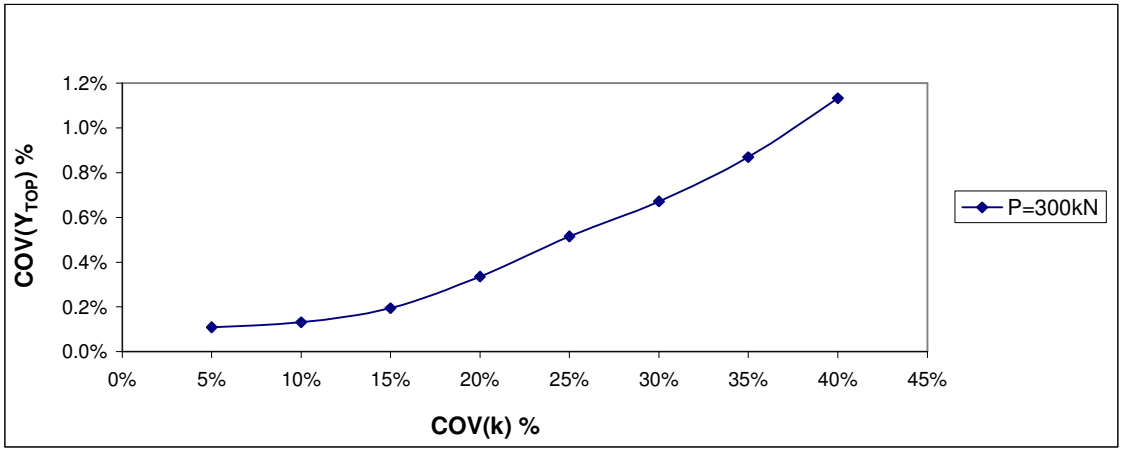


Fig. B.17 Variability of COV (Y_{TOP}) vs. COV(k) for single fixed head long pile (10T) subjected to lateral force 300kN.

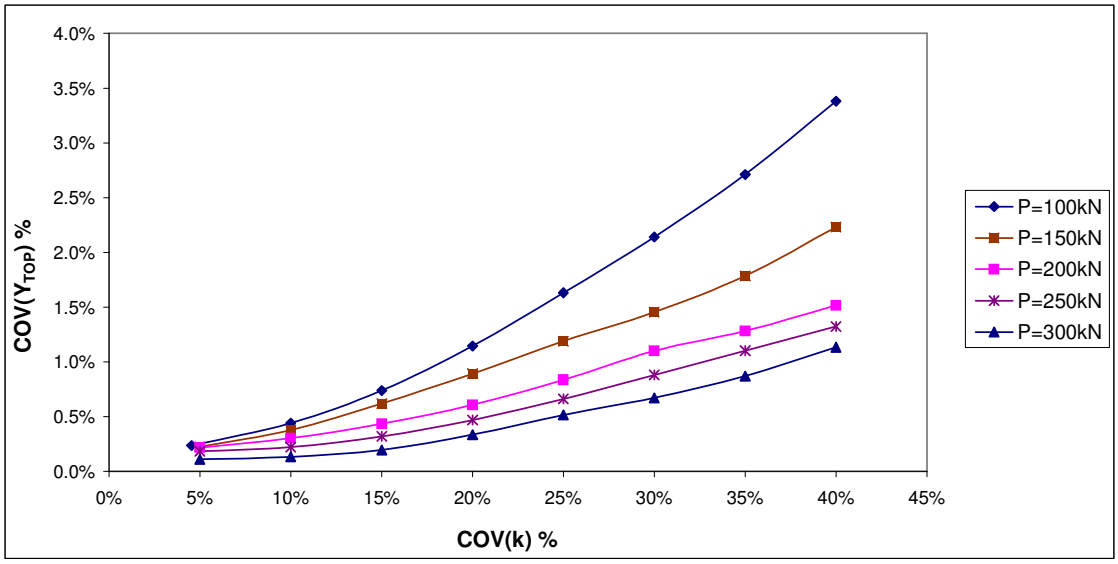


Fig. B.18 Variability of COV (Y_{TOP}) vs. COV (k) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.31 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying

(B) and load 100kN.

P=100kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.4263	1.12E-02				
5%	0.406			4.12E-04	1.50E-09	6.22E-03	0.09%
		0.3857	1.12E-02				
		0.4466	1.12E-02				
10%	0.406			1.65E-03	2.50E-09	6.22E-03	0.30%
		0.3654	1.11E-02				
		0.4669	1.12E-02				
15%	0.406			3.71E-03	2.65E-09	6.22E-03	0.50%
		0.3451	1.11E-02				
		0.4872	1.11E-02				
20%	0.406			6.59E-03	2.87E-09	6.22E-03	0.72%
		0.3248	1.10E-02				
		0.5075	1.11E-02				
25%	0.406			1.03E-02	1.00E-08	6.22E-03	0.93%
		0.3045	1.09E-02				
		0.5278	1.10E-02				
30%	0.406			1.48E-02	2.00E-09	6.22E-03	1.12%
		0.2842	1.08E-02				
		0.5472	1.09E-02				
35%	0.406			2.02E-02	2.28E-08	6.22E-03	1.27%
		0.2648	1.06E-02				
		0.5684	1.08E-02				
40%	0.406			2.64E-02	2.25E-08	6.22E-03	1.34%
		0.2436	1.05E-02				

Table B.32 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (B) and load 150kN.

P=150kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.4263	1.12E-02				
5%	0.406			4.12E-04	1.00E-08	7.40E-03	0.13%
		0.3857	1.12E-02				
		0.4466	1.12E-02				
10%	0.406			1.65E-03	1.56E-08	7.40E-03	0.71%
		0.3654	1.11E-02				
		0.4669	1.12E-02				
15%	0.406			3.71E-03	6.25E-08	7.40E-03	1.20%
		0.3451	1.11E-02				
		0.4872	1.11E-02				
20%	0.406			6.59E-03	6.27E-08	7.40E-03	1.55%
		0.3248	1.10E-02				
		0.5075	1.11E-02				
25%	0.406			1.03E-02	2.02E-07	7.40E-03	1.90%
		0.3045	1.09E-02				
		0.5278	1.10E-02				
30%	0.406			1.48E-02	2.03E-07	7.40E-03	2.17%
		0.2842	1.08E-02				
		0.5472	1.09E-02				
35%	0.406			2.02E-02	2.05E-07	7.40E-03	2.32%
		0.2648	1.06E-02				
		0.5684	1.08E-02				
40%	0.406			2.64E-02	3.03E-07	7.40E-03	2.36%
		0.2436	1.05E-02				

Table B.33 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (B) and load 200kN.

P=200kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	1.65E-02				
5%	0.406			4.12E-04	1.25E-08	1.65E-02	0.22%
		0.3857	1.65E-02				
		0.4466	1.67E-02				
10%	0.406			1.65E-03	2.25E-08	1.65E-02	0.91%
		0.3654	1.64E-02				
		0.4669	1.67E-02				
15%	0.406			3.71E-03	6.25E-08	1.65E-02	1.39%
		0.3451	1.62E-02				
		0.4872	1.67E-02				
20%	0.406			6.59E-03	9.00E-08	1.65E-02	1.82%
		0.3248	1.61E-02				
		0.5075	1.67E-02				
25%	0.406			1.03E-02	1.23E-07	1.65E-02	2.19%
		0.3045	1.60E-02				
		0.5278	1.66E-02				
30%	0.406			1.48E-02	1.60E-07	1.65E-02	2.50%
		0.2842	1.58E-02				
		0.5472	1.66E-02				
35%	0.406			2.02E-02	2.05E-07	1.65E-02	2.74%
		0.2648	1.57E-02				
		0.5684	1.65E-02				
40%	0.406			2.64E-02	2.50E-07	1.65E-02	2.95%
		0.2436	1.55E-02				

Table B.34 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (B) and load 250kN.

P=250kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	2.65E-02				
5%	0.406			4.12E-04	1.50E-09	2.98E-02	0.37%
		0.3857	2.65E-02				
		0.4466	2.67E-02				
10%	0.406			1.65E-03	2.25E-08	2.98E-02	1.06%
		0.3654	2.64E-02				
		0.4669	2.67E-02				
15%	0.406			3.71E-03	6.25E-08	2.98E-02	1.54%
		0.3451	2.62E-02				
		0.4872	2.67E-02				
20%	0.406			6.59E-03	2.03E-07	2.98E-02	1.95%
		0.3248	2.58E-02				
		0.5075	2.68E-02				
25%	0.406			1.03E-02	4.90E-07	2.98E-02	2.38%
		0.3045	2.54E-02				
		0.5278	2.69E-02				
30%	0.406			1.48E-02	6.40E-07	2.98E-02	2.76%
		0.2842	2.53E-02				
		0.5472	2.69E-02				
35%	0.406			2.02E-02	8.20E-07	2.98E-02	3.04%
		0.2648	2.51E-02				
		0.5684	2.69E-02				
40%	0.406			2.64E-02	9.02E-07	2.98E-02	3.19%
		0.2436	2.50E-02				

Table B.35 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (B) and load 300kN.

P=300kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	6.18E-03				
5%	0.406			4.12E-04	1.23E-09	4.77E-02	0.56%
		0.3857	6.25E-03				
		0.4466	6.13E-03				
10%	0.406			1.65E-03	3.60E-09	4.77E-02	1.10%
		0.3654	6.25E-03				
		0.4669	6.07E-03				
15%	0.406			3.71E-03	8.10E-09	4.77E-02	1.57%
		0.3451	6.25E-03				
		0.4872	5.99E-03				
20%	0.406			6.59E-03	1.69E-08	4.77E-02	2.09%
		0.3248	6.25E-03				
		0.5075	5.91E-03				
25%	0.406			1.03E-02	2.56E-08	4.77E-02	2.57%
		0.3045	6.23E-03				
		0.5278	5.82E-03				
30%	0.406			1.48E-02	3.61E-08	4.77E-02	3.05%
		0.2842	6.20E-03				
		0.5472	5.71E-03				
35%	0.406			2.02E-02	4.90E-08	4.77E-02	3.56%
		0.2648	6.15E-03				
		0.5684	5.61E-03				
40%	0.406			2.64E-02	5.76E-08	4.77E-02	3.86%
		0.2436	6.09E-03				

Table B.36 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(B) and lateral load 100kN.

P=100kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.50E-09	0.09%
10%	1.65E-03	2.50E-09	0.30%
15%	3.71E-03	2.65E-09	0.50%
20%	6.59E-03	2.87E-09	0.72%
25%	1.03E-02	1.00E-08	0.93%
30%	1.48E-02	2.00E-09	1.12%
35%	2.02E-02	2.28E-08	1.27%
40%	2.64E-02	2.25E-08	1.34%

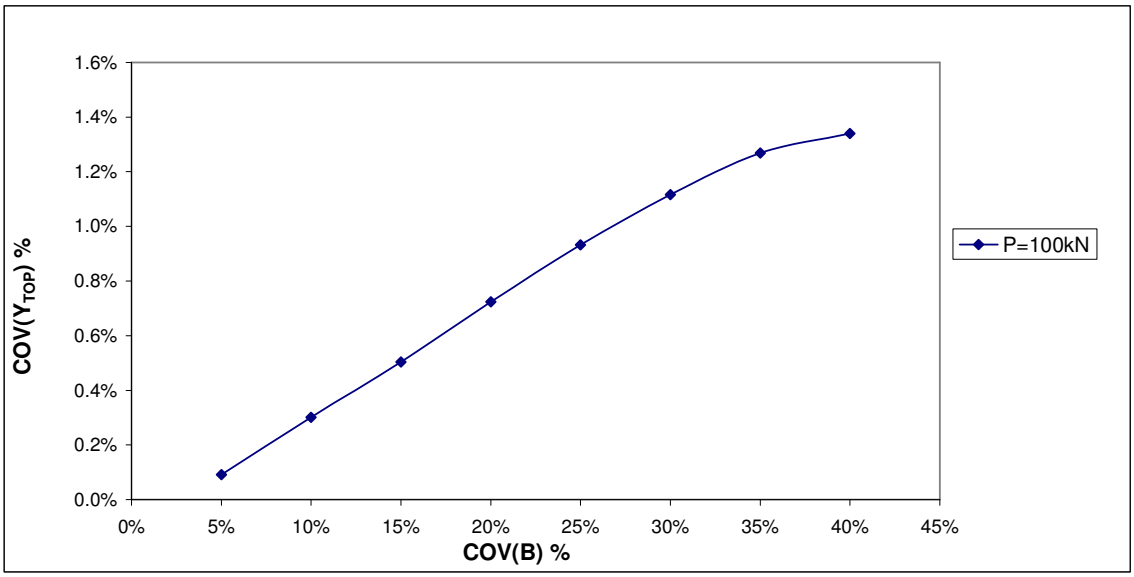


Fig. B.19 Variability of COV (Y_{TOP}) vs. COV(B) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.37 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(B) and lateral load 150kN.

P=150kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.00E-08	0.13%
10%	1.65E-03	1.56E-08	0.71%
15%	3.71E-03	6.25E-08	1.20%
20%	6.59E-03	6.27E-08	1.55%
25%	1.03E-02	2.02E-07	1.90%
30%	1.48E-02	2.03E-07	2.17%
35%	2.02E-02	2.05E-07	2.32%
40%	2.64E-02	3.03E-07	2.36%

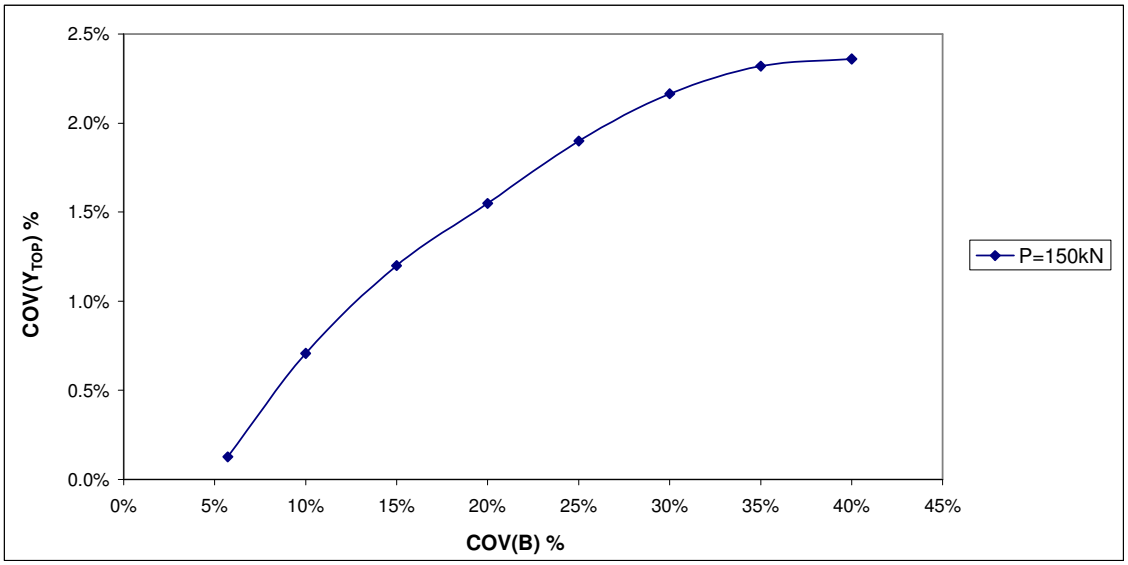


Fig. B.20 Variability of COV (Y_{TOP}) vs. COV(B) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.38 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(B) and lateral load 200kN.

P=200kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.25E-08	0.22%
10%	1.65E-03	2.25E-08	0.91%
15%	3.71E-03	6.25E-08	1.39%
20%	6.59E-03	9.00E-08	1.82%
25%	1.03E-02	1.23E-07	2.19%
30%	1.48E-02	1.60E-07	2.50%
35%	2.02E-02	2.05E-07	2.74%
40%	2.64E-02	2.50E-07	2.95%

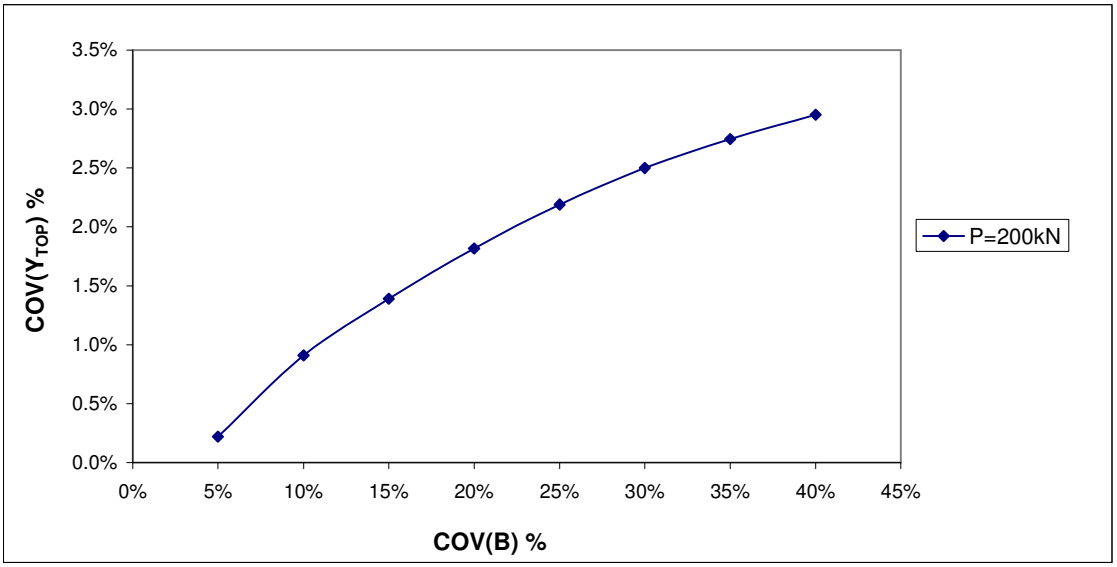


Fig. B.21 Variability of COV (Y_{TOP}) vs. COV(B) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.39 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(B) and lateral load 250kN.

P=250kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.50E-09	0.37%
10%	1.65E-03	2.25E-08	1.06%
15%	3.71E-03	6.25E-08	1.54%
20%	6.59E-03	2.03E-07	1.95%
25%	1.03E-02	4.90E-07	2.38%
30%	1.48E-02	6.40E-07	2.76%
35%	2.02E-02	8.20E-07	3.04%
40%	2.64E-02	9.02E-07	3.19%

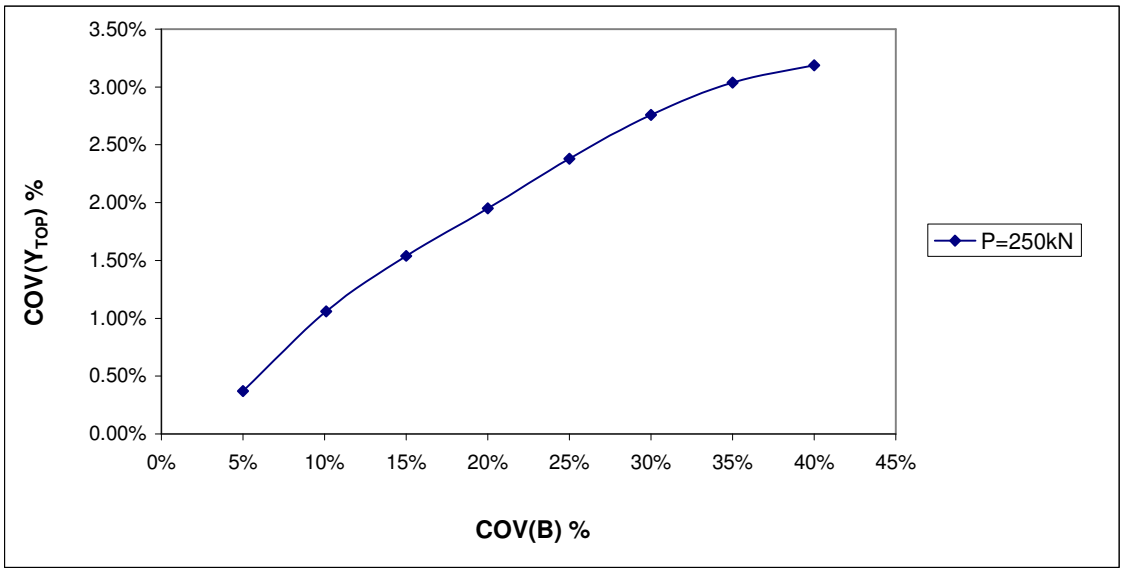


Fig. B.22 Variability of COV (Y_{TOP}) vs. COV(B) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.40 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(B) and lateral load 300kN.

P=300kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.23E-09	0.56%
10%	1.65E-03	3.60E-09	1.10%
15%	3.71E-03	8.10E-09	1.57%
20%	6.59E-03	1.69E-08	2.09%
25%	1.03E-02	2.56E-08	2.57%
30%	1.48E-02	3.61E-08	3.05%
35%	2.02E-02	4.90E-08	3.56%
40%	2.64E-02	5.76E-08	3.86%

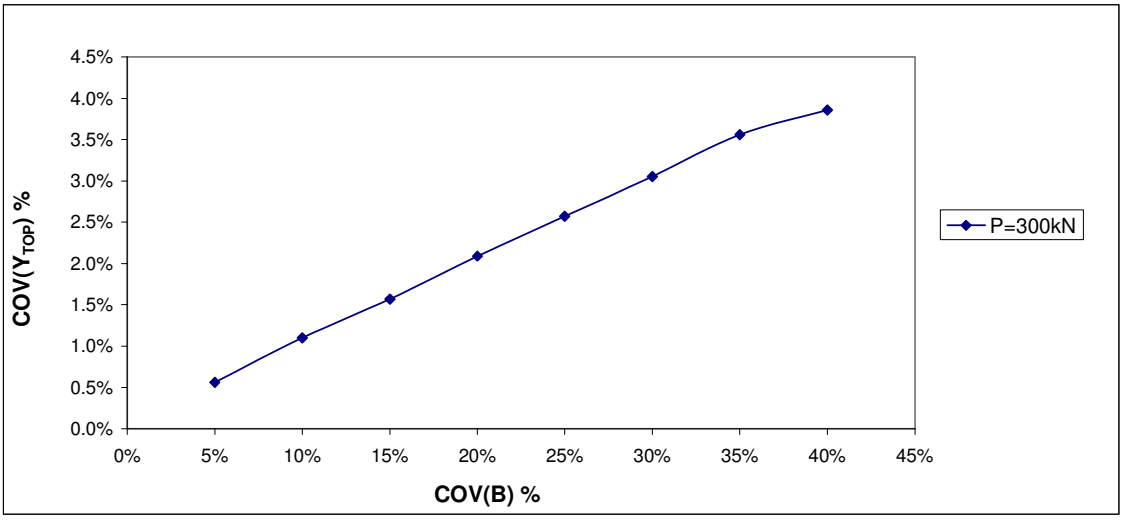


Fig. B.23 Variability of COV (Y_{TOP}) vs. COV(B) for single fixed head long pile (10T) subjected to lateral force 300kN.

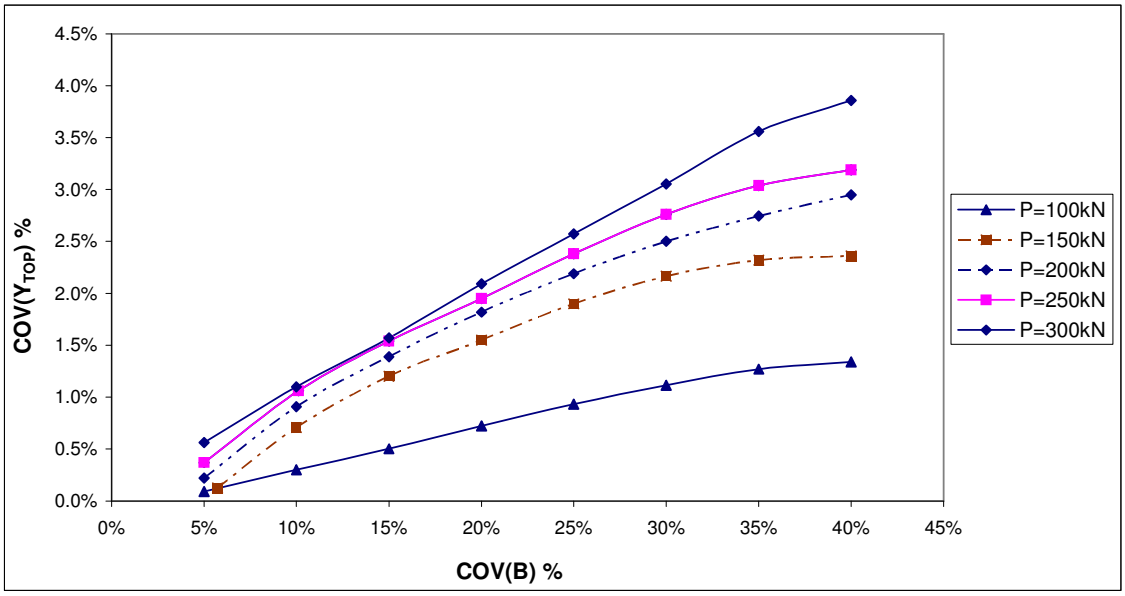


Fig. B.24 Variability of COV (Y_{TOP}) vs. COV (B) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.41 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (EI) and load 100kN.

P=100kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) ($kN-m^2$)	Y_{TOP} (m)	VAR(EI) $(kN-m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	6.03E-03				
5%	61000			9.30E+06	1.00E-08	6.22E-03	1.61%
		57950	6.43E-03				
		67100	5.82E-03				
10%	61000			3.72E+07	4.41E-08	6.22E-03	5.57%
		54900	6.66E-03				
		70150	4.72E-03				
15%	61000			8.37E+07	3.00E-07	6.22E-03	9.93%
		51850	6.91E-03				
		73200	4.60E-03				
20%	61000			1.49E+08	1.41E-06	6.22E-03	15.22%
		48800	9.35E-03				
		76250	4.48E-03				
25%	61000			2.33E+08	7.77E-07	6.22E-03	19.16%
		45750	9.79E-03				
		79300	4.38E-03				
30%	61000			3.35E+08	2.12E-06	6.22E-03	22.45%
		42700	1.02E-02				
		82350	4.27E-03				
35%	61000			4.56E+08	2.66E-06	6.22E-03	24.76%
		39650	1.08E-02				
		85400	4.18E-03				
40%	61000			5.95E+08	3.17E-06	6.22E-03	27.41%
		36600	1.13E-02				

Table B.42 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (EI) and load 150kN.

P=150kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) ($kN-m^2$)	Y_{TOP} (m)	VAR(EI) $(kN-m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	1.08E-02				
5%	61000			9.30E+06	4.00E-08	7.40E-03	1.79%
		57950	1.16E-02				
		67100	1.05E-02				
10%	61000			3.72E+07	1.41E-07	7.40E-03	7.00%
		54900	1.20E-02				
		70150	8.49E-03				
15%	61000			8.37E+07	9.56E-07	7.40E-03	12.00%
		51850	1.24E-02				
		73200	8.26E-03				
20%	61000			1.49E+08	4.56E-06	7.40E-03	17.00%
		48800	1.68E-02				
		76250	8.04E-03				
25%	61000			2.33E+08	2.46E-06	7.40E-03	20.49%
		45750	1.75E-02				
		79300	7.84E-03				
30%	61000			3.35E+08	6.84E-06	7.40E-03	23.57%
		42700	1.83E-02				
		82350	7.65E-03				
35%	61000			4.56E+08	8.48E-06	7.40E-03	26.00%
		39650	1.93E-02				
		85400	7.48E-03				
40%	61000			5.95E+08	1.03E-05	7.40E-03	28.62%
		36600	2.03E-02				

Table B.43 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying

(EI) and load 200kN.

P=200kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	1.60E-02				
5%	61000			9.30E+06	7.56E-08	1.65E-02	1.67%
		57950	1.71E-02				
		67100	1.56E-02				
10%	61000			3.72E+07	2.76E-07	1.65E-02	6.79%
		54900	1.77E-02				
		70150	1.26E-02				
15%	61000			8.37E+07	2.10E-06	1.65E-02	11.54%
		51850	1.84E-02				
		73200	1.22E-02				
20%	61000			1.49E+08	1.06E-05	1.65E-02	17.33%
		48800	2.52E-02				
		76250	1.19E-02				
25%	61000			2.33E+08	5.79E-06	1.65E-02	21.68%
		45750	2.64E-02				
		79300	1.16E-02				
30%	61000			3.35E+08	1.62E-05	1.65E-02	24.39%
		42700	2.77E-02				
		82350	1.13E-02				
35%	61000			4.56E+08	2.02E-05	1.65E-02	27.27%
		39650	2.93E-02				
		85400	1.11E-02				
40%	61000			5.95E+08	2.50E-05	1.65E-02	30.30%
		36600	3.11E-02				

Table B.44 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (EI) and load 250kN.

P=250kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	2.19E-02				
5%	61000			9.30E+06	1.41E-07	2.98E-02	1.65%
		57950	2.34E-02				
		67100	2.12E-02				
10%	61000			3.72E+07	6.01E-07	2.98E-02	7.44%
		54900	2.43E-02				
		70150	1.71E-02				
15%	61000			8.37E+07	4.20E-06	2.98E-02	13.85%
		51850	2.53E-02				
		73200	1.66E-02				
20%	61000			1.49E+08	2.30E-05	2.98E-02	19.65%
		48800	3.58E-02				
		76250	1.62E-02				
25%	61000			2.33E+08	1.27E-05	2.98E-02	23.64%
		45750	3.77E-02				
		79300	1.58E-02				
30%	61000			3.35E+08	3.60E-05	2.98E-02	27.16%
		42700	3.98E-02				
		82350	1.54E-02				
35%	61000			4.56E+08	4.45E-05	2.98E-02	30.42%
		39650	4.21E-02				
		85400	1.51E-02				
40%	61000			5.95E+08	5.55E-05	2.98E-02	32.82%
		36600	4.49E-02				

Table B.45 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (EI) and load 300kN.

P=300kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	2.87E-02				
5%	61000			9.30E+06	3.03E-07	4.77E-02	1.85%
		57950	3.09E-02				
		67100	2.77E-02				
10%	61000			3.72E+07	1.27E-06	4.77E-02	8.67%
		54900	3.22E-02				
		70150	2.19E-02				
15%	61000			8.37E+07	8.56E-06	4.77E-02	14.97%
		51850	3.36E-02				
		73200	2.13E-02				
20%	61000			1.49E+08	4.66E-05	4.77E-02	20.56%
		48800	4.86E-02				
		76250	2.08E-02				
25%	61000			2.33E+08	2.56E-05	4.77E-02	25.00%
		45750	5.13E-02				
		79300	2.02E-02				
30%	61000			3.35E+08	7.27E-05	4.77E-02	28.61%
		42700	5.43E-02				
		82350	1.97E-02				
35%	61000			4.56E+08	9.07E-05	4.77E-02	31.96%
		39650	5.78E-02				
		85400	1.93E-02				
40%	61000			5.95E+08	1.13E-04	4.77E-02	35.65%
		36600	6.18E-02				

Table B.46 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(EI) and lateral load 100kN.

P=100kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	1.00E-08	1.61%
10%	3.72E+07	4.41E-08	5.57%
15%	8.37E+07	3.00E-07	9.93%
20%	1.49E+08	1.41E-06	15.22%
25%	2.33E+08	7.77E-07	19.16%
30%	3.35E+08	2.12E-06	22.45%
35%	4.56E+08	2.66E-06	24.76%
40%	5.95E+08	3.17E-06	27.41%

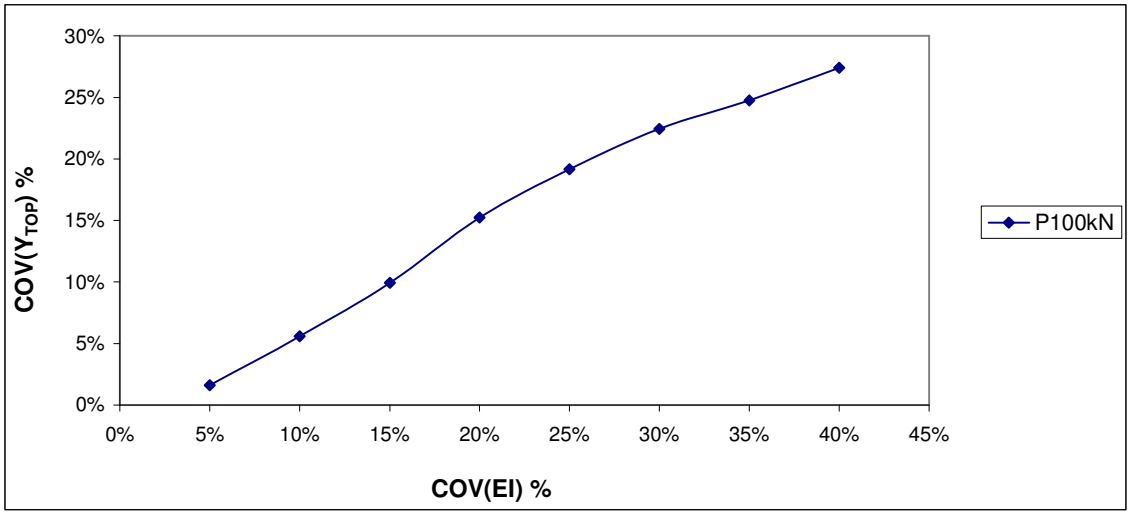


Fig. B.25 Variability of COV (Y_{TOP}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.47 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(EI) and lateral load 150kN.

P=150kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	4.00E-08	1.79%
10%	3.72E+07	1.41E-07	7.00%
15%	8.37E+07	9.56E-07	12.00%
20%	1.49E+08	4.56E-06	17.00%
25%	2.33E+08	2.46E-06	20.49%
30%	3.35E+08	6.84E-06	23.57%
35%	4.56E+08	8.48E-06	26.00%
40%	5.95E+08	1.03E-05	28.62%

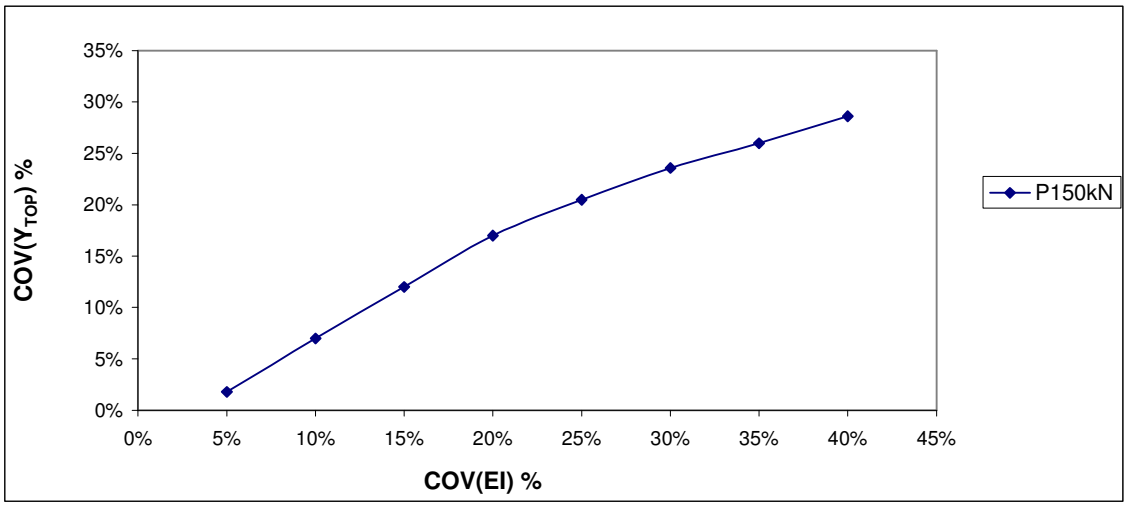


Fig. B.26 Variability of COV (Y_{TOP}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.48 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(EI) and lateral load 200kN.

P=200kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	7.56E-08	1.67%
10%	3.72E+07	2.76E-07	6.79%
15%	8.37E+07	2.10E-06	11.54%
20%	1.49E+08	1.06E-05	17.33%
25%	2.33E+08	5.79E-06	21.68%
30%	3.35E+08	1.62E-05	24.39%
35%	4.56E+08	2.02E-05	27.27%
40%	5.95E+08	2.50E-05	30.30%

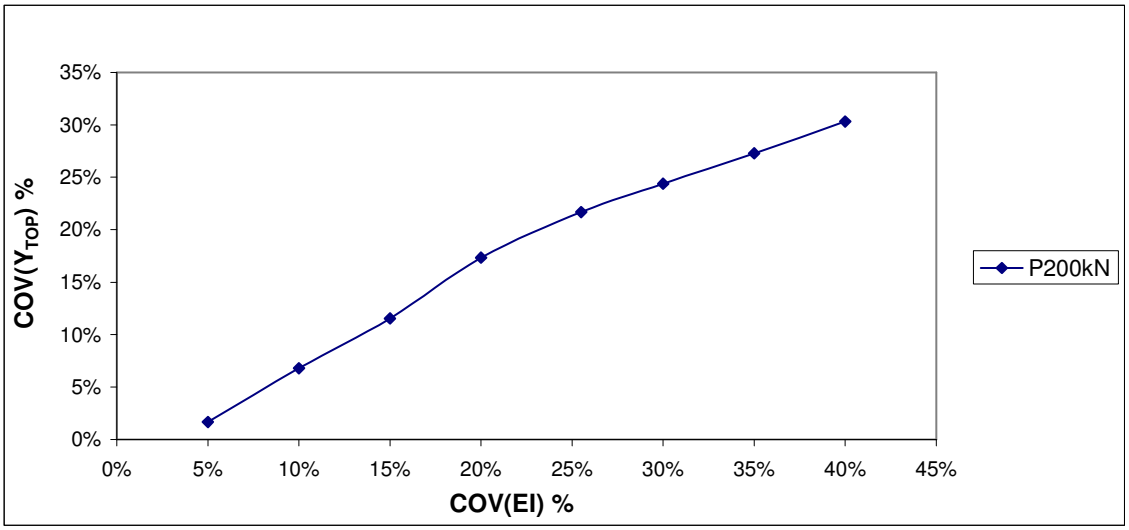


Fig. B.27 Variability of COV (Y_{TOP}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.49 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(EI) and lateral load 250kN.

P=250kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	1.41E-07	1.65%
10%	3.72E+07	6.01E-07	7.44%
15%	8.37E+07	4.20E-06	13.85%
20%	1.49E+08	2.30E-05	19.65%
25%	2.33E+08	1.27E-05	23.64%
30%	3.35E+08	3.60E-05	27.16%
35%	4.56E+08	4.45E-05	30.42%
40%	5.95E+08	5.55E-05	32.82%

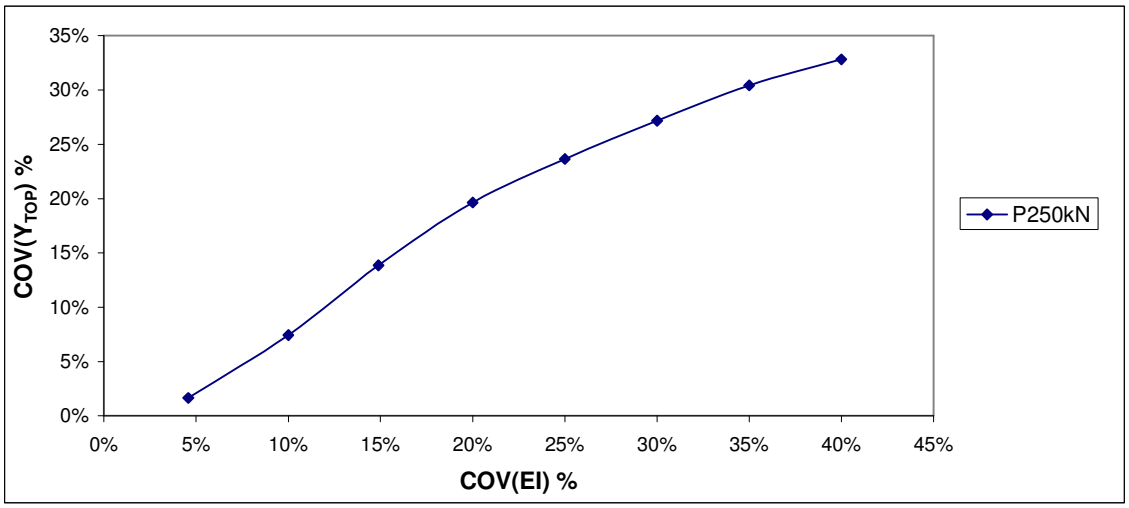


Fig. B.28 Variability of COV (Y_{TOP}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.50 Value of COV (Y_{TOP}) for fixed head long pile with varying COV(EI) and lateral load 300kN.

P=300kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	3.03E-07	1.85%
10%	3.72E+07	1.27E-06	8.67%
15%	8.37E+07	8.56E-06	14.97%
20%	1.49E+08	4.66E-05	20.56%
25%	2.33E+08	2.56E-05	25.00%
30%	3.35E+08	7.27E-05	28.61%
35%	4.56E+08	9.07E-05	31.96%
40%	5.95E+08	1.13E-04	35.65%

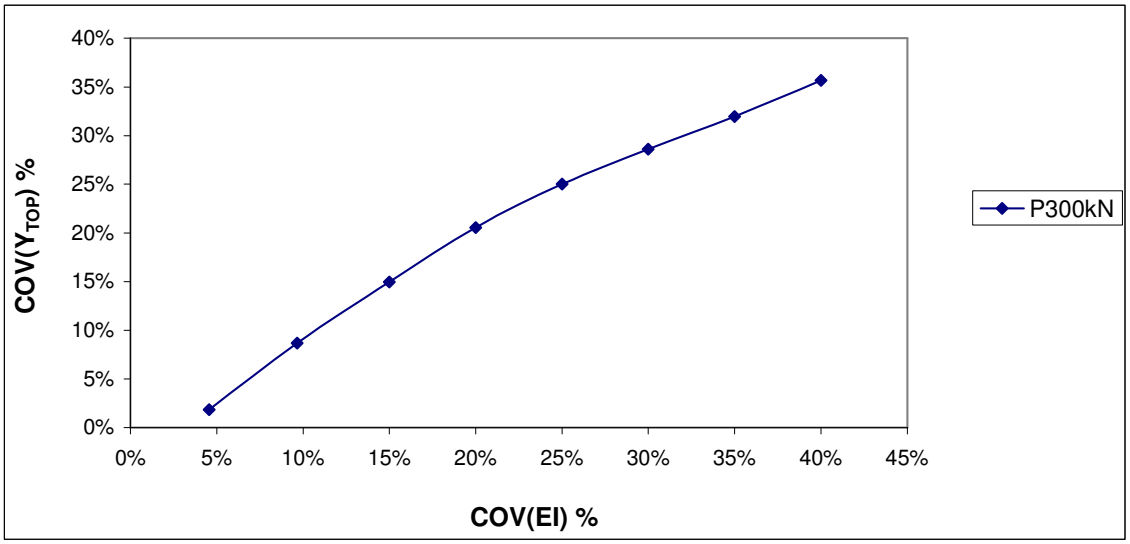


Fig. B.29 Variability of COV (Y_{TOP}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 300kN.

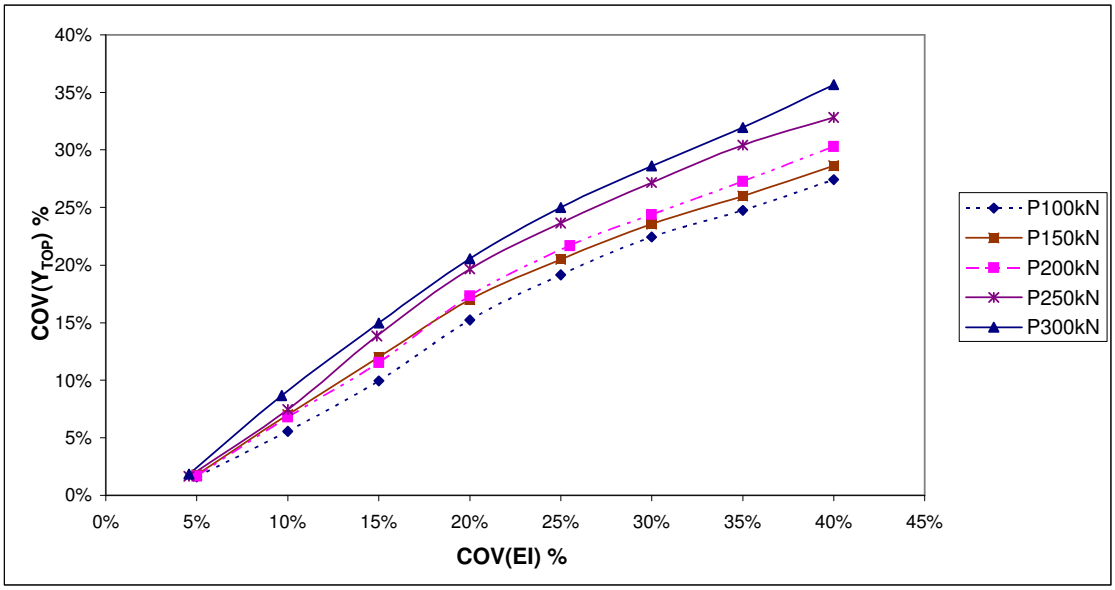


Fig. B.30 Variability of COV (Y_{TOP}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.51 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (P) and load 100kN.

P=100kN							
COV(P) (%)	P° (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		105	6.68E-03				
5%	100			2.50E+01	6.40E-07	6.22E-03	7.14%
		95	5.74E-03				
		110	7.14E-03				
10%	100			1.00E+02	2.48E-06	6.22E-03	14.06%
		90	5.32E-03				
		115	7.61E-03				
15%	100			2.25E+02	5.52E-06	6.22E-03	20.98%
		85	4.89E-03				
		120	8.08E-03				
20%	100			4.00E+02	9.73E-06	6.22E-03	27.86%
		80	4.48E-03				
		125	8.57E-03				
25%	100			6.25E+02	1.50E-05	6.22E-03	34.60%
		75	4.09E-03				
		130	9.06E-03				
30%	100			9.00E+02	2.19E-05	6.22E-03	41.74%
		70	3.70E-03				
		135	9.56E-03				
35%	100			1.23E+03	2.94E-05	6.22E-03	48.39%
		65	3.32E-03				
		140	1.01E-02				
40%	100			1.60E+03	3.84E-05	6.22E-03	55.31%
		60	2.92E-03				

Table B.52 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (P) and load 150kN.

P=150KN							
COV(P) (%)	P° (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		157.5	1.20E-02				
5%	150			5.63E+01	1.32E-06	7.40E-03	6.97%
		142.5	1.04E-02				
		165	1.28E-02				
10%	150			2.25E+02	5.29E-06	7.40E-03	13.94%
		135	9.65E-03				
		172.5	1.36E-02				
15%	150			5.06E+02	1.19E-05	7.40E-03	20.91%
		127.5	8.90E-03				
		180	1.44E-02				
20%	150			9.00E+02	2.07E-05	7.40E-03	27.58%
		120	8.16E-03				
		187.5	1.52E-02				
25%	150			1.41E+03	3.31E-05	7.40E-03	34.85%
		112.5	7.45E-03				
		195	1.61E-02				
30%	150			2.03E+03	4.83E-05	7.40E-03	42.12%
		105	6.75E-03				
		202.5	1.69E-02				
35%	150			2.76E+03	6.59E-05	7.40E-03	49.21%
		97.5	6.06E-03				
		210	1.78E-02				
40%	150			3.60E+03	8.67E-05	7.40E-03	56.42%
		90	5.41E-03				

Table B.53 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (P) and load 200kN.

P=200kN							
COV(P) (%)	P° (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		210	2.44E-02				
5%	200			1.00E+02	2.21E-07	1.65E-02	7.56%
		190	2.11E-02				
		220	2.62E-02				
10%	200			4.00E+02	8.28E-07	1.65E-02	14.63%
		180	1.96E-02				
		230	2.80E-02				
15%	200			9.00E+02	1.85E-06	1.65E-02	21.86%
		170	1.81E-02				
		240	2.98E-02				
20%	200			1.60E+03	3.24E-06	1.65E-02	28.94%
		160	1.66E-02				
		250	3.18E-02				
25%	200			2.50E+03	5.02E-06	1.65E-02	36.01%
		150	1.52E-02				
		260	3.38E-02				
30%	200			3.60E+03	7.18E-06	1.65E-02	43.09%
		140	1.39E-02				
		270	3.59E-02				
35%	200			4.90E+03	9.73E-06	1.65E-02	50.16%
		130	1.25E-02				
		280	3.81E-02				
40%	200			6.40E+03	1.29E-05	1.65E-02	57.72%
		120	1.12E-02				

Table B.54 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (P) and load 250kN.

P=250kN							
COV(P) (%)	P° (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		262.5	3.21E-02				
5%	250			1.56E+02	2.72E-06	2.98E-02	7.27%
		237.5	2.75E-02				
		275	3.46E-02				
10%	250			6.25E+02	1.09E-05	2.98E-02	14.54%
		225	2.53E-02				
		287.5	3.72E-02				
15%	250			1.41E+03	2.45E-05	2.98E-02	21.81%
		212.5	2.33E-02				
		300	3.99E-02				
20%	250			2.50E+03	4.36E-05	2.98E-02	29.07%
		200	2.13E-02				
		312.5	4.27E-02				
25%	250			3.91E+03	6.89E-05	2.98E-02	36.56%
		187.5	1.95E-02				
		325	4.56E-02				
30%	250			5.63E+03	9.90E-05	2.98E-02	43.83%
		175	1.77E-02				
		337.5	4.87E-02				
35%	250			7.66E+03	1.37E-04	2.98E-02	51.54%
		162.5	1.60E-02				
		350	5.18E-02				
40%	250			1.00E+04	1.81E-04	2.98E-02	59.25%
		150	1.43E-02				

Table B.55 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (P) and load 300kN.

P=300kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		315	5.18E-02				
5%	300			2.25E+02	5.29E-06	4.77E-02	7.72%
		285	4.36E-02				
		330	5.62E-02				
10%	300			9.00E+02	2.16E-05	4.77E-02	15.60%
		270	3.99E-02				
		345	6.08E-02				
15%	300			2.03E+03	4.83E-05	4.77E-02	23.32%
		255	3.63E-02				
		360	6.55E-02				
20%	300			3.60E+03	8.65E-05	4.77E-02	31.21%
		240	3.29E-02				
		375	7.05E-02				
25%	300			5.63E+03	1.35E-04	4.77E-02	38.93%
		225	2.98E-02				
		390	7.57E-02				
30%	300			8.10E+03	1.95E-04	4.77E-02	46.81%
		210	2.67E-02				
		405	8.11E-02				
35%	300			1.10E+04	2.67E-04	4.77E-02	54.87%
		195	2.40E-02				
		420	8.66E-02				
40%	300			1.44E+04	3.52E-04	4.77E-02	62.92%
		180	2.13E-02				

Table B.56 Value of COV(Y_{TOP}) for fixed head long pile with varying COV(P) and lateral load 100kN.

P=100kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.50E+01	6.40E-07	7.14%
10%	1.00E+02	2.48E-06	14.06%
15%	2.25E+02	5.52E-06	20.98%
20%	4.00E+02	9.73E-06	27.86%
25%	6.25E+02	1.50E-05	34.60%
30%	9.00E+02	2.19E-05	41.74%
35%	1.23E+03	2.94E-05	48.39%
40%	1.60E+03	3.84E-05	55.31%

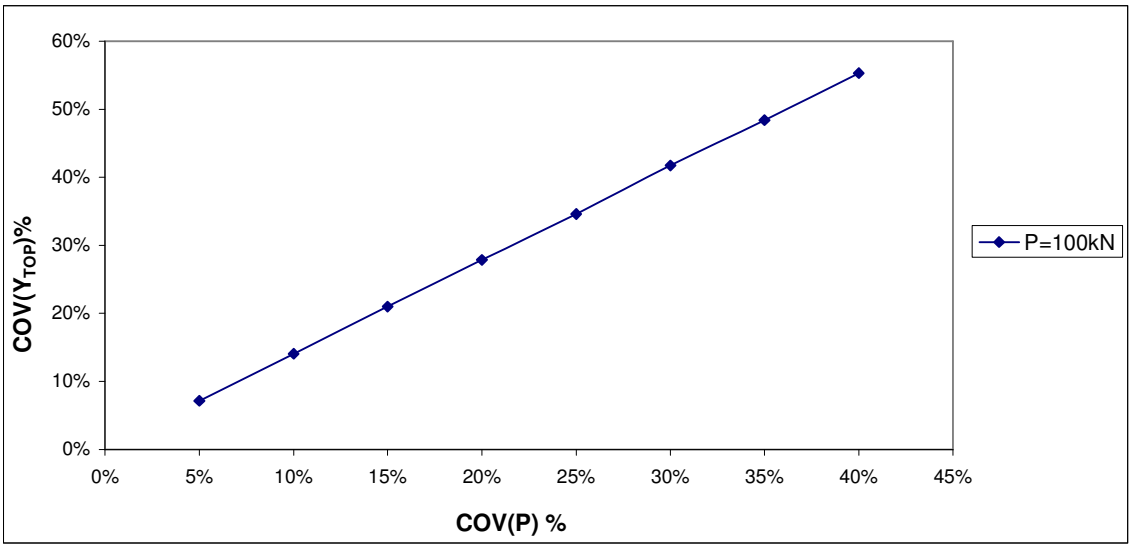


Fig. B.31 Variability of COV (Y_{TOP}) vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.57 Value of COV(Y_{TOP}) for fixed head long pile with varying COV(P) and lateral load 150kN.

P=150kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	5.63E+01	1.32E-06	6.97%
10%	2.25E+02	5.29E-06	13.94%
15%	5.06E+02	1.19E-05	20.91%
20%	9.00E+02	2.07E-05	27.58%
25%	1.41E+03	3.31E-05	34.85%
30%	2.03E+03	4.83E-05	42.12%
35%	2.76E+03	6.59E-05	49.21%
40%	3.60E+03	8.67E-05	56.42%

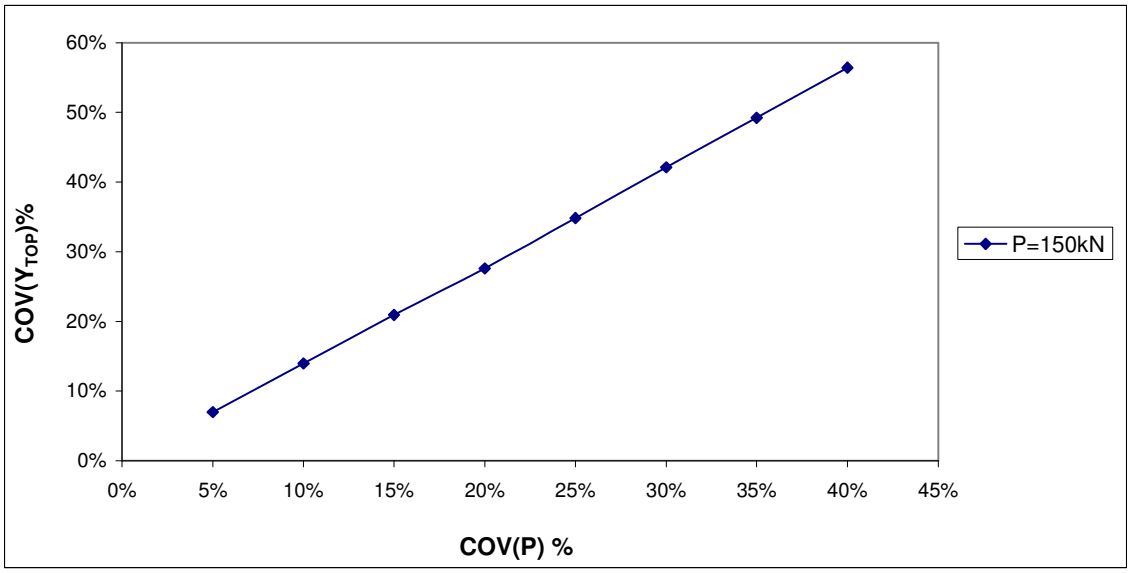


Fig. B.32 Variability of COV (Y_{TOP}) vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.58 Value of COV(Y_{TOP}) for fixed head long pile with varying COV(P) and lateral load 200kN.

P=200kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	1.00E+02	2.21E-07	7.56%
10%	4.00E+02	8.28E-07	14.63%
15%	9.00E+02	1.85E-06	21.86%
20%	1.60E+03	3.24E-06	28.94%
25%	2.50E+03	5.02E-06	36.01%
30%	3.60E+03	7.18E-06	43.09%
35%	4.90E+03	9.73E-06	50.16%
40%	6.40E+03	1.29E-05	57.72%

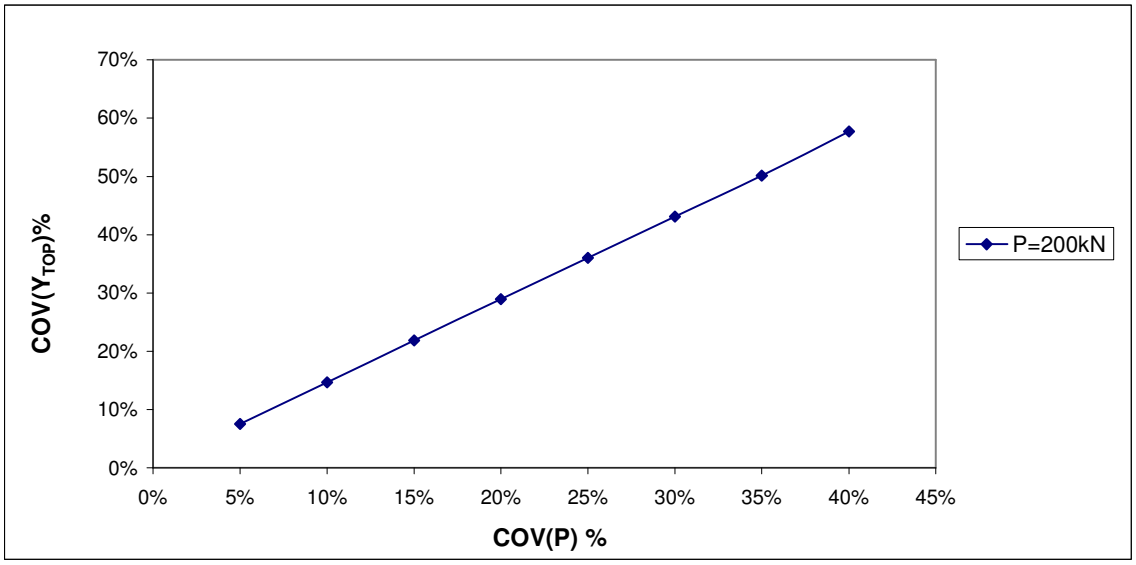


Fig. B.33 Variability of COV (Y_{TOP}) vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.59 Value of COV(Y_{TOP}) for fixed head long pile with varying COV(P) and lateral load 250kN.

P=250kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	1.56E+02	2.72E-06	7.27%
10%	6.25E+02	1.09E-05	14.54%
15%	1.41E+03	2.45E-05	21.81%
20%	2.50E+03	4.36E-05	29.07%
25%	3.91E+03	6.89E-05	36.56%
30%	5.63E+03	9.90E-05	43.83%
35%	7.66E+03	1.37E-04	51.54%
40%	1.00E+04	1.81E-04	59.25%

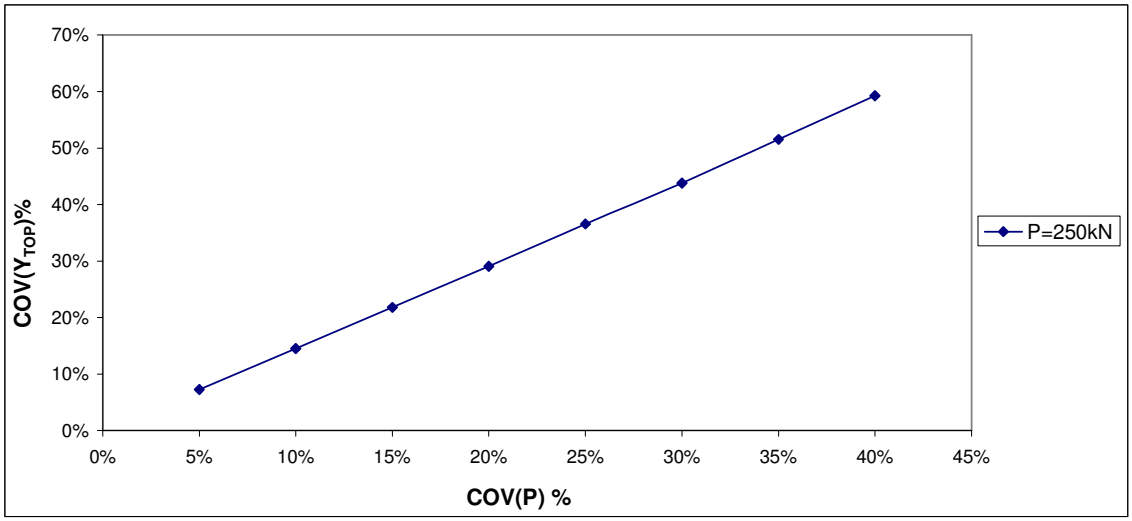


Fig. B.34 Variability of COV (Y_{TOP}) vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.60 Value of COV(Y_{TOP}) for fixed head long pile with varying COV(P) and lateral load 300kN.

P=300kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+02	5.29E-06	7.72%
10%	9.00E+02	2.16E-05	15.60%
15%	2.03E+03	4.83E-05	23.32%
20%	3.60E+03	8.65E-05	31.21%
25%	5.63E+03	1.35E-04	38.93%
30%	8.10E+03	1.95E-04	46.81%
35%	1.10E+04	2.67E-04	54.87%
40%	1.44E+04	3.52E-04	62.92%

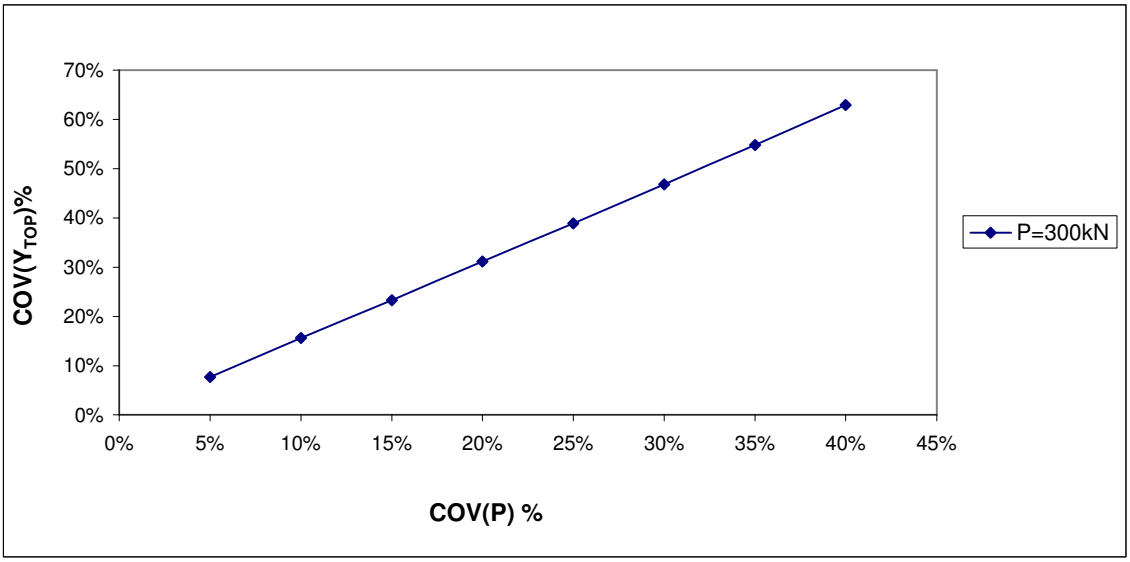


Fig. B.35 Variability of COV (Y_{TOP}) vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 300kN.

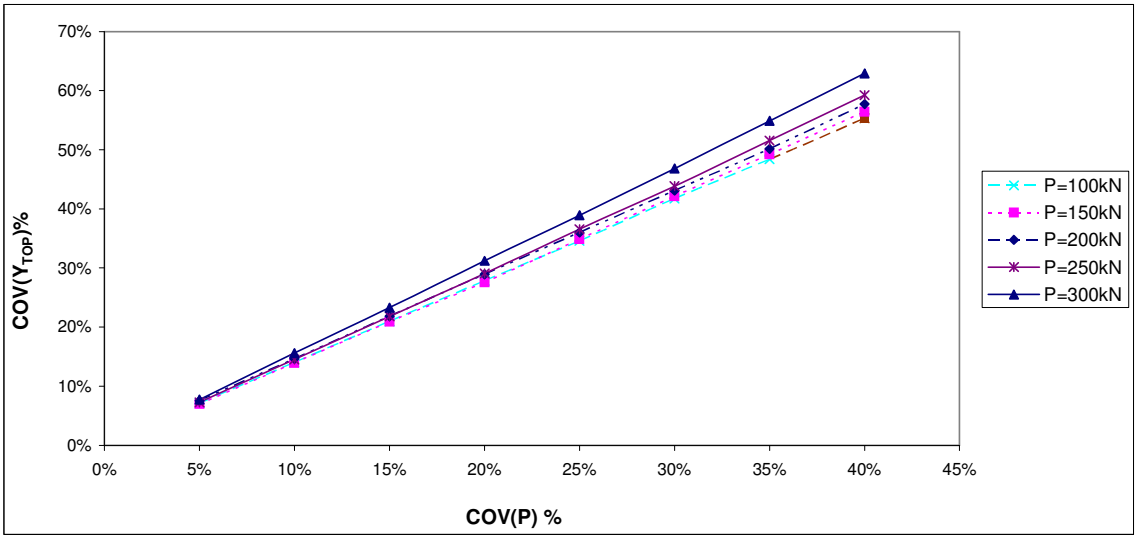


Fig. B.36 Variability of COV(Y_{TOP}) vs. COV(P) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

B-2 Reliability Index (β) of top deflection vs. COV(Variables)

Table B.61 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with Varying 'Φ' subjected to lateral load 100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.84E-08	0.000225	5%	0.0150	6.2513
1.16E-06	0.000225	10%	0.0150	6.2360
2.62E-06	0.000225	15%	0.0151	6.2159
4.93E-06	0.000225	20%	0.0152	6.1846
7.90E-06	0.000225	25%	0.0153	6.1451
1.20E-05	0.000225	30%	0.0154	6.0920
1.70E-05	0.000225	35%	0.0156	6.0282
2.37E-05	0.000225	40%	0.0158	5.9470

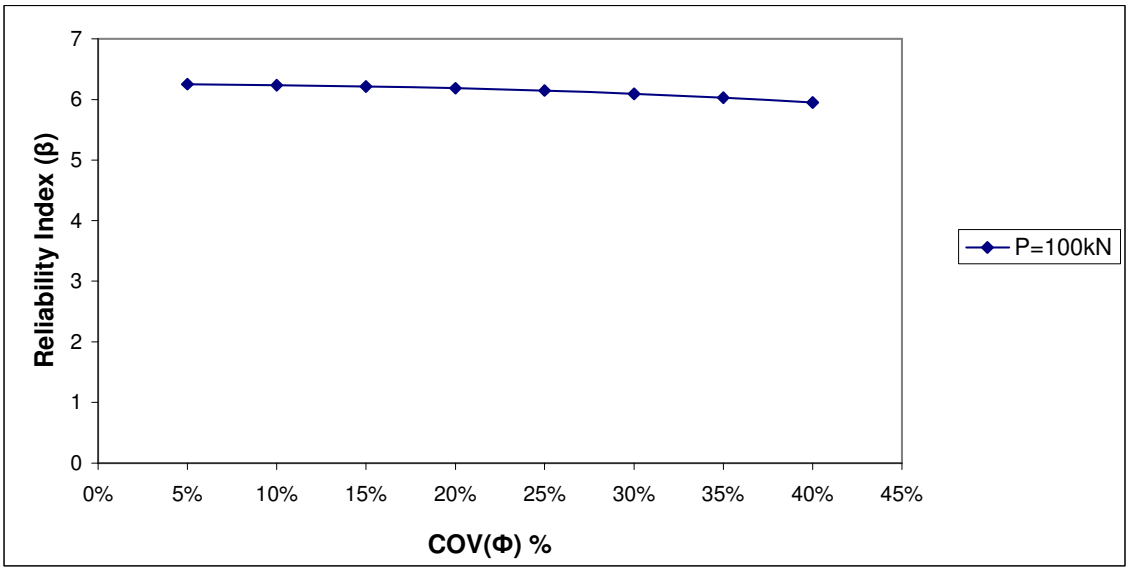


Fig. B.37 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.62 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with Varying 'Φ' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
9.03E-07	0.000225	5%	0.0150	5.9082
3.65E-06	0.000225	10%	0.0151	5.8726
8.32E-06	0.000225	15%	0.0153	5.8135
1.50E-05	0.000225	20%	0.0155	5.7323
2.43E-05	0.000225	25%	0.0158	5.6246
3.65E-05	0.000225	30%	0.0162	5.4915
5.37E-05	0.000225	35%	0.0167	5.3189
7.90E-05	0.000225	40%	0.0174	5.0928

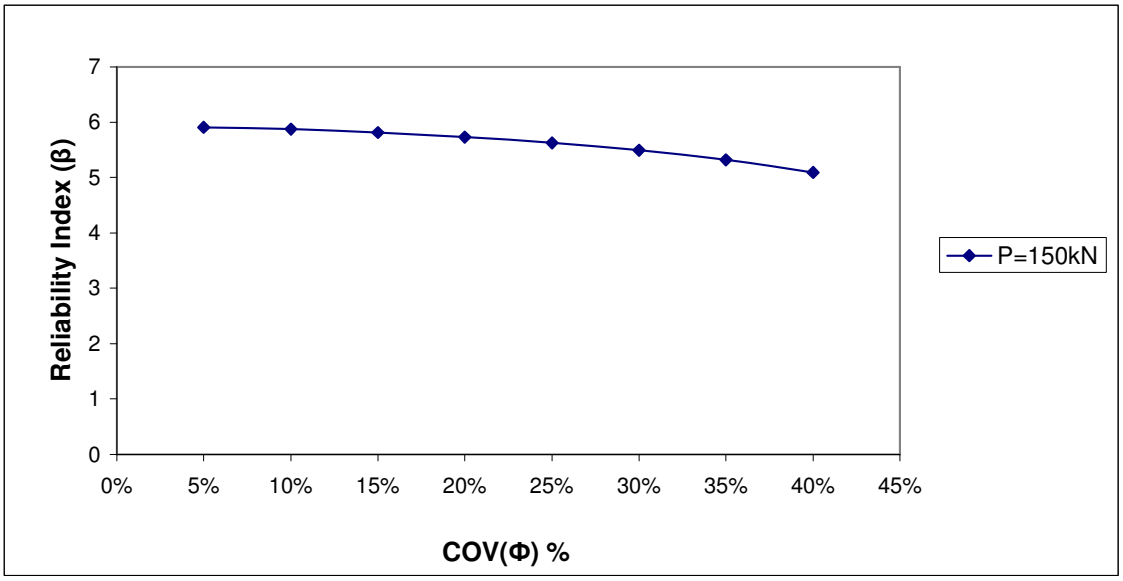


Fig. B.38 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.63 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with Varying 'Φ' subjected to lateral load 200kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.60E-07	0.000225	5%	0.0150	5.5622
7.84E-06	0.000225	10%	0.0153	5.4721
1.85E-05	0.000225	15%	0.0156	5.3511
3.42E-05	0.000225	20%	0.0161	5.1862
5.70E-05	0.000225	25%	0.0168	4.9723
9.03E-05	0.000225	30%	0.0178	4.7028
1.38E-04	0.000225	35%	0.0191	4.3815
2.11E-04	0.000225	40%	0.0209	3.9984

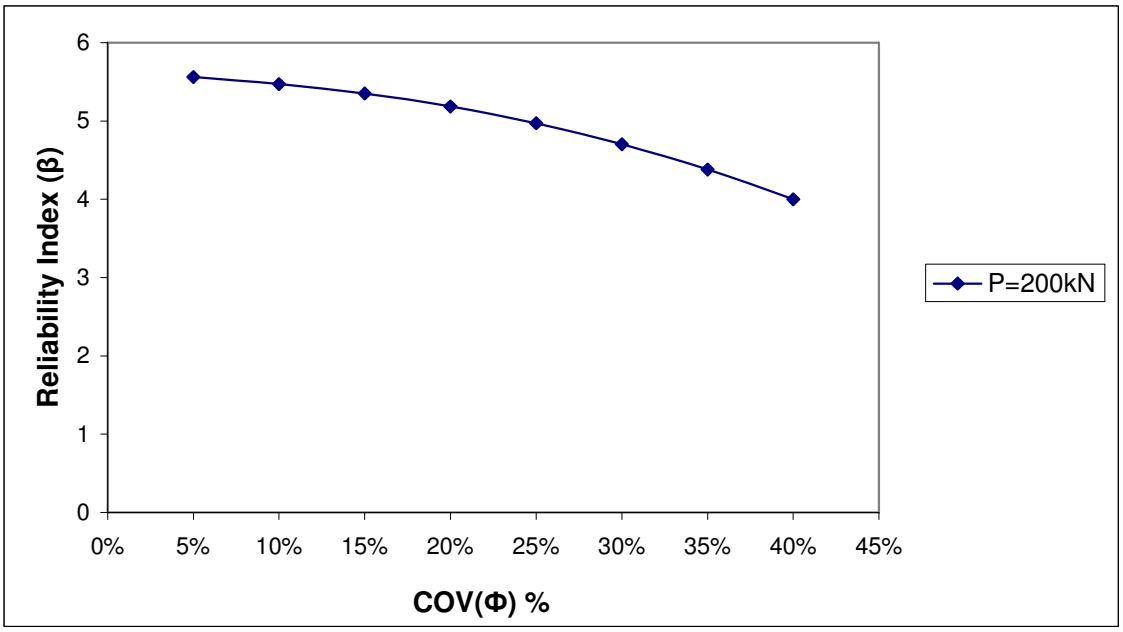


Fig. B.39 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.64 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with Varying 'Φ' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.20E-06	0.000225	5%	0.0151	5.1059
1.60E-05	0.000225	10%	0.0155	4.9793
3.84E-05	0.000225	15%	0.0162	4.7625
7.31E-05	0.000225	20%	0.0173	4.4771
1.23E-04	0.000225	25%	0.0187	4.1425
2.00E-04	0.000225	30%	0.0206	3.7486
3.12E-04	0.000225	35%	0.0232	3.3372
5.02E-04	0.000225	40%	0.0270	2.8674

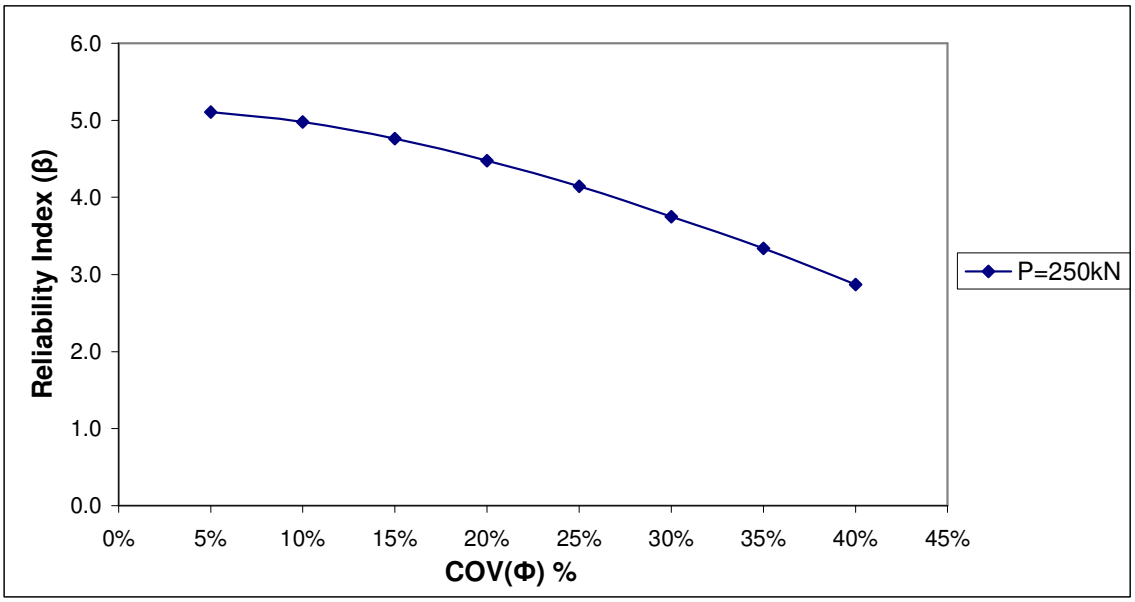


Fig. B.40 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.65 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with Varying 'Φ' subjected to lateral load 300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.44E-06	0.000225	5%	0.0150	4.6651
3.36E-05	0.000225	10%	0.0161	4.3651
7.83E-05	0.000225	15%	0.0174	4.0307
1.49E-04	0.000225	20%	0.0193	3.6307
2.54E-04	0.000225	25%	0.0219	3.2062
4.18E-04	0.000225	30%	0.0254	2.7680
6.76E-04	0.000225	35%	0.0300	2.3387
1.09E-03	0.000225	40%	0.0363	1.9342

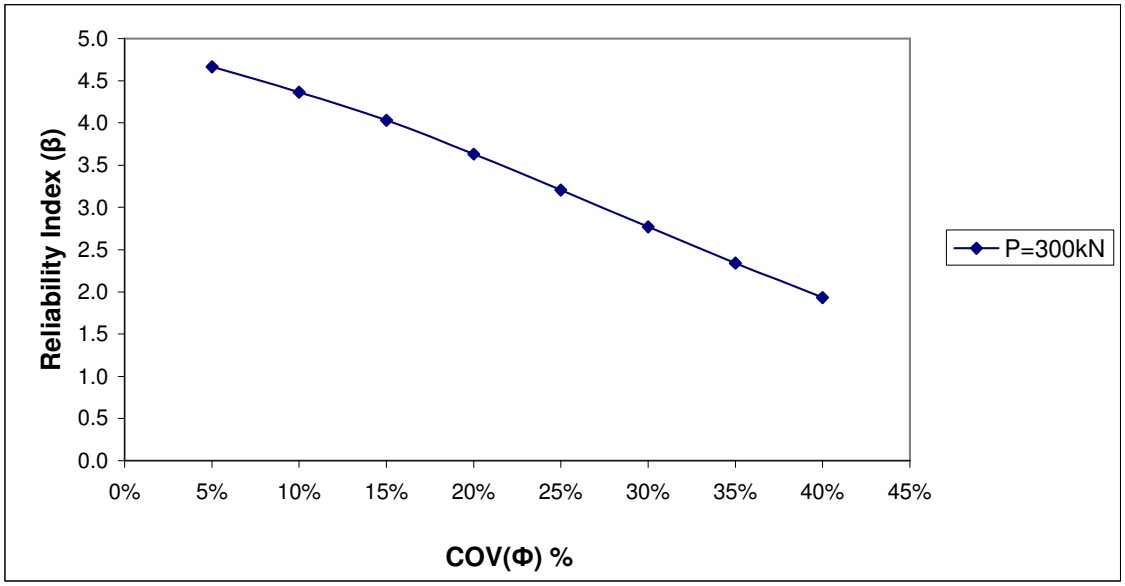


Fig. B.41 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 300kN.

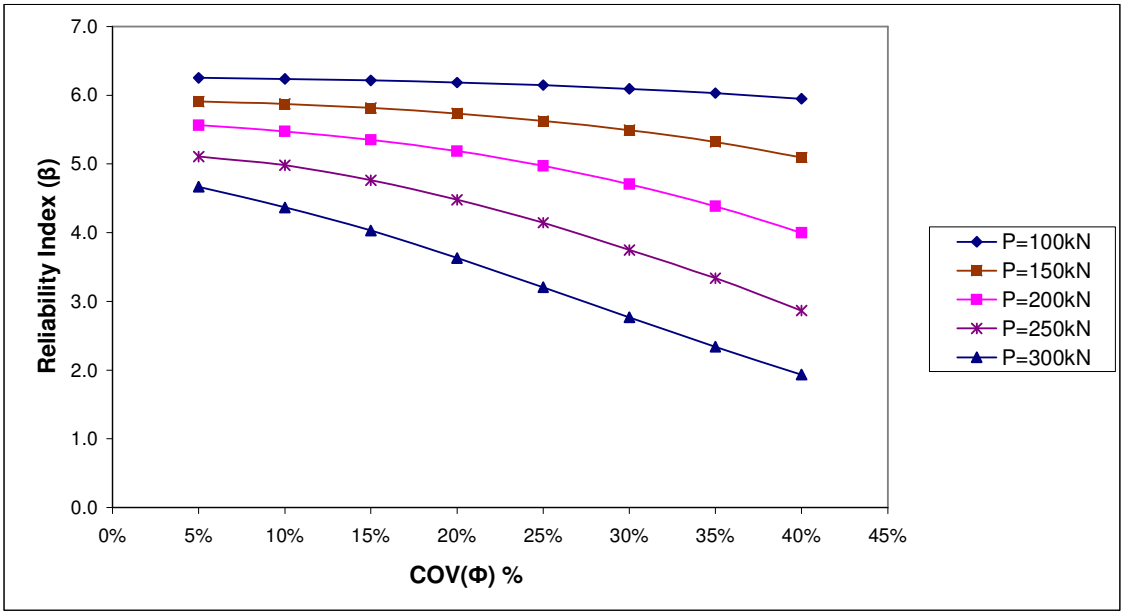


Fig. B.42 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.66 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'γ' subjected to lateral load 100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.60E-07	0.000225	5%	0.0150	6.2498
6.40E-07	0.000225	10%	0.0150	6.2431
1.56E-06	0.000225	15%	0.0151	6.2304
2.66E-06	0.000225	20%	0.0151	6.2154
4.49E-06	0.000225	25%	0.0151	6.1905
6.50E-06	0.000225	30%	0.0152	6.1636
9.46E-06	0.000225	35%	0.0153	6.1246
1.29E-05	0.000225	40%	0.0154	6.0803

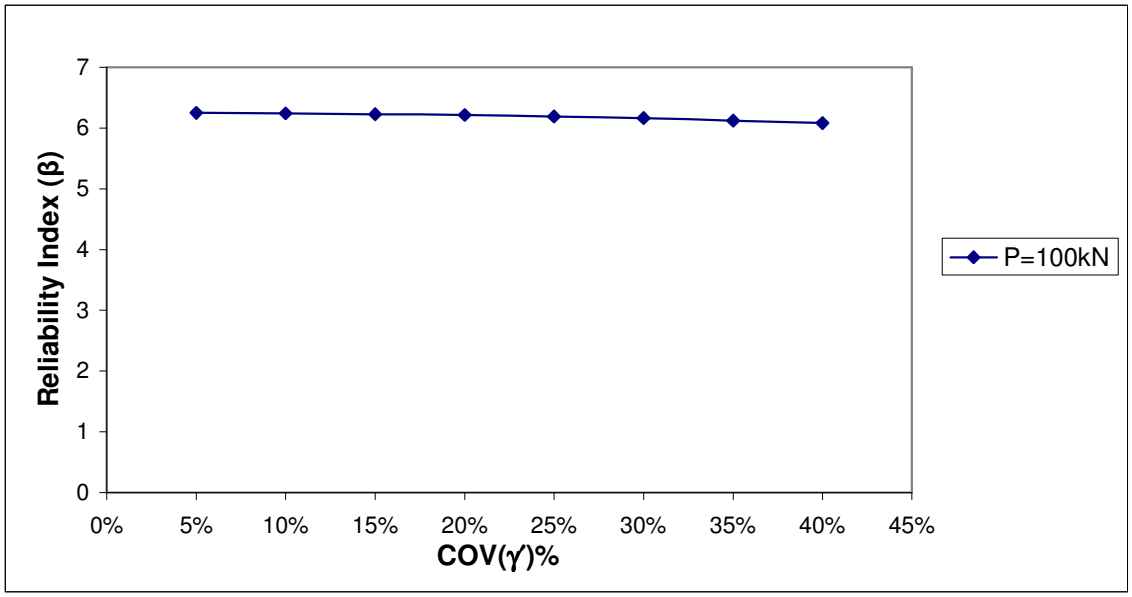


Fig. B.43 Reliability Index (β) of Y_{TOP} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.67 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with

varying 'γ' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.03E-07	0.000225	5%	0.0150	5.9160
1.32E-06	0.000225	10%	0.0150	5.9027
3.06E-06	0.000225	15%	0.0151	5.8801
5.76E-06	0.000225	20%	0.0152	5.8456
9.61E-06	0.000225	25%	0.0153	5.7975
1.44E-05	0.000225	30%	0.0155	5.7387
2.12E-05	0.000225	35%	0.0157	5.6598
2.92E-05	0.000225	40%	0.0159	5.5701

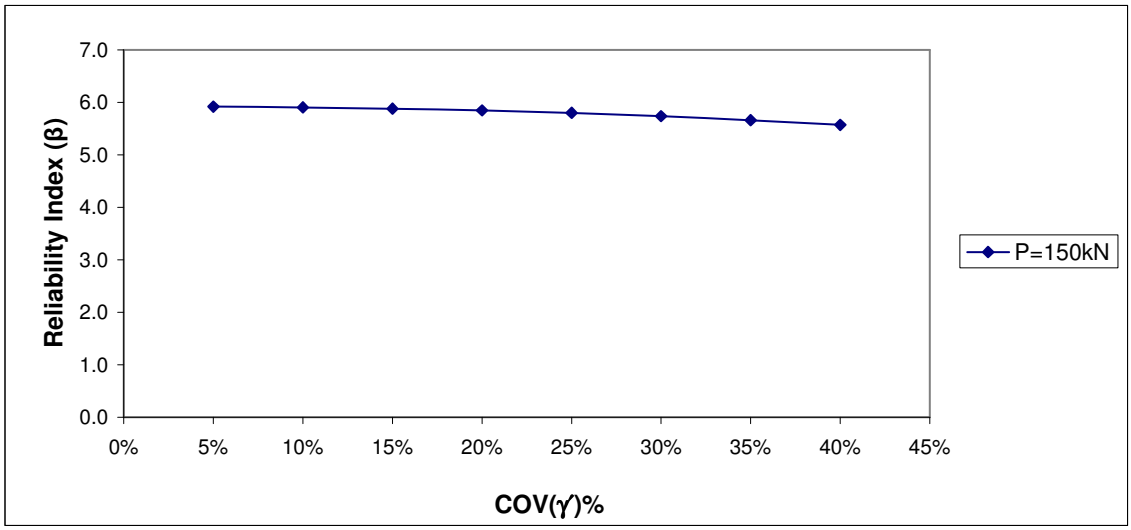


Fig. B.44 Reliability Index (β) of Y_{TOP} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.68 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with

varying 'γ' subjected to lateral load 200kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.00E-08	0.000225	5%	0.0150	5.5659
2.26E-07	0.000225	10%	0.0150	5.5639
4.97E-07	0.000225	15%	0.0150	5.5605
8.93E-07	0.000225	20%	0.0150	5.5557
1.44E-06	0.000225	25%	0.0150	5.5489
2.16E-06	0.000225	30%	0.0151	5.5401
3.17E-06	0.000225	35%	0.0151	5.4300
4.43E-06	0.000225	40%	0.0151	5.2700

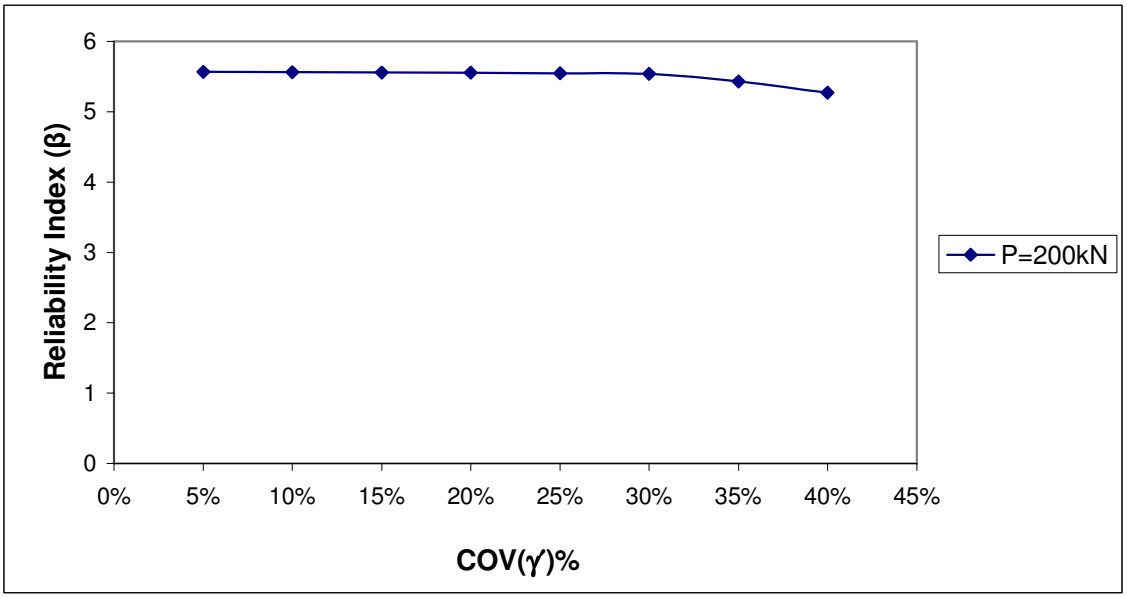


Fig. B.45 Reliability Index (β) of Y_{TOP} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.69 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'γ' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
7.22E-07	0.000225	5%	0.0150	5.1451
2.89E-06	0.000225	10%	0.0151	5.1206
6.76E-06	0.000225	15%	0.0152	5.0776
1.19E-05	0.000225	20%	0.0154	5.0222
1.94E-05	0.000225	25%	0.0156	4.9450
3.03E-05	0.000225	30%	0.0160	4.8383
4.42E-05	0.000225	35%	0.0164	4.7111
6.32E-05	0.000225	40%	0.0170	4.5533

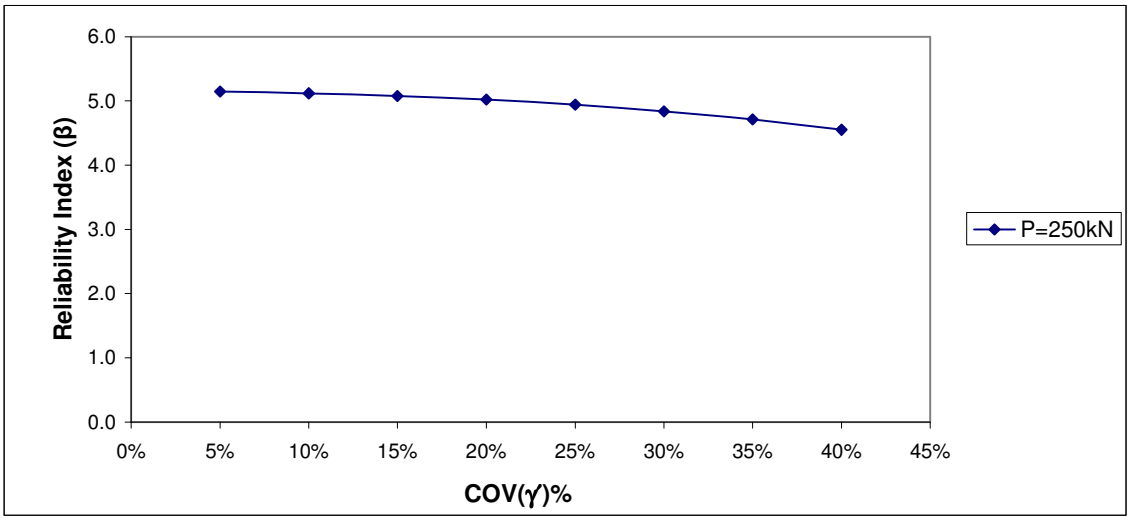


Fig. B.46 Reliability Index (β) of Y_{TOP} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.70 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'γ' subjected to lateral load 300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.44E-06	0.000225	5%	0.0150	4.6651
5.76E-06	0.000225	10%	0.0152	4.6212
1.30E-05	0.000225	15%	0.0154	4.5508
2.45E-05	0.000225	20%	0.0158	4.4443
4.03E-05	0.000225	25%	0.0163	4.3097
6.08E-05	0.000225	30%	0.0169	4.1522
8.93E-05	0.000225	35%	0.0177	3.9597
1.28E-04	0.000225	40%	0.0188	3.7380

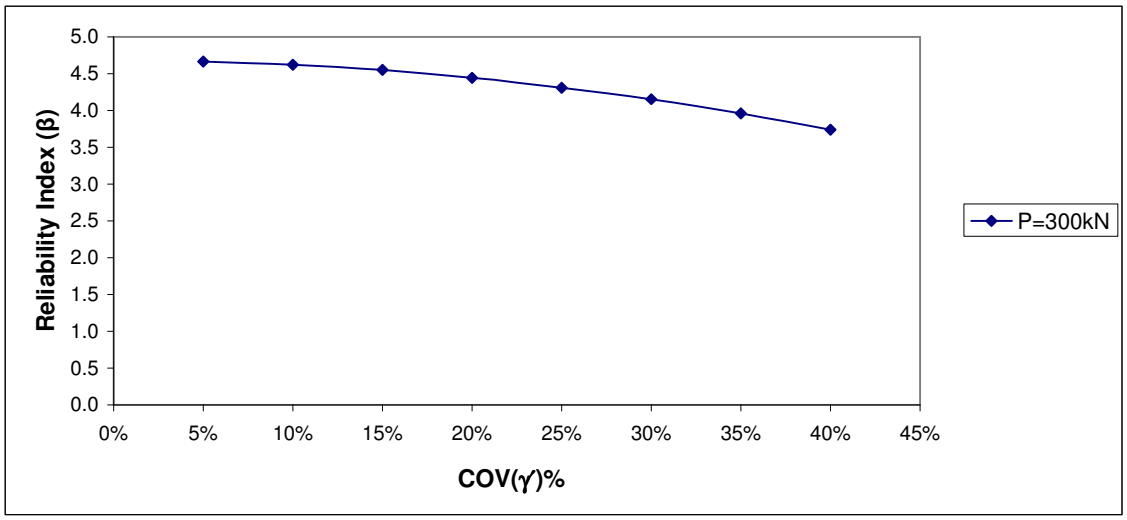


Fig. B.47 Reliability Index (β) of Y_{TOP} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 300kN.

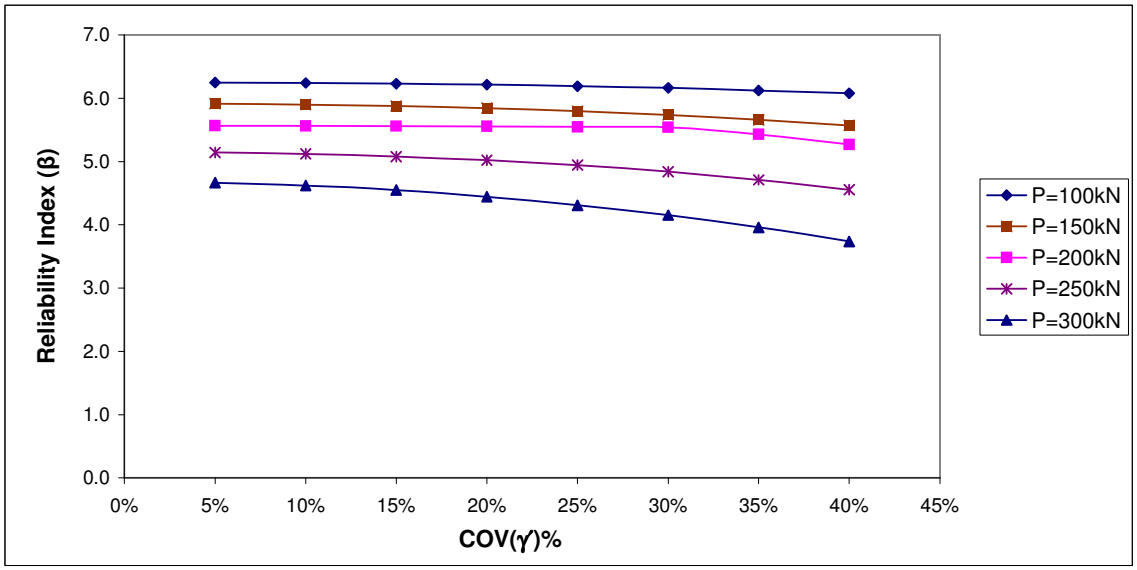


Fig. B.48 Reliability Index (β) of Y_{TOP} vs. COV (γ') for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.71 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'k' subjected to lateral load 100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.25E-10	0.000225	5%	0.0150	6.2520
6.56E-10	0.000225	10%	0.0150	6.2520
2.50E-09	0.000225	15%	0.0150	6.2520
6.40E-09	0.000225	20%	0.0150	6.2519
1.21E-08	0.000225	25%	0.0150	6.2518
1.96E-08	0.000225	30%	0.0150	6.2517
3.06E-08	0.000225	35%	0.0150	6.2516
5.06E-08	0.000225	40%	0.0150	6.2513

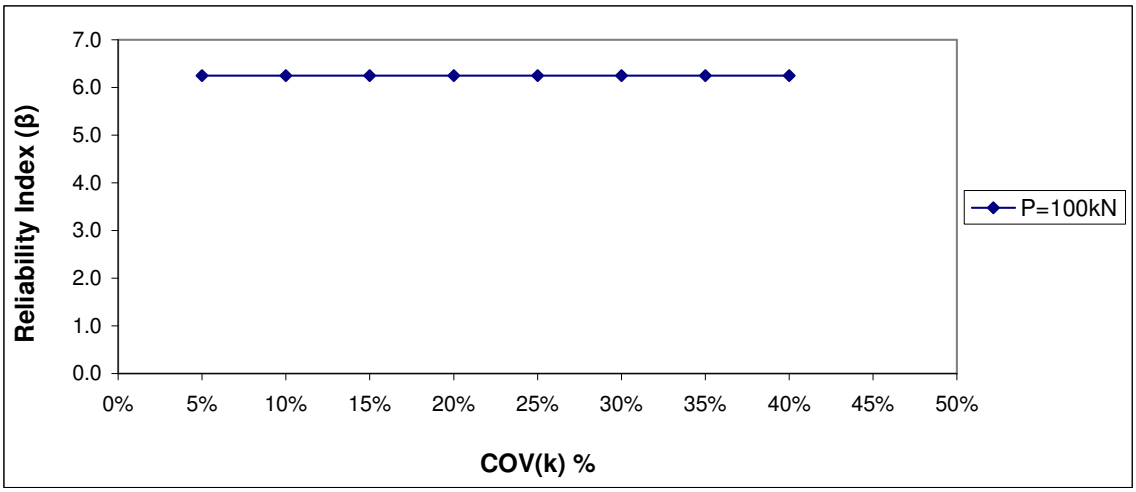


Fig. B.49 Reliability Index (β) of Y_{TOP} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.72 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'k' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.50E-09	0.000225	5%	0.0150	5.9200
2.63E-09	0.000225	10%	0.0150	5.9200
1.00E-08	0.000225	15%	0.0150	5.9199
1.70E-09	0.000225	20%	0.0150	5.9200
2.25E-08	0.000225	25%	0.0150	5.9197
2.43E-08	0.000225	30%	0.0150	5.9197
4.00E-08	0.000225	35%	0.0150	5.9195
6.25E-08	0.000225	40%	0.0150	5.9192

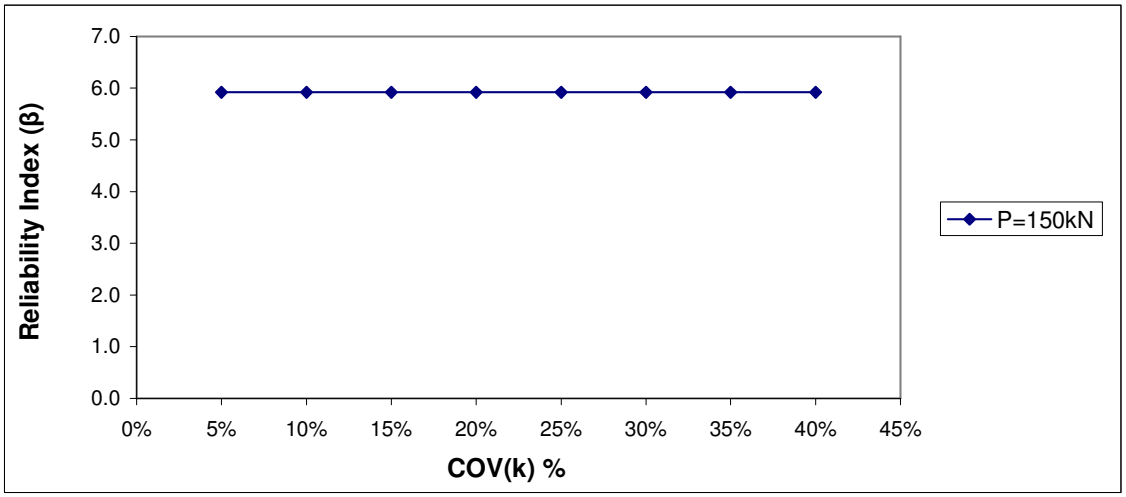


Fig. B.50 Reliability Index (β) of Y_{TOP} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.73 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'k' subjected to lateral load 200kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.33E-09	0.000225	5%	0.0150	5.5666
2.47E-09	0.000225	10%	0.0150	5.5666
2.54E-09	0.000225	15%	0.0150	5.5666
1.00E-08	0.000225	20%	0.0150	5.5665
2.25E-08	0.000225	25%	0.0150	5.5664
4.00E-08	0.000225	30%	0.0150	5.5662
4.30E-08	0.000225	35%	0.0150	5.5661
6.25E-08	0.000225	40%	0.0150	5.5659

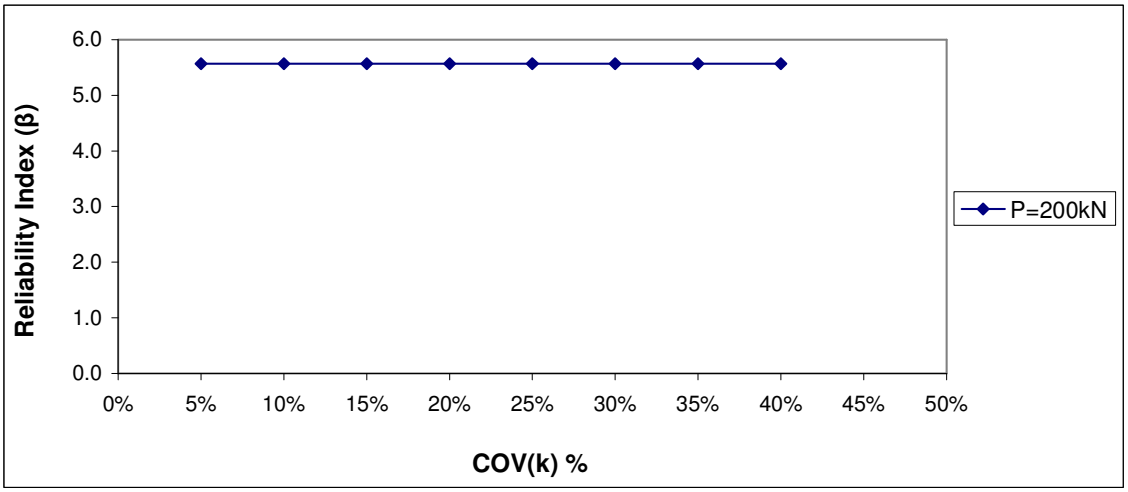


Fig. B.51 Reliability Index (β) of Y_{TOP} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.74 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'k' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.50E-09	0.000225	5%	0.0150	5.1533
2.53E-09	0.000225	10%	0.0150	5.1533
2.57E-09	0.000225	15%	0.0150	5.1533
2.25E-08	0.000225	20%	0.0150	5.1531
2.46E-08	0.000225	25%	0.0150	5.1531
4.00E-08	0.000225	30%	0.0150	5.1529
6.25E-08	0.000225	35%	0.0150	5.1526
9.00E-08	0.000225	40%	0.0150	5.1523

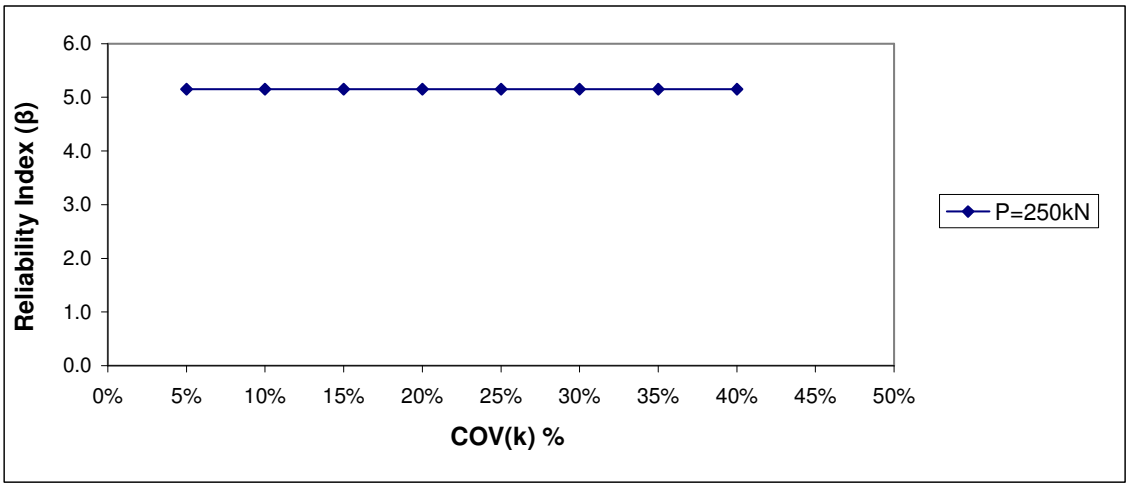


Fig. B.52 Reliability Index (β) of Y_{TOP} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.75 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'k' subjected to lateral load 300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.30E-09	0.000225	5%	0.0150	4.6800
2.43E-09	0.000225	10%	0.0150	4.6800
2.50E-09	0.000225	15%	0.0150	4.6800
1.00E-08	0.000225	20%	0.0150	4.6799
4.00E-08	0.000225	25%	0.0150	4.6798
4.10E-08	0.000225	30%	0.0150	4.6796
6.25E-08	0.000225	35%	0.0150	4.6796
1.23E-07	0.000225	40%	0.0150	4.6795

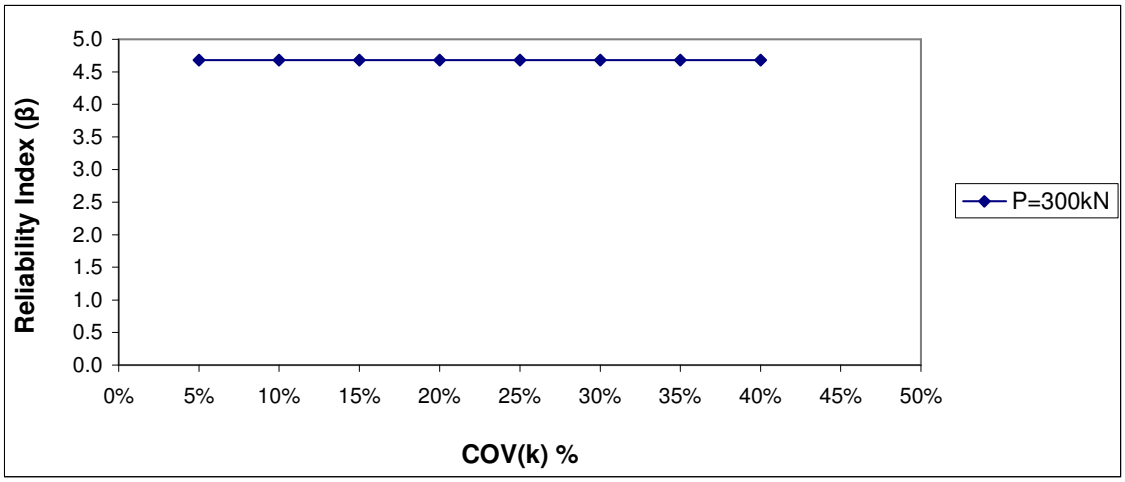


Fig. B.53 Reliability Index (β) of Y_{TOP} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 300kN.

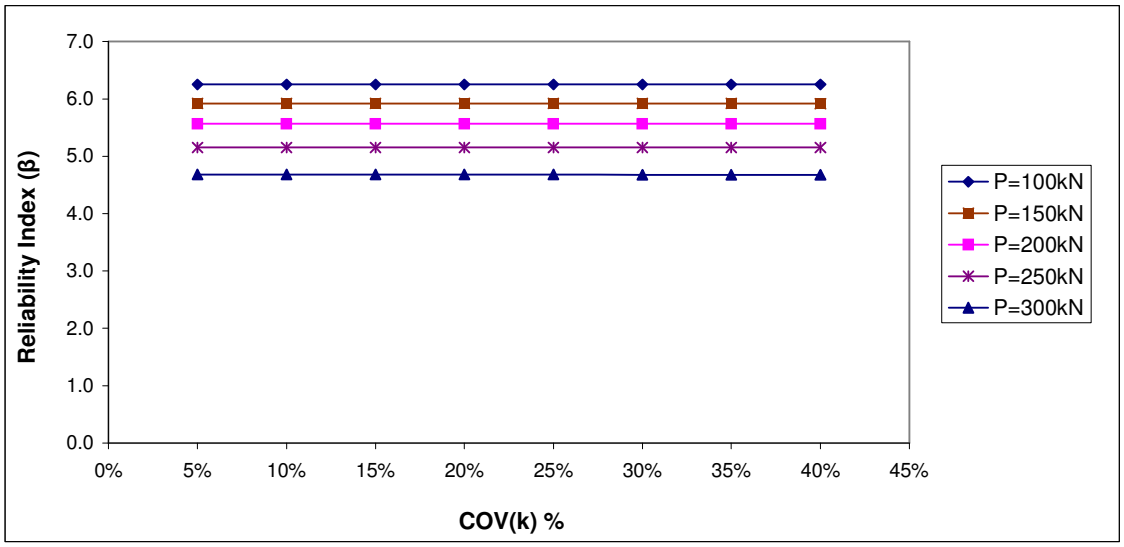


Fig. B.54 Reliability Index (β) of Y_{TOP} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.76 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'B' subjected to lateral load 100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.50E-09	0.000225	5%	0.0150	6.2520
2.50E-09	0.000225	10%	0.0150	6.2520
2.50E-09	0.000225	15%	0.0150	6.2520
2.50E-09	0.000225	20%	0.0150	6.2520
1.00E-08	0.000225	25%	0.0150	6.2519
1.00E-08	0.000225	30%	0.0150	6.2519
2.28E-08	0.000225	35%	0.0150	6.2517
2.25E-08	0.000225	40%	0.0150	6.2517

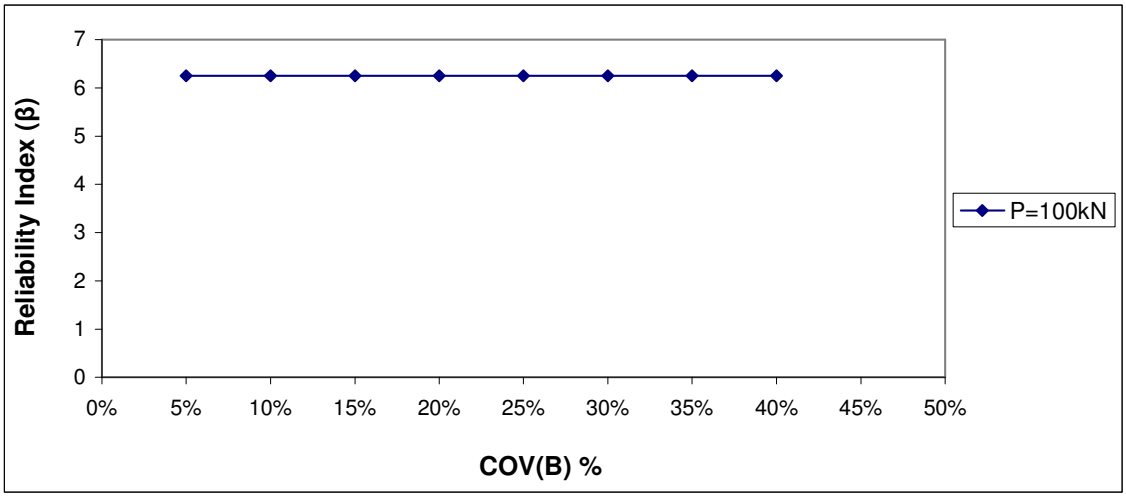


Fig. B.55 Reliability Index (β) of Y_{TOP} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.77 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'B' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.00E-08	0.000225	5%	0.0150	5.9199
1.56E-08	0.000225	10%	0.0150	5.9198
6.25E-08	0.000225	15%	0.0150	5.9192
6.27E-08	0.000225	20%	0.0150	5.9192
2.02E-07	0.000225	25%	0.0150	5.9173
2.03E-07	0.000225	30%	0.0150	5.9173
2.05E-07	0.000225	35%	0.0150	5.9173
3.03E-07	0.000225	40%	0.0150	5.9160

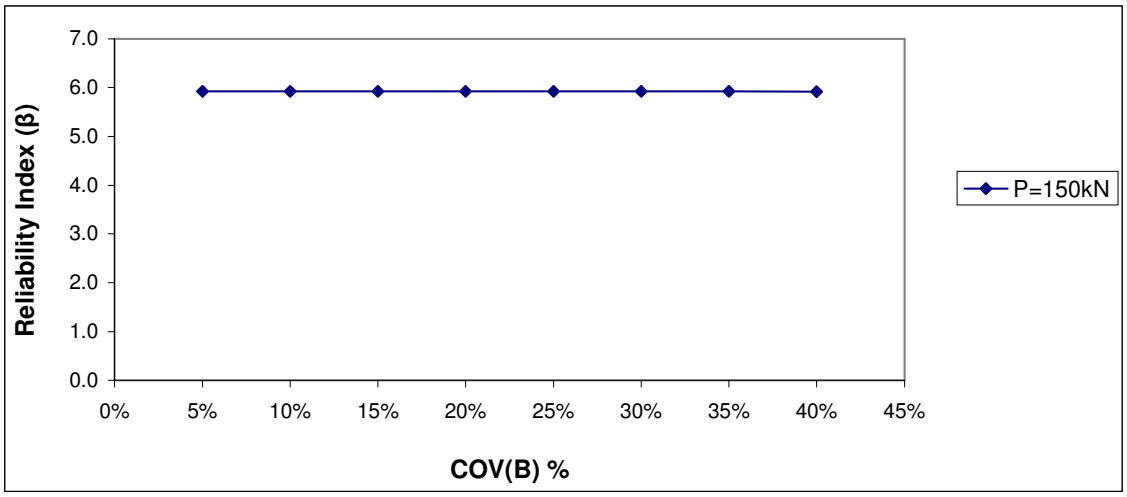


Fig. B.56 Reliability Index (β) of Y_{TOP} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.78 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'B' subjected to lateral load 200kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.25E-08	0.000225	5%	0.0150	5.5665
2.25E-08	0.000225	10%	0.0150	5.5664
6.25E-08	0.000225	15%	0.0150	5.5659
9.00E-08	0.000225	20%	0.0150	5.5656
1.23E-07	0.000225	25%	0.0150	5.5652
1.60E-07	0.000225	30%	0.0150	5.5647
2.05E-07	0.000225	35%	0.0150	5.5641
2.50E-07	0.000225	40%	0.0150	5.5636

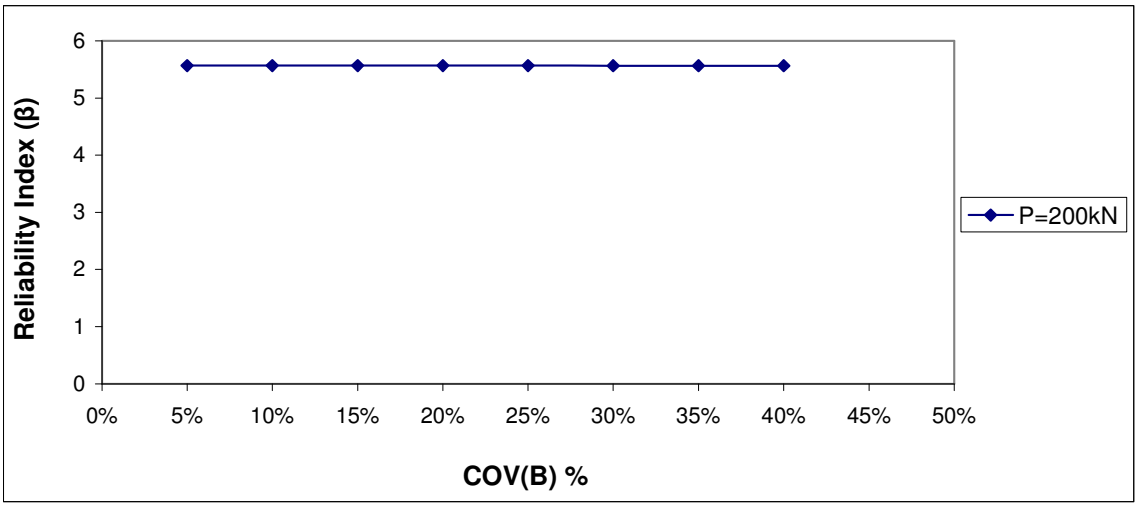


Fig. B.57 Reliability Index (β) of Y_{TOP} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.79 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'B' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.50E-09	0.000225	5%	0.0150	5.1533
2.25E-08	0.000225	10%	0.0150	5.1531
6.25E-08	0.000225	15%	0.0150	5.1526
2.03E-07	0.000225	20%	0.0150	5.1510
4.90E-07	0.000225	25%	0.0150	5.1477
6.40E-07	0.000225	30%	0.0150	5.1460
8.20E-07	0.000225	35%	0.0150	5.1440
9.02E-07	0.000225	40%	0.0150	5.1430

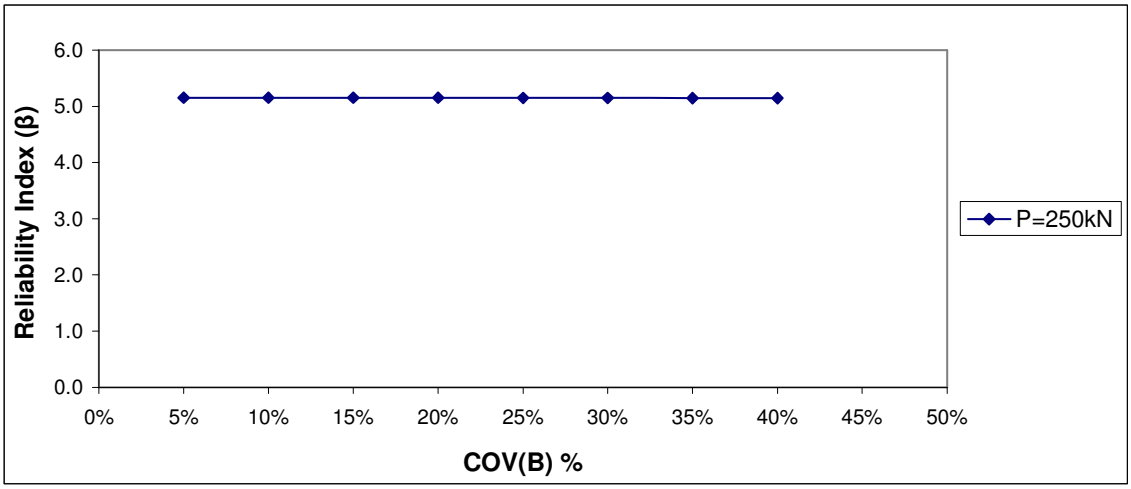


Fig. B.58 Reliability Index (β) of Y_{TOP} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.80 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'B' subjected to lateral load 300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.23E-09	0.000225	5%	0.0150	4.6800
3.60E-09	0.000225	10%	0.0150	4.6800
8.10E-09	0.000225	15%	0.0150	4.6799
1.69E-08	0.000225	20%	0.0150	4.6798
2.56E-08	0.000225	25%	0.0150	4.6797
3.61E-08	0.000225	30%	0.0150	4.6796
4.90E-08	0.000225	35%	0.0150	4.6795
5.76E-08	0.000225	40%	0.0150	4.6794

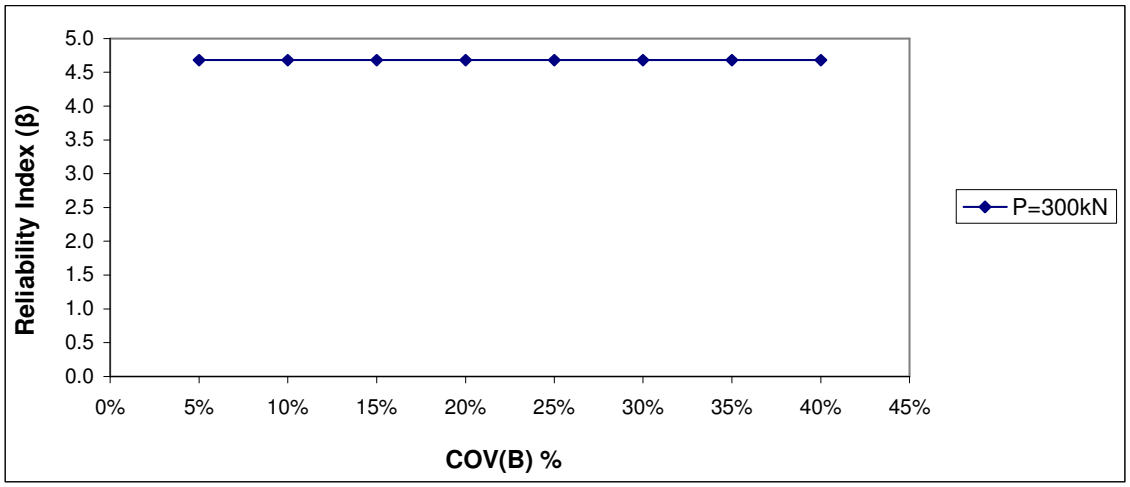


Fig. B.59 Reliability Index (β) of Y_{TOP} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 300kN.

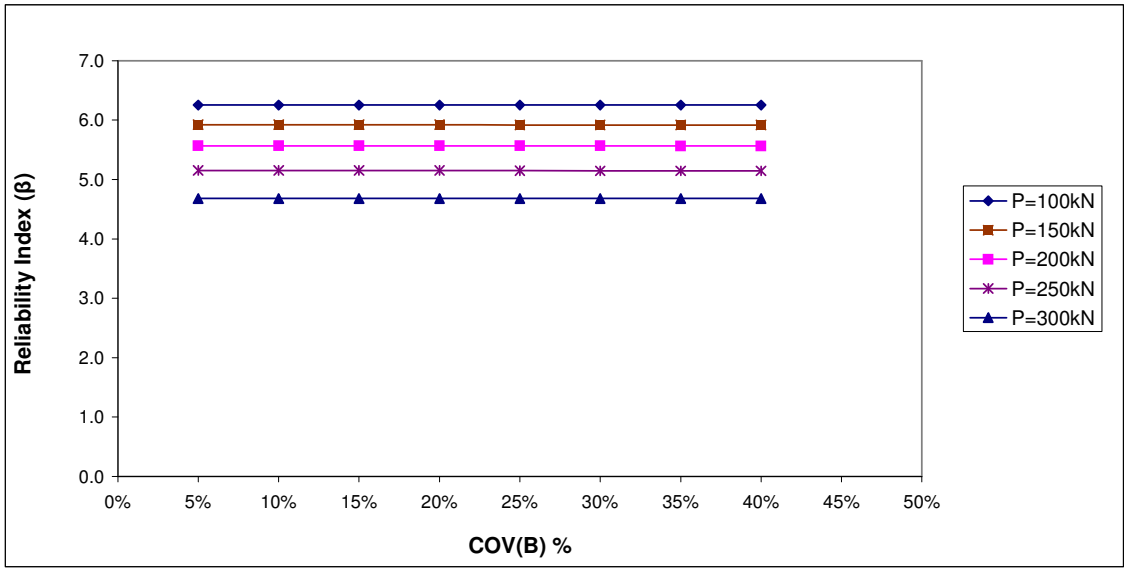


Fig. B.60 Reliability Index (β) of Y_{TOP} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.81 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'EI' subjected to lateral load 100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.00E-08	0.000225	5%	0.0150	6.2519
4.41E-08	0.000225	10%	0.0150	6.2514
3.00E-07	0.000225	15%	0.0150	6.2478
1.41E-06	0.000225	20%	0.0150	6.2325
7.77E-07	0.000225	25%	0.0150	6.2280
2.12E-06	0.000225	30%	0.0151	6.2228
2.66E-06	0.000225	35%	0.0151	6.2153
3.17E-06	0.000225	40%	0.0151	6.2084

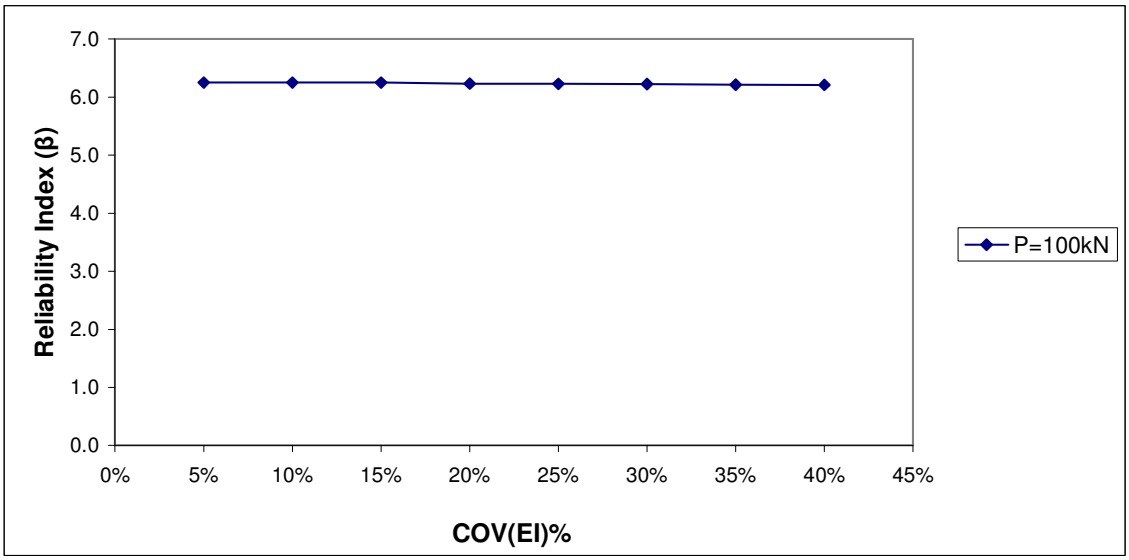


Fig. B.61 Reliability Index (β) of Y_{TOP} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.82 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'EI' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.00E-08	0.000225	5%	0.0150	5.9195
1.41E-07	0.000225	10%	0.0150	5.9182
9.56E-07	0.000225	15%	0.0150	5.9075
4.56E-06	0.000225	20%	0.0152	5.9000
2.46E-06	0.000225	25%	0.0151	5.8600
6.84E-06	0.000225	30%	0.0152	5.8320
8.48E-06	0.000225	35%	0.0153	5.8115
1.03E-05	0.000225	40%	0.0153	5.7893

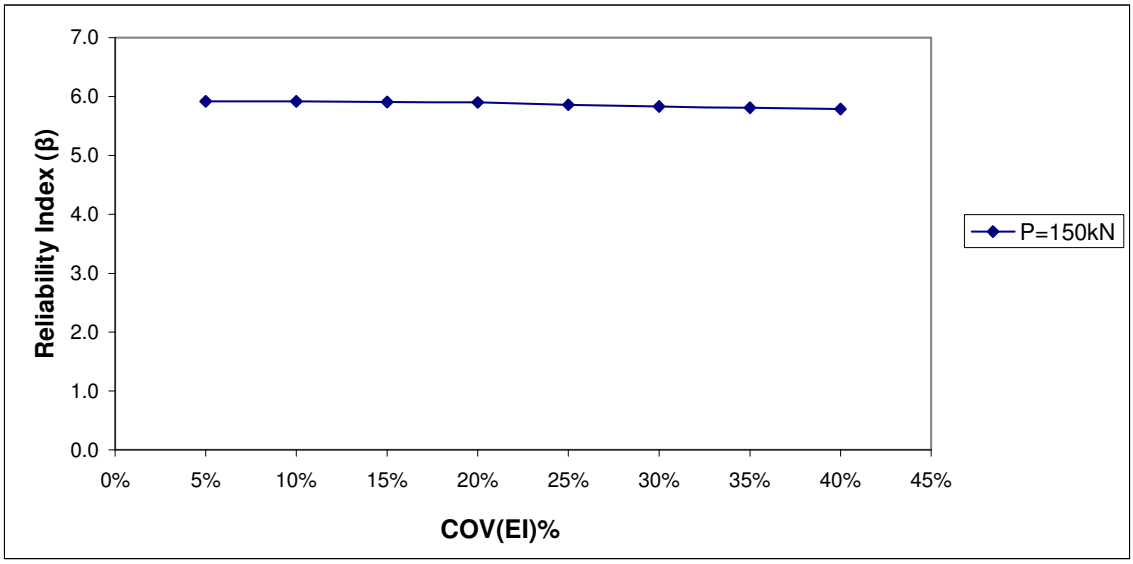


Fig. B.62 Reliability Index (β) of Y_{TOP} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.83 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'EI' subjected to lateral load 200kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
7.56E-08	0.000225	5%	0.0150	5.5657
2.76E-07	0.000225	10%	0.0150	5.5633
2.10E-06	0.000225	15%	0.0151	5.5408
1.06E-05	0.000225	20%	0.0153	5.4404
5.79E-06	0.000225	25%	0.0152	5.4000
1.62E-05	0.000225	30%	0.0155	5.3765
2.02E-05	0.000225	35%	0.0157	5.3320
2.50E-05	0.000225	40%	0.0158	5.2810

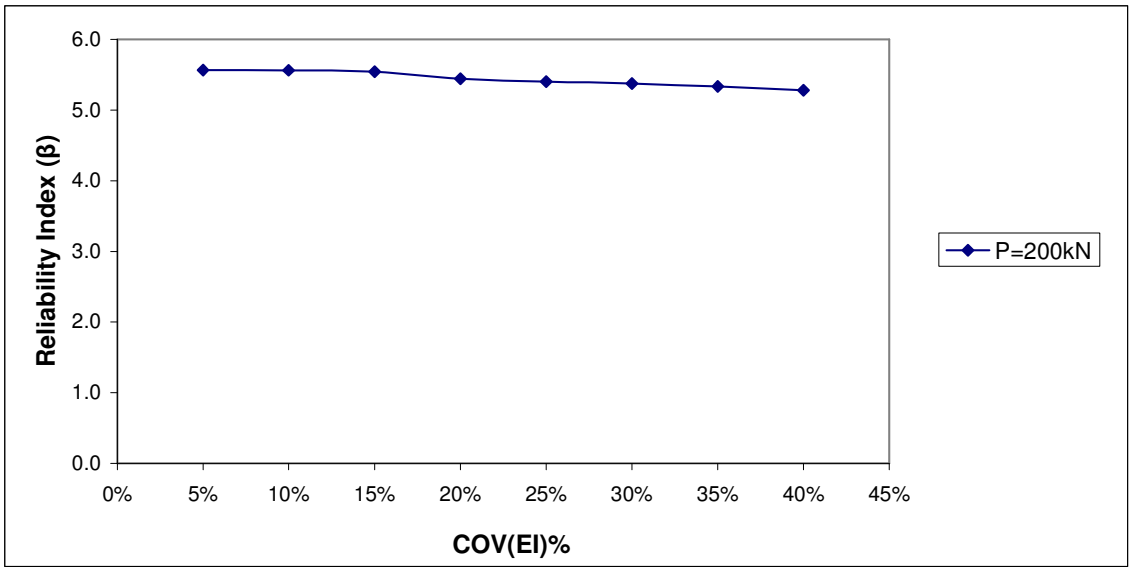


Fig. B.63 Reliability Index (β) of Y_{TOP} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.84 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'EI' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.41E-07	0.000225	5%	0.0150	5.1517
6.01E-07	0.000225	10%	0.0150	5.1465
4.20E-06	0.000225	15%	0.0151	5.1058
2.30E-05	0.000225	20%	0.0157	4.9600
1.27E-05	0.000225	25%	0.0154	4.8600
3.60E-05	0.000225	30%	0.0162	4.7847
4.45E-05	0.000225	35%	0.0164	4.7084
5.55E-05	0.000225	40%	0.0167	4.6154

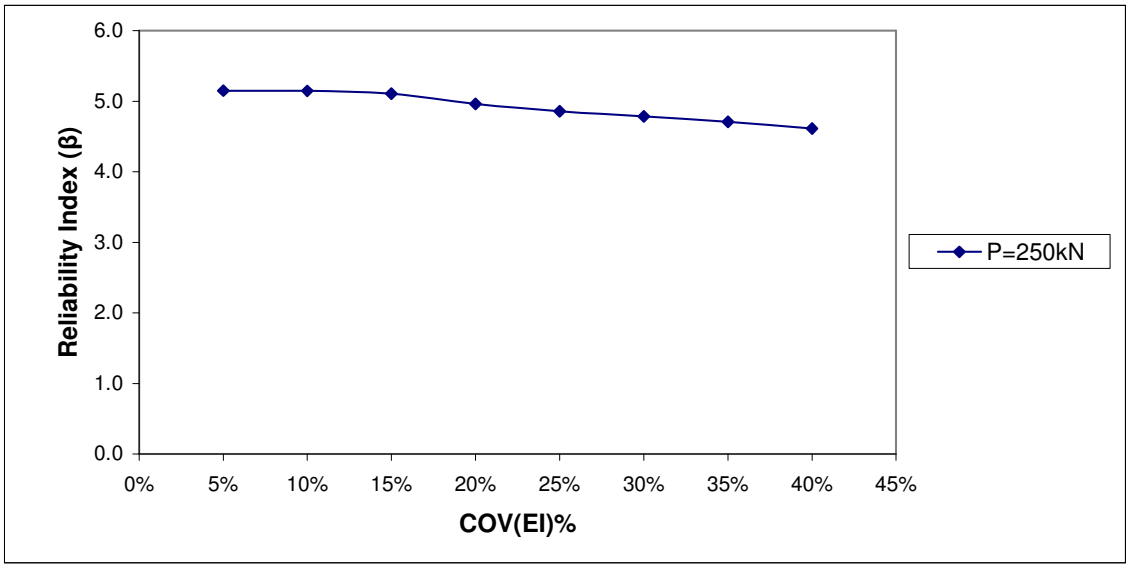


Fig. B.64 Reliability Index (β) of Y_{TOP} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.85 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'EI' subjected to lateral load 300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.03E-07	0.000225	5%	0.0150	4.6769
1.27E-06	0.000225	10%	0.0150	4.6669
8.56E-06	0.000225	15%	0.0153	4.5934
4.66E-05	0.000225	20%	0.0165	4.4400
2.56E-05	0.000225	25%	0.0158	4.2700
7.27E-05	0.000225	30%	0.0173	4.0800
9.07E-05	0.000225	35%	0.0178	3.9510
1.13E-04	0.000225	40%	0.0184	3.8190

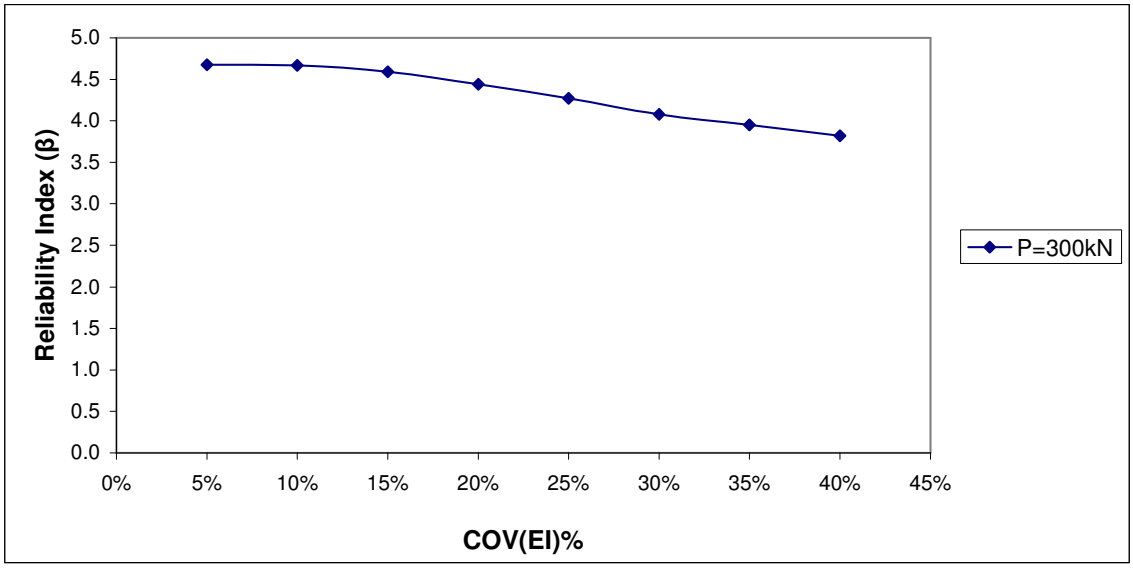


Fig. B.65 Reliability Index (β) of Y_{TOP} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 300kN.

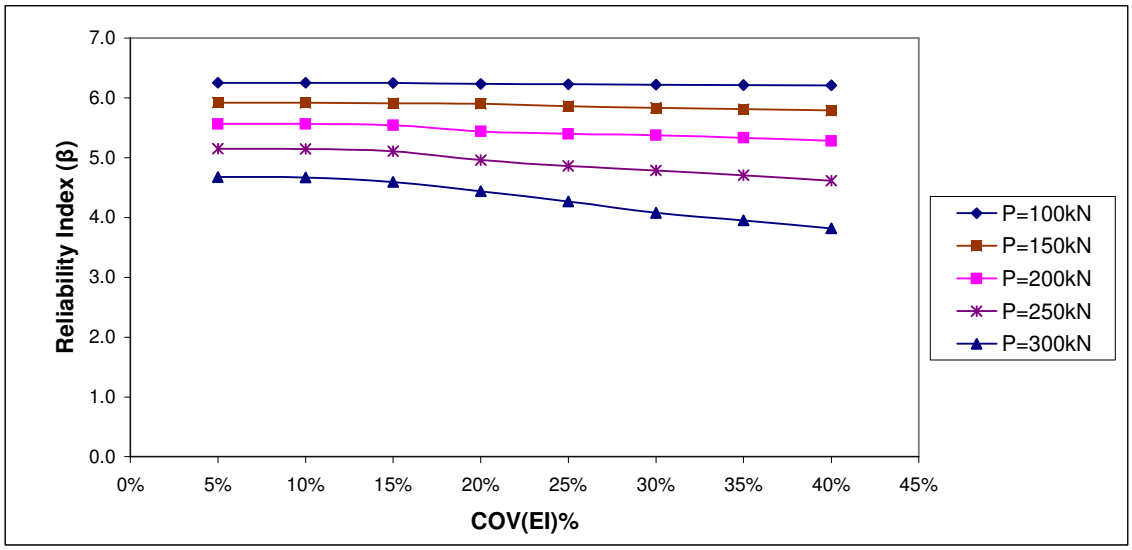


Fig.B.66 Reliability Index (β) of Y_{TOP} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.86 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'P' subjected to lateral load 100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.40E-07	0.000225	5%	0.0150	6.2431
2.48E-06	0.000225	10%	0.0151	6.2178
5.52E-06	0.000225	15%	0.0152	6.1767
9.73E-06	0.000225	20%	0.0153	6.1210
1.50E-05	0.000225	25%	0.0155	6.0533
2.19E-05	0.000225	30%	0.0157	5.9688
2.94E-05	0.000225	35%	0.0159	5.8799
3.84E-05	0.000225	40%	0.0162	5.7786

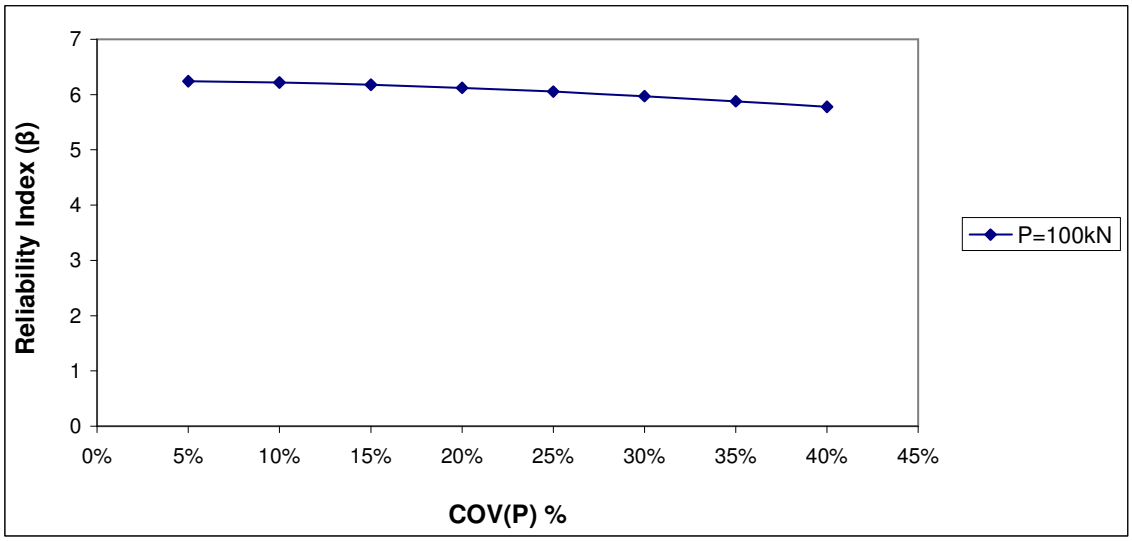


Fig. B.67 Reliability Index (β) of Y_{TOP} vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.87 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'P' subjected to lateral load 150kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.32E-06	0.000225	5%	0.0150	5.9027
5.29E-06	0.000225	10%	0.0152	5.8516
1.19E-05	0.000225	15%	0.0154	5.7694
2.07E-05	0.000225	20%	0.0157	5.6651
3.31E-05	0.000225	25%	0.0161	5.5278
4.83E-05	0.000225	30%	0.0165	5.3714
6.59E-05	0.000225	35%	0.0171	5.2061
8.67E-05	0.000225	40%	0.0177	5.0299

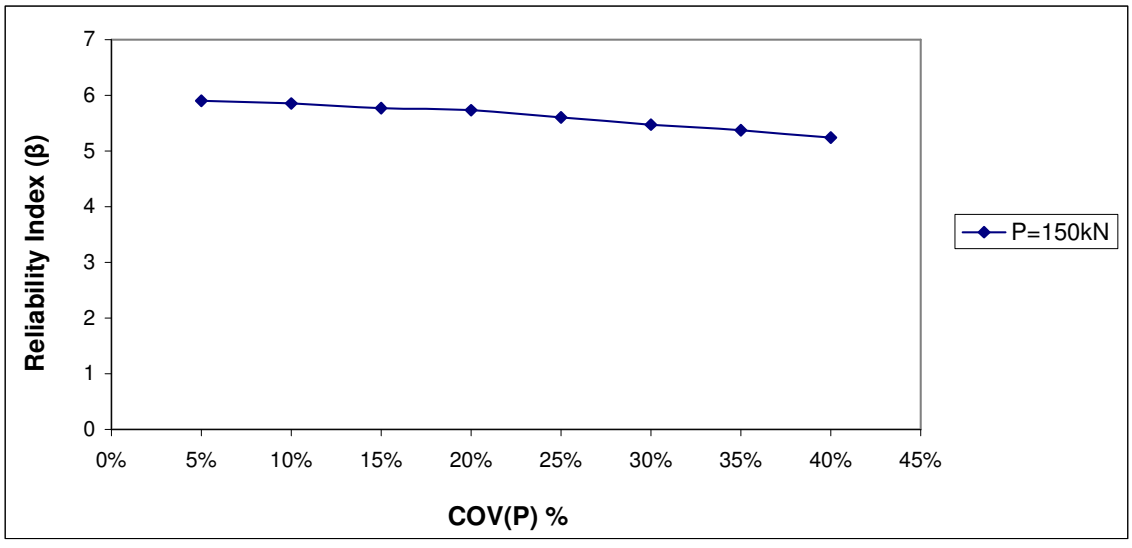


Fig. B.68 Reliability Index (β) of Y_{TOP} vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.88 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'P' subjected to lateral load 200kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.21E-07	0.000225	5%	0.0150	5.5639
8.28E-07	0.000225	10%	0.0150	5.5565
1.85E-06	0.000225	15%	0.0151	5.4700
3.24E-06	0.000225	20%	0.0151	5.3700
5.02E-06	0.000225	25%	0.0152	5.2000
7.18E-06	0.000225	30%	0.0152	4.9800
9.73E-06	0.000225	35%	0.0153	4.8200
1.29E-05	0.000225	40%	0.0154	4.6000

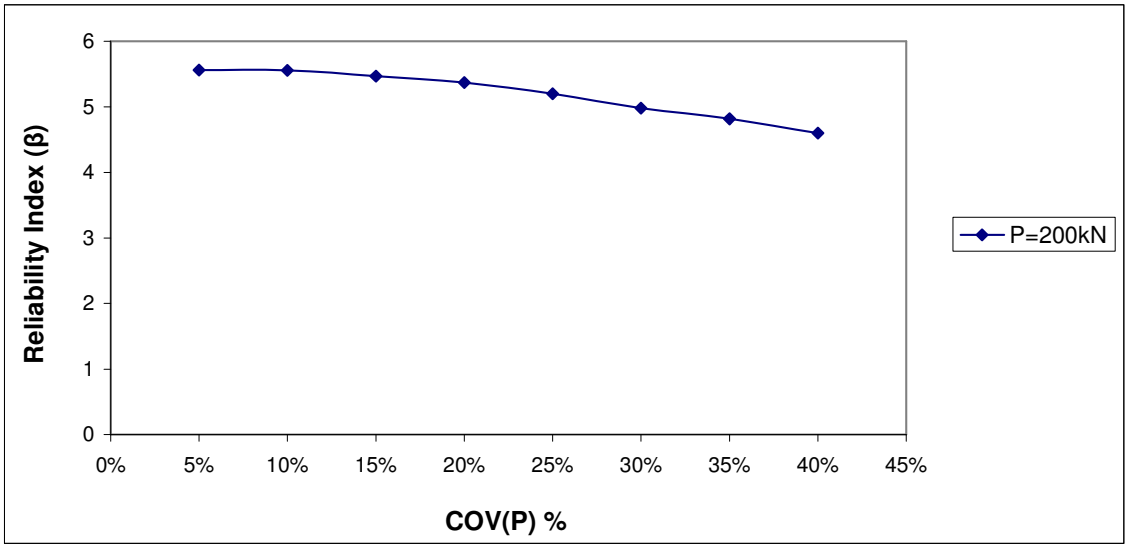


Fig. B.69 Reliability Index (β) of Y_{TOP} vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.89 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'P' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.72E-06	0.000225	5%	0.0151	5.1224
1.09E-05	0.000225	10%	0.0154	5.0330
2.45E-05	0.000225	15%	0.0158	4.8938
4.36E-05	0.000225	20%	0.0164	4.7169
6.89E-05	0.000225	25%	0.0171	4.5091
9.90E-05	0.000225	30%	0.0180	4.2944
1.37E-04	0.000225	35%	0.0190	4.0634
1.81E-04	0.000225	40%	0.0201	3.8368

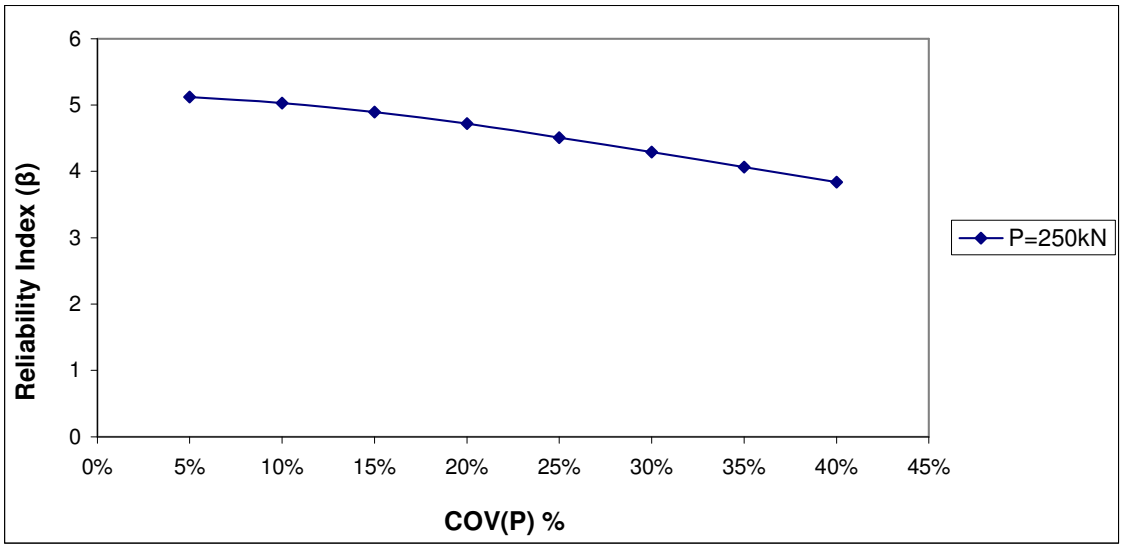


Fig. B.70 Reliability Index (β) of Y_{TOP} vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.90 Reliability Index (β) connected to Y_{TOP} for fixed head single long (10T) pile with varying 'P' subjected to lateral load 300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.29E-06	0.000225	5%	0.0152	4.6259
2.16E-05	0.000225	10%	0.0157	4.4701
4.83E-05	0.000225	15%	0.0165	4.2463
8.65E-05	0.000225	20%	0.0176	3.9775
1.35E-04	0.000225	25%	0.0190	3.7021
1.95E-04	0.000225	30%	0.0205	3.4270
2.67E-04	0.000225	35%	0.0222	3.1638
3.52E-04	0.000225	40%	0.0240	2.9236

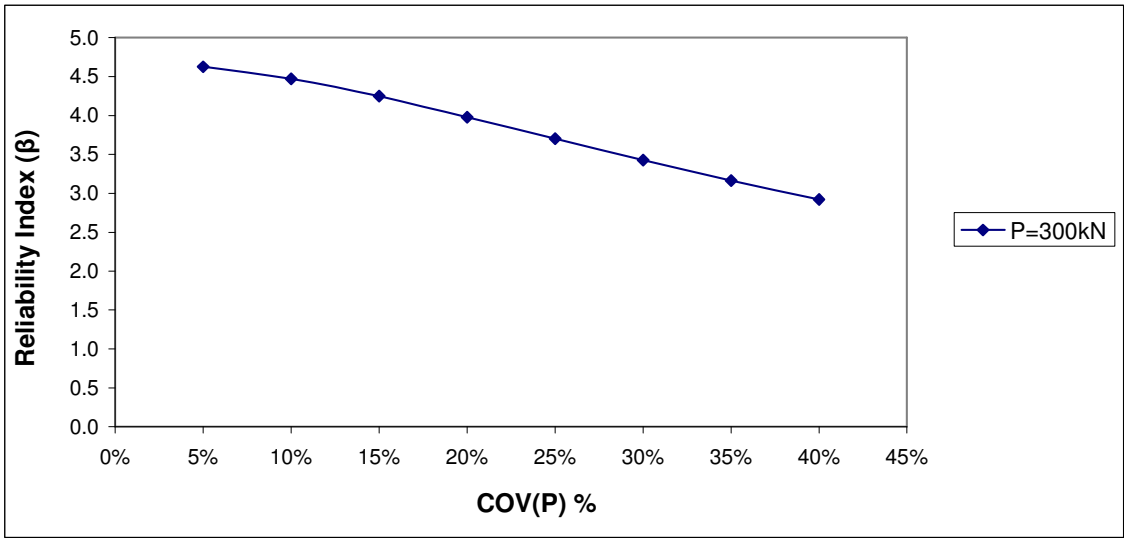


Fig. B.71 Reliability Index (β) of Y_{TOP} vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 300kN.

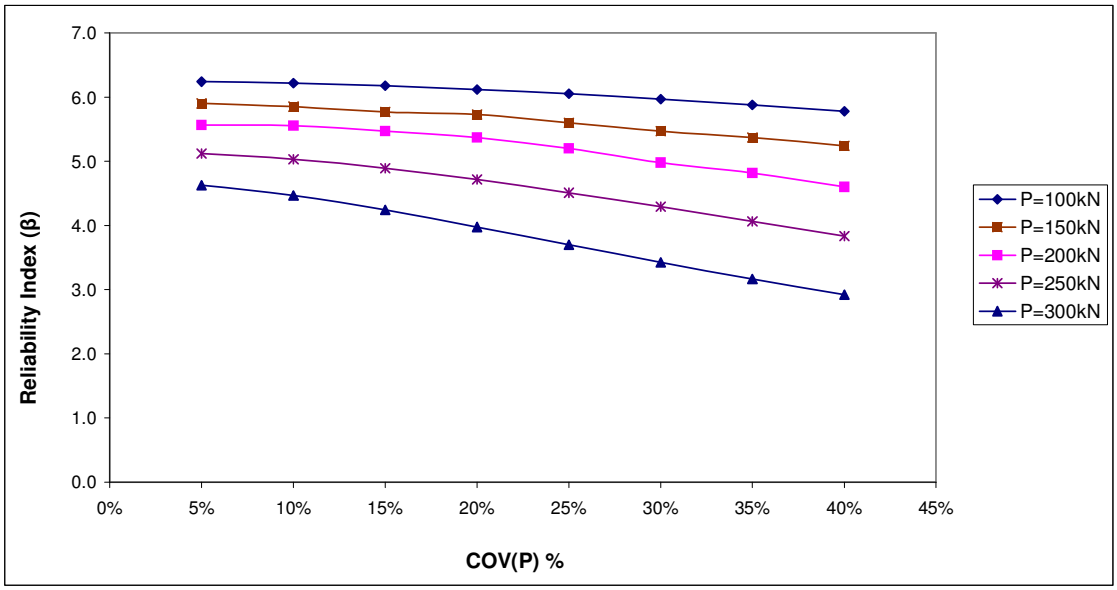


Fig. B.72 Reliability Index (β) of Y_{TOP} vs. COV (P) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

B.3 Probability of failure, $p_f(Y_{TOP})$ of top deflection vs. COV (Variables)

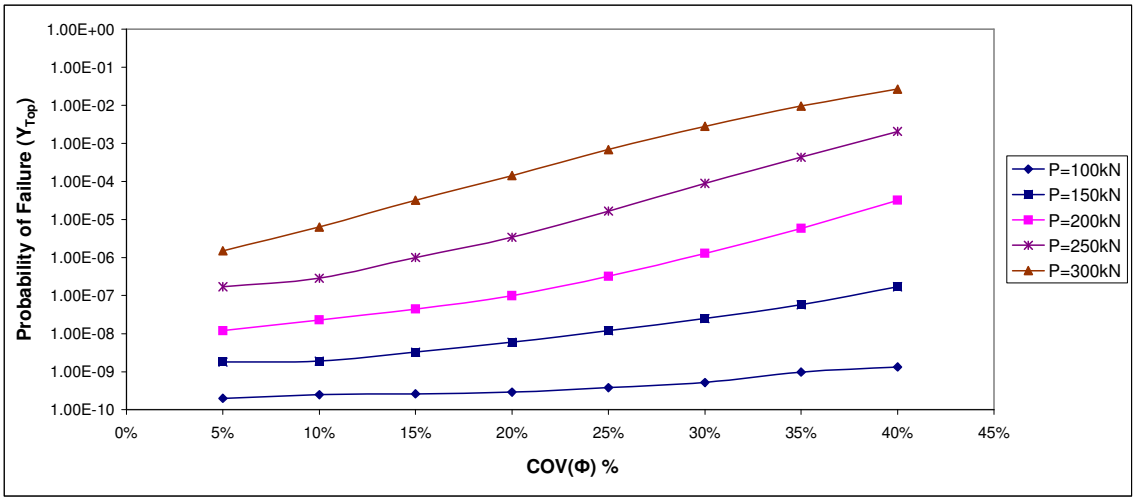


Fig. B.73 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV(Φ) for single fixed head long pile of length 10T.

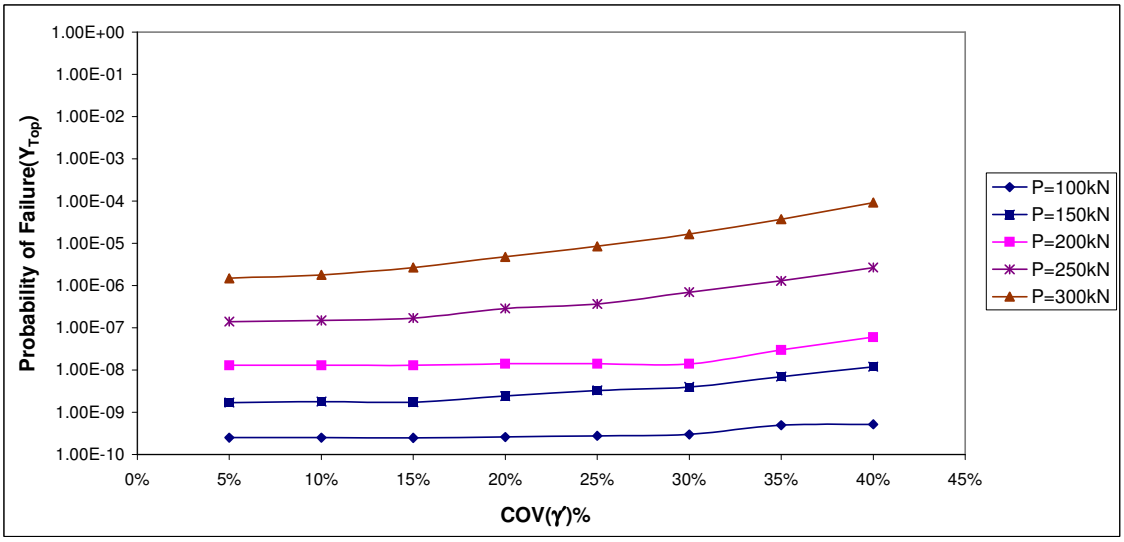


Fig. B.74 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV(γ') for single fixed head long pile of length 10T .

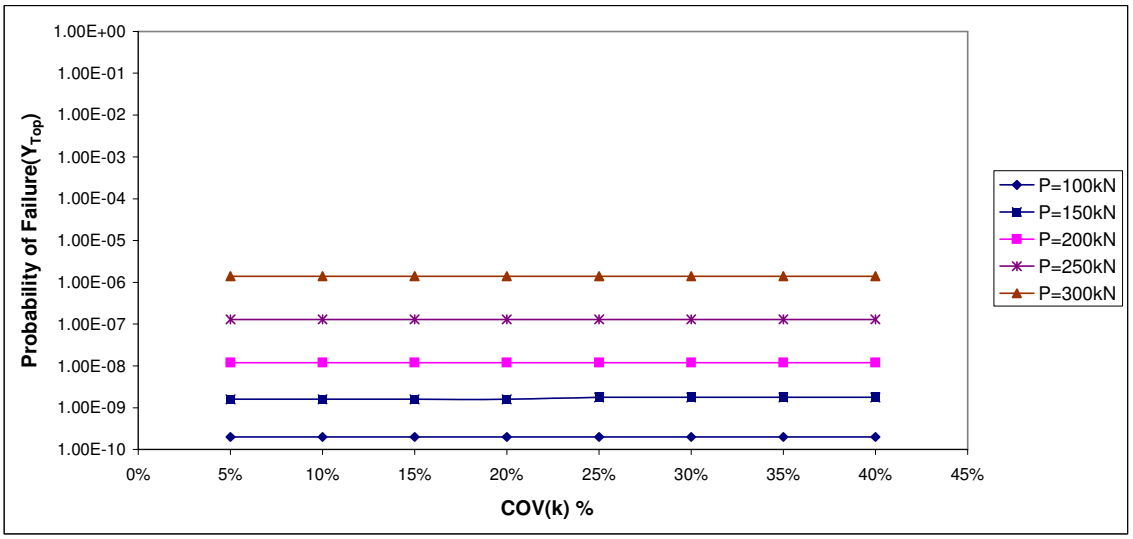


Fig. B.75 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV(k) for single fixed head long pile of length 10T.

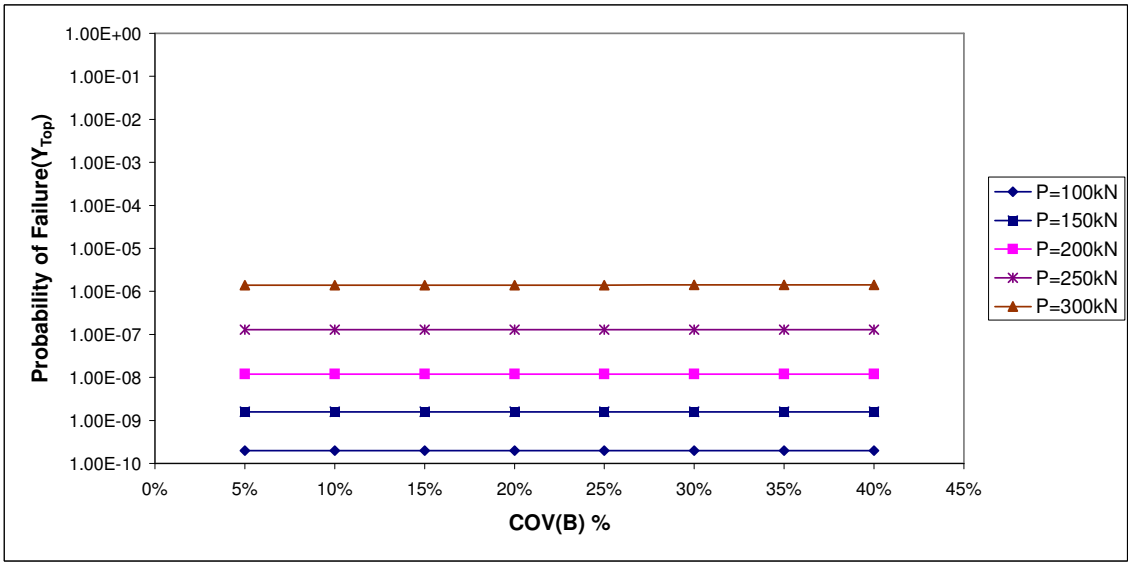


Fig. B.76 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV(B) for single fixed head long pile of length 10T.

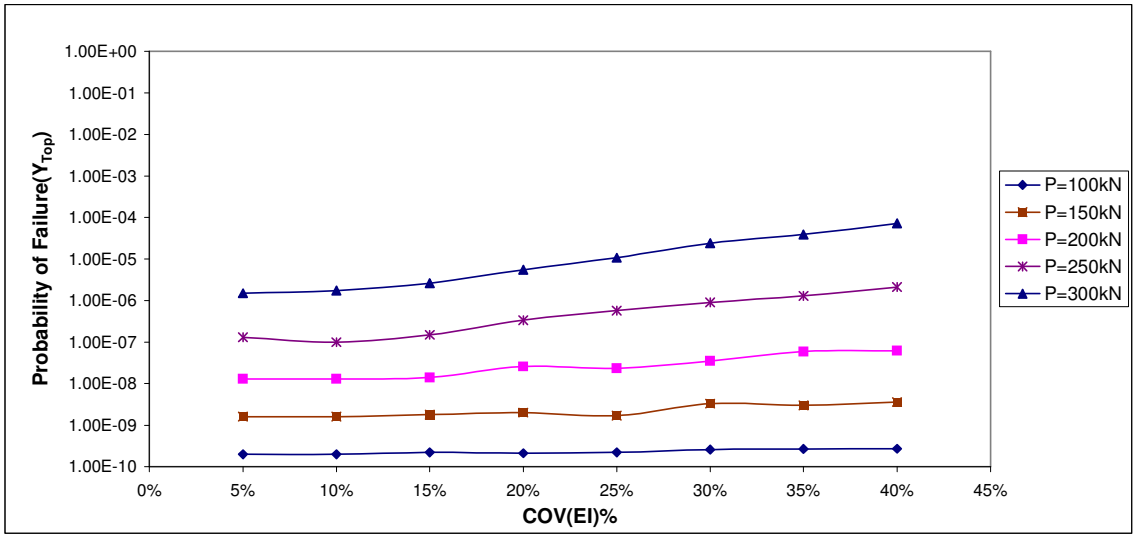


Fig. B.77 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (EI) for single fixed head long pile of length 10T.

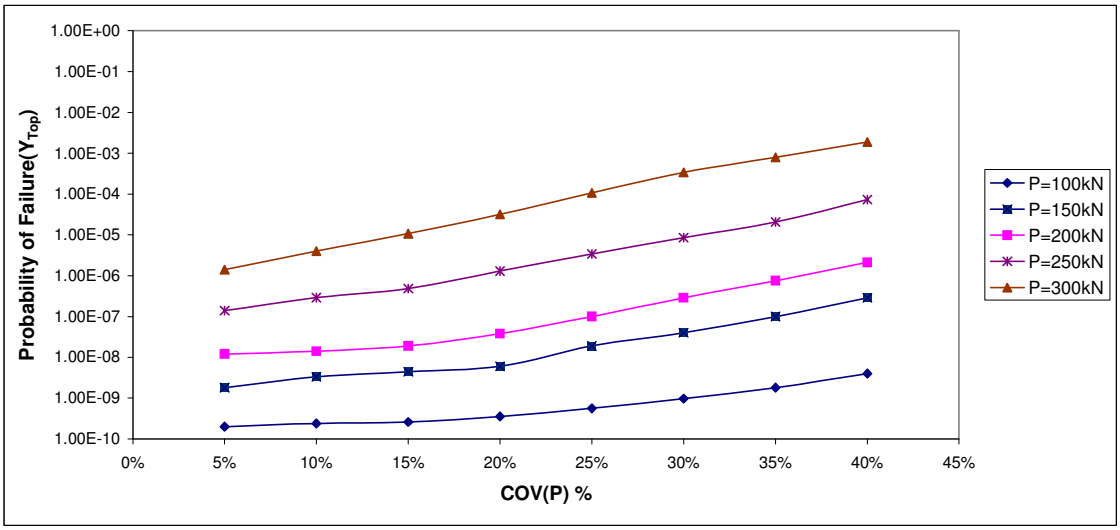


Fig. B.78 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (P) for single fixed head long pile of length 10T.

B.4 Moment of fixed head single long pile and coefficient of (M_{max}) vs. COV (Variables)

Table B.91 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (Φ) and load 100kN.

P=100kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-1.52E+02				
5%	30			2.25E+00	6.25E+00	1.57E+02	2.20%
		28.5	-1.47E+02				
		33	-1.47E+02				
10%	30			9.00E+00	1.10E+02	1.57E+02	5.00%
		27	-1.68E+02				
		34.5	-1.43E+02				
15%	30			2.03E+01	2.25E+02	1.57E+02	8.30%
		25.5	-1.73E+02				
		36	-1.38E+02				
20%	30			3.60E+01	4.20E+02	1.57E+02	11.30%
		24	-1.79E+02				
		37.5	-1.34E+02				
25%	30			5.63E+01	6.50E+02	1.57E+02	14.90%
		22.5	-1.85E+02				
		39	-1.30E+02				
30%	30			8.10E+01	9.30E+02	1.57E+02	18.00%
		21	-1.91E+02				
		40.5	-1.26E+02				
35%	30			1.10E+02	1.30E+03	1.57E+02	22.20%
		19.5	-1.98E+02				
		42	-1.25E+02				
40%	30			1.44E+02	1.60E+03	1.57E+02	24.80%
		18	-2.05E+02				

Table B.92 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (Φ) and load 150kN.

P=150kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-2.46E+02				
5%	30			2.25E+00	5.63E+01	2.53E+02	2.96%
		28.5	-2.61E+02				
		33	-2.38E+02				
10%	30			9.00E+00	2.40E+02	2.53E+02	6.13%
		27	-2.69E+02				
		34.5	-2.31E+02				
15%	30			2.03E+01	5.29E+02	2.53E+02	9.09%
		25.5	-2.77E+02				
		36	-2.24E+02				
20%	30			3.60E+01	9.30E+02	2.53E+02	12.06%
		24	-2.85E+02				
		37.5	-2.17E+02				
25%	30			5.63E+01	1.48E+03	2.53E+02	15.22%
		22.5	-2.94E+02				
		39	-2.11E+02				
30%	30			8.10E+01	2.12E+03	2.53E+02	18.18%
		21	-3.03E+02				
		40.5	-2.04E+02				
35%	30			1.10E+02	3.03E+03	2.53E+02	21.74%
		19.5	-3.14E+02				
		42	-1.98E+02				
40%	30			1.44E+02	4.16E+03	2.53E+02	25.49%
		18	-3.27E+02				

Table B.93 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (Φ) and load 200kN.

P=200kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-3.41E+02				
5%	30			2.25E+00	2.50E+01	3.51E+02	2.40%
		28.5	-3.31E+02				
		33	-3.31E+02				
10%	30			9.00E+00	4.20E+02	3.51E+02	6.10%
		27	-3.72E+02				
		34.5	-3.21E+02				
15%	30			2.03E+01	9.92E+02	3.51E+02	9.30%
		25.5	-3.84E+02				
		36	-3.12E+02				
20%	30			3.60E+01	1.81E+03	3.51E+02	12.11%
		24	-3.97E+02				
		37.5	-3.03E+02				
25%	30			5.63E+01	2.92E+03	3.51E+02	15.38%
		22.5	-4.11E+02				
		39	-2.94E+02				
30%	30			8.10E+01	4.42E+03	3.51E+02	18.95%
		21	-4.27E+02				
		40.5	-2.85E+02				
35%	30			1.10E+02	6.40E+03	3.51E+02	22.79%
		19.5	-4.45E+02				
		42	-2.77E+02				
40%	30			1.44E+02	8.93E+03	3.51E+02	26.92%
		18	-4.66E+02				

Table B.94 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (Φ) and load 250kN.

P250kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-4.41E+02				
5%	30			2.25E+00	1.96E+02	4.54E+02	3.08%
		28.5	-4.69E+02				
		33	-4.28E+02				
10%	30			9.00E+00	8.12E+02	4.54E+02	6.28%
		27	-4.85E+02				
		34.5	-4.15E+02				
15%	30			2.03E+01	1.89E+03	4.54E+02	9.58%
		25.5	-5.02E+02				
		36	-4.03E+02				
20%	30			3.60E+01	3.48E+03	4.54E+02	13.00%
		24	-5.21E+02				
		37.5	-3.92E+02				
25%	30			5.63E+01	5.55E+03	4.54E+02	16.41%
		22.5	-5.41E+02				
		39	-3.81E+02				
30%	30			8.10E+01	8.46E+03	4.54E+02	20.26%
		21	-5.65E+02				
		40.5	-3.70E+02				
35%	30			1.10E+02	1.27E+04	4.54E+02	24.78%
		19.5	-5.95E+02				
		42	-3.59E+02				
40%	30			1.44E+02	1.76E+04	4.54E+02	29.19%
		18	-6.24E+02				

Table B.95 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (Φ) and load 300kN.

P=300kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-5.46E+02				
5%	30			2.25E+00	7.23E+01	5.65E+02	1.50%
		28.5	-5.29E+02				
		33	-5.29E+02				
10%	30			9.00E+00	1.48E+03	5.65E+02	6.81%
		27	-6.06E+02				
		34.5	-5.12E+02				
15%	30			2.03E+01	3.42E+03	5.65E+02	10.35%
		25.5	-6.29E+02				
		36	-4.97E+02				
20%	30			3.60E+01	6.24E+03	5.65E+02	13.98%
		24	-6.55E+02				
		37.5	-4.82E+02				
25%	30			5.63E+01	1.00E+04	5.65E+02	17.70%
		22.5	-6.82E+02				
		39	-4.68E+02				
30%	30			8.10E+01	1.53E+04	5.65E+02	21.86%
		21	-7.15E+02				
		40.5	-4.54E+02				
35%	30			1.10E+02	2.22E+04	5.65E+02	26.37%
		19.5	-7.52E+02				
		42	-4.41E+02				
40%	30			1.44E+02	3.17E+04	5.65E+02	31.50%
		18	-7.97E+02				

Table B.96 Value of COV (M_{max}) for fixed head long pile with varying COV(Φ) and lateral load 100kN.

P=100kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	6.25E+00	2.20%
10%	9.00E+00	1.10E+02	5.00%
15%	2.03E+01	2.25E+02	8.30%
20%	3.60E+01	4.20E+02	11.30%
25%	5.63E+01	6.50E+02	14.90%
30%	8.10E+01	9.30E+02	18.00%
35%	1.10E+02	1.30E+03	22.20%
40%	1.44E+02	1.60E+03	24.80%

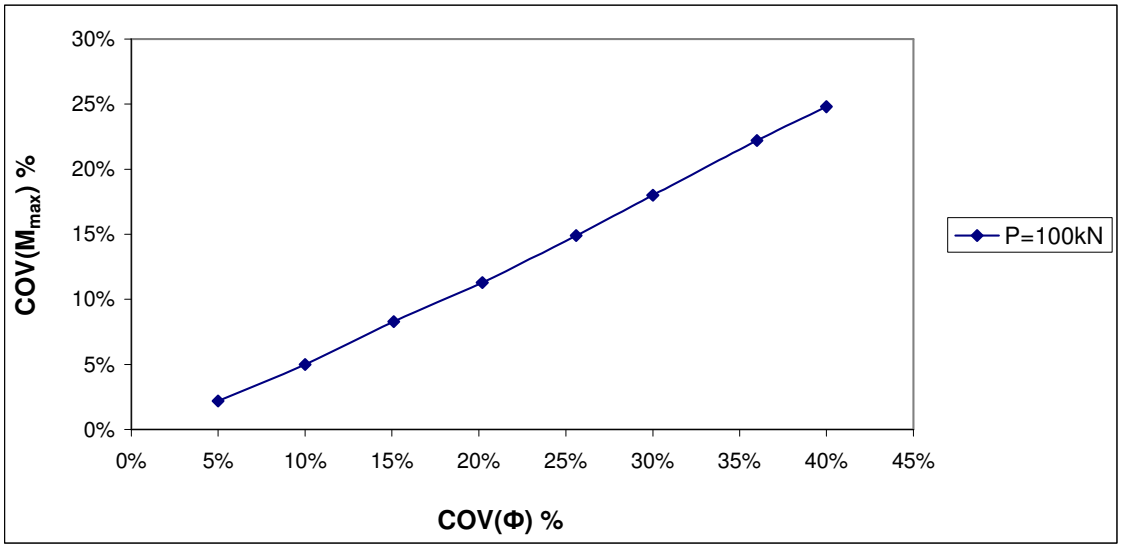


Fig. B.79 Variability of COV (M_{max}) vs. COV(Φ) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.97 Value of COV (M_{max}) for fixed head long pile with varying COV(Φ) and lateral load 150kN.

P=150kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	5.63E+01	2.96%
10%	9.00E+00	2.40E+02	6.13%
15%	2.03E+01	5.29E+02	9.09%
20%	3.60E+01	9.30E+02	12.06%
25%	5.63E+01	1.48E+03	15.22%
30%	8.10E+01	2.12E+03	18.18%
35%	1.10E+02	3.03E+03	21.74%
40%	1.44E+02	4.16E+03	25.49%

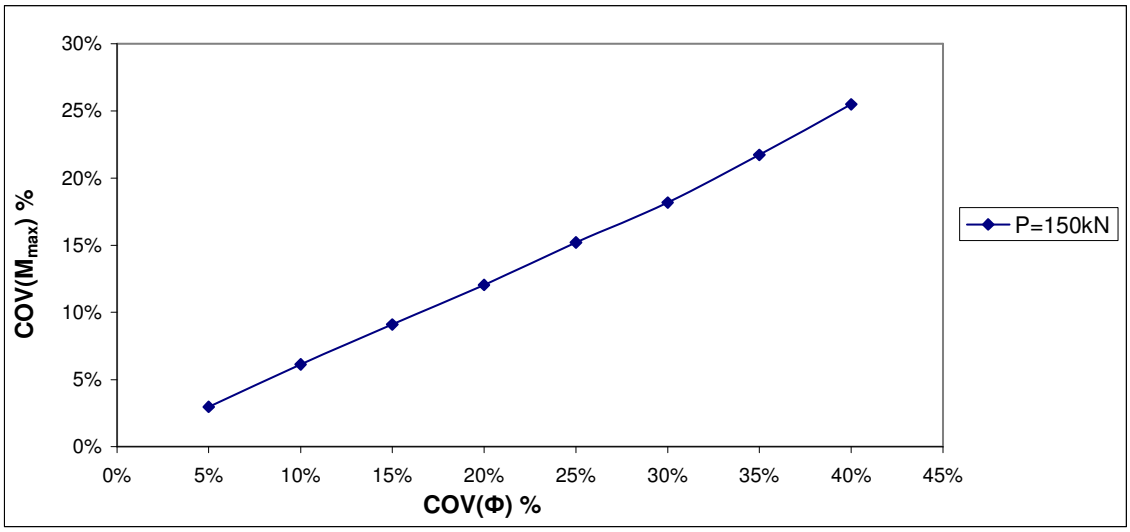


Fig. B.80 Variability of COV (M_{max}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.98 Value of COV (M_{max}) for fixed head long pile with varying COV(Φ) and lateral load 200kN.

P=200kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) (kN-m)^2	COV(M_{max}) (%)
5%	2.25E+00	2.50E+01	2.40%
10%	9.00E+00	4.20E+02	6.10%
15%	2.03E+01	9.92E+02	9.30%
20%	3.60E+01	1.81E+03	12.11%
25%	5.63E+01	2.92E+03	15.38%
30%	8.10E+01	4.42E+03	18.95%
35%	1.10E+02	6.40E+03	22.79%
40%	1.44E+02	8.93E+03	26.92%

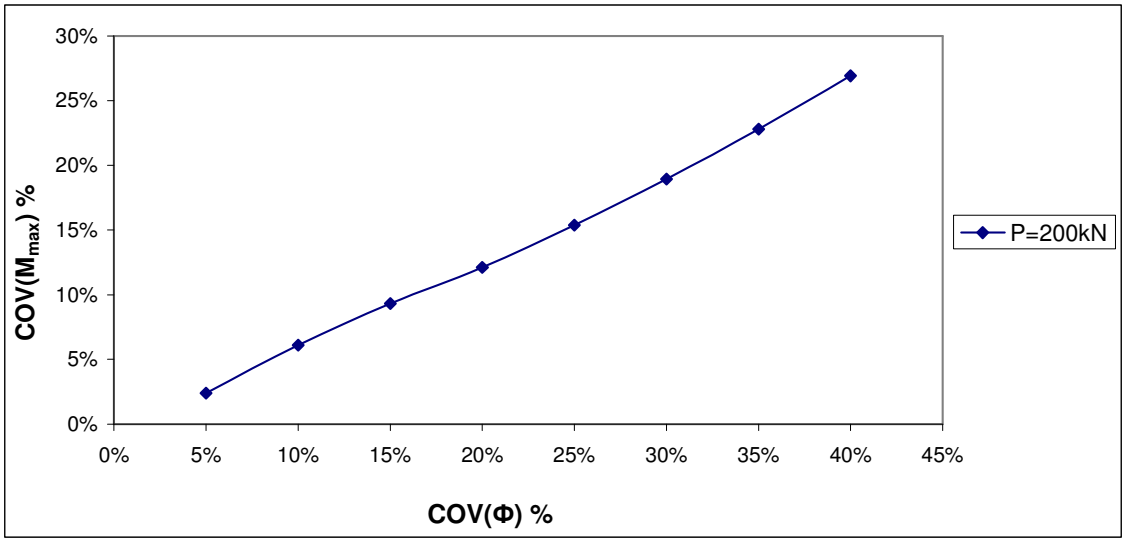


Fig. B.81 Variability of COV (M_{max}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.99 Value of COV (M_{max}) for fixed head long pile with varying COV(Φ) and lateral load 250kN.

P=250kN			
COV(Φ) (%)	VAR(Φ) degree	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	1.96E+02	3.08%
10%	9.00E+00	8.12E+02	6.28%
15%	2.03E+01	1.89E+03	9.58%
20%	3.60E+01	3.48E+03	13.00%
25%	5.63E+01	5.55E+03	16.41%
30%	8.10E+01	8.46E+03	20.26%
35%	1.10E+02	1.27E+04	24.78%
40%	1.44E+02	1.76E+04	29.19%

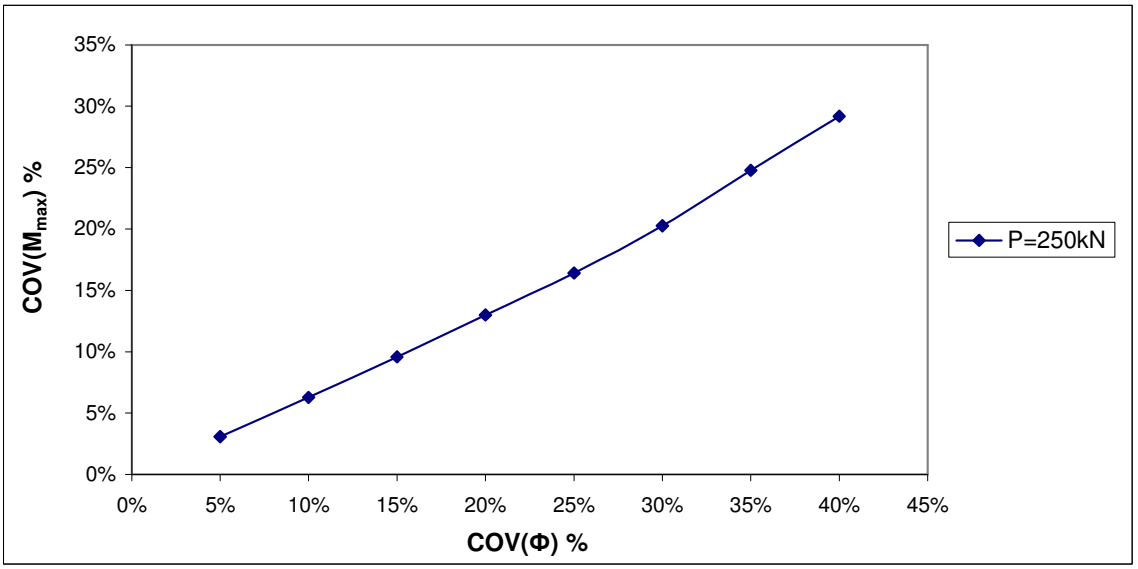


Fig. B.82 Variability of COV (M_{max}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.100 Value of COV (M_{max}) for fixed head long pile with varying COV(Φ) and lateral load 300kN.

P=300kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	7.23E+01	1.50%
10%	9.00E+00	1.48E+03	6.81%
15%	2.03E+01	3.42E+03	10.35%
20%	3.60E+01	6.24E+03	13.98%
25%	5.63E+01	1.00E+04	17.70%
30%	8.10E+01	1.53E+04	21.86%
35%	1.10E+02	2.22E+04	26.37%
40%	1.44E+02	3.17E+04	31.50%

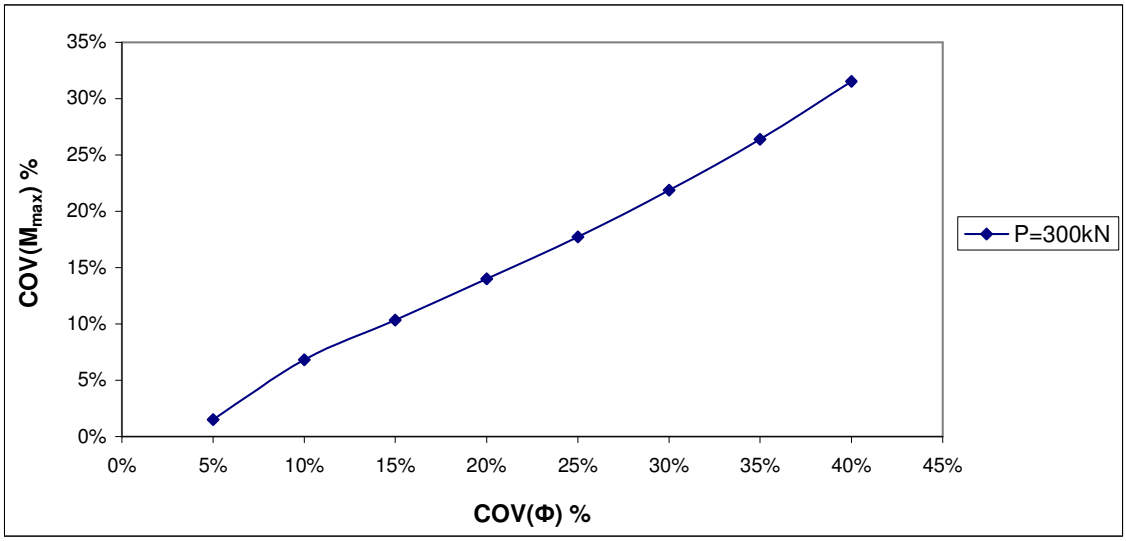


Fig. B.83 Variability of COV (M_{max}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 300kN.

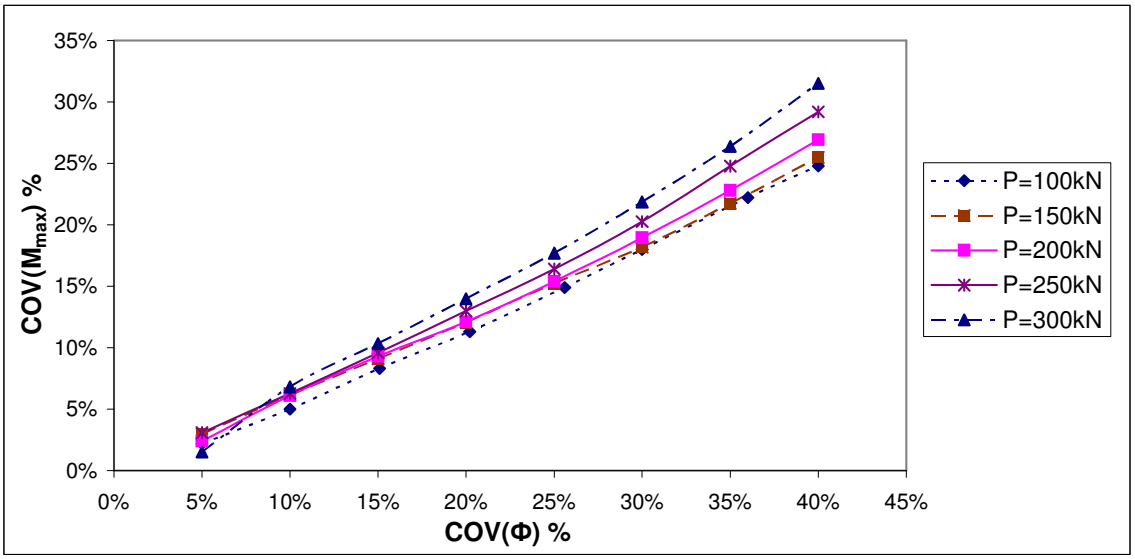


Fig. B.84 Variability of COV (M_{max}) vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.101 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (γ) and load 100kN.

P=100kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}° (kN-m)	COV(M_{max}) (%)
		11.025	-1.55E+02				
5%	10.5			2.76E-01	6.25E+00	1.57E+02	1.59%
		9.975	-1.60E+02				
		11.55	-1.53E+02				
10%	10.5			1.10E+00	2.03E+01	1.57E+02	2.61%
		9.45	-1.62E+02				
		12.075	-1.51E+02				
15%	10.5			2.48E+00	4.23E+01	1.57E+02	3.86%
		8.925	-1.64E+02				
		12.6	-1.49E+02				
20%	10.5			4.41E+00	8.10E+01	1.57E+02	5.11%
		8.4	-1.67E+02				
		13.125	-1.48E+02				
25%	10.5			6.89E+00	1.21E+02	1.57E+02	6.40%
		7.875	-1.70E+02				
		13.65	-1.46E+02				
30%	10.5			9.92E+00	1.82E+02	1.57E+02	7.54%
		7.35	-1.73E+02				
		14.175	-1.44E+02				
35%	10.5			1.35E+01	2.72E+02	1.57E+02	8.91%
		6.825	-1.77E+02				
		14.7	-1.43E+02				
40%	10.5			1.76E+01	3.61E+02	1.57E+02	10.22%
		6.3	-1.81E+02				

Table B.102 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (γ) and load 150kN.

P=150kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}° (kN-m)	COV(M_{max}) (%)
		11.025	-2.50E+02				
5%	10.5			2.76E-01	9.00E+00	2.53E+02	1.19%
		9.975	-2.56E+02				
		11.55	-2.47E+02				
10%	10.5			1.10E+00	4.23E+01	2.53E+02	2.57%
		9.45	-2.60E+02				
		12.075	-2.44E+02				
15%	10.5			2.48E+00	1.00E+02	2.53E+02	3.95%
		8.925	-2.64E+02				
		12.6	-2.41E+02				
20%	10.5			4.41E+00	1.82E+02	2.53E+02	5.34%
		8.4	-2.68E+02				
		13.125	-2.39E+02				
25%	10.5			6.89E+00	2.72E+02	2.53E+02	6.52%
		7.875	-2.72E+02				
		13.65	-2.36E+02				
30%	10.5			9.92E+00	4.20E+02	2.53E+02	8.10%
		7.35	-2.77E+02				
		14.175	-2.34E+02				
35%	10.5			1.35E+01	5.76E+02	2.53E+02	9.49%
		6.825	-2.82E+02				
		14.7	-2.32E+02				
40%	10.5			1.76E+01	7.56E+02	2.53E+02	10.87%
		6.3	-2.87E+02				

Table B.103 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (γ) and load 200kN.

P=200kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}° (kN-m)	COV(M_{max}) (%)
		11.025	-3.46E+02				
5%	10.5			2.76E-01	2.03E+01	3.51E+02	1.28%
		9.975	-3.55E+02				
		11.55	-3.43E+02				
10%	10.5			1.10E+00	7.22E+01	3.51E+02	2.42%
		9.45	-3.60E+02				
		12.075	-3.39E+02				
15%	10.5			2.48E+00	1.69E+02	3.51E+02	3.70%
		8.925	-3.65E+02				
		12.6	-3.35E+02				
20%	10.5			4.41E+00	3.24E+02	3.51E+02	5.13%
		8.4	-3.71E+02				
		13.125	-3.32E+02				
25%	10.5			6.89E+00	5.06E+02	3.51E+02	6.41%
		7.875	-3.77E+02				
		13.65	-3.28E+02				
30%	10.5			9.92E+00	7.84E+02	3.51E+02	7.98%
		7.35	-3.84E+02				
		14.175	-3.25E+02				
35%	10.5			1.35E+01	1.12E+03	3.51E+02	9.54%
		6.825	-3.92E+02				
		14.7	-3.22E+02				
40%	10.5			1.76E+01	1.52E+03	3.51E+02	11.11%
		6.3	-4.00E+02				

Table B.104 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (γ) and load 250kN.

P=250kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}° (kN-m)	COV(M_{max}) (%)
		11.025	-4.49E+02				
5%	10.5			2.76E-01	3.60E+01	4.54E+02	1.32%
		9.975	-4.61E+02				
		11.55	-4.43E+02				
10%	10.5			1.10E+00	1.56E+02	4.54E+02	2.75%
		9.45	-4.68E+02				
		12.075	-4.38E+02				
15%	10.5			2.48E+00	3.42E+02	4.54E+02	4.07%
		8.925	-4.75E+02				
		12.6	-4.33E+02				
20%	10.5			4.41E+00	6.25E+02	4.54E+02	5.51%
		8.4	-4.83E+02				
		13.125	-4.29E+02				
25%	10.5			6.89E+00	9.92E+02	4.54E+02	6.94%
		7.875	-4.92E+02				
		13.65	-4.25E+02				
30%	10.5			9.92E+00	1.44E+03	4.54E+02	8.37%
		7.35	-5.01E+02				
		14.175	-4.20E+02				
35%	10.5			1.35E+01	2.12E+03	4.54E+02	10.13%
		6.825	-5.12E+02				
		14.7	-4.17E+02				
40%	10.5			1.76E+01	2.86E+03	4.54E+02	11.78%
		6.3	-5.24E+02				

Table B.105 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (γ) and load 300kN.

P=300kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		11.025	-5.57E+02				
5%	10.5			2.76E-01	6.40E+01	5.65E+02	1.42%
		9.975	-5.73E+02				
		11.55	-5.50E+02				
10%	10.5			1.10E+00	2.72E+02	5.65E+02	2.92%
		9.45	-5.83E+02				
		12.075	-5.43E+02				
15%	10.5			2.48E+00	6.00E+02	5.65E+02	4.34%
		8.925	-5.92E+02				
		12.6	-5.36E+02				
20%	10.5			4.41E+00	1.12E+03	5.65E+02	5.93%
		8.4	-6.03E+02				
		13.125	-5.30E+02				
25%	10.5			6.89E+00	1.81E+03	5.65E+02	7.52%
		7.875	-6.15E+02				
		13.65	-5.24E+02				
30%	10.5			9.92E+00	2.70E+03	5.65E+02	9.20%
		7.35	-6.28E+02				
		14.175	-5.19E+02				
35%	10.5			1.35E+01	3.78E+03	5.65E+02	10.88%
		6.825	-6.42E+02				
		14.7	-5.14E+02				
40%	10.5			1.76E+01	5.18E+03	5.65E+02	12.74%
		6.3	-6.58E+02				

Table B.106 Value of COV (M_{max}) for fixed head long pile with varying COV(γ) and lateral load 100kN.

P=100kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	6.25E+00	1.59%
10%	1.10E+00	2.03E+01	2.61%
15%	2.48E+00	4.23E+01	3.86%
20%	4.41E+00	8.10E+01	5.11%
25%	6.89E+00	1.21E+02	6.40%
30%	9.92E+00	1.82E+02	7.54%
35%	1.35E+01	2.72E+02	8.91%
40%	1.76E+01	3.61E+02	10.22%

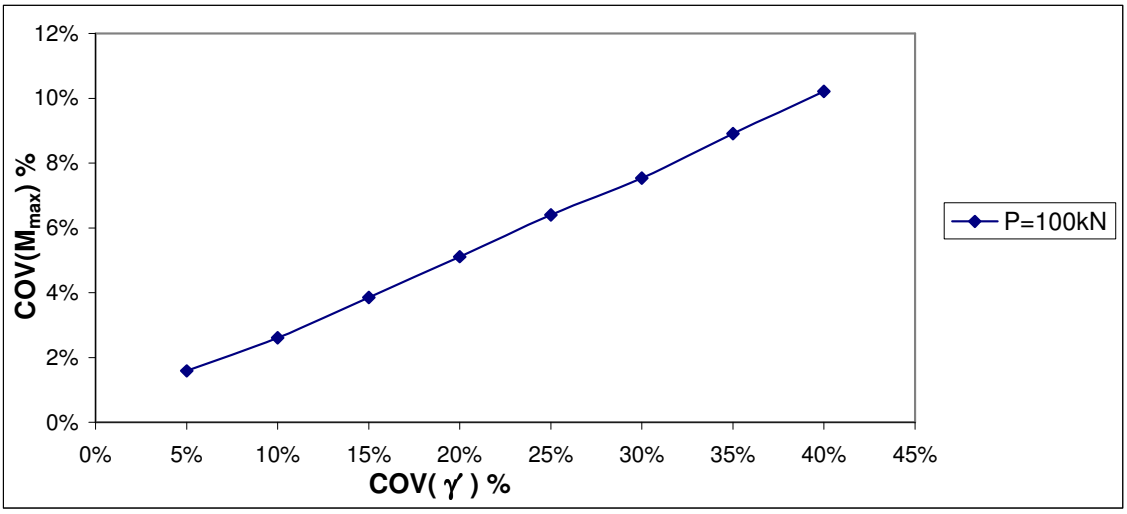


Fig. B.85 Variability of COV (M_{max}) vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.107 Value of COV (M_{max}) for fixed head long pile with varying COV(γ) and lateral load 150kN.

P=150kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	9.00E+00	1.19%
10%	1.10E+00	4.23E+01	2.57%
15%	2.48E+00	1.00E+02	3.95%
20%	4.41E+00	1.82E+02	5.34%
25%	6.89E+00	2.72E+02	6.52%
30%	9.92E+00	4.20E+02	8.10%
35%	1.35E+01	5.76E+02	9.49%
40%	1.76E+01	7.56E+02	10.87%

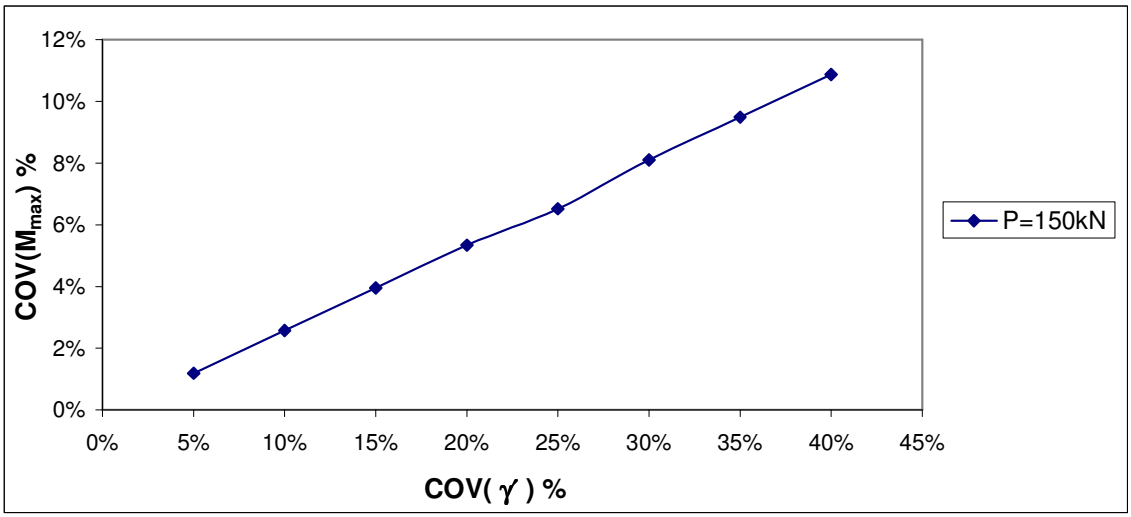


Fig. B.86 Variability of COV (M_{max}) vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.108 Value of COV (M_{max}) for fixed head long pile with varying COV(γ) and lateral load 200kN.

P=200kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	2.03E+01	1.28%
10%	1.10E+00	7.22E+01	2.42%
15%	2.48E+00	1.69E+02	3.70%
20%	4.41E+00	3.24E+02	5.13%
25%	6.89E+00	5.06E+02	6.41%
30%	9.92E+00	7.84E+02	7.98%
35%	1.35E+01	1.12E+03	9.54%
40%	1.76E+01	1.52E+03	11.11%

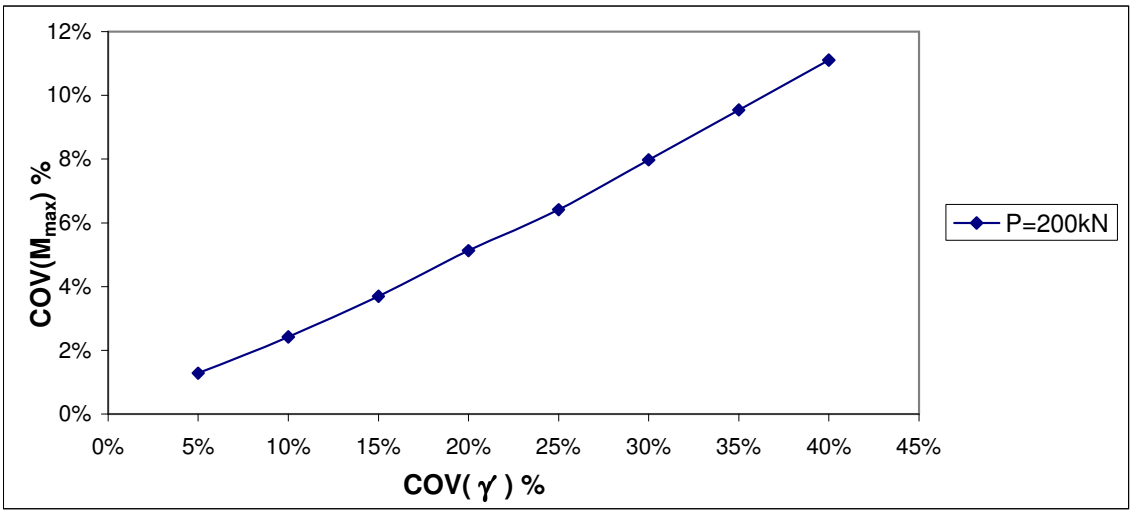


Fig. B.87 Variability of COV (M_{max}) vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.109 Value of COV (M_{max}) for fixed head long pile with varying COV(γ) and lateral load 250kN.

P=250kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	3.60E+01	1.32%
10%	1.10E+00	1.56E+02	2.75%
15%	2.48E+00	3.42E+02	4.07%
20%	4.41E+00	6.25E+02	5.51%
25%	6.89E+00	9.92E+02	6.94%
30%	9.92E+00	1.44E+03	8.37%
35%	1.35E+01	2.12E+03	10.13%
40%	1.76E+01	2.86E+03	11.78%

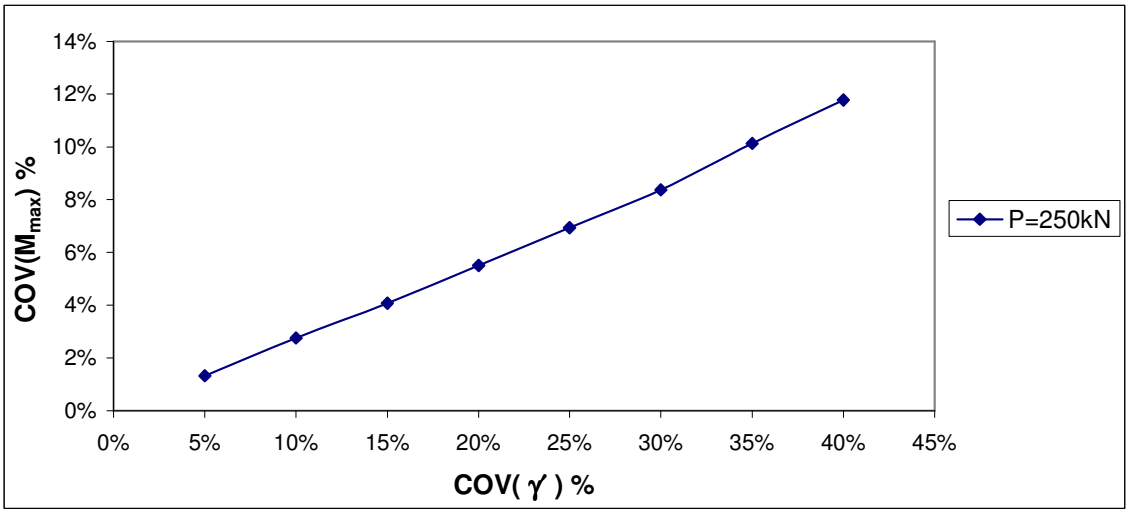


Fig. B.88 Variability of COV (M_{max}) vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.110 Value of COV (M_{max}) for fixed head long pile with varying COV(γ) and lateral load 300kN.

P=300kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	6.40E+01	1.42%
10%	1.10E+00	2.72E+02	2.92%
15%	2.48E+00	6.00E+02	4.34%
20%	4.41E+00	1.12E+03	5.93%
25%	6.89E+00	1.81E+03	7.52%
30%	9.92E+00	2.70E+03	9.20%
35%	1.35E+01	3.78E+03	10.88%
40%	1.76E+01	5.18E+03	12.74%

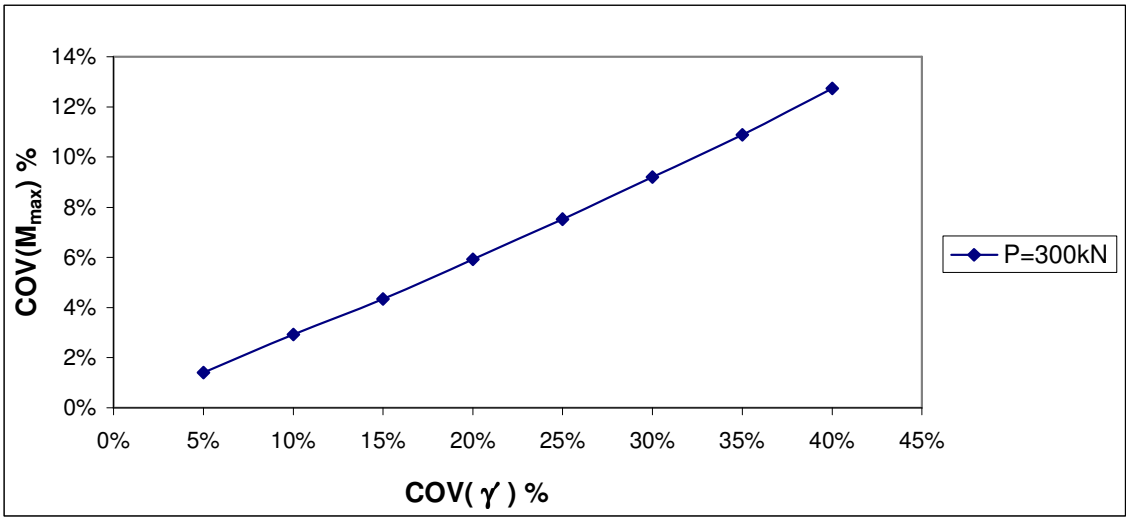


Fig. B.89 Variability of COV (M_{max}) vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 300kN.

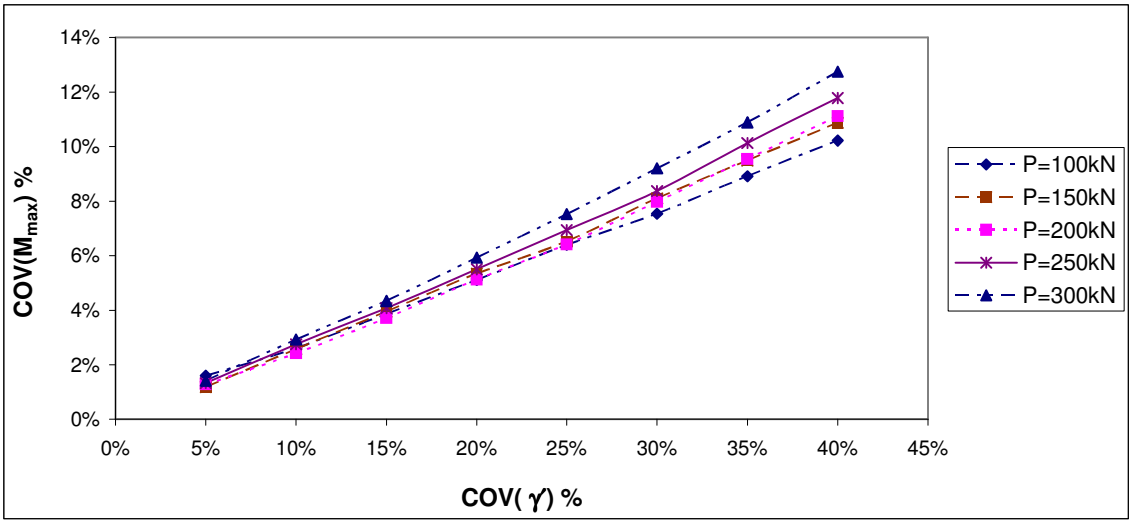


Fig. B.90 Variability of COV (M_{max}) vs. COV(γ) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.111 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (k) and load 100kN.

P=100kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	1.57E+02				
5%	16300			6.64E+05	2.00E-02	1.57E+02	0.03%
		15485	1.57E+02				
		17930	1.57E+02				
10%	16300			2.66E+06	6.50E-02	1.57E+02	0.08%
		14670	1.57E+02				
		18745	1.57E+02				
15%	16300			5.98E+06	1.86E-01	1.57E+02	0.13%
		13855	1.57E+02				
		19560	1.57E+02				
20%	16300			1.06E+07	2.00E-01	1.57E+02	0.18%
		13040	1.57E+02				
		20375	1.57E+02				
25%	16300			1.66E+07	2.50E-01	1.57E+02	0.23%
		12225	1.57E+02				
		21190	1.57E+02				
30%	16300			2.39E+07	2.62E-01	1.57E+02	0.28%
		11410	1.57E+02				
		22005	1.57E+02				
35%	16300			3.25E+07	2.83E-01	1.57E+02	0.31%
		10595	1.57E+02				
		22820	1.57E+02				
40%	16300			4.25E+07	2.94E-01	1.57E+02	0.32%
		9780	1.57E+02				

Table B.112 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (k) and load 150kN.

P=150kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	-2.53E+02				
5%	16300			6.64E+05	1.88E-02	2.53E+02	0.01%
		15485	-2.53E+02				
		17930	-2.53E+02				
10%	16300			2.66E+06	3.50E-02	2.53E+02	0.05%
		14670	-2.53E+02				
		18745	-2.53E+02				
15%	16300			5.98E+06	1.35E-01	2.53E+02	0.09%
		13855	-2.53E+02				
		19560	-2.53E+02				
20%	16300			1.06E+07	1.57E-01	2.53E+02	0.13%
		13040	-2.53E+02				
		20375	-2.53E+02				
25%	16300			1.66E+07	2.22E-01	2.53E+02	0.18%
		12225	-2.53E+02				
		21190	-2.53E+02				
30%	16300			2.39E+07	2.42E-01	2.53E+02	0.21%
		11410	-2.54E+02				
		22005	-2.53E+02				
35%	16300			3.25E+07	2.50E-01	2.53E+02	0.24%
		10595	-2.54E+02				
		22820	-2.53E+02				
40%	16300			4.25E+07	2.60E-01	2.53E+02	0.25%
		9780	-2.54E+02				

Table B.113 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (k) and load 200kN.

P=200kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	-3.51E+02				
5%	16300			6.64E+05	1.83E-02	3.51E+02	0.02%
		15485	-3.51E+02				
		17930	-3.51E+02				
10%	16300			2.66E+06	3.48E-02	3.51E+02	0.05%
		14670	-3.51E+02				
		18745	-3.51E+02				
15%	16300			5.98E+06	1.30E-01	3.51E+02	0.10%
		13855	-3.51E+02				
		19560	-3.50E+02				
20%	16300			1.06E+07	1.27E-01	3.51E+02	0.14%
		13040	-3.51E+02				
		20375	-3.50E+02				
25%	16300			1.66E+07	1.99E-01	3.51E+02	0.19%
		12225	-3.51E+02				
		21190	-3.50E+02				
30%	16300			2.39E+07	2.65E-01	3.51E+02	0.22%
		11410	-3.51E+02				
		22005	-3.50E+02				
35%	16300			3.25E+07	2.49E-01	3.51E+02	0.26%
		10595	-3.51E+02				
		22820	-3.50E+02				
40%	16300			4.25E+07	2.58E-01	3.51E+02	0.28%
		9780	-3.51E+02				

Table B.114 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (k) and load 250kN.

P=250kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	-4.55E+02				
5%	16300			6.64E+05	1.59E-01	4.54E+02	0.01%
		15485	-4.55E+02				
		17930	-4.55E+02				
10%	16300			2.66E+06	1.99E-01	4.54E+02	0.04%
		14670	-4.55E+02				
		18745	-4.54E+02				
15%	16300			5.98E+06	1.00E+00	4.54E+02	0.08%
		13855	-4.55E+02				
		19560	-4.54E+02				
20%	16300			1.06E+07	1.32E+00	4.54E+02	0.12%
		13040	-4.55E+02				
		20375	-4.54E+02				
25%	16300			1.66E+07	2.10E+00	4.54E+02	0.16%
		12225	-4.55E+02				
		21190	-4.54E+02				
30%	16300			2.39E+07	2.32E+00	4.54E+02	0.19%
		11410	-4.55E+02				
		22005	-4.54E+02				
35%	16300			3.25E+07	2.62E+00	4.54E+02	0.22%
		10595	-4.56E+02				
		22820	-4.54E+02				
40%	16300			4.25E+07	2.86E+00	4.54E+02	0.23%
		9780	-4.56E+02				

Table B.115 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (k) and load 300kN.

P=300kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		17115	-5.65E+02				
5%	16300			6.64E+05	1.59E-01	5.65E+02	0.01%
		15485	-5.65E+02				
		17930	-5.65E+02				
10%	16300			2.66E+06	1.80E-01	5.65E+02	0.03%
		14670	-5.65E+02				
		18745	-5.65E+02				
15%	16300			5.98E+06	1.99E-01	5.65E+02	0.06%
		13855	-5.65E+02				
		19560	-5.65E+02				
20%	16300			1.06E+07	1.32E+00	5.65E+02	0.11%
		13040	-5.65E+02				
		20375	-5.65E+02				
25%	16300			1.66E+07	2.03E+00	5.65E+02	0.14%
		12225	-5.66E+02				
		21190	-5.64E+02				
30%	16300			2.39E+07	2.15E+00	5.65E+02	0.18%
		11410	-5.66E+02				
		22005	-5.64E+02				
35%	16300			3.25E+07	2.43E+00	5.65E+02	0.20%
		10595	-5.66E+02				
		22820	-5.64E+02				
40%	16300			4.25E+07	2.66E+00	5.65E+02	0.21%
		9780	-5.67E+02				

Table B.116 Value of COV (M_{max}) for fixed head long pile with varying COV(k) and lateral load 100kN.

P=100kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.00E-02	0.03%
10%	2.66E+06	6.50E-02	0.08%
15%	5.98E+06	1.86E-01	0.13%
20%	1.06E+07	2.00E-01	0.18%
25%	1.66E+07	2.50E-01	0.23%
30%	2.39E+07	2.62E-01	0.28%
35%	3.25E+07	2.83E-01	0.31%
40%	4.25E+07	2.94E-01	0.32%

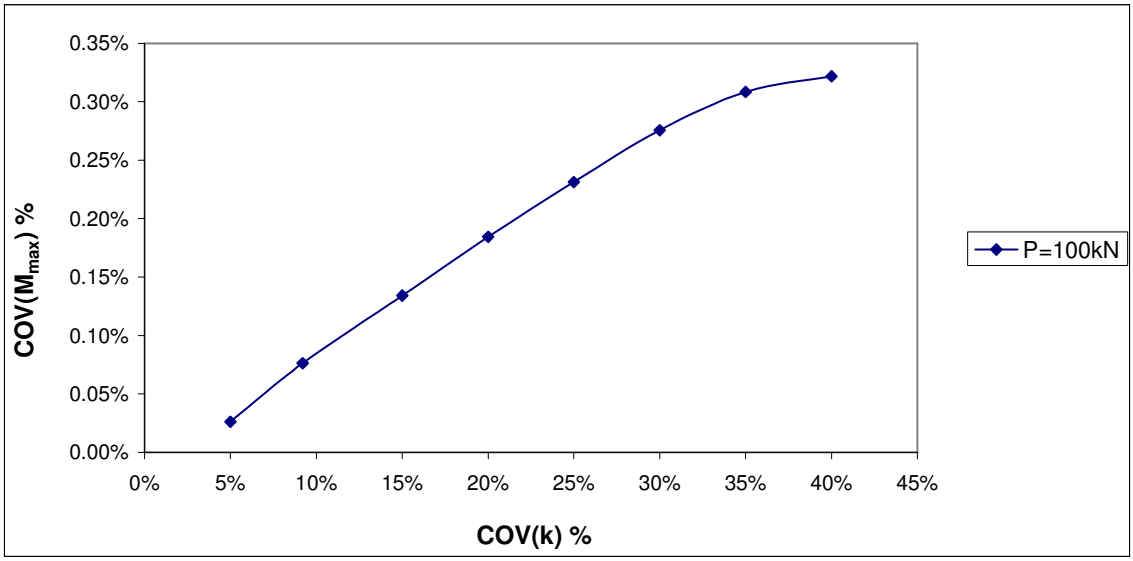


Fig. B.91 Variability of COV (M_{max}) vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.117 Value of COV (M_{max}) for fixed head long pile with varying COV(k) and lateral load 150kN.

P=150kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.88E-02	0.01%
10%	2.66E+06	3.50E-02	0.05%
15%	5.98E+06	1.35E-01	0.09%
20%	1.06E+07	1.57E-01	0.13%
25%	1.66E+07	2.22E-01	0.18%
30%	2.39E+07	2.42E-01	0.21%
35%	3.25E+07	2.50E-01	0.24%
40%	4.25E+07	2.60E-01	0.25%

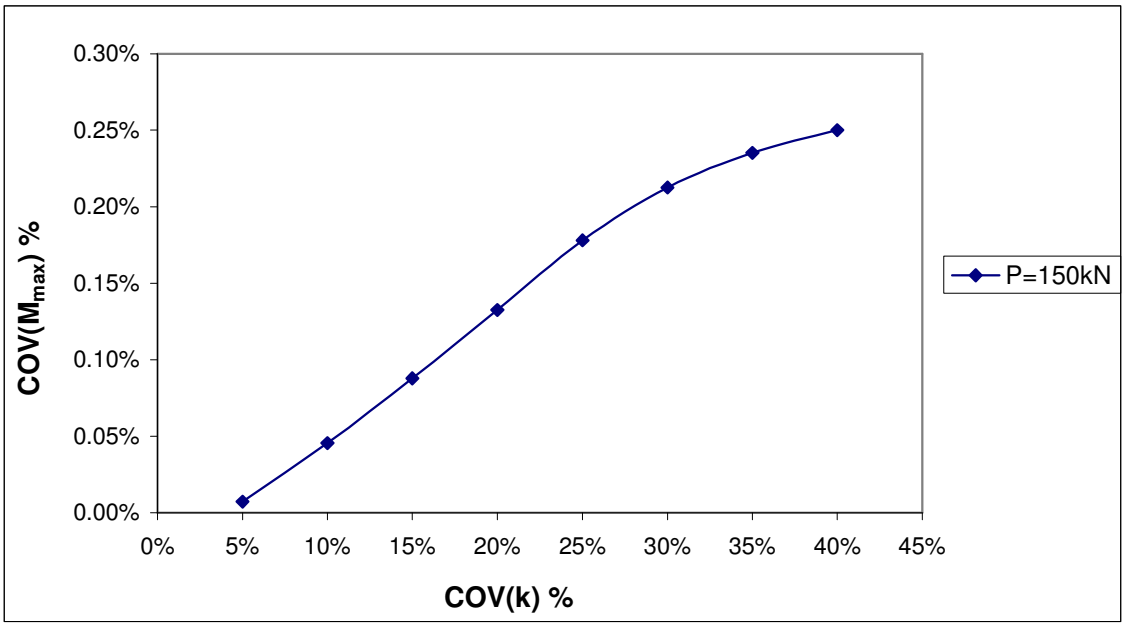


Fig. B.92 Variability of COV (M_{max}) vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.118 Value of COV (M_{max}) for fixed head long pile with varying COV(k) and lateral load 200kN.

P=200kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.83E-02	0.02%
10%	2.66E+06	3.48E-02	0.05%
15%	5.98E+06	1.30E-01	0.10%
20%	1.06E+07	1.27E-01	0.14%
25%	1.66E+07	1.99E-01	0.19%
30%	2.39E+07	2.65E-01	0.22%
35%	3.25E+07	2.49E-01	0.26%
40%	4.25E+07	2.58E-01	0.28%

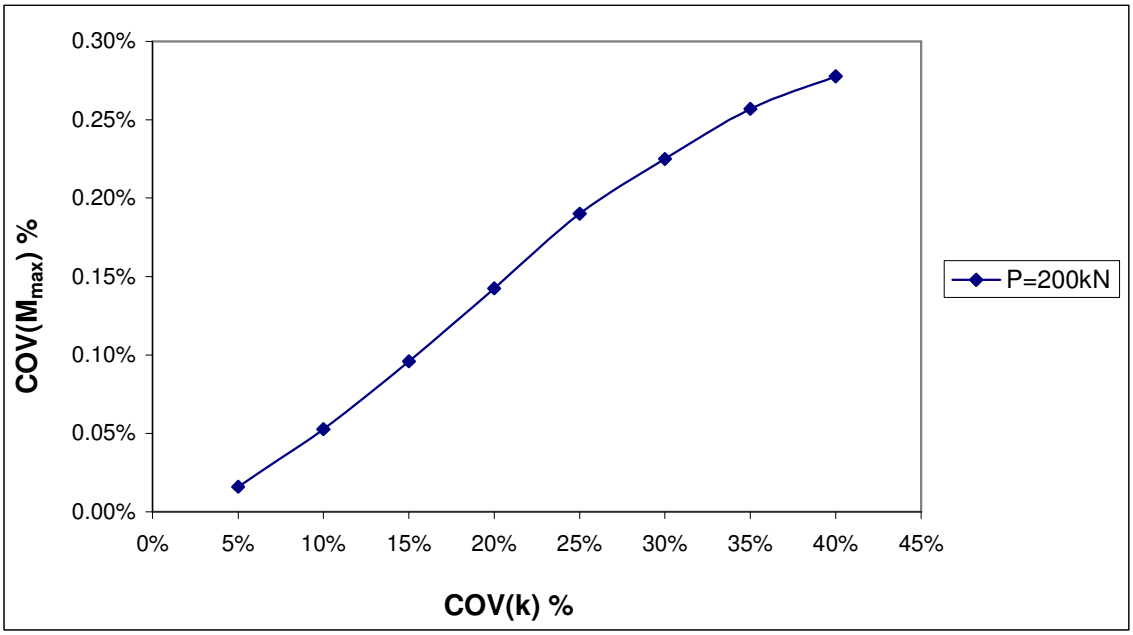


Fig. B.93 Variability of COV (M_{max}) vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.119 Value of COV (M_{max}) for fixed head long pile with varying COV(k) and lateral load 250kN.

P=250kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.59E-01	0.01%
10%	2.66E+06	1.99E-01	0.04%
15%	5.98E+06	1.00E+00	0.08%
20%	1.06E+07	1.32E+00	0.12%
25%	1.66E+07	2.10E+00	0.16%
30%	2.39E+07	2.32E+00	0.19%
35%	3.25E+07	2.62E+00	0.22%
40%	4.25E+07	2.86E+00	0.23%

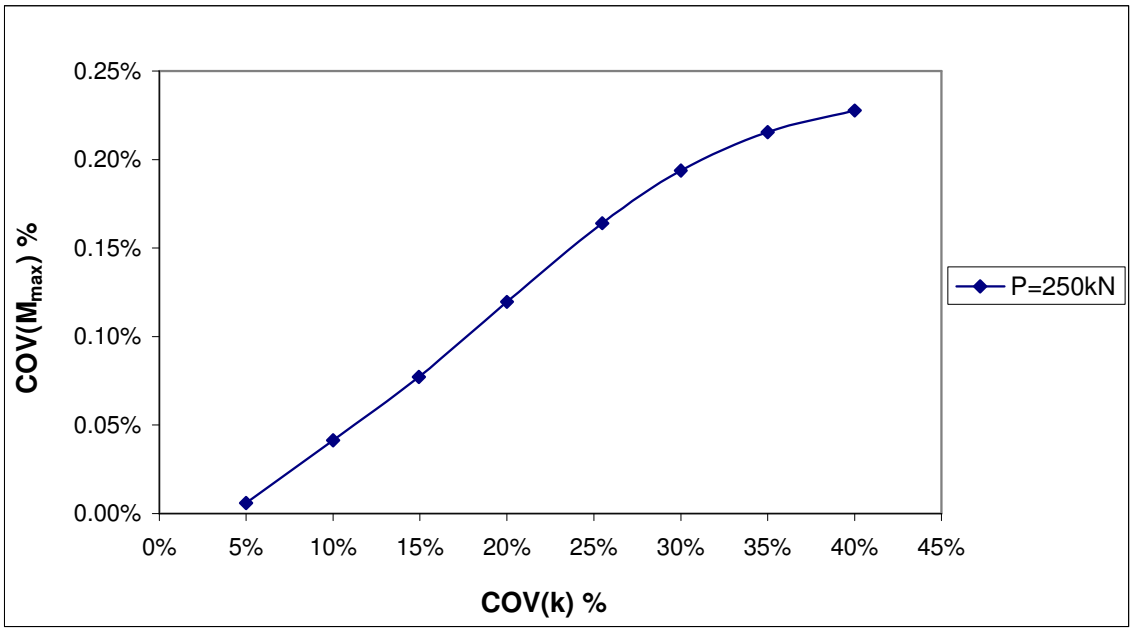


Fig. B.94 Variability of COV (M_{max}) vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 250kN

Table B.120 Value of COV (M_{max}) for fixed head long pile with varying COV(k) and lateral load 300kN.

P=300kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.59E-01	0.01%
10%	2.66E+06	1.80E-01	0.03%
15%	5.98E+06	1.99E-01	0.06%
20%	1.06E+07	1.32E+00	0.11%
25%	1.66E+07	2.03E+00	0.14%
30%	2.39E+07	2.15E+00	0.18%
35%	3.25E+07	2.43E+00	0.20%
40%	4.25E+07	2.66E+00	0.21%

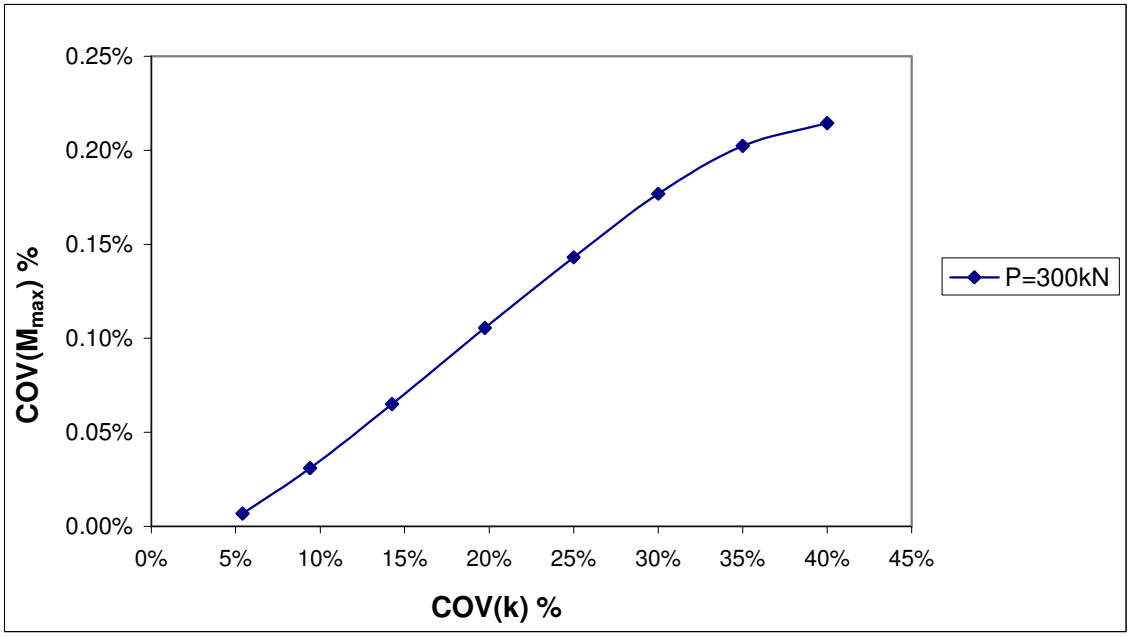


Fig. B.95 Variability of COV (M_{max}) vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 300kN.

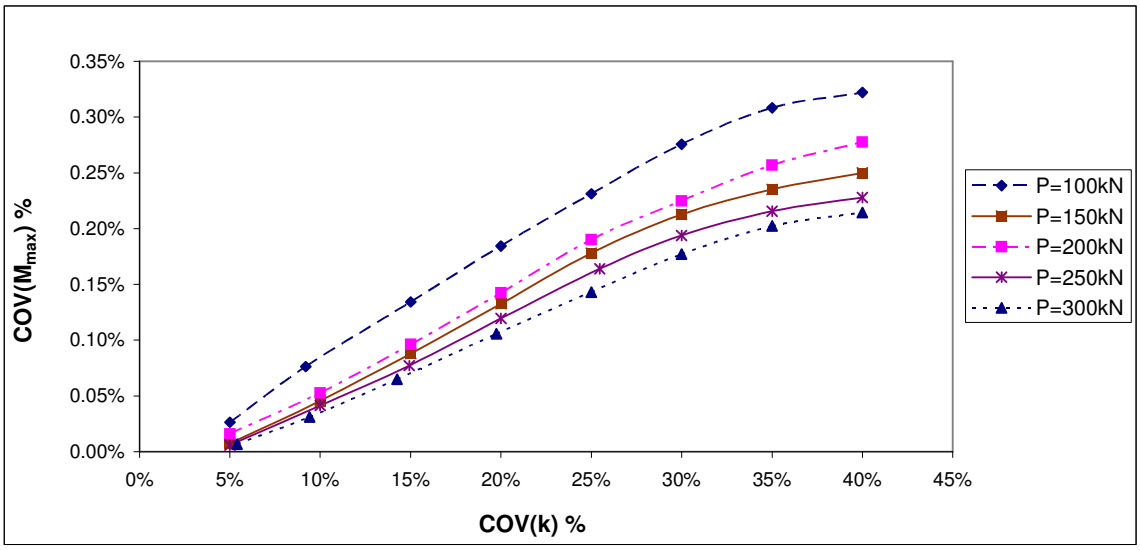


Fig. B.96 Variability of COV (M_{max}) vs. COV (k) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.121 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (B) and load 100kN.

P=100kN							
COV(B) (%)	B° (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	-1.56E-02				
5%	0.406			4.12E-04	0.00E+00	4.54E+02	0.00%
		0.3857	-1.56E-02				
		0.4466	-1.56E-02				
10%	0.406			1.65E-03	1.00E+00	4.54E+02	0.71%
		0.3654	-1.56E-02				
		0.4669	-1.56E-02				
15%	0.406			3.71E-03	2.25E+00	4.54E+02	1.24%
		0.3451	-1.56E-02				
		0.4872	-1.56E-02				
20%	0.406			6.59E-03	6.25E+00	4.54E+02	1.69%
		0.3248	-1.56E-02				
		0.5075	-1.56E-02				
25%	0.406			1.03E-02	9.00E+00	4.54E+02	2.16%
		0.3045	-1.56E-02				
		0.5278	-1.56E-02				
30%	0.406			1.48E-02	1.23E+01	4.54E+02	2.58%
		0.2842	-1.56E-02				
		0.5472	-1.56E-02				
35%	0.406			2.02E-02	1.24E+01	4.54E+02	2.83%
		0.2648	-1.56E-02				
		0.5684	-1.56E-02				
40%	0.406			2.64E-02	1.60E+01	4.54E+02	3.00%
		0.2436	-1.56E-02				

Table B.122 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (B) and load 150kN.

P=150kN							
COV(B) (%)	B° (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	-2.53E+02				
5%	0.406			4.12E-04	0.00E+00	2.53E+02	0.00%
		0.3857	-2.53E+02				
		0.4466	-2.52E+02				
10%	0.406			1.65E-03	2.50E-01	2.53E+02	0.74%
		0.3654	-2.53E+02				
		0.4669	-2.52E+02				
15%	0.406			3.71E-03	2.58E-01	2.53E+02	1.52%
		0.3451	-2.53E+02				
		0.4872	-2.51E+02				
20%	0.406			6.59E-03	1.00E+00	2.53E+02	2.17%
		0.3248	-2.53E+02				
		0.5075	-2.50E+02				
25%	0.406			1.03E-02	1.65E+00	2.53E+02	2.66%
		0.3045	-2.52E+02				
		0.5278	-2.49E+02				
30%	0.406			1.48E-02	1.93E+00	2.53E+02	3.07%
		0.2842	-2.51E+02				
		0.5472	-2.49E+02				
35%	0.406			2.02E-02	2.00E+00	2.53E+02	3.56%
		0.2648	-2.51E+02				
		0.5684	-2.47E+02				
40%	0.406			2.64E-02	2.25E+00	2.53E+02	3.86%
		0.2436	-2.50E+02				

Table B.123 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (B) and load 200kN.

P=200kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		0.4263	-3.50E+02				
5%	0.406			4.12E-04	0.00E+00	3.51E+02	0.00%
		0.3857	-3.50E+02				
		0.4466	-3.50E+02				
10%	0.406			1.65E-03	1.00E+00	3.51E+02	0.86%
		0.3654	-3.50E+02				
		0.4669	-3.48E+02				
15%	0.406			3.71E-03	1.36E+00	3.51E+02	1.76%
		0.3451	-3.50E+02				
		0.4872	-3.48E+02				
20%	0.406			6.59E-03	2.25E+00	3.51E+02	2.47%
		0.3248	-3.51E+02				
		0.5075	-3.48E+02				
25%	0.406			1.03E-02	2.89E+00	3.51E+02	3.07%
		0.3045	-3.51E+02				
		0.5278	-3.49E+02				
30%	0.406			1.48E-02	4.00E+00	3.51E+02	3.65%
		0.2842	-3.52E+02				
		0.5472	-3.48E+02				
35%	0.406			2.02E-02	4.05E+00	3.51E+02	4.02%
		0.2648	-3.52E+02				
		0.5684	-3.48E+02				
40%	0.406			2.64E-02	6.25E+00	3.51E+02	4.17%
		0.2436	-3.53E+02				

Table B.124 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (B) and load 250kN.

P=250kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		0.4263	-4.55E+02				
5%	0.406			4.12E-04	0.00E+00	4.54E+02	0.00%
		0.3857	-4.55E+02				
		0.4466	-4.54E+02				
10%	0.406			1.65E-03	2.50E-01	4.54E+02	1.29%
		0.3654	-4.55E+02				
		0.4669	-4.54E+02				
15%	0.406			3.71E-03	2.75E-01	4.54E+02	2.28%
		0.3451	-4.55E+02				
		0.4872	-4.54E+02				
20%	0.406			6.59E-03	2.99E-01	4.54E+02	3.06%
		0.3248	-4.55E+02				
		0.5075	-4.53E+02				
25%	0.406			1.03E-02	1.00E+00	4.54E+02	3.74%
		0.3045	-4.55E+02				
		0.5278	-4.53E+02				
30%	0.406			1.48E-02	1.01E+00	4.54E+02	4.30%
		0.2842	-4.55E+02				
		0.5472	-4.53E+02				
35%	0.406			2.02E-02	1.63E+00	4.54E+02	4.67%
		0.2648	-4.55E+02				
		0.5684	-4.52E+02				
40%	0.406			2.64E-02	2.25E+00	4.54E+02	4.84%
		0.2436	-4.55E+02				

Table B.125 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (B) and load 300kN.

P=300kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	-5.66E+02				
5%	0.406			4.12E-04	0.00E+00	5.65E+02	0.00%
		0.3857	-5.66E+02				
		0.4466	-5.63E+02				
10%	0.406			1.65E-03	2.25E+00	5.65E+02	1.70%
		0.3654	-5.66E+02				
		0.4669	-5.63E+02				
15%	0.406			3.71E-03	4.00E+00	5.65E+02	2.68%
		0.3451	-5.67E+02				
		0.4872	-5.62E+02				
20%	0.406			6.59E-03	9.00E+00	5.65E+02	3.44%
		0.3248	-5.68E+02				
		0.5075	-5.62E+02				
25%	0.406			1.03E-02	1.23E+01	5.65E+02	4.03%
		0.3045	-5.69E+02				
		0.5278	-5.61E+02				
30%	0.406			1.48E-02	1.60E+01	5.65E+02	4.50%
		0.2842	-5.69E+02				
		0.5472	-5.60E+02				
35%	0.406			2.02E-02	2.53E+01	5.65E+02	4.94%
		0.2648	-5.70E+02				
		0.5684	-5.60E+02				
40%	0.406			2.64E-02	3.03E+01	5.65E+02	5.26%
		0.2436	-5.71E+02				

Table B.126 Value of COV (M_{max}) for fixed head long pile with varying COV(B) and lateral load 100kN.

P=100kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	0.00E+00	0.00%
10%	1.65E-03	1.00E+00	0.71%
15%	3.71E-03	2.25E+00	1.24%
20%	6.59E-03	6.25E+00	1.69%
25%	1.03E-02	9.00E+00	2.16%
30%	1.48E-02	1.23E+01	2.58%
35%	2.02E-02	1.24E+01	2.83%
40%	2.64E-02	1.60E+01	3.00%

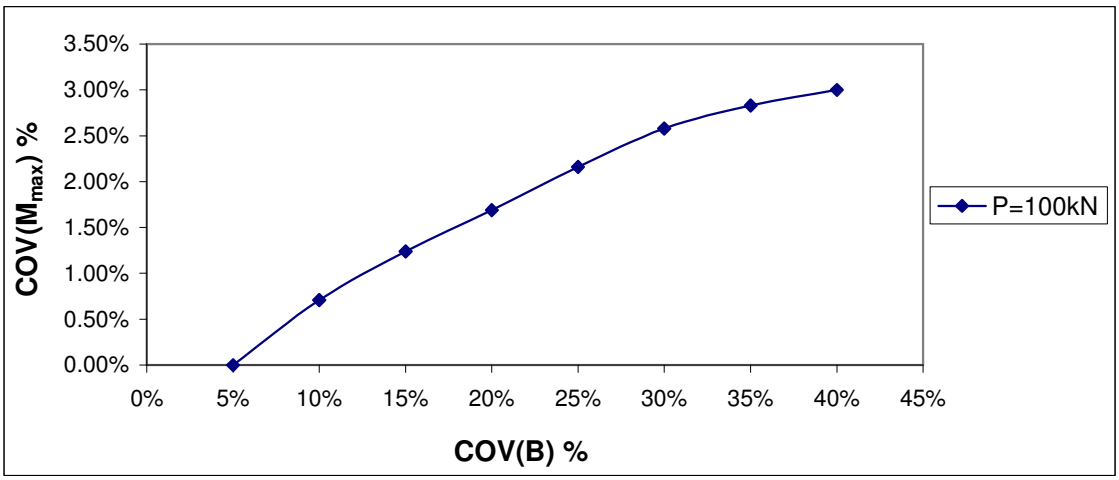


Fig. B.97 Variability of COV (M_{max}) vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.127 Value of COV (M_{max}) for fixed head long pile with varying COV(B) and lateral load 150kN.

P=150kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	0.00E+00	0.00%
10%	1.65E-03	2.50E-01	0.74%
15%	3.71E-03	2.58E-01	1.52%
20%	6.59E-03	1.00E+00	2.17%
25%	1.03E-02	1.65E+00	2.66%
30%	1.48E-02	1.93E+00	3.07%
35%	2.02E-02	2.00E+00	3.56%
40%	2.64E-02	2.25E+00	3.86%

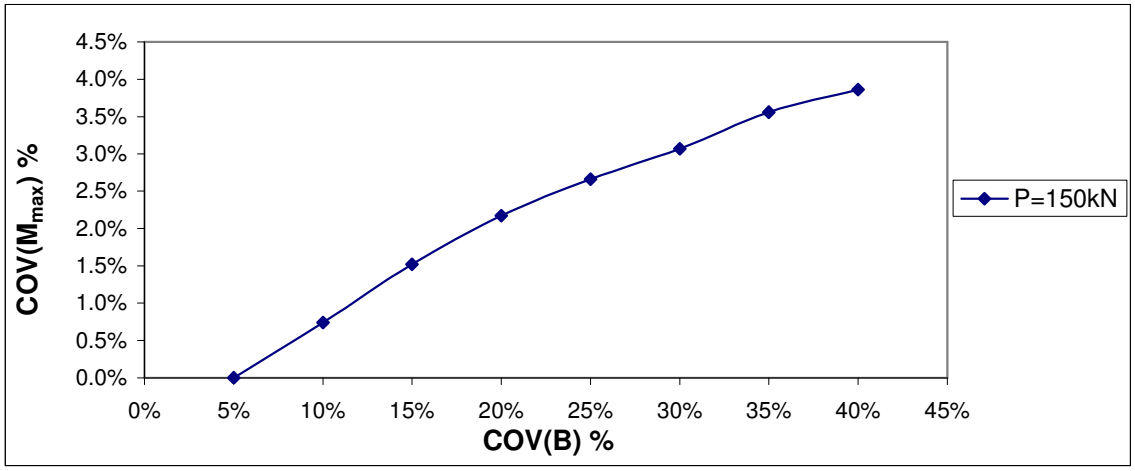


Fig. B.98 Variability of COV (M_{max}) vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.128 Value of COV (M_{max}) for fixed head long pile with varying COV(B) and lateral load 200kN.

P=200kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	0.00E+00	0.00%
10%	1.65E-03	1.00E+00	0.86%
15%	3.71E-03	1.36E+00	1.76%
20%	6.59E-03	2.25E+00	2.47%
25%	1.03E-02	2.89E+00	3.07%
30%	1.48E-02	4.00E+00	3.65%
35%	2.02E-02	4.05E+00	4.02%
40%	2.64E-02	6.25E+00	4.17%

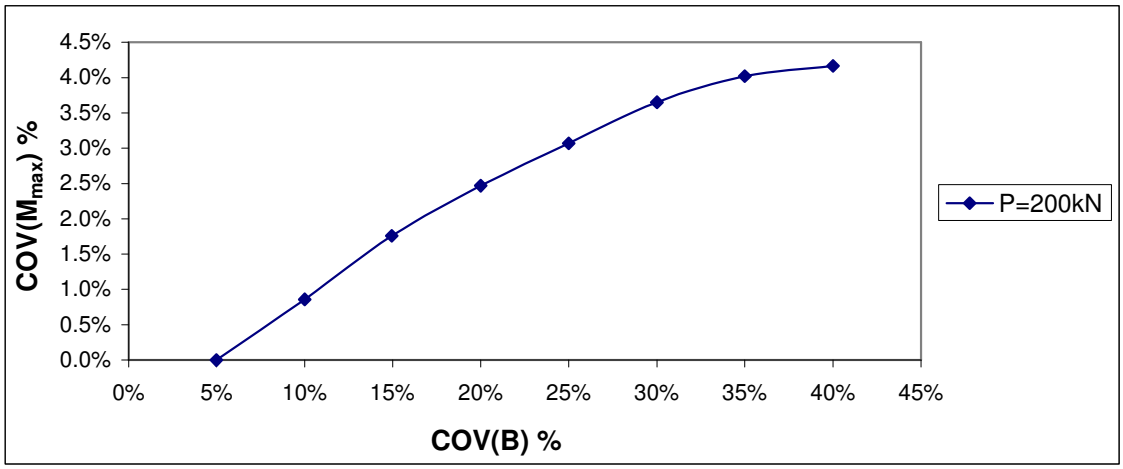


Fig. B.99 Variability of COV (M_{max}) vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.129 Value of COV (M_{max}) for fixed head long pile with varying COV(B) and lateral load 250kN.

P=250kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	0.00E+00	0.00%
10%	1.65E-03	2.50E-01	1.29%
15%	3.71E-03	2.75E-01	2.28%
20%	6.59E-03	2.99E-01	3.06%
25%	1.03E-02	1.00E+00	3.74%
30%	1.48E-02	1.01E+00	4.30%
35%	2.02E-02	1.63E+00	4.67%
40%	2.64E-02	2.25E+00	4.84%

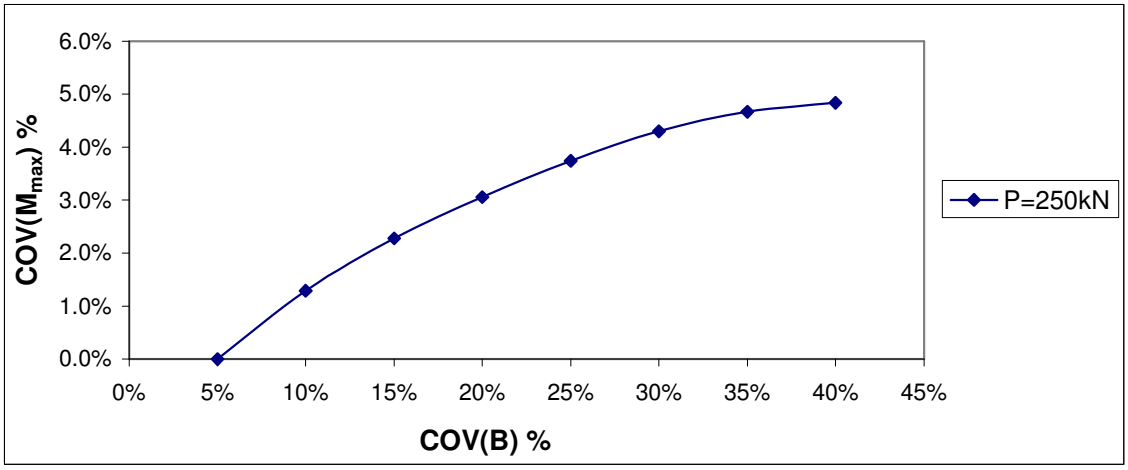


Fig. B.100 Variability of COV (M_{max}) vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.130 Value of COV (M_{max}) for fixed head long pile with varying COV(B) and lateral load 300kN.

P=300kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	0.00E+00	0.00%
10%	1.65E-03	2.25E+00	1.70%
15%	3.71E-03	4.00E+00	2.68%
20%	6.59E-03	9.00E+00	3.44%
25%	1.03E-02	1.23E+01	4.03%
30%	1.48E-02	1.60E+01	4.50%
35%	2.02E-02	2.53E+01	4.94%
40%	2.64E-02	3.03E+01	5.26%

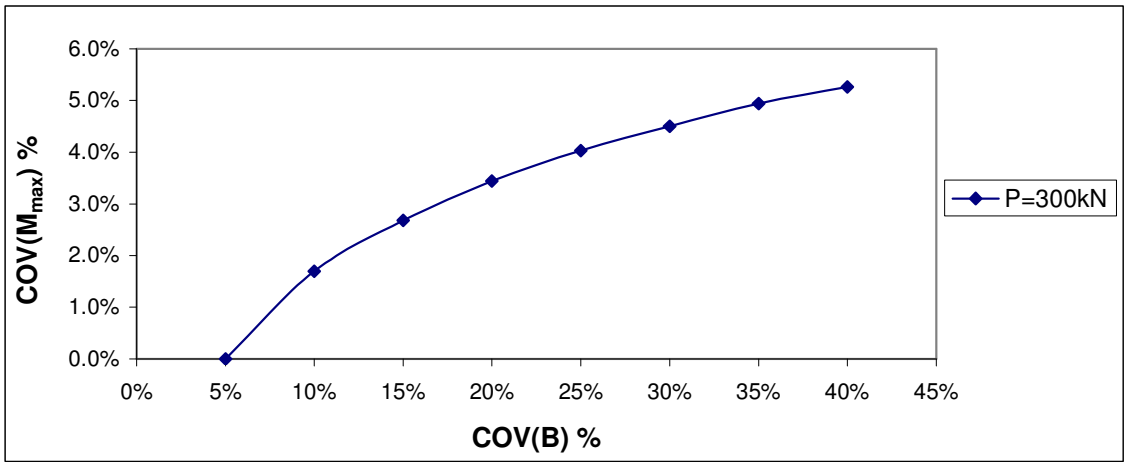


Fig. B.101 Variability of COV (M_{max}) vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 300kN.

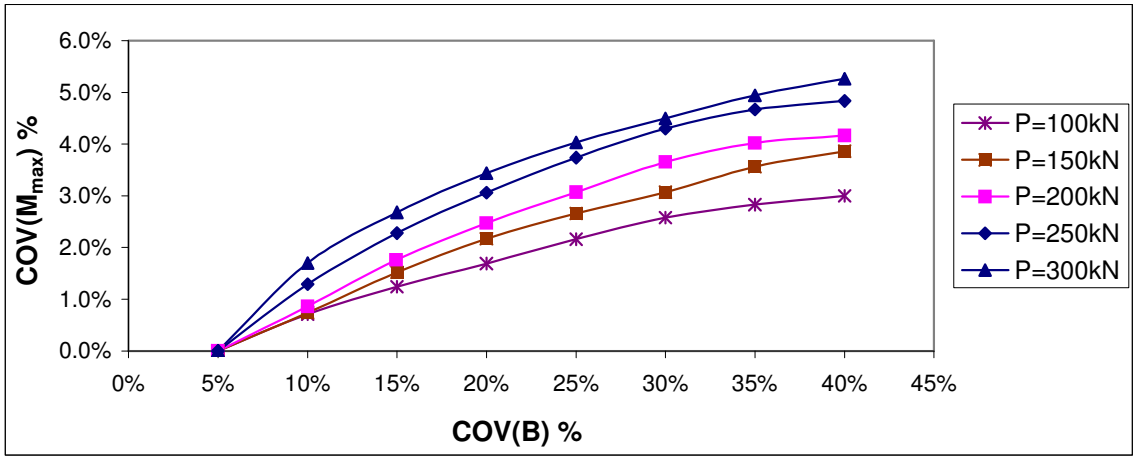


Fig. B.102 Variability of COV (M_{max}) vs. COV (B) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.131 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (EI) and load 100kN.

P=100kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		64050	-1.58E+02				
5%	61000			9.30E+06	1.00E+00	1.57E+02	0.18%
		57950	-1.56E+02				
		67100	-1.59E+02				
10%	61000			3.72E+07	4.00E+00	1.57E+02	0.57%
		54900	-1.55E+02				
		70150	-1.65E+02				
15%	61000			8.37E+07	4.23E+01	1.57E+02	1.15%
		51850	-1.54E+02				
		73200	-1.65E+02				
20%	61000			1.49E+08	1.16E+02	1.57E+02	1.58%
		48800	-1.47E+02				
		76250	-1.66E+02				
25%	61000			2.33E+08	1.29E+02	1.57E+02	1.92%
		45750	-1.46E+02				
		79300	-1.67E+02				
30%	61000			3.35E+08	1.69E+02	1.57E+02	2.23%
		42700	-1.45E+02				
		82350	-1.68E+02				
35%	61000			4.56E+08	1.89E+02	1.57E+02	2.43%
		39650	-1.44E+02				
		85400	-1.68E+02				
40%	61000			5.95E+08	2.18E+02	1.57E+02	2.61%
		36600	-1.43E+02				

Table B.132 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (EI) and load 150kN.

P=150kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		64050	-2.54E+02				
5%	61000			9.30E+06	1.00E+00	2.53E+02	0.22%
		57950	-2.52E+02				
		67100	-2.56E+02				
10%	61000			3.72E+07	4.00E+00	2.53E+02	0.62%
		54900	-2.50E+02				
		70150	-2.65E+02				
15%	61000			8.37E+07	4.90E+01	2.53E+02	1.54%
		51850	-2.48E+02				
		73200	-2.67E+02				
20%	61000			1.49E+08	1.27E+02	2.53E+02	2.11%
		48800	-2.35E+02				
		76250	-2.68E+02				
25%	61000			2.33E+08	1.33E+02	2.53E+02	2.59%
		45750	-2.34E+02				
		79300	-2.69E+02				
30%	61000			3.35E+08	1.76E+02	2.53E+02	2.86%
		42700	-2.32E+02				
		82350	-2.70E+02				
35%	61000			4.56E+08	1.96E+02	2.53E+02	3.08%
		39650	-2.30E+02				
		85400	-2.71E+02				
40%	61000			5.95E+08	2.25E+02	2.53E+02	3.30%
		36600	-2.28E+02				

Table B.133 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (EI) and load 200kN.

P=200kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN-m^2)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		64050	-3.53E+02				
5%	61000			9.30E+06	1.00E+00	3.51E+02	0.28%
		57950	-3.49E+02				
		67100	-3.55E+02				
10%	61000			3.72E+07	4.00E+00	3.51E+02	0.78%
		54900	-3.47E+02				
		70150	-3.68E+02				
15%	61000			8.37E+07	3.60E+01	3.51E+02	1.71%
		51850	-3.44E+02				
		73200	-3.70E+02				
20%	61000			1.49E+08	1.05E+02	3.51E+02	2.44%
		48800	-3.29E+02				
		76250	-3.72E+02				
25%	61000			2.33E+08	1.17E+02	3.51E+02	2.88%
		45750	-3.27E+02				
		79300	-3.74E+02				
30%	61000			3.35E+08	1.44E+02	3.51E+02	3.30%
		42700	-3.26E+02				
		82350	-3.75E+02				
35%	61000			4.56E+08	1.62E+02	3.51E+02	3.63%
		39650	-3.24E+02				
		85400	-3.77E+02				
40%	61000			5.95E+08	1.89E+02	3.51E+02	3.85%
		36600	-3.22E+02				

Table B.134 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (EI) and load 250kN.

P=250kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN-m^2)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		64050	-4.56E+02				
5%	61000			9.30E+06	2.50E-01	4.54E+02	0.32%
		57950	-4.52E+02				
		67100	-4.58E+02				
10%	61000			3.72E+07	1.00E+00	4.54E+02	0.86%
		54900	-4.50E+02				
		70150	-4.75E+02				
15%	61000			8.37E+07	7.57E+00	4.54E+02	1.91%
		51850	-4.47E+02				
		73200	-4.77E+02				
20%	61000			1.49E+08	1.10E+01	4.54E+02	2.71%
		48800	-4.32E+02				
		76250	-4.79E+02				
25%	61000			2.33E+08	2.03E+01	4.54E+02	3.19%
		45750	-4.31E+02				
		79300	-4.82E+02				
30%	61000			3.35E+08	3.03E+01	4.54E+02	3.50%
		42700	-4.29E+02				
		82350	-4.84E+02				
35%	61000			4.56E+08	3.60E+01	4.54E+02	3.82%
		39650	-4.28E+02				
		85400	-4.86E+02				
40%	61000			5.95E+08	3.91E+01	4.54E+02	3.98%
		36600	-4.26E+02				

Table B.135 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (EI) and load 300kN.

P=300kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		64050	-5.67E+02				
5%	61000			9.30E+06	2.50E-01	5.65E+02	0.30%
		57950	-5.63E+02				
		67100	-5.69E+02				
10%	61000			3.72E+07	2.25E+00	5.65E+02	0.92%
		54900	-5.61E+02				
		70150	-5.85E+02				
15%	61000			8.37E+07	1.81E+01	5.65E+02	1.68%
		51850	-5.59E+02				
		73200	-5.88E+02				
20%	61000			1.49E+08	3.18E+01	5.65E+02	2.88%
		48800	-5.45E+02				
		76250	-5.90E+02				
25%	61000			2.33E+08	6.40E+01	5.65E+02	3.38%
		45750	-5.43E+02				
		79300	-5.93E+02				
30%	61000			3.35E+08	8.56E+01	5.65E+02	3.75%
		42700	-5.41E+02				
		82350	-5.95E+02				
35%	61000			4.56E+08	1.00E+02	5.65E+02	4.04%
		39650	-5.40E+02				
		85400	-5.97E+02				
40%	61000			5.95E+08	1.16E+02	5.65E+02	4.25%
		36600	-5.38E+02				

Table B.136 Value of COV (M_{max}) for fixed head long pile with varying COV(EI) and lateral load 100kN.

P=100kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.00E+00	0.18%
10%	3.72E+07	4.00E+00	0.57%
15%	8.37E+07	4.23E+01	1.15%
20%	1.49E+08	1.16E+02	1.58%
25%	2.33E+08	1.29E+02	1.92%
30%	3.35E+08	1.69E+02	2.23%
35%	4.56E+08	1.89E+02	2.43%
40%	5.95E+08	2.18E+02	2.61%

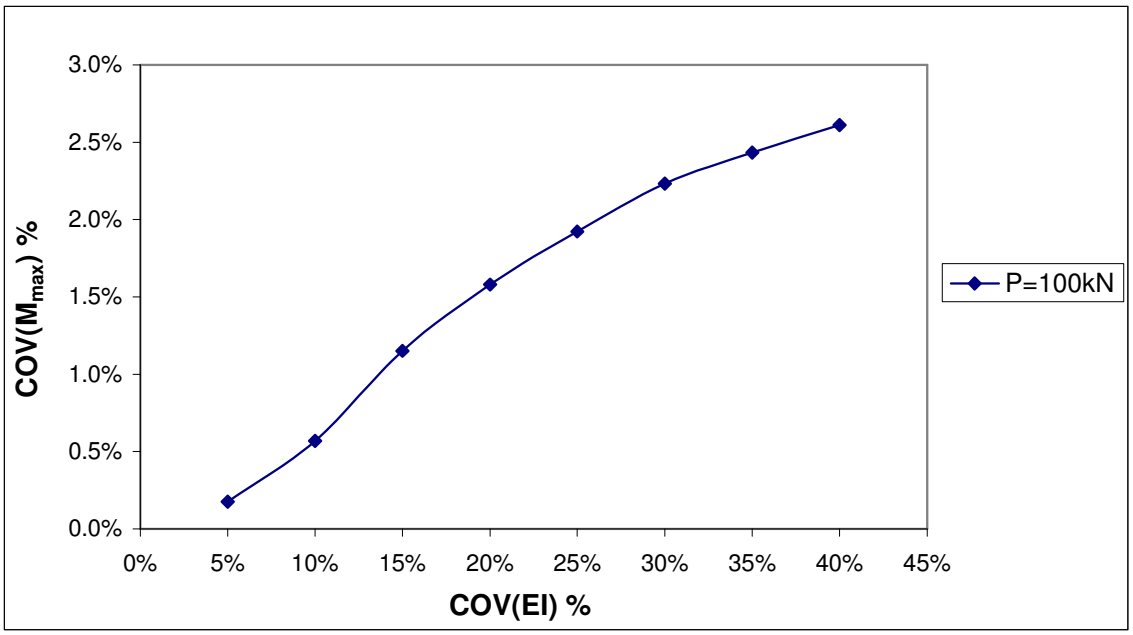


Fig. B.103 Variability of COV (M_{max}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.137 Value of COV (M_{max}) for fixed head long pile with varying COV(EI) and lateral load 150kN.

P=150kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.00E+00	0.22%
10%	3.72E+07	4.00E+00	0.62%
15%	8.37E+07	4.90E+01	1.54%
20%	1.49E+08	1.27E+02	2.11%
25%	2.33E+08	1.33E+02	2.59%
30%	3.35E+08	1.76E+02	2.86%
35%	4.56E+08	1.96E+02	3.08%
40%	5.95E+08	2.25E+02	3.30%

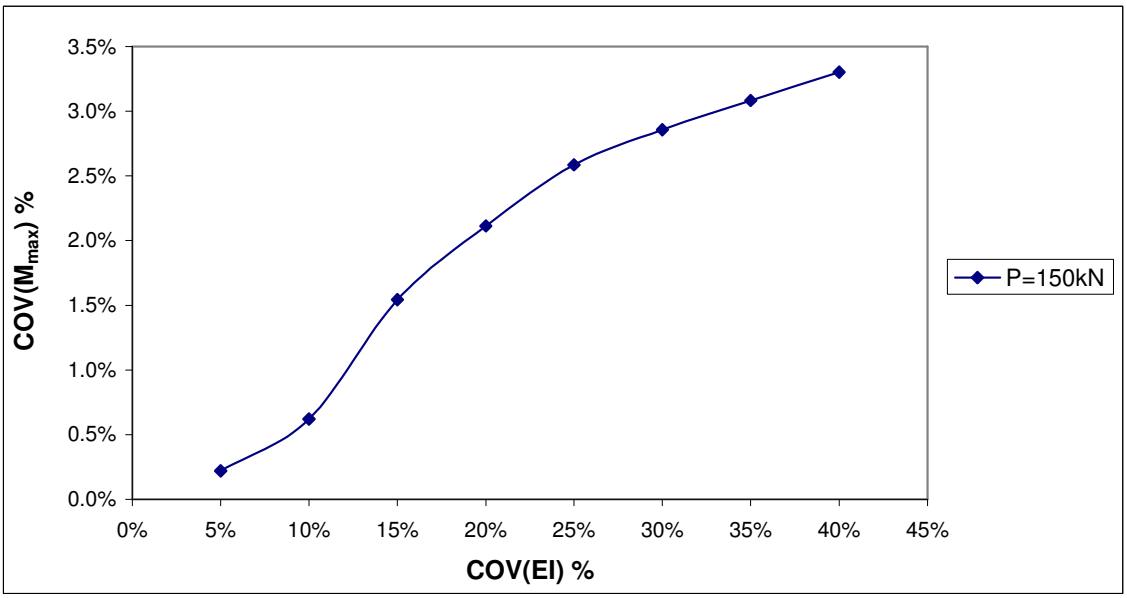


Fig. B.104 Variability of COV (M_{max}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.138 Value of COV (M_{max}) for fixed head long pile with varying COV(EI) and lateral load 200kN.

P=200kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.00E+00	0.28%
10%	3.72E+07	4.00E+00	0.78%
15%	8.37E+07	3.60E+01	1.71%
20%	1.49E+08	1.05E+02	2.44%
25%	2.33E+08	1.17E+02	2.88%
30%	3.35E+08	1.44E+02	3.30%
35%	4.56E+08	1.62E+02	3.63%
40%	5.95E+08	1.89E+02	3.85%

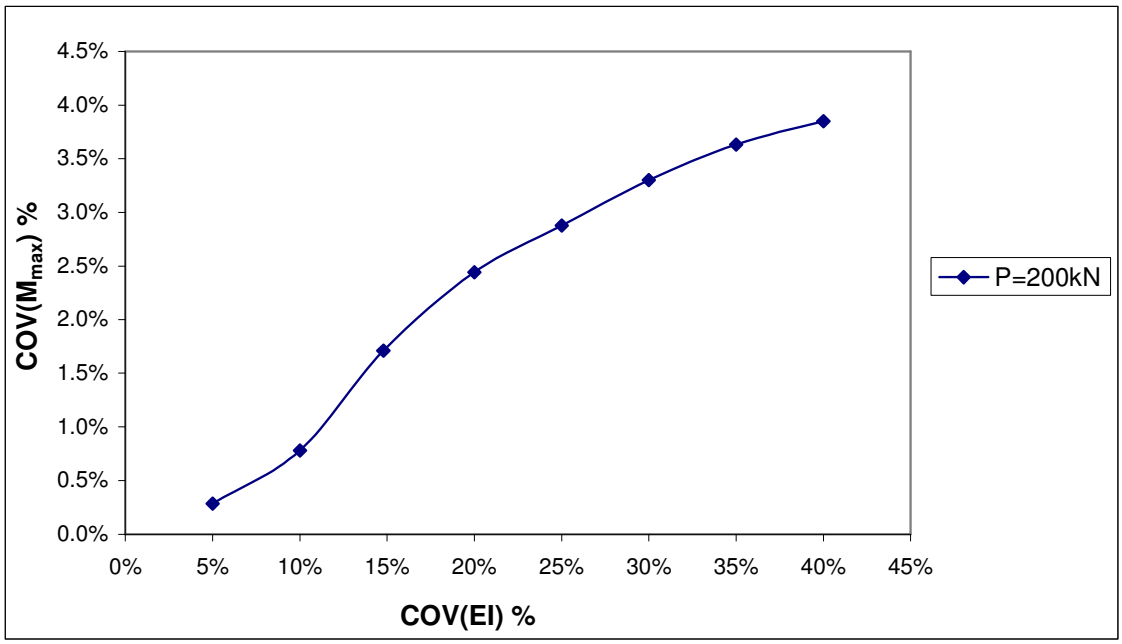


Fig. B.105 Variability of COV (M_{max}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.139 Value of COV (M_{max}) for fixed head long pile with varying COV(EI) and lateral load 250kN.

P=250kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	2.50E-01	0.32%
10%	3.72E+07	1.00E+00	0.86%
15%	8.37E+07	7.57E+00	1.91%
20%	1.49E+08	1.10E+01	2.71%
25%	2.33E+08	2.03E+01	3.19%
30%	3.35E+08	3.03E+01	3.50%
35%	4.56E+08	3.60E+01	3.82%
40%	5.95E+08	3.91E+01	3.98%

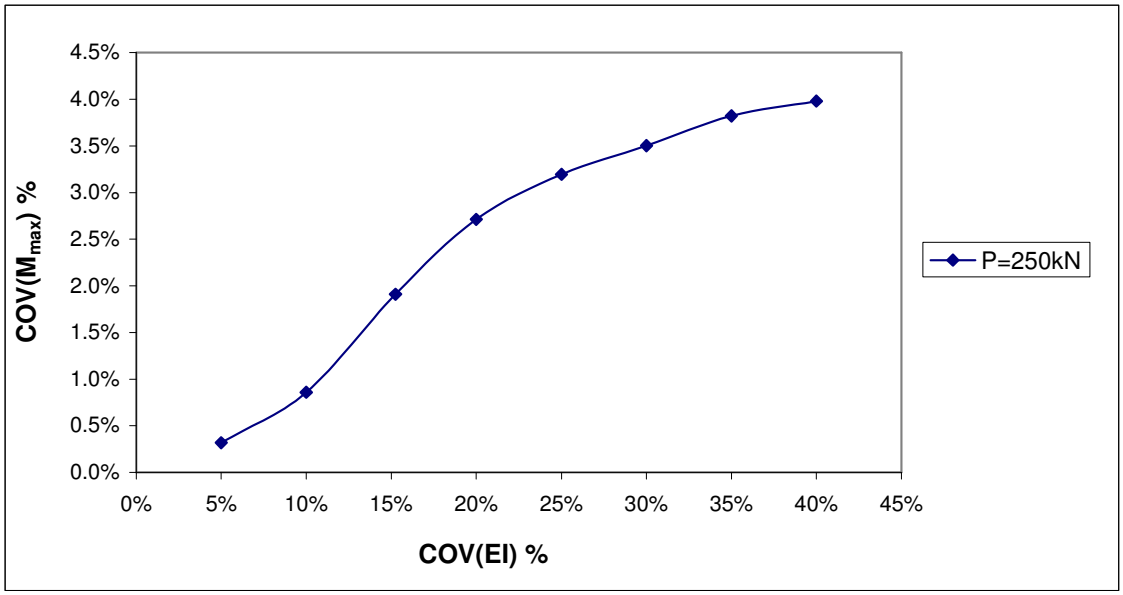


Fig. B.106 Variability of COV (M_{max}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.140 Value of COV (M_{max}) for fixed head long pile with varying COV(EI) and lateral load 300kN.

P=300kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	2.50E-01	0.30%
10%	3.72E+07	2.25E+00	0.92%
15%	8.37E+07	1.81E+01	1.68%
20%	1.49E+08	3.18E+01	2.88%
25%	2.33E+08	6.40E+01	3.38%
30%	3.35E+08	8.56E+01	3.75%
35%	4.56E+08	1.00E+02	4.04%
40%	5.95E+08	1.16E+02	4.25%

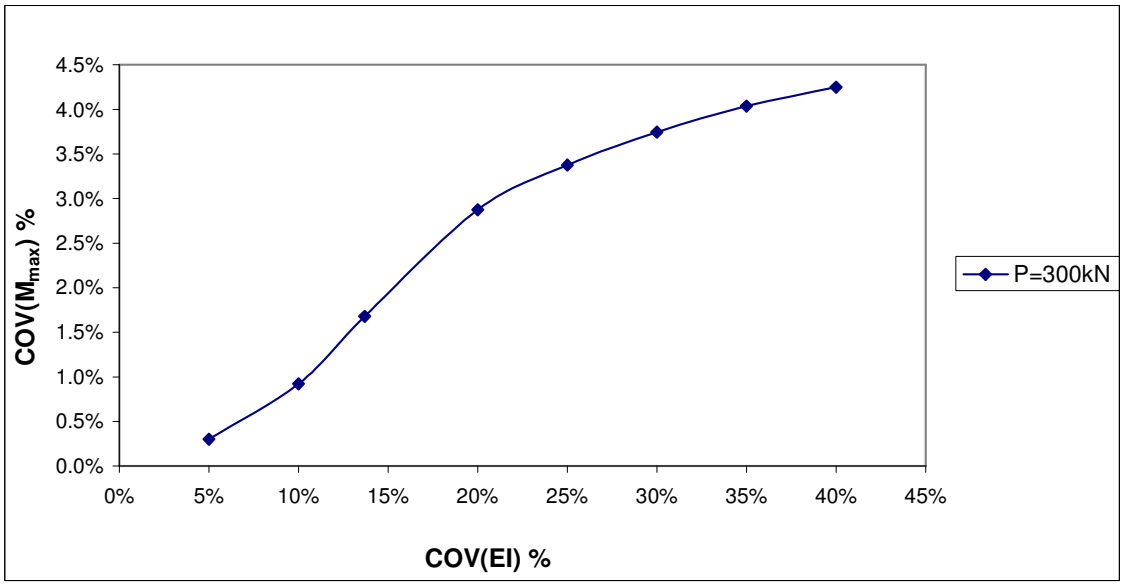


Fig. B.107 Variability of COV (M_{max}) vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 300kN.

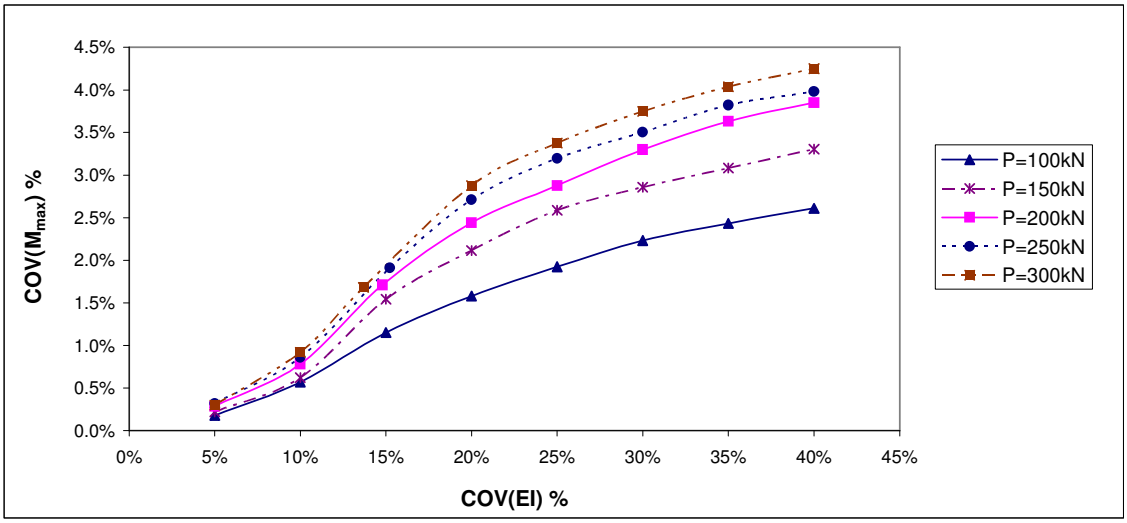


Fig.B.108 Variability of COV(M_{max}) vs. COV(EI) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.141 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (P) and load 100kN.

P=100kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		105	-1.67E+02				
5%	100			2.50E+01	9.03E+01	1.57E+02	6.05%
		95	-1.48E+02				
		110	-1.76E+02				
10%	100			1.00E+02	3.42E+02	1.57E+02	11.78%
		90	-1.39E+02				
		115	-1.85E+02				
15%	100			2.25E+02	7.56E+02	1.57E+02	17.52%
		85	-1.30E+02				
		120	-1.95E+02				
20%	100			4.00E+02	1.37E+03	1.57E+02	22.90%
		80	-1.21E+02				
		125	-2.04E+02				
25%	100			6.25E+02	2.12E+03	1.57E+02	28.30%
		75	-1.12E+02				
		130	-2.14E+02				
30%	100			9.00E+02	3.08E+03	1.57E+02	34.00%
		70	-1.03E+02				
		135	-2.23E+02				
35%	100			1.23E+03	4.14E+03	1.57E+02	39.80%
		65	-9.43E+01				
		140	-2.33E+02				
40%	100			1.60E+03	5.45E+03	1.57E+02	45.40%
		60	-8.53E+01				

Table B.142 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (P) and load 150kN.

P=150kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		157.5	-2.68E+02				
5%	150			5.63E+01	2.10E+02	2.53E+02	5.73%
		142.5	-2.39E+02				
		165	-2.82E+02				
10%	150			2.25E+02	8.41E+02	2.53E+02	11.46%
		135	-2.24E+02				
		172.5	-2.97E+02				
15%	150			5.06E+02	1.89E+03	2.53E+02	17.19%
		127.5	-2.10E+02				
		180	-3.12E+02				
20%	150			9.00E+02	3.42E+03	2.53E+02	23.12%
		120	-1.95E+02				
		187.5	-3.26E+02				
25%	150			1.41E+03	5.26E+03	2.53E+02	28.66%
		112.5	-1.81E+02				
		195	-3.41E+02				
30%	150			2.03E+03	7.57E+03	2.53E+02	34.39%
		105	-1.67E+02				
		202.5	-3.56E+02				
35%	150			2.76E+03	1.03E+04	2.53E+02	40.12%
		97.5	-1.53E+02				
		210	-3.71E+02				
40%	150			3.60E+03	1.35E+04	2.53E+02	45.85%
		90	-1.39E+02				

Table B.143 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (P) and load 200kN.

P=200kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		210	-3.71E+02				
5%	200			1.00E+02	4.00E+02	3.51E+02	5.70%
		190	-3.31E+02				
		220	-3.91E+02				
10%	200			4.00E+02	1.60E+03	3.51E+02	11.40%
		180	-3.11E+02				
		230	-4.12E+02				
15%	200			9.00E+02	3.60E+03	3.51E+02	17.09%
		170	-2.92E+02				
		240	-4.32E+02				
20%	200			1.60E+03	6.40E+03	3.51E+02	22.79%
		160	-2.72E+02				
		250	-4.54E+02				
25%	200			2.50E+03	8.28E+03	3.51E+02	28.70%
		150	-2.72E+02				
		260	-4.76E+02				
30%	200			3.60E+03	1.48E+04	3.51E+02	34.62%
		140	-2.33E+02				
		270	-4.97E+02				
35%	200			4.90E+03	2.00E+04	3.51E+02	40.31%
		130	-2.14E+02				
		280	-5.20E+02				
40%	200			6.40E+03	2.64E+04	3.51E+02	46.30%
		120	-1.95E+02				

Table B.144 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (P) and load 250kN.

P=250kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		262.5	-4.82E+02				
5%	250			1.56E+02	7.29E+02	4.54E+02	5.95%
		237.5	-4.28E+02				
		275	-5.09E+02				
10%	250			6.25E+02	2.86E+03	4.54E+02	11.78%
		225	-4.02E+02				
		287.5	-5.37E+02				
15%	250			1.41E+03	6.48E+03	4.54E+02	17.73%
		212.5	-3.76E+02				
		300	-5.65E+02				
20%	250			2.50E+03	1.14E+04	4.54E+02	23.57%
		200	-3.51E+02				
		312.5	-5.94E+02				
25%	250			3.91E+03	1.80E+04	4.54E+02	29.52%
		187.5	-3.26E+02				
		325	-6.23E+02				
30%	250			5.63E+03	2.58E+04	4.54E+02	35.35%
		175	-3.02E+02				
		337.5	-6.53E+02				
35%	250			7.66E+03	3.53E+04	4.54E+02	41.41%
		162.5	-2.77E+02				
		350	-6.84E+02				
40%	250			1.00E+04	4.64E+04	4.54E+02	47.47%
		150	-2.53E+02				

Table B.145 Probabilistic modeling of laterally loaded fixed head long pile 10T with varying (P) and load 300kN.

P=300kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		315	-6.00E+02				
5%	300			2.25E+02	1.19E+03	5.65E+02	6.11%
		285	-5.31E+02				
		330	-6.35E+02				
10%	300			9.00E+02	4.76E+03	5.65E+02	12.21%
		270	-4.97E+02				
		345	-6.71E+02				
15%	300			2.03E+03	1.06E+04	5.65E+02	18.23%
		255	-4.65E+02				
		360	-7.08E+02				
20%	300			3.60E+03	1.90E+04	5.65E+02	24.42%
		240	-4.32E+02				
		375	-7.45E+02				
25%	300			5.63E+03	2.96E+04	5.65E+02	30.44%
		225	-4.01E+02				
		390	-7.83E+02				
30%	300			8.10E+03	4.24E+04	5.65E+02	36.46%
		210	-3.71E+02				
		405	-8.22E+02				
35%	300			1.10E+04	5.78E+04	5.65E+02	42.57%
		195	-3.41E+02				
		420	-8.60E+02				
40%	300			1.44E+04	7.54E+04	5.65E+02	48.58%
		180	-3.11E+02				

Table B.146 Value of COV (M_{max}) for fixed head long pile with varying COV(P) and lateral load 100kN.

P=100kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.50E+01	9.03E+01	6.05%
10%	1.00E+02	3.42E+02	11.78%
15%	2.25E+02	7.56E+02	17.52%
20%	4.00E+02	1.37E+03	22.90%
25%	6.25E+02	2.12E+03	28.30%
30%	9.00E+02	3.08E+03	34.00%
35%	1.23E+03	4.14E+03	39.80%
40%	1.60E+03	5.45E+03	45.40%

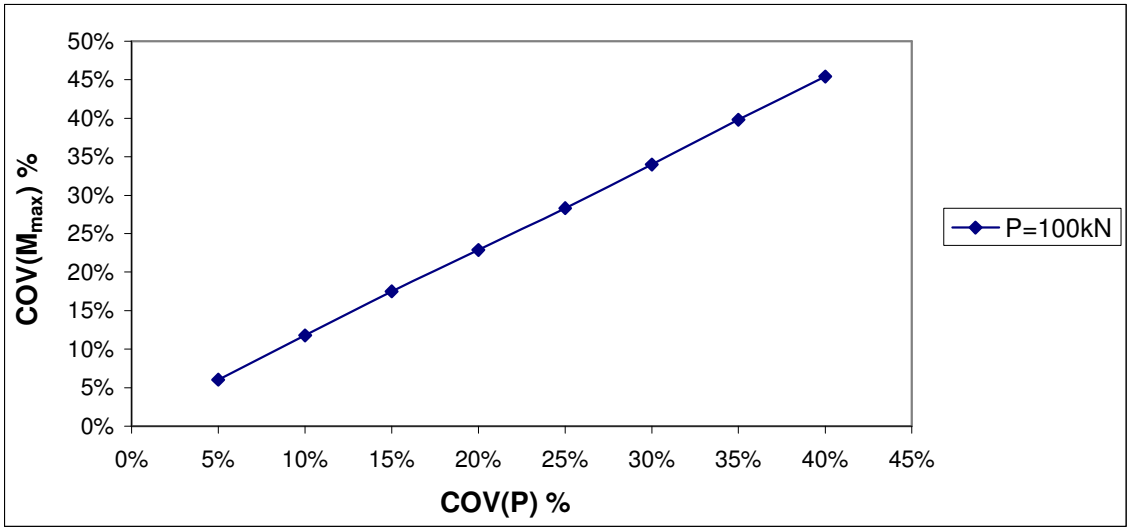


Fig. B.109 Variability of COV (M_{max}) vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.147 Value of COV (M_{max}) for fixed head long pile with varying COV(P) and lateral load 150kN.

P=150kN			
COV(P) (%)	VAR(P) $(kN)^2$	(M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	5.63E+01	2.10E+02	5.73%
10%	2.25E+02	8.41E+02	11.46%
15%	5.06E+02	1.89E+03	17.19%
20%	9.00E+02	3.42E+03	23.12%
25%	1.41E+03	5.26E+03	28.66%
30%	2.03E+03	7.57E+03	34.39%
35%	2.76E+03	1.03E+04	40.12%
40%	3.60E+03	1.35E+04	45.85%

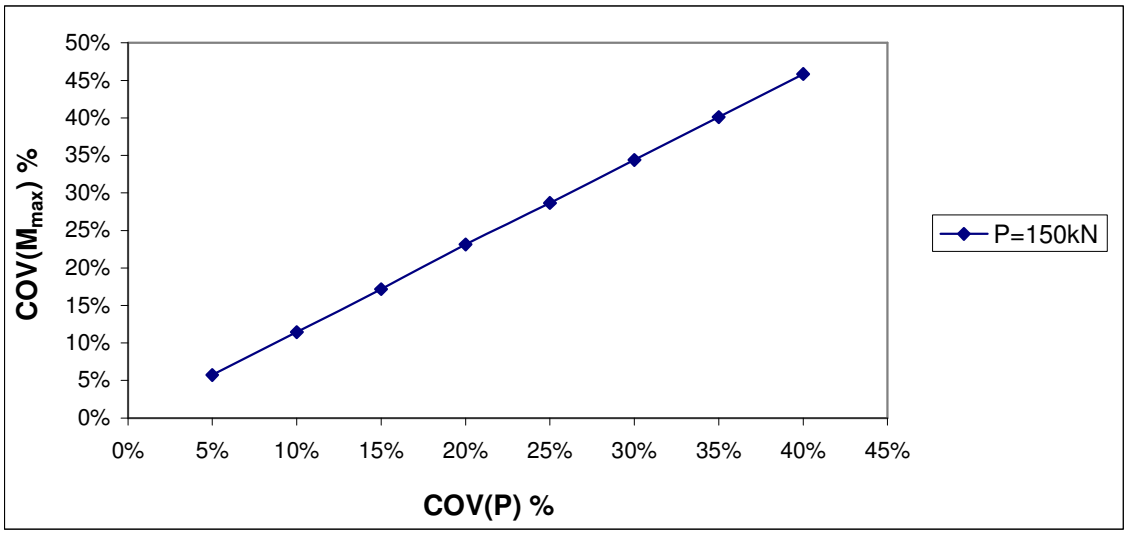


Fig. B.110 Variability of COV (M_{max}) vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.148 Value of COV (M_{max}) for fixed head long pile with varying COV(P) and lateral load 200kN.

P=200kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	1.00E+02	4.00E+02	5.70%
10%	4.00E+02	1.60E+03	11.40%
15%	9.00E+02	3.60E+03	17.09%
20%	1.60E+03	6.40E+03	22.79%
25%	2.50E+03	8.28E+03	28.70%
30%	3.60E+03	1.48E+04	34.62%
35%	4.90E+03	2.00E+04	40.31%
40%	6.40E+03	2.64E+04	46.30%

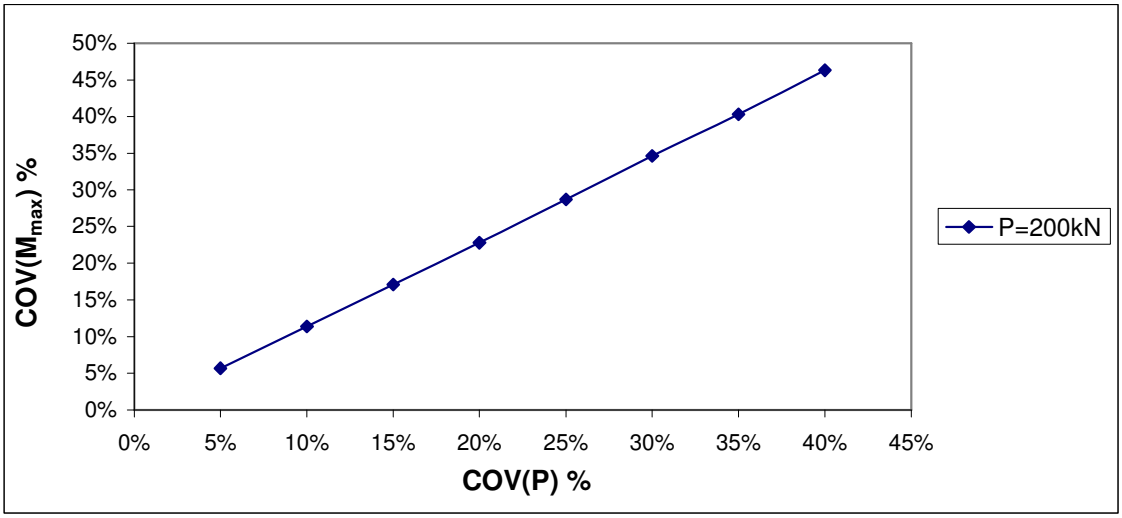


Fig. B.111 Variability of COV (M_{max}) vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.149 Value of COV (M_{max}) for fixed head long pile with varying COV(P) and lateral load 250kN.

P=250kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	1.56E+02	7.29E+02	5.95%
10%	6.25E+02	2.86E+03	11.78%
15%	1.41E+03	6.48E+03	17.73%
20%	2.50E+03	1.14E+04	23.57%
25%	3.91E+03	1.80E+04	29.52%
30%	5.63E+03	2.58E+04	35.35%
35%	7.66E+03	3.53E+04	41.41%
40%	1.00E+04	4.64E+04	47.47%

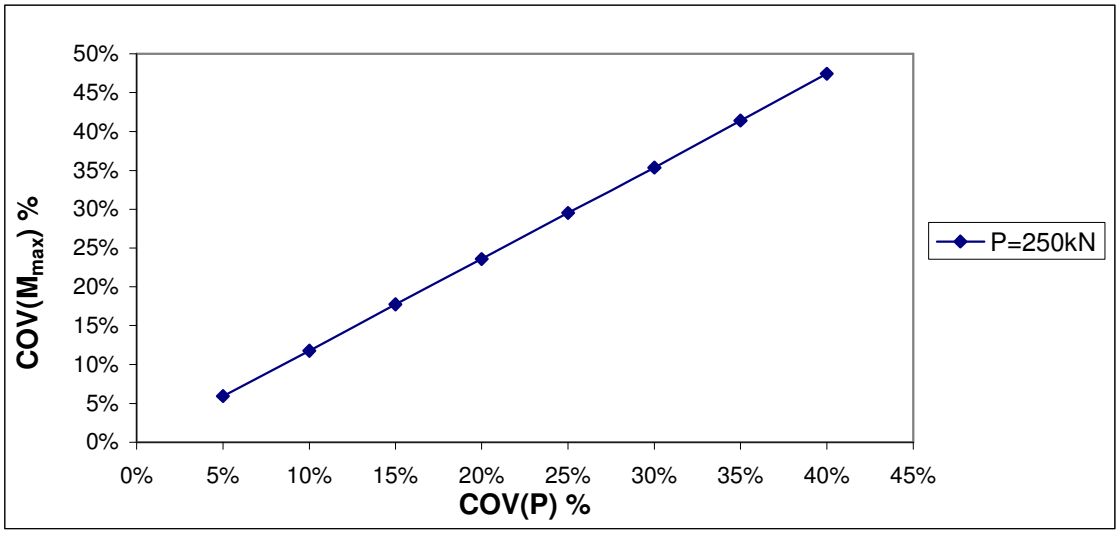


Fig. B.112 Variability of COV (M_{max}) vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.150 Value of COV (M_{max}) for fixed head long pile with varying COV(P) and lateral load 300kN.

P=300kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+02	1.19E+03	6.11%
10%	9.00E+02	4.76E+03	12.21%
15%	2.03E+03	1.06E+04	18.23%
20%	3.60E+03	1.90E+04	24.42%
25%	5.63E+03	2.96E+04	30.44%
30%	8.10E+03	4.24E+04	36.46%
35%	1.10E+04	5.78E+04	42.57%
40%	1.44E+04	7.54E+04	48.58%

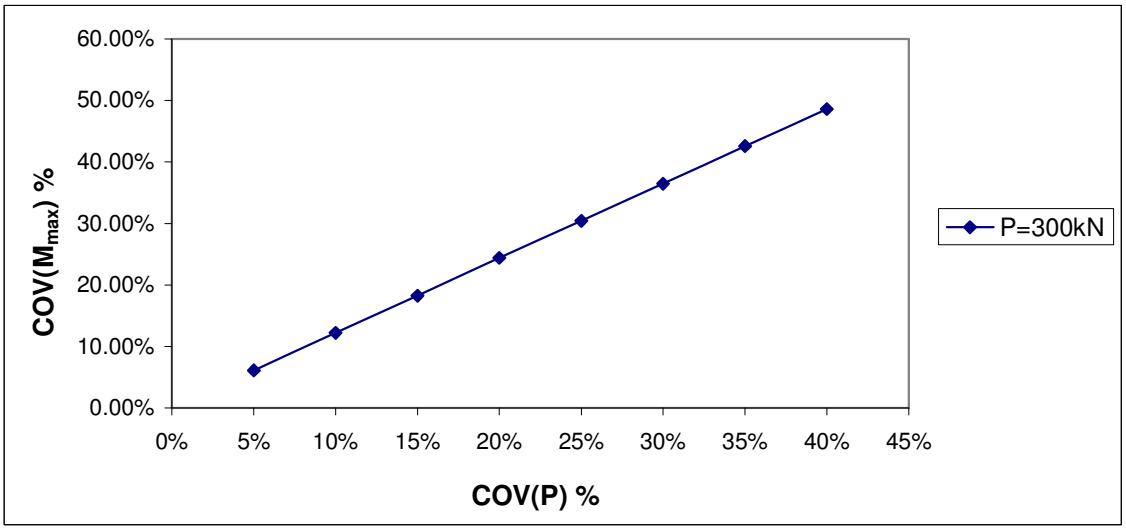


Fig. B.113 Variability of COV (M_{max}) vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 300kN.

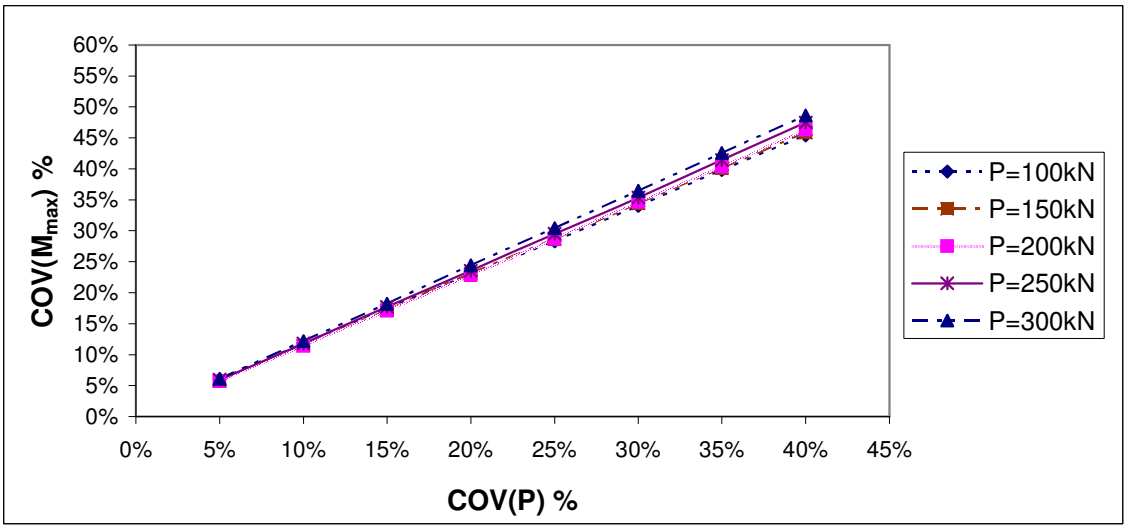


Fig. B.114 Variability of COV(M_{max}) vs. COV(P) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

B.5 Reliability Index (β) of bending moment vs. COV (Variables)

Table B.151 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'Φ' subjected to lateral load 100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
6.25E+00	10696.73	5%	103.4552	5.1472
1.10E+02	10696.73	10%	103.9566	5.1223
2.25E+02	10696.73	15%	104.5071	5.0953
4.20E+02	10696.73	20%	105.4371	5.0504
6.50E+02	10696.73	25%	106.5222	4.9990
9.30E+02	10696.73	30%	107.8285	4.9384
1.30E+03	10696.73	35%	109.5113	4.8625
1.60E+03	10696.73	40%	110.8906	4.8020

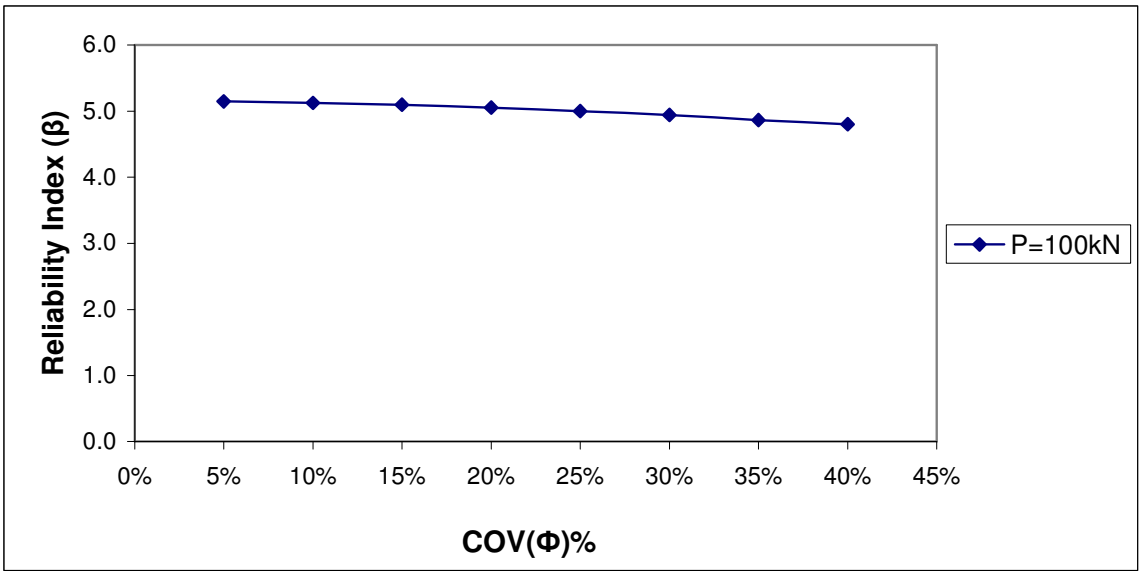


Fig. B.115 Reliability Index (β) of M_{max} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.152 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'Φ' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
5.63E+01	10696.73	5%	103.6966	4.2094
2.40E+02	10696.73	10%	104.5800	4.1738
5.29E+02	10696.73	15%	105.9515	4.1198
9.30E+02	10696.73	20%	107.8285	4.0481
1.48E+03	10696.73	25%	110.3584	3.9553
2.12E+03	10696.73	30%	113.1933	3.8562
3.03E+03	10696.73	35%	117.1398	3.7263
4.16E+03	10696.73	40%	121.8892	3.5811

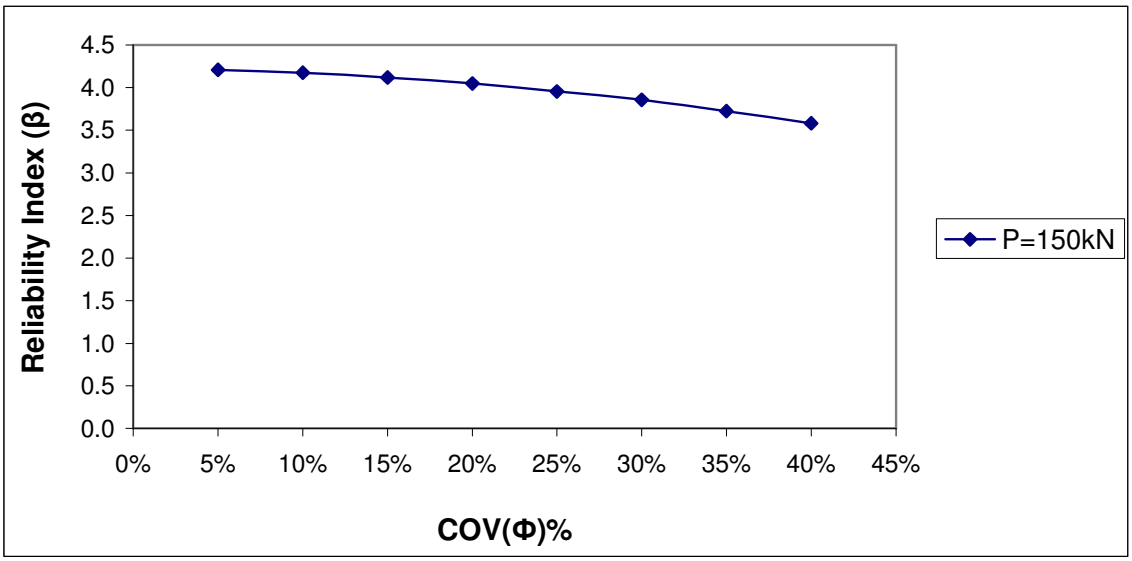


Fig. B.116 Reliability Index (β) of M_{max} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.153 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'Φ' subjected to lateral load 200kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E+01	10696.73	5%	103.5458	3.2691
4.20E+02	10696.73	10%	105.4371	3.2104
9.92E+02	10696.73	15%	108.1156	3.1309
1.81E+03	10696.73	20%	111.8167	3.0273
2.92E+03	10696.73	25%	116.6736	2.9013
4.42E+03	10696.73	30%	122.9593	2.7529
6.40E+03	10696.73	35%	130.7545	2.5888
8.93E+03	10696.73	40%	140.0963	2.4162

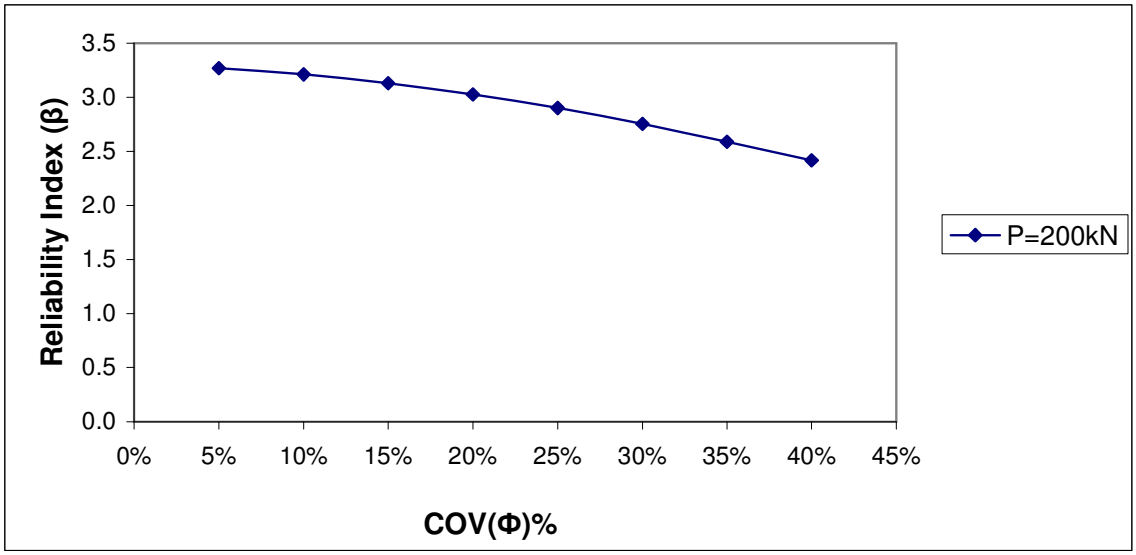


Fig. B.117 Reliability Index (β) of M_{max} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.154 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'Φ' subjected to lateral load 250kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.96E+02	10696.73	5%	104.3682	2.2564
8.12E+02	10696.73	10%	107.2799	2.1952
1.89E+03	10696.73	15%	112.2006	2.0989
3.48E+03	10696.73	20%	119.0703	1.9778
5.55E+03	10696.73	25%	127.4636	1.8476
8.46E+03	10696.73	30%	138.4223	1.7013
1.27E+04	10696.73	35%	152.8168	1.5411
1.76E+04	10696.73	40%	168.0862	1.4011

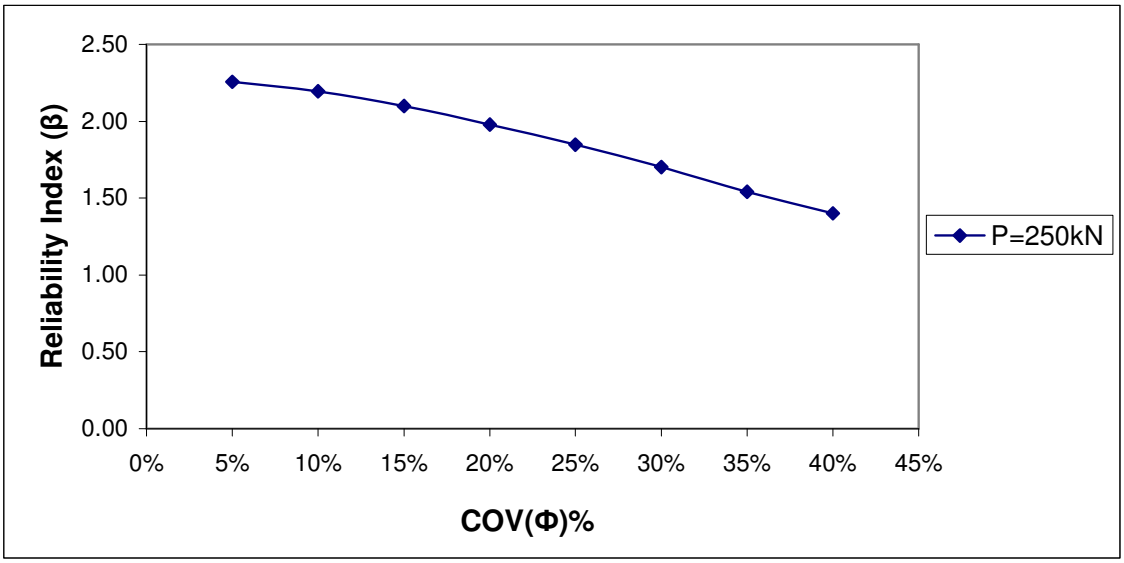


Fig. B.118 Reliability Index (β) of M_{max} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.155 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'Φ' subjected to lateral load 300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
7.23E+01	10696.73	5%	103.7737	1.1997
1.48E+03	10696.73	10%	110.3584	1.1281
3.42E+03	10696.73	15%	118.8233	1.0478
6.24E+03	10696.73	20%	130.1450	0.9566
1.00E+04	10696.73	25%	143.8636	0.8654
1.53E+04	10696.73	30%	161.0869	0.7729
2.22E+04	10696.73	35%	181.3773	0.6864
3.17E+04	10696.73	40%	205.8658	0.6048

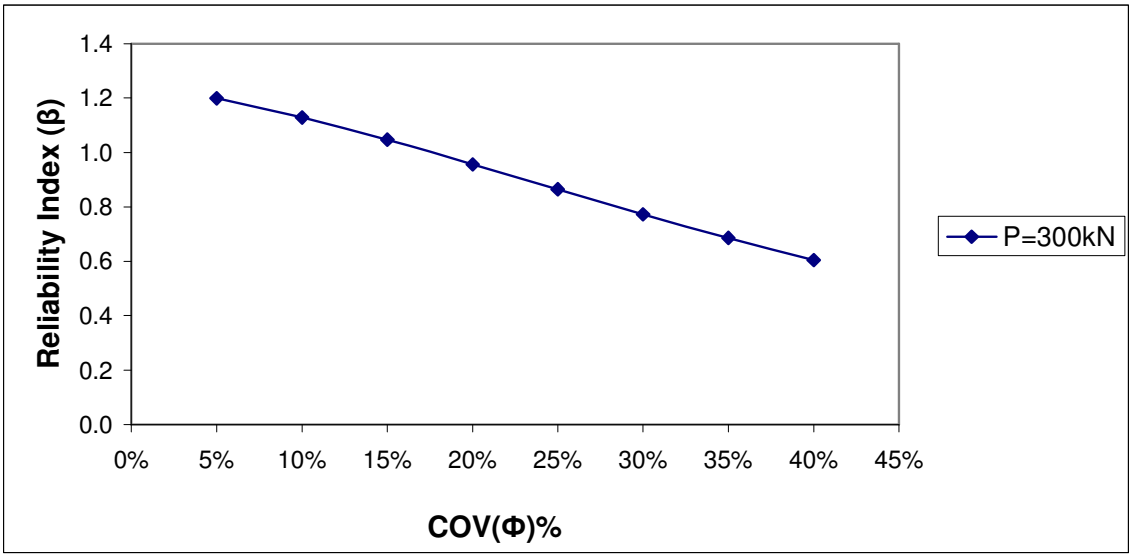


Fig. B.119 Reliability Index (β) of M_{max} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force 300kN.

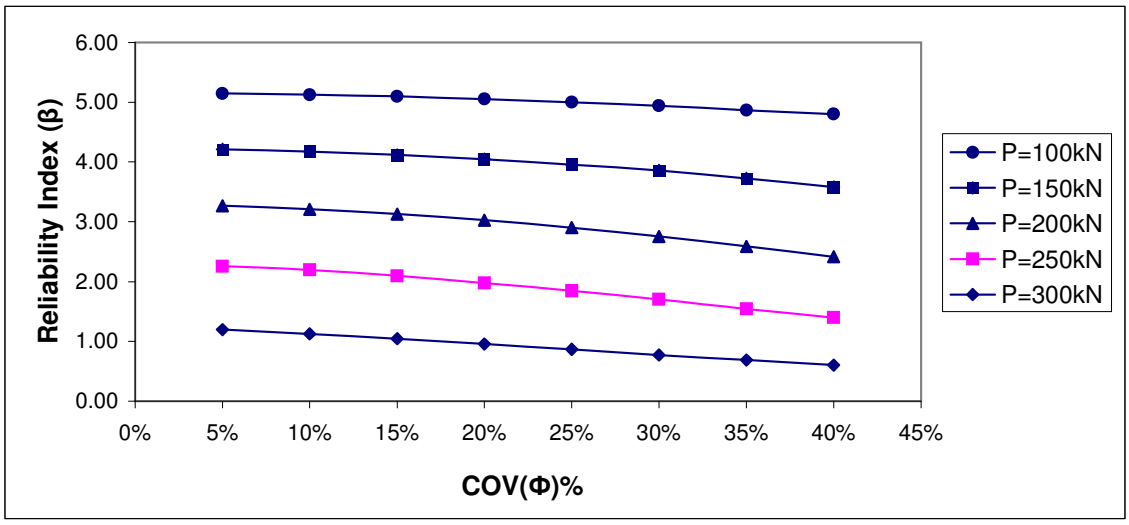


Fig. B.120 Reliability Index (β) of M_{max} vs. COV (Φ) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.156 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'γ' subjected to lateral load 100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
6.25E+00	10696.73	5%	103.4552	5.1472
2.03E+01	10696.73	10%	103.5229	5.1438
4.23E+01	10696.73	15%	103.6291	5.1385
8.10E+01	10696.73	20%	103.8158	5.1293
1.21E+02	10696.73	25%	104.0083	5.1198
1.82E+02	10696.73	30%	104.3024	5.1053
2.72E+02	10696.73	35%	104.7329	5.0844
3.61E+02	10696.73	40%	105.1557	5.0639

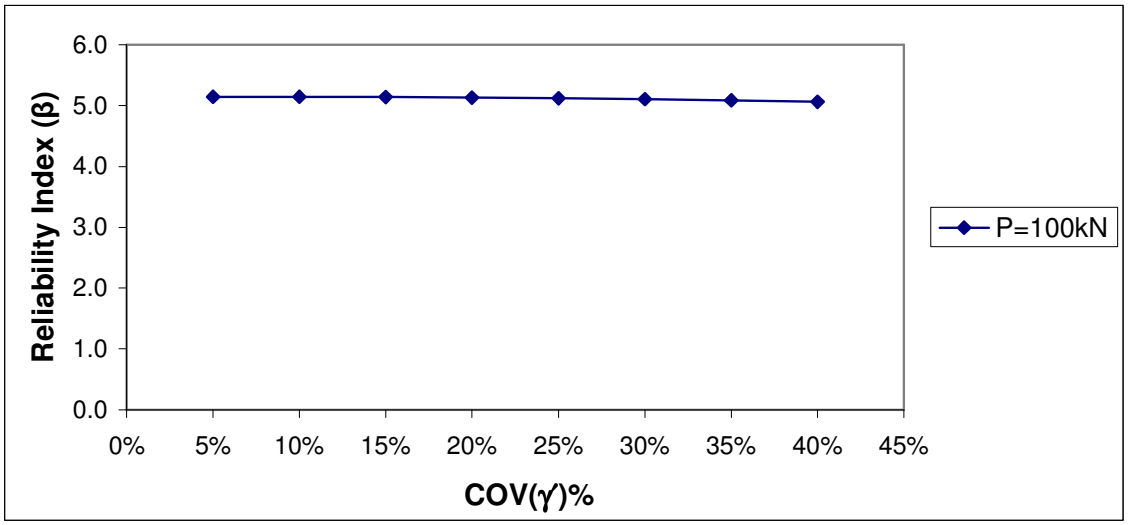


Fig. B.121 Reliability Index (β) of M_{max} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.157 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'γ' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ($M_{max}^{M_1}$) (kN-m)	Reliability Index (β)
9.00E+00	10696.73	5%	103.4685	4.2187
4.23E+01	10696.73	10%	103.6291	4.2121
1.00E+02	10696.73	15%	103.9073	4.2009
1.82E+02	10696.73	20%	104.3024	4.1849
2.72E+02	10696.73	25%	104.7329	4.1677
4.20E+02	10696.73	30%	105.4371	4.1399
5.76E+02	10696.73	35%	106.1731	4.1112
7.56E+02	10696.73	40%	107.0186	4.0787

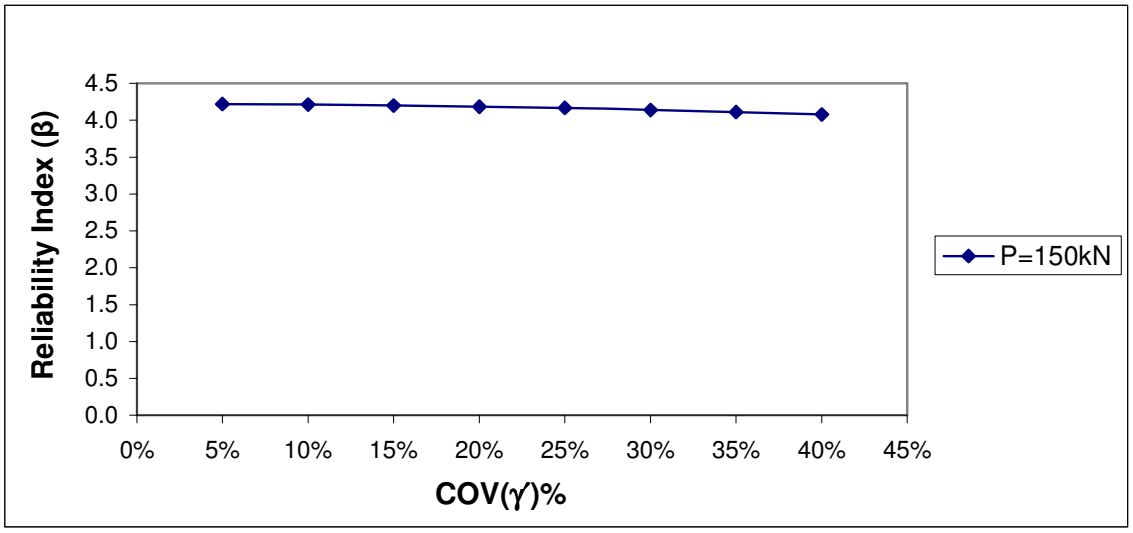


Fig. B.122 Reliability Index (β) of M_{max} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.158 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'γ' subjected to lateral load 200kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
2.03E+01	10696.73	5%	103.5229	3.2698
7.22E+01	10696.73	10%	103.7737	3.2619
1.69E+02	10696.73	15%	104.2388	3.2474
3.24E+02	10696.73	20%	104.9797	3.2244
5.06E+02	10696.73	25%	105.8441	3.1981
7.84E+02	10696.73	30%	107.1482	3.1592
1.12E+03	10696.73	35%	108.7151	3.1136
1.52E+03	10696.73	40%	110.5338	3.0624

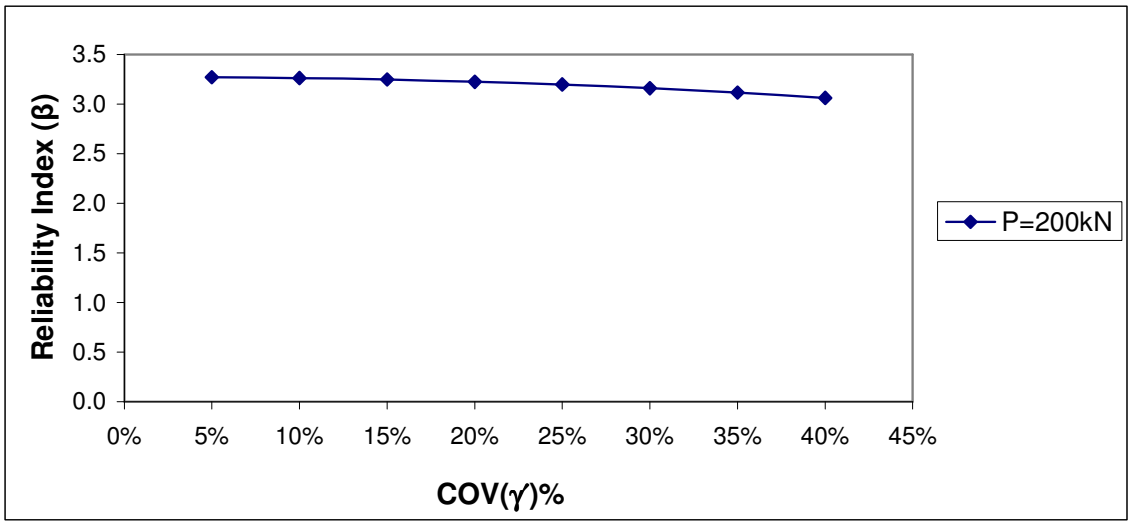


Fig. B.123 Reliability Index (β) of M_{max} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.159 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'γ' subjected to lateral load 250kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
3.60E+01	10696.73	5%	103.5989	2.2732
1.56E+02	10696.73	10%	104.1776	2.2606
3.42E+02	10696.73	15%	105.0666	2.2414
6.25E+02	10696.73	20%	106.4036	2.2133
9.92E+02	10696.73	25%	108.1156	2.1782
1.44E+03	10696.73	30%	110.1850	2.1373
2.12E+03	10696.73	35%	113.1933	2.0805
2.86E+03	10696.73	40%	116.4430	2.0224

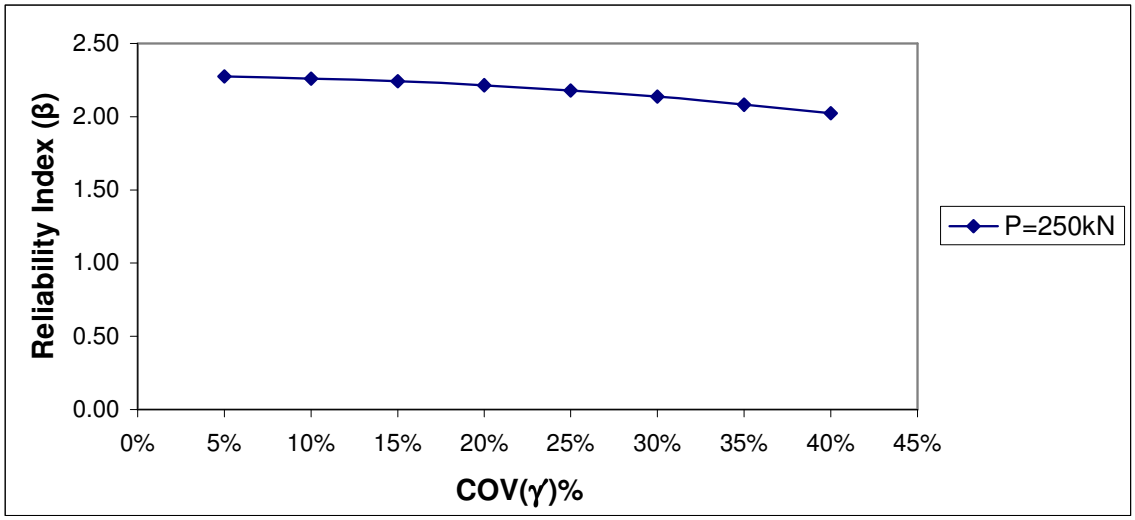


Fig. B.124 Reliability Index (β) of M_{max} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.160 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'γ' subjected to lateral load 300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
6.40E+01	10696.73	5%	103.7339	1.2002
2.72E+02	10696.73	10%	104.7329	1.1887
6.00E+02	10696.73	15%	106.2873	1.1714
1.12E+03	10696.73	20%	108.7151	1.1452
1.81E+03	10696.73	25%	111.8167	1.1134
2.70E+03	10696.73	30%	115.7615	1.0755
3.78E+03	10696.73	35%	120.3286	1.0347
5.18E+03	10696.73	40%	126.0188	0.9879

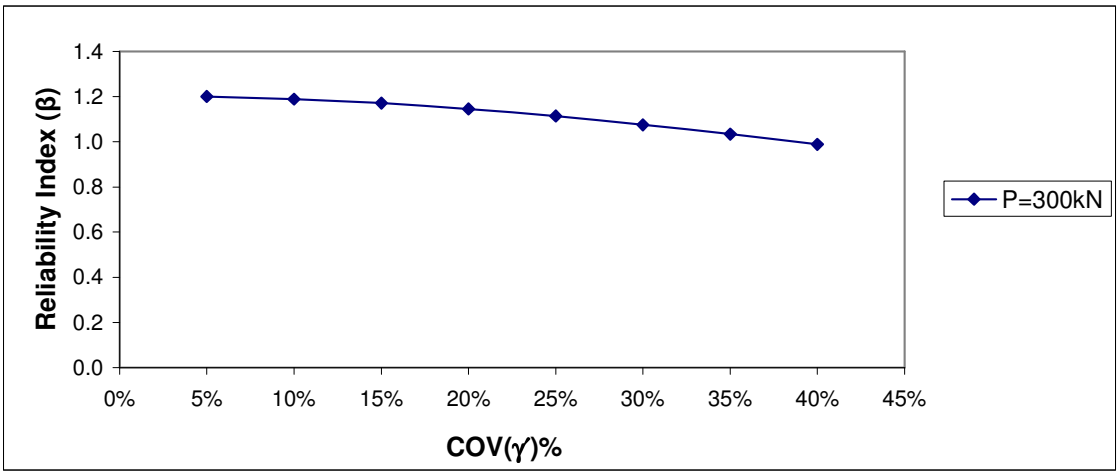


Fig. B.125 Reliability Index (β) of M_{max} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force 300kN.

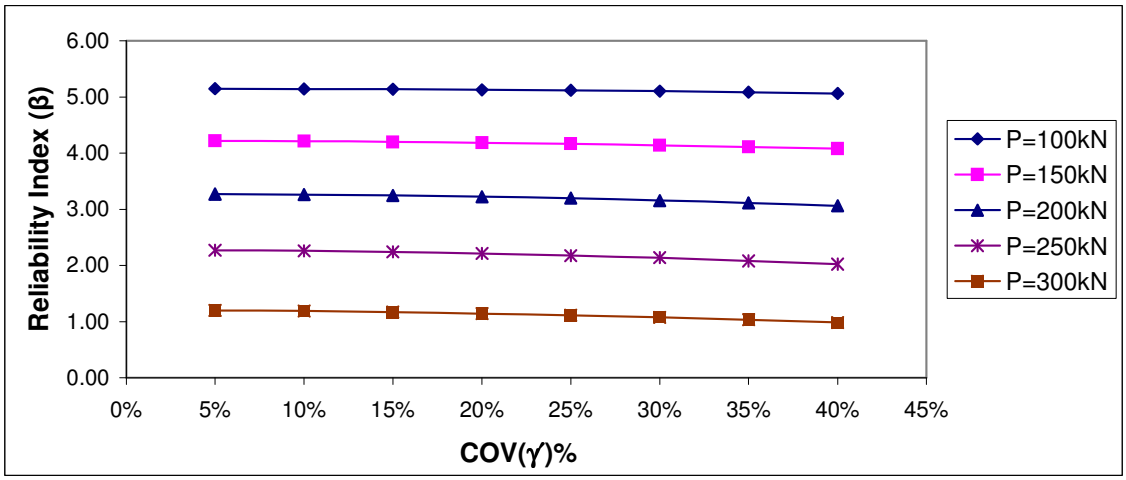


Fig. B.126 Reliability Index (β) of M_{max} vs. COV (γ) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.161 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'k' subjected to lateral load 100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.00E-02	10696.73	5%	103.4251	5.1487
6.50E-02	10696.73	10%	103.4253	5.1487
1.86E-01	10696.73	15%	103.4259	5.1487
2.00E-01	10696.73	20%	103.4260	5.1487
2.50E-01	10696.73	25%	103.4262	5.1486
2.62E-01	10696.73	30%	103.4263	5.1486
2.83E-01	10696.73	35%	103.4264	5.1486
2.94E-01	10696.73	40%	103.4264	5.1486

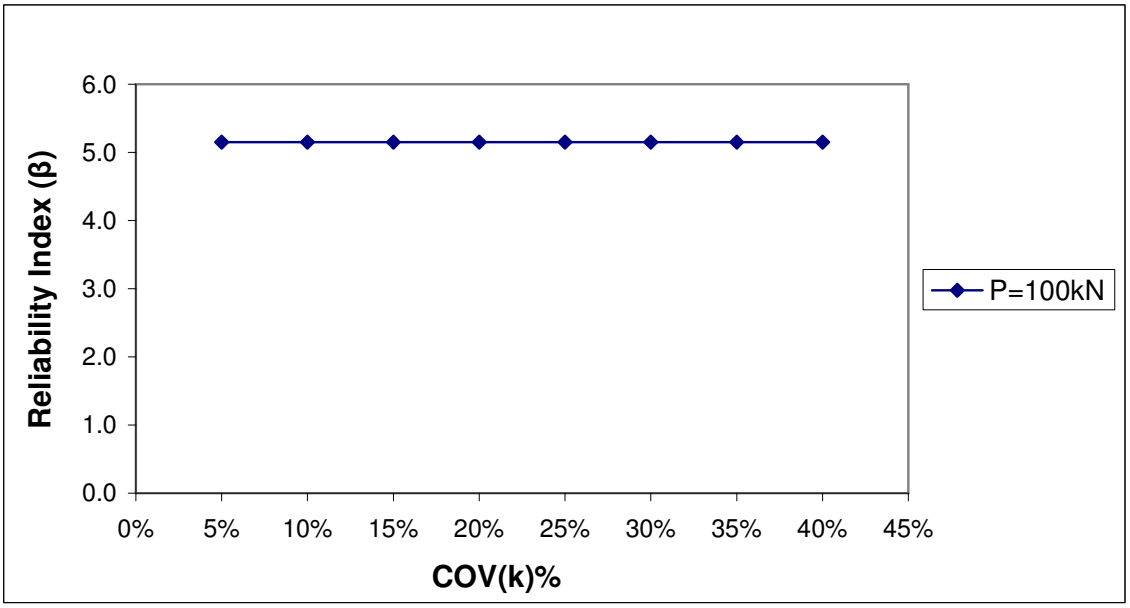


Fig. B.127 Reliability Index (β) of M_{max} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.162 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'k' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.88E-02	10696.73	5%	103.4251	4.2204
3.50E-02	10696.73	10%	103.4252	4.2204
1.35E-01	10696.73	15%	103.4257	4.2204
1.57E-01	10696.73	20%	103.4258	4.2204
2.22E-01	10696.73	25%	103.4261	4.2204
2.42E-01	10696.73	30%	103.4262	4.2204
2.50E-01	10696.73	35%	103.4262	4.2204
2.60E-01	10696.73	40%	103.4263	4.2204

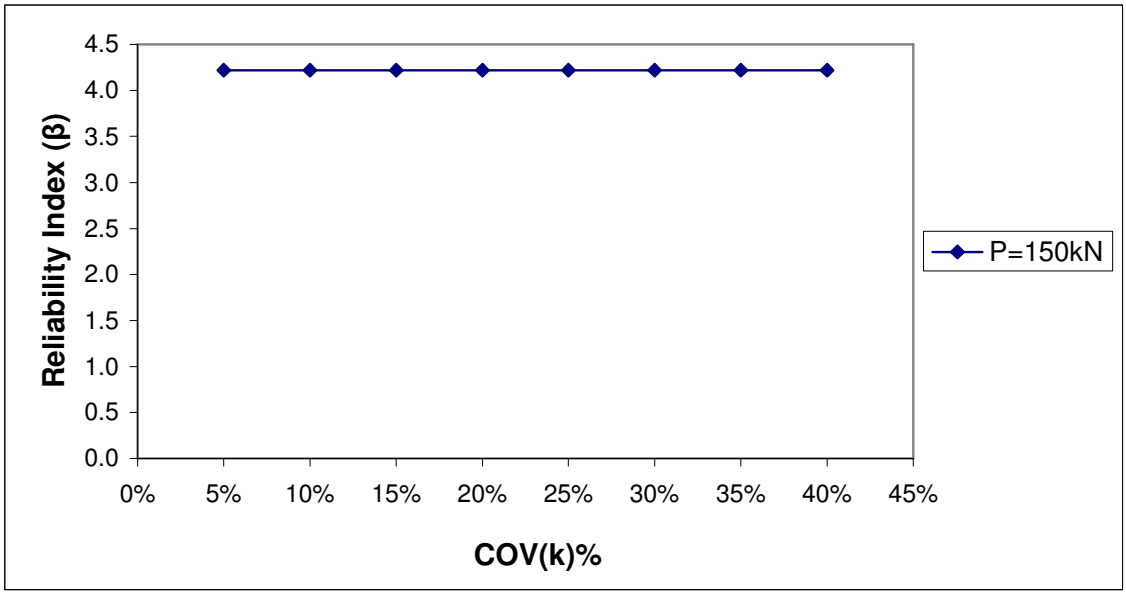


Fig. B.128 Reliability Index (β) of M_{max} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.163 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'k' subjected to lateral load 200kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.83E-02	10696.73	5%	103.4251	3.2729
3.48E-02	10696.73	10%	103.4252	3.2729
1.30E-01	10696.73	15%	103.4256	3.2729
1.27E-01	10696.73	20%	103.4256	3.2729
1.99E-01	10696.73	25%	103.4260	3.2729
2.65E-01	10696.73	30%	103.4263	3.2729
2.49E-01	10696.73	35%	103.4262	3.2729
2.58E-01	10696.73	40%	103.4262	3.2729

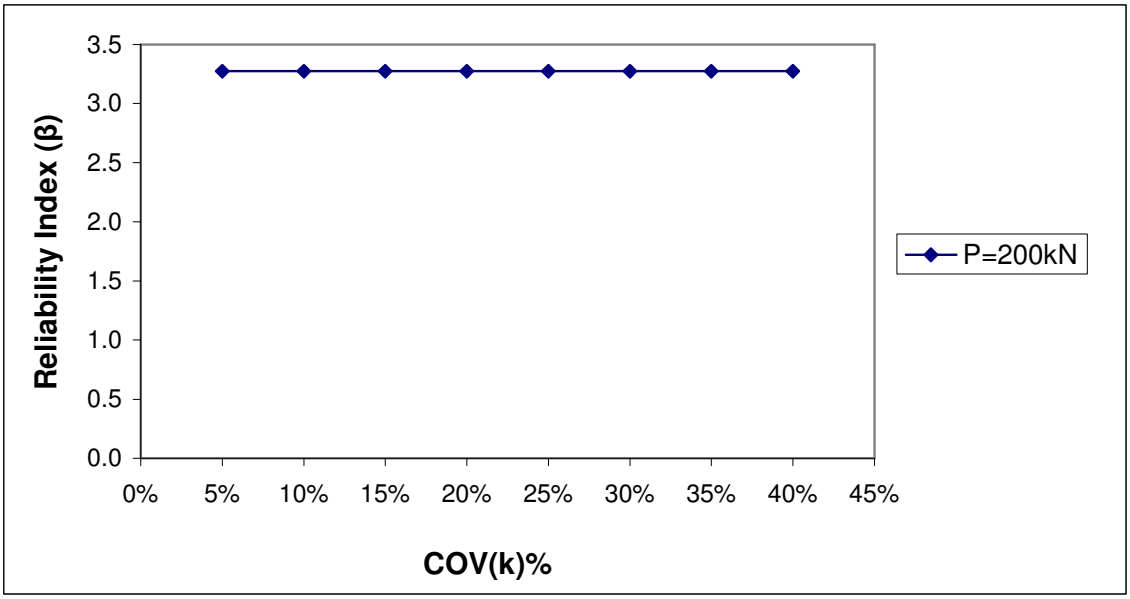


Fig. B.129 Reliability Index (β) of M_{max} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.164 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'k' subjected to lateral load 250kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.59E-01	10696.73	5%	103.4258	2.2770
1.99E-01	10696.73	10%	103.4260	2.2770
1.00E+00	10696.73	15%	103.4298	2.2770
1.32E+00	10696.73	20%	103.4314	2.2770
2.10E+00	10696.73	25%	103.4352	2.2770
2.32E+00	10696.73	30%	103.4362	2.2770
2.62E+00	10696.73	35%	103.4377	2.2769
2.86E+00	10696.73	40%	103.4388	2.2769

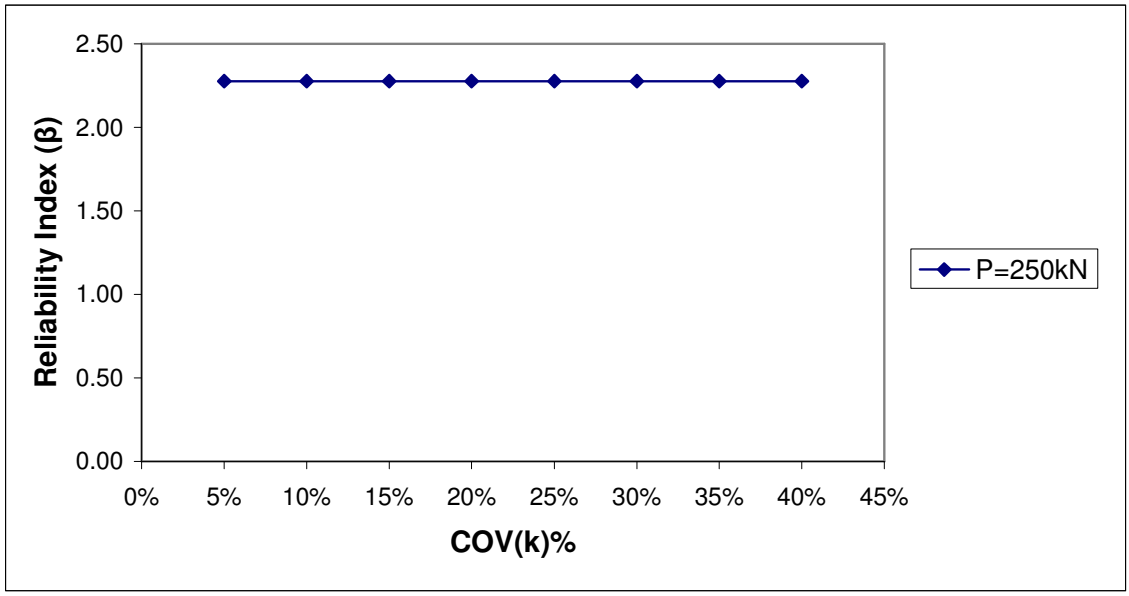


Fig. B.130 Reliability Index (β) of M_{max} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.165 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'k' subjected to lateral load 300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.59E-01	10696.73	5%	103.4258	1.2038
1.80E-01	10696.73	10%	103.4259	1.2038
1.99E-01	10696.73	15%	103.4260	1.2038
1.32E+00	10696.73	20%	103.4314	1.2038
2.03E+00	10696.73	25%	103.4348	1.2038
2.15E+00	10696.73	30%	103.4354	1.2037
2.43E+00	10696.73	35%	103.4367	1.2037
2.66E+00	10696.73	40%	103.4379	1.2036

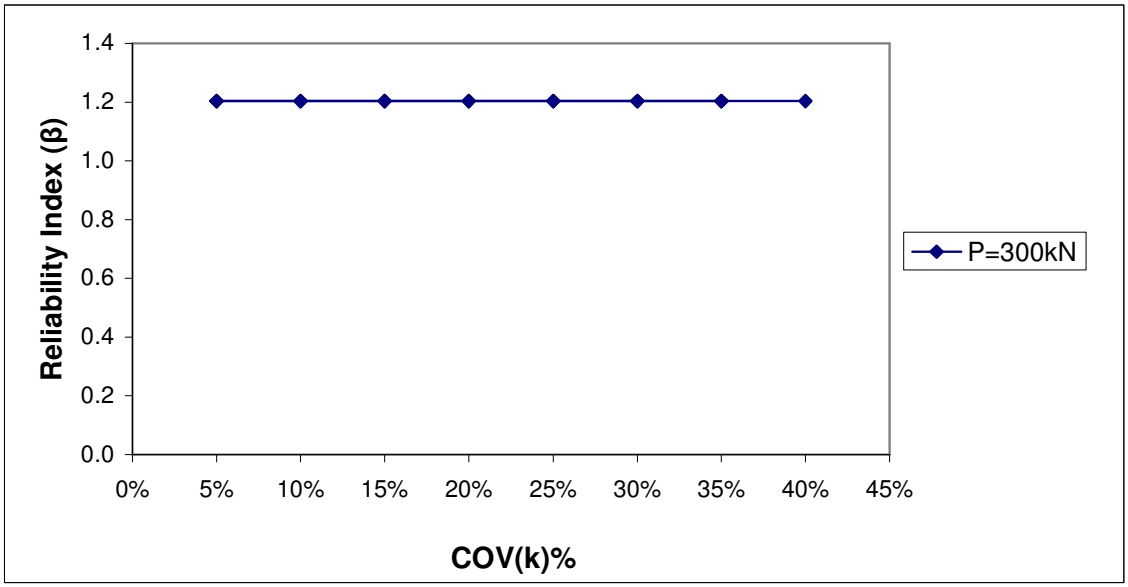


Fig. B.131 Reliability Index (β) of M_{max} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force 300kN.

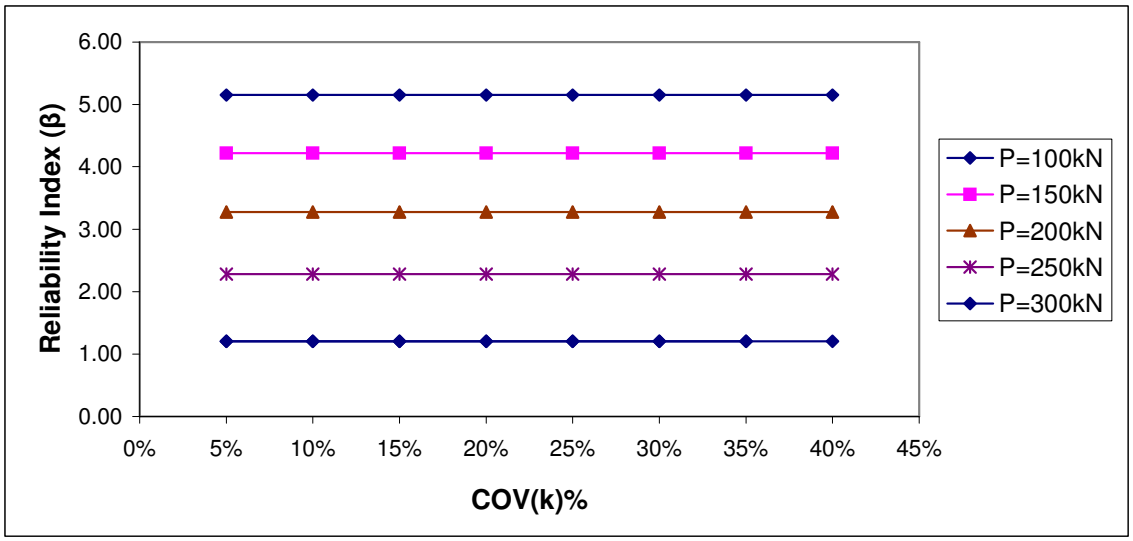


Fig. B.132 Reliability Index (β) of M_{max} vs. COV (k) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.166 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'B' subjected to lateral load 100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
0.00E+00	10696.73	5%	103.4250	5.1200
1.00E+00	10696.73	10%	103.4298	5.1235
2.25E+00	10696.73	15%	103.4359	5.1200
6.25E+00	10696.73	20%	103.4552	5.1200
9.00E+00	10696.73	25%	103.4685	5.1200
1.23E+01	10696.73	30%	103.4842	5.1017
1.24E+01	10696.73	35%	103.4850	5.0957
1.60E+01	10696.73	40%	103.5023	5.1000

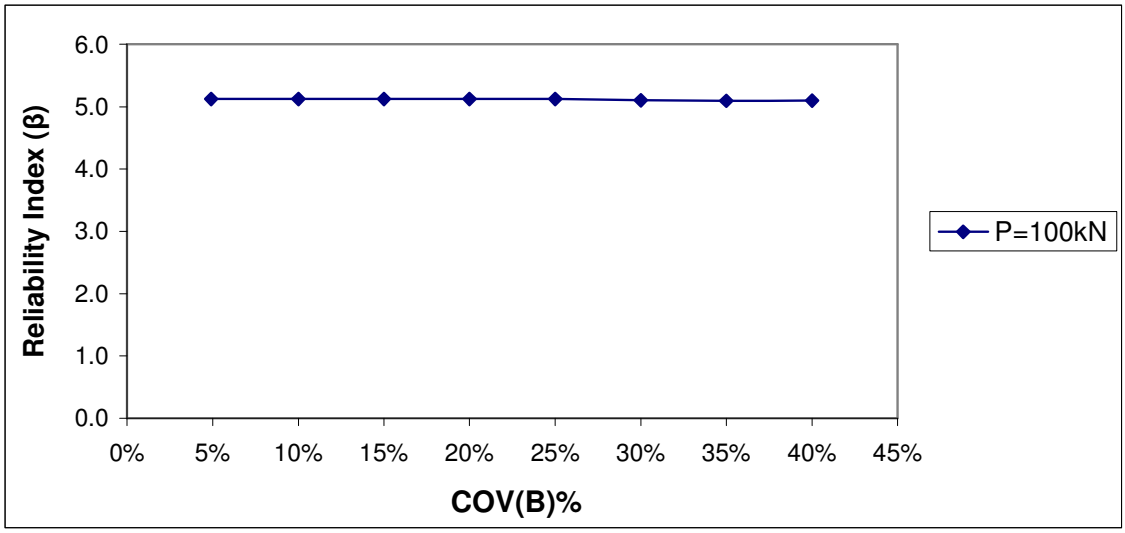


Fig. B133 Reliability Index (β) of M_{max} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.167 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'B' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
0.00E+00	10696.73	5%	103.4250	4.2201196
2.50E-01	10696.73	10%	103.4262	4.21940028
2.58E-01	10696.73	15%	103.4262	4.21080028
1.00E+00	10696.73	20%	103.4298	4.19302523
1.65E+00	10696.73	25%	103.4330	4.1779
1.93E+00	10696.73	30%	103.4343	4.1778
2.00E+00	10696.73	35%	103.4347	4.1765
2.25E+00	10696.73	40%	103.4359	4.1763

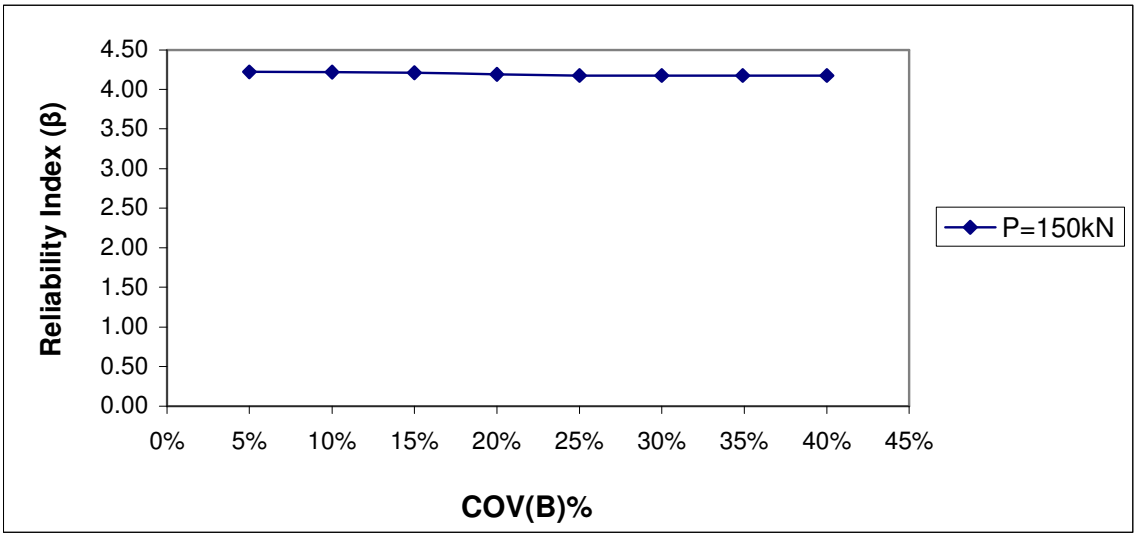


Fig. B134 Reliability Index (β) of M_{max} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.168 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'B' subjected to lateral load 200kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
0.00E+00	10696.73	5%	103.4250	3.2629
1.00E+00	10696.73	10%	103.4298	3.2628
1.36E+00	10696.73	15%	103.4316	3.2627
2.25E+00	10696.73	20%	103.4359	3.2626
2.89E+00	10696.73	25%	103.4390	3.2625
4.00E+00	10696.73	30%	103.4443	3.2523
4.05E+00	10696.73	35%	103.4446	3.2463
6.25E+00	10696.73	40%	103.4552	3.2319

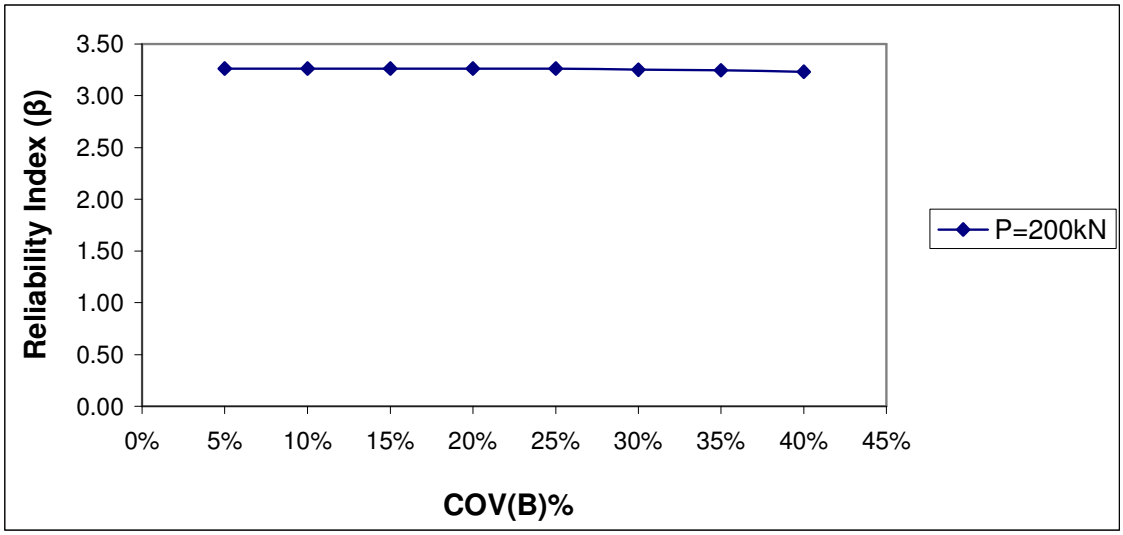


Fig. B135 Reliability Index (β) of M_{max} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.169 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'B' subjected to lateral load 250kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
0.00E+00	10696.73	5%	103.4250	2.2760
2.50E-01	10696.73	10%	103.4262	2.2765
2.75E-01	10696.73	15%	103.4263	2.2760
2.99E-01	10696.73	20%	103.4264	2.2757
1.00E+00	10696.73	25%	103.4298	2.2756
1.01E+00	10696.73	30%	103.4299	2.2737
1.63E+00	10696.73	35%	103.4329	2.2731
2.25E+00	10696.73	40%	103.4359	2.2729

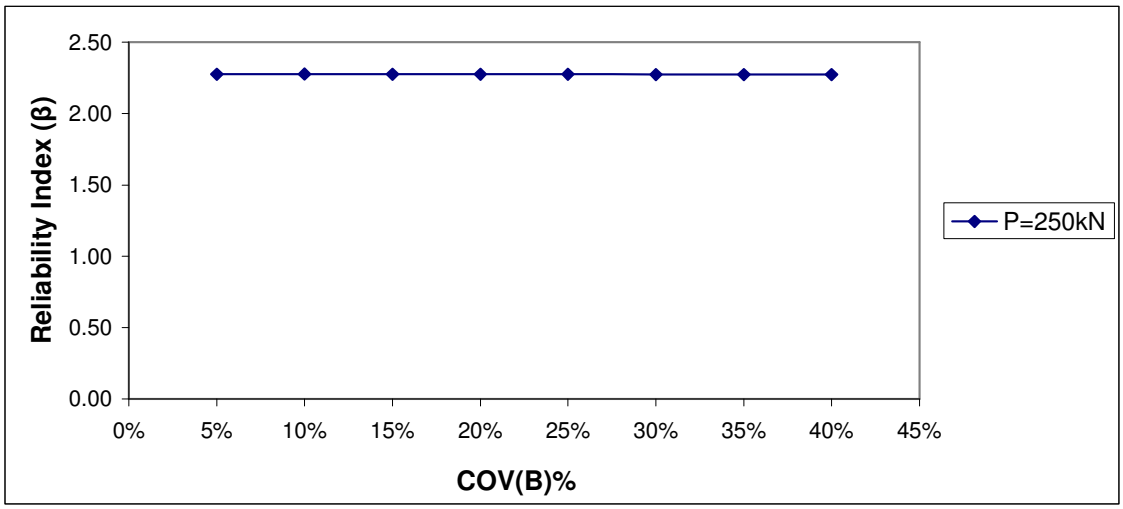


Fig. B136 Reliability Index (β) of M_{max} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.170 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'B' subjected to lateral load 300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
0.00E+00	10696.73	5%	103.4250	1.2037
2.25E+00	10696.73	10%	103.4359	1.2036
4.00E+00	10696.73	15%	103.4443	1.2025
9.00E+00	10696.73	20%	103.4685	1.2063
1.23E+01	10696.73	25%	103.4842	1.2017
1.60E+01	10696.73	30%	103.5023	1.1987
2.53E+01	10696.73	35%	103.5473	1.1980
3.03E+01	10696.73	40%	103.5711	1.1971

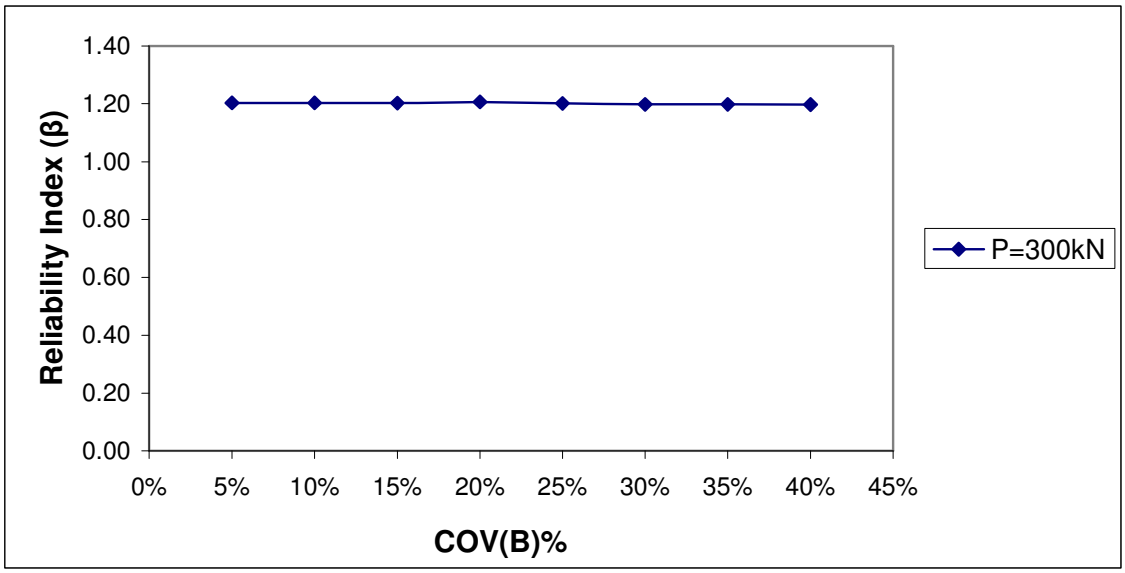


Fig. B137 Reliability Index (β) of M_{max} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force 300kN.

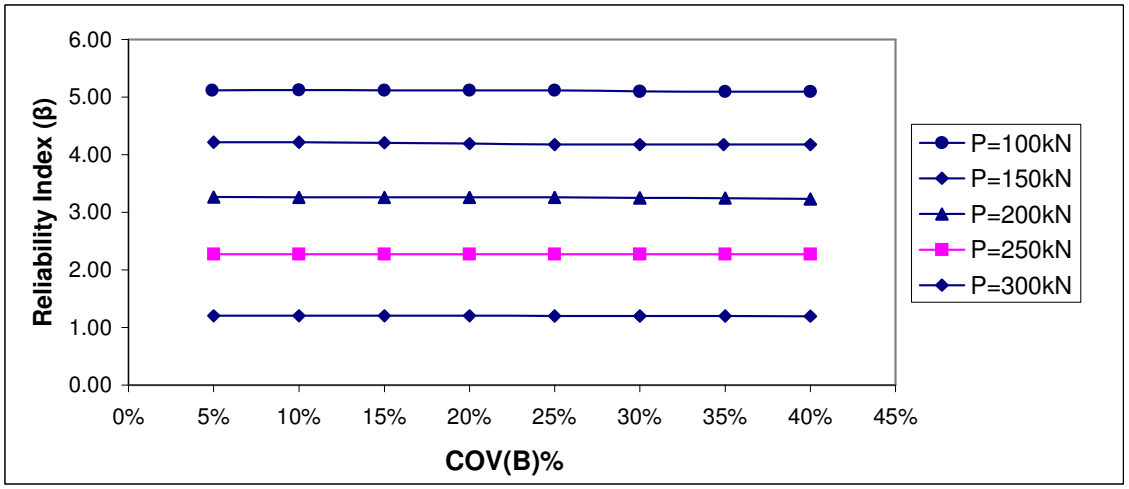


Fig. B.138 Reliability Index (β) of M_{max} vs. COV (B) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.171 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'EI' subjected to lateral load 100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E+00	10696.73	5%	103.4298	5.1484
4.00E+00	10696.73	10%	103.4443	5.1477
4.23E+01	10696.73	15%	103.6291	5.1385
1.16E+02	10696.73	20%	103.9822	5.1341
1.29E+02	10696.73	25%	104.0447	5.1211
1.69E+02	10696.73	30%	104.2388	5.1085
1.89E+02	10696.73	35%	104.3346	5.1038
2.18E+02	10696.73	40%	104.4715	5.0971

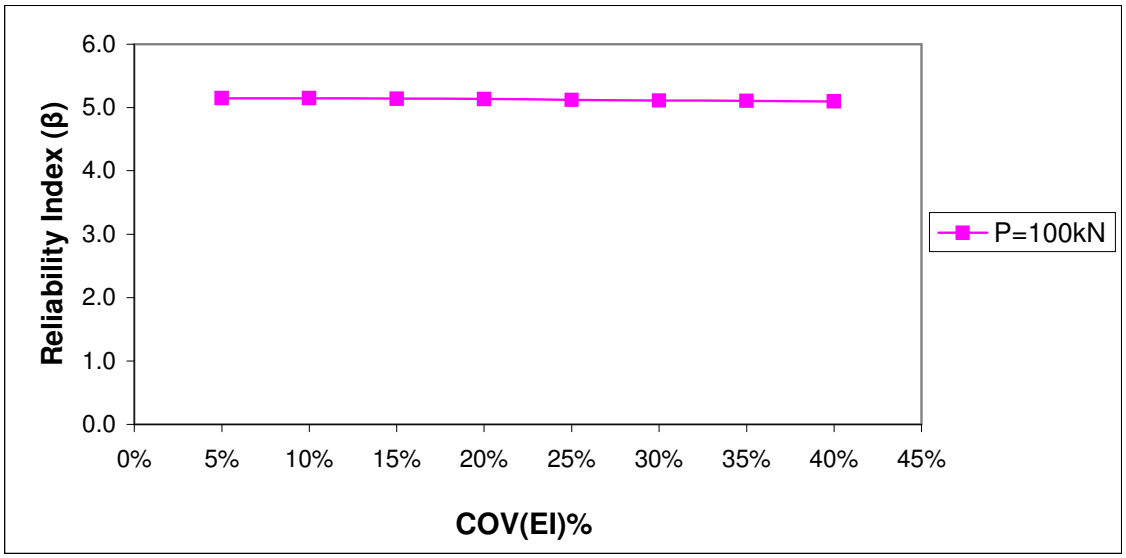


Fig. B.139 Reliability Index (β) of M_{max} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.172 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'EI' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E+00	10696.73	5%	103.4298	4.2203
4.00E+00	10696.73	10%	103.4443	4.2197
4.90E+01	10696.73	15%	103.6617	4.2108
1.27E+02	10696.73	20%	104.0351	4.1957
1.33E+02	10696.73	25%	104.0639	4.1945
1.76E+02	10696.73	30%	104.2703	4.1862
1.96E+02	10696.73	35%	104.3678	4.1823
2.25E+02	10696.73	40%	104.5071	4.1768

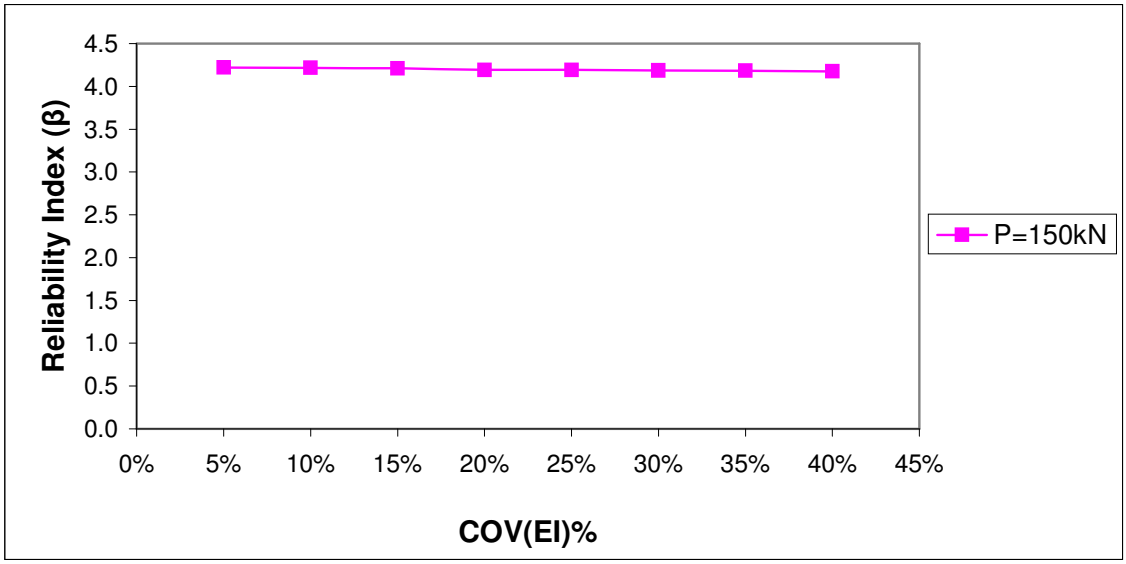


Fig. B.140 Reliability Index (β) of M_{max} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 150kN.

Table B.173 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'EI' subjected to lateral load 200kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E+00	10696.73	5%	103.4298	3.2728
4.00E+00	10696.73	10%	103.4443	3.2723
3.60E+01	10696.73	15%	103.5990	3.2674
1.05E+02	10696.73	20%	103.9317	3.2569
1.17E+02	10696.73	25%	103.9894	3.2551
1.44E+02	10696.73	30%	104.1188	3.2511
1.62E+02	10696.73	35%	104.2076	3.2483
1.89E+02	10696.73	40%	104.3350	3.2444

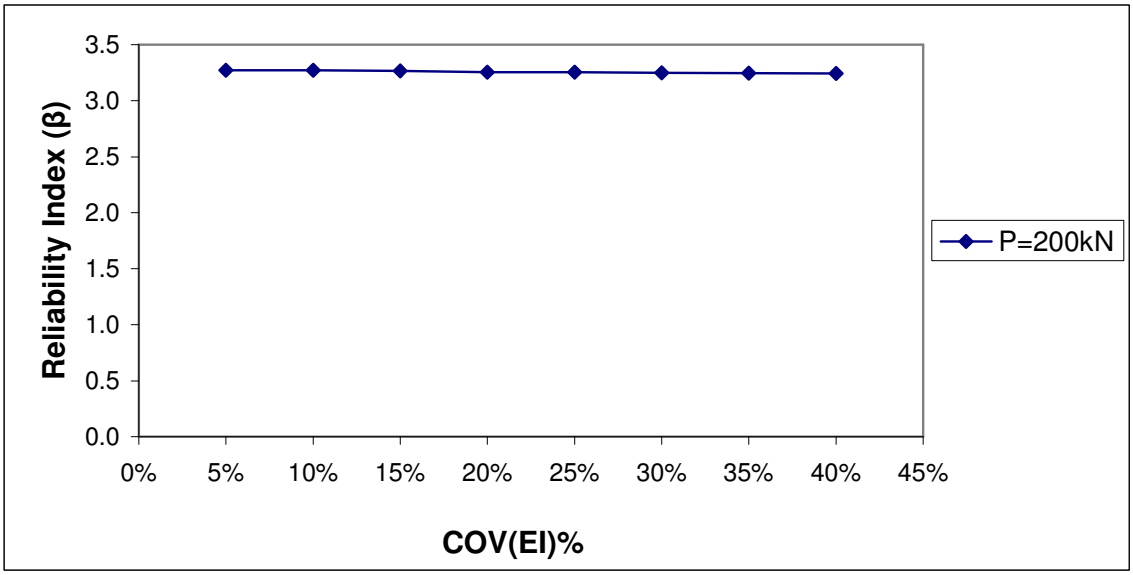


Fig. B.141 Reliability Index (β) of M_{max} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 200kN.

Table B.174 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'EI' subjected to lateral load 250kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-01	10696.73	5%	103.4262	2.2770
1.00E+00	10696.73	10%	103.4298	2.2769
7.57E+00	10696.73	15%	103.4616	2.2762
1.10E+01	10696.73	20%	103.4782	2.2758
2.03E+01	10696.73	25%	103.4782	2.2758
3.03E+01	10696.73	30%	103.5711	2.2738
3.60E+01	10696.73	35%	103.5988	2.2732
3.91E+01	10696.73	40%	103.6137	2.2729

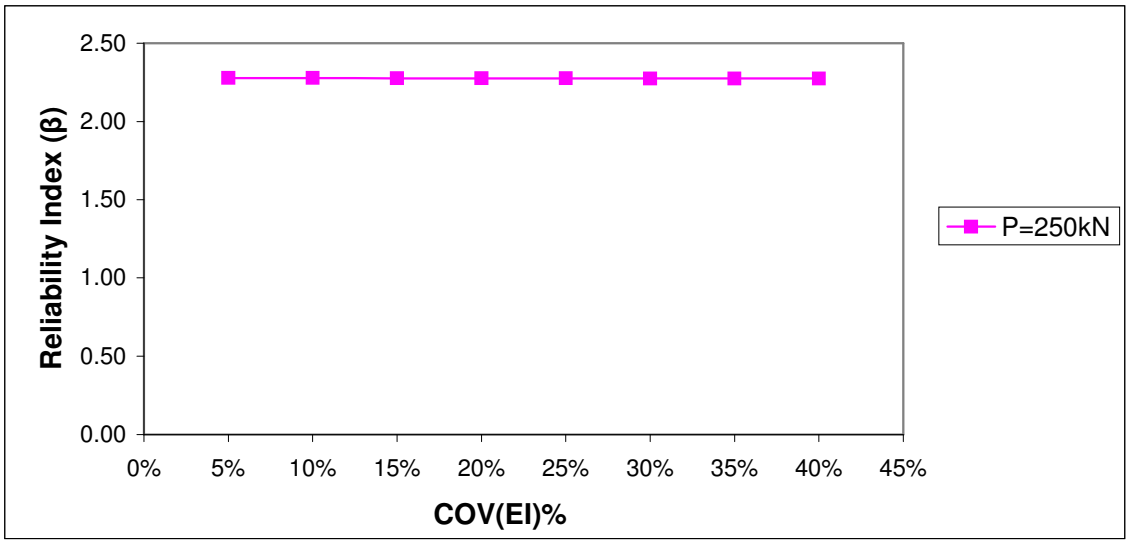


Fig. B.142 Reliability Index (β) of M_{max} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 250kN.

Table B.175 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'EI' subjected to lateral load 300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-01	10696.73	5%	103.4262	1.2038
2.25E+00	10696.73	10%	103.4359	1.2036
1.81E+01	10696.73	15%	103.5123	1.2028
3.18E+01	10696.73	20%	103.7339	1.2027
6.40E+01	10696.73	25%	103.5788	1.2020
8.56E+01	10696.73	30%	103.8378	1.1990
1.00E+02	10696.73	35%	103.9071	1.1982
1.16E+02	10696.73	40%	103.9822	1.1973

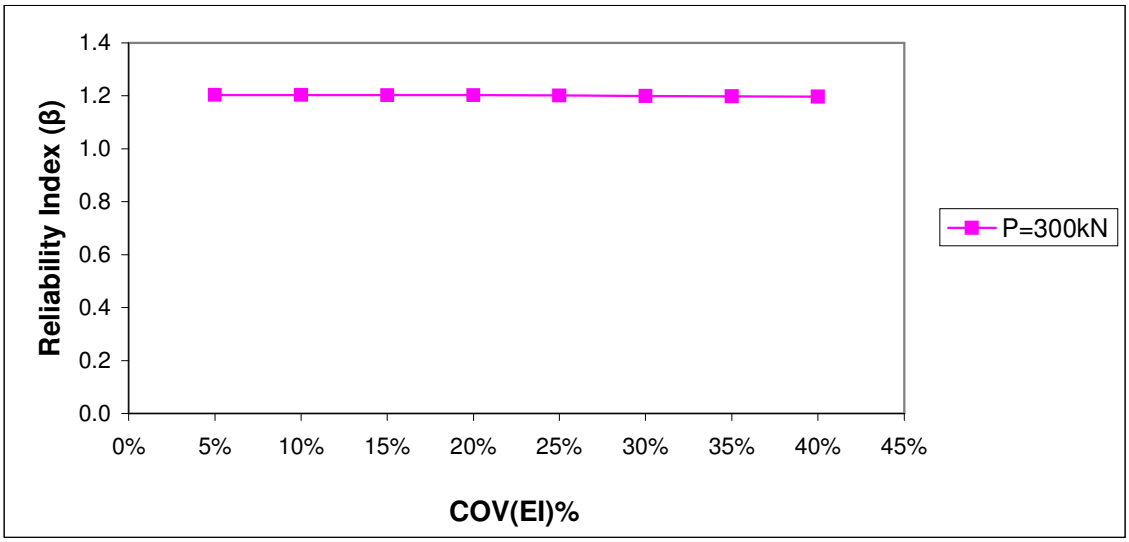


Fig. B.143 Reliability Index (β) of M_{max} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force 300kN.

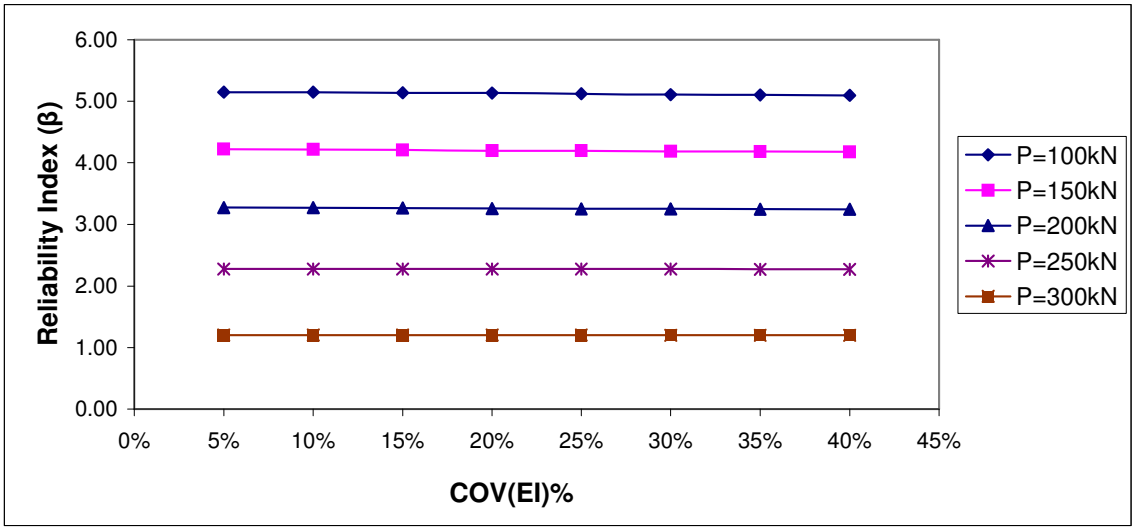


Fig. B144 Reliability Index (β) of M_{max} vs. COV (EI) for single fixed head long pile (10T) subjected to lateral force of discrete variability.

Table B.176 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'P' subjected to lateral load 100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
9.03E+01	10696.73	5%	103.8604	5.1271
3.42E+02	10696.73	10%	105.0666	5.0682
7.56E+02	10696.73	15%	107.0186	4.9758
1.37E+03	10696.73	20%	109.8441	4.8478
2.12E+03	10696.73	25%	113.1933	4.7043
3.08E+03	10696.73	30%	117.3754	4.5367
4.14E+03	10696.73	35%	121.8099	4.3716
5.45E+03	10696.73	40%	127.0848	4.1901

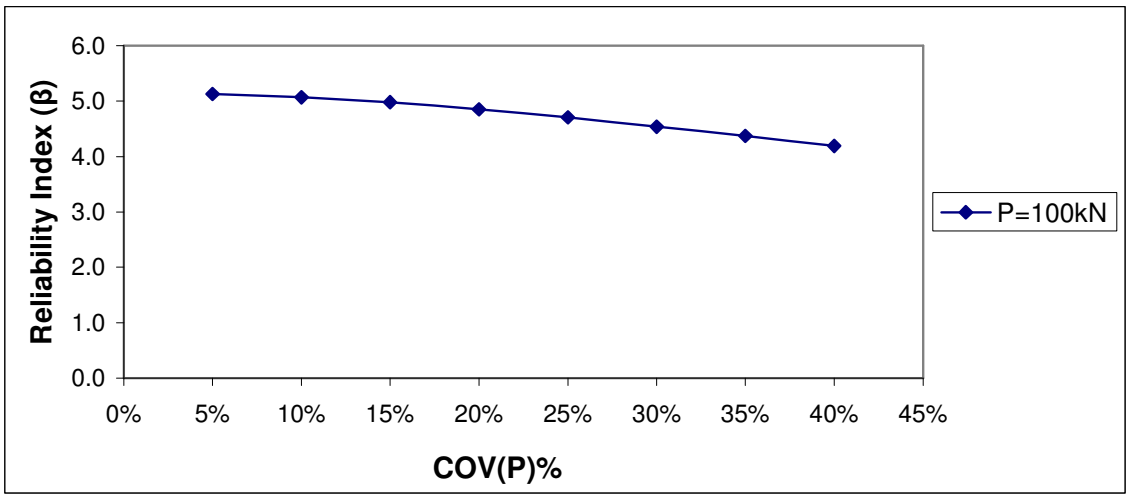


Fig. B.145 Reliability Index (β) of M_{max} vs. COV (P) for single fixed head long pile (10T) subjected to lateral force 100kN.

Table B.177 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'P' subjected to lateral load 150kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.10E+02	10696.73	5%	104.4365	4.1796
8.41E+02	10696.73	10%	107.4138	4.0637
1.89E+03	10696.73	15%	112.2006	3.8904
3.42E+03	10696.73	20%	118.8233	3.6735
5.26E+03	10696.73	25%	126.3051	3.4559
7.57E+03	10696.73	30%	135.1508	3.2297
1.03E+04	10696.73	35%	144.9103	3.0122
1.35E+04	10696.73	40%	155.4115	2.8087

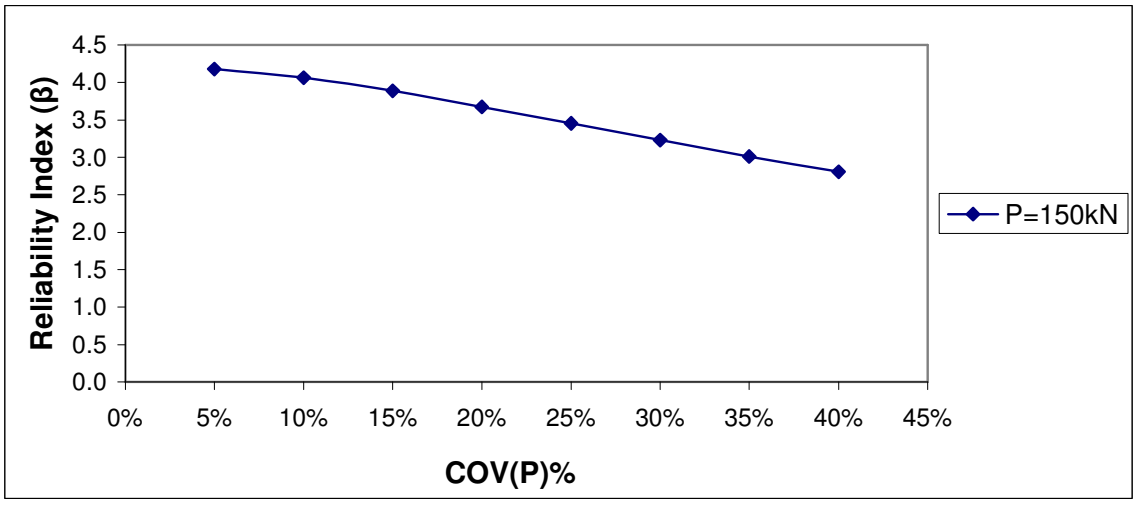


Fig. B.146 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force 150kN.

Table B.178 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'P' subjected to lateral load 200kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.00E+02	10696.73	5%	105.3410	3.2134
1.60E+03	10696.73	10%	110.8906	3.0526
3.60E+03	10696.73	15%	119.5689	2.8310
6.40E+03	10696.73	20%	130.7545	2.5888
8.28E+03	10696.73	25%	137.7597	2.3700
1.48E+04	10696.73	30%	159.5587	2.1215
2.00E+04	10696.73	35%	175.2683	1.9313
2.64E+04	10696.73	40%	192.6213	1.7573

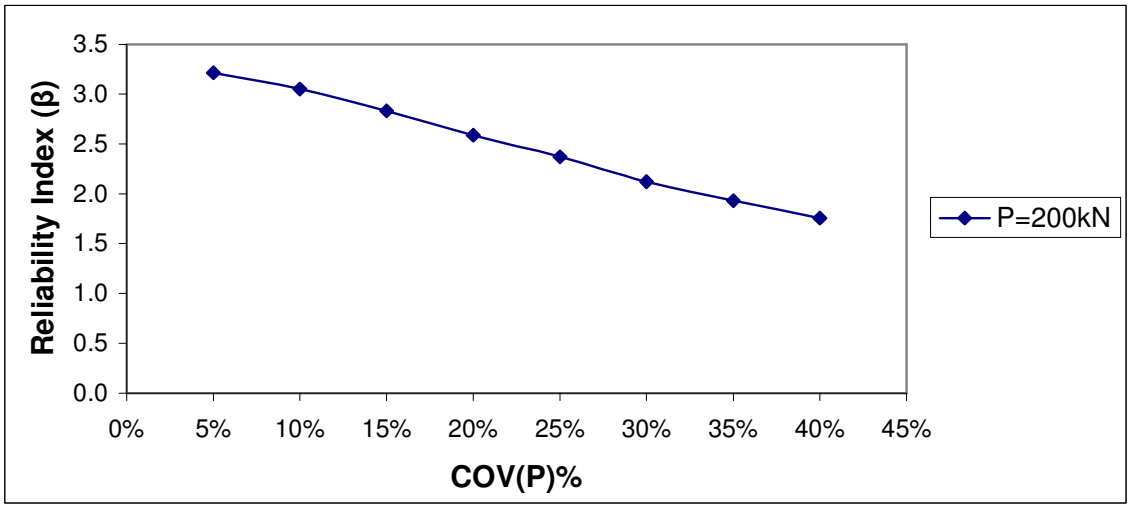


Fig. B.147 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force 200kN.

Table B.179 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'P' subjected to lateral load 250kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
7.29E+02	10696.73	5%	106.8912	2.2032
2.86E+03	10696.73	10%	116.4430	2.0224
6.48E+03	10696.73	15%	131.0610	1.7969
1.14E+04	10696.73	20%	148.8144	1.5825
1.80E+04	10696.73	25%	169.2712	1.3913
2.58E+04	10696.73	30%	190.9371	1.2334
3.53E+04	10696.73	35%	214.5710	1.0975
4.64E+04	10696.73	40%	239.0334	0.9852

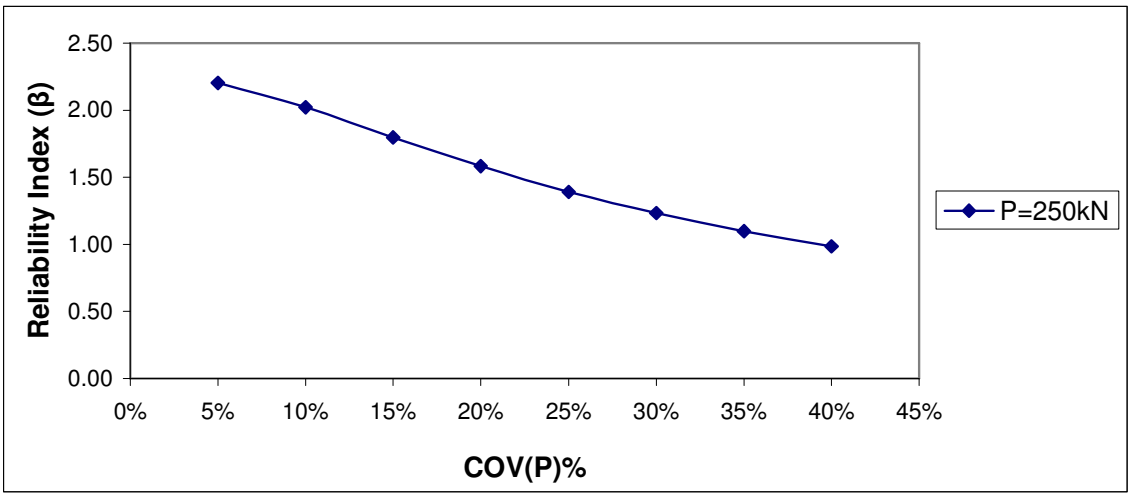


Fig. B.148 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force 250kN.

Table B.180 Reliability Index (β) connected to M_{max} for fixed head single pile (10T) with varying 'P' subjected to lateral load 300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.19E+03	10696.73	5%	109.0274	1.1419
4.76E+03	10696.73	10%	124.3291	1.0014
1.06E+04	10696.73	15%	145.9648	0.8529
1.90E+04	10696.73	20%	172.4550	0.7219
2.96E+04	10696.73	25%	200.7006	0.6203
4.24E+04	10696.73	30%	230.5054	0.5401
5.78E+04	10696.73	35%	261.7957	0.4756
7.54E+04	10696.73	40%	293.3377	0.4244

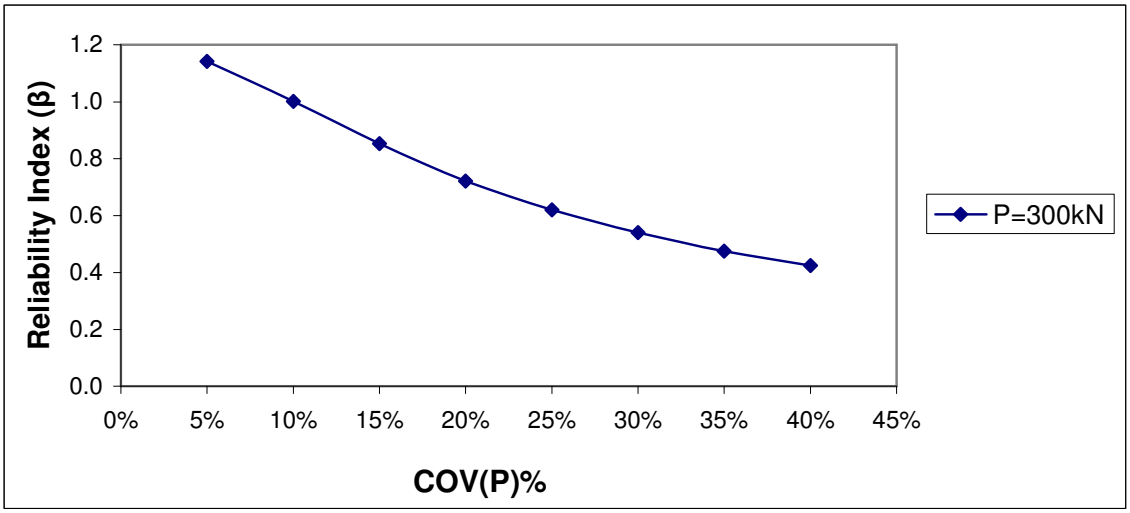


Fig. B.149 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force 300kN.

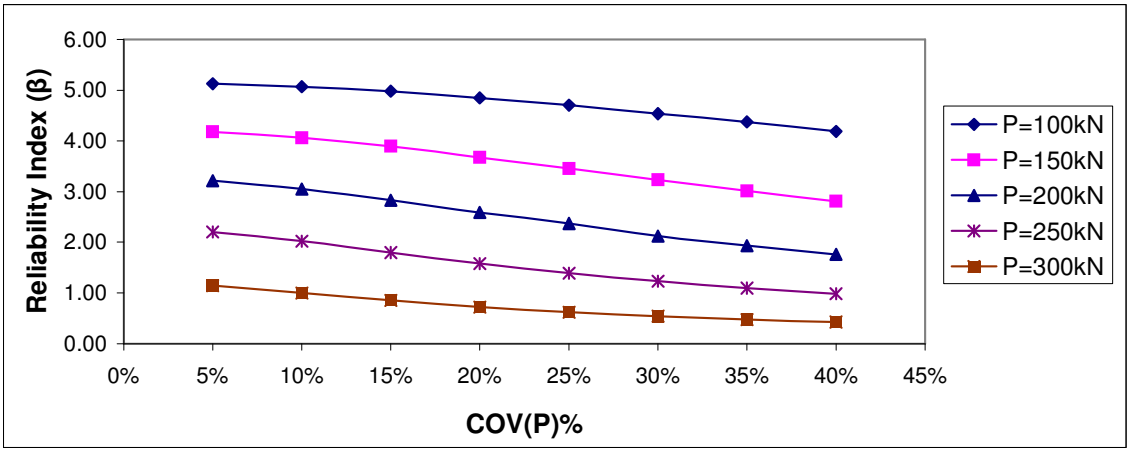


Fig. B.150 Reliability Index (β) of M_{max} vs. COV (P) for single free head long pile (10T) subjected to lateral force of discrete variability.

B.6 Probability of failure, p_f (M_{max}) of bending moment vs. COV (Variables).

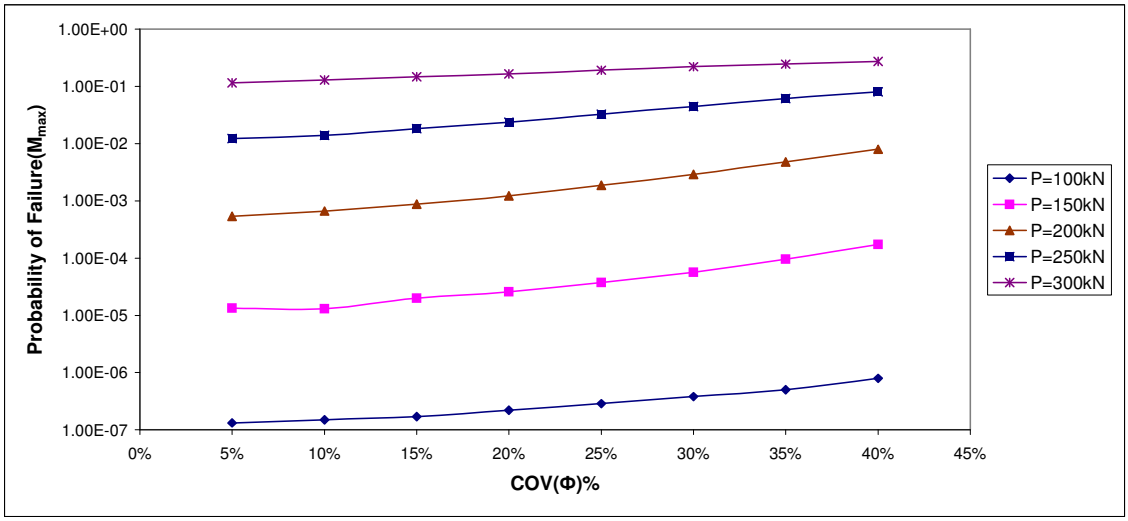


Fig. B.151 Probability of failure of bending moment p_f (M_{max}) vs. COV (Φ) for single fixed head long pile of length 10T.

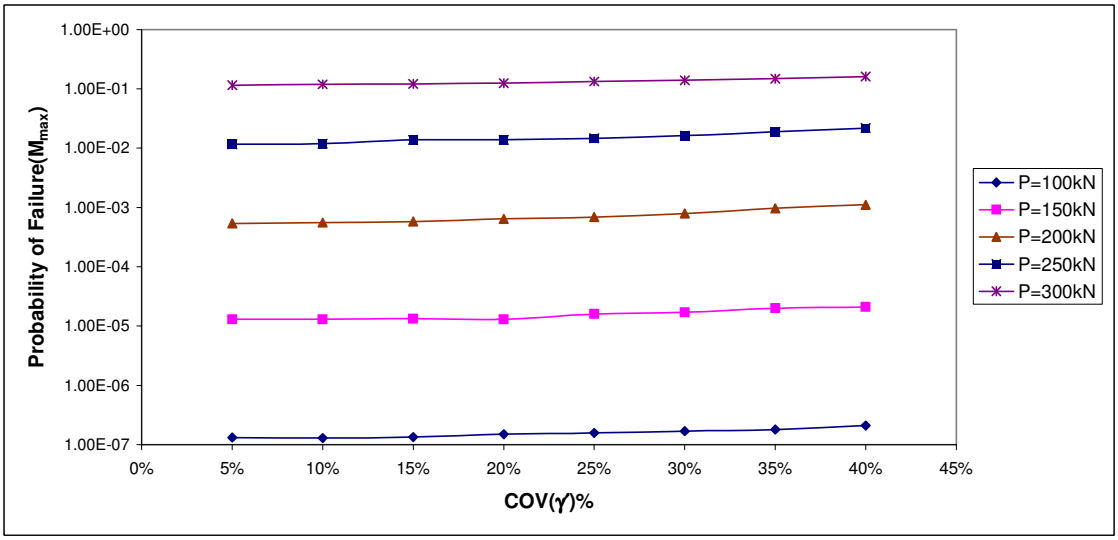


Fig. B.152 Probability of failure of bending moment p_f (M_{max}) vs. COV (γ) for single fixed head long pile of length 10T.

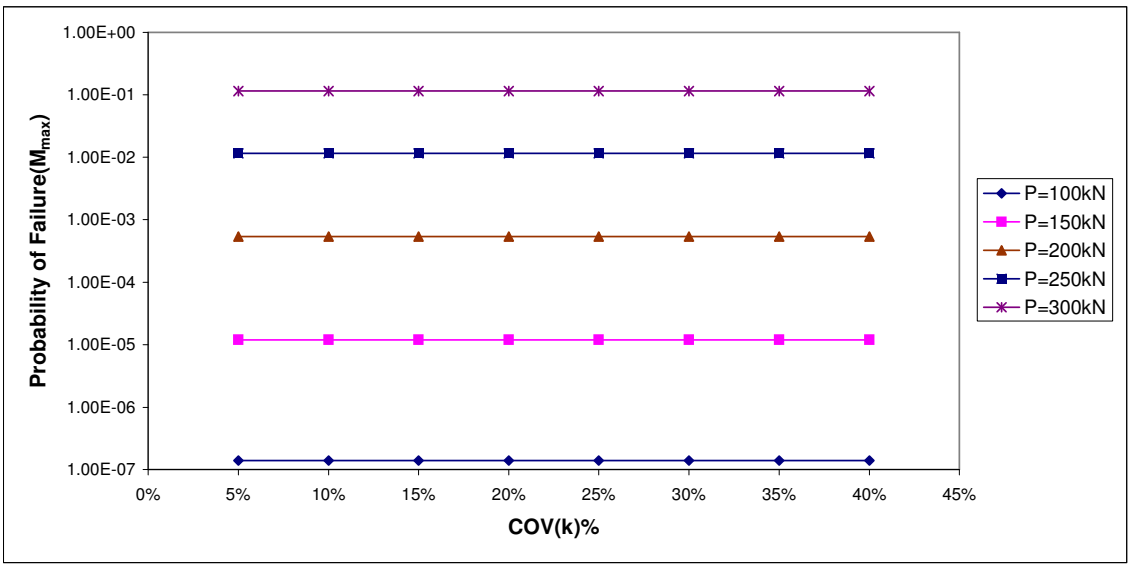


Fig. B.153 Probability of failure of bending moment p_f (M_{max}) vs. COV (k) for single fixed head long pile of length 10T.

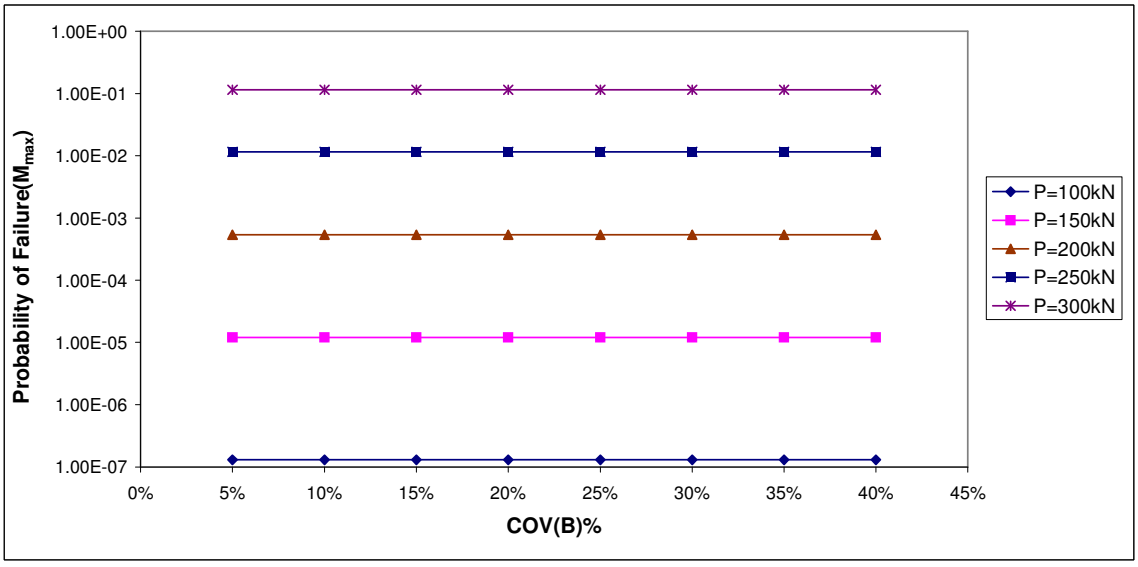


Fig. B.154 Probability of failure of bending moment p_f (M_{max}) vs. COV (B) for single fixed head long pile of length 10T.

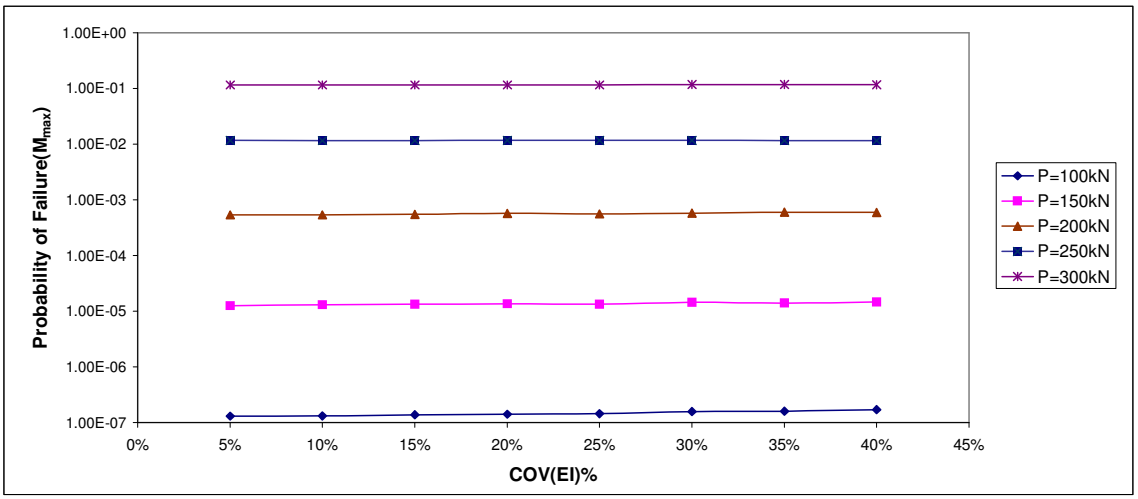


Fig. B.155 Probability of failure of bending moment p_f (M_{max}) vs. COV (EI) for single fixed head long pile of length 10T.

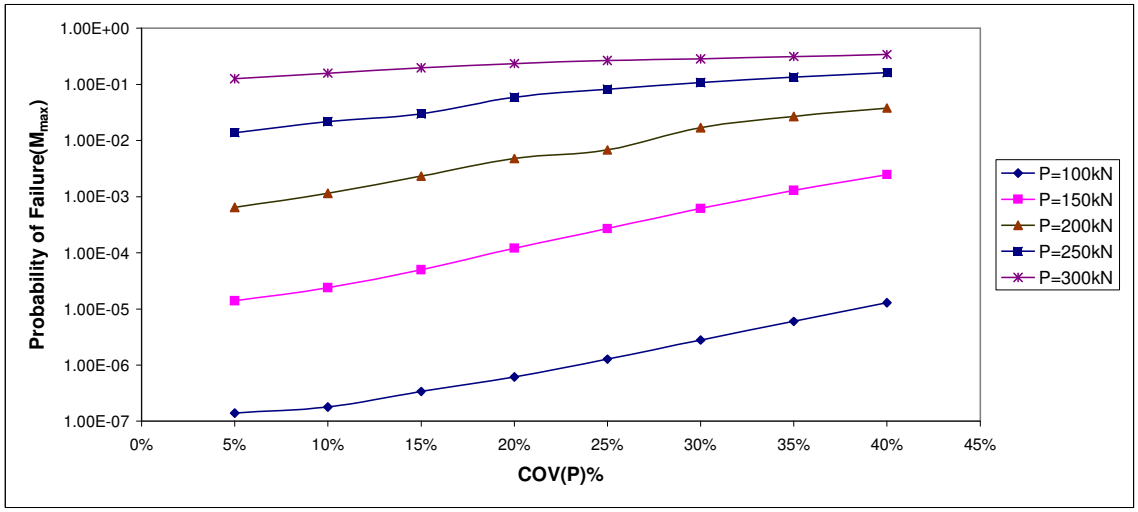


Fig. B.156 Probability of failure of bending moment p_f (M_{max}) vs. COV (P) for single fixed head long pile of length 10T.

APPENDIX C

LATERALLY LOADED FREE HEAD LONG (10T) PILE GROUP WITH (3D) SPACING

C-1 Deflection of free head long pile group (Y_{Top}) and COV (Y_{Top}) vs. COV (Variables)

Table C.1 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (Φ) and load 250kN.

P=250kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	9.32E-03				
5%	30			2.25E+00	8.11E-07	4.13E-03	8.84%
		28.5	1.11E-02				
		33.0	8.57E-03				
10%	30			9.00E+00	3.25E-06	4.13E-03	17.68%
		27.0	1.22E-02				
		34.5	7.85E-03				
15%	30			2.03E+01	7.49E-06	4.13E-03	26.85%
		25.5	1.33E-02				
		36.0	7.25E-03				
20%	30			3.60E+01	1.35E-05	4.13E-03	36.08%
		24.0	1.46E-02				
		37.5	6.65E-03				
25%	30			5.63E+01	2.19E-05	4.13E-03	45.97%
		22.5	1.60E-02				
		39.0	6.17E-03				
30%	30			8.10E+01	3.28E-05	4.13E-03	56.16%
		21.0	1.76E-02				
		40.5	5.72E-03				
35%	30			1.10E+02	4.73E-05	4.13E-03	67.49%
		19.5	1.95E-02				
		42.0	5.54E-03				
40%	30			1.44E+02	6.50E-05	4.13E-03	79.13%
		18.0	2.17E-02				

Table C.2 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (Φ) and load 450kN.

P=450kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	1.68E-02				
5%	30			2.25E+00	2.43E-06	7.40E-03	8.55%
		28.5	1.99E-02				
		33.0	1.54E-02				
10%	30			9.00E+00	9.80E-06	7.40E-03	17.15%
		27.0	2.17E-02				
		34.5	1.42E-02				
15%	30			2.03E+01	2.27E-05	7.40E-03	26.11%
		25.5	2.37E-02				
		36.0	1.31E-02				
20%	30			3.60E+01	4.14E-05	7.40E-03	35.26%
		24.0	2.60E-02				
		37.5	1.20E-02				
25%	30			5.63E+01	6.79E-05	7.40E-03	45.15%
		22.5	2.85E-02				
		39.0	1.11E-02				
30%	30			8.10E+01	1.04E-04	7.40E-03	55.97%
		21.0	3.16E-02				
		40.5	1.03E-02				
35%	30			1.10E+02	1.56E-04	7.40E-03	68.44%
		19.5	3.52E-02				
		42.0	9.55E-03				
40%	30			1.44E+02	2.28E-04	7.40E-03	82.81%
		18.0	3.98E-02				

Table C.3 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (Φ) and load 650kN.

P=650kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	2.52E-02				
5%	30			2.25E+00	5.76E-06	1.63E-02	8.74%
		28.5	3.00E-02				
		33.0	2.32E-02				
10%	30			9.00E+00	2.36E-05	1.63E-02	17.67%
		27.0	3.29E-02				
		34.5	2.13E-02				
15%	30			2.03E+01	5.49E-05	1.63E-02	26.97%
		25.5	3.61E-02				
		36.0	1.96E-02				
20%	30			3.60E+01	1.03E-04	1.63E-02	36.95%
		24.0	3.99E-02				
		37.5	1.81E-02				
25%	30			5.63E+01	1.72E-04	1.63E-02	47.71%
		22.5	4.43E-02				
		39.0	1.67E-02				
30%	30			8.10E+01	2.74E-04	1.63E-02	60.21%
		21.0	4.98E-02				
		40.5	1.55E-02				
35%	30			1.10E+02	4.19E-04	1.63E-02	74.52%
		19.5	5.64E-02				
		42.0	1.43E-02				
40%	30			1.44E+02	6.37E-04	1.63E-02	91.85%
		18.0	6.48E-02				

Table C.4 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (Φ) and load 950kN.

P=950kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	3.49E-02				
5%	30			2.25E+00	1.30E-05	3.23E-02	9.40%
		28.5	4.21E-02				
		33.0	3.19E-02				
10%	30			9.00E+00	5.29E-05	3.23E-02	18.99%
		27.0	4.65E-02				
		34.5	2.93E-02				
15%	30			2.03E+01	1.23E-04	3.23E-02	29.01%
		25.5	5.15E-02				
		36.0	2.69E-02				
20%	30			3.60E+01	2.31E-04	3.23E-02	39.67%
		24.0	5.73E-02				
		37.5	2.48E-02				
25%	30			5.63E+01	3.93E-04	3.23E-02	51.80%
		22.5	6.44E-02				
		39.0	2.29E-02				
30%	30			8.10E+01	6.29E-04	3.23E-02	65.52%
		21.0	7.30E-02				
		40.5	2.11E-02				
35%	30			1.10E+02	9.89E-04	3.23E-02	82.17%
		19.5	8.40E-02				
		42.0	1.96E-02				
40%	30			1.44E+02	1.54E-03	3.23E-02	102.61%
		18.0	9.81E-02				

Table C.5 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (Φ) and load 1025kN.

P=1025kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	4.64E-02				
5%	30			2.25E+00	2.62E-05	4.55E-02	10.23%
		28.5	5.66E-02				
		33.0	4.21E-02				
10%	30			9.00E+00	1.07E-04	4.55E-02	20.69%
		27.0	6.28E-02				
		34.5	3.84E-02				
15%	30			2.03E+01	2.49E-04	4.55E-02	31.59%
		25.5	7.00E-02				
		36.0	3.50E-02				
20%	30			3.60E+01	4.72E-04	4.55E-02	43.47%
		24.0	7.85E-02				
		37.5	3.22E-02				
25%	30			5.63E+01	8.05E-04	4.55E-02	56.74%
		22.5	8.90E-02				
		39.0	2.96E-02				
30%	30			8.10E+01	1.31E-03	4.55E-02	72.45%
		21.0	1.02E-01				
		40.5	2.73E-02				
35%	30			1.10E+02	2.10E-03	4.55E-02	91.62%
		19.5	1.19E-01				
		42.0	2.51E-02				
40%	30			1.44E+02	3.36E-03	4.55E-02	115.88%
		18.0	1.41E-01				

Table C.6 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 250kN.

P=250kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	8.11E-07	8.84%
10%	9.00E+00	3.25E-06	17.68%
15%	2.03E+01	7.49E-06	26.85%
20%	3.60E+01	1.35E-05	36.08%
25%	5.63E+01	2.19E-05	45.97%
30%	8.10E+01	3.28E-05	56.16%
35%	1.10E+02	4.73E-05	67.49%
40%	1.44E+02	6.50E-05	79.13%

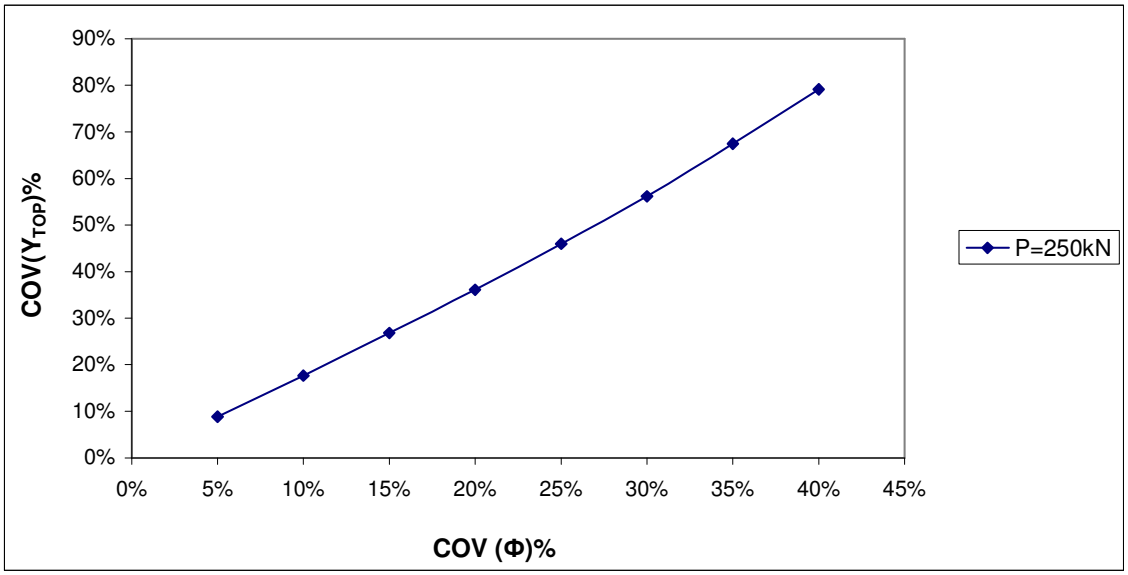


Fig. C.1 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.7 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 450kN.

P=450kN			
COV(Φ) (%)	VAR(Φ) (degree)	(Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	2.43E-06	8.55%
10%	9.00E+00	9.80E-06	17.15%
15%	2.03E+01	2.27E-05	26.11%
20%	3.60E+01	4.14E-05	35.26%
25%	5.63E+01	6.79E-05	45.15%
30%	8.10E+01	1.04E-04	55.97%
35%	1.10E+02	1.56E-04	68.44%
40%	1.44E+02	2.28E-04	82.81%

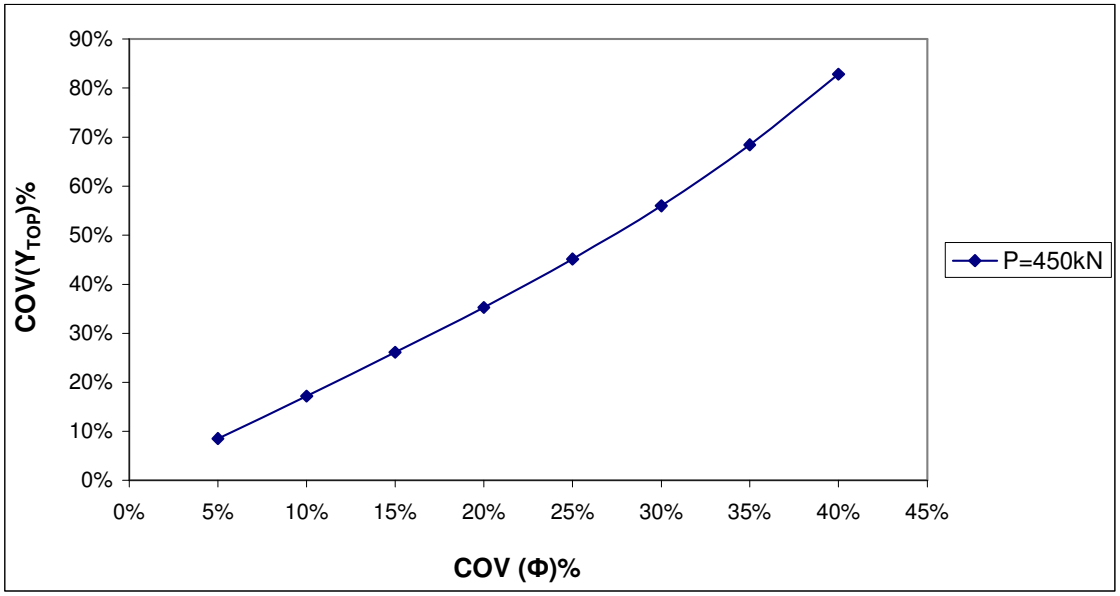


Fig. C.2 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.8 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 650kN.

P=650kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	5.76E-06	8.74%
10%	9.00E+00	2.36E-05	17.67%
15%	2.03E+01	5.49E-05	26.97%
20%	3.60E+01	1.03E-04	36.95%
25%	5.63E+01	1.72E-04	47.71%
30%	8.10E+01	2.74E-04	60.21%
35%	1.10E+02	4.19E-04	74.52%
40%	1.44E+02	6.37E-04	91.85%

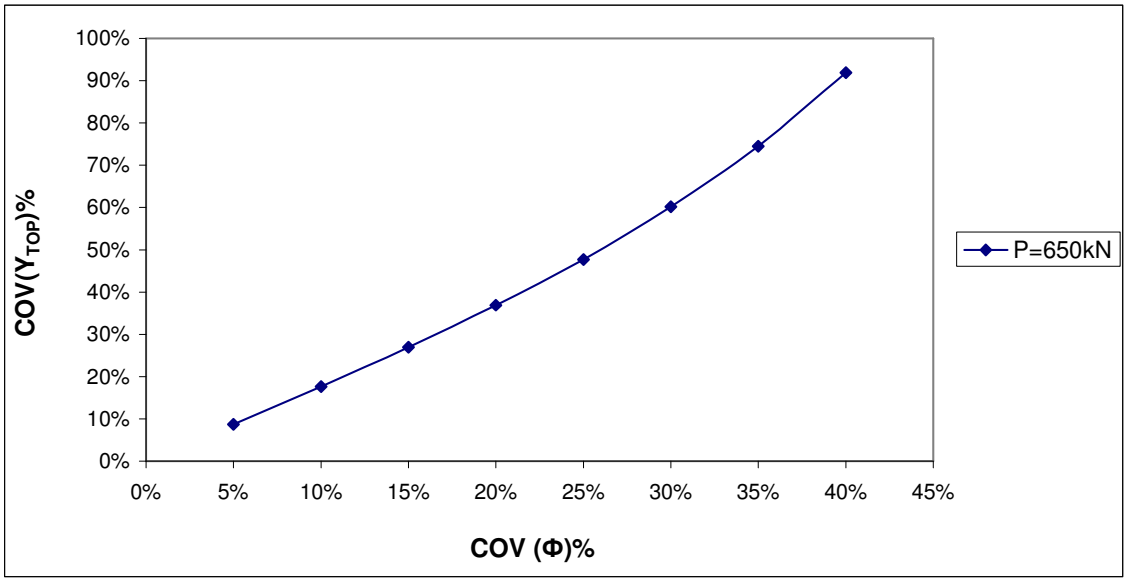


Fig. C.3 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.9 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 950kN.

P=950kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	1.30E-05	9.40%
10%	9.00E+00	5.29E-05	18.99%
15%	2.03E+01	1.23E-04	29.01%
20%	3.60E+01	2.31E-04	39.67%
25%	5.63E+01	3.93E-04	51.80%
30%	8.10E+01	6.29E-04	65.52%
35%	1.10E+02	9.89E-04	82.17%
40%	1.44E+02	1.54E-03	102.61%

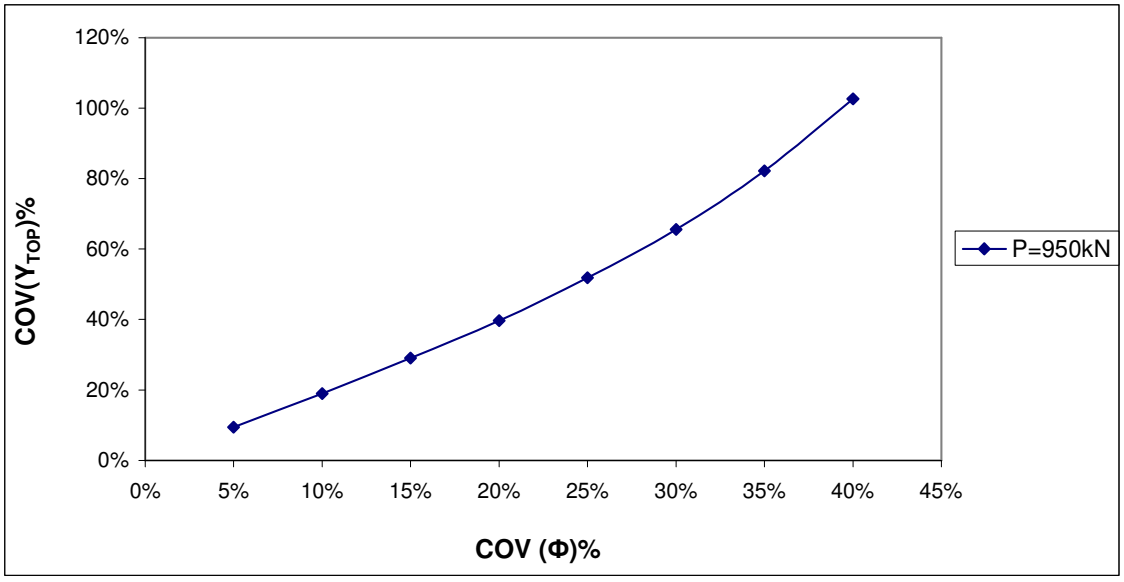


Fig. C.4 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.10 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 1025kN.

P=1025kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	2.62E-05	10.23%
10%	9.00E+00	1.07E-04	20.69%
15%	2.03E+01	2.49E-04	31.59%
20%	3.60E+01	4.72E-04	43.47%
25%	5.63E+01	8.05E-04	56.74%
30%	8.10E+01	1.31E-03	72.45%
35%	1.10E+02	2.10E-03	91.62%
40%	1.44E+02	3.36E-03	115.88%

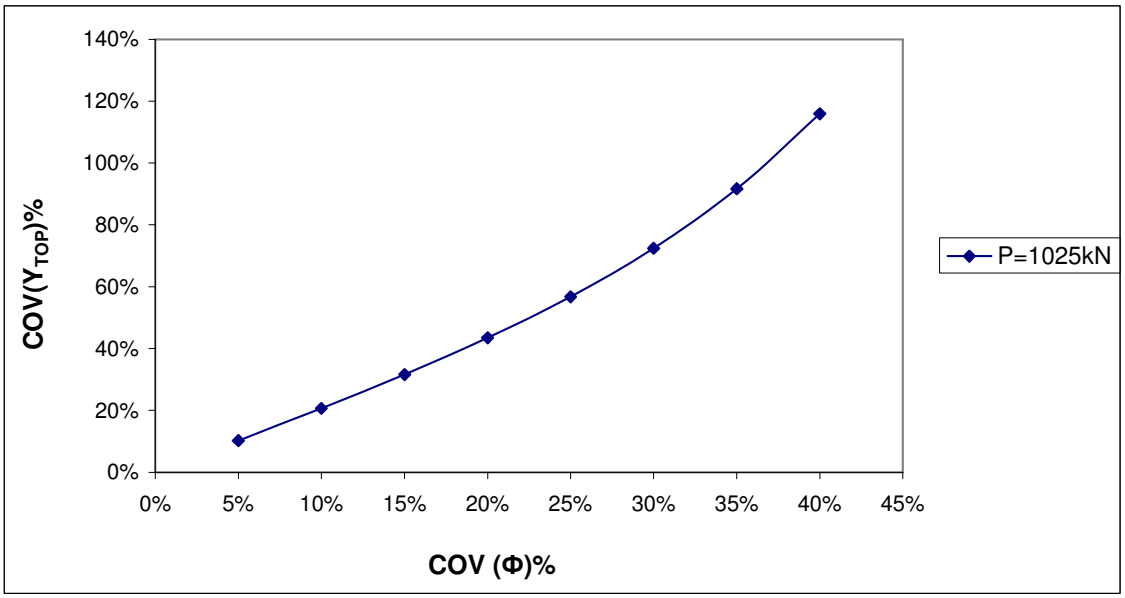


Fig. C.5 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

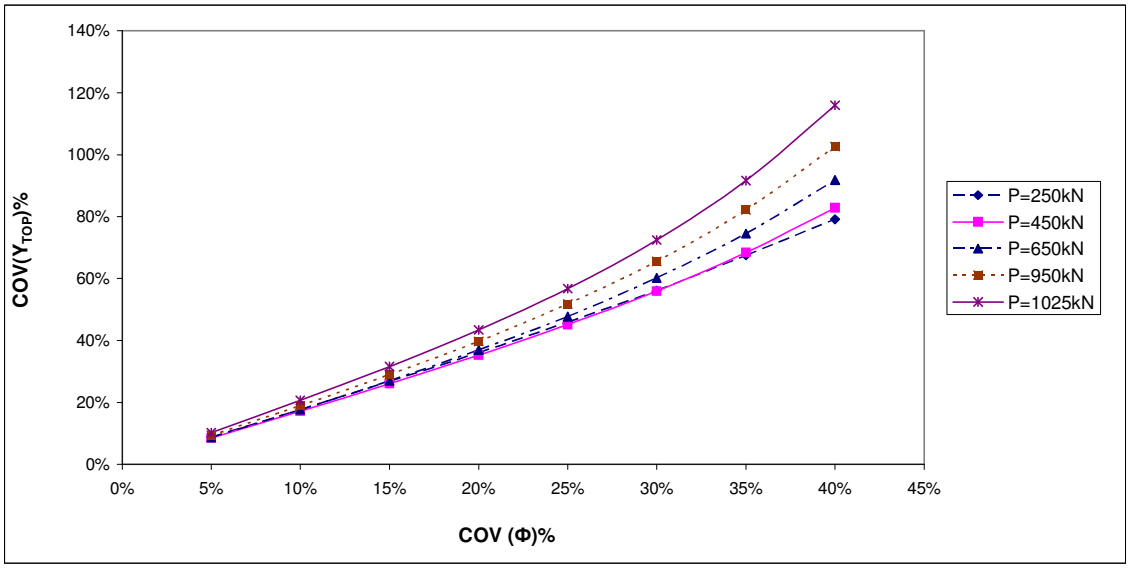


Fig. C.6 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table C.11 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (γ') and load 250kN.

P=250kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^{o} (m)	COV(Y_{TOP}) (%)
		11.025	9.82E-03				
5%	10.5			2.76E-01	4.29E-07	4.13E-03	3.59%
		9.975	1.06E-02				
		11.55	9.48E-03				
10%	10.5			1.10E+00	1.73E-06	4.13E-03	7.21%
		9.45	1.10E-02				
		12.075	9.17E-03				
15%	10.5			2.48E+00	3.96E-06	4.13E-03	10.90%
		8.925	1.15E-02				
		12.6	8.89E-03				
20%	10.5			4.41E+00	7.24E-06	4.13E-03	14.74%
		8.4	1.20E-02				
		13.125	8.63E-03				
25%	10.5			6.89E+00	1.17E-05	4.13E-03	18.74%
		7.875	1.26E-02				
		13.65	8.38E-03				
30%	10.5			9.92E+00	1.76E-05	4.13E-03	23.01%
		7.35	1.33E-02				
		14.175	8.15E-03				
35%	10.5			1.35E+01	2.54E-05	4.13E-03	27.62%
		6.825	1.40E-02				
		14.7	7.92E-03				
40%	10.5			1.76E+01	3.56E-05	4.13E-03	32.71%
		6.3	1.48E-02				

Table C.12 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (γ') and load 450kN.

P=450kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^{o} (m)	COV(Y_{TOP}) (%)
		11.025	1.76E-02				
5%	10.5			2.76E-01	1.44E-07	7.40E-03	3.72%
		9.975	1.89E-02				
		11.55	1.70E-02				
10%	10.5			1.10E+00	5.89E-07	7.40E-03	7.53%
		9.45	1.97E-02				
		12.075	1.65E-02				
15%	10.5			2.48E+00	1.35E-06	7.40E-03	11.41%
		8.925	2.05E-02				
		12.6	1.60E-02				
20%	10.5			4.41E+00	2.45E-06	7.40E-03	15.36%
		8.4	2.14E-02				
		13.125	1.56E-02				
25%	10.5			6.89E+00	3.94E-06	7.40E-03	19.47%
		7.875	2.24E-02				
		13.65	1.51E-02				
30%	10.5			9.92E+00	5.94E-06	7.40E-03	23.93%
		7.35	2.35E-02				
		14.175	1.47E-02				
35%	10.5			1.35E+01	8.57E-06	7.40E-03	28.73%
		6.825	2.48E-02				
		14.7	1.43E-02				
40%	10.5			1.76E+01	1.19E-05	7.40E-03	33.91%
		6.3	2.63E-02				

Table C.13 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (γ) and load 650kN.

P=650kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.025	2.65E-02				
5%	10.5			2.76E-01	1.03E-06	1.63E-02	4.79%
		9.975	2.85E-02				
		11.55	2.56E-02				
10%	10.5			1.10E+00	4.08E-06	1.63E-02	9.53%
		9.45	2.97E-02				
		12.075	2.49E-02				
15%	10.5			2.48E+00	9.15E-06	1.63E-02	14.27%
		8.925	3.09E-02				
		12.6	2.41E-02				
20%	10.5			4.41E+00	1.69E-05	1.63E-02	19.39%
		8.4	3.23E-02				
		13.125	2.34E-02				
25%	10.5			6.89E+00	2.80E-05	1.63E-02	24.98%
		7.875	3.40E-02				
		13.65	2.27E-02				
30%	10.5			9.92E+00	4.26E-05	1.63E-02	30.80%
		7.35	3.58E-02				
		14.175	2.21E-02				
35%	10.5			1.35E+01	6.19E-05	1.63E-02	37.10%
		6.825	3.79E-02				
		14.7	2.16E-02				
40%	10.5			1.76E+01	8.79E-05	1.63E-02	43.24%
		6.3	4.03E-02				

Table C.14 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (γ) and load 950kN.

P=950kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.025	3.69E-02				
5%	10.5			2.76E-01	2.10E-06	3.23E-02	4.49%
		9.975	3.98E-02				
		11.55	3.56E-02				
10%	10.5			1.10E+00	8.79E-06	3.23E-02	9.18%
		9.45	4.15E-02				
		12.075	3.44E-02				
15%	10.5			2.48E+00	2.10E-05	3.23E-02	14.18%
		8.925	4.35E-02				
		12.6	3.33E-02				
20%	10.5			4.41E+00	3.85E-05	3.23E-02	19.21%
		8.4	4.57E-02				
		13.125	3.23E-02				
25%	10.5			6.89E+00	6.20E-05	3.23E-02	24.38%
		7.875	4.80E-02				
		13.65	3.14E-02				
30%	10.5			9.92E+00	9.43E-05	3.23E-02	30.06%
		7.35	5.08E-02				
		14.175	3.06E-02				
35%	10.5			1.35E+01	1.38E-04	3.23E-02	36.39%
		6.825	5.41E-02				
		14.7	2.98E-02				
40%	10.5			1.76E+01	1.95E-04	3.23E-02	43.53%
		6.3	5.77E-02				

Table C.15 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (γ) and load 1025kN.

P=1025kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.025	4.91E-02				
5%	10.5			2.76E-01	4.33E-06	4.55E-02	4.57%
		9.975	5.33E-02				
		11.55	4.73E-02				
10%	10.5			1.10E+00	1.78E-05	4.55E-02	9.27%
		9.45	5.58E-02				
		12.075	4.57E-02				
15%	10.5			2.48E+00	4.14E-05	4.55E-02	14.14%
		8.925	5.85E-02				
		12.6	4.41E-02				
20%	10.5			4.41E+00	7.60E-05	4.55E-02	19.15%
		8.4	6.15E-02				
		13.125	4.27E-02				
25%	10.5			6.89E+00	1.25E-04	4.55E-02	24.53%
		7.875	6.50E-02				
		13.65	4.14E-02				
30%	10.5			9.92E+00	1.91E-04	4.55E-02	30.34%
		7.35	6.90E-02				
		14.175	4.02E-02				
35%	10.5			1.35E+01	2.76E-04	4.55E-02	36.54%
		6.825	7.35E-02				
		14.7	3.91E-02				
40%	10.5			1.76E+01	3.92E-04	4.55E-02	44.22%
		6.3	7.87E-02				

Table C.16 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 250kN.

P=250kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	4.29E-07	3.59%
10%	1.10E+00	1.73E-06	7.21%
15%	2.48E+00	3.96E-06	10.90%
20%	4.41E+00	7.24E-06	14.74%
25%	6.89E+00	1.17E-05	18.74%
30%	9.92E+00	1.76E-05	23.01%
35%	1.35E+01	2.54E-05	27.62%
40%	1.76E+01	3.56E-05	32.71%

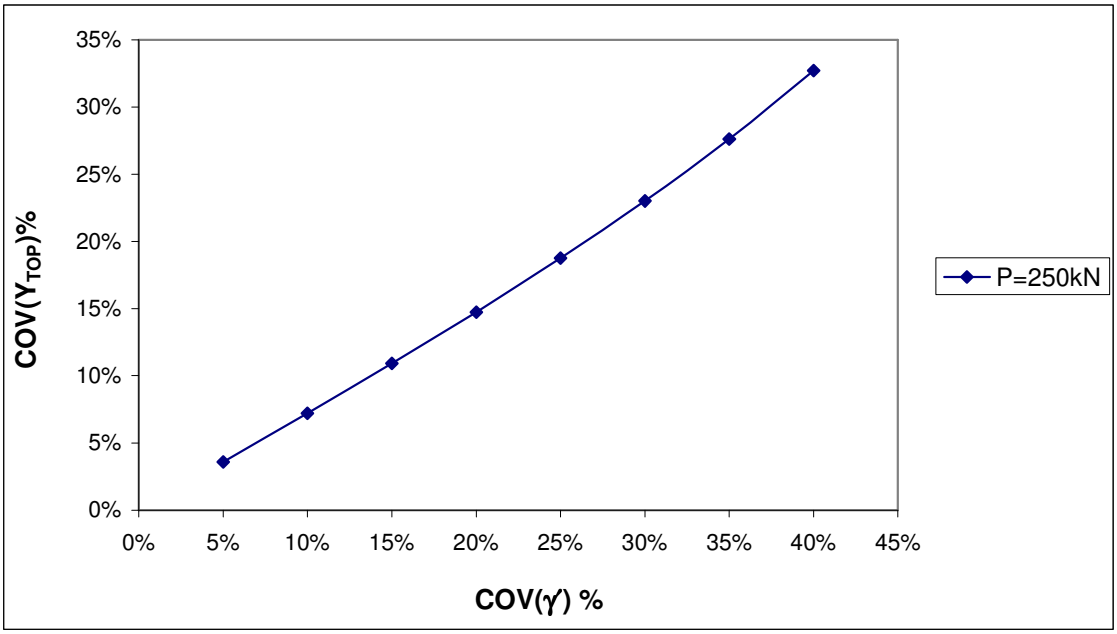


Fig. C.7 Variability of COV (Y_{TOP}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.17 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 450kN.

P=450kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	1.44E-07	3.72%
10%	1.10E+00	5.89E-07	7.53%
15%	2.48E+00	1.35E-06	11.41%
20%	4.41E+00	2.45E-06	15.36%
25%	6.89E+00	3.94E-06	19.47%
30%	9.92E+00	5.94E-06	23.93%
35%	1.35E+01	8.57E-06	28.73%
40%	1.76E+01	1.19E-05	33.91%

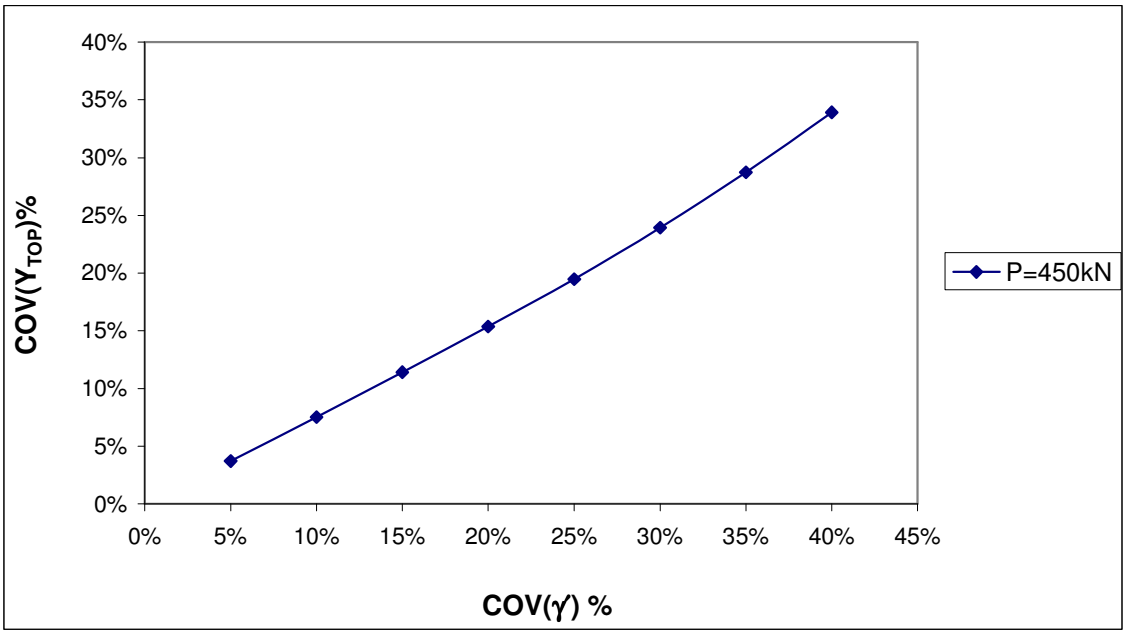


Fig. C.8 Variability of COV (Y_{TOP}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.18 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 650kN.

P=650kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	1.03E-06	4.79%
10%	1.10E+00	4.08E-06	9.53%
15%	2.48E+00	9.15E-06	14.27%
20%	4.41E+00	1.69E-05	19.39%
25%	6.89E+00	2.80E-05	24.98%
30%	9.92E+00	4.26E-05	30.80%
35%	1.35E+01	6.19E-05	37.10%
40%	1.76E+01	8.79E-05	43.24%

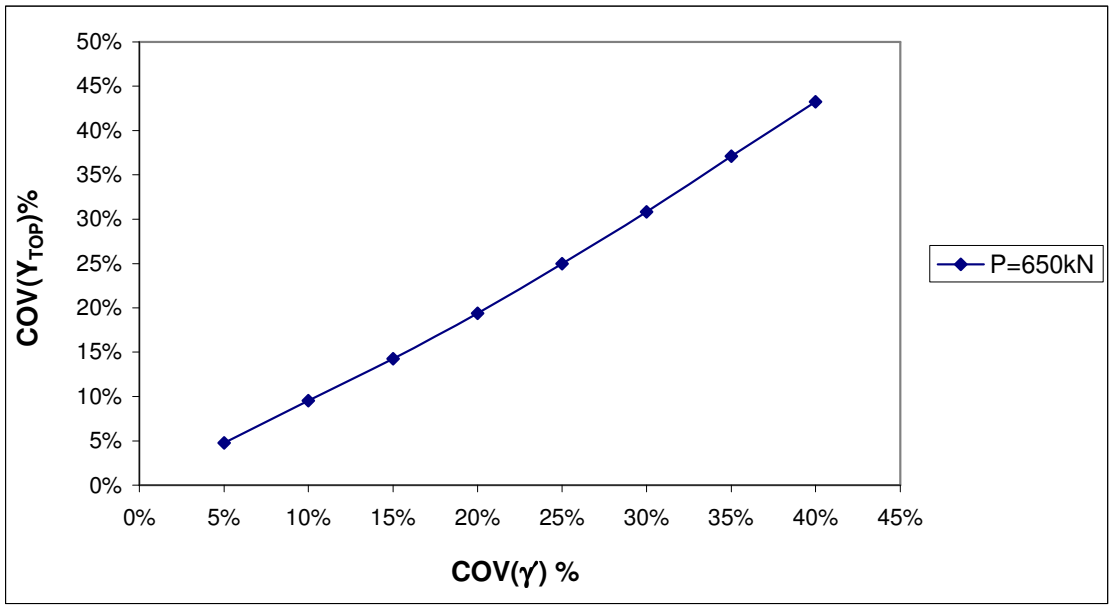


Fig. C.9 Variability of COV (Y_{TOP}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.19 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 950kN.

P=950kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	2.10E-06	4.49%
10%	1.10E+00	8.79E-06	9.18%
15%	2.48E+00	2.10E-05	14.18%
20%	4.41E+00	3.85E-05	19.21%
25%	6.89E+00	6.20E-05	24.38%
30%	9.92E+00	9.43E-05	30.06%
35%	1.35E+01	1.38E-04	36.39%
40%	1.76E+01	1.95E-04	43.53%

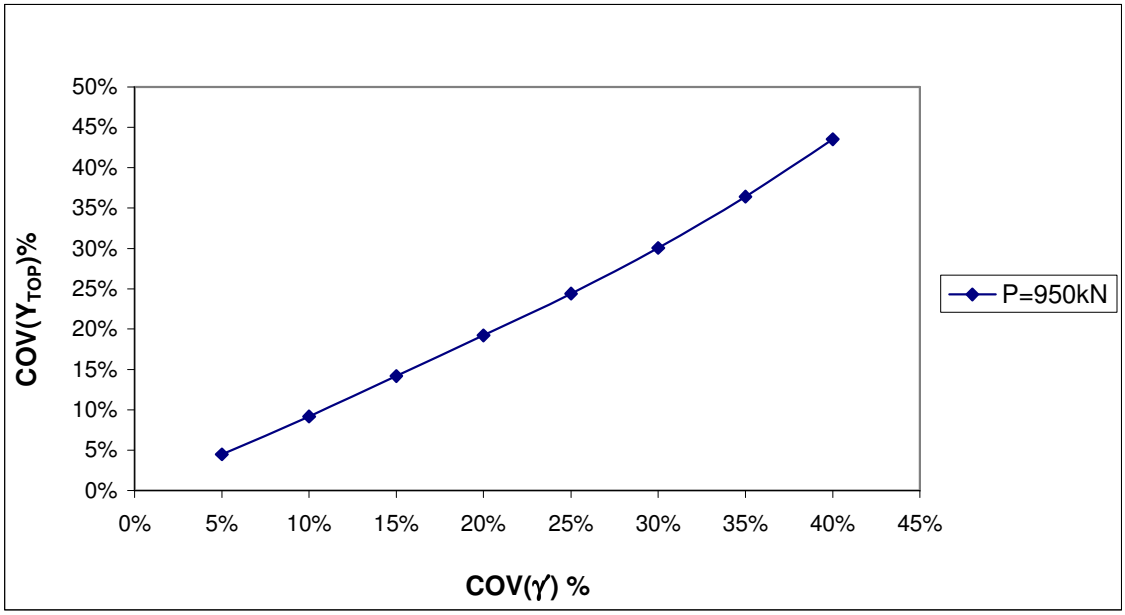


Fig. C.10 Variability of COV (Y_{TOP}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.20 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(γ') and lateral load 1025kN.

P=1025kN			
COV(γ') (%)	VAR(γ') $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	4.33E-06	4.57%
10%	1.10E+00	1.78E-05	9.27%
15%	2.48E+00	4.14E-05	14.14%
20%	4.41E+00	7.60E-05	19.15%
25%	6.89E+00	1.25E-04	24.53%
30%	9.92E+00	1.91E-04	30.34%
35%	1.35E+01	2.76E-04	36.54%
40%	1.76E+01	3.92E-04	44.22%

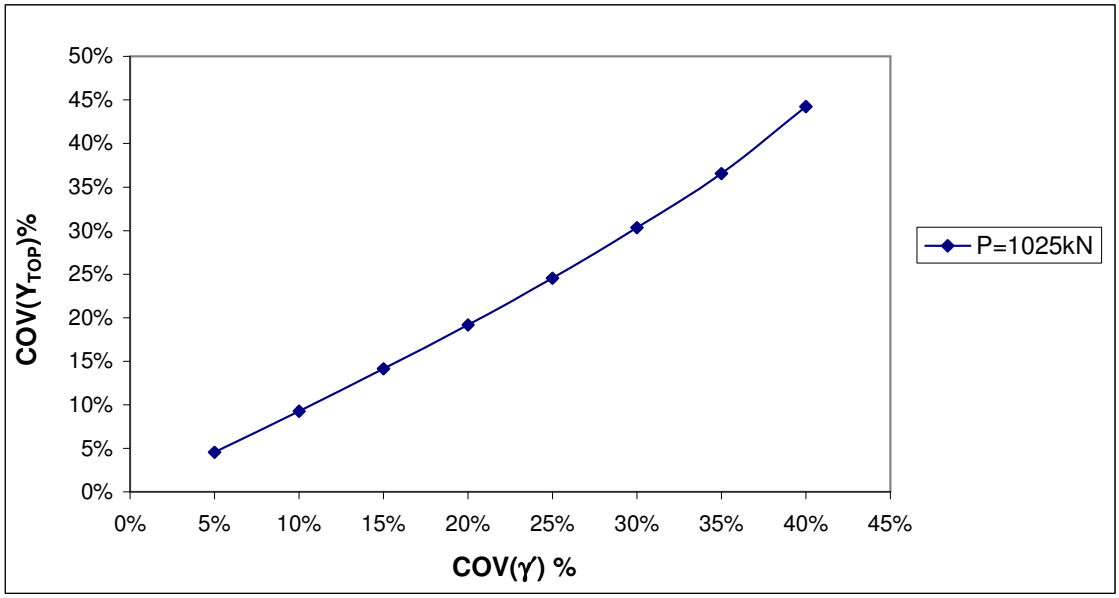


Fig. C.11 Variability of COV (Y_{TOP}) vs. COV (γ') for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

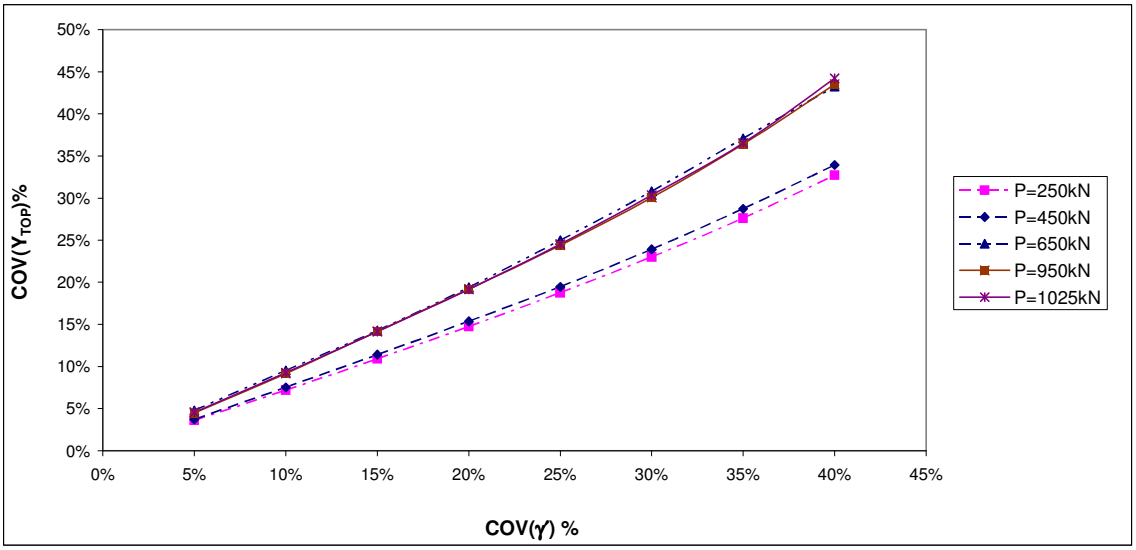


Fig. C.12 Variability of COV (Y_{TOP}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table C.21 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (k) and load 250kN.

P=250kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	1.02E-02				
5%	16300			6.64E+05	9.00E-10	4.13E-03	0.73%
		15485	1.02E-02				
		17930	1.01E-02				
10%	16300			2.66E+06	3.60E-09	4.13E-03	1.45%
		14670	1.03E-02				
		18745	1.01E-02				
15%	16300			5.98E+06	9.03E-09	4.13E-03	2.30%
		13855	1.03E-02				
		19560	1.01E-02				
20%	16300			1.06E+07	1.56E-08	4.13E-03	3.03%
		13040	1.03E-02				
		20375	1.01E-02				
25%	16300			1.66E+07	2.56E-08	4.13E-03	3.87%
		12225	1.04E-02				
		21190	1.01E-02				
30%	16300			2.39E+07	4.20E-08	4.13E-03	4.96%
		11410	1.05E-02				
		22005	1.00E-02				
35%	16300			3.25E+07	6.76E-08	4.13E-03	6.30%
		10595	1.06E-02				
		22820	1.00E-02				
40%	16300			4.25E+07	9.92E-08	4.13E-03	7.63%
		9780	1.07E-02				

Table C.22 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (k) and load 450kN.

P=450kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	1.82E-02				
5%	16300			6.64E+05	1.23E-09	7.40E-03	0.30%
		15485	1.83E-02				
		17930	1.82E-02				
10%	16300			2.66E+06	4.90E-09	7.40E-03	0.59%
		14670	1.83E-02				
		18745	1.82E-02				
15%	16300			5.98E+06	1.21E-08	7.40E-03	0.93%
		13855	1.84E-02				
		19560	1.81E-02				
20%	16300			1.06E+07	2.10E-08	7.40E-03	1.23%
		13040	1.84E-02				
		20375	1.81E-02				
25%	16300			1.66E+07	3.61E-08	7.40E-03	1.61%
		12225	1.85E-02				
		21190	1.81E-02				
30%	16300			2.39E+07	5.76E-08	7.40E-03	2.03%
		11410	1.86E-02				
		22005	1.81E-02				
35%	16300			3.25E+07	9.30E-08	7.40E-03	2.58%
		10595	1.87E-02				
		22820	1.81E-02				
40%	16300			4.25E+07	1.37E-07	7.40E-03	3.14%
		9780	1.88E-02				

Table C.23 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (k) and load 650kN.

P=650kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	2.74E-02				
5%	16300			6.64E+05	1.23E-09	1.63E-02	0.17%
		15485	2.75E-02				
		17930	2.74E-02				
10%	16300			2.66E+06	5.63E-09	1.63E-02	0.35%
		14670	2.76E-02				
		18745	2.74E-02				
15%	16300			5.98E+06	1.56E-08	1.63E-02	0.59%
		13855	2.76E-02				
		19560	2.74E-02				
20%	16300			1.06E+07	2.89E-08	1.63E-02	0.80%
		13040	2.77E-02				
		20375	2.73E-02				
25%	16300			1.66E+07	5.29E-08	1.63E-02	1.08%
		12225	2.78E-02				
		21190	2.73E-02				
30%	16300			2.39E+07	8.70E-08	1.63E-02	1.39%
		11410	2.79E-02				
		22005	2.73E-02				
35%	16300			3.25E+07	1.30E-07	1.63E-02	1.70%
		10595	2.80E-02				
		22820	2.73E-02				
40%	16300			4.25E+07	1.81E-07	1.63E-02	2.00%
		9780	2.81E-02				

Table C.24 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (k) and load 950kN.

P=950kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	3.82E-02				
5%	16300			6.64E+05	3.02E-09	3.23E-02	0.17%
		15485	3.83E-02				
		17930	3.82E-02				
10%	16300			2.66E+06	1.21E-08	3.23E-02	0.34%
		14670	3.84E-02				
		18745	3.82E-02				
15%	16300			5.98E+06	2.56E-08	3.23E-02	0.50%
		13855	3.85E-02				
		19560	3.81E-02				
20%	16300			1.06E+07	4.84E-08	3.23E-02	0.68%
		13040	3.86E-02				
		20375	3.81E-02				
25%	16300			1.66E+07	7.29E-08	3.23E-02	0.84%
		12225	3.86E-02				
		21190	3.81E-02				
30%	16300			2.39E+07	1.16E-07	3.23E-02	1.05%
		11410	3.87E-02				
		22005	3.80E-02				
35%	16300			3.25E+07	1.76E-07	3.23E-02	1.30%
		10595	3.89E-02				
		22820	3.80E-02				
40%	16300			4.25E+07	2.70E-07	3.23E-02	1.61%
		9780	3.91E-02				

Table C.25 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (k) and load 1025kN.

P=1025kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	5.10E-02				
5%	16300			6.64E+05	3.02E-09	4.55E-02	0.12%
		15485	5.11E-02				
		17930	5.10E-02				
10%	16300			2.66E+06	1.44E-08	4.55E-02	0.26%
		14670	5.12E-02				
		18745	5.09E-02				
15%	16300			5.98E+06	3.61E-08	4.55E-02	0.42%
		13855	5.13E-02				
		19560	5.09E-02				
20%	16300			1.06E+07	7.02E-08	4.55E-02	0.58%
		13040	5.14E-02				
		20375	5.08E-02				
25%	16300			1.66E+07	1.23E-07	4.55E-02	0.77%
		12225	5.15E-02				
		21190	5.08E-02				
30%	16300			2.39E+07	1.94E-07	4.55E-02	0.97%
		11410	5.17E-02				
		22005	5.08E-02				
35%	16300			3.25E+07	3.02E-07	4.55E-02	1.21%
		10595	5.19E-02				
		22820	5.07E-02				
40%	16300			4.25E+07	4.36E-07	4.55E-02	1.45%
		9780	5.20E-02				

Table C.26 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 250kN.

P=250kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	9.00E-10	0.73%
10%	2.66E+06	3.60E-09	1.45%
15%	5.98E+06	9.03E-09	2.30%
20%	1.06E+07	1.56E-08	3.03%
25%	1.66E+07	2.56E-08	3.87%
30%	2.39E+07	4.20E-08	4.96%
35%	3.25E+07	6.76E-08	6.30%
40%	4.25E+07	9.92E-08	7.63%

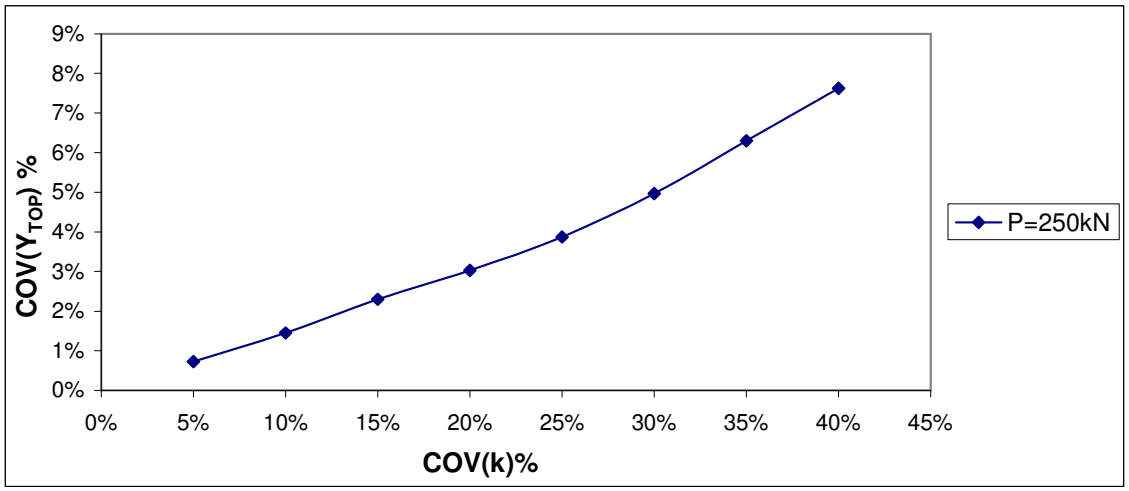


Fig. C.13 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.27 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 450kN.

P=450kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	1.23E-09	2.97E-03
10%	2.66E+06	4.90E-09	5.93E-03
15%	5.98E+06	1.21E-08	9.32E-03
20%	1.06E+07	2.10E-08	1.23E-02
25%	1.66E+07	3.61E-08	1.61E-02
30%	2.39E+07	5.76E-08	2.03E-02
35%	3.25E+07	9.30E-08	2.58E-02
40%	4.25E+07	1.37E-07	3.14E-02

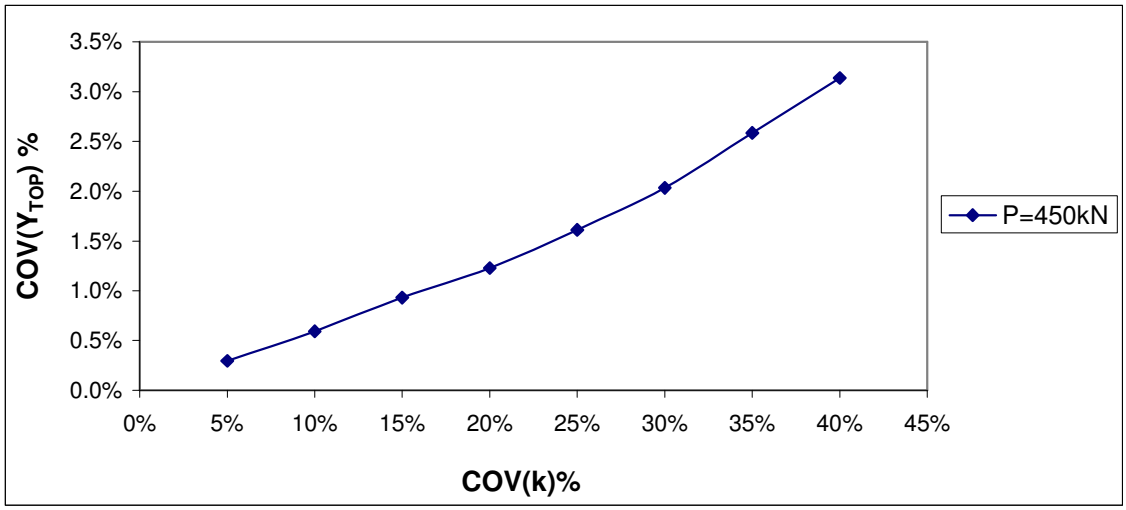


Fig. C.14 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.28 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 650kN.

P=650kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	1.23E-09	0.17%
10%	2.66E+06	5.63E-09	0.35%
15%	5.98E+06	1.56E-08	0.59%
20%	1.06E+07	2.89E-08	0.80%
25%	1.66E+07	5.29E-08	1.08%
30%	2.39E+07	8.70E-08	1.39%
35%	3.25E+07	1.30E-07	1.70%
40%	4.25E+07	1.81E-07	2.00%

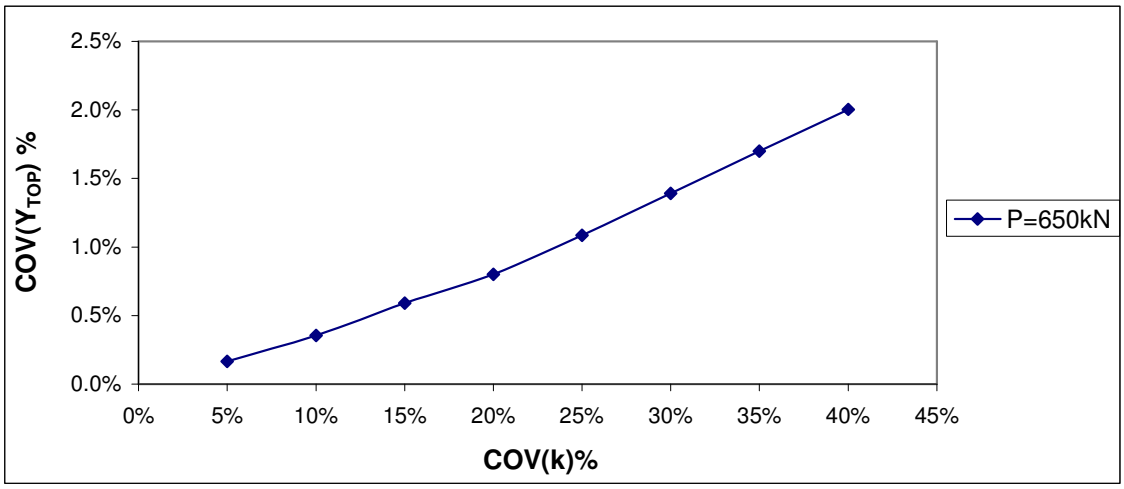


Fig. C.15 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.29 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 950kN.

P=950kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	3.02E-09	0.17%
10%	2.66E+06	1.21E-08	0.34%
15%	5.98E+06	2.56E-08	0.50%
20%	1.06E+07	4.84E-08	0.68%
25%	1.66E+07	7.29E-08	0.84%
30%	2.39E+07	1.16E-07	1.05%
35%	3.25E+07	1.76E-07	1.30%
40%	4.25E+07	2.70E-07	1.61%

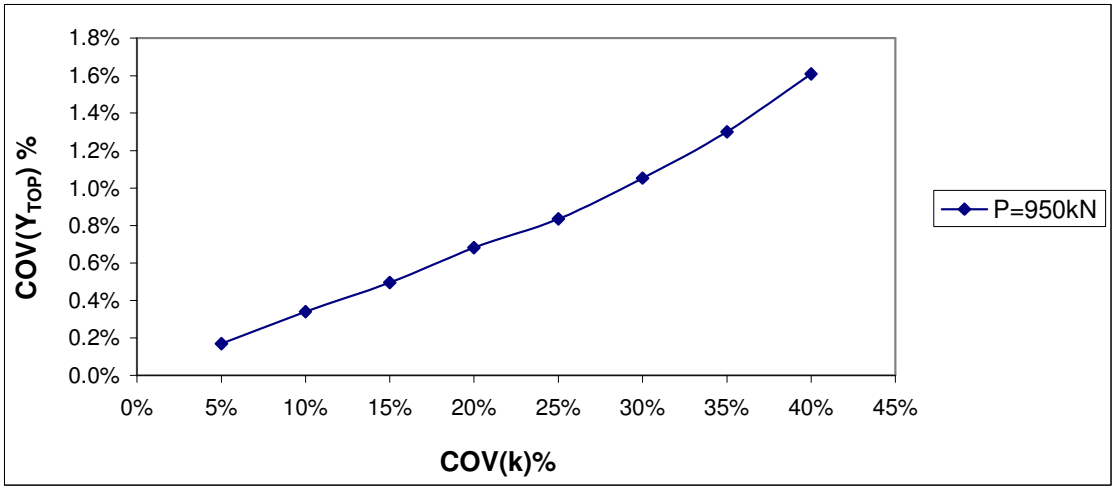


Fig. C.16 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.30 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 1025kN.

P=1025kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	3.02E-09	0.12%
10%	2.66E+06	1.44E-08	0.26%
15%	5.98E+06	3.61E-08	0.42%
20%	1.06E+07	7.02E-08	0.58%
25%	1.66E+07	1.23E-07	0.77%
30%	2.39E+07	1.94E-07	0.97%
35%	3.25E+07	3.02E-07	1.21%
40%	4.25E+07	4.36E-07	1.45%

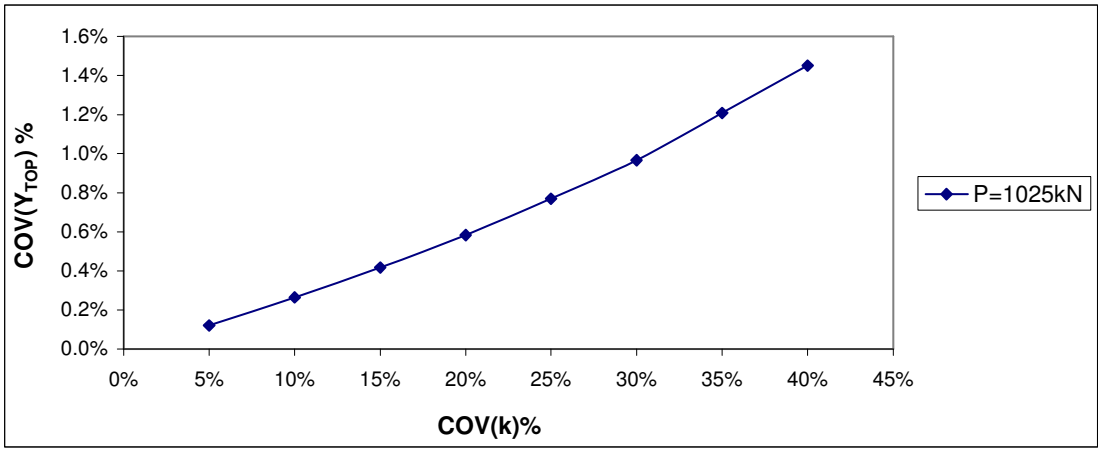


Fig. C.17 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

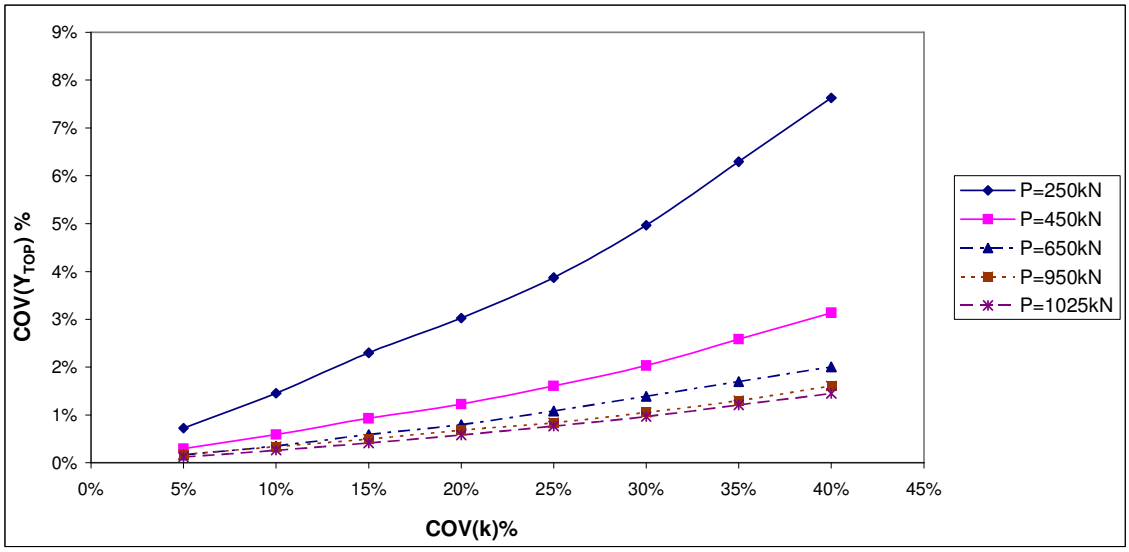


Fig. C.18 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table C.31 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (B) and load 250kN.

P=250kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	1.01E-02				
5%	0.406			4.12E-04	6.25E-10	4.13E-03	0.90%
		0.3857	1.03E-02				
		0.4466	9.95E-03				
10%	0.406			1.65E-03	1.30E-07	4.13E-03	1.30%
		0.3654	1.03E-02				
		0.4669	9.83E-03				
15%	0.406			3.71E-03	1.64E-07	4.13E-03	2.60%
		0.3451	1.03E-02				
		0.4872	9.73E-03				
20%	0.406			6.59E-03	2.03E-07	4.13E-03	3.81%
		0.3248	1.03E-02				
		0.5075	9.56E-03				
25%	0.406			1.03E-02	2.55E-07	4.13E-03	5.90%
		0.3045	1.03E-02				
		0.5278	9.35E-03				
30%	0.406			1.48E-02	1.19E-06	4.13E-03	9.24%
		0.2842	1.02E-02				
		0.5472	9.17E-03				
35%	0.406			2.02E-02	1.42E-06	4.13E-03	12.50%
		0.2648	1.01E-02				
		0.5684	9.00E-03				
40%	0.406			2.64E-02	5.31E-06	4.13E-03	19.53%
		0.2436	1.00E-02				

Table C.32 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (B) and load 450kN.

P=450kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	1.83E-02				
5%	0.406			4.12E-04	9.02E-09	7.40E-03	2.30%
		0.3857	1.83E-02				
		0.4466	1.89E-02				
10%	0.406			1.65E-03	2.71E-08	7.40E-03	3.18%
		0.3654	1.82E-02				
		0.4669	1.89E-02				
15%	0.406			3.71E-03	5.50E-08	7.40E-03	4.30%
		0.3451	1.81E-02				
		0.4872	1.89E-02				
20%	0.406			6.59E-03	8.27E-08	7.40E-03	6.30%
		0.3248	1.80E-02				
		0.5075	1.89E-02				
25%	0.406			1.03E-02	1.38E-07	7.40E-03	8.72%
		0.3045	1.79E-02				
		0.5278	1.99E-02				
30%	0.406			1.48E-02	1.98E-07	7.40E-03	11.50%
		0.2842	1.77E-02				
		0.5472	1.99E-02				
35%	0.406			2.02E-02	2.37E-07	7.40E-03	15.34%
		0.2648	1.75E-02				
		0.5684	2.20E-02				
40%	0.406			2.64E-02	2.70E-07	7.40E-03	21.10%
		0.2436	1.74E-02				

Table C.33 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (B) and load 650kN.

P=650kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	2.75E-02				
5%	0.406			4.12E-04	1.60E-09	1.63E-02	1.50%
		0.3857	2.74E-02				
		0.4466	2.90E-02				
10%	0.406			1.65E-03	7.14E-07	1.63E-02	3.40%
		0.3654	2.73E-02				
		0.4669	2.90E-02				
15%	0.406			3.71E-03	7.14E-07	1.63E-02	6.30%
		0.3451	2.73E-02				
		0.4872	3.20E-02				
20%	0.406			6.59E-03	5.50E-06	1.63E-02	11.06%
		0.3248	2.73E-02				
		0.5075	3.20E-02				
25%	0.406			1.03E-02	1.23E-05	1.63E-02	15.50%
		0.3045	2.50E-02				
		0.5278	3.40E-02				
30%	0.406			1.48E-02	1.94E-05	1.63E-02	20.75%
		0.2842	2.52E-02				
		0.5472	3.40E-02				
35%	0.406			2.02E-02	2.53E-05	1.63E-02	23.74%
		0.2648	2.40E-02				
		0.5684	3.60E-02				
40%	0.406			2.64E-02	4.23E-05	1.63E-02	30.66%
		0.2436	2.30E-02				

Table C.34 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (B) and load 950kN.

P=950kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	4.00E-02				
5%	0.406			4.12E-04	5.63E-07	3.23E-02	2.32%
		0.3857	3.85E-02				
		0.4466	4.30E-02				
10%	0.406			1.65E-03	5.29E-06	3.23E-02	4.40%
		0.3654	3.84E-02				
		0.4669	4.50E-02				
15%	0.406			3.71E-03	1.12E-05	3.23E-02	7.20%
		0.3451	3.83E-02				
		0.4872	4.60E-02				
20%	0.406			6.59E-03	2.76E-05	3.23E-02	10.80%
		0.3248	3.55E-02				
		0.5075	4.70E-02				
25%	0.406			1.03E-02	3.91E-05	3.23E-02	15.30%
		0.3045	3.45E-02				
		0.5278	4.80E-02				
30%	0.406			1.48E-02	5.26E-05	3.23E-02	20.80%
		0.2842	3.35E-02				
		0.5472	4.90E-02				
35%	0.406			2.02E-02	6.89E-05	3.23E-02	26.50%
		0.2648	3.25E-02				
		0.5684	5.10E-02				
40%	0.406			2.64E-02	1.05E-04	3.23E-02	32.30%
		0.2436	3.05E-02				

Table C.35 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (B) and load 1025kN.

P=1025kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	5.06E-02				
5%	0.406			4.12E-04	1.21E-06	4.55E-02	2.42%
		0.3857	5.28E-02				
		0.4466	5.06E-02				
10%	0.406			1.65E-03	4.16E-06	4.55E-02	4.48%
		0.3654	5.47E-02				
		0.4669	5.04E-02				
15%	0.406			3.71E-03	1.02E-05	4.55E-02	7.03%
		0.3451	5.68E-02				
		0.4872	4.90E-02				
20%	0.406			6.59E-03	2.50E-05	4.55E-02	11.00%
		0.3248	5.90E-02				
		0.5075	4.70E-02				
25%	0.406			1.03E-02	5.63E-05	4.55E-02	16.48%
		0.3045	6.20E-02				
		0.5278	4.30E-02				
30%	0.406			1.48E-02	1.21E-04	4.55E-02	22.60%
		0.2842	6.50E-02				
		0.5472	3.90E-02				
35%	0.406			2.02E-02	2.13E-04	4.55E-02	28.30%
		0.2648	6.80E-02				
		0.5684	3.70E-02				
40%	0.406			2.64E-02	2.56E-04	4.55E-02	35.16%
		0.2436	6.90E-02				

Table C.36 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 250kN.

P=250kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	6.25E-10	0.90%
10%	1.65E-03	1.30E-07	1.30%
15%	3.71E-03	1.64E-07	2.60%
20%	6.59E-03	2.03E-07	3.81%
25%	1.03E-02	2.55E-07	5.90%
30%	1.48E-02	1.19E-06	9.24%
35%	2.02E-02	1.42E-06	12.50%
40%	2.64E-02	5.31E-06	19.53%

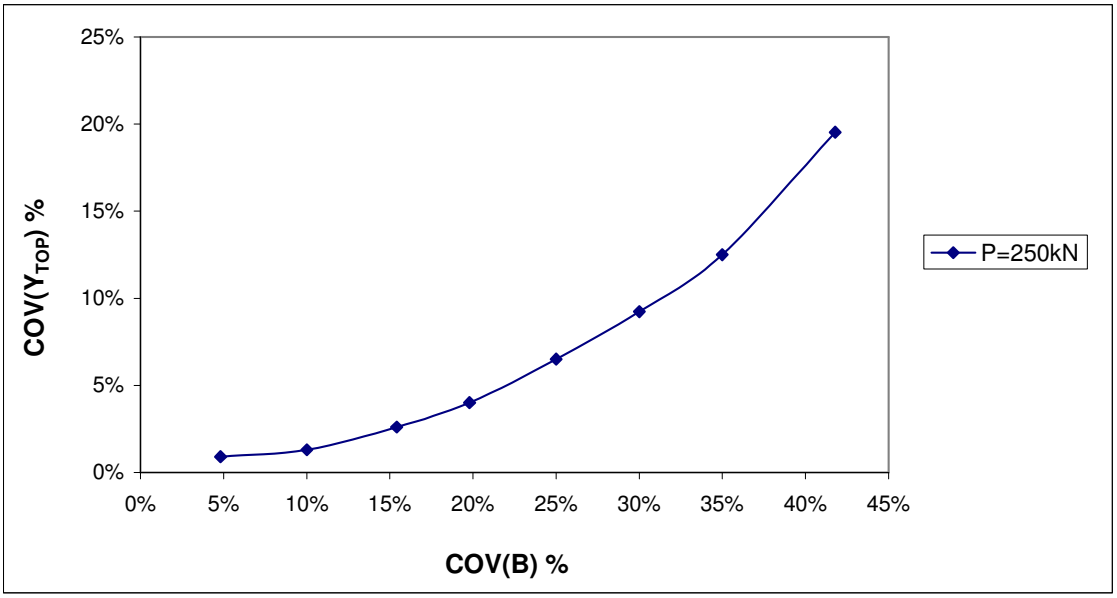


Fig. C.19 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.37 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 450kN.

P=450kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	9.02E-09	2.30%
10%	1.65E-03	2.71E-08	3.18%
15%	3.71E-03	5.50E-08	4.30%
20%	6.59E-03	8.27E-08	6.30%
25%	1.03E-02	1.38E-07	8.72%
30%	1.48E-02	1.98E-07	11.50%
35%	2.02E-02	2.37E-07	15.34%
40%	2.64E-02	2.70E-07	21.10%

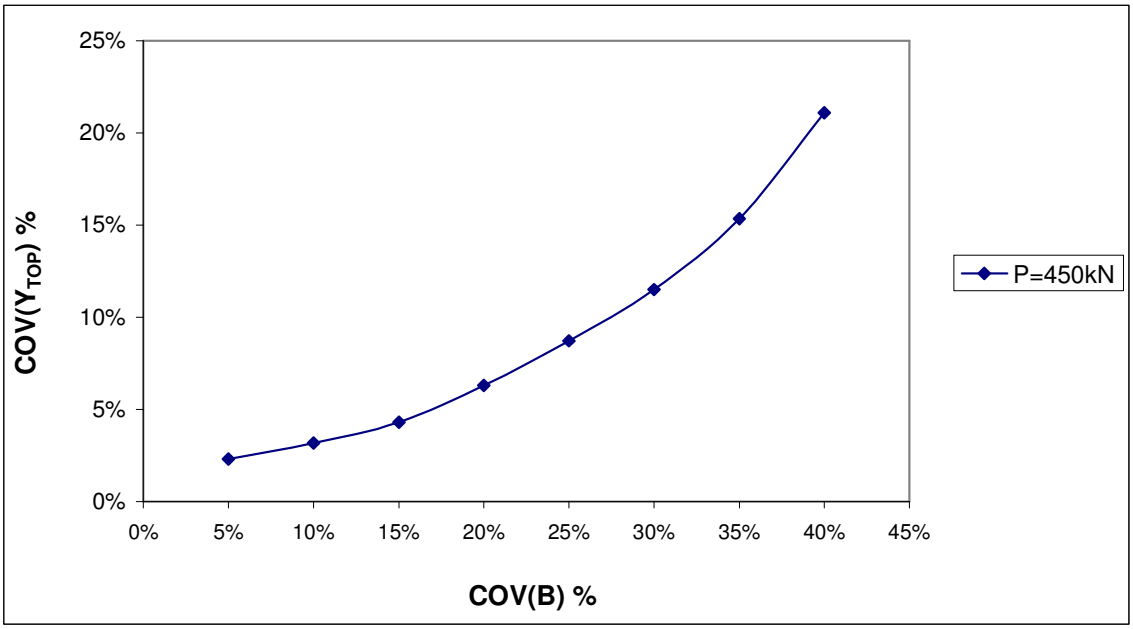


Fig. C.20 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.38 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 650kN.

P=650kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.60E-09	1.50%
10%	1.65E-03	7.14E-07	3.40%
15%	3.71E-03	7.14E-07	6.30%
20%	6.59E-03	5.50E-06	11.06%
25%	1.03E-02	1.23E-05	15.50%
30%	1.48E-02	1.94E-05	20.75%
35%	2.02E-02	2.53E-05	23.74%
40%	2.64E-02	4.23E-05	30.66%

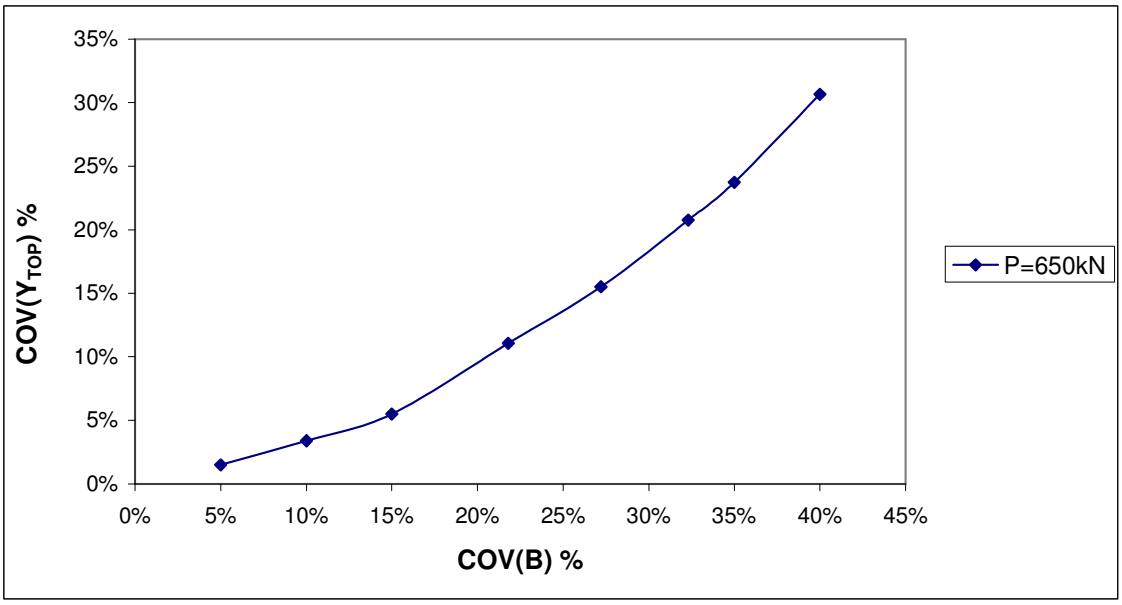


Fig. C.21 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.39 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 950kN.

P=950kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	5.63E-07	2.32%
10%	1.65E-03	5.29E-06	4.40%
15%	3.71E-03	1.12E-05	7.20%
20%	6.59E-03	2.76E-05	10.80%
25%	1.03E-02	3.91E-05	15.30%
30%	1.48E-02	5.26E-05	20.80%
35%	2.02E-02	6.89E-05	26.50%
40%	2.64E-02	1.05E-04	32.30%

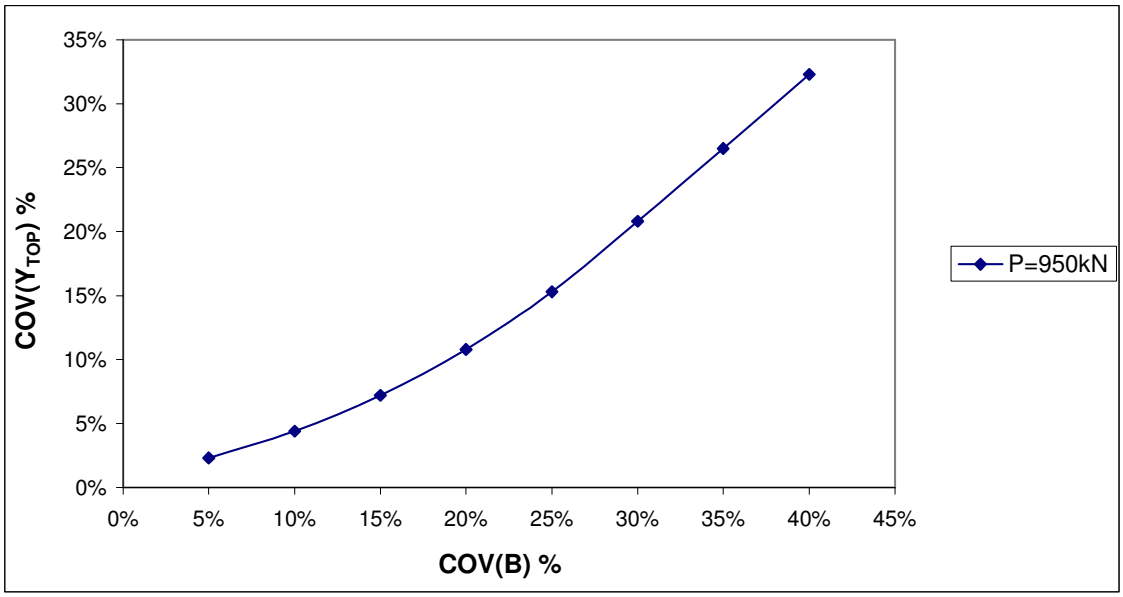


Fig. C.22 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.40 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 1025kN.

P=1025kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.21E-06	2.42%
10%	1.65E-03	4.16E-06	4.48%
15%	3.71E-03	1.02E-05	7.03%
20%	6.59E-03	2.50E-05	11.00%
25%	1.03E-02	5.63E-05	16.48%
30%	1.48E-02	1.21E-04	22.60%
35%	2.02E-02	2.13E-04	28.30%
40%	2.64E-02	2.56E-04	35.16%

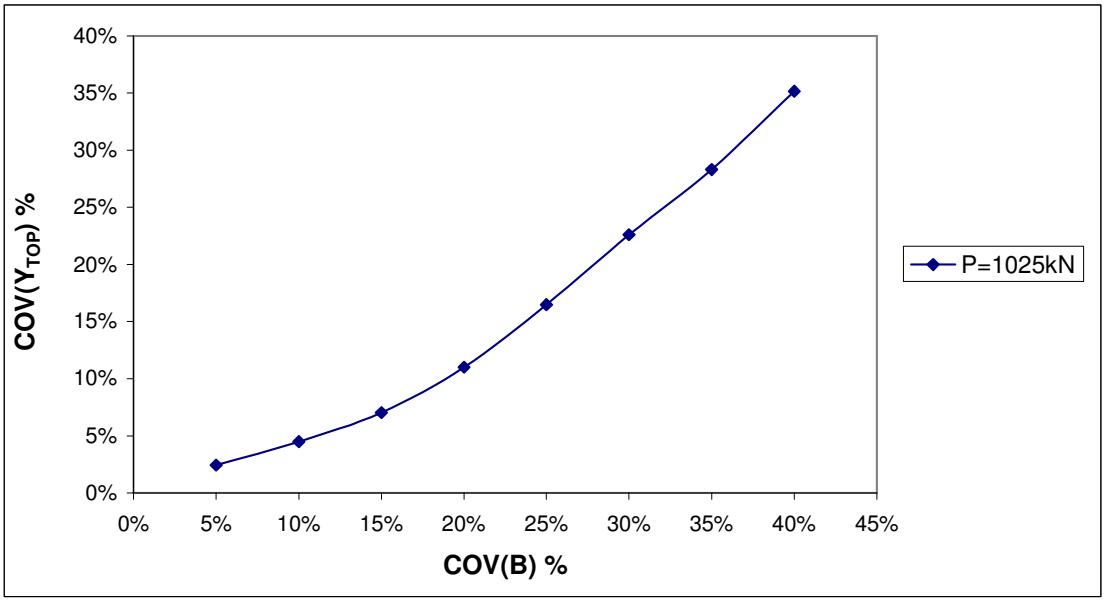


Fig. C.23 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

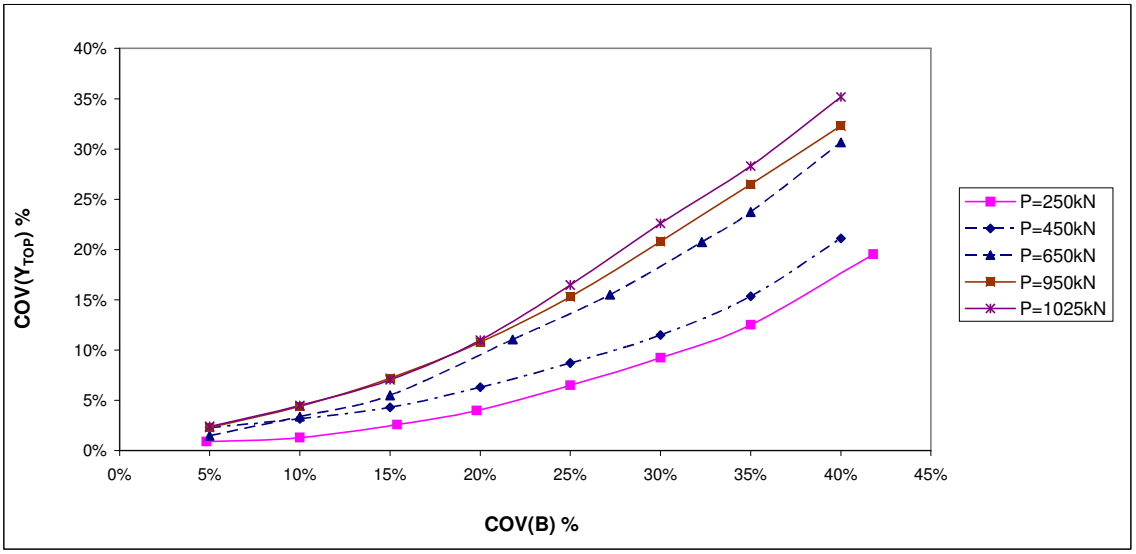


Fig. C.24 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table C.41 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (EI) and load 250kN.

P=250kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	9.87E-03				
5%	61000			9.30E+06	2.80E-08	4.13E-03	2.22%
		57950	1.05E-02				
		67100	9.58E-03				
10%	61000			3.72E+07	1.11E-07	4.13E-03	4.45%
		54900	1.09E-02				
		70150	9.30E-03				
15%	61000			8.37E+07	2.57E-07	4.13E-03	6.70%
		51850	1.13E-02				
		73200	9.05E-03				
20%	61000			1.49E+08	4.69E-07	4.13E-03	8.87%
		48800	1.18E-02				
		76250	8.82E-03				
25%	61000			2.33E+08	3.34E-07	4.13E-03	11.10%
		45750	1.23E-02				
		79300	8.59E-03				
30%	61000			3.35E+08	1.14E-06	4.13E-03	14.20%
		42700	1.29E-02				
		82350	8.39E-03				
35%	61000			4.56E+08	1.64E-06	4.13E-03	17.15%
		39650	1.35E-02				
		85400	8.19E-03				
40%	61000			5.95E+08	2.28E-06	4.13E-03	20.22%
		36600	1.42E-02				

Table C.42 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (EI) and load 450kN.

P=450kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	1.77E-02				
5%	61000			9.30E+06	8.85E-08	7.40E-03	2.82%
		57950	1.89E-02				
		67100	1.72E-02				
10%	61000			3.72E+07	3.57E-07	7.40E-03	5.30%
		54900	1.96E-02				
		70150	1.67E-02				
15%	61000			8.37E+07	8.15E-07	7.40E-03	7.90%
		51850	2.03E-02				
		73200	1.62E-02				
20%	61000			1.49E+08	1.49E-06	7.40E-03	10.92%
		48800	2.11E-02				
		76250	1.58E-02				
25%	61000			2.33E+08	1.06E-06	7.40E-03	14.40%
		45750	2.20E-02				
		79300	1.54E-02				
30%	61000			3.35E+08	3.66E-06	7.40E-03	17.82%
		42700	2.31E-02				
		82350	1.50E-02				
35%	61000			4.56E+08	5.28E-06	7.40E-03	21.70%
		39650	2.42E-02				
		85400	1.47E-02				
40%	61000			5.95E+08	7.40E-06	7.40E-03	25.00%
		36600	2.56E-02				

Table C.43 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (EI) and load 650kN.

P=650kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	2.66E-02				
5%	61000			9.30E+06	8.84E-07	1.63E-02	4.10%
		57950	2.85E-02				
		67100	2.58E-02				
10%	61000			3.72E+07	3.55E-06	1.63E-02	8.30%
		54900	2.95E-02				
		70150	2.50E-02				
15%	61000			8.37E+07	8.07E-06	1.63E-02	13.20%
		51850	3.07E-02				
		73200	2.43E-02				
20%	61000			1.49E+08	1.47E-05	1.63E-02	17.80%
		48800	3.20E-02				
		76250	2.37E-02				
25%	61000			2.33E+08	2.38E-05	1.63E-02	22.70%
		45750	3.34E-02				
		79300	2.31E-02				
30%	61000			3.35E+08	3.62E-05	1.63E-02	28.10%
		42700	3.51E-02				
		82350	2.25E-02				
35%	61000			4.56E+08	5.29E-05	1.63E-02	33.80%
		39650	3.71E-02				
		85400	2.20E-02				
40%	61000			5.95E+08	7.50E-05	1.63E-02	39.50%
		36600	3.93E-02				

Table C.44 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (EI) and load 950kN.

P=950kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	3.70E-02				
5%	61000			9.30E+06	1.88E-06	3.23E-02	4.24%
		57950	3.97E-02				
		67100	3.58E-02				
10%	61000			3.72E+07	7.67E-06	3.23E-02	8.58%
		54900	4.13E-02				
		70150	3.46E-02				
15%	61000			8.37E+07	1.78E-05	3.23E-02	13.07%
		51850	4.31E-02				
		73200	3.36E-02				
20%	61000			1.49E+08	3.30E-05	3.23E-02	17.79%
		48800	4.51E-02				
		76250	3.26E-02				
25%	61000			2.33E+08	5.45E-05	3.23E-02	22.85%
		45750	4.74E-02				
		79300	3.18E-02				
30%	61000			3.35E+08	8.33E-05	3.23E-02	28.25%
		42700	5.00E-02				
		82350	3.09E-02				
35%	61000			4.56E+08	1.21E-04	3.23E-02	34.09%
		39650	5.29E-02				
		85400	3.02E-02				
40%	61000			5.95E+08	1.71E-04	3.23E-02	40.46%
		36600	5.63E-02				

Table C.45 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (EI) and load 1025kN.

P=1025kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	4.92E-02				
5%	61000			9.30E+06	3.80E-06	4.55E-02	4.29%
		57950	5.31E-02				
		67100	4.75E-02				
10%	61000			3.72E+07	1.55E-05	4.55E-02	8.66%
		54900	5.54E-02				
		70150	4.60E-02				
15%	61000			8.37E+07	3.59E-05	4.55E-02	13.18%
		51850	5.80E-02				
		73200	4.45E-02				
20%	61000			1.49E+08	6.67E-05	4.55E-02	17.96%
		48800	6.09E-02				
		76250	4.32E-02				
25%	61000			2.33E+08	1.10E-04	4.55E-02	23.02%
		45750	6.41E-02				
		79300	4.19E-02				
30%	61000			3.35E+08	1.67E-04	4.55E-02	28.44%
		42700	6.78E-02				
		82350	4.08E-02				
35%	61000			4.56E+08	2.44E-04	4.55E-02	34.34%
		39650	7.20E-02				
		85400	3.97E-02				
40%	61000			5.95E+08	3.45E-04	4.55E-02	40.84%
		36600	7.68E-02				

Table C.46 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 250kN.

P=250kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	2.80E-08	2.22%
10%	3.72E+07	1.11E-07	4.45%
15%	8.37E+07	2.57E-07	6.70%
20%	1.49E+08	4.69E-07	8.87%
25%	2.33E+08	3.34E-07	11.10%
30%	3.35E+08	1.14E-06	14.20%
35%	4.56E+08	1.64E-06	17.15%
40%	5.95E+08	2.28E-06	20.22%

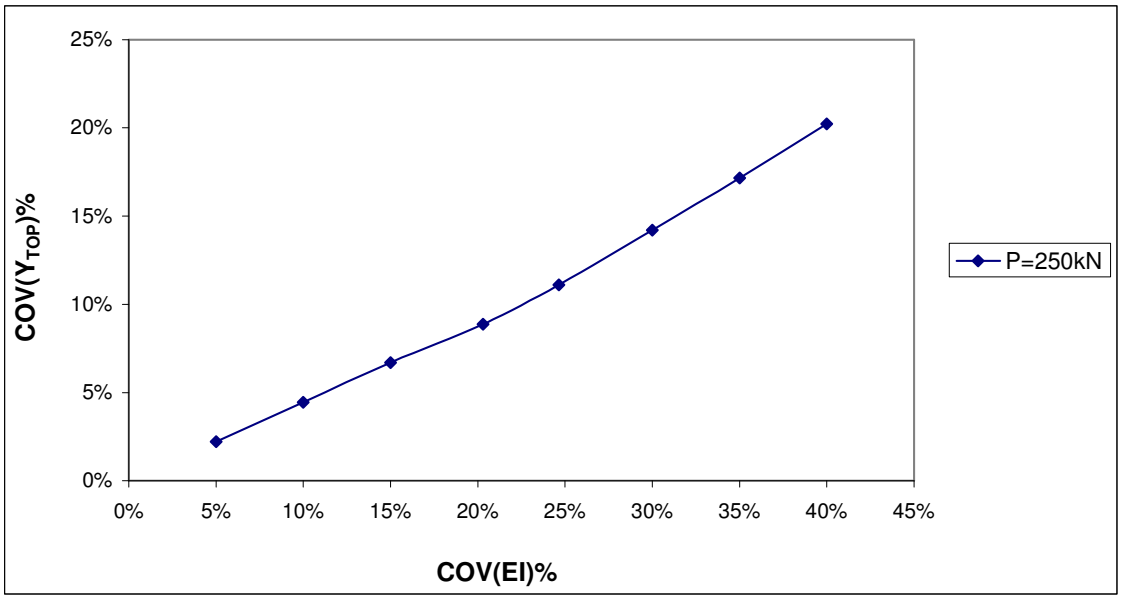


Fig. C.25 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.47 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 450kN.

P=450kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	8.85E-08	2.82%
10%	3.72E+07	3.57E-07	5.30%
15%	8.37E+07	8.15E-07	7.90%
20%	1.49E+08	1.49E-06	10.92%
25%	2.33E+08	1.06E-06	14.40%
30%	3.35E+08	3.66E-06	17.82%
35%	4.56E+08	5.28E-06	21.70%
40%	5.95E+08	7.40E-06	25.00%

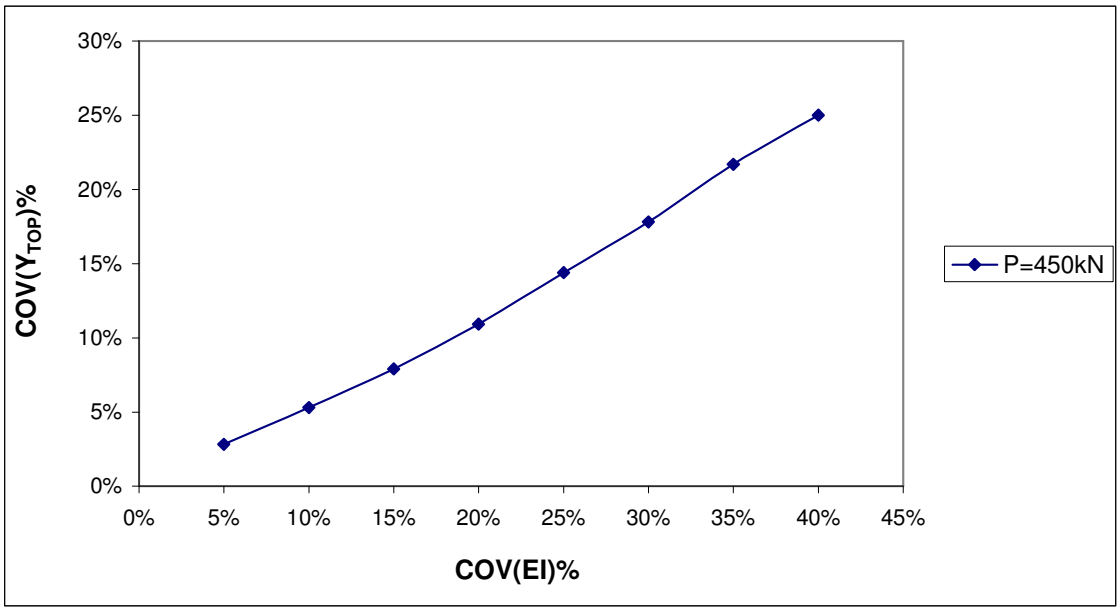


Fig. C.26 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.48 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 650kN.

P=650kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	8.84E-07	4.10%
10%	3.72E+07	3.55E-06	8.30%
15%	8.37E+07	8.07E-06	13.20%
20%	1.49E+08	1.47E-05	17.80%
25%	2.33E+08	2.38E-05	22.70%
30%	3.35E+08	3.62E-05	28.10%
35%	4.56E+08	5.29E-05	33.80%
40%	5.95E+08	7.50E-05	39.50%

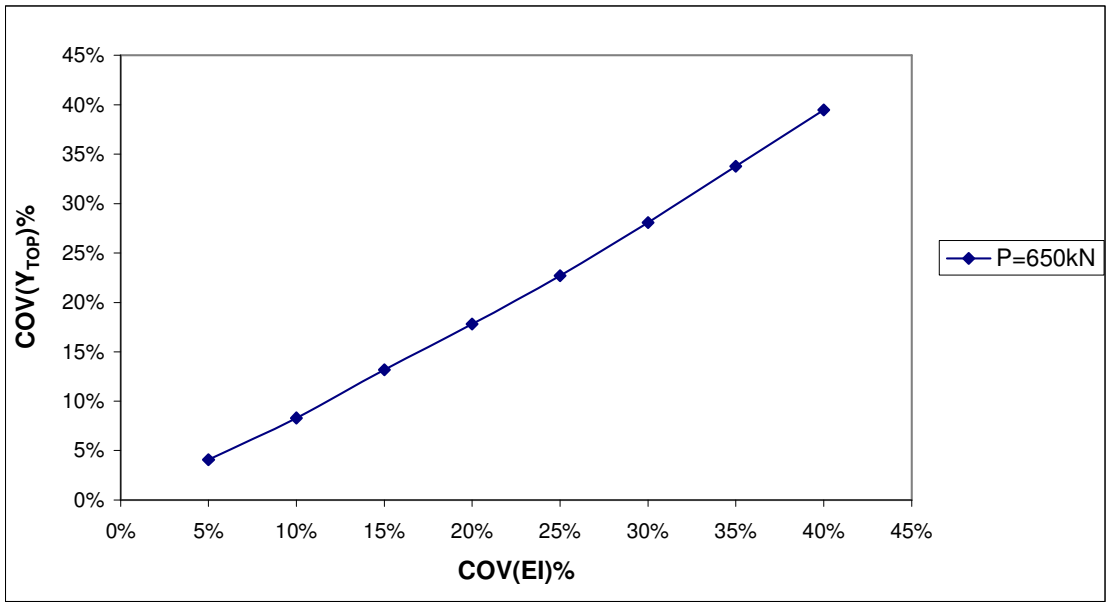


Fig. C.27 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.49 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 950kN.

P=950kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	1.88E-06	4.24%
10%	3.72E+07	7.67E-06	8.58%
15%	8.37E+07	1.78E-05	13.07%
20%	1.49E+08	3.30E-05	17.79%
25%	2.33E+08	5.45E-05	22.85%
30%	3.35E+08	8.33E-05	28.25%
35%	4.56E+08	1.21E-04	34.09%
40%	5.95E+08	1.71E-04	40.46%

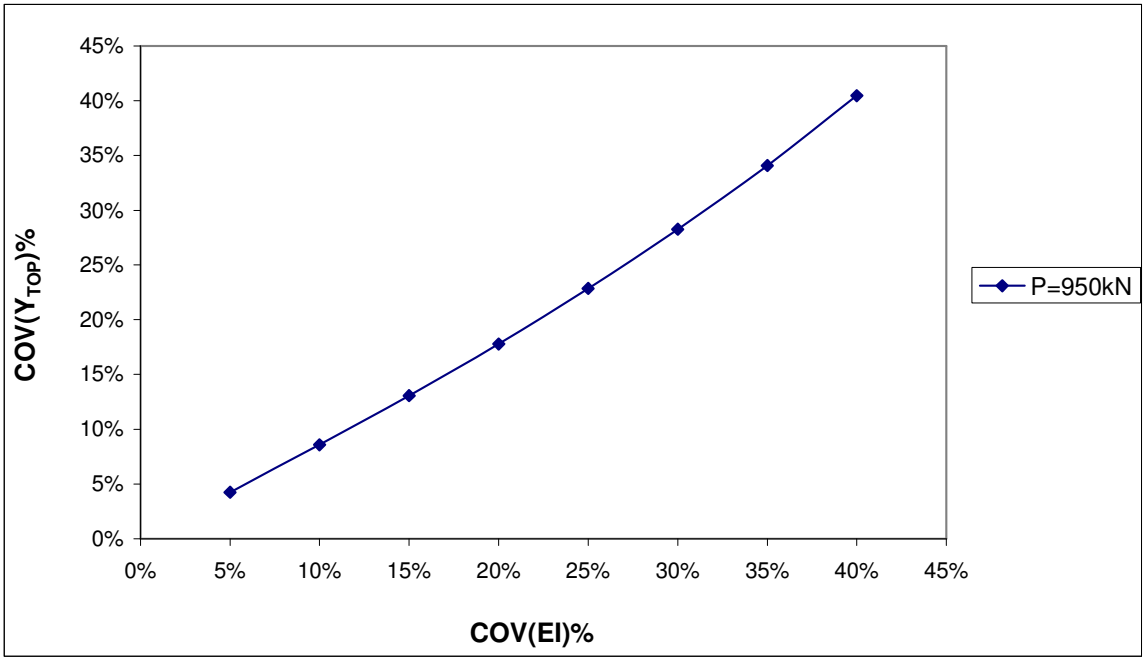


Fig. C.28 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.50 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 1025kN.

P=1025kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	3.80E-06	4.29%
10%	3.72E+07	1.55E-05	8.66%
15%	8.37E+07	3.59E-05	13.18%
20%	1.49E+08	6.67E-05	17.96%
25%	2.33E+08	1.10E-04	23.02%
30%	3.35E+08	1.67E-04	28.44%
35%	4.56E+08	2.44E-04	34.34%
40%	5.95E+08	3.45E-04	40.84%

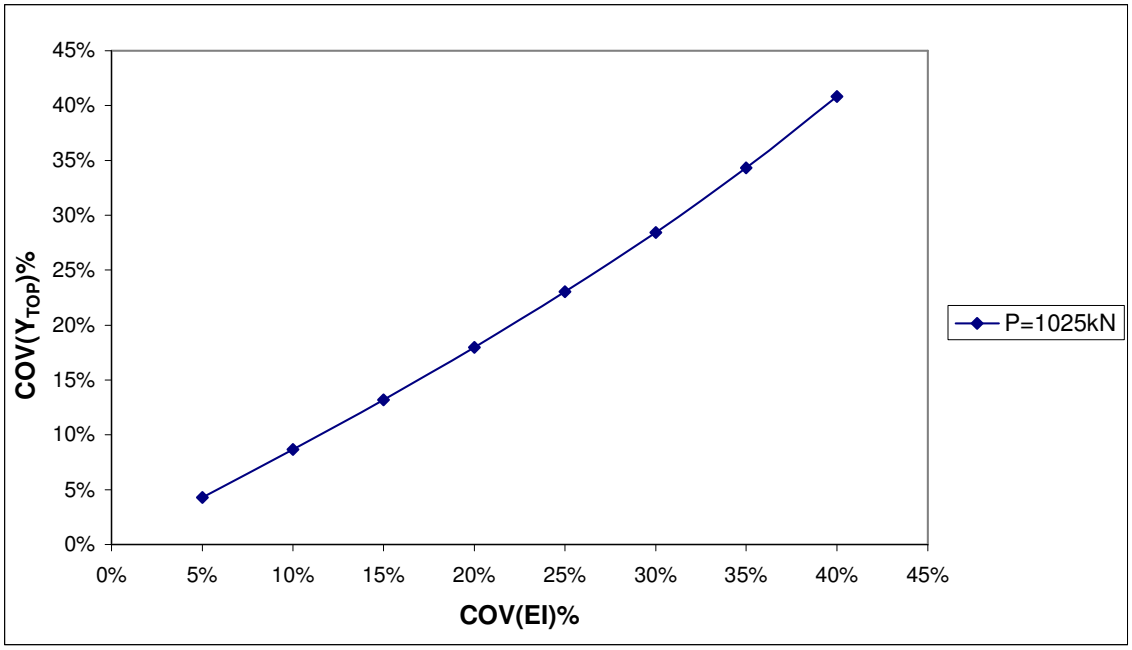


Fig. C.29 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

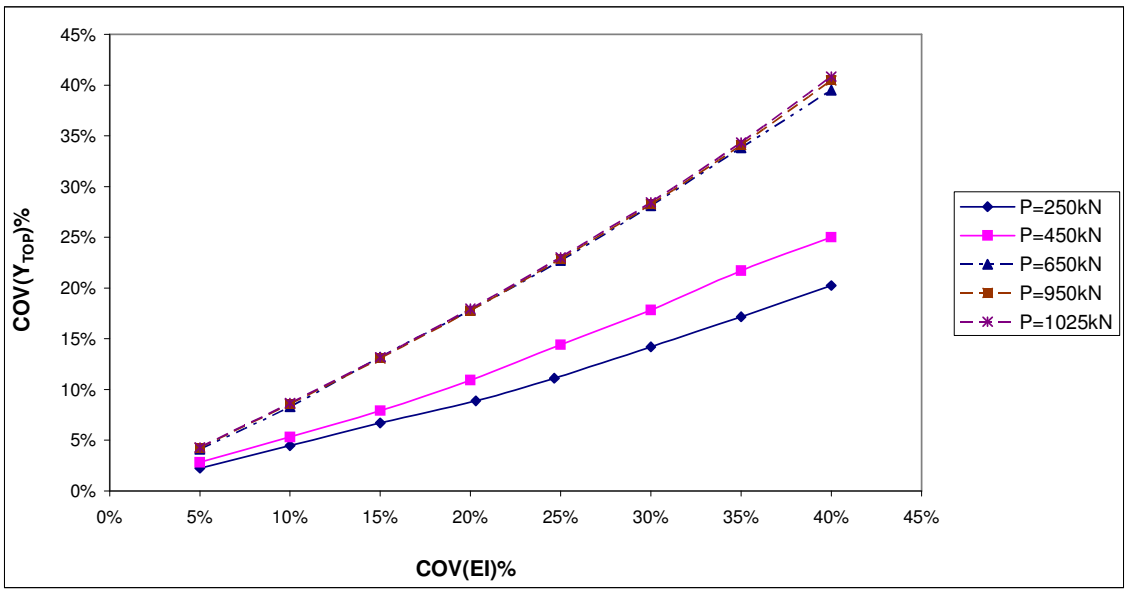


Fig. C.30 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table C.51 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (P) and load 250kN.

P=250kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		262.5	1.09E-02				
5%	250			1.56E+02	5.57E-07	4.13E-03	9.09%
		237.5	9.45E-03				
		275.0	1.17E-02				
10%	250			6.25E+02	1.56E-06	4.13E-03	18.42%
		225.0	9.20E-03				
		287.5	1.25E-02				
15%	250			1.41E+03	3.20E-06	4.13E-03	27.51%
		212.5	8.90E-03				
		300.0	1.30E-02				
20%	250			2.50E+03	4.84E-06	4.13E-03	36.58%
		200.0	8.60E-03				
		312.5	1.35E-02				
25%	250			3.91E+03	6.00E-06	4.13E-03	45.91%
		187.5	8.60E-03				
		325.0	1.40E-02				
30%	250			5.63E+03	7.84E-06	4.13E-03	55.15%
		175.0	8.40E-03				
		337.5	1.43E-02				
35%	250			7.66E+03	9.30E-06	4.13E-03	64.37%
		162.5	8.20E-03				
		350.0	1.48E-02				
40%	250			1.00E+04	1.19E-05	4.13E-03	73.73%
		150.0	7.90E-03				

Table C.52 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (P) and load 450kN.

P=450kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		472.5	1.96E-02				
5%	450			5.06E+02	1.66E-06	7.40E-03	9.01%
		427.5	1.70E-02				
		495.0	2.09E-02				
10%	450			2.03E+03	6.63E-06	7.40E-03	18.33%
		405.0	1.57E-02				
		517.5	2.22E-02				
15%	450			4.56E+03	1.50E-05	7.40E-03	27.43%
		382.5	1.45E-02				
		540.0	2.36E-02				
20%	450			8.10E+03	2.68E-05	7.40E-03	36.55%
		360.0	1.33E-02				
		562.5	2.50E-02				
25%	450			1.27E+04	4.19E-05	7.40E-03	45.80%
		337.5	1.21E-02				
		585.0	2.65E-02				
30%	450			1.82E+04	6.03E-05	7.40E-03	55.23%
		315.0	1.09E-02				
		607.5	2.80E-02				
35%	450			2.48E+04	8.25E-05	7.40E-03	64.61%
		292.5	9.82E-03				
		630.0	2.95E-02				
40%	450			3.24E+04	1.08E-04	7.40E-03	73.98%
		270.0	8.72E-03				

Table C.53 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (P) and load 650kN.

P=650kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		682.5	2.95E-02				
5%	650			1.06E+03	4.00E-06	1.63E-02	9.43%
		617.5	2.55E-02				
		715	3.15E-02				
10%	650			4.23E+03	1.57E-05	1.63E-02	18.68%
		585	2.36E-02				
		747.5	3.37E-02				
15%	650			9.51E+03	3.56E-05	1.63E-02	28.16%
		552.5	2.18E-02				
		780	3.60E-02				
20%	650			1.69E+04	6.40E-05	1.63E-02	37.74%
		520	2.00E-02				
		812.5	3.83E-02				
25%	650			2.64E+04	1.00E-04	1.63E-02	47.24%
		487.5	1.83E-02				
		845	4.06E-02				
30%	650			3.80E+04	1.45E-04	1.63E-02	56.77%
		455	1.66E-02				
		877.5	4.31E-02				
35%	650			5.18E+04	1.99E-04	1.63E-02	66.60%
		422.5	1.49E-02				
		910	4.58E-02				
40%	650			6.76E+04	2.64E-04	1.63E-02	76.63%
		390	1.33E-02				

Table C.54 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (P) and load 950kN.

P=950kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		997.5	4.12E-02				
5%	950			2.26E+03	8.47E-06	3.23E-02	10.93%
		902.5	3.54E-02				
		1045.0	4.44E-02				
10%	950			9.03E+03	3.50E-05	3.23E-02	21.30%
		855.0	3.26E-02				
		1092.5	4.77E-02				
15%	950			2.03E+04	7.85E-05	3.23E-02	31.10%
		807.5	3.00E-02				
		1140.0	5.11E-02				
20%	950			3.61E+04	1.39E-04	3.23E-02	40.60%
		760.0	2.75E-02				
		1187.5	5.46E-02				
25%	950			5.64E+04	2.19E-04	3.23E-02	49.80%
		712.5	2.50E-02				
		1235.0	5.84E-02				
30%	950			8.12E+04	3.18E-04	3.23E-02	59.70%
		665.0	2.27E-02		0.00E+00		
		1282.5	6.22E-02				
35%	950			1.11E+05	4.36E-04	3.23E-02	69.30%
		617.5	2.04E-02				
		1330.0	6.60E-02				
40%	950			1.44E+05	5.71E-04	3.23E-02	78.00%
		570.0	1.83E-02				

Table C.55 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (P) and load 1025kN.

P=1025kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		1076.3	5.53E-02				
5%	1025			2.63E+03	1.71E-05	4.55E-02	14.00%
		973.8	4.71E-02				
		1127.5	5.99E-02				
10%	1025			1.05E+04	7.02E-05	4.55E-02	23.20%
		922.5	4.31E-02				
		1178.8	6.45E-02				
15%	1025			2.36E+04	1.57E-04	4.55E-02	32.80%
		871.3	3.94E-02				
		1230.0	6.93E-02				
20%	1025			4.20E+04	2.77E-04	4.55E-02	42.60%
		820.0	3.60E-02				
		1281.3	7.44E-02				
25%	1025			6.57E+04	4.36E-04	4.55E-02	51.80%
		768.8	3.26E-02				
		1332.5	7.97E-02				
30%	1025			9.46E+04	6.30E-04	4.55E-02	61.40%
		717.5	2.95E-02				
		1383.8	8.51E-02				
35%	1025			1.29E+05	8.58E-04	4.55E-02	71.60%
		666.3	2.65E-02				
		1435.0	9.07E-02				
40%	1025			1.68E+05	1.13E-03	4.55E-02	80.60%
		615.0	2.36E-02				

Table C.56 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 250kN.

P=250kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	1.56E+02	5.57E-07	9.09%
10%	6.25E+02	1.56E-06	18.42%
15%	1.41E+03	3.20E-06	27.51%
20%	2.50E+03	4.84E-06	36.58%
25%	3.91E+03	6.00E-06	45.91%
30%	5.63E+03	7.84E-06	55.15%
35%	7.66E+03	9.30E-06	64.37%
40%	1.00E+04	1.19E-05	73.73%

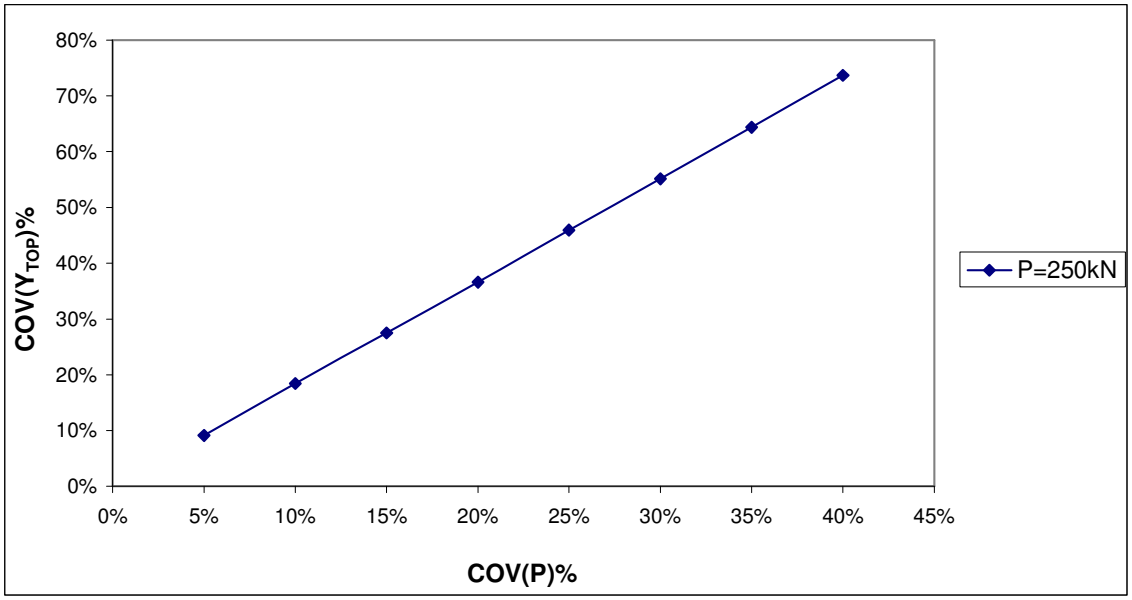


Fig. C.31 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.57 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 450kN.

P=450kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	5.06E+02	1.66E-06	9.01%
10%	2.03E+03	6.63E-06	18.33%
15%	4.56E+03	1.50E-05	27.43%
20%	8.10E+03	2.68E-05	36.55%
25%	1.27E+04	4.19E-05	45.80%
30%	1.82E+04	6.03E-05	55.23%
35%	2.48E+04	8.25E-05	64.61%
40%	3.24E+04	1.08E-04	73.98%

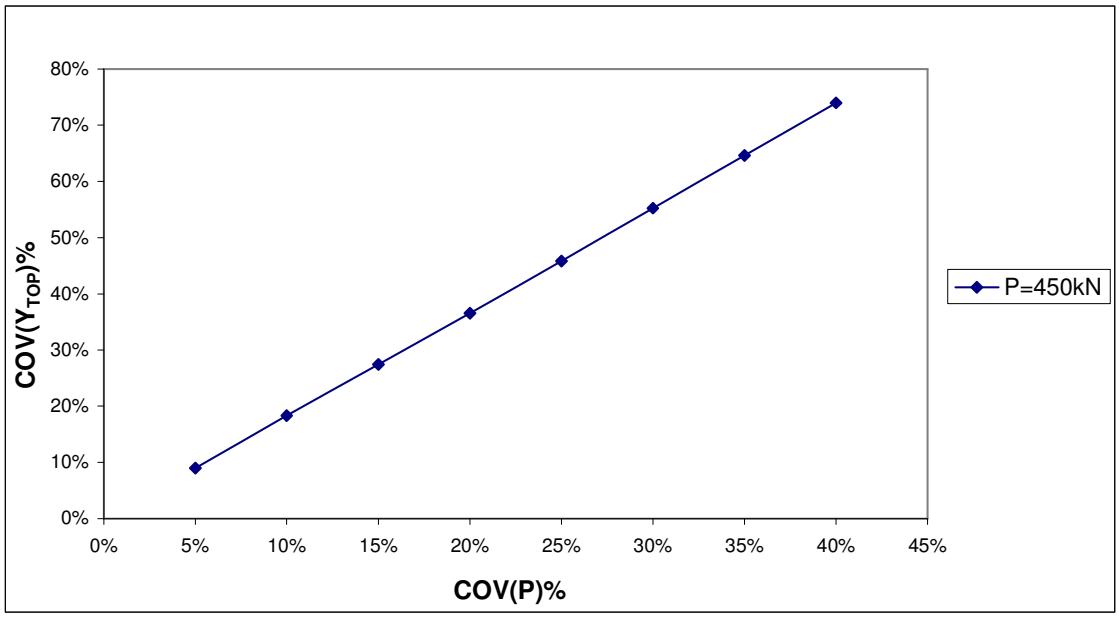


Fig. C.32 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.58 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 650kN.

P=650kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	1.06E+03	4.00E-06	9.43%
10%	4.23E+03	1.57E-05	18.68%
15%	9.51E+03	3.56E-05	28.16%
20%	1.69E+04	6.40E-05	37.74%
25%	2.64E+04	1.00E-04	47.24%
30%	3.80E+04	1.45E-04	56.77%
35%	5.18E+04	1.99E-04	66.60%
40%	6.76E+04	2.64E-04	76.63%

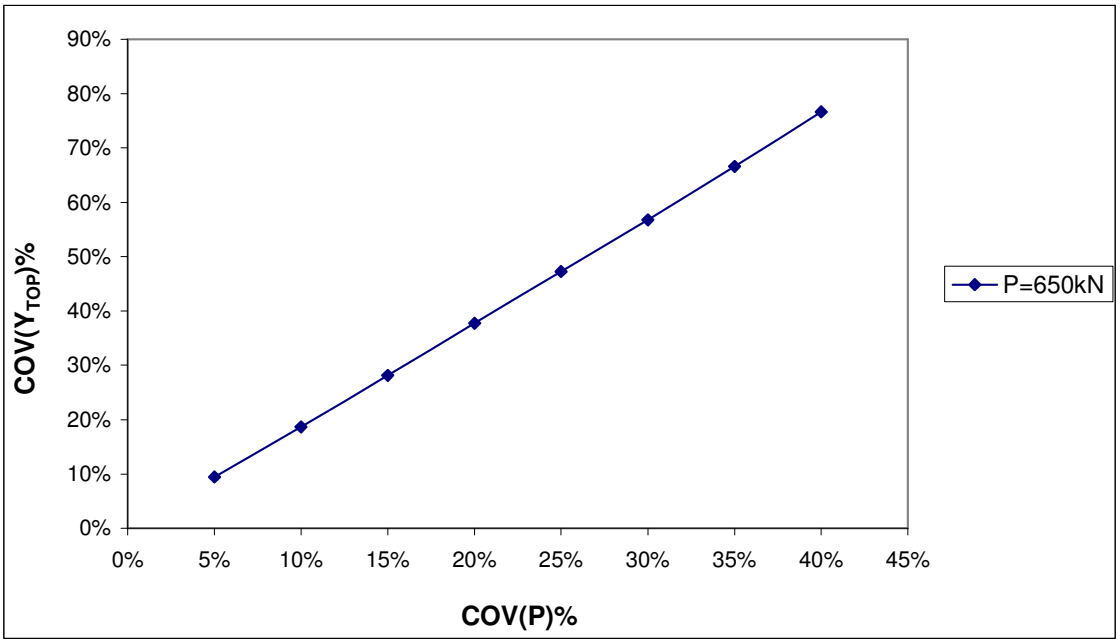


Fig. C.33 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.59 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 950kN.

P=950kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.26E+03	8.47E-06	10.93%
10%	9.03E+03	3.50E-05	21.30%
15%	2.03E+04	7.85E-05	31.10%
20%	3.61E+04	1.39E-04	40.60%
25%	5.64E+04	2.19E-04	49.80%
30%	8.12E+04	3.18E-04	59.70%
35%	1.11E+05	4.36E-04	69.30%
40%	1.44E+05	5.71E-04	78.00%

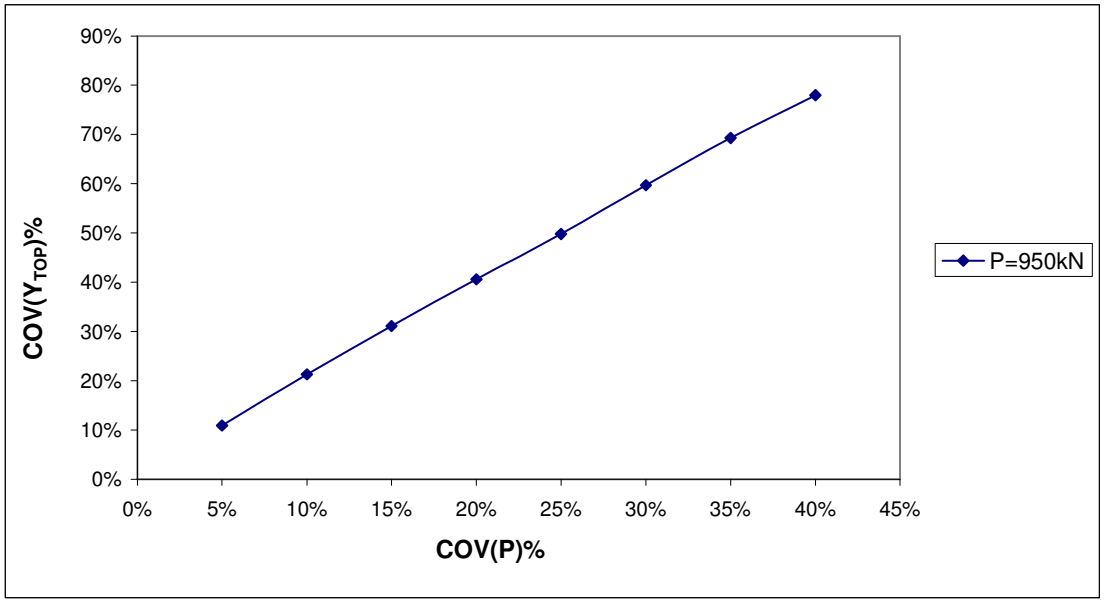


Fig. C.34 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.60 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 1025kN.

P1025kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR Y_{TOP} $(m)^2$	COV(YTOP) (%)
5%	2.63E+03	1.71E-05	14.00%
10%	1.05E+04	7.02E-05	23.20%
15%	2.36E+04	1.57E-04	32.80%
20%	4.20E+04	2.77E-04	42.60%
25%	6.57E+04	4.36E-04	51.80%
30%	9.46E+04	6.30E-04	61.40%
35%	1.29E+05	8.58E-04	71.60%
40%	1.68E+05	1.13E-03	80.60%

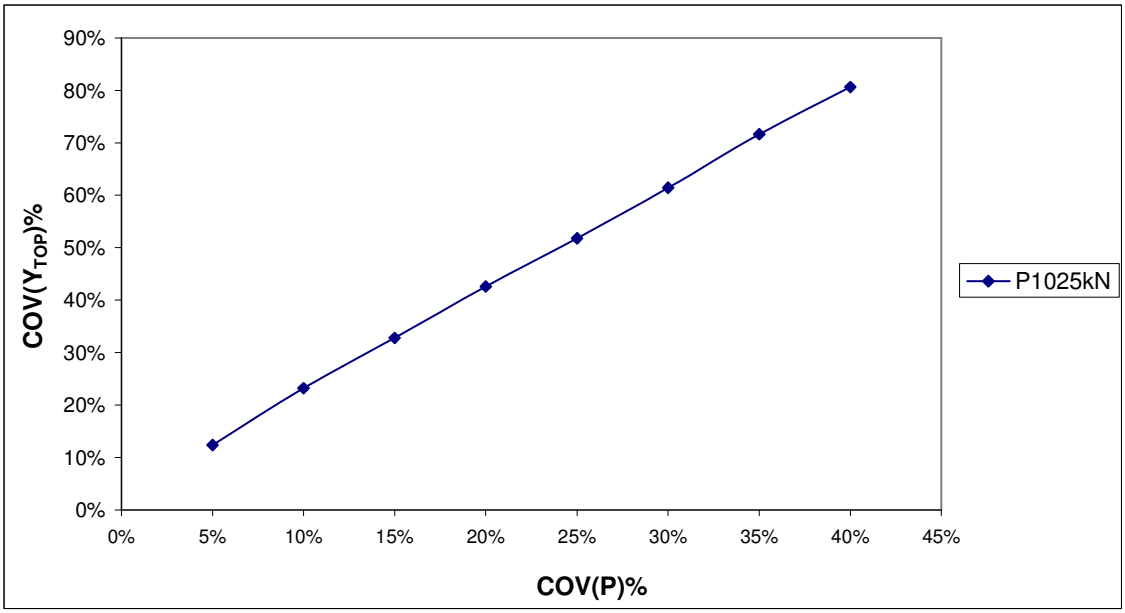


Fig. C.35 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

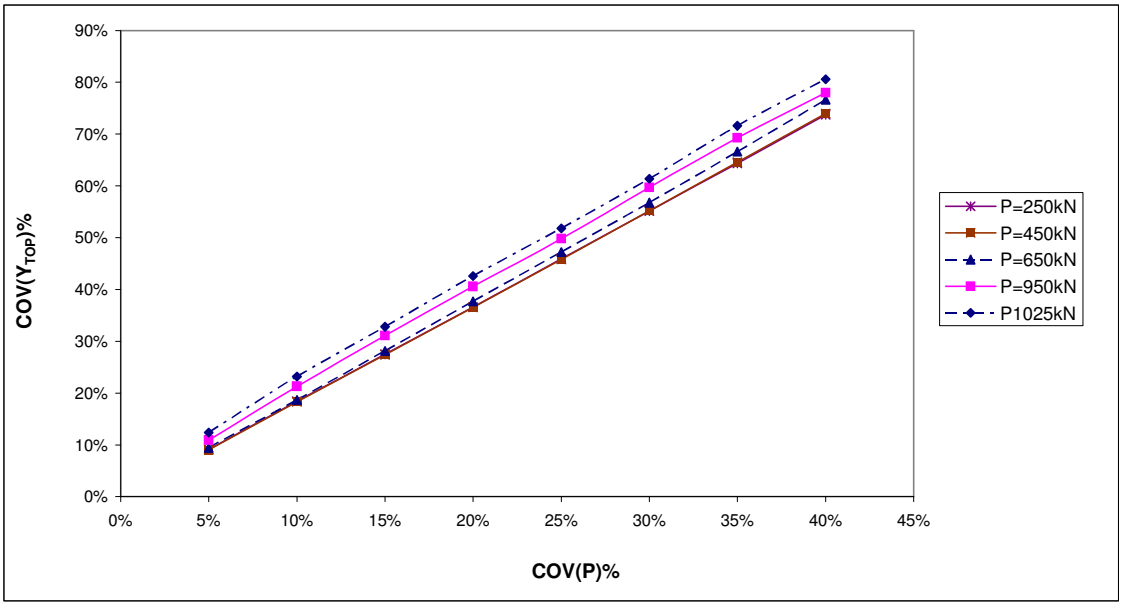


Fig. C.36 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

C-2 Reliability Index (β) of top deflection vs. COV (Variables)

Table C.61 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
8.11E-07	0.000225	5%	0.0150	6.3798
3.25E-06	0.000225	10%	0.0151	6.3457
7.49E-06	0.000225	15%	0.0152	6.2876
1.35E-05	0.000225	20%	0.0154	6.2075
2.19E-05	0.000225	25%	0.0157	6.1007
3.28E-05	0.000225	30%	0.0161	5.9715
4.73E-05	0.000225	35%	0.0165	5.8098
6.50E-05	0.000225	40%	0.0170	5.6295

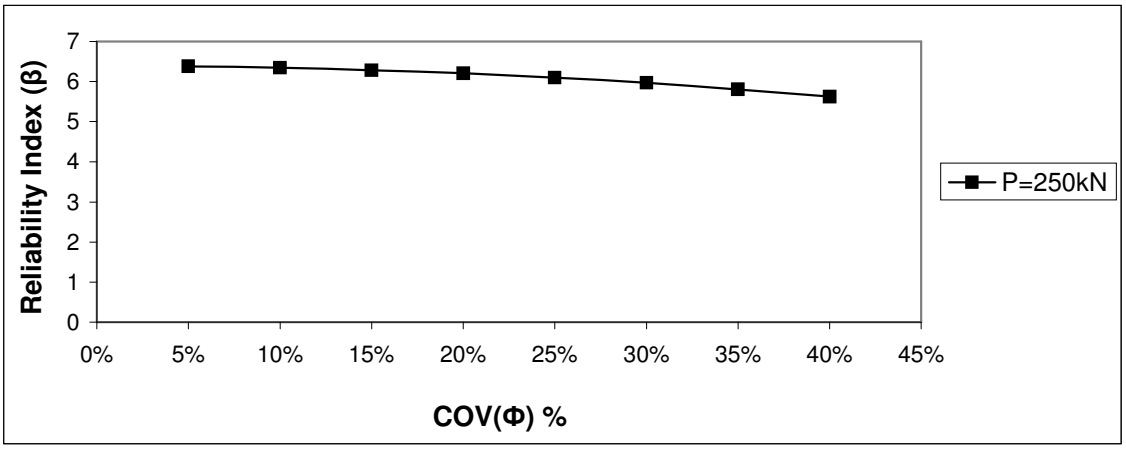


Fig. C.37 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.62 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 450kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.43E-06	0.000225	5%	0.0151	5.8485
9.80E-06	0.000225	10%	0.0153	5.7560
2.27E-05	0.000225	15%	0.0157	5.6040
4.14E-05	0.000225	20%	0.0163	5.4037
6.79E-05	0.000225	25%	0.0171	5.1536
1.04E-04	0.000225	30%	0.0181	4.8601
1.56E-04	0.000225	35%	0.0195	4.5186
2.28E-04	0.000225	40%	0.0213	4.1421

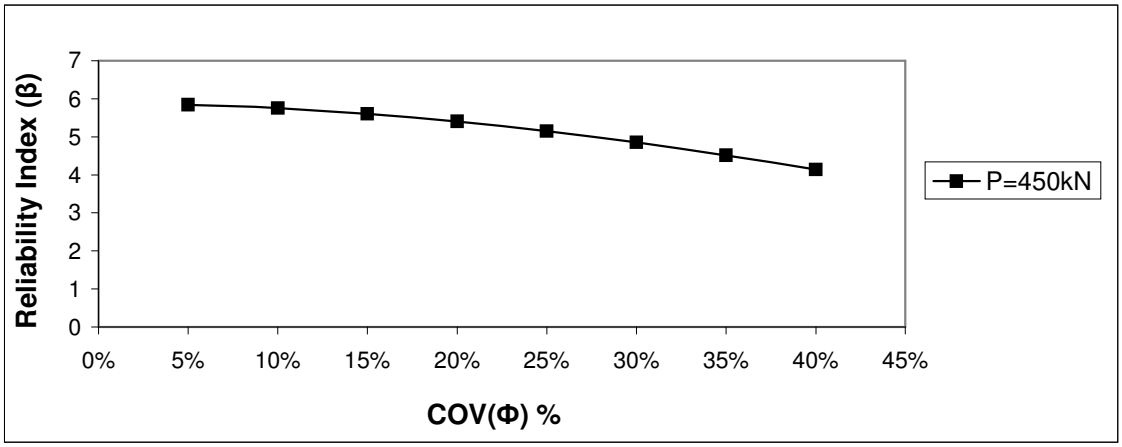


Fig. C.38 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.63 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.76E-06	0.000225	5%	0.0152	5.1874
2.36E-05	0.000225	10%	0.0158	4.9981
5.49E-05	0.000225	15%	0.0167	4.7100
1.03E-04	0.000225	20%	0.0181	4.3509
1.72E-04	0.000225	25%	0.0199	3.9561
2.74E-04	0.000225	30%	0.0223	3.5291
4.19E-04	0.000225	35%	0.0254	3.1051
6.37E-04	0.000225	40%	0.0294	2.6846

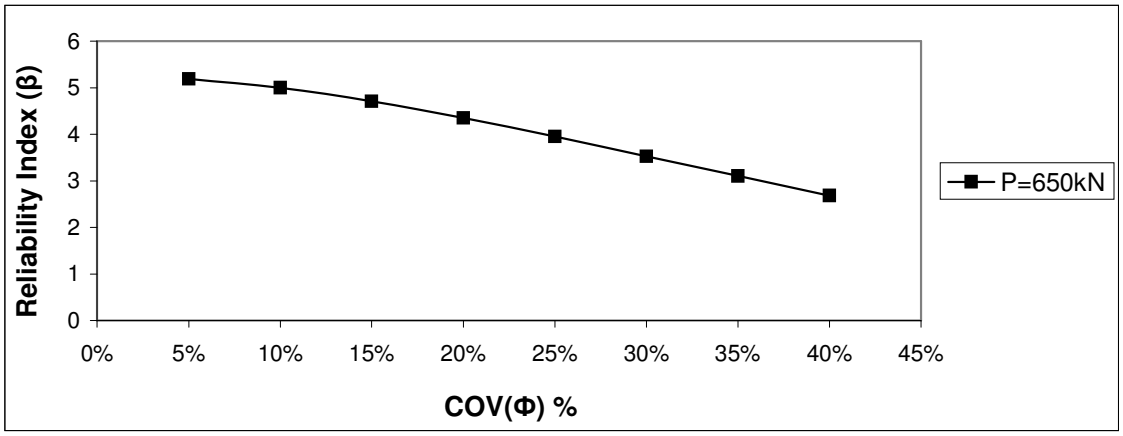


Fig. C.39 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.64 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 950kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.30E-05	0.000225	5%	0.0154	4.3887
5.29E-05	0.000225	10%	0.0167	4.0615
1.23E-04	0.000225	15%	0.0187	3.6274
2.31E-04	0.000225	20%	0.0213	3.1718
3.93E-04	0.000225	25%	0.0249	2.7228
6.29E-04	0.000225	30%	0.0292	2.3166
9.89E-04	0.000225	35%	0.0348	1.9427
1.54E-03	0.000225	40%	0.0420	1.6101

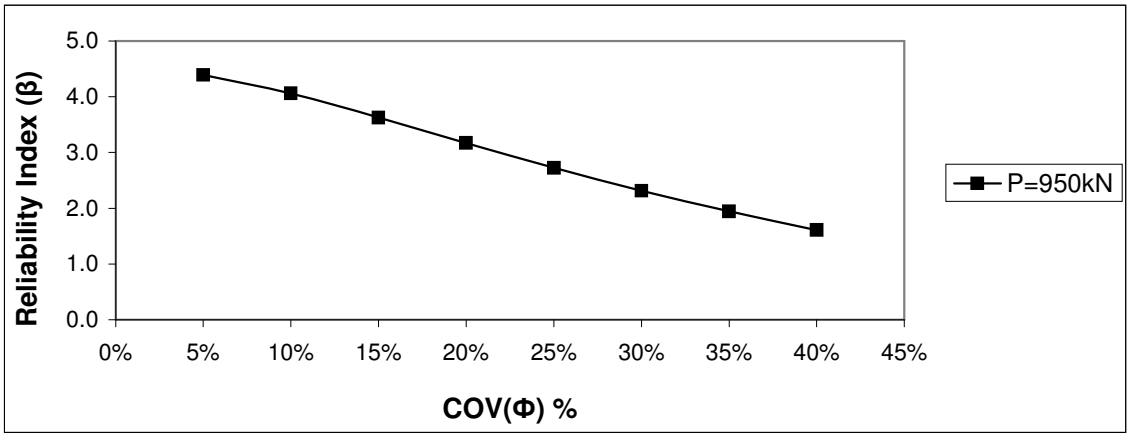


Fig. C.40 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.65 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 1025kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.62E-05	0.000225	5%	0.0158	3.4389
1.07E-04	0.000225	10%	0.0182	2.9910
2.49E-04	0.000225	15%	0.0218	2.5020
4.72E-04	0.000225	20%	0.0264	2.0637
8.05E-04	0.000225	25%	0.0321	1.6983
1.31E-03	0.000225	30%	0.0392	1.3900
2.10E-03	0.000225	35%	0.0482	1.1306
3.36E-03	0.000225	40%	0.0599	0.9106

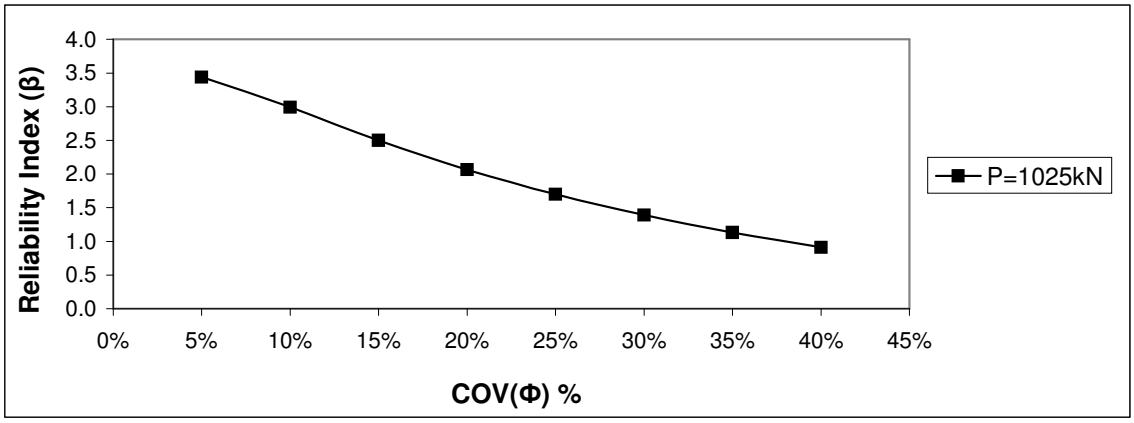


Fig. C.41 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 1025kN.

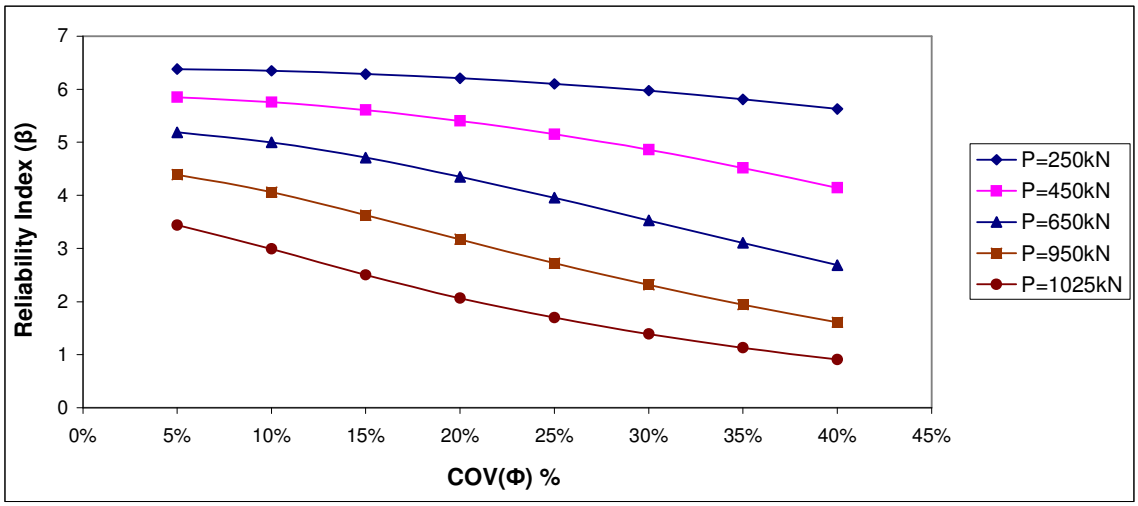


Fig. C.42 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table C.66 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.29E-07	0.000225	5%	0.0150	6.3852
1.73E-06	0.000225	10%	0.0151	6.3669
3.96E-06	0.000225	15%	0.0151	6.3358
7.24E-06	0.000225	20%	0.0152	6.3400
1.17E-05	0.000225	25%	0.0154	6.3400
1.76E-05	0.000225	30%	0.0156	6.3100
2.54E-05	0.000225	35%	0.0158	6.2800
3.56E-05	0.000225	40%	0.0161	6.2800

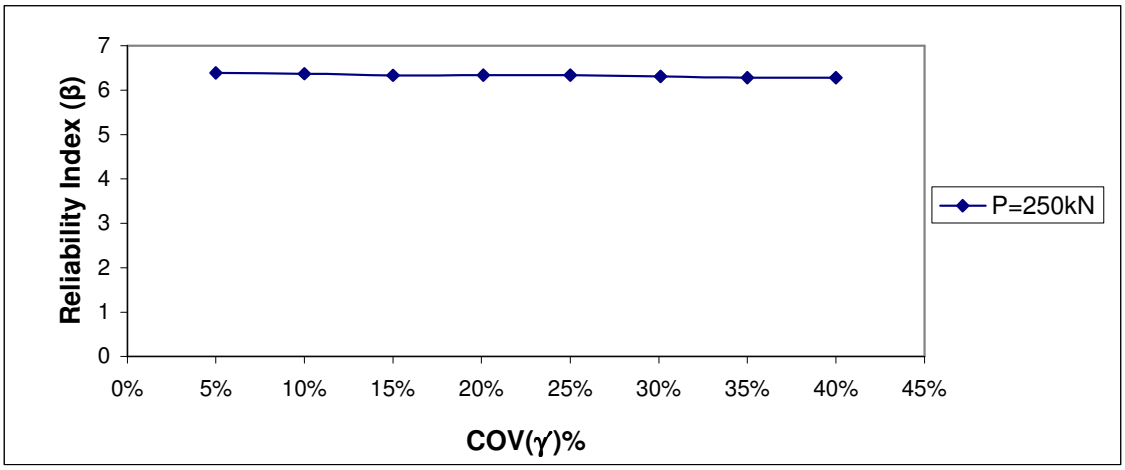


Fig. C.43 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.67 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 450kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.44E-07	0.000225	5%	0.0150	5.8781
5.89E-07	0.000225	10%	0.0150	5.8723
1.35E-06	0.000225	15%	0.0150	5.8624
2.45E-06	0.000225	20%	0.0151	5.8482
3.94E-06	0.000225	25%	0.0151	5.8292
5.94E-06	0.000225	30%	0.0152	5.8038
8.57E-06	0.000225	35%	0.0153	5.7711
1.19E-05	0.000225	40%	0.0154	5.7299

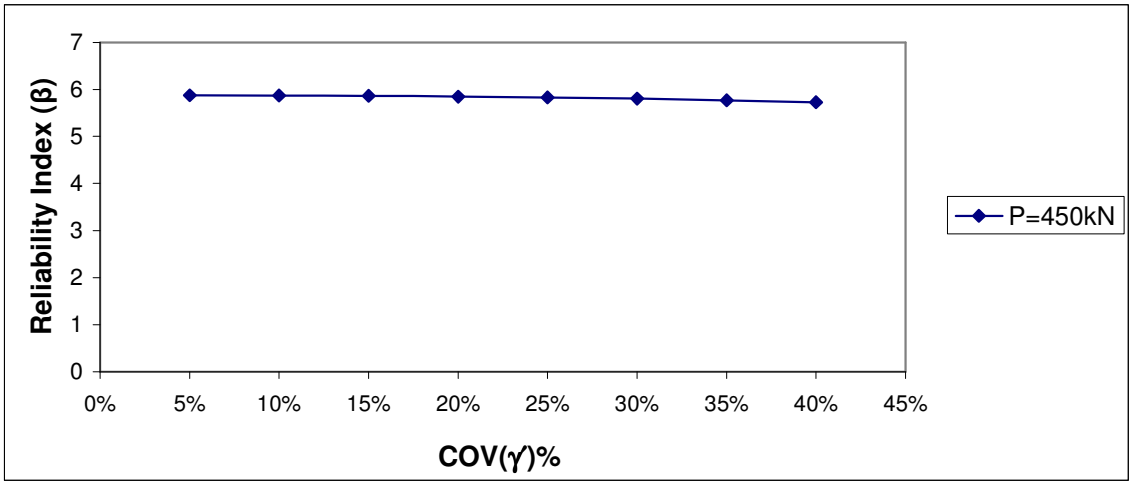


Fig. C.44 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.68 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.03E-06	0.000225	5%	0.0150	5.2413
4.08E-06	0.000225	10%	0.0151	5.2063
9.15E-06	0.000225	15%	0.0153	5.1497
1.69E-05	0.000225	20%	0.0156	5.0666
2.80E-05	0.000225	25%	0.0159	4.9538
4.26E-05	0.000225	30%	0.0164	4.8167
6.19E-05	0.000225	35%	0.0169	4.6526
8.79E-05	0.000225	40%	0.0177	4.4548

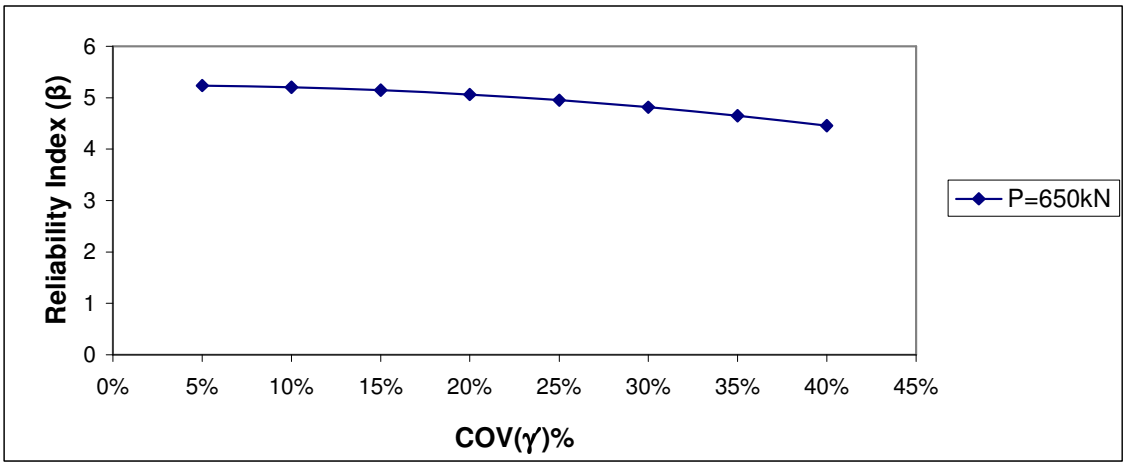


Fig. C.45 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.69 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 950kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.10E-06	0.000225	5%	0.0151	4.4924
8.79E-06	0.000225	10%	0.0153	4.4277
2.10E-05	0.000225	15%	0.0157	4.3166
3.85E-05	0.000225	20%	0.0162	4.1706
6.20E-05	0.000225	25%	0.0169	3.9961
9.43E-05	0.000225	30%	0.0179	3.7888
1.38E-04	0.000225	35%	0.0191	3.5524
1.95E-04	0.000225	40%	0.0205	3.3033

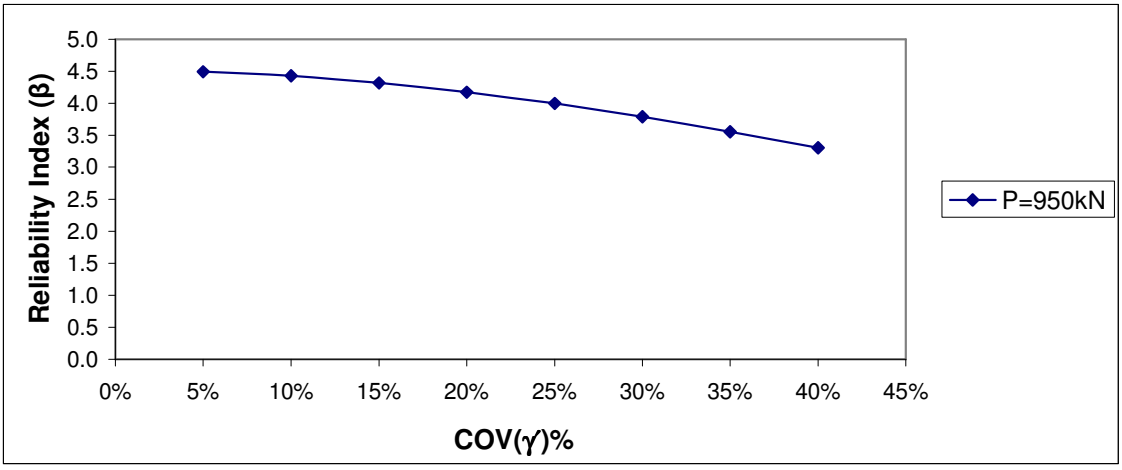


Fig. C.46 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.70 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 1025kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.33E-06	0.000225	5%	0.0151	3.5989
1.78E-05	0.000225	10%	0.0156	3.4976
4.14E-05	0.000225	15%	0.0163	3.3390
7.60E-05	0.000225	20%	0.0173	3.1416
1.25E-04	0.000225	25%	0.0187	2.9150
1.91E-04	0.000225	30%	0.0204	2.6734
2.76E-04	0.000225	35%	0.0224	2.4339
3.92E-04	0.000225	40%	0.0248	2.1937

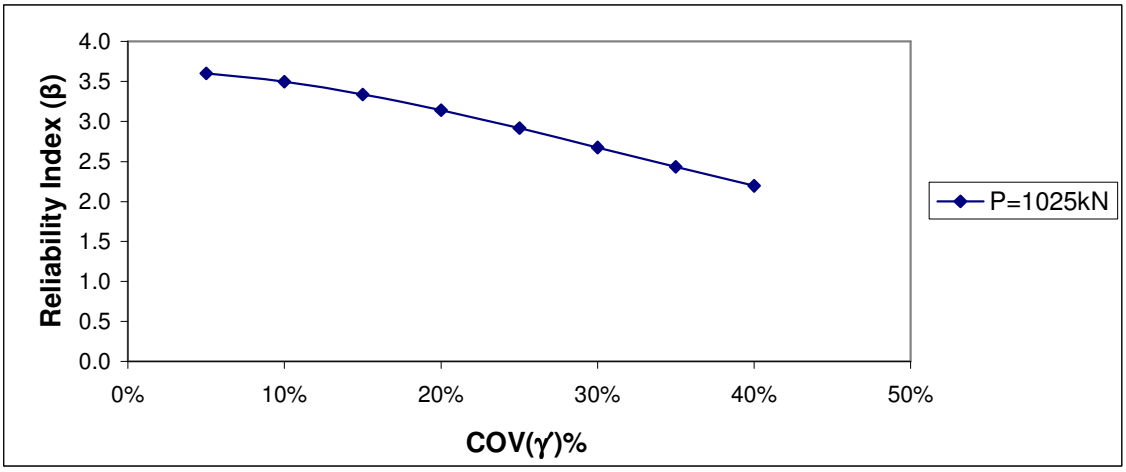


Fig. C.47 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 1025kN.

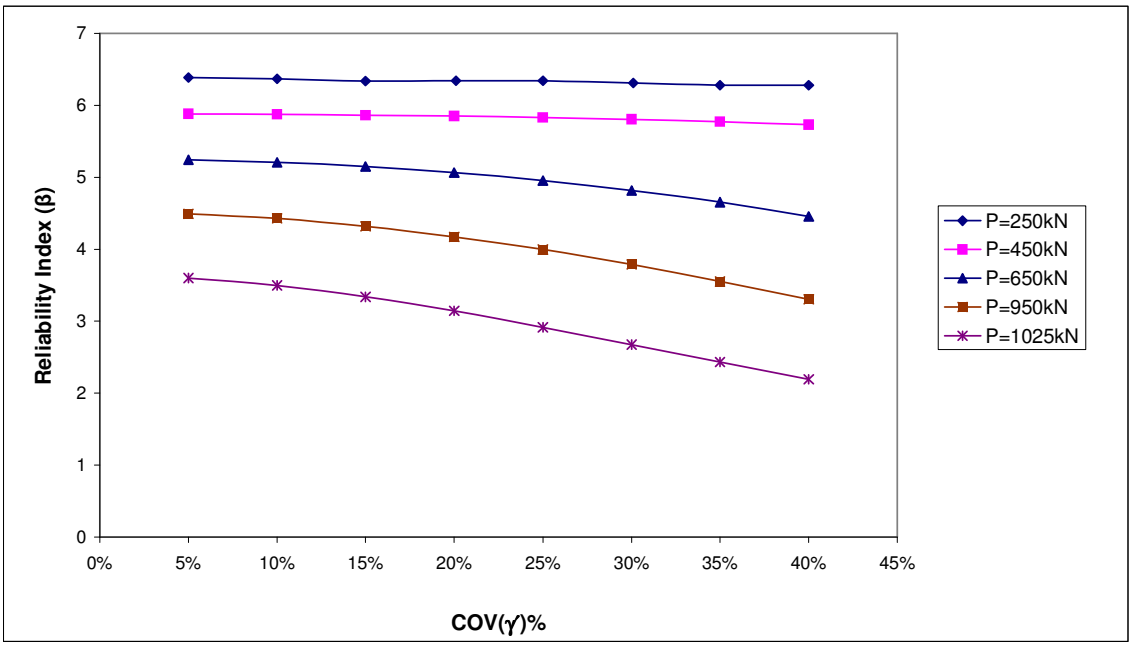


Fig. C.48 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table C.71 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
9.00E-10	0.000225	5%	0.0150	6.3913
3.60E-09	0.000225	10%	0.0150	6.3913
9.03E-09	0.000225	15%	0.0150	6.3912
1.56E-08	0.000225	20%	0.0150	6.3911
2.56E-08	0.000225	25%	0.0150	6.3910
4.20E-08	0.000225	30%	0.0150	6.3907
6.76E-08	0.000225	35%	0.0150	6.3904
9.92E-08	0.000225	40%	0.0150	6.3899

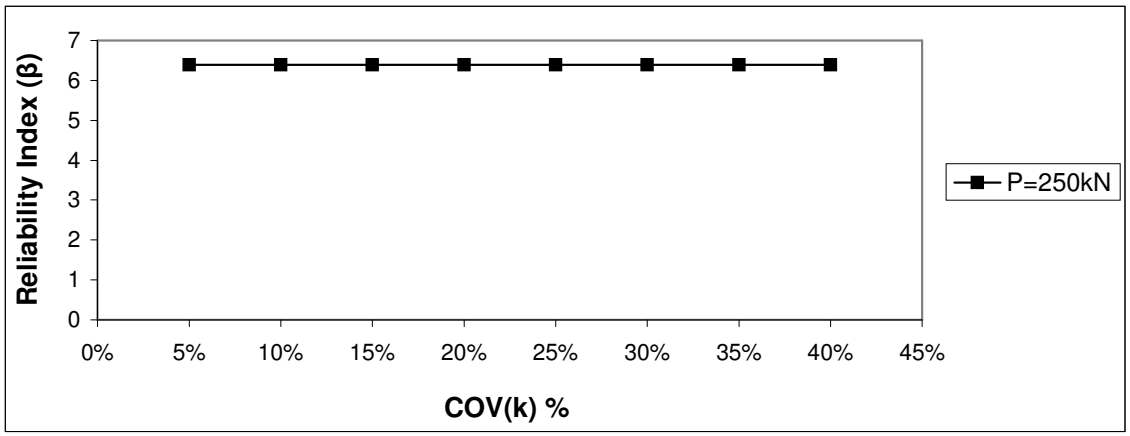


Fig. C.49 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.72 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 450kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
1.23E-09	0.000225	5%	0.0150	5.8800
4.90E-09	0.000225	10%	0.0150	5.8799
1.21E-08	0.000225	15%	0.0150	5.8798
2.10E-08	0.000225	20%	0.0150	5.8797
3.61E-08	0.000225	25%	0.0150	5.8795
5.76E-08	0.000225	30%	0.0150	5.8792
9.30E-08	0.000225	35%	0.0150	5.8788
1.37E-07	0.000225	40%	0.0150	5.8782

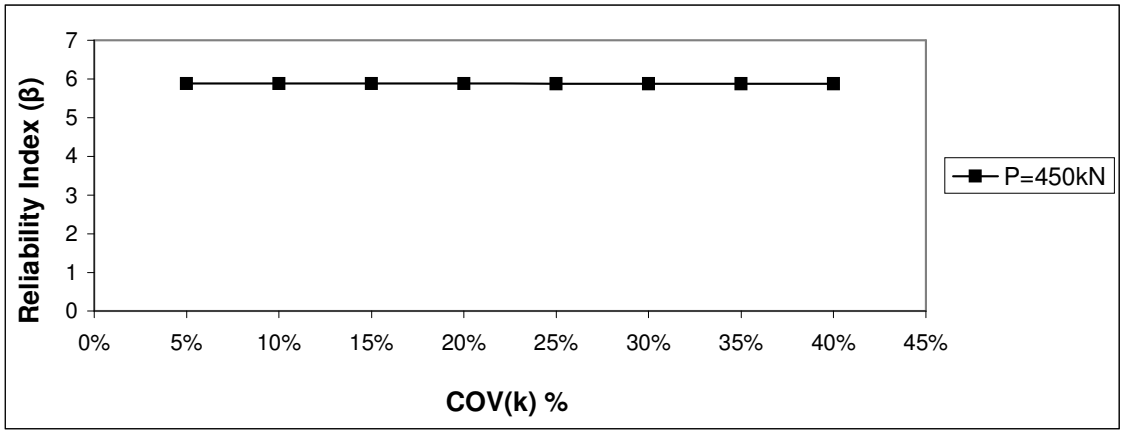


Fig. C.50 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.73 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
1.23E-09	0.000225	5%	0.0150	5.2533
5.63E-09	0.000225	10%	0.0150	5.2533
1.56E-08	0.000225	15%	0.0150	5.2532
2.89E-08	0.000225	20%	0.0150	5.2530
5.29E-08	0.000225	25%	0.0150	5.2527
8.70E-08	0.000225	30%	0.0150	5.2523
1.30E-07	0.000225	35%	0.0150	5.2518
1.81E-07	0.000225	40%	0.0150	5.2512

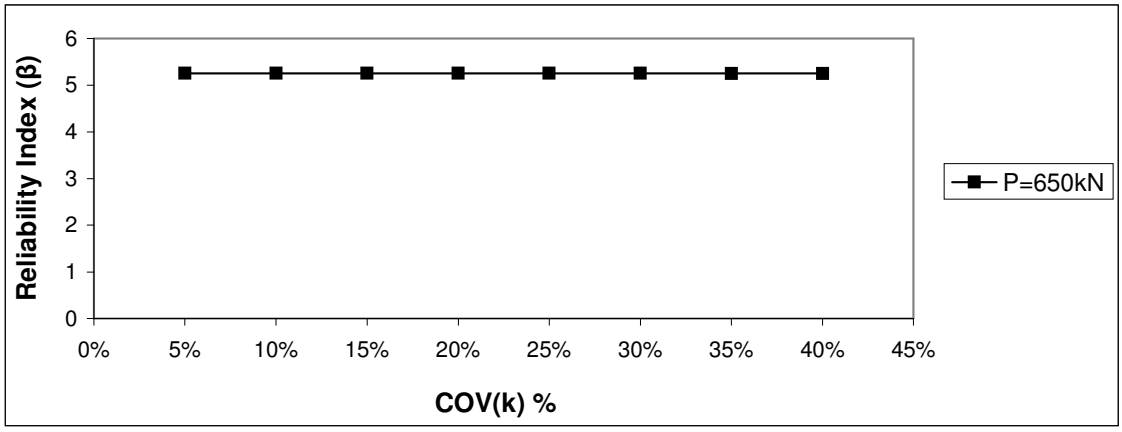


Fig. C.51 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.74 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 950kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
3.02E-09	0.000225	5%	0.0150	4.5133
1.21E-08	0.000225	10%	0.0150	4.5132
2.56E-08	0.000225	15%	0.0150	4.5131
4.84E-08	0.000225	20%	0.0150	4.5128
7.29E-08	0.000225	25%	0.0150	4.5126
1.16E-07	0.000225	30%	0.0150	4.5122
1.76E-07	0.000225	35%	0.0150	4.5116
2.70E-07	0.000225	40%	0.0150	4.5106

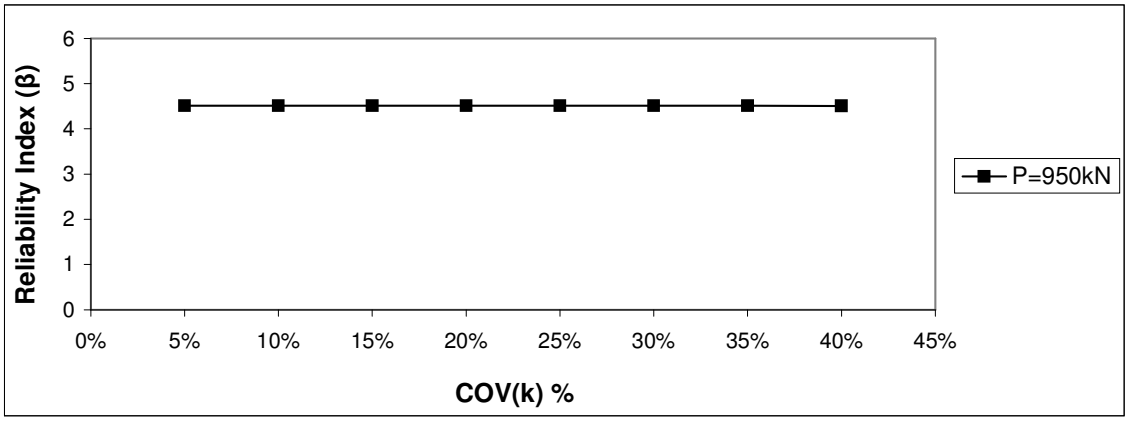


Fig. C.52 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.75 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 1025kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
3.02E-09	0.000225	5%	0.0150	3.6333
1.44E-08	0.000225	10%	0.0150	3.6332
3.61E-08	0.000225	15%	0.0150	3.6330
7.02E-08	0.000225	20%	0.0150	3.6328
1.23E-07	0.000225	25%	0.0150	3.6323
1.94E-07	0.000225	30%	0.0150	3.6318
3.02E-07	0.000225	35%	0.0150	3.6309
4.36E-07	0.000225	40%	0.0150	3.6298

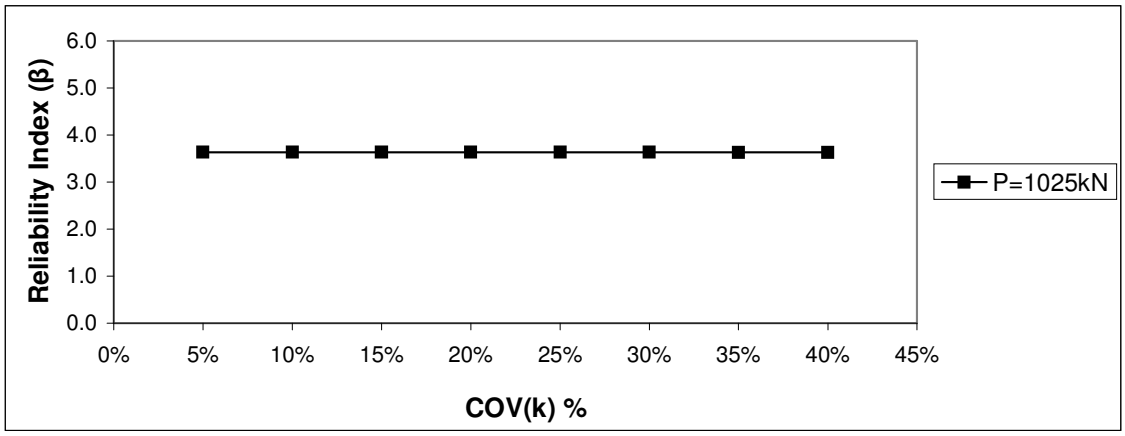


Fig. C.53 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 1025kN.

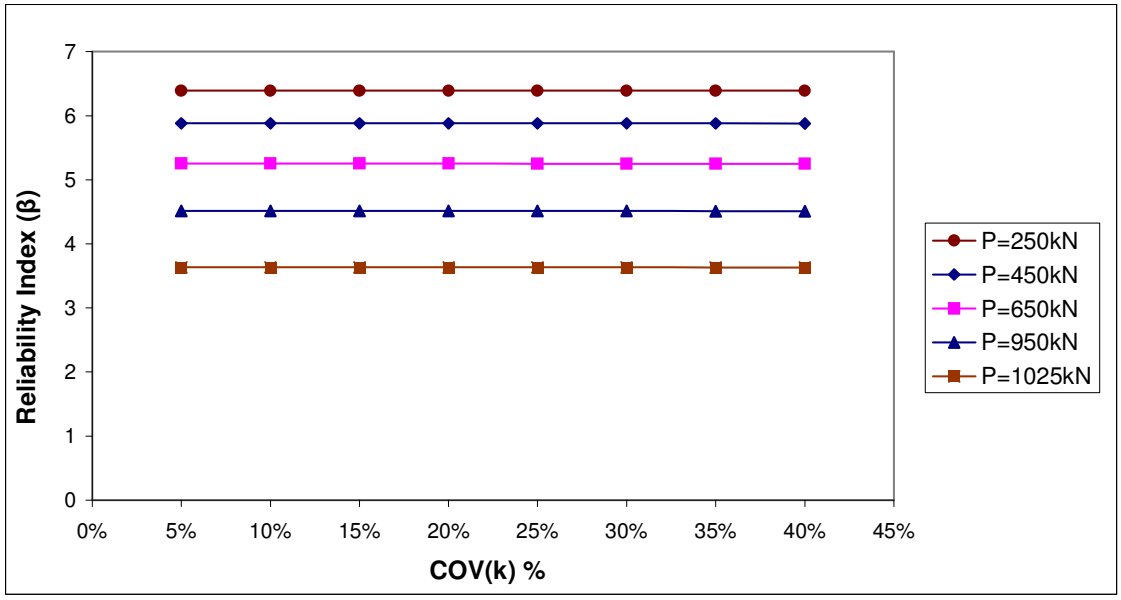


Fig. C.54 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table C.76 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'B' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
9.02E-09	0.000225	5%	0.0150	6.3912
2.71E-08	0.000225	10%	0.0150	6.3909
5.50E-08	0.000225	15%	0.0150	6.3906
8.27E-08	0.000225	20%	0.0150	6.3902
1.38E-07	0.000225	25%	0.0150	6.3894
1.98E-07	0.000225	30%	0.0150	6.3885
2.37E-07	0.000225	35%	0.0150	6.3880
2.70E-07	0.000225	40%	0.0150	6.3875

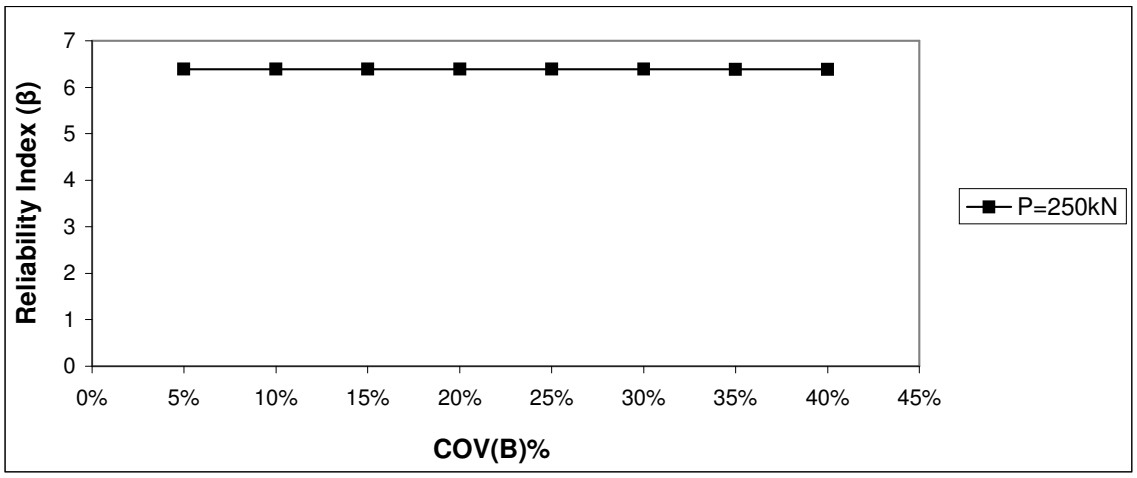


Fig. C.55 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.77 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'B' subjected to lateral load 450kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
6.25E-10	0.000225	5%	0.0150	5.8800
1.30E-07	0.000225	10%	0.0150	5.8783
1.64E-07	0.000225	15%	0.0150	5.8779
2.03E-07	0.000225	20%	0.0150	5.8774
2.55E-07	0.000225	25%	0.0150	5.8767
1.19E-06	0.000225	30%	0.0150	5.8645
1.42E-06	0.000225	35%	0.0150	5.8615
5.31E-06	0.000225	40%	0.0152	5.8118

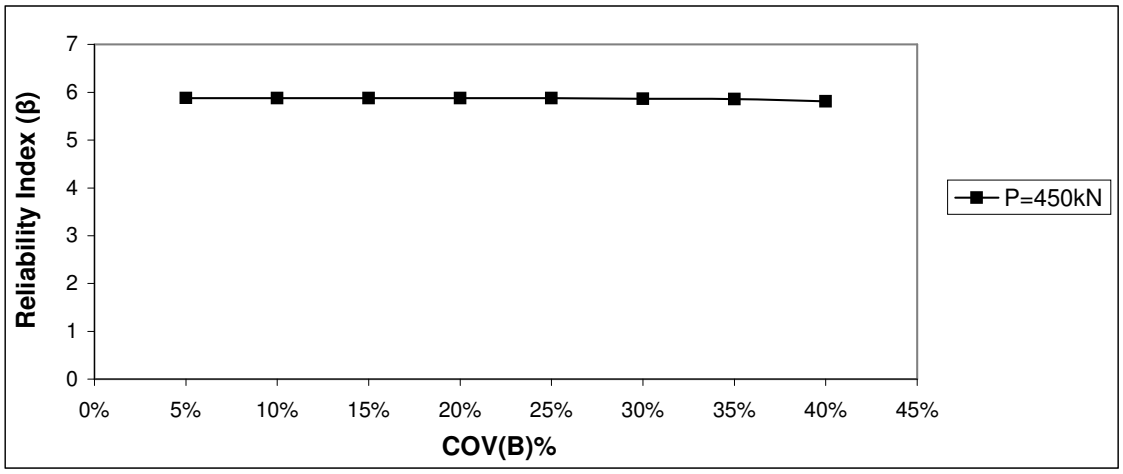


Fig. C.56 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.78 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'B' subjected to lateral load 650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
1.60E-09	0.000225	5%	0.0150	5.2533
7.14E-07	0.000225	10%	0.0150	5.2450
7.14E-07	0.000225	15%	0.0150	5.2450
5.50E-06	0.000225	20%	0.0152	5.1903
1.23E-05	0.000225	25%	0.0154	5.1159
1.94E-05	0.000225	30%	0.0156	5.0409
2.53E-05	0.000225	35%	0.0158	4.9806
4.23E-05	0.000225	40%	0.0163	4.8202

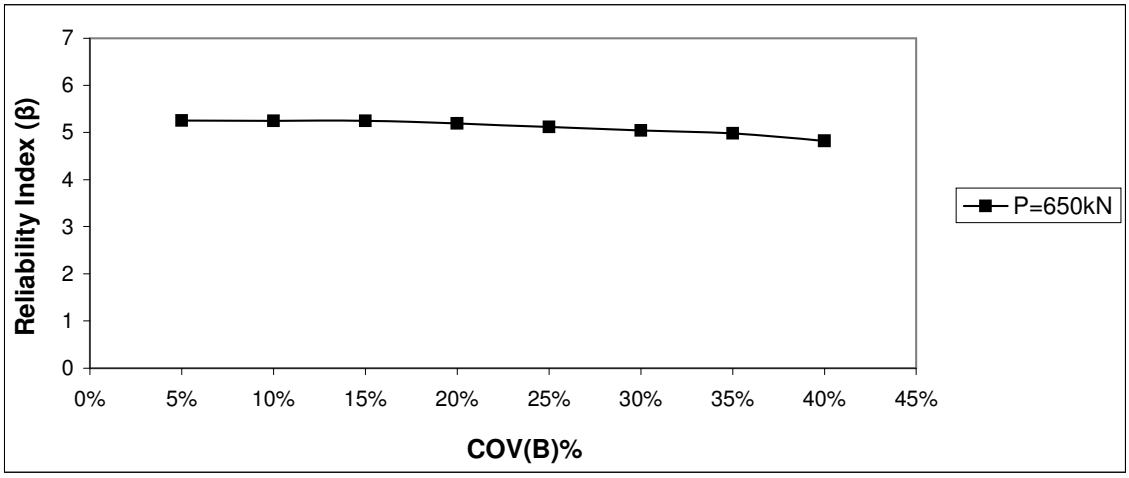


Fig. C.57 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.79 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'B' subjected to lateral load 950kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
5.63E-07	0.000225	5%	0.01502	4.5077
5.29E-06	0.000225	10%	0.01518	4.4612
1.12E-05	0.000225	15%	0.01537	4.4048
2.76E-05	0.000225	20%	0.01589	4.2599
3.91E-05	0.000225	25%	0.01625	4.1662
5.26E-05	0.000225	30%	0.01666	4.0636
6.89E-05	0.000225	35%	0.01714	3.9488
1.05E-04	0.000225	40%	0.01817	3.7264

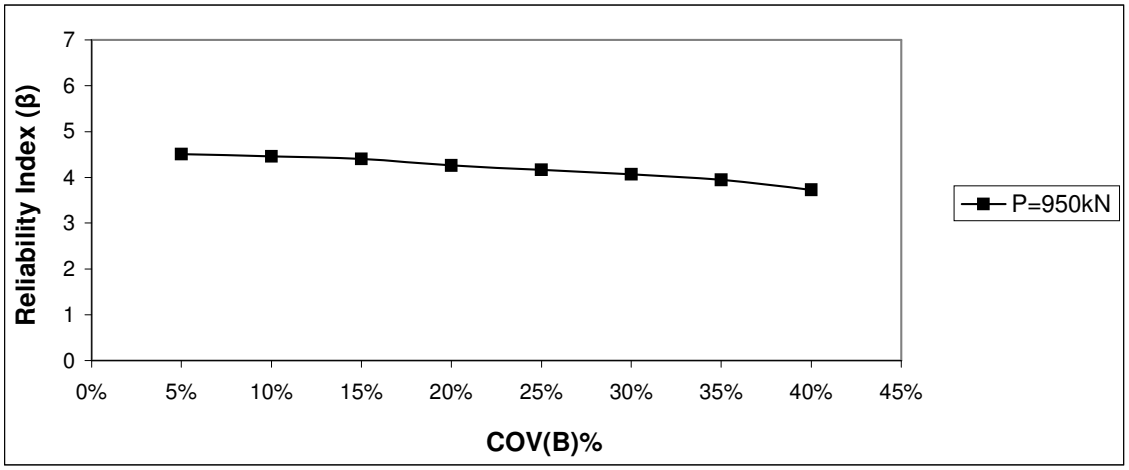


Fig. C.58 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.80 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'B' subjected to lateral load 1025kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
1.21E-06	0.000225	5%	0.0150	3.6236
4.16E-06	0.000225	10%	0.0151	3.6002
1.02E-05	0.000225	15%	0.0153	3.5534
2.50E-05	0.000225	20%	0.0158	3.4469
5.63E-05	0.000225	25%	0.0168	3.2498
1.21E-04	0.000225	30%	0.0186	2.9299
2.13E-04	0.000225	35%	0.0209	2.6730
0.000256	0.000225	40%	0.0219	2.4850

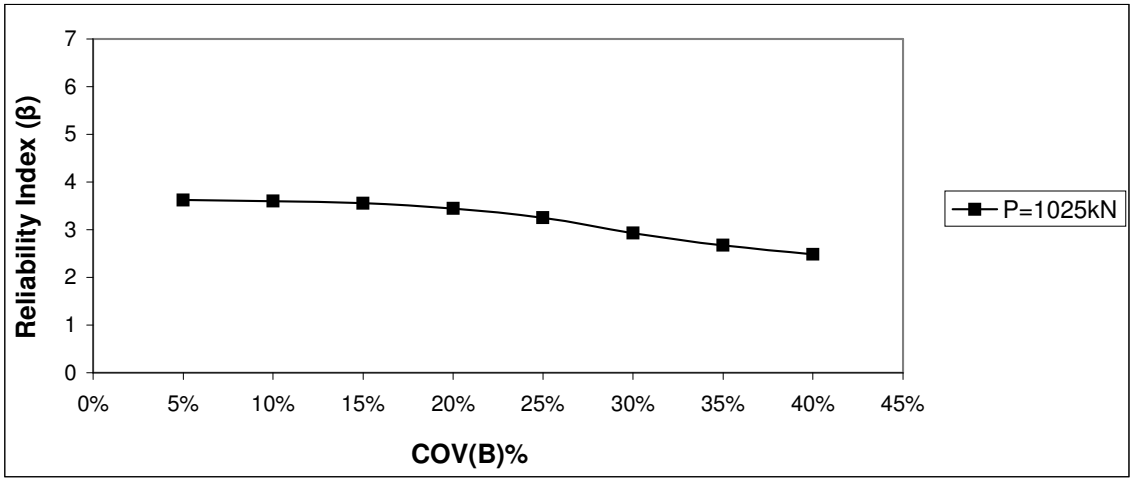


Fig. C.59 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 1025kN.

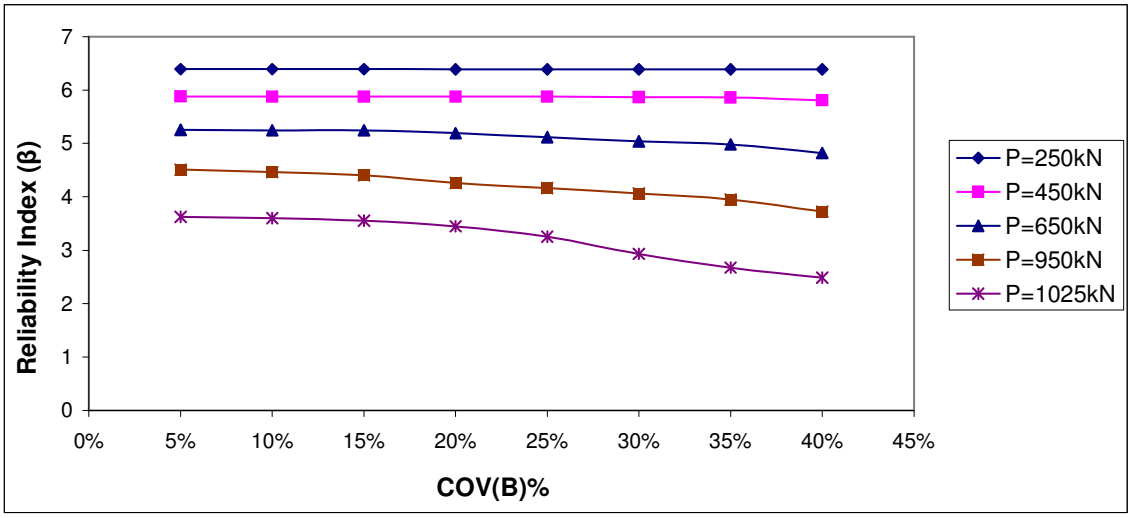


Fig. C.60 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table C.81 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.80E-08	0.000225	5%	0.0150	6.4000
1.11E-07	0.000225	10%	0.0150	6.3898
2.57E-07	0.000225	15%	0.0150	6.3877
4.69E-07	0.000225	20%	0.0150	6.3847
3.34E-07	0.000225	25%	0.0150	6.3866
1.14E-06	0.000225	30%	0.0150	6.3752
1.64E-06	0.000225	35%	0.0151	6.3682
2.28E-06	0.000225	40%	0.0151	6.3592

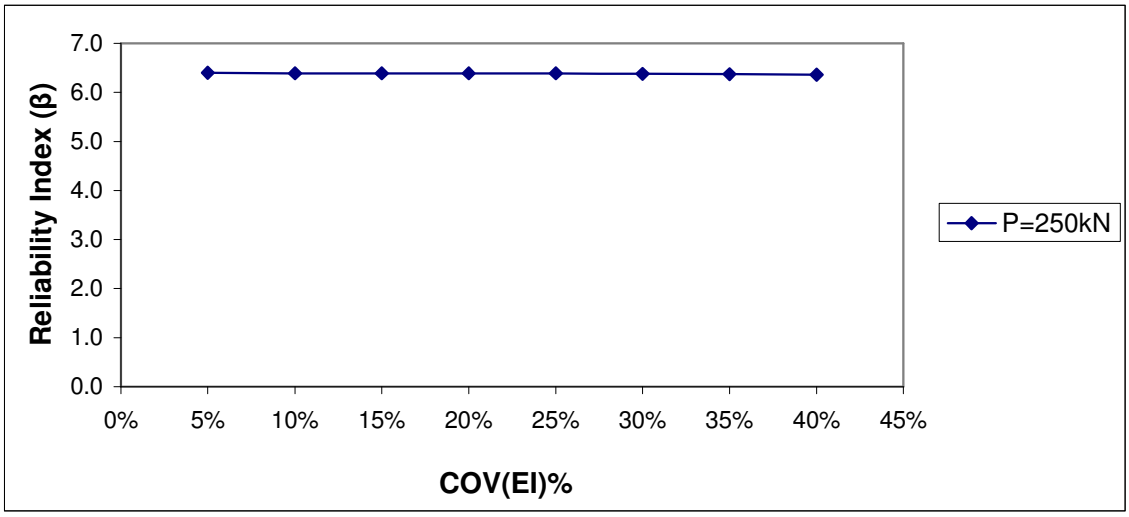


Fig. C.61 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.82 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 450kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
8.85E-08	0.000225	5%	0.0150	5.8788
3.57E-07	0.000225	10%	0.0150	5.8753
8.15E-07	0.000225	15%	0.0150	5.8694
1.49E-06	0.000225	20%	0.0150	5.8606
1.06E-06	0.000225	25%	0.0150	5.8662
3.66E-06	0.000225	30%	0.0151	5.8328
5.28E-06	0.000225	35%	0.0152	5.8122
7.40E-06	0.000225	40%	0.0152	5.7856

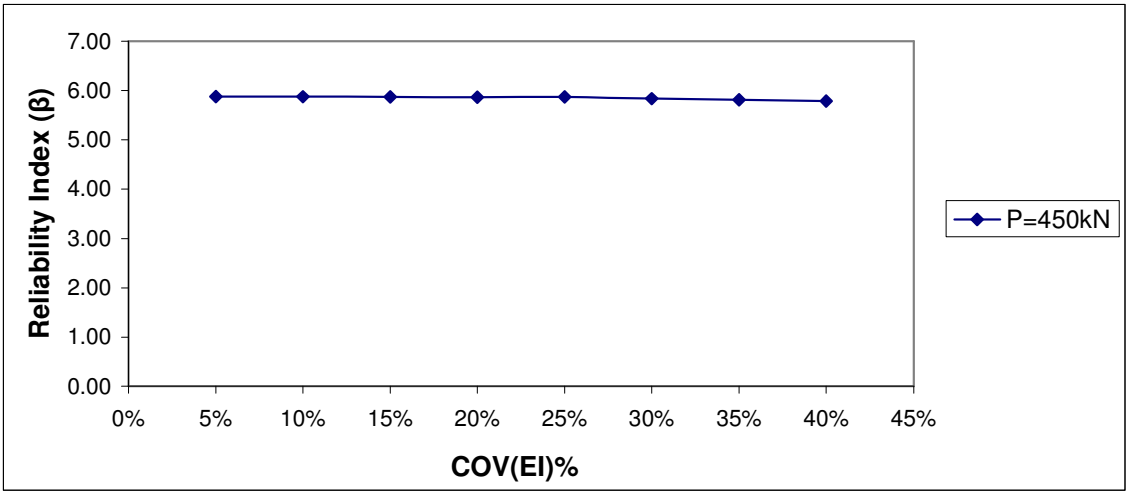


Fig. C.62 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.83 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
8.84E-07	0.000225	5%	0.0150	5.2430
3.55E-06	0.000225	10%	0.0151	5.2123
8.07E-06	0.000225	15%	0.0153	5.1616
1.47E-05	0.000225	20%	0.0155	5.0900
2.38E-05	0.000225	25%	0.0158	4.9961
3.62E-05	0.000225	30%	0.0162	4.8754
5.29E-05	0.000225	35%	0.0167	4.7267
7.50E-05	0.000225	40%	0.0173	4.5496

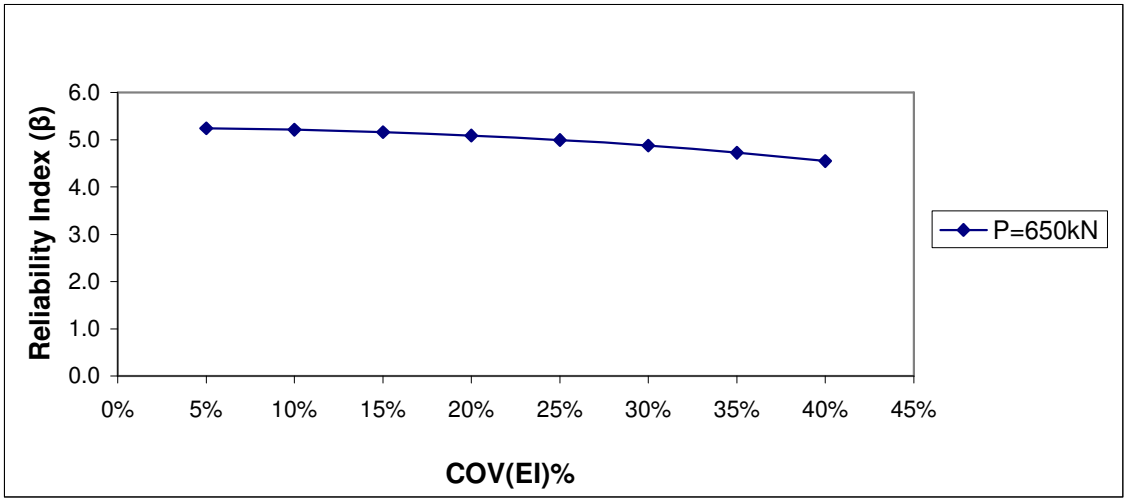


Fig. C.63 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.84 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 950kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.88E-06	0.000225	5%	0.0151	4.4946
7.67E-06	0.000225	10%	0.0153	4.4383
1.78E-05	0.000225	15%	0.0156	4.3447
3.30E-05	0.000225	20%	0.0161	4.2148
5.45E-05	0.000225	25%	0.0167	4.0497
8.33E-05	0.000225	30%	0.0176	3.8559
1.21E-04	0.000225	35%	0.0186	3.6384
1.71E-04	0.000225	40%	0.0199	3.4028

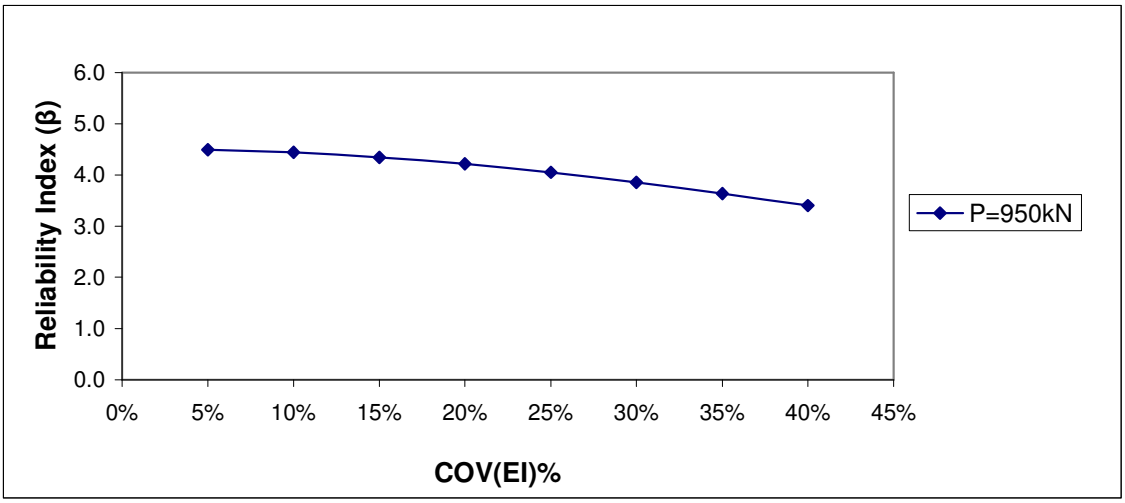


Fig. C.64 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.85 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 1025kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.80E-06	0.000225	5%	0.0151	3.6030
1.55E-05	0.000225	10%	0.0155	3.5141
3.59E-05	0.000225	15%	0.0162	3.3739
6.67E-05	0.000225	20%	0.0171	3.1907
1.10E-04	0.000225	25%	0.0183	2.9789
1.67E-04	0.000225	30%	0.0198	2.7511
2.44E-04	0.000225	35%	0.0217	2.5162
3.45E-04	0.000225	40%	0.0239	2.2823

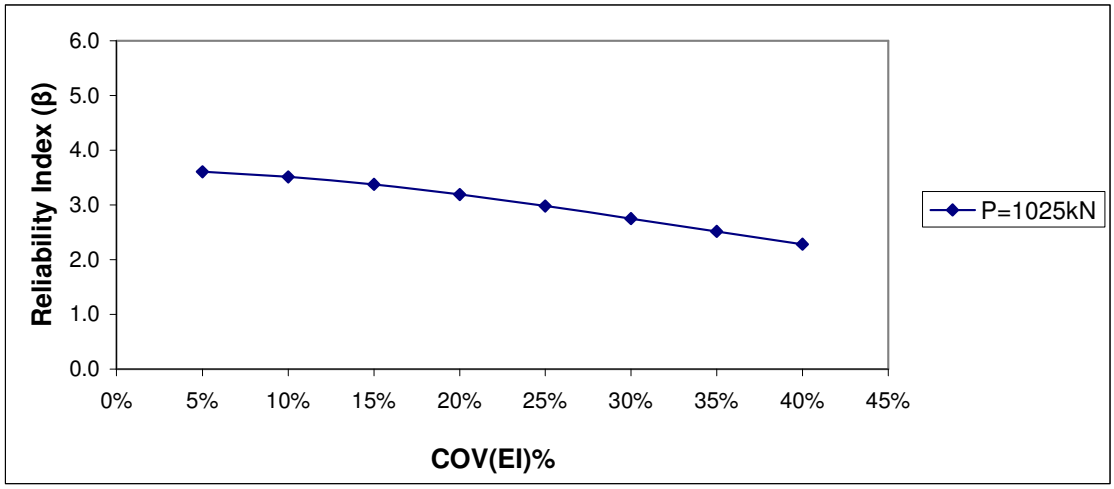


Fig. C.65 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 1025kN.

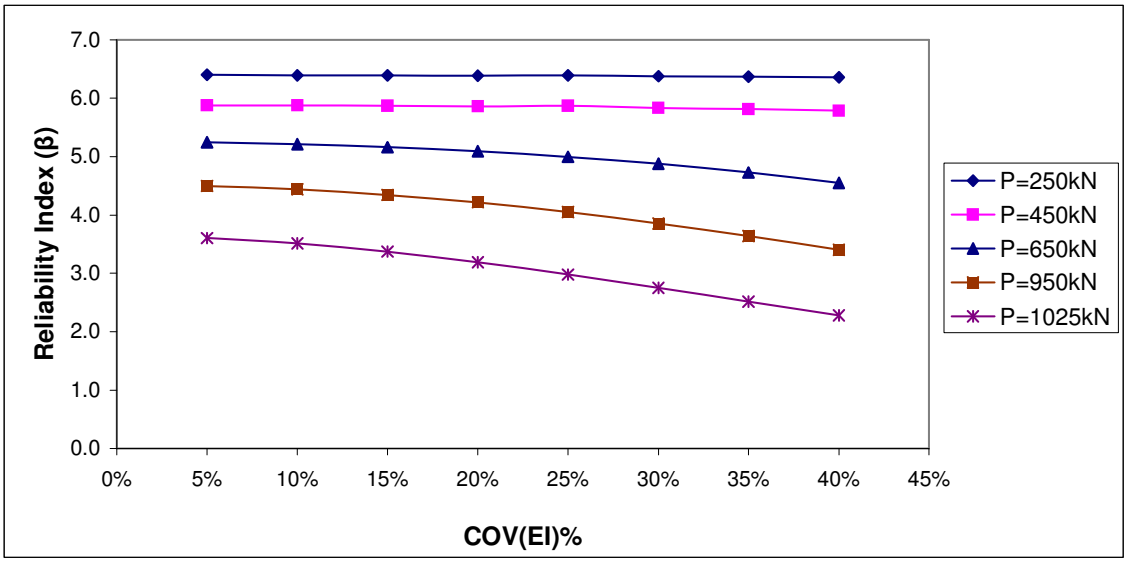


Fig. C.66 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table C.86 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'P' subjected to lateral load 250kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
5.57E-07	0.000225	5%	0.0150	6.3834
1.56E-06	0.000225	10%	0.0151	6.3693
3.20E-06	0.000225	15%	0.0151	6.3463
4.84E-06	0.000225	20%	0.0152	6.3237
6.00E-06	0.000225	25%	0.0152	6.3077
7.84E-06	0.000225	30%	0.0153	6.2828
9.30E-06	0.000225	35%	0.0153	6.2632
1.19E-05	0.000225	40%	0.0154	6.2287

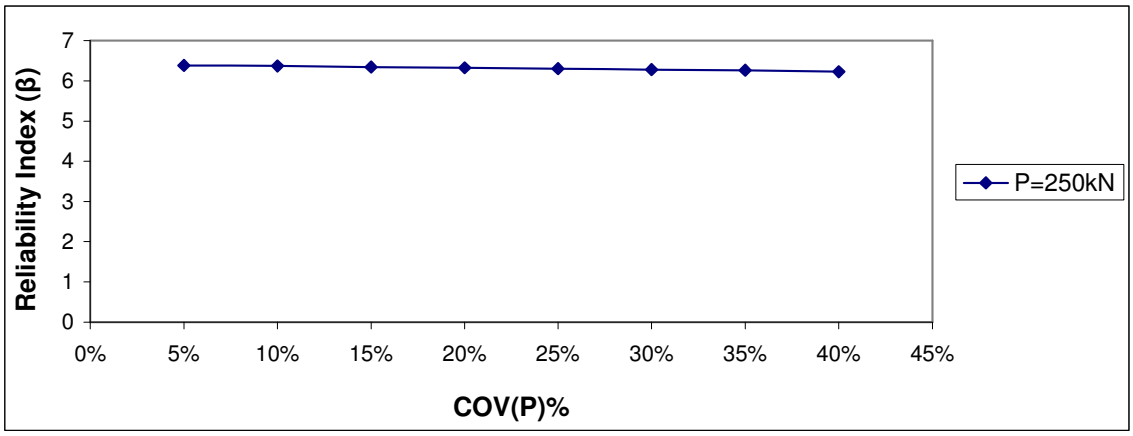


Fig. C.67 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.87 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'P' subjected to lateral load 450kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
1.66E-06	0.000225	5%	0.0151	5.8584
6.63E-06	0.000225	10%	0.0152	5.7952
1.50E-05	0.000225	15%	0.0155	5.6931
2.68E-05	0.000225	20%	0.0159	5.5585
4.19E-05	0.000225	25%	0.0163	5.3992
6.03E-05	0.000225	30%	0.0169	5.2218
8.25E-05	0.000225	35%	0.0175	5.0300
1.08E-04	0.000225	40%	0.0182	4.8335

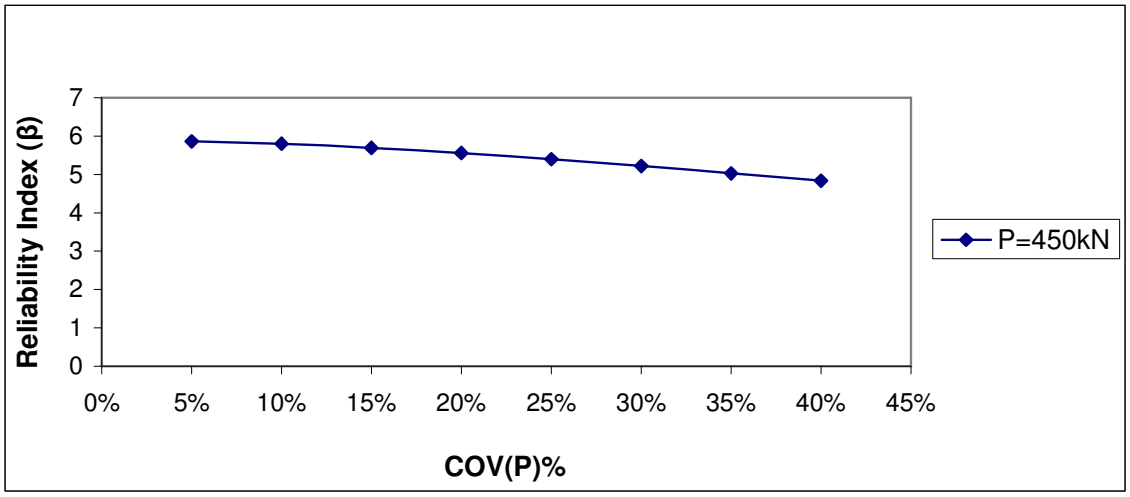


Fig. C.68 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.88 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'P' subjected to lateral load 650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
4.00E-06	0.000225	5%	0.0151	5.2073
1.57E-05	0.000225	10%	0.0155	5.0793
3.56E-05	0.000225	15%	0.0161	4.8810
6.40E-05	0.000225	20%	0.0170	4.6353
1.00E-04	0.000225	25%	0.0180	4.3690
1.45E-04	0.000225	30%	0.0192	4.0975
1.99E-04	0.000225	35%	0.0206	3.8252
2.64E-04	0.000225	40%	0.0221	3.5638

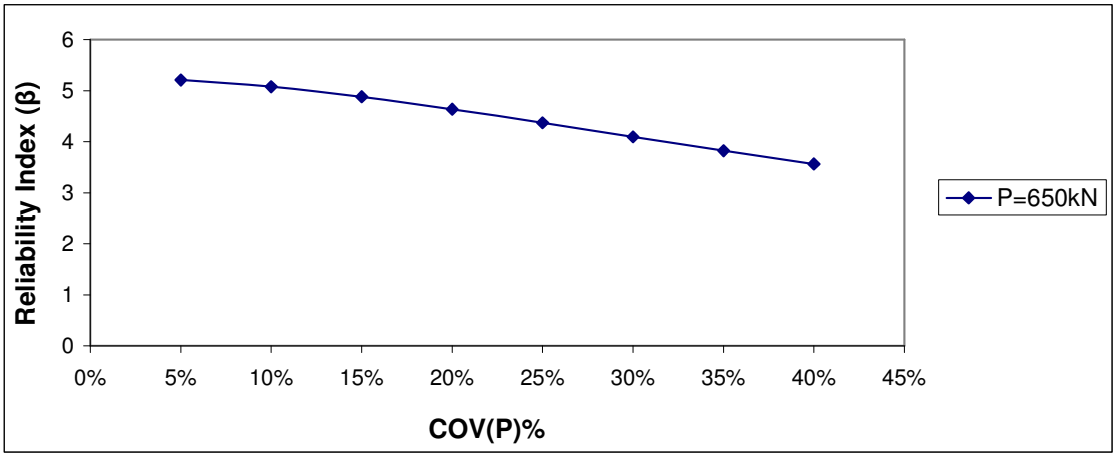


Fig. C.69 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.89 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'P' subjected to lateral load 950kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
8.47E-06	0.000225	5%	0.0153	4.4307
3.50E-05	0.000225	10%	0.0161	4.1982
7.85E-05	0.000225	15%	0.0174	3.8861
1.39E-04	0.000225	20%	0.0191	3.5467
2.19E-04	0.000225	25%	0.0211	3.2133
3.18E-04	0.000225	30%	0.0233	2.9046
4.36E-04	0.000225	35%	0.0257	2.6341
5.71E-04	0.000225	40%	0.0282	2.3996

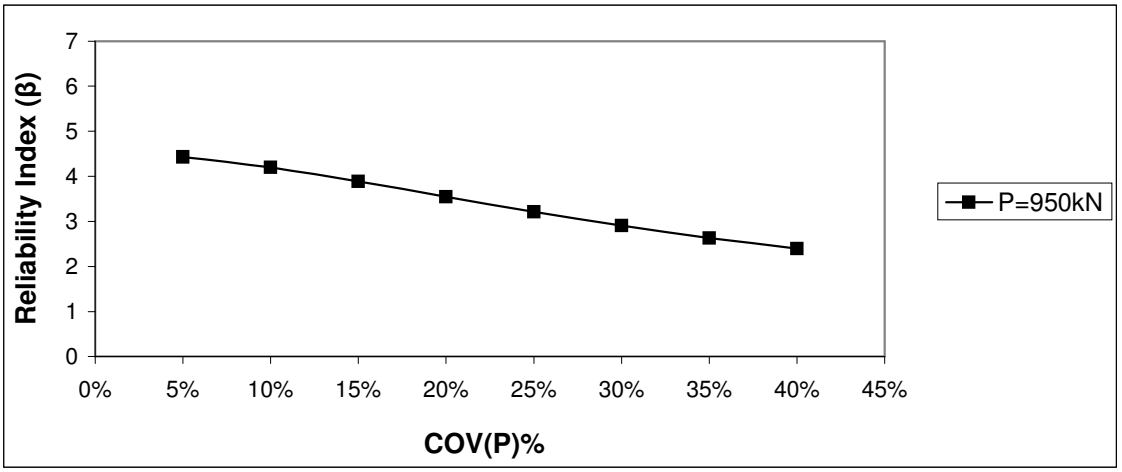


Fig. C.70 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.90 Reliability Index (β) connected to Y_{TOP} for free head long(10T) group with spacing (3D) and with varying 'P' subjected to lateral load 1025kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{max2})$ (m)	Reliability Index (β)
1.71E-05	0.000225	5%	0.0156	3.5027
7.02E-05	0.000225	10%	0.0172	3.1719
1.57E-04	0.000225	15%	0.0195	2.7898
2.77E-04	0.000225	20%	0.0224	2.4323
4.36E-04	0.000225	25%	0.0257	2.1192
6.30E-04	0.000225	30%	0.0292	1.8641
8.58E-04	0.000225	35%	0.0329	1.6562
1.13E-03	0.000225	40%	0.0367	1.4832

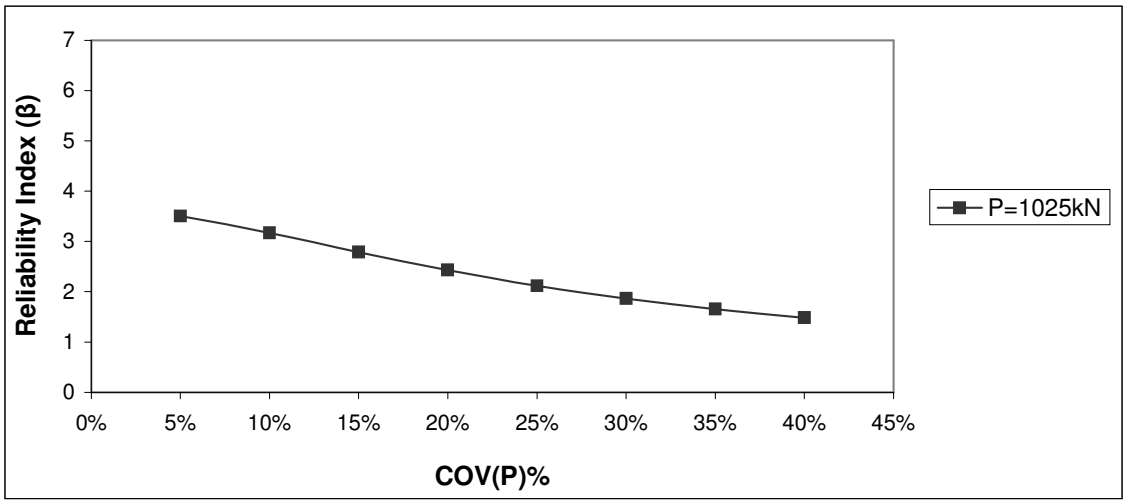


Fig. C.71 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 1025kN.

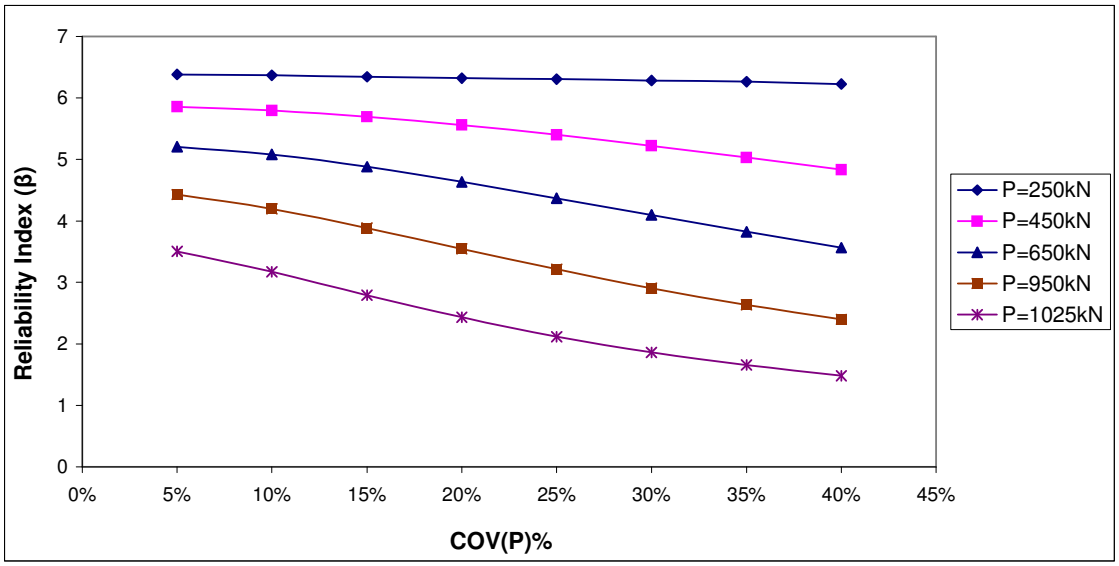


Fig. C.72 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force of discrete variability.

C.3 Probability of failure, p_f .of top deflection $p_f(Y_{TOP})$ vs. COV (Variables).

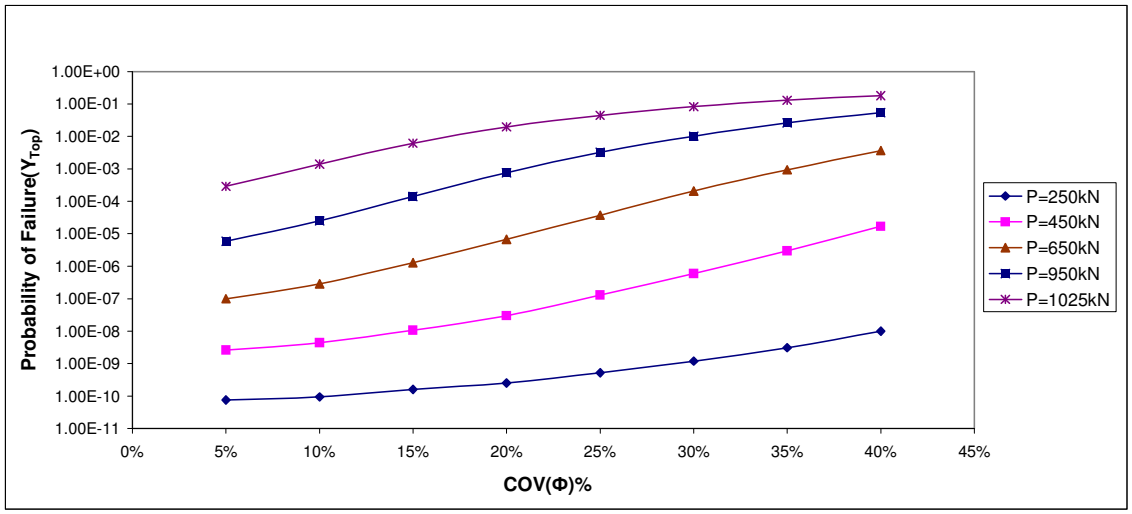


Fig. C.73 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (Φ) for free head long pile group of length 10T.

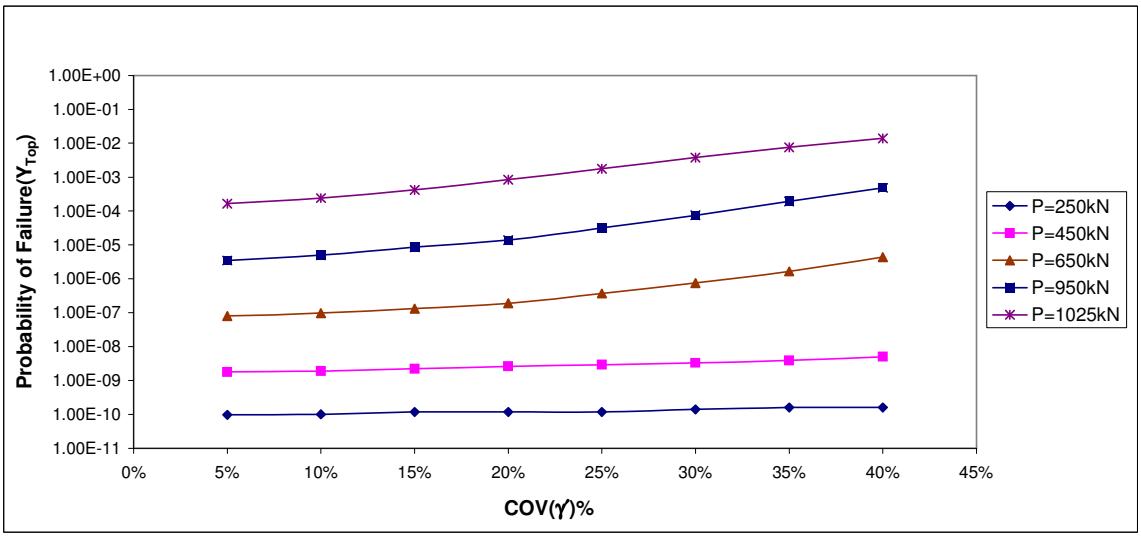


Fig. C.74 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (γ') for free head long pile group of length 10T.

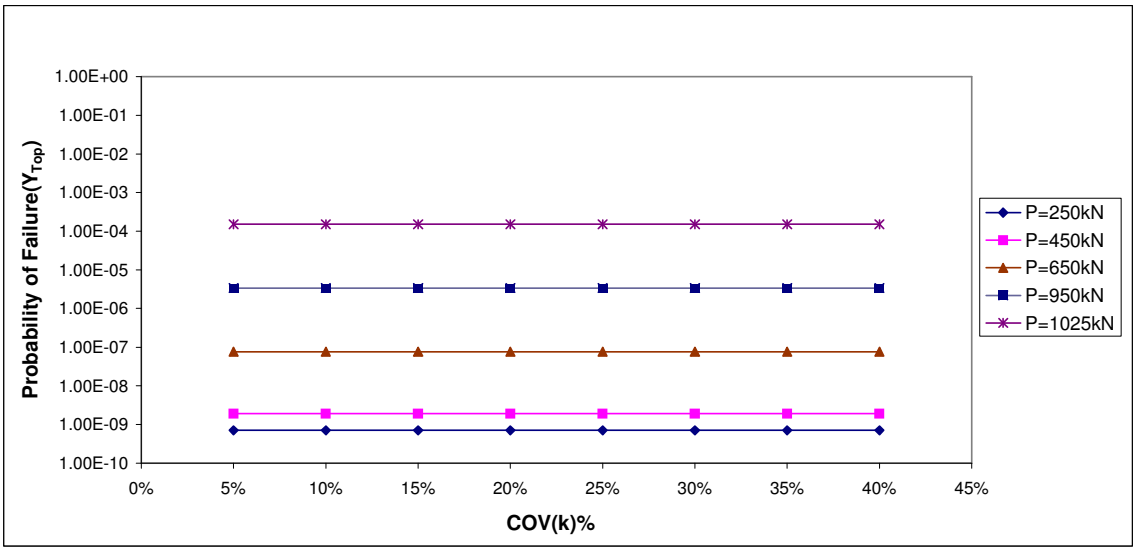


Fig. C.75 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (k) for free head long pile group of length 10T.

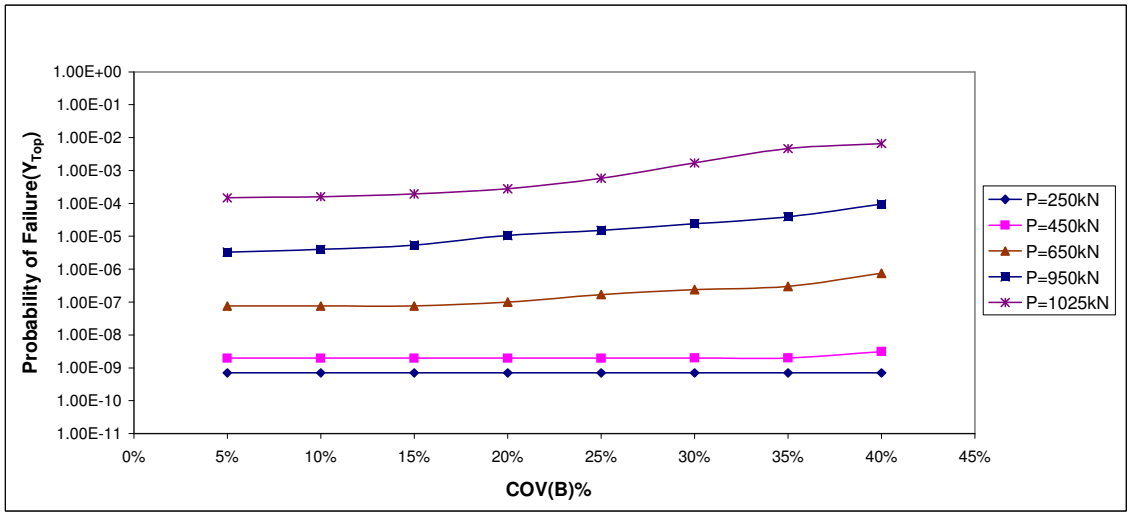


Fig. C.76 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (B) for free head long pile group of length 10T.

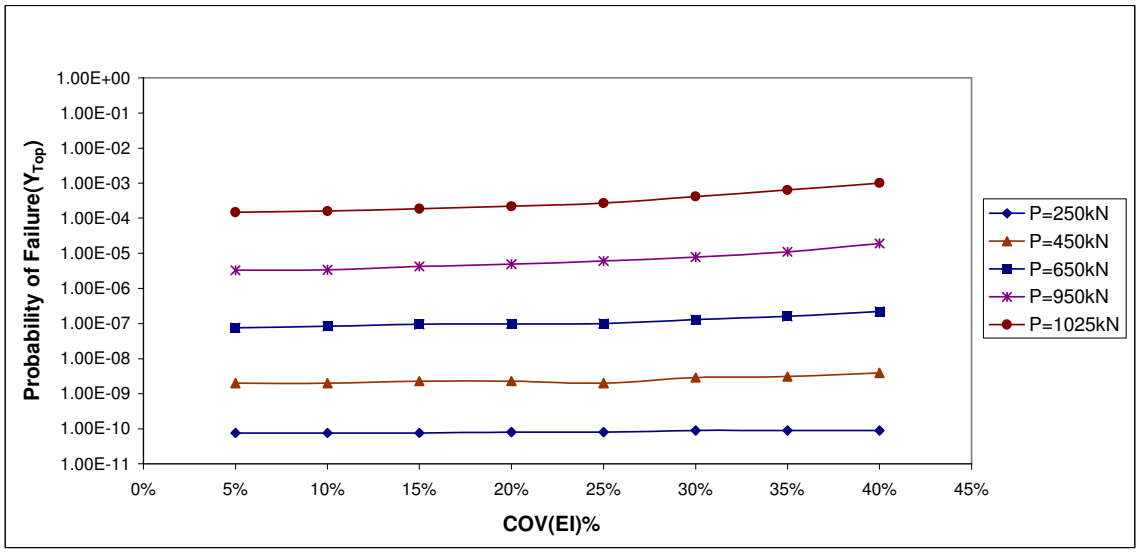


Fig. C.77 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (EI) for free head long pile group of length 10T.

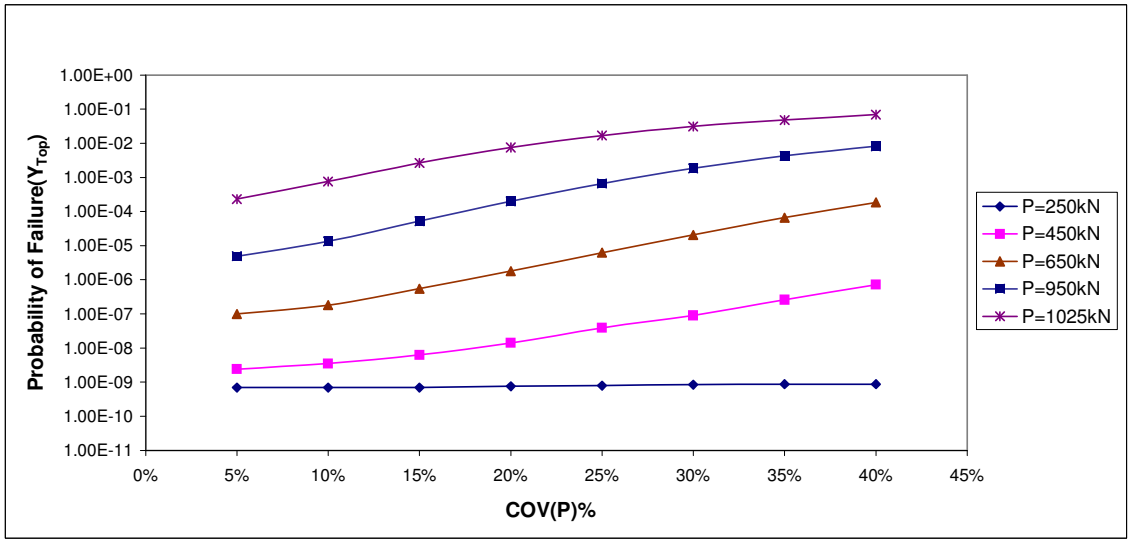


Fig. C.78 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (P) for free head long pile group of length 10T.

C.4 Moment of free head long pile group and coefficient of (M_{max}) vs. COV (Variables)

Table C.91 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (Φ) and load 250kN.

P=250kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	7.61E+01				
5%	30			2.25E+00	7.67E+00	4.40E+01	3.61%
		28.5	8.16E+01				
		33.0	7.29E+01				
10%	30			9.00E+00	3.36E+01	4.40E+01	7.54%
		27.0	8.45E+01				
		34.5	6.95E+01				
15%	30			2.03E+01	8.62E+01	4.40E+01	11.71%
		25.5	8.81E+01				
		36.0	6.72E+01				
20%	30			3.60E+01	1.43E+02	4.40E+01	15.62%
		24.0	9.11E+01				
		37.5	6.46E+01				
25%	30			5.63E+01	2.18E+02	4.40E+01	19.40%
		22.5	9.41E+01				
		39.0	6.17E+01				
30%	30			8.10E+01	3.13E+02	4.40E+01	24.33%
		21.0	9.71E+01				
		40.5	5.87E+01				
35%	30			1.10E+02	4.43E+02	4.40E+01	29.22%
		19.5	1.01E+02				
		42.0	5.72E+01				
40%	30			1.44E+02	5.60E+02	4.40E+01	34.53%
		18.0	1.05E+02				

Table C.92 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (Φ) and load 450kN.

P=450kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	1.24E+02				
5%	30			2.25E+00	2.07E+01	9.13E+01	4.03%
		28.5	1.33E+02				
		33.0	1.20E+02				
10%	30			9.00E+00	7.31E+01	9.13E+01	8.43%
		27.0	1.37E+02				
		34.5	1.16E+02				
15%	30			2.03E+01	1.66E+02	9.13E+01	12.87%
		25.5	1.42E+02				
		36.0	1.12E+02				
20%	30			3.60E+01	2.92E+02	9.13E+01	17.26%
		24.0	1.46E+02				
		37.5	1.06E+02				
25%	30			5.63E+01	5.11E+02	9.13E+01	21.77%
		22.5	1.52E+02				
		39.0	1.03E+02				
30%	30			8.10E+01	7.51E+02	9.13E+01	27.30%
		21.0	1.58E+02				
		40.5	9.90E+01				
35%	30			1.10E+02	1.05E+03	9.13E+01	32.60%
		19.5	1.64E+02				
		42.0	9.48E+01				
40%	30			1.44E+02	1.42E+03	9.13E+01	38.00%
		18.0	1.70E+02				

Table C.93 Probabilistic modeling of laterally loaded free head long (10T) pile group with

spacing (3D) with varying (Φ) and load 650kN.

P=650kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	1.74E+02				
5%	30			2.25E+00	4.10E+01	1.42E+02	4.51%
		28.5	1.87E+02				
		33.0	1.68E+02				
10%	30			9.00E+00	1.59E+02	1.42E+02	8.89%
		27.0	1.94E+02				
		34.5	1.63E+02				
15%	30			2.03E+01	3.42E+02	1.42E+02	13.05%
		25.5	2.00E+02				
		36.0	1.58E+02				
20%	30			3.60E+01	6.45E+02	1.42E+02	17.91%
		24.0	2.09E+02				
		37.5	1.52E+02				
25%	30			5.63E+01	1.08E+03	1.42E+02	23.17%
		22.5	2.18E+02				
		39.0	1.47E+02				
30%	30			8.10E+01	1.63E+03	1.42E+02	28.46%
		21.0	2.27E+02				
		40.5	1.41E+02				
35%	30			1.10E+02	2.39E+03	1.42E+02	34.49%
		19.5	2.38E+02				
		42.0	1.36E+02				
40%	30			1.44E+02	3.30E+03	1.42E+02	40.51%
		18.0	2.51E+02				

Table C.94 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (Φ) and load 950kN.

P=950kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	2.30E+02				
5%	30			2.25E+00	7.40E+01	2.38E+02	4.98%
		28.5	2.47E+02				
		33.0	2.21E+02				
10%	30			9.00E+00	3.22E+02	2.38E+02	9.36%
		27.0	2.57E+02				
		34.5	2.13E+02				
15%	30			2.03E+01	7.78E+02	2.38E+02	14.13%
		25.5	2.69E+02				
		36.0	2.06E+02				
20%	30			3.60E+01	1.38E+03	2.38E+02	18.73%
		24.0	2.80E+02				
		37.5	2.00E+02				
25%	30			5.63E+01	2.13E+03	2.38E+02	24.75%
		22.5	2.92E+02				
		39.0	1.92E+02				
30%	30			8.10E+01	3.36E+03	2.38E+02	30.00%
		21.0	3.08E+02				
		40.5	1.85E+02				
35%	30			1.10E+02	4.84E+03	2.38E+02	35.40%
		19.5	3.24E+02				
		42.0	1.77E+02				
40%	30			1.44E+02	6.77E+03	2.38E+02	41.27%
		18.0	3.42E+02				

Table C.95 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (Φ) and load 1025kN.

P=1025kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	2.90E+02				
5%	30			2.25E+00	1.27E+00	2.94E+02	6.30%
		28.5	3.14E+02				
		33.0	2.79E+02				
10%	30			9.00E+00	6.13E+02	2.94E+02	13.18%
		27.0	3.29E+02				
		34.5	2.68E+02				
15%	30			2.03E+01	1.43E+03	2.94E+02	21.12%
		25.5	3.43E+02				
		36.0	2.57E+02				
20%	30			3.60E+01	2.57E+03	2.94E+02	27.18%
		24.0	3.58E+02				
		37.5	2.49E+02				
25%	30			5.63E+01	4.09E+03	2.94E+02	33.56%
		22.5	3.77E+02				
		39.0	2.40E+02				
30%	30			8.10E+01	5.97E+03	2.94E+02	40.25%
		21.0	3.95E+02				
		40.5	2.31E+02				
35%	30			1.10E+02	8.63E+03	2.94E+02	47.90%
		19.5	4.17E+02				
		42.0	2.21E+02				
40%	30			1.44E+02	9.96E+03	2.94E+02	53.84%
		18.0	4.21E+02				

Table C.96 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 250kN.

P=250kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV (M_{max}) (%)
5%	2.25E+00	7.67E+00	3.61%
10%	9.00E+00	3.36E+01	7.54%
15%	2.03E+01	8.62E+01	11.71%
20%	3.60E+01	1.43E+02	15.62%
25%	5.63E+01	2.18E+02	19.40%
30%	8.10E+01	3.13E+02	24.33%
35%	1.10E+02	4.43E+02	29.22%
40%	1.44E+02	5.60E+02	34.53%

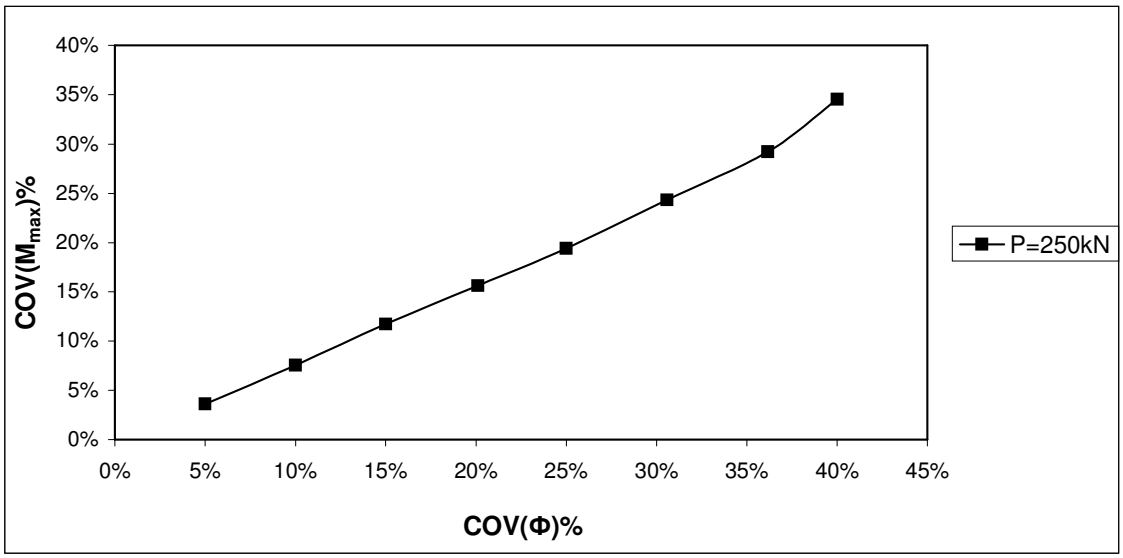


Fig. C.79 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.97 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 450kN.

P=450kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV (M_{max}) (%)
5%	2.25E+00	2.07E+01	4.03%
10%	9.00E+00	7.31E+01	8.43%
15%	2.03E+01	1.66E+02	12.87%
20%	3.60E+01	2.92E+02	17.26%
25%	5.63E+01	5.11E+02	21.77%
30%	8.10E+01	7.51E+02	27.30%
35%	1.10E+02	1.05E+03	32.60%
40%	1.44E+02	1.42E+03	38.00%

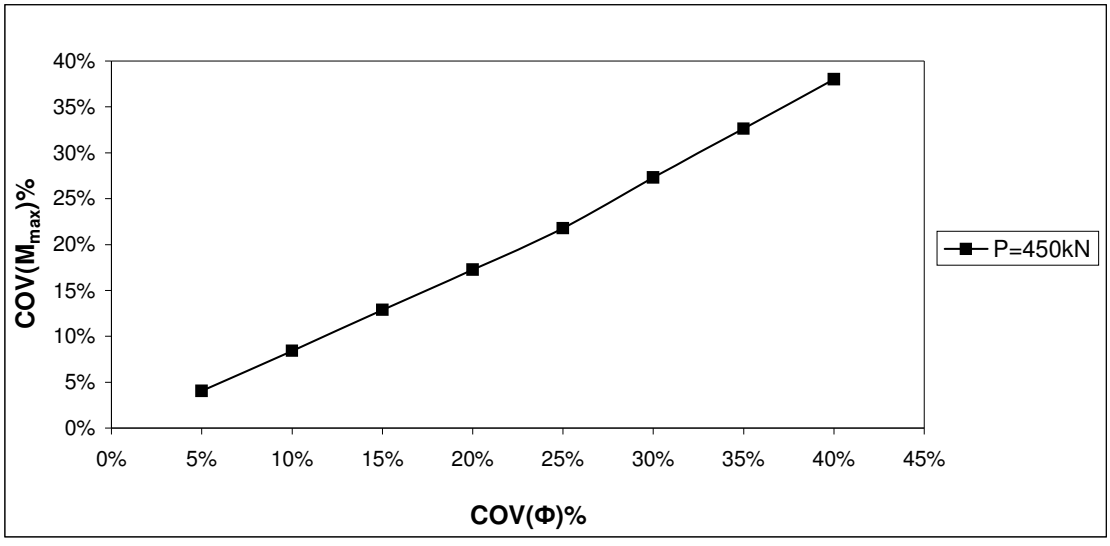


Fig. C.80 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.98 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 650kN.

P=650kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV (M_{max}) (%)
5%	2.25E+00	4.10E+01	4.51%
10%	9.00E+00	1.59E+02	8.89%
15%	2.03E+01	3.42E+02	13.05%
20%	3.60E+01	6.45E+02	17.91%
25%	5.63E+01	1.08E+03	23.17%
30%	8.10E+01	1.63E+03	28.46%
35%	1.10E+02	2.39E+03	34.49%
40%	1.44E+02	3.30E+03	40.51%

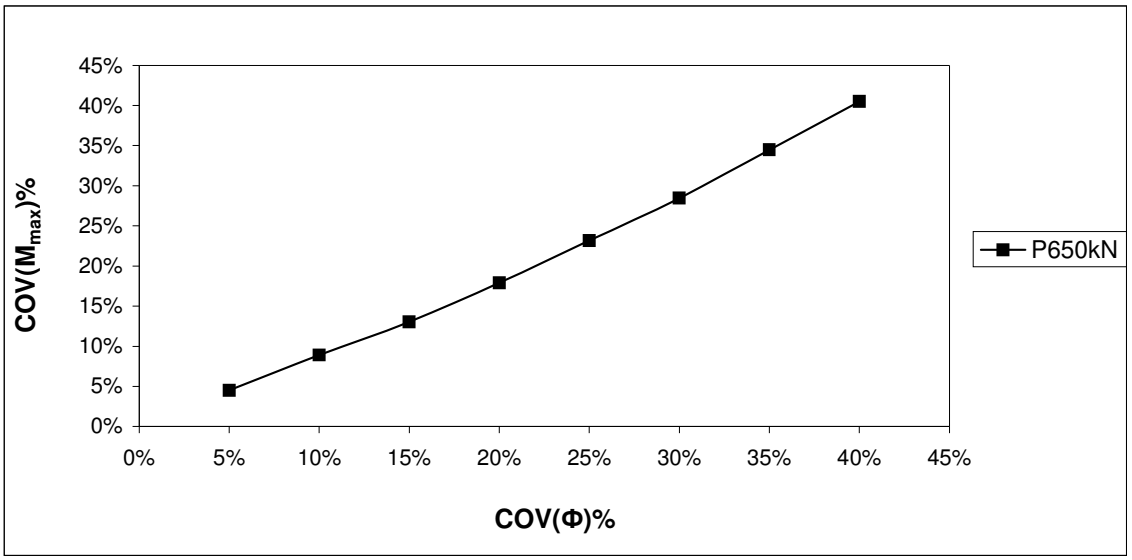


Fig. C.81 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.99 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 950kN.

P=950kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV (M_{max}) (%)
5%	2.25E+00	7.40E+01	4.98%
10%	9.00E+00	3.22E+02	9.36%
15%	2.03E+01	7.78E+02	14.13%
20%	3.60E+01	1.38E+03	18.73%
25%	5.63E+01	2.13E+03	24.75%
30%	8.10E+01	3.36E+03	30.00%
35%	1.10E+02	4.84E+03	35.40%
40%	1.44E+02	6.77E+03	41.27%

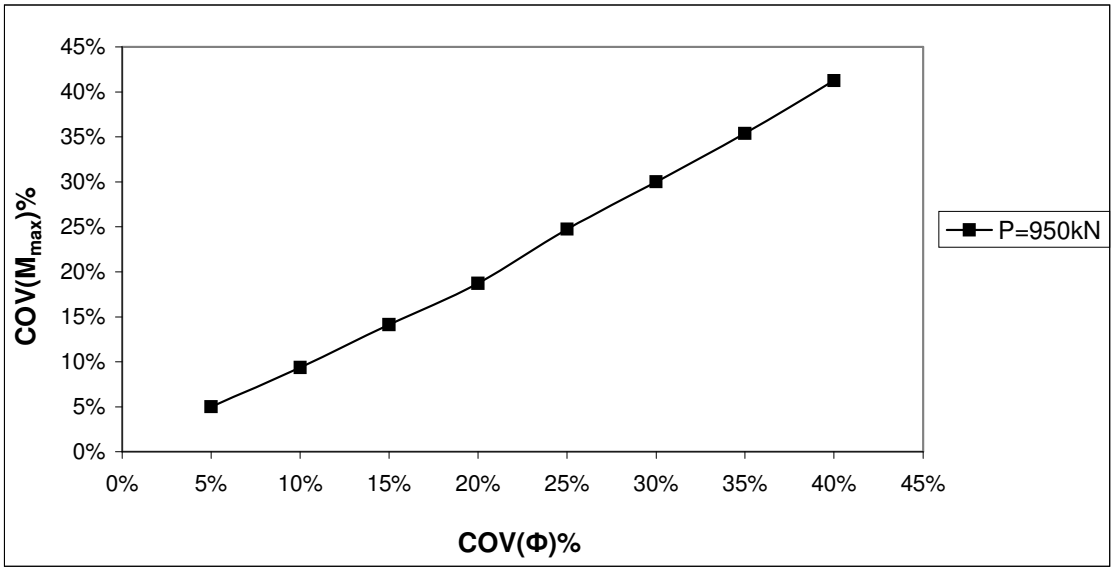


Fig. C.82 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.100 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 1025kN.

P=1025kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV (M_{max}) (%)
5%	2.25E+00	1.40E+02	6.30%
10%	9.00E+00	6.13E+02	13.18%
15%	2.03E+01	1.43E+03	21.12%
20%	3.60E+01	2.57E+03	27.18%
25%	5.63E+01	4.09E+03	33.56%
30%	8.10E+01	5.97E+03	40.25%
35%	1.10E+02	8.63E+03	47.90%
40%	1.44E+02	1.18E+04	53.84%

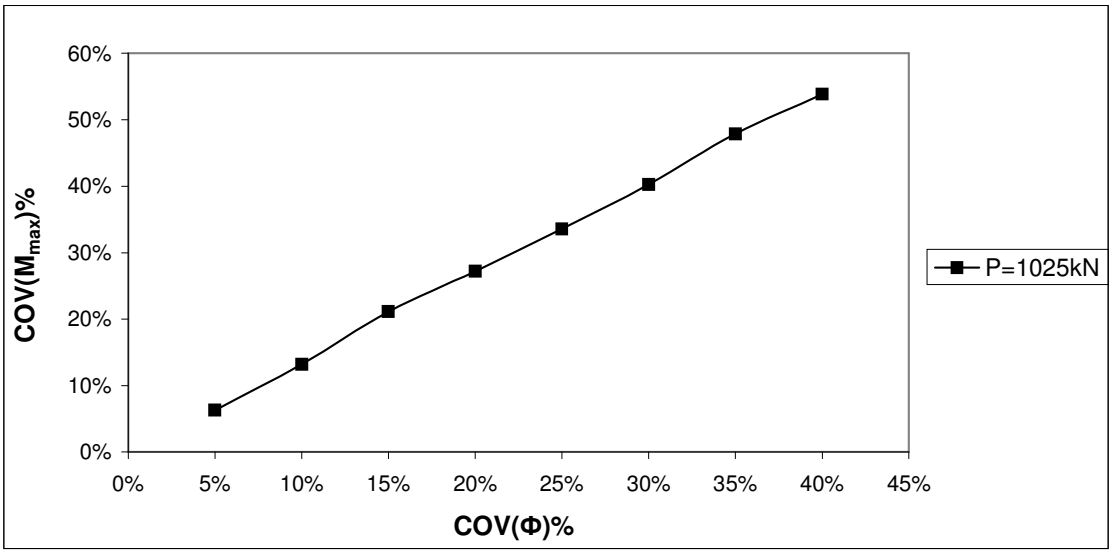


Fig. C.83 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

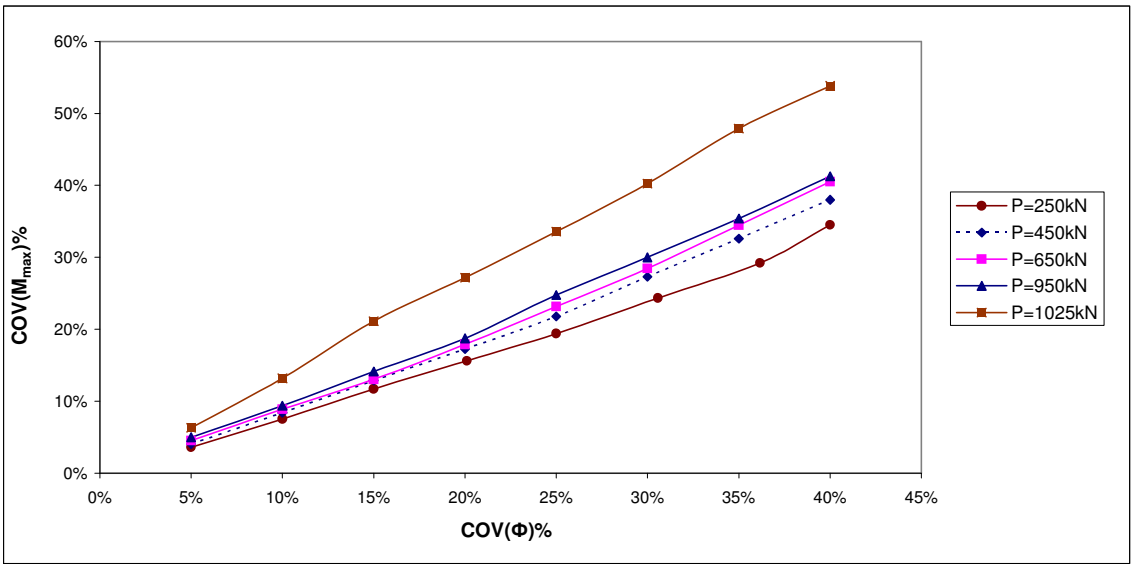


Fig. C.84 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table C.101 Probabilistic modeling of laterally loaded free head long (10T) pile group with

spacing (3D) with varying (γ) and load 250kN.

P=250kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}° (kN-m)	COV(M_{max}) (%)
		11.0	7.78E+01				
5%	10.5			2.76E-01	1.28E+00	4.40E+01	1.60%
		10.0	8.01E+01				
		11.6	7.67E+01				
10%	10.5			1.10E+00	5.48E+00	4.40E+01	3.09%
		9.5	8.14E+01				
		12.1	7.53E+01				
15%	10.5			2.48E+00	1.37E+01	4.40E+01	4.65%
		8.9	8.27E+01				
		12.6	7.41E+01				
20%	10.5			4.41E+00	2.59E+01	4.40E+01	6.02%
		8.4	8.43E+01				
		13.1	7.30E+01				
25%	10.5			6.89E+00	4.28E+01	4.40E+01	7.47%
		7.9	8.61E+01				
		13.7	7.20E+01				
30%	10.5			9.92E+00	6.59E+01	4.40E+01	8.95%
		7.4	8.82E+01				
		14.2	7.09E+01				
35%	10.5			1.35E+01	9.25E+01	4.40E+01	10.48%
		6.8	9.02E+01				
		14.7	6.99E+01				
40%	10.5			1.76E+01	1.24E+02	4.40E+01	12.08%
		6.3	9.21E+01				

Table C.102 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (γ) and load 450kN.

P=450kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}° (kN-m)	COV(M_{max}) (%)
		11.0	1.26E+02				
5%	10.5			2.76E-01	4.20E+00	9.13E+01	1.00%
		10.0	1.30E+02				
		11.6	1.24E+02				
10%	10.5			1.10E+00	1.56E+01	9.13E+01	2.40%
		9.5	1.32E+02				
		12.1	1.23E+02				
15%	10.5			2.48E+00	3.54E+01	9.13E+01	4.00%
		8.9	1.35E+02				
		12.6	1.22E+02				
20%	10.5			4.41E+00	5.93E+01	9.13E+01	6.00%
		8.4	1.37E+02				
		13.1	1.20E+02				
25%	10.5			6.89E+00	9.12E+01	9.13E+01	7.80%
		7.9	1.39E+02				
		13.7	1.19E+02				
30%	10.5			9.92E+00	1.31E+02	9.13E+01	9.80%
		7.4	1.42E+02				
		14.2	1.18E+02				
35%	10.5			1.35E+01	1.80E+02	9.13E+01	11.60%
		6.8	1.45E+02				
		14.7	1.16E+02				
40%	10.5			1.76E+01	2.39E+02	9.13E+01	13.40%
		6.3	1.47E+02				

Table C.103 Probabilistic modeling of laterally loaded free head long (10T) pile group with

spacing (3D) with varying (γ) and load 650kN.

P=650kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^o (kN-m)	COV(M_{max}) (%)
		11.0	1.78E+02				
5%	10.5			2.76E-01	8.12E+00	1.42E+02	1.49%
		10.0	1.84E+02				
		11.6	1.75E+02				
10%	10.5			1.10E+00	3.14E+01	1.42E+02	3.09%
		9.5	1.87E+02				
		12.1	1.73E+02				
15%	10.5			2.48E+00	6.81E+01	1.42E+02	4.66%
		8.9	1.89E+02				
		12.6	1.71E+02				
20%	10.5			4.41E+00	1.24E+02	1.42E+02	6.44%
		8.4	1.93E+02				
		13.1	1.68E+02				
25%	10.5			6.89E+00	1.95E+02	1.42E+02	8.40%
		7.9	1.96E+02				
		13.7	1.67E+02				
30%	10.5			9.92E+00	2.77E+02	1.42E+02	10.39%
		7.4	2.00E+02				
		14.2	1.65E+02				
35%	10.5			1.35E+01	4.10E+02	1.42E+02	12.41%
		6.8	2.05E+02				
		14.7	1.63E+02				
40%	10.5			1.76E+01	5.69E+02	1.42E+02	14.50%
		6.3	2.11E+02				

Table C.104 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (γ) and load 950kN.

P=950kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^o (kN-m)	COV(M_{max}) (%)
		11.0	2.35E+02				
5%	10.5			2.76E-01	1.26E+01	2.38E+02	2.01%
		10.0	2.42E+02				
		11.6	2.32E+02				
10%	10.5			1.10E+00	5.40E+01	2.38E+02	3.95%
		9.5	2.46E+02				
		12.1	2.28E+02				
15%	10.5			2.48E+00	1.23E+02	2.38E+02	5.82%
		8.9	2.50E+02				
		12.6	2.24E+02				
20%	10.5			4.41E+00	2.36E+02	2.38E+02	7.86%
		8.4	2.55E+02				
		13.1	2.21E+02				
25%	10.5			6.89E+00	4.00E+02	2.38E+02	9.84%
		7.9	2.61E+02				
		13.7	2.19E+02				
30%	10.5			9.92E+00	6.13E+02	2.38E+02	11.74%
		7.4	2.68E+02				
		14.2	2.16E+02				
35%	10.5			1.35E+01	8.73E+02	2.38E+02	14.28%
		6.8	2.75E+02				
		14.7	2.13E+02				
40%	10.5			1.76E+01	1.19E+03	2.38E+02	16.82%
		6.3	2.82E+02				

Table C.105 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (γ) and load 1025kN.

P=1025kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		11.0	2.97E+02				
5%	10.5			2.76E-01	2.16E+01	2.94E+02	2.57%
		10.0	3.06E+02				
		11.6	2.92E+02				
10%	10.5			1.10E+00	9.80E+01	2.94E+02	5.32%
		9.5	3.12E+02				
		12.1	2.88E+02				
15%	10.5			2.48E+00	2.43E+02	2.94E+02	8.41%
		8.9	3.19E+02				
		12.6	2.84E+02				
20%	10.5			4.41E+00	4.49E+02	2.94E+02	11.57%
		8.4	3.26E+02				
		13.1	2.80E+02				
25%	10.5			6.89E+00	7.32E+02	2.94E+02	14.89%
		7.9	3.34E+02				
		13.7	2.76E+02				
30%	10.5			9.92E+00	1.09E+03	2.94E+02	18.46%
		7.4	3.42E+02				
		14.2	2.72E+02				
35%	10.5			1.35E+01	1.51E+03	2.94E+02	21.88%
		6.8	3.50E+02				
		14.7	2.69E+02				
40%	10.5			1.76E+01	2.09E+03	2.94E+02	25.33%
		6.3	3.60E+02				

Table C.106 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 250kN.

P=250kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	1.28E+00	1.60%
10%	1.10E+00	5.48E+00	3.09%
15%	2.48E+00	1.37E+01	4.65%
20%	4.41E+00	2.59E+01	6.02%
25%	6.89E+00	4.28E+01	7.47%
30%	9.92E+00	6.59E+01	8.95%
35%	1.35E+01	9.25E+01	10.48%
40%	1.76E+01	1.24E+02	12.08%

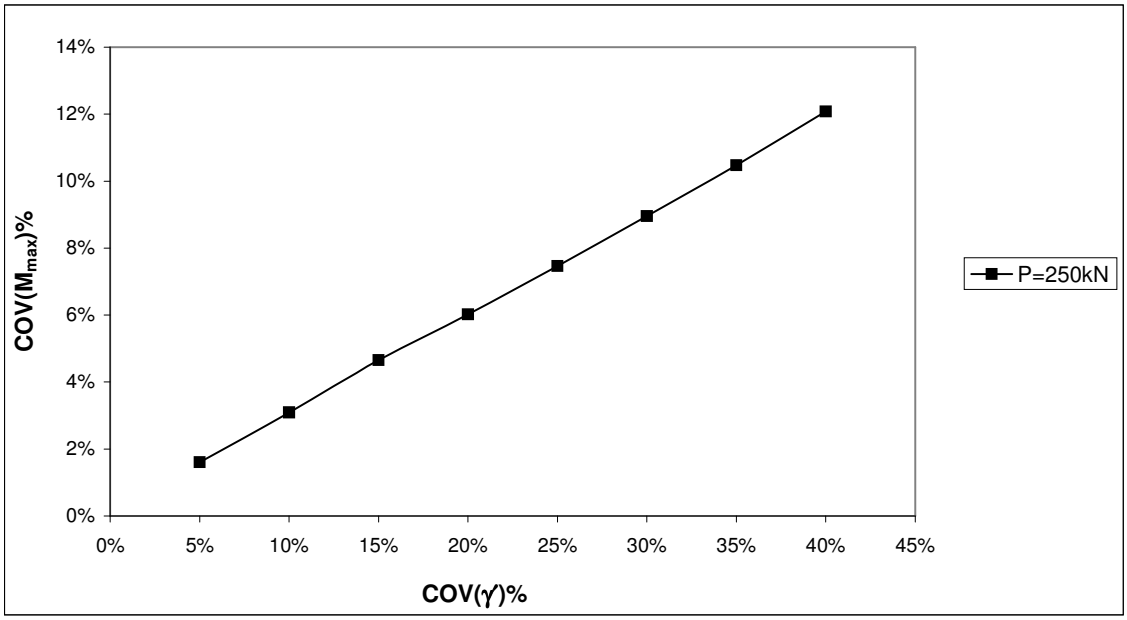


Fig. C.85 Variability of COV (M_{max}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.107 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 450kN.

P=450kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	4.20E+00	1.00%
10%	1.10E+00	1.56E+01	2.40%
15%	2.48E+00	3.54E+01	4.00%
20%	4.41E+00	5.93E+01	6.00%
25%	6.89E+00	9.12E+01	7.80%
30%	9.92E+00	1.31E+02	9.80%
35%	1.35E+01	1.80E+02	11.60%
40%	1.76E+01	2.39E+02	13.40%

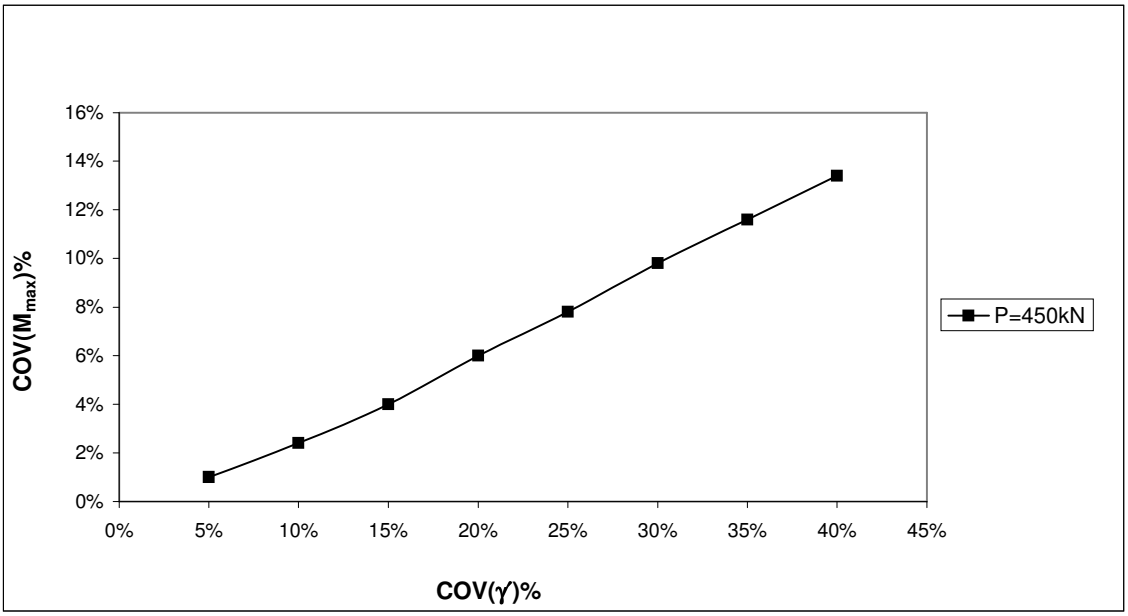


Fig. C.86 Variability of COV (M_{max}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.108 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 650kN.

P=650kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	8.12E+00	1.49%
10%	2.66E+06	3.14E+01	3.09%
15%	5.98E+06	6.81E+01	4.66%
20%	1.06E+07	1.24E+02	6.44%
25%	1.66E+07	1.95E+02	8.40%
30%	2.39E+07	2.77E+02	10.39%
35%	3.25E+07	4.10E+02	12.41%
40%	4.25E+07	5.69E+02	14.50%

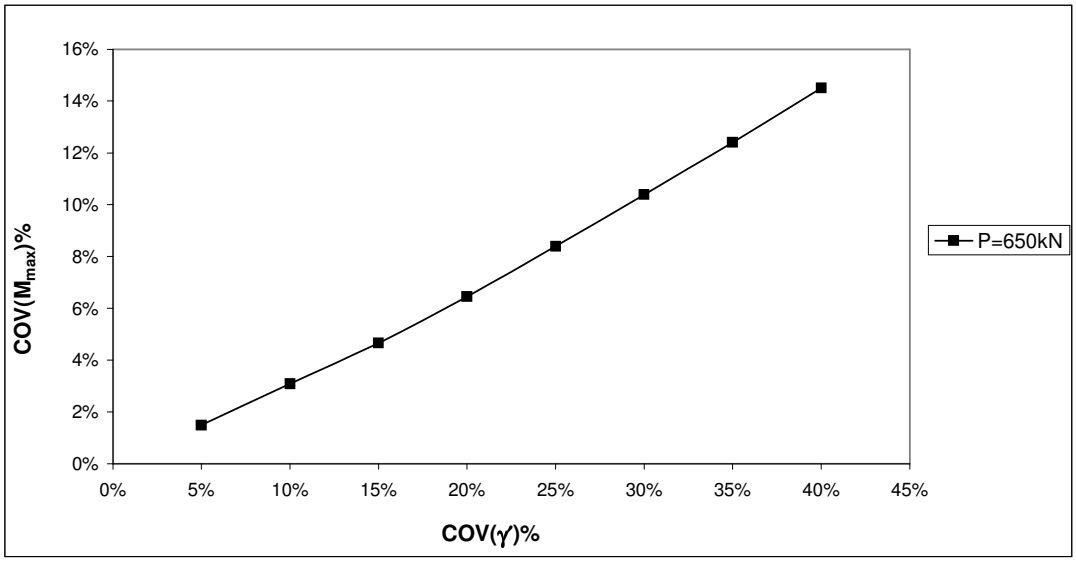


Fig. C.87 Variability of COV (M_{max}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.108 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 950kN.

P=950kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.26E+01	2.01%
10%	2.66E+06	5.40E+01	3.95%
15%	5.98E+06	1.23E+02	5.82%
20%	1.06E+07	2.36E+02	7.86%
25%	1.66E+07	4.00E+02	9.84%
30%	2.39E+07	6.13E+02	11.74%
35%	3.25E+07	8.73E+02	14.28%
40%	4.25E+07	1.19E+03	16.82%

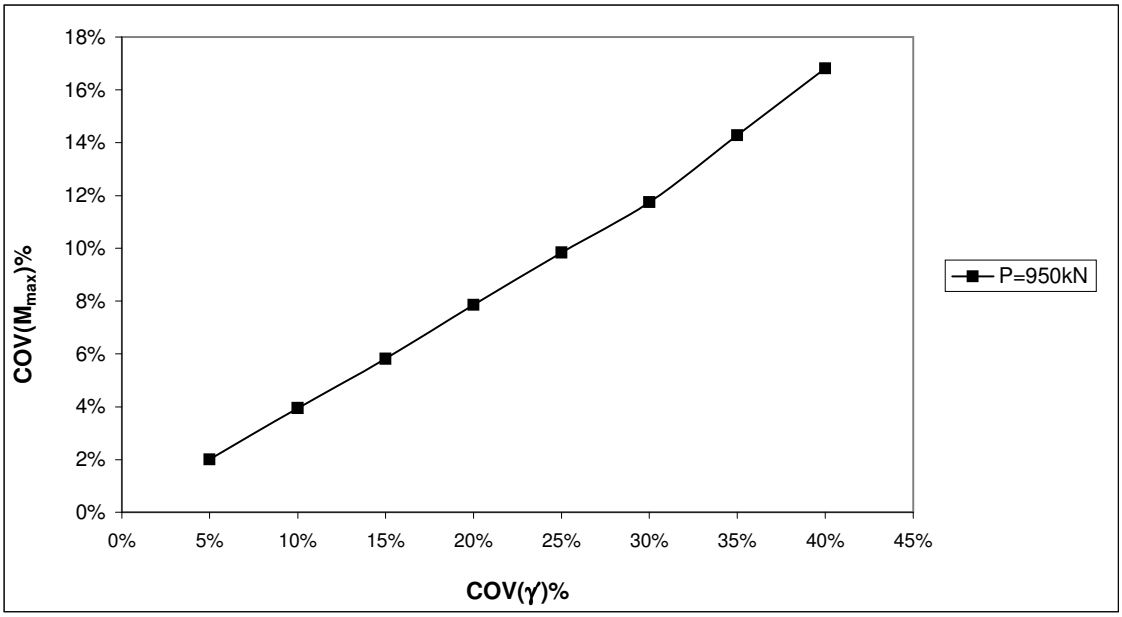


Fig. C.88 Variability of COV (M_{max}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.110 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 1025kN.

P=1025kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.16E+01	2.57%
10%	2.66E+06	9.80E+01	5.32%
15%	5.98E+06	2.43E+02	8.41%
20%	1.06E+07	4.49E+02	11.57%
25%	1.66E+07	7.32E+02	14.89%
30%	2.39E+07	1.09E+03	18.46%
35%	3.25E+07	1.51E+03	21.88%
40%	4.25E+07	2.09E+03	25.33%

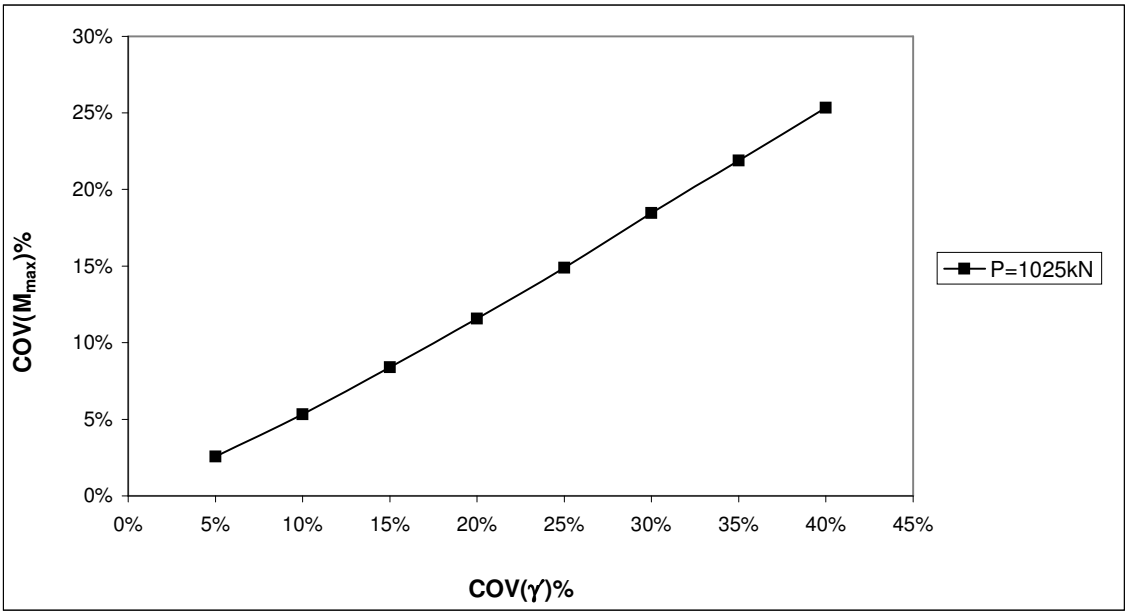


Fig. C.89 Variability of COV (M_{max}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

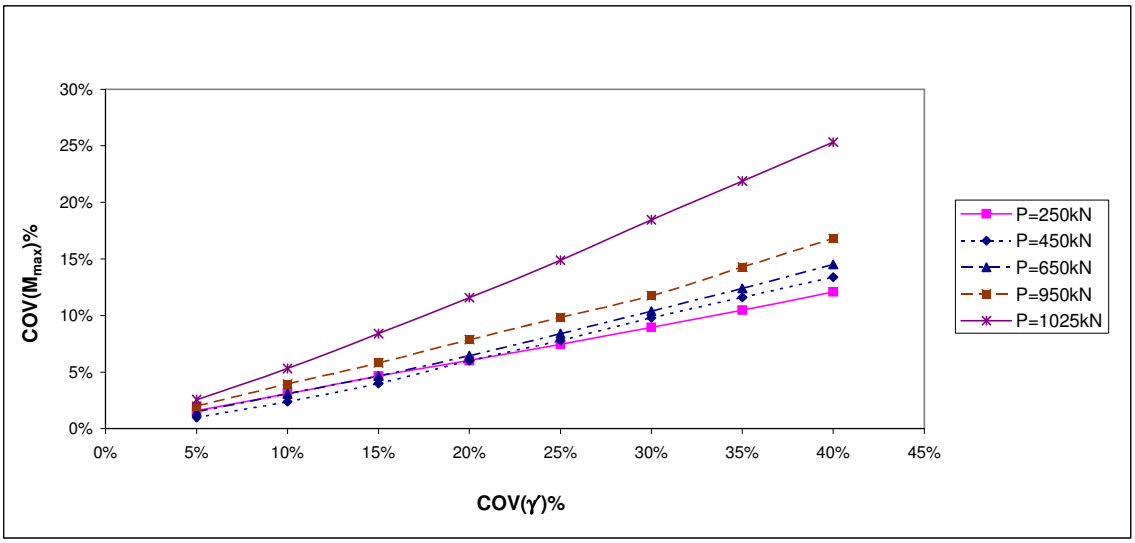


Fig. C.90 Variability of COV (M_{max}) vs. COV (γ) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table C.111 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (k) and load 250kN.

P=250kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	7.89E+01				
5%	16300			6.64E+05	0.00E+00	4.40E+01	0.05%
		15485	7.89E+01				
		17930	7.89E+01				
10%	16300			2.66E+06	2.25E-04	4.40E+01	0.15%
		14670	7.89E+01				
		18745	7.89E+01				
15%	16300			5.98E+06	9.00E-04	4.40E+01	0.29%
		13855	7.89E+01				
		19560	7.90E+01				
20%	16300			1.06E+07	1.44E-02	4.40E+01	0.43%
		13040	7.88E+01				
		20375	7.91E+01				
25%	16300			1.66E+07	7.02E-02	4.40E+01	0.60%
		12225	7.85E+01				
		21190	7.91E+01				
30%	16300			2.39E+07	1.33E-01	4.40E+01	0.83%
		11410	7.84E+01				
		22005	7.92E+01				
35%	16300			3.25E+07	1.89E-01	4.40E+01	0.97%
		10595	7.83E+01				
		22820	7.93E+01				
40%	16300			4.25E+07	2.50E-01	4.40E+01	1.14%
		9780	7.83E+01				

Table C.112 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (k) and load 450kN.

P=450kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	1.28E+02				
5%	16300			6.64E+05	0.00E+00	9.13E+01	0.02%
		15485	1.28E+02				
		17930	1.28E+02				
10%	16300			2.66E+06	2.50E-03	9.13E+01	0.06%
		14670	1.28E+02				
		18745	1.28E+02				
15%	16300			5.98E+06	1.00E-02	9.13E+01	0.15%
		13855	1.28E+02				
		19560	1.28E+02				
20%	16300			1.06E+07	4.00E-02	9.13E+01	0.26%
		13040	1.28E+02				
		20375	1.28E+02				
25%	16300			1.66E+07	2.02E-01	9.13E+01	0.40%
		12225	1.27E+02				
		21190	1.28E+02				
30%	16300			2.39E+07	3.60E-01	9.13E+01	0.56%
		11410	1.27E+02				
		22005	1.28E+02				
35%	16300			3.25E+07	4.90E-01	9.13E+01	0.75%
		10595	1.27E+02				
		22820	1.28E+02				
40%	16300			4.25E+07	7.23E-01	9.13E+01	0.93%
		9780	1.27E+02				

Table C.113 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (k) and load 650kN.

P=650kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	1.81E+02				
5%	16300			6.64E+05	1.00E-02	1.42E+02	0.02%
		15485	1.81E+02				
		17930	1.81E+02				
10%	16300			2.66E+06	4.00E-02	1.42E+02	0.05%
		14670	1.81E+02				
		18745	1.81E+02				
15%	16300			5.98E+06	9.00E-02	1.42E+02	0.10%
		13855	1.81E+02				
		19560	1.81E+02				
20%	16300			1.06E+07	1.22E-01	1.42E+02	0.15%
		13040	1.80E+02				
		20375	1.81E+02				
25%	16300			1.66E+07	9.00E-02	1.42E+02	0.23%
		12225	1.80E+02				
		21190	1.81E+02				
30%	16300			2.39E+07	1.22E-01	1.42E+02	0.30%
		11410	1.80E+02				
		22005	1.81E+02				
35%	16300			3.25E+07	1.22E-01	1.42E+02	0.40%
		10595	1.80E+02				
		22820	1.81E+02				
40%	16300			4.25E+07	2.03E-01	1.42E+02	0.50%
		9780	1.80E+02				

Table C.114 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (k) and load 950kN.

P=950kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	2.38E+02				
5%	16300			6.64E+05	0.00E+00	2.38E+02	0.01%
		15485	2.38E+02				
		17930	2.38E+02				
10%	16300			2.66E+06	2.50E-03	2.38E+02	0.02%
		14670	2.38E+02				
		18745	2.38E+02				
15%	16300			5.98E+06	1.00E-02	2.38E+02	0.04%
		13855	2.38E+02				
		19560	2.39E+02				
20%	16300			1.06E+07	1.00E-02	2.38E+02	0.07%
		13040	2.38E+02				
		20375	2.39E+02				
25%	16300			1.66E+07	2.25E-02	2.38E+02	0.10%
		12225	2.38E+02				
		21190	2.39E+02				
30%	16300			2.39E+07	9.00E-02	2.38E+02	0.15%
		11410	2.38E+02				
		22005	2.39E+02				
35%	16300			3.25E+07	2.50E-01	2.38E+02	0.20%
		10595	2.38E+02				
		22820	2.39E+02				
40%	16300			4.25E+07	3.60E-01	2.38E+02	0.25%
		9780	2.38E+02				

Table C.115 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (k) and load 1025kN.

P=1025kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	3.01E+02				
5%	16300			6.64E+05	2.50E-03	2.94E+02	0.01%
		15485	3.01E+02				
		17930	3.01E+02				
10%	16300			2.66E+06	0.00E+00	2.94E+02	0.01%
		14670	3.01E+02				
		18745	3.01E+02				
15%	16300			5.98E+06	2.50E-03	2.94E+02	0.01%
		13855	3.01E+02				
		19560	3.01E+02				
20%	16300			1.06E+07	1.00E-02	2.94E+02	0.02%
		13040	3.01E+02				
		20375	3.01E+02				
25%	16300			1.66E+07	2.50E-03	2.94E+02	0.02%
		12225	3.01E+02				
		21190	3.01E+02				
30%	16300			2.39E+07	0.00E+00	2.94E+02	0.03%
		11410	3.01E+02				
		22005	3.01E+02				
35%	16300			3.25E+07	1.00E-02	2.94E+02	0.04%
		10595	3.01E+02				
		22820	3.01E+02				
40%	16300			4.25E+07	2.25E-02	2.94E+02	0.05%
		9780	3.01E+02				

Table C.116 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 250kN.

P250kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	0.00E+00	0.05%
10%	2.66E+06	2.25E-04	0.15%
15%	5.98E+06	9.00E-04	0.29%
20%	1.06E+07	1.44E-02	0.43%
25%	1.66E+07	7.02E-02	0.60%
30%	2.39E+07	1.33E-01	0.79%
35%	3.25E+07	1.89E-01	0.97%
40%	4.25E+07	2.50E-01	1.14%

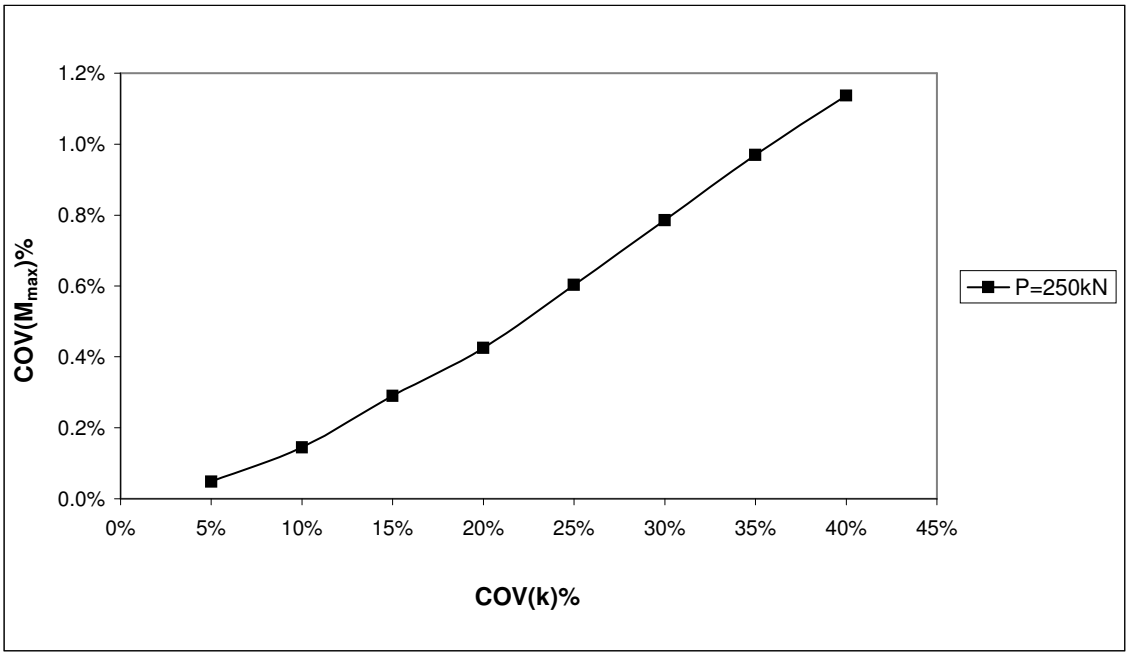


Fig. C.91 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.117 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 450kN.

P450kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	0.00E+00	0.02%
10%	2.66E+06	2.50E-03	0.06%
15%	5.98E+06	1.00E-02	0.15%
20%	1.06E+07	4.00E-02	0.26%
25%	1.66E+07	2.02E-01	0.40%
30%	2.39E+07	3.60E-01	0.56%
35%	3.25E+07	4.90E-01	0.75%
40%	4.25E+07	7.23E-01	0.93%

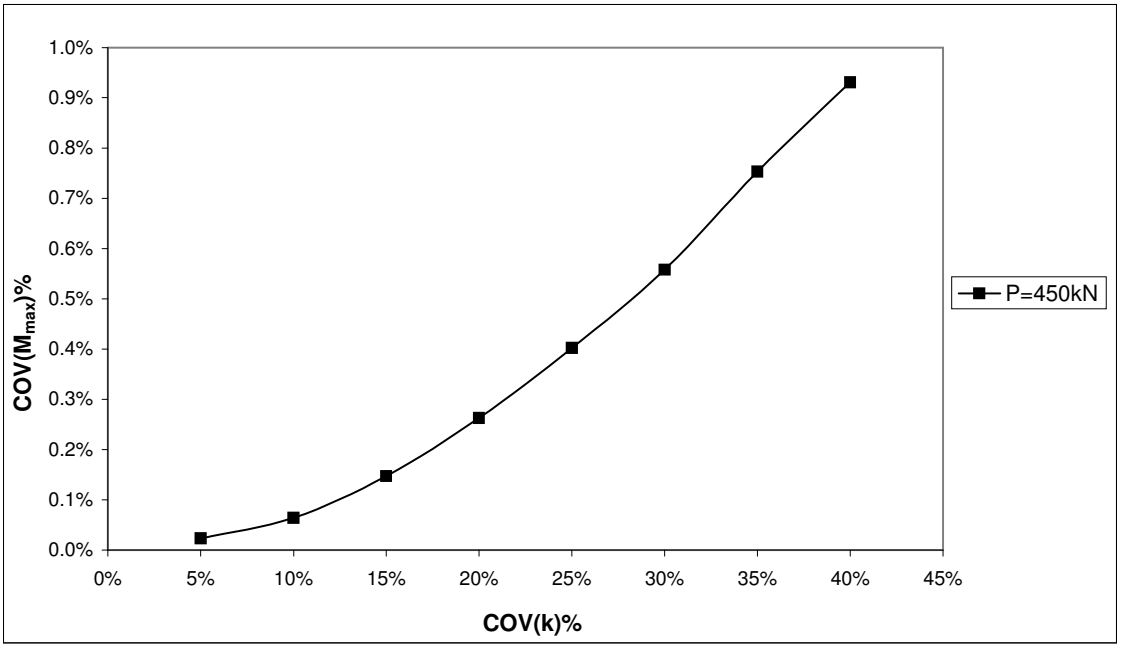


Fig. C.92 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.118 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 650kN.

P650kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.00E-02	0.02%
10%	2.66E+06	4.00E-02	0.05%
15%	5.98E+06	9.00E-02	0.10%
20%	1.06E+07	1.22E-01	0.15%
25%	1.66E+07	9.00E-02	0.23%
30%	2.39E+07	1.22E-01	0.30%
35%	3.25E+07	1.22E-01	0.40%
40%	4.25E+07	2.03E-01	0.50%

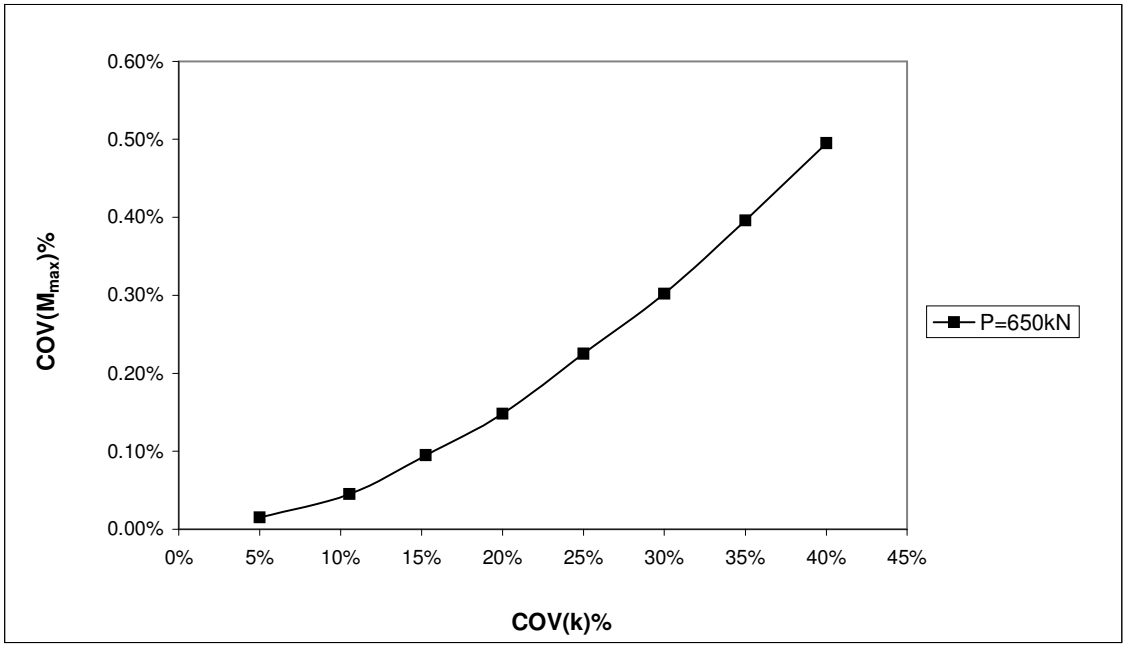


Fig. C.93 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.119 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 950kN.

P950kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	0.00E+00	0.01%
10%	2.66E+06	2.50E-03	0.02%
15%	5.98E+06	1.00E-02	0.04%
20%	1.06E+07	1.00E-02	0.07%
25%	1.66E+07	2.25E-02	0.10%
30%	2.39E+07	9.00E-02	0.15%
35%	3.25E+07	2.50E-01	0.20%
40%	4.25E+07	3.60E-01	0.25%

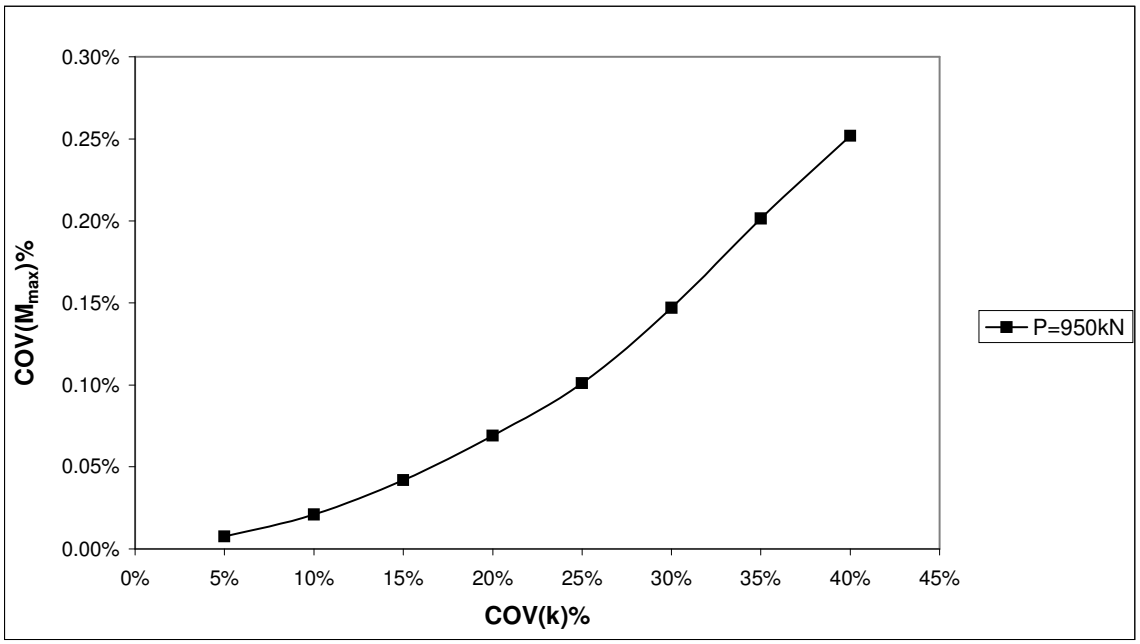


Fig. C.94 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.120 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 1025kN.

P1025kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.50E-03	0.01%
10%	2.66E+06	0.00E+00	0.01%
15%	5.98E+06	2.50E-03	0.01%
20%	1.06E+07	1.00E-02	0.02%
25%	1.66E+07	2.50E-03	0.02%
30%	2.39E+07	0.00E+00	0.03%
35%	3.25E+07	1.00E-02	0.04%
40%	4.25E+07	2.25E-02	0.05%

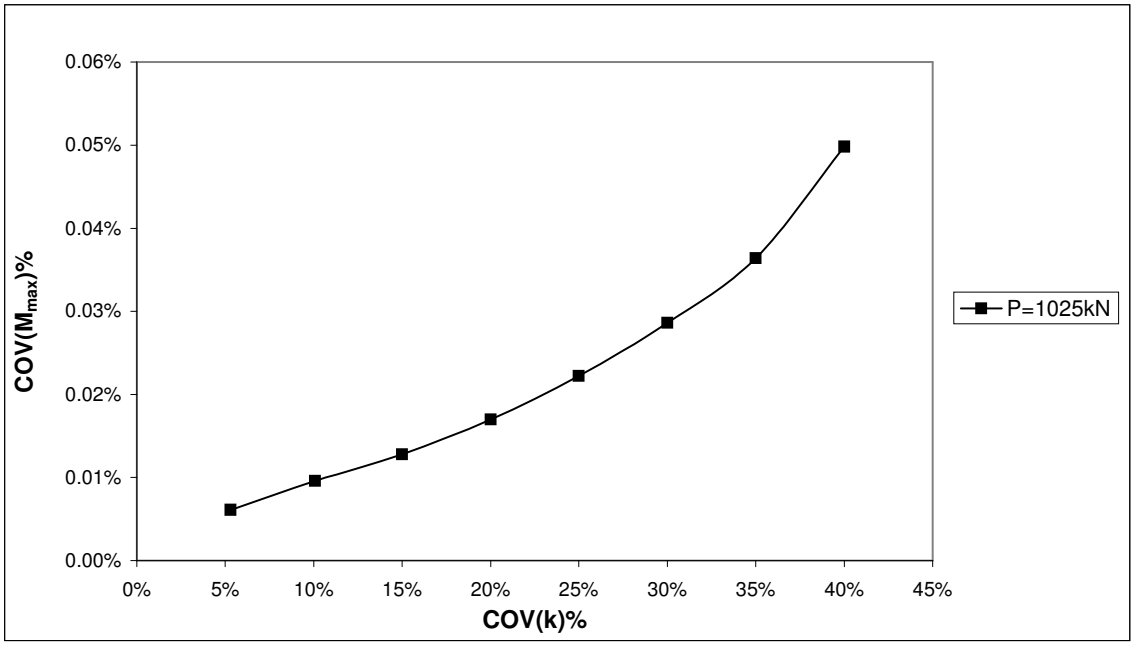


Fig. C.95 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

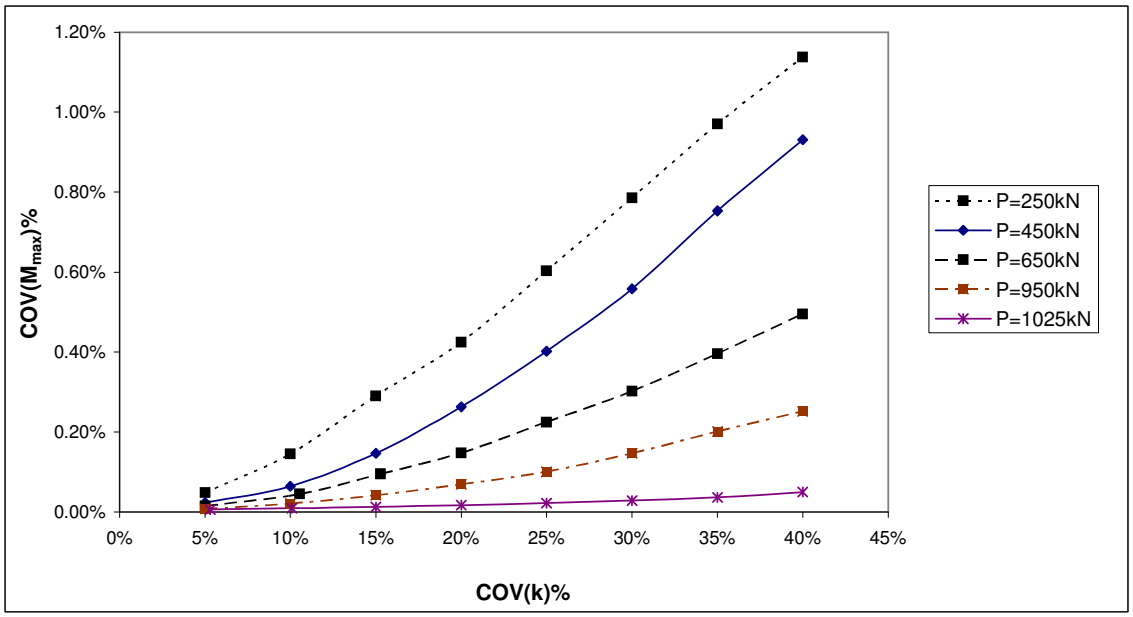


Fig. C.96 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table C.121 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (B) and load 250kN.

P=250kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	7.82E+01				
5%	0.406			4.12E-04	4.22E-01	4.40E+01	0.21%
		0.3857	7.95E+01				
		0.4466	7.74E+01				
10%	0.406			1.65E-03	1.60E+00	4.40E+01	0.59%
		0.3654	7.99E+01				
		0.4669	7.67E+01				
15%	0.406			3.71E-03	3.37E+00	4.40E+01	0.99%
		0.3451	8.03E+01				
		0.4872	7.60E+01				
20%	0.406			6.59E-03	5.64E+00	4.40E+01	1.38%
		0.3248	8.07E+01				
		0.5075	7.52E+01				
25%	0.406			1.03E-02	8.79E+00	4.40E+01	1.87%
		0.3045	8.11E+01				
		0.5278	7.44E+01				
30%	0.406			1.48E-02	1.19E+01	4.40E+01	2.43%
		0.2842	8.13E+01				
		0.5472	7.37E+01				
35%	0.406			2.02E-02	1.44E+01	4.40E+01	2.87%
		0.2648	8.12E+01				
		0.5684	7.30E+01				
40%	0.406			2.64E-02	1.60E+01	4.40E+01	3.31%
		0.2436	8.10E+01				

Table C.122 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (B) and load 450kN.

P=450kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	1.28E+02				
5%	0.406			4.12E-04	2.25E-02	9.13E+01	0.44%
		0.3857	1.28E+02				
		0.4466	1.27E+02				
10%	0.406			1.65E-03	9.03E-01	9.13E+01	0.84%
		0.3654	1.29E+02				
		0.4669	1.26E+02				
15%	0.406			3.71E-03	1.82E+00	9.13E+01	1.32%
		0.3451	1.29E+02				
		0.4872	1.25E+02				
20%	0.406			6.59E-03	3.06E+00	9.13E+01	1.76%
		0.3248	1.29E+02				
		0.5075	1.24E+02				
25%	0.406			1.03E-02	5.06E+00	9.13E+01	2.20%
		0.3045	1.29E+02				
		0.5278	1.23E+02				
30%	0.406			1.48E-02	6.76E+00	9.13E+01	2.64%
		0.2842	1.29E+02				
		0.5472	1.23E+02				
35%	0.406			2.02E-02	8.23E+00	9.13E+01	3.13%
		0.2648	1.28E+02				
		0.5684	1.22E+02				
40%	0.406			2.64E-02	1.06E+01	9.13E+01	3.42%
		0.2436	1.28E+02				

Table C.123 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (B) and load 650kN.

P=650kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	1.81E+02				
5%	0.406			4.12E-04	9.00E-02	1.42E+02	0.68%
		0.3857	1.82E+02				
		0.4466	1.80E+02				
10%	0.406			1.65E-03	1.10E+00	1.42E+02	1.16%
		0.3654	1.82E+02				
		0.4669	1.79E+02				
15%	0.406			3.71E-03	1.96E+00	1.42E+02	1.69%
		0.3451	1.82E+02				
		0.4872	1.78E+02				
20%	0.406			6.59E-03	3.80E+00	1.42E+02	2.20%
		0.3248	1.82E+02				
		0.5075	1.78E+02				
25%	0.406			1.03E-02	7.02E+00	1.42E+02	2.74%
		0.3045	1.83E+02				
		0.5278	1.76E+02				
30%	0.406			1.48E-02	1.19E+01	1.42E+02	3.29%
		0.2842	1.83E+02				
		0.5472	1.76E+02				
35%	0.406			2.02E-02	1.66E+01	1.42E+02	3.70%
		0.2648	1.84E+02				
		0.5684	1.75E+02				
40%	0.406			2.64E-02	2.21E+01	1.42E+02	3.93%
		0.2436	1.84E+02				

Table C.124 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (B) and load 950kN.

P=950kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	2.37E+02				
5%	0.406			4.12E-04	1.10E+00	2.38E+02	0.68%
		0.3857	2.39E+02				
		0.4466	2.36E+02				
10%	0.406			1.65E-03	4.00E+00	2.38E+02	1.30%
		0.3654	2.40E+02				
		0.4669	2.35E+02				
15%	0.406			3.71E-03	9.92E+00	2.38E+02	1.90%
		0.3451	2.42E+02				
		0.4872	2.34E+02				
20%	0.406			6.59E-03	1.76E+01	2.38E+02	2.52%
		0.3248	2.43E+02				
		0.5075	2.33E+02				
25%	0.406			1.03E-02	2.76E+01	2.38E+02	2.99%
		0.3045	2.44E+02				
		0.5278	2.32E+02				
30%	0.406			1.48E-02	3.97E+01	2.38E+02	3.46%
		0.2842	2.45E+02				
		0.5472	2.32E+02				
35%	0.406			2.02E-02	5.70E+01	2.38E+02	3.94%
		0.2648	2.47E+02				
		0.5684	2.31E+02				
40%	0.406			2.64E-02	7.92E+01	2.38E+02	4.15%
		0.2436	2.48E+02				

Table C.125 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (B) and load 1025kN.

P=1025kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	2.99E+02				
5%	0.406			4.12E-04	4.00E+00	2.94E+02	1.48%
		0.3857	3.03E+02				
		0.4466	2.98E+02				
10%	0.406			1.65E-03	1.16E+01	2.94E+02	2.88%
		0.3654	3.05E+02				
		0.4669	2.97E+02				
15%	0.406			3.71E-03	2.45E+01	2.94E+02	4.17%
		0.3451	3.06E+02				
		0.4872	2.95E+02				
20%	0.406			6.59E-03	4.16E+01	2.94E+02	5.40%
		0.3248	3.08E+02				
		0.5075	2.93E+02				
25%	0.406			1.03E-02	6.48E+01	2.94E+02	6.74%
		0.3045	3.09E+02				
		0.5278	2.92E+02				
30%	0.406			1.48E-02	9.31E+01	2.94E+02	7.85%
		0.2842	3.11E+02				
		0.5472	2.91E+02				
35%	0.406			2.02E-02	1.34E+02	2.94E+02	8.63%
		0.2648	3.14E+02				
		0.5684	2.90E+02				
40%	0.406			2.64E-02	1.77E+02	2.94E+02	9.11%
		0.2436	3.16E+02				

Table C.126 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 250kN.

P=250kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	4.22E-01	0.21%
10%	1.65E-03	1.60E+00	0.59%
15%	3.71E-03	3.37E+00	0.99%
20%	6.59E-03	5.64E+00	1.38%
25%	1.03E-02	8.79E+00	1.87%
30%	1.48E-02	1.19E+01	2.43%
35%	2.02E-02	1.44E+01	2.87%
40%	2.64E-02	1.60E+01	3.31%

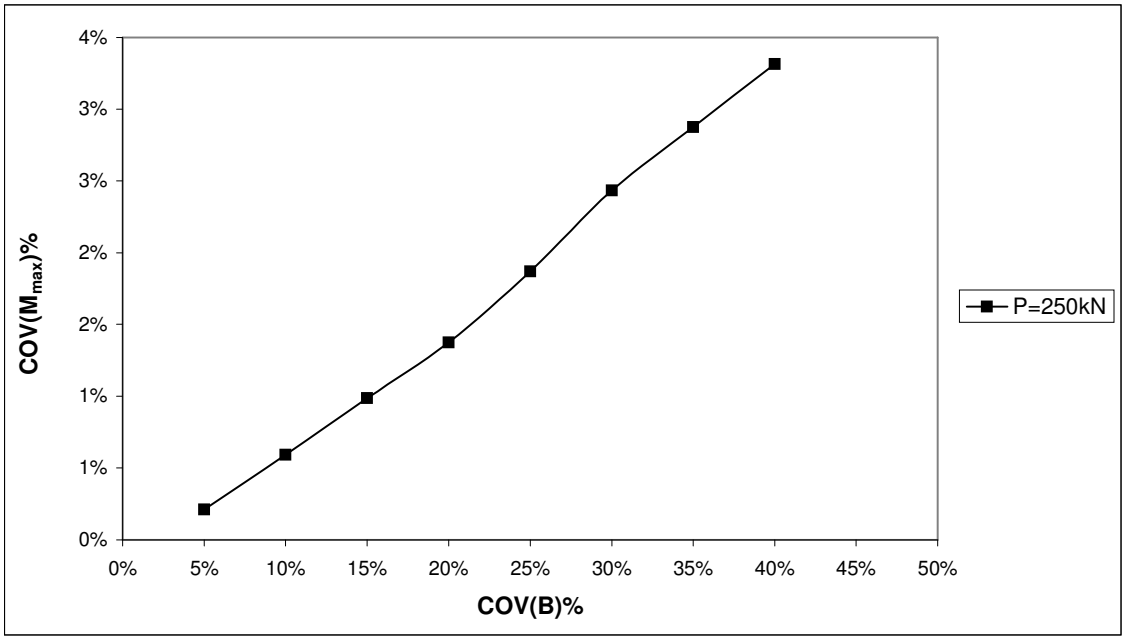


Fig. C.97 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.127 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 450kN.

P=450kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	2.25E-02	0.44%
10%	1.65E-03	9.03E-01	0.84%
15%	3.71E-03	1.82E+00	1.32%
20%	6.59E-03	3.06E+00	1.76%
25%	1.03E-02	5.06E+00	2.20%
30%	1.48E-02	6.76E+00	2.64%
35%	2.02E-02	8.23E+00	3.13%
40%	2.64E-02	1.06E+01	3.42%

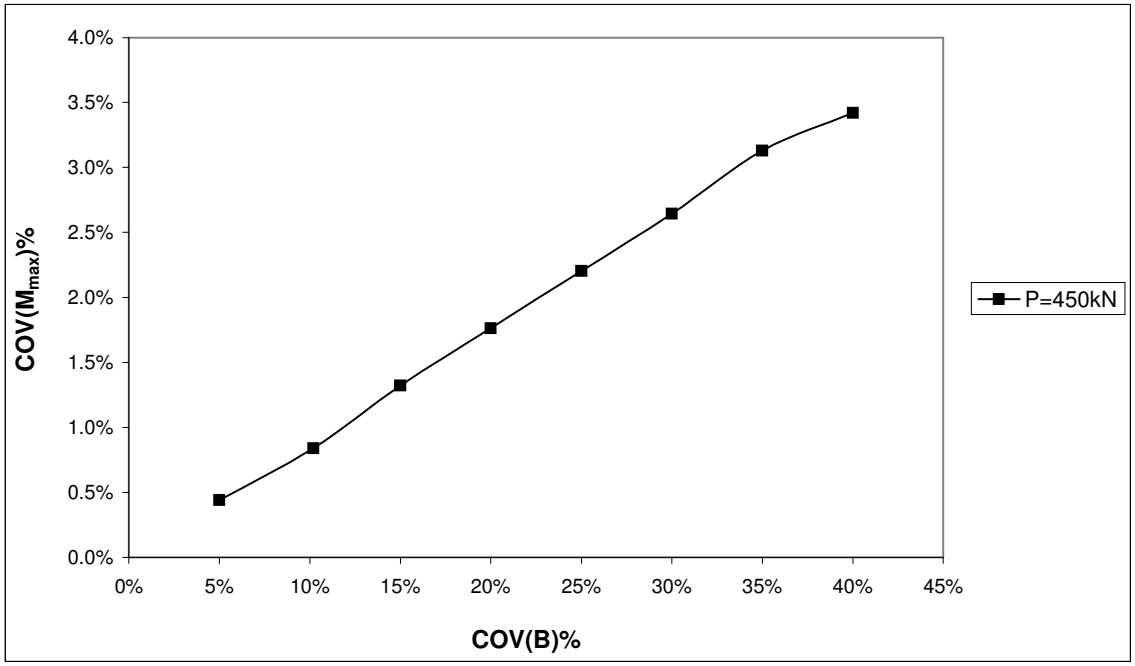


Fig. C.98 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.128 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 650kN.

P=650kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	9.00E-02	0.68%
10%	1.65E-03	1.10E+00	1.16%
15%	3.71E-03	1.96E+00	1.69%
20%	6.59E-03	3.80E+00	2.20%
25%	1.03E-02	7.02E+00	2.74%
30%	1.48E-02	1.19E+01	3.29%
35%	2.02E-02	1.66E+01	3.70%
40%	2.64E-02	2.21E+01	3.93%

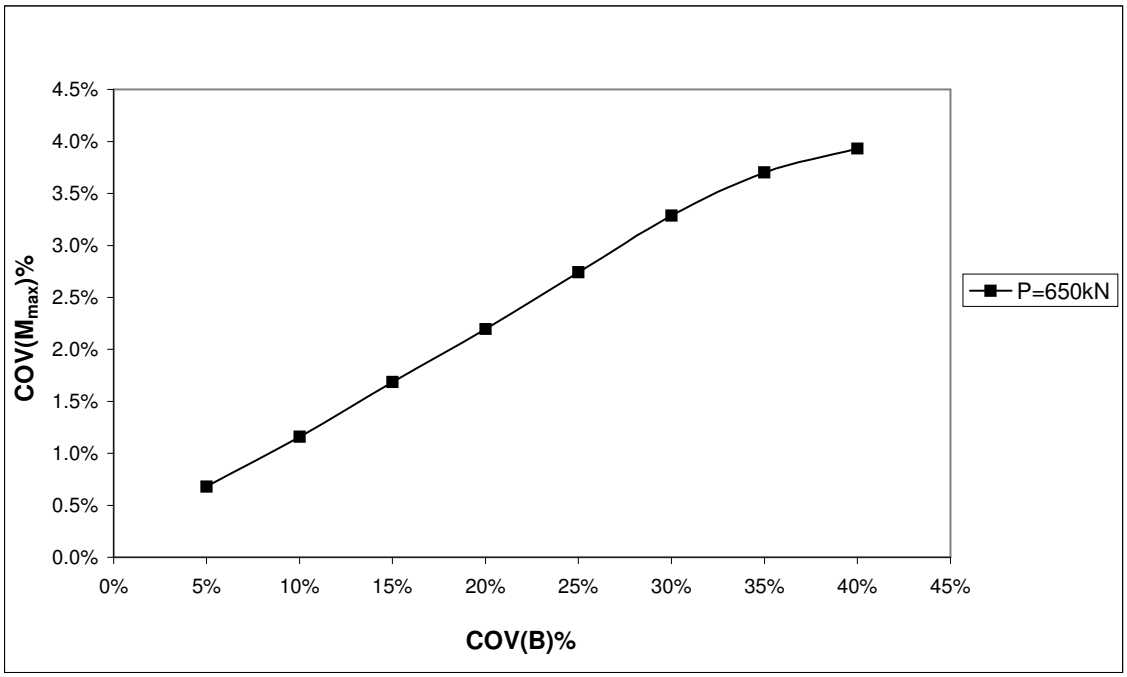


Fig. C.99 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.129 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 950kN.

P=950kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	1.10E+00	0.68%
10%	1.65E-03	4.00E+00	1.30%
15%	3.71E-03	9.92E+00	1.90%
20%	6.59E-03	1.76E+01	2.52%
25%	1.03E-02	2.76E+01	2.99%
30%	1.48E-02	3.97E+01	3.46%
35%	2.02E-02	5.70E+01	3.94%
40%	2.64E-02	7.92E+01	4.15%

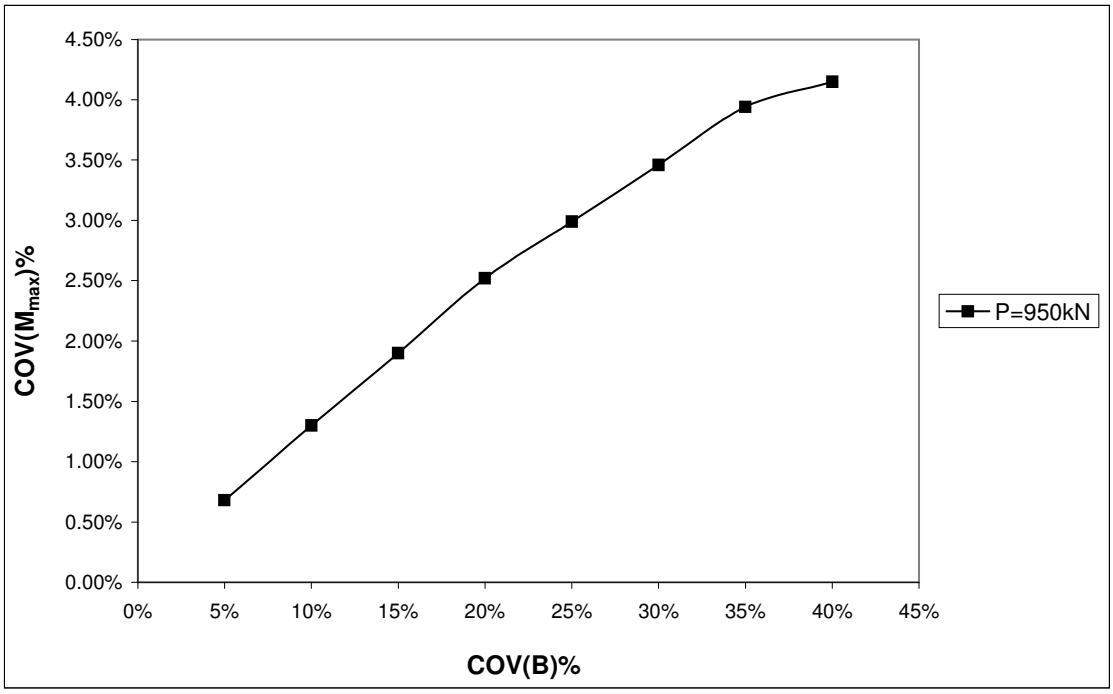


Fig. C.100 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.130 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 1025kN.

P=1025kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	4.00E+00	1.48%
10%	1.65E-03	1.16E+01	2.88%
15%	3.71E-03	2.45E+01	4.17%
20%	6.59E-03	4.16E+01	5.40%
25%	1.03E-02	6.48E+01	6.74%
30%	1.48E-02	9.31E+01	7.85%
35%	2.02E-02	1.34E+02	8.63%
40%	2.64E-02	1.77E+02	9.11%

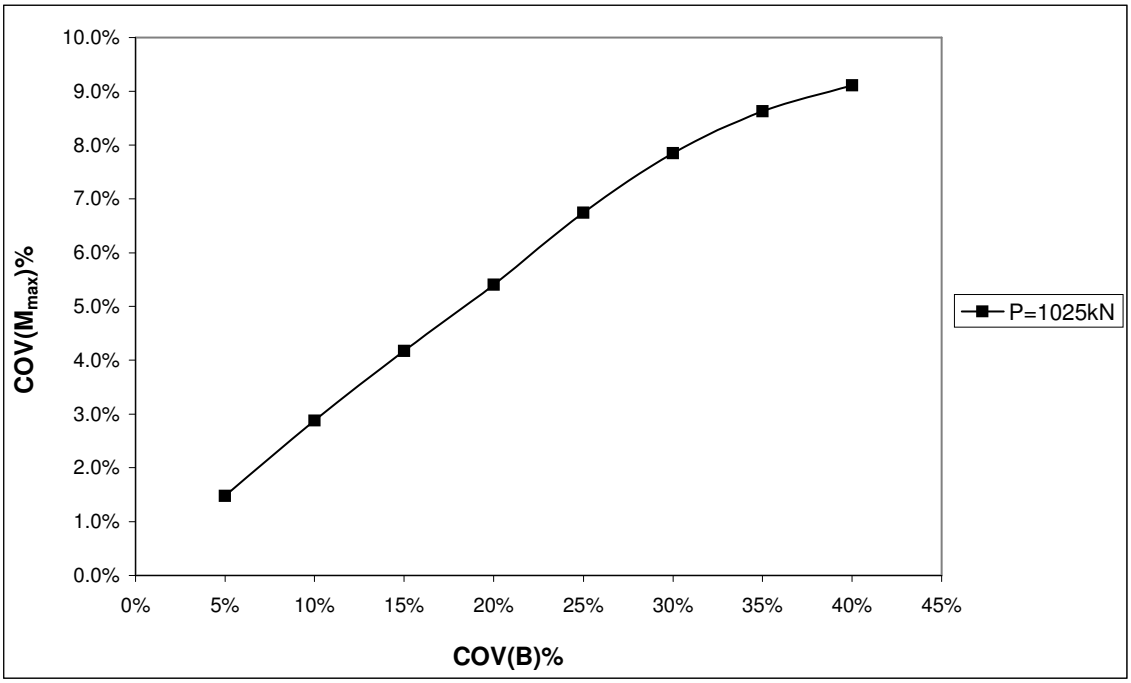


Fig. C.101 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

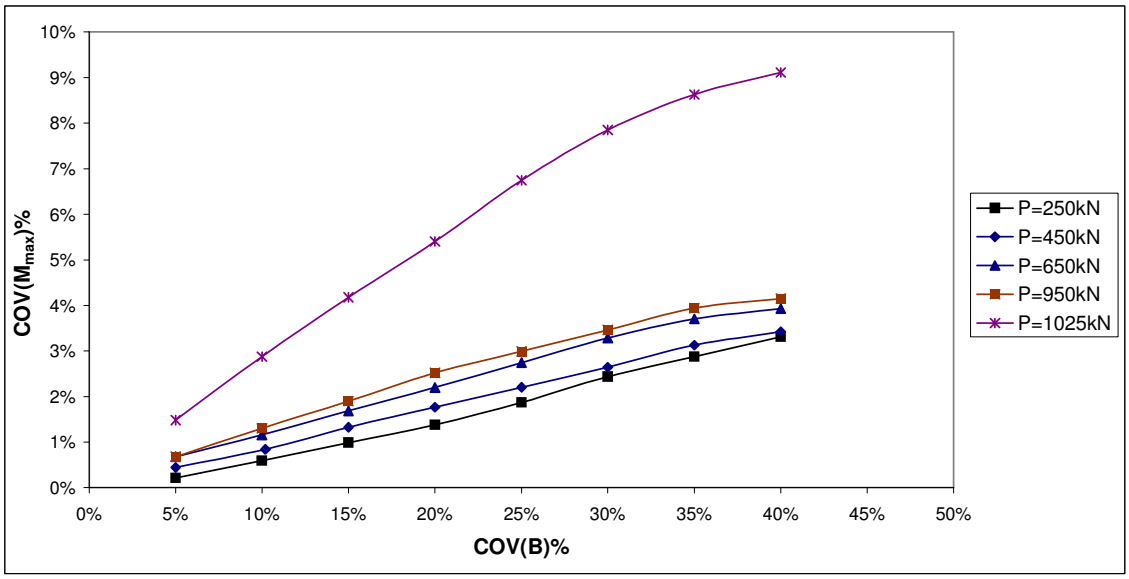


Fig. C.102 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table C.131 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (EI) and load 250kN.

P=250kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		64050	7.92E+01				
5%	61000			9.30E+06	2.81E-02	4.40E+01	0.04%
		57950	7.86E+01				
		67100	7.95E+01				
10%	61000			3.72E+07	1.12E-01	4.40E+01	0.07%
		54900	7.82E+01				
		70150	7.98E+01				
15%	61000			8.37E+07	2.55E-01	4.40E+01	0.09%
		51850	7.78E+01				
		73200	8.01E+01				
20%	61000			1.49E+08	4.66E-01	4.40E+01	0.14%
		48800	7.74E+01				
		76250	8.04E+01				
25%	61000			2.33E+08	3.28E-01	4.40E+01	0.19%
		45750	7.69E+01				
		79300	8.06E+01				
30%	61000			3.35E+08	1.10E+00	4.40E+01	0.26%
		42700	7.64E+01				
		82350	8.08E+01				
35%	61000			4.56E+08	1.56E+00	4.40E+01	0.32%
		39650	7.58E+01				
		85400	8.11E+01				
40%	61000			5.95E+08	2.12E+00	4.40E+01	0.40%
		36600	7.52E+01				

Table C.132 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (EI) and load 450kN.

P=450kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		64050	1.29E+02				
5%	61000			9.30E+06	1.41E-01	9.13E+01	0.14%
		57950	1.27E+02				
		67100	1.29E+02				
10%	61000			3.72E+07	6.01E-01	9.13E+01	0.26%
		54900	1.26E+02				
		70150	1.30E+02				
15%	61000			8.37E+07	1.32E+00	9.13E+01	0.37%
		51850	1.26E+02				
		73200	1.31E+02				
20%	61000			1.49E+08	2.10E+00	9.13E+01	0.47%
		48800	1.25E+02				
		76250	1.31E+02				
25%	61000			2.33E+08	1.39E+00	9.13E+01	0.55%
		45750	1.24E+02				
		79300	1.32E+02				
30%	61000			3.35E+08	4.41E+00	9.13E+01	0.66%
		42700	1.24E+02				
		82350	1.33E+02				
35%	61000			4.56E+08	5.64E+00	9.13E+01	0.77%
		39650	1.23E+02				
		85400	1.33E+02				
40%	61000			5.95E+08	7.29E+00	9.13E+01	0.89%
		36600	1.22E+02				

Table C.133 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (EI) and load 650kN.

P=650kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	1.82E+02				
5%	61000			9.30E+06	1.41E-01	1.42E+02	0.26%
		57950	1.80E+02				
		67100	1.83E+02				
10%	61000			3.72E+07	6.01E-01	1.42E+02	0.55%
		54900	1.80E+02				
		70150	1.83E+02				
15%	61000			8.37E+07	1.50E+00	1.42E+02	0.86%
		51850	1.79E+02				
		73200	1.84E+02				
20%	61000			1.49E+08	2.72E+00	1.42E+02	1.16%
		48800	1.78E+02				
		76250	1.85E+02				
25%	61000			2.33E+08	1.94E+00	1.42E+02	1.39%
		45750	1.76E+02				
		79300	1.86E+02				
30%	61000			3.35E+08	6.25E+00	1.42E+02	1.76%
		42700	1.76E+02				
		82350	1.86E+02				
35%	61000			4.56E+08	8.41E+00	1.42E+02	2.04%
		39650	1.75E+02				
		85400	1.87E+02				
40%	61000			5.95E+08	1.07E+01	1.42E+02	2.31%
		36600	1.74E+02				

Table C.134 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (EI) and load 950kN.

P=950kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	2.39E+02				
5%	61000			9.30E+06	1.06E-01	2.38E+02	0.41%
		57950	2.38E+02				
		67100	2.39E+02				
10%	61000			3.72E+07	3.91E-01	2.38E+02	0.75%
		54900	2.37E+02				
		70150	2.40E+02				
15%	61000			8.37E+07	7.66E-01	2.38E+02	1.16%
		51850	2.36E+02				
		73200	2.41E+02				
20%	61000			1.49E+08	1.27E+00	2.38E+02	1.51%
		48800	2.36E+02				
		76250	2.41E+02				
25%	61000			2.33E+08	7.74E-01	2.38E+02	1.85%
		45750	2.36E+02				
		79300	2.41E+02				
30%	61000			3.35E+08	2.48E+00	2.38E+02	2.30%
		42700	2.35E+02				
		82350	2.42E+02				
35%	61000			4.56E+08	3.33E+00	2.38E+02	2.60%
		39650	2.35E+02				
		85400	2.43E+02				
40%	61000			5.95E+08	4.52E+00	2.38E+02	2.96%
		36600	2.34E+02				

Table C.135 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (EI) and load 1025kN.

P=1025kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		64050	3.01E+02				
5%	61000			9.30E+06	1.56E-02	2.94E+02	0.38%
		57950	3.01E+02				
		67100	3.02E+02				
10%	61000			3.72E+07	4.00E-02	2.94E+02	0.76%
		54900	3.01E+02				
		70150	3.02E+02				
15%	61000			8.37E+07	7.57E-02	2.94E+02	1.15%
		51850	3.01E+02				
		73200	3.02E+02				
20%	61000			1.49E+08	1.60E-01	2.94E+02	1.55%
		48800	3.01E+02				
		76250	3.03E+02				
25%	61000			2.33E+08	1.21E-01	2.94E+02	1.93%
		45750	3.01E+02				
		79300	3.03E+02				
30%	61000			3.35E+08	5.63E-01	2.94E+02	2.39%
		42700	3.00E+02				
		82350	3.04E+02				
35%	61000			4.56E+08	9.02E-01	2.94E+02	2.84%
		39650	3.00E+02				
		85400	3.05E+02				
40%	61000			5.95E+08	1.38E+00	2.94E+02	3.32%
		36600	3.00E+02				

Table C.136 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 250kN.

P=250kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	2.81E-02	0.04%
10%	3.72E+07	1.12E-01	0.07%
15%	8.37E+07	2.55E-01	0.09%
20%	1.49E+08	4.66E-01	0.14%
25%	2.33E+08	3.28E-01	0.19%
30%	3.35E+08	1.10E+00	0.26%
35%	4.56E+08	1.56E+00	0.32%
40%	5.95E+08	2.12E+00	0.40%

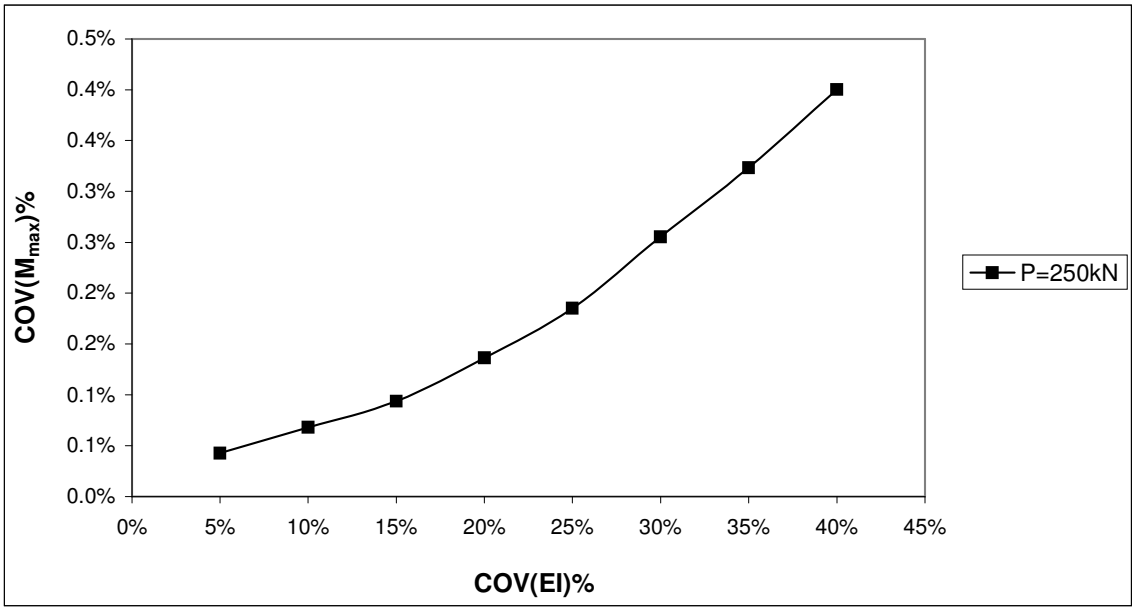


Fig. C.103 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.137 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 450kN.

P=450kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.41E-01	0.14%
10%	3.72E+07	6.01E-01	0.26%
15%	8.37E+07	1.32E+00	0.37%
20%	1.49E+08	2.10E+00	0.47%
25%	2.33E+08	1.39E+00	0.55%
30%	3.35E+08	4.41E+00	0.66%
35%	4.56E+08	5.64E+00	0.77%
40%	5.95E+08	7.29E+00	0.89%

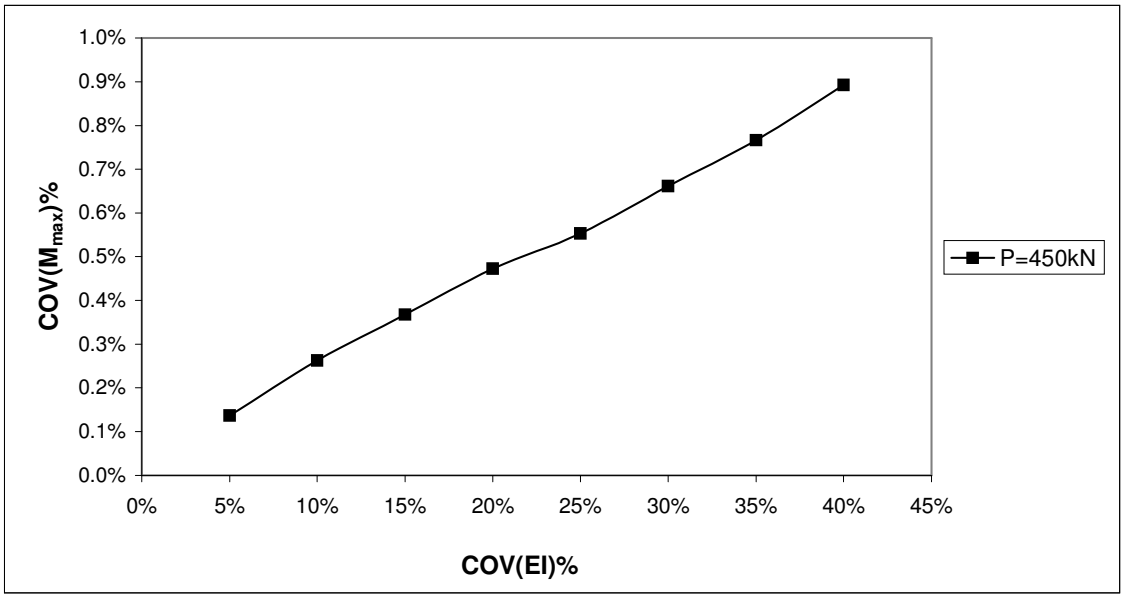


Fig. C.104 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.138 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 650kN.

P=650kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.41E-01	0.26%
10%	3.72E+07	6.01E-01	0.55%
15%	8.37E+07	1.50E+00	0.86%
20%	1.49E+08	2.72E+00	1.16%
25%	2.33E+08	1.94E+00	1.39%
30%	3.35E+08	6.25E+00	1.76%
35%	4.56E+08	8.41E+00	2.04%
40%	5.95E+08	1.07E+01	2.31%

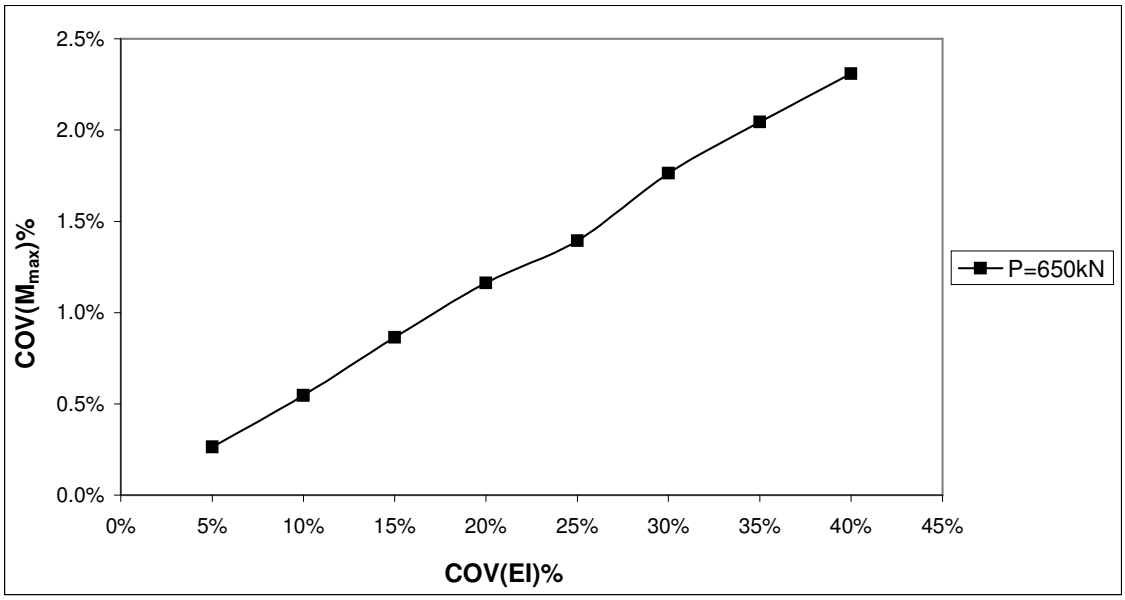


Fig. C.105 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.139 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 950kN.

P=950kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.06E-01	0.41%
10%	3.72E+07	3.91E-01	0.75%
15%	8.37E+07	7.66E-01	1.16%
20%	1.49E+08	1.27E+00	1.51%
25%	2.33E+08	7.74E-01	1.85%
30%	3.35E+08	2.48E+00	2.30%
35%	4.56E+08	3.33E+00	2.60%
40%	5.95E+08	4.52E+00	2.96%

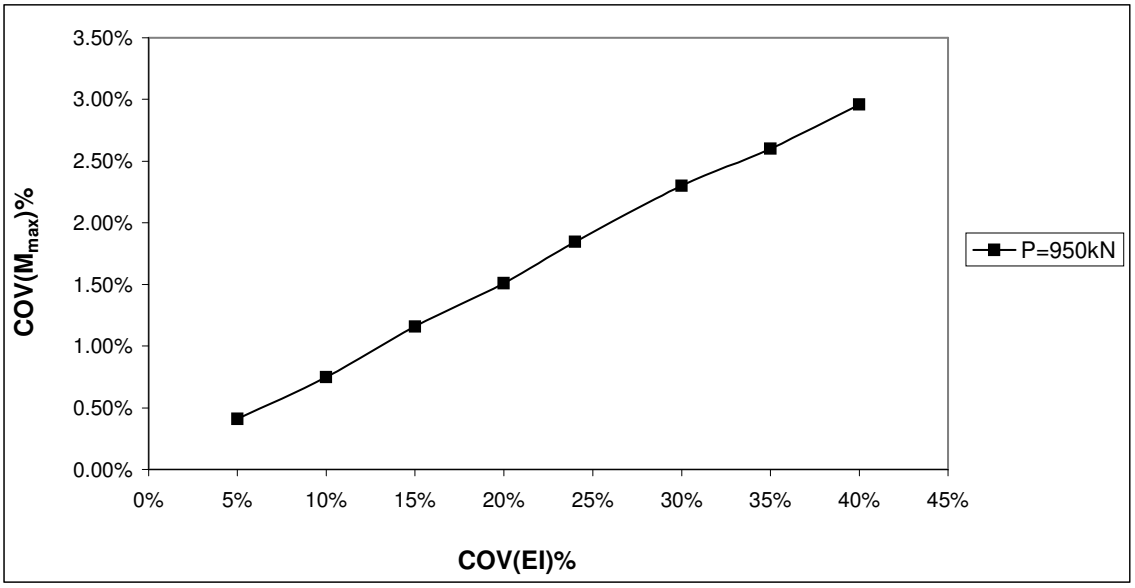


Fig. C.106 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.140 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 1025kN.

P=1025kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.56E-02	0.38%
10%	3.72E+07	4.00E-02	0.76%
15%	8.37E+07	7.57E-02	1.15%
20%	1.49E+08	1.60E-01	1.55%
25%	2.33E+08	1.21E-01	1.93%
30%	3.35E+08	5.63E-01	2.39%
35%	4.56E+08	9.02E-01	2.84%
40%	5.95E+08	1.38E+00	3.32%

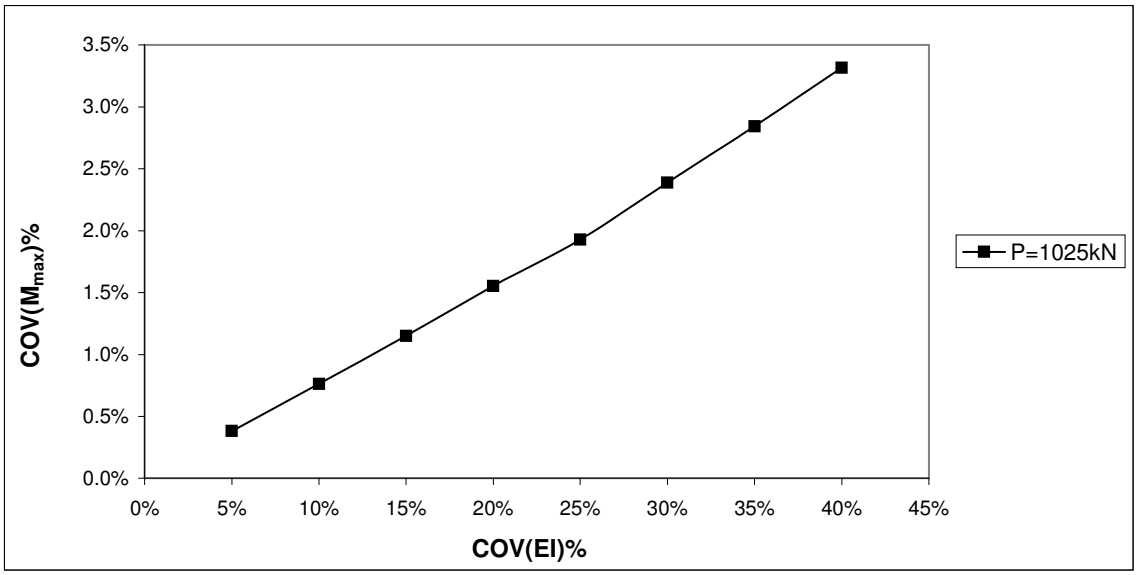


Fig. C.107 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

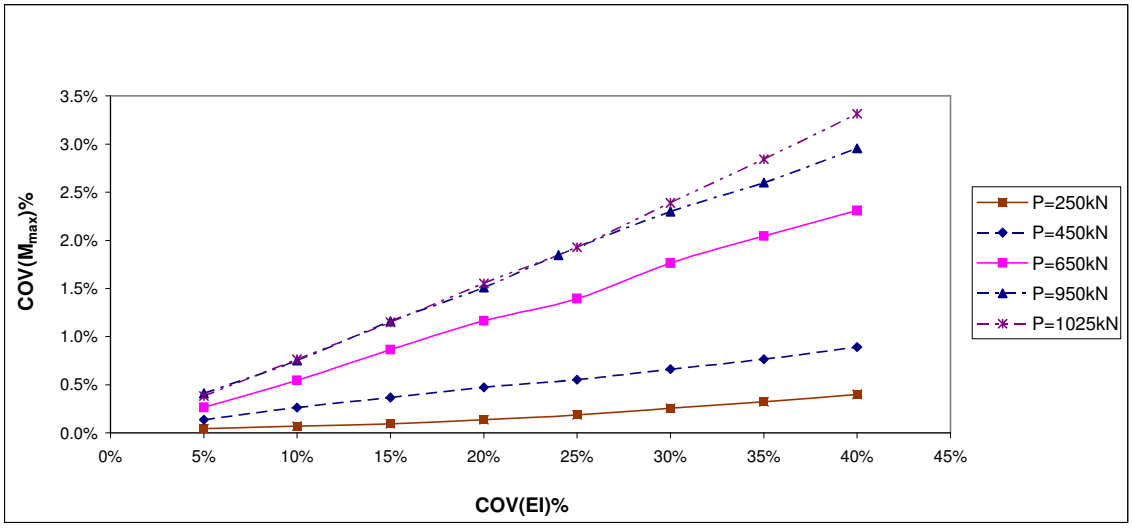


Fig. C.108 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table C.141 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (P) and load 250kN.

P=250kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		262.5	8.37E+01				
5%	250			1.56E+02	2.26E+01	4.40E+01	5.50%
		237.5	7.42E+01				
		275	8.84E+01				
10%	250			6.25E+02	9.03E+01	4.40E+01	10.40%
		225	6.94E+01				
		287.5	9.33E+01				
15%	250			1.41E+03	2.03E+02	4.40E+01	16.40%
		212.5	6.47E+01				
		300	9.81E+01				
20%	250			2.50E+03	3.66E+02	4.40E+01	23.40%
		200	5.99E+01				
		312.5	1.03E+02				
25%	250			3.91E+03	5.76E+02	4.40E+01	29.40%
		187.5	5.51E+01				
		325	1.08E+02				
30%	250			5.63E+03	8.27E+02	4.40E+01	36.00%
		175	5.05E+01				
		337.5	1.13E+02				
35%	250			7.66E+03	1.11E+03	4.40E+01	43.30%
		162.5	4.59E+01				
		350	1.18E+02				
40%	250			1.00E+04	1.46E+03	4.40E+01	50.70%
		150	4.14E+01				

Table C.142 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (P) and load 450kN.

P=450kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		472.5	1.36E+02				
5%	450			5.06E+02	5.85E+01	9.13E+01	6.28%
		427.5	1.20E+02				
		495	1.43E+02				
10%	450			2.03E+03	2.34E+02	9.13E+01	12.70%
		405	1.13E+02				
		517.5	1.51E+02				
15%	450			4.56E+03	5.22E+02	9.13E+01	18.95%
		382.5	1.06E+02				
		540	1.59E+02				
20%	450			8.10E+03	9.32E+02	9.13E+01	8.40%
		360	9.81E+01				
		562.5	1.67E+02				
25%	450			1.27E+04	1.46E+03	9.13E+01	31.57%
		337.5	9.08E+01				
		585	1.76E+02				
30%	450			1.82E+04	2.11E+03	9.13E+01	38.40%
		315	8.37E+01				
		607.5	1.84E+02				
35%	450			2.48E+04	2.88E+03	9.13E+01	45.40%
		292.5	7.65E+01				
		630	1.92E+02				
40%	450			3.24E+04	3.76E+03	9.13E+01	53.00%
		270	6.94E+01				

Table C.143 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (P) and load 650kN.

P=650kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		682.5	1.92E+02				
5%	650			1.06E+03	1.22E+02	1.42E+02	7.79%
		617.5	1.70E+02				
		715	2.03E+02				
10%	650			4.23E+03	4.82E+02	1.42E+02	15.48%
		585	1.59E+02				
		747.5	2.15E+02				
15%	650			9.51E+03	1.09E+03	1.42E+02	23.31%
		552.5	1.49E+02				
		780	2.26E+02				
20%	650			1.69E+04	1.94E+03	1.42E+02	31.10%
		520	1.38E+02				
		812.5	2.38E+02				
25%	650			2.64E+04	3.05E+03	1.42E+02	38.93%
		487.5	1.28E+02				
		845	2.50E+02				
30%	650			3.80E+04	4.38E+03	1.42E+02	46.69%
		455	1.18E+02				
		877.5	2.63E+02				
35%	650			5.18E+04	5.99E+03	1.42E+02	54.58%
		422.5	1.08E+02				
		910	2.76E+02				
40%	650			6.76E+04	7.87E+03	1.42E+02	62.57%
		390	9.81E+01				

Table C.144 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (P) and load 950kN.

P=950kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		997.5	2.53E+02				
5%	950			2.26E+03	2.24E+02	2.38E+02	8.38%
		902.5	2.23E+02				
		1045	2.69E+02				
10%	950			9.03E+03	9.15E+02	2.38E+02	16.75%
		855	2.09E+02				
		1092.5	2.85E+02				
15%	950	142.5		2.03E+04	2.04E+03	2.38E+02	25.02%
		807.5	1.95E+02				
		1140	3.01E+02				
20%	950			3.61E+04	4.00E+02	2.38E+02	33.43%
			1.81E+02				
		1187.5	3.18E+02				
25%	950			5.64E+04	5.66E+03	2.38E+02	41.86%
		712.5	1.67E+02				
		1235	3.34E+02				
30%	950			8.12E+04	8.13E+03	2.38E+02	50.28%
		665	1.54E+02				
		1282.5	3.52E+02				
35%	950			1.11E+05	1.12E+04	2.38E+02	58.79%
		617.5	1.41E+02				
		1330	3.70E+02				
40%	950			1.44E+05	1.46E+04	2.38E+02	67.17%
		570	1.28E+02				

Table C.145 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (3D) with varying (P) and load 1025kN.

P=1025kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		1076.25	3.21E+02				
5%	1025			2.63E+03	3.79E+02	2.94E+02	10.81%
		973.75	2.82E+02				
		1127.5	3.41E+02				
10%	1025			1.05E+04	1.52E+03	2.94E+02	21.61%
		922.5	2.63E+02				
		1178.75	3.63E+02				
15%	1025			2.36E+04	3.42E+03	2.94E+02	32.45%
		871.25	2.44E+02				
		1230	3.85E+02				
20%	1025			4.20E+04	6.15E+03	2.94E+02	43.53%
		820	2.26E+02				
		1281.25	4.08E+02				
25%	1025			6.57E+04	9.68E+03	2.94E+02	54.58%
		768.75	2.09E+02				
		1332.5	4.31E+02				
30%	1025			9.46E+04	1.39E+04	2.94E+02	65.41%
		717.5	1.92E+02				
		1383.75	4.53E+02				
35%	1025			1.29E+05	1.87E+04	2.94E+02	75.96%
		666.25	1.76E+02				
		1435	4.77E+02				
40%	1025			1.68E+05	2.45E+04	2.94E+02	86.90%
		615	1.69E+02				

Table C.146 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 250kN.

P=250kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	1.56E+02	2.26E+01	5.50%
10%	6.25E+02	9.03E+01	10.40%
15%	1.41E+03	2.03E+02	16.40%
20%	2.50E+03	3.66E+02	23.40%
25%	3.91E+03	5.76E+02	29.40%
30%	5.63E+03	8.27E+02	36.00%
35%	7.66E+03	1.11E+03	43.30%
40%	1.00E+04	1.46E+03	50.70%

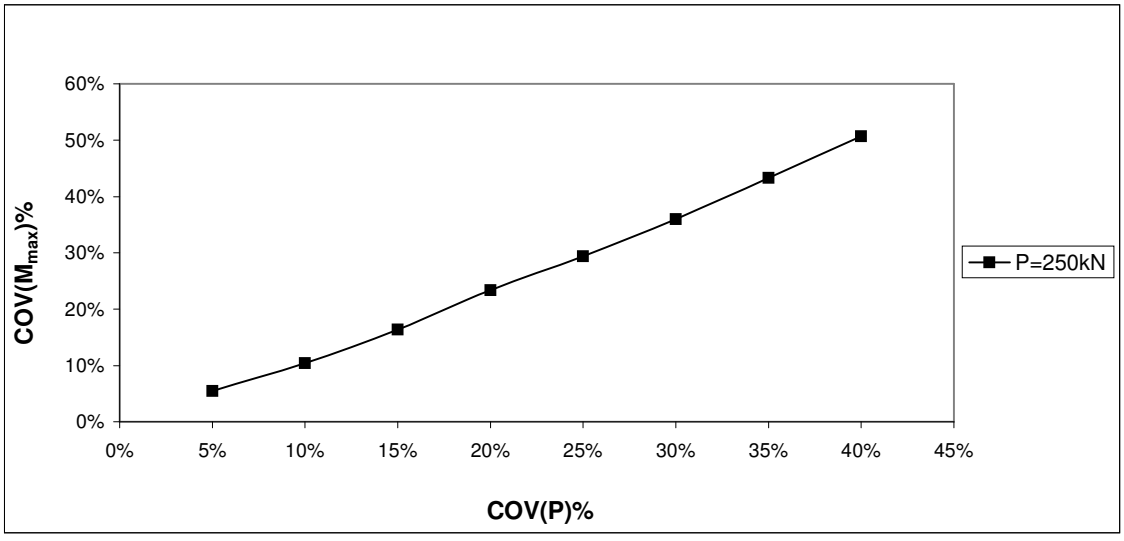


Fig. C.109 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force 250kN.

Table C.147 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 450kN.

P=450kN			
COV(P) (%)	VAR(P) $(kN)^2$	(M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	5.06E+02	5.85E+01	6.28%
10%	2.03E+03	2.34E+02	12.70%
15%	4.56E+03	5.22E+02	18.95%
20%	8.10E+03	9.32E+02	25.19%
25%	1.27E+04	1.46E+03	31.57%
30%	1.82E+04	2.11E+03	38.40%
35%	2.48E+04	2.88E+03	45.40%
40%	3.24E+04	3.76E+03	53.00%

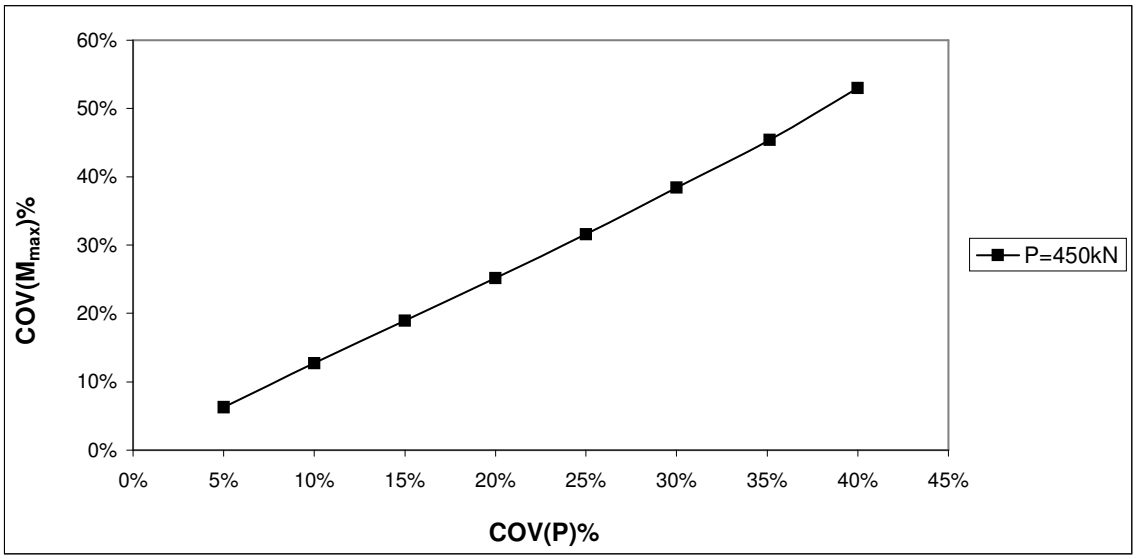


Fig. C.110 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force 450kN.

Table C.148 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 650kN.

P=650kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	1.06E+03	1.22E+02	7.79%
10%	4.23E+03	4.82E+02	15.48%
15%	9.51E+03	1.09E+03	23.31%
20%	1.69E+04	1.94E+03	31.10%
25%	2.64E+04	3.05E+03	38.93%
30%	3.80E+04	4.38E+03	46.69%
35%	5.18E+04	5.99E+03	54.58%
40%	6.76E+04	7.87E+03	62.57%

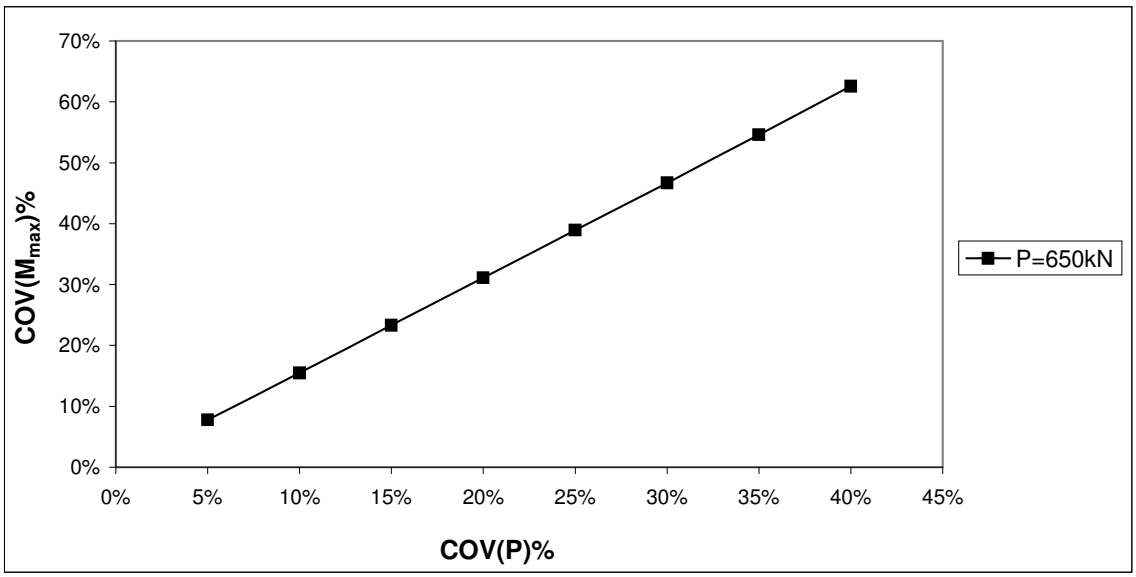


Fig. C.111 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force 650kN.

Table C.149 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 950kN.

P=950kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.26E+03	2.24E+02	8.38%
10%	9.03E+03	9.15E+02	16.75%
15%	2.03E+04	2.04E+03	25.02%
20%	3.61E+04	3.60E+03	33.43%
25%	5.64E+04	5.66E+03	41.86%
30%	8.12E+04	8.13E+03	50.28%
35%	1.11E+05	1.12E+04	58.79%
40%	1.44E+05	1.46E+04	67.16%

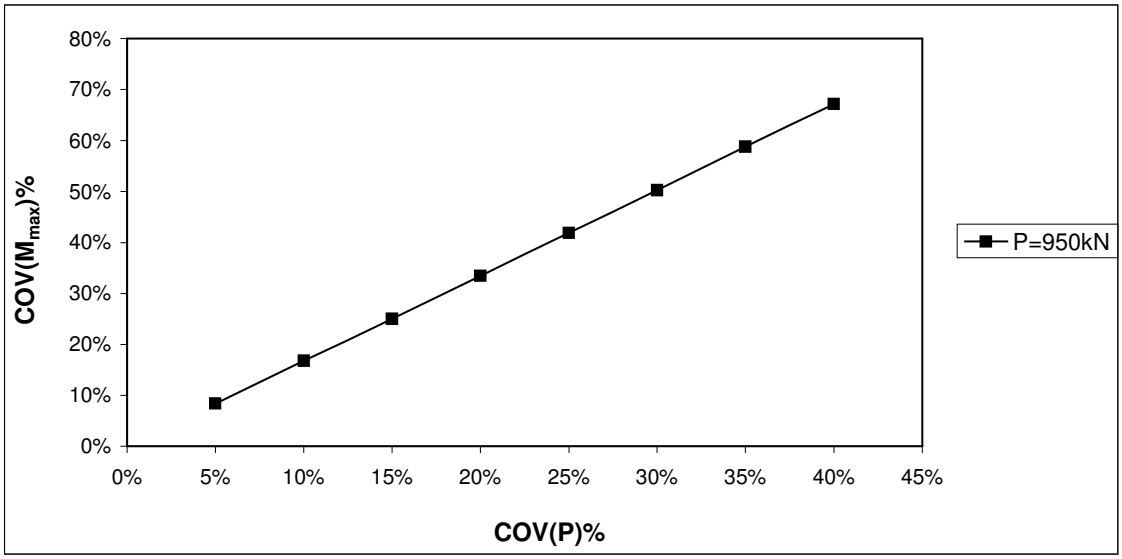


Fig. C.112 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force 950kN.

Table C.150 Value of COV (M_{max}) for free head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 1025kN.

P=1025kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.63E+03	3.82E+02	10.81%
10%	1.05E+04	1.54E+03	21.61%
15%	2.36E+04	3.51E+03	32.45%
20%	4.20E+04	6.28E+03	43.53%
25%	6.57E+04	9.92E+03	54.58%
30%	9.46E+04	1.42E+04	65.41%
35%	1.29E+05	1.93E+04	75.96%
40%	1.68E+05	2.52E+04	86.90%

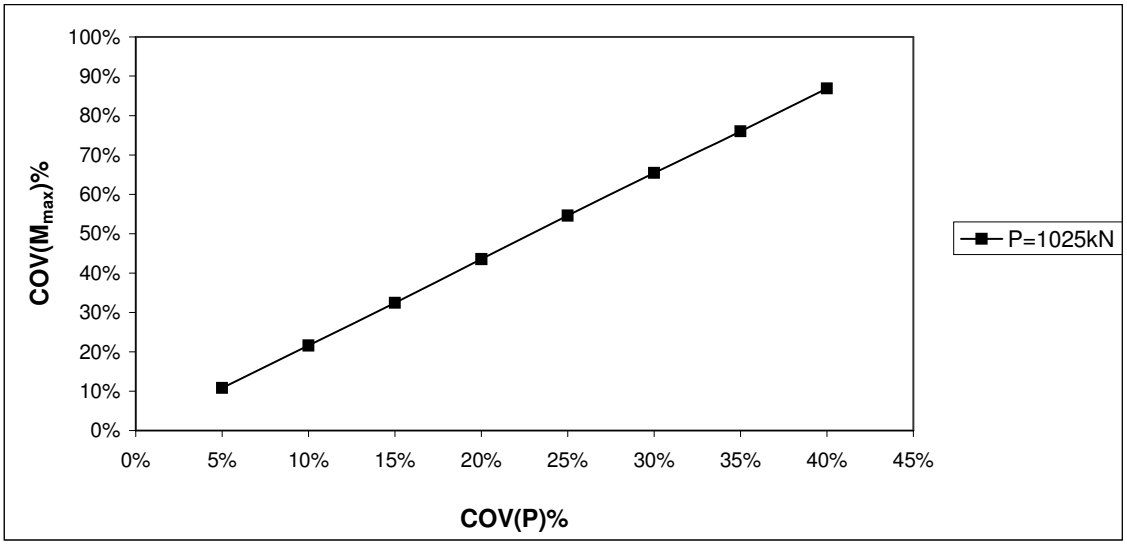


Fig. C.113 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force 1025kN.

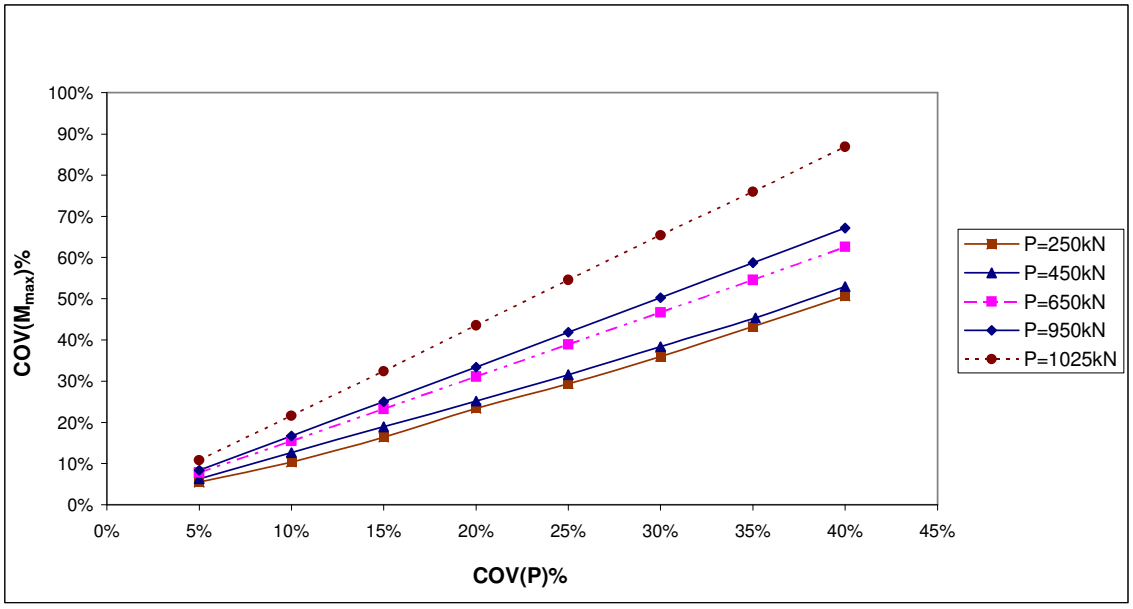


Fig. C.114 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

C.5 Reliability Index (β) of bending moment vs. COV (Variables).

Table C.151 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 250kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
7.67E+00	10696.73	5%	103.4621	6.2394
3.36E+01	10696.73	10%	103.5872	6.2318
8.62E+01	10696.73	15%	103.8409	6.2166
1.43E+02	10696.73	20%	104.1131	6.2004
2.18E+02	10696.73	25%	104.4722	6.1791
3.13E+02	10696.73	30%	104.9278	6.1522
4.43E+02	10696.73	35%	105.5464	6.1162
5.60E+02	10696.73	40%	106.0990	6.0843

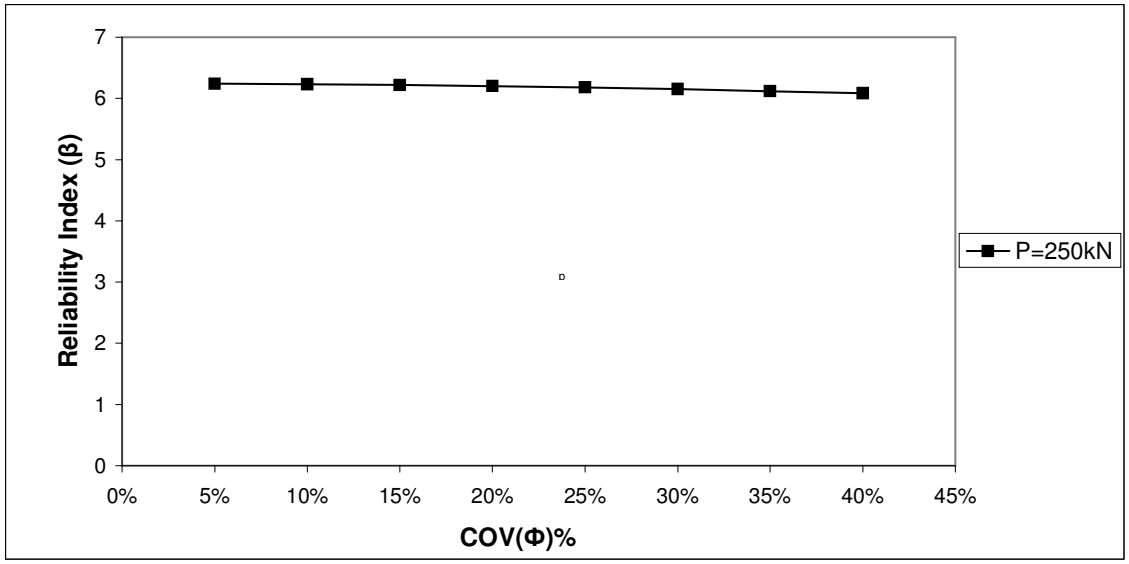


Fig. C.115 Reliability Index (β) of M_{max} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.152 Reliability Index (β) connected to M_{max} for free head long (10T) group with. spacing (3D) and with varying 'Φ' subjected to lateral load 450kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.07E+01	10696.73	5%	103.5250	5.7781
7.31E+01	10696.73	10%	103.7778	5.7640
1.66E+02	10696.73	15%	104.2264	5.7392
2.92E+02	10696.73	20%	104.8291	5.7062
5.11E+02	10696.73	25%	105.8654	5.6504
7.51E+02	10696.73	30%	106.9929	5.5908
1.05E+03	10696.73	35%	108.3603	5.5203
1.42E+03	10696.73	40%	110.0767	5.4342

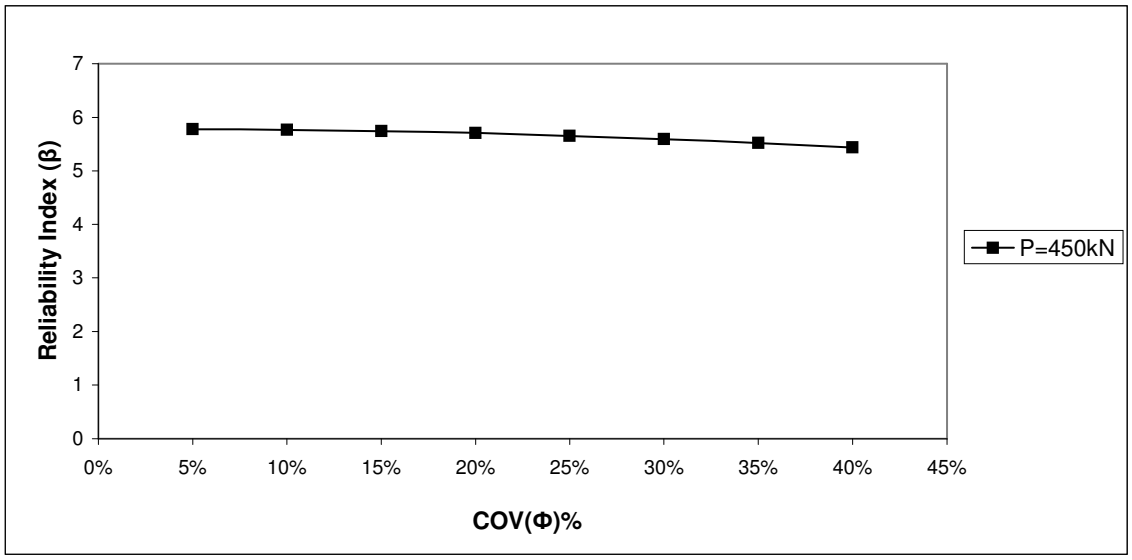


Fig. C.116 Reliability Index (β) of M_{max} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.153 Reliability Index (β) connected to M_{max} for free head long (10T) group with. spacing (3D) and with varying 'Φ' subjected to lateral load 650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.10E+01	10696.73	5%	103.6228	5.2855
1.59E+02	10696.73	10%	104.1897	5.2568
3.42E+02	10696.73	15%	105.0666	5.2129
6.45E+02	10696.73	20%	106.4983	5.1428
1.08E+03	10696.73	25%	108.5166	5.0472
1.63E+03	10696.73	30%	111.0174	4.9335
2.39E+03	10696.73	35%	114.4025	4.7875
3.30E+03	10696.73	40%	118.3099	4.6294

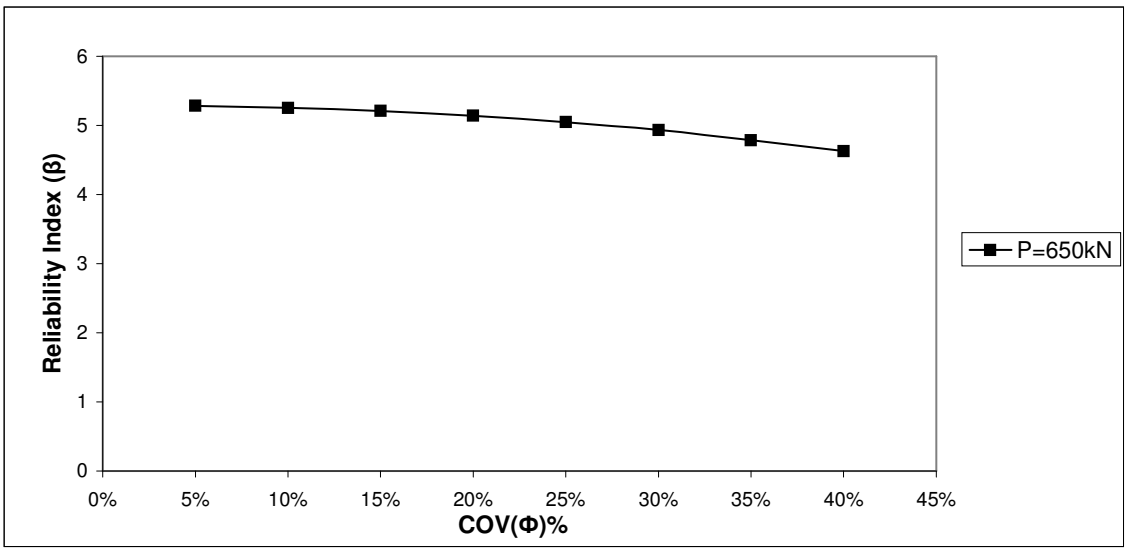


Fig. C.117 Reliability Index (β) of M_{max} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.154 Reliability Index (β) connected to M_{max} for free head long (10T) group with. spacing (3D) and with varying 'Φ' subjected to lateral load 950kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
7.40E+01	10696.73	5%	103.7819	4.3485
3.22E+02	10696.73	10%	104.9711	4.2993
7.78E+02	10696.73	15%	107.1221	4.2130
1.38E+03	10696.73	20%	109.9116	4.1060
2.13E+03	10696.73	25%	113.2748	3.9841
3.36E+03	10696.73	30%	118.5535	3.8067
4.84E+03	10696.73	35%	124.6631	3.6202
6.77E+03	10696.73	40%	132.1431	3.4152

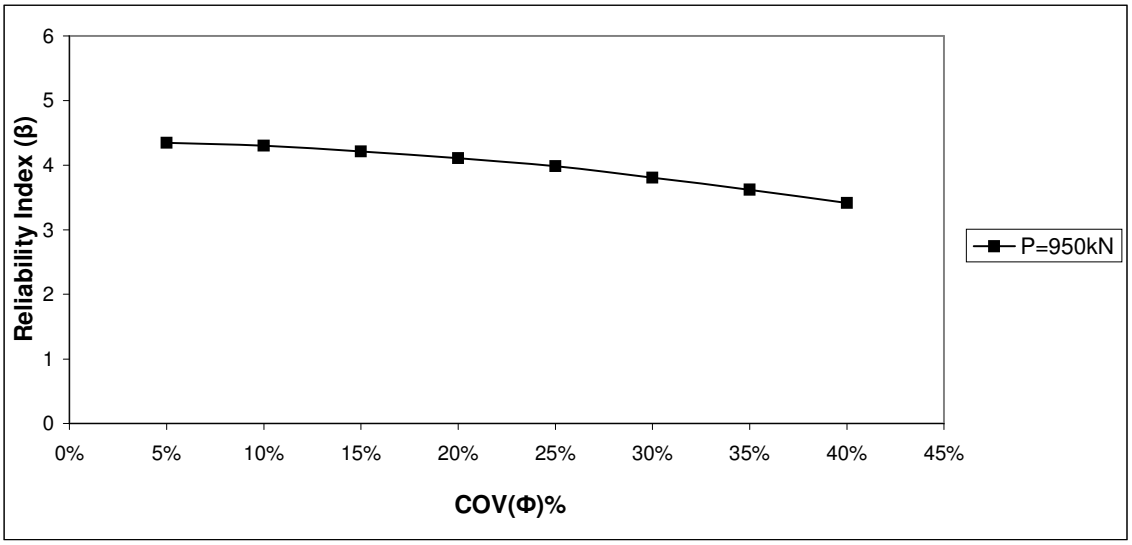


Fig. C.118 Reliability Index (β) of M_{max} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.155 Reliability Index (β) connected to M_{max} for free head long (10T) group with. spacing (3D) and with varying 'Φ' subjected to lateral load 1025kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.40E+02	10696.73	5%	104.1016	3.8021
6.13E+02	10696.73	10%	106.3452	3.7218
1.43E+03	10696.73	15%	110.1162	3.5944
2.57E+03	10696.73	20%	115.1834	3.4363
4.09E+03	10696.73	25%	121.5991	3.2550
5.97E+03	10696.73	30%	129.0903	3.0661
8.63E+03	10696.73	35%	139.0221	2.8470
1.18E+04	10696.73	40%	150.1139	2.6367

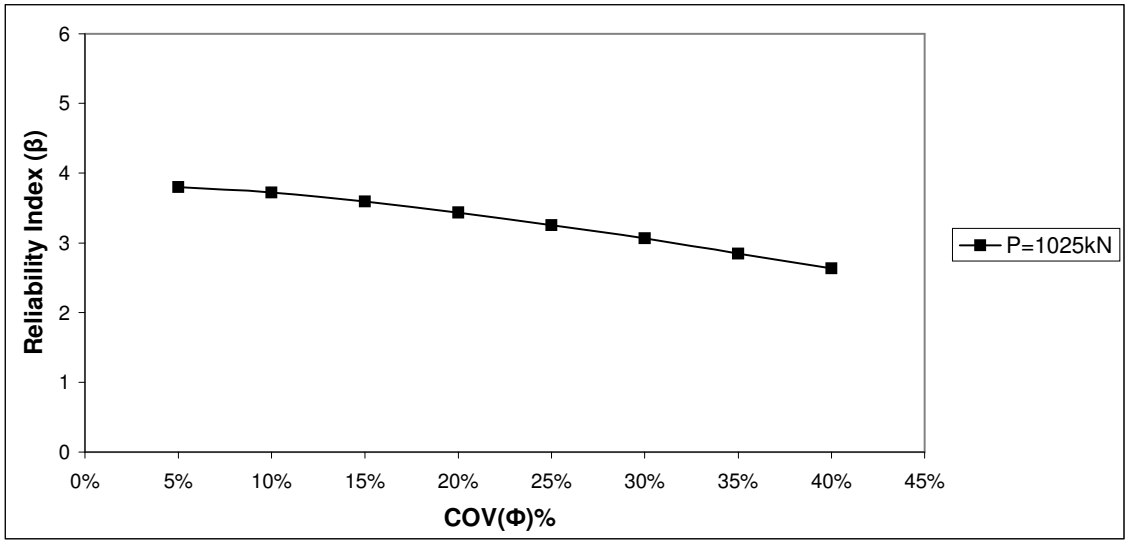


Fig. C.119 Reliability Index (β) of M_{max} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 1025kN.

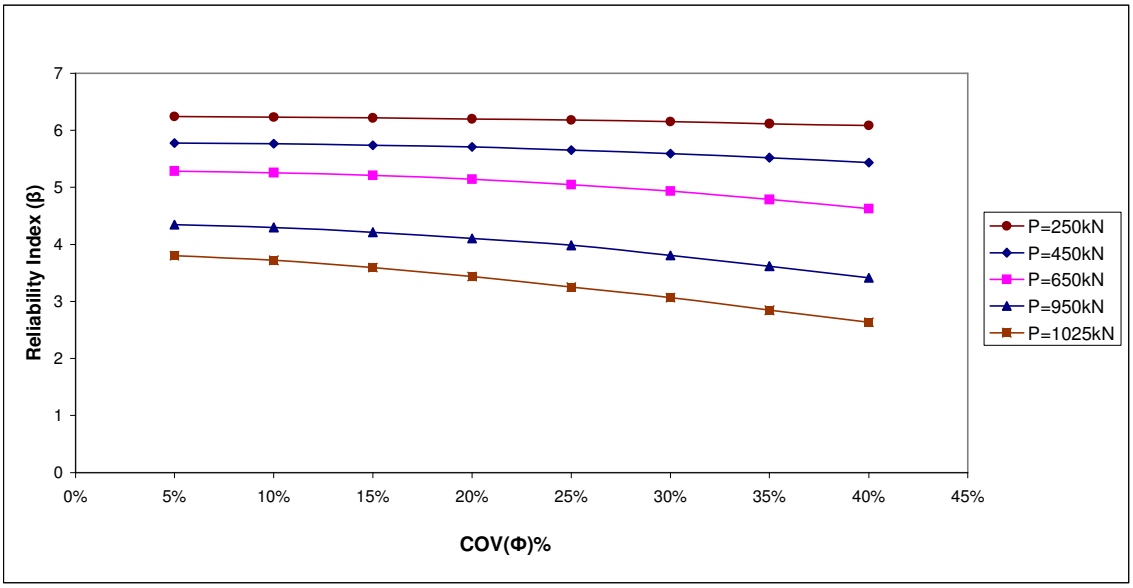


Fig. C.120 Reliability Index (β) of M_{max} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table C.156 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 250kN .

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.28E+00	10696.73	5%	103.4312	6.2413
5.48E+00	10696.73	10%	103.4515	6.2400
1.37E+01	10696.73	15%	103.4910	6.2376
2.59E+01	10696.73	20%	103.5499	6.2341
4.28E+01	10696.73	25%	103.6319	6.2292
6.59E+01	10696.73	30%	103.7429	6.2225
9.25E+01	10696.73	35%	103.8714	6.2148
1.24E+02	10696.73	40%	104.0227	6.2058

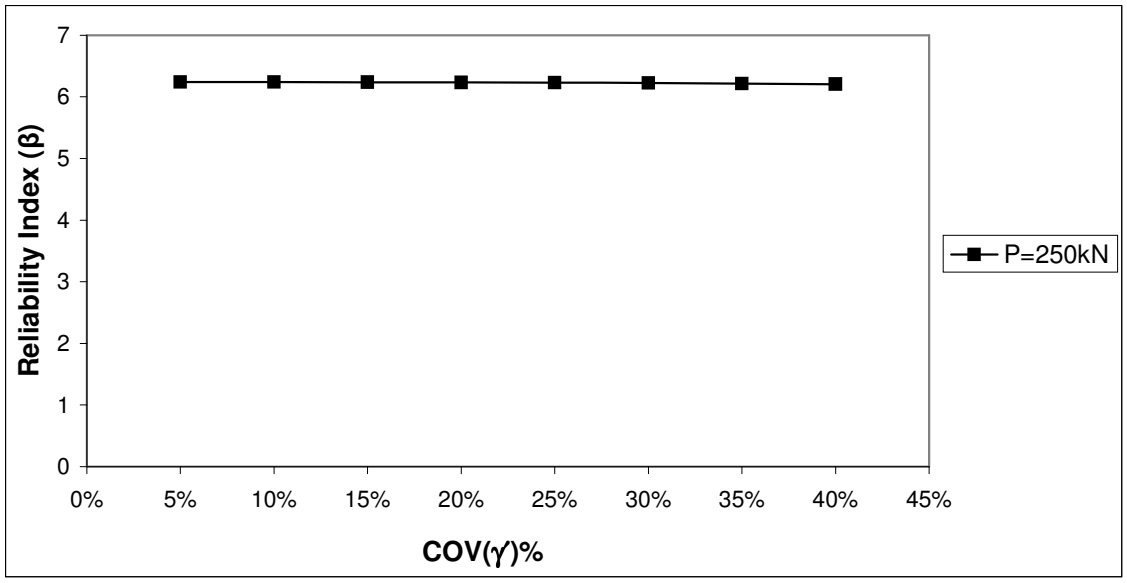


Fig. C.121 Reliability Index (β) of M_{max} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.157 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 450kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
4.20E+00	10696.73	5%	103.4453	5.7826
1.56E+01	10696.73	10%	103.5004	5.7795
3.54E+01	10696.73	15%	103.5960	5.7742
5.93E+01	10696.73	20%	103.7112	5.7677
9.12E+01	10696.73	25%	103.8650	5.7592
1.31E+02	10696.73	30%	104.0569	5.7486
1.80E+02	10696.73	35%	104.2895	5.7358
2.39E+02	10696.73	40%	104.5726	5.7202

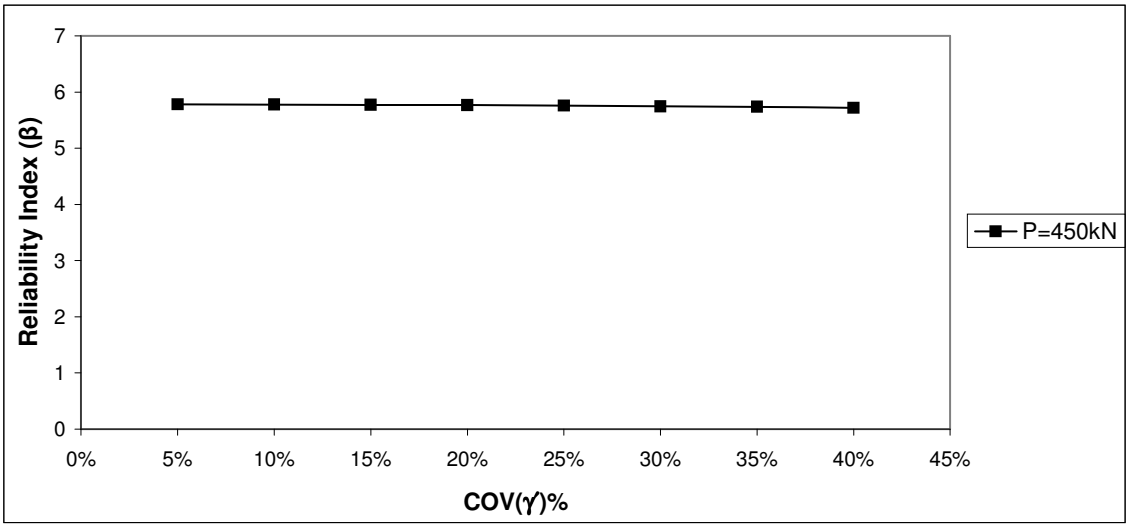


Fig. C.122 Reliability Index (β) of M_{max} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.158 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
8.12E+00	10696.73	5%	103.4643	5.2936
3.14E+01	10696.73	10%	103.5765	5.2879
6.81E+01	10696.73	15%	103.7535	5.2789
1.24E+02	10696.73	20%	104.0243	5.2651
1.95E+02	10696.73	25%	104.3616	5.2481
2.77E+02	10696.73	30%	104.7566	5.2283
4.10E+02	10696.73	35%	105.3888	5.1969
5.69E+02	10696.73	40%	106.1393	5.1602

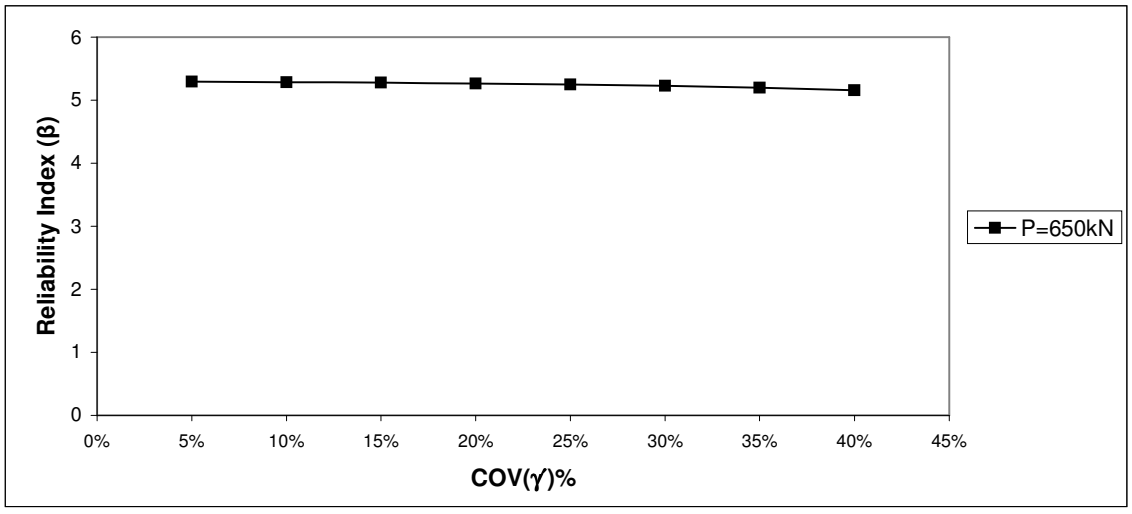


Fig. C.123 Reliability Index (β) of M_{max} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.159 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 950kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.26E+01	10696.73	5%	103.4859	4.3610
5.40E+01	10696.73	10%	103.6858	4.3526
1.23E+02	10696.73	15%	104.0189	4.3386
2.36E+02	10696.73	20%	104.5579	4.3163
4.00E+02	10696.73	25%	105.3410	4.2842
6.13E+02	10696.73	30%	106.3452	4.2437
8.73E+02	10696.73	35%	107.5636	4.1957
1.19E+03	10696.73	40%	109.0433	4.1387

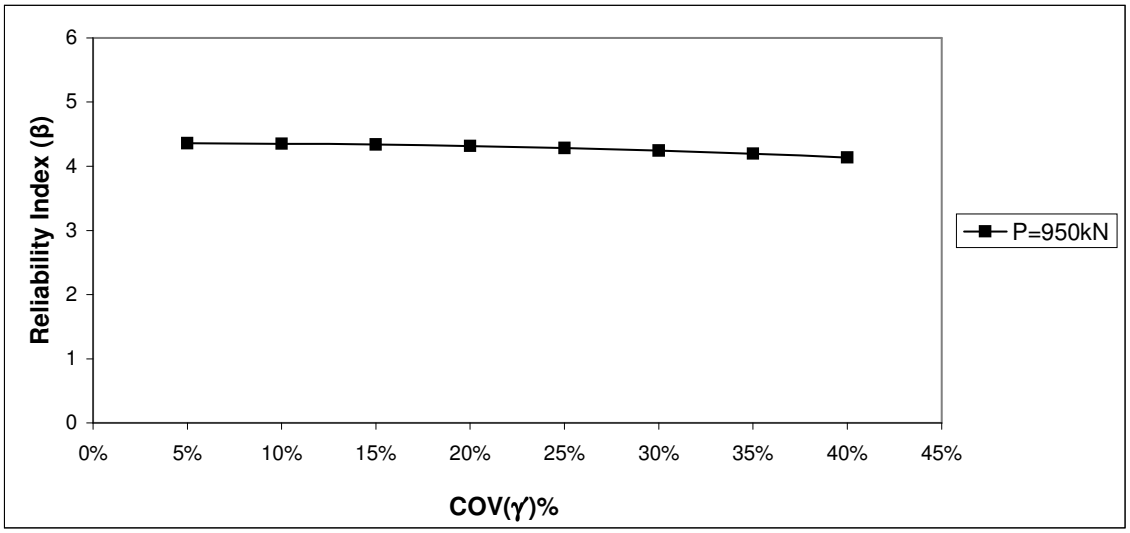


Fig. C.124 Reliability Index (β) of M_{max} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.160 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 1025kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
2.16E+01	10696.73	5%	103.5295	3.8231
9.80E+01	10696.73	10%	103.8977	3.8095
2.43E+02	10696.73	15%	104.5949	3.7841
4.49E+02	10696.73	20%	105.5754	3.7490
7.32E+02	10696.73	25%	106.9038	3.7024
1.09E+03	10696.73	30%	108.5621	3.6458
1.51E+03	10696.73	35%	110.4986	3.5819
2.09E+03	10696.73	40%	113.0920	3.4998

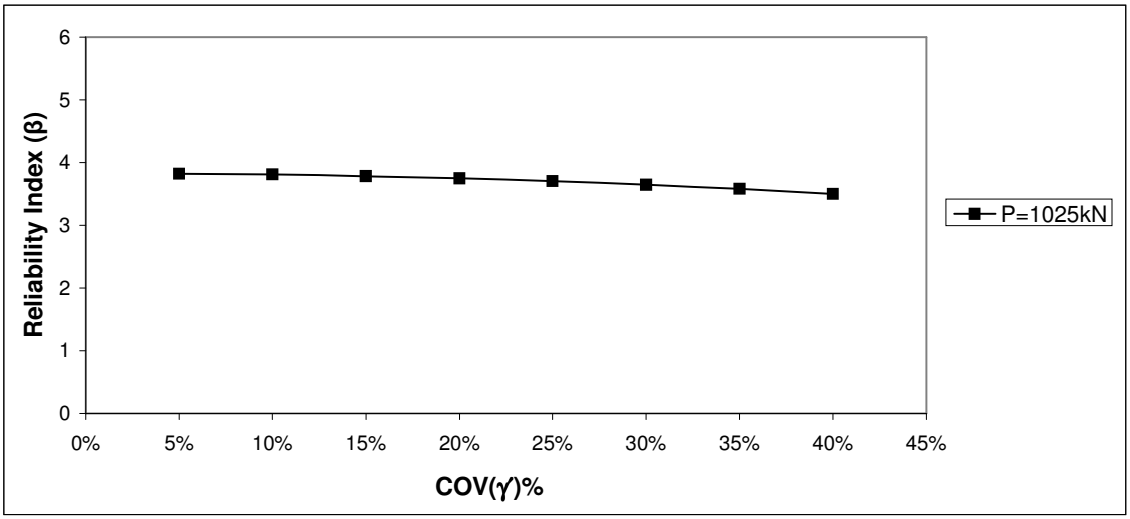


Fig. C.125 Reliability Index (β) of M_{max} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 1025kN.

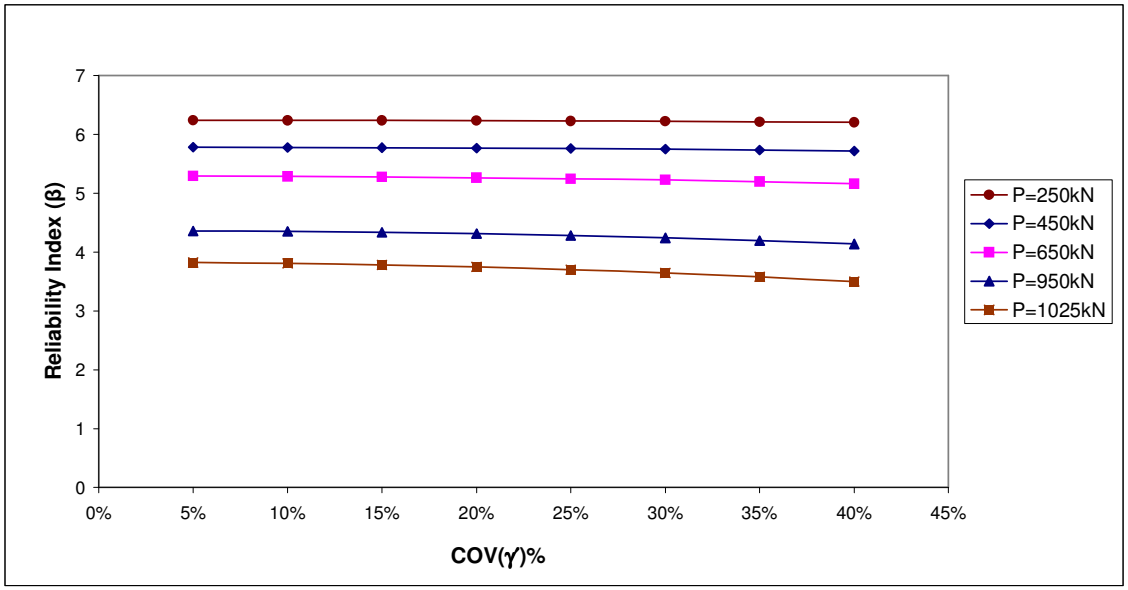


Fig. C.126 Reliability Index (β) of M_{max} vs. COV (γ') for free head long pile group (10T) subjected to lateral force of discrete variability.

Table C.161 Reliability Index(β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 250kN .

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E-04	10696.73	5%	103.4250	6.2416
2.25E-04	10696.73	10%	103.4250	6.2416
9.00E-04	10696.73	15%	103.4250	6.2416
1.44E-02	10696.73	20%	103.4251	6.2416
7.02E-02	10696.73	25%	103.4253	6.2416
1.33E-01	10696.73	30%	103.4256	6.2416
1.89E-01	10696.73	35%	103.4259	6.2416
2.50E-01	10696.73	40%	103.4262	6.2416

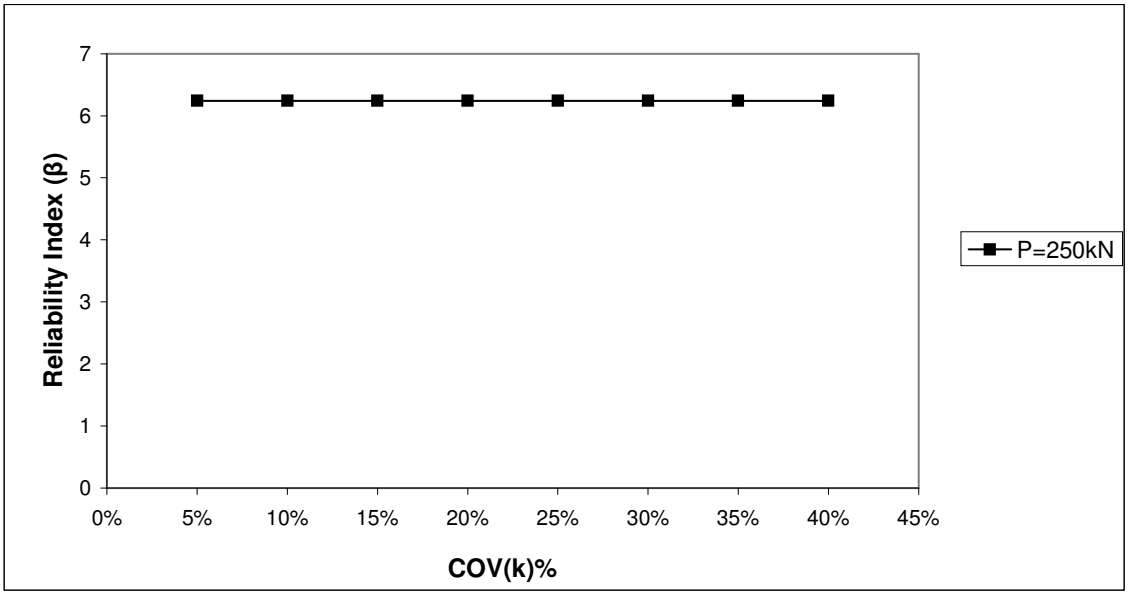


Fig. C.127 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.162 Reliability Index(β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 450kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
0.00E+00	10696.73	5%	103.4250	5.7837
2.50E-03	10696.73	10%	103.4250	5.7837
1.00E-02	10696.73	15%	103.4250	5.7837
4.00E-02	10696.73	20%	103.4252	5.7837
2.02E-01	10696.73	25%	103.4260	5.7837
3.60E-01	10696.73	30%	103.4267	5.7836
4.90E-01	10696.73	35%	103.4274	5.7836
7.23E-01	10696.73	40%	103.4285	5.7835

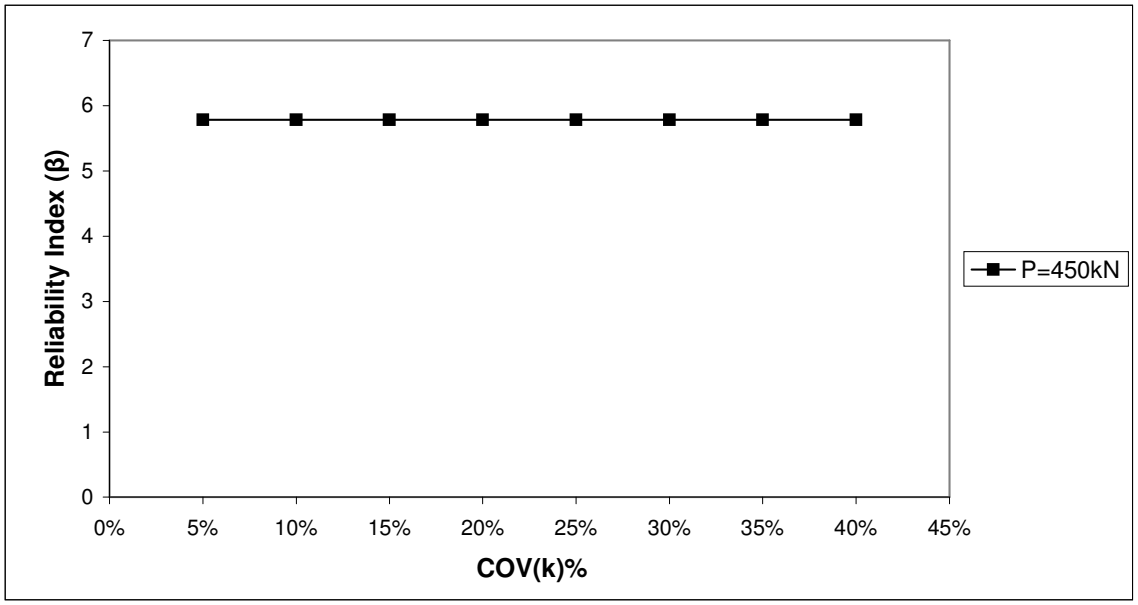


Fig. C.128 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.163 Reliability Index(β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E-02	10696.73	5%	103.4250	5.2956
4.00E-02	10696.73	10%	103.4252	5.2956
9.00E-02	10696.73	15%	103.4254	5.2956
1.22E-01	10696.73	20%	103.4256	5.2956
9.00E-02	10696.73	25%	103.4254	5.2956
1.22E-01	10696.73	30%	103.4256	5.2956
1.22E-01	10696.73	35%	103.4256	5.2956
2.03E-01	10696.73	40%	103.4260	5.2956

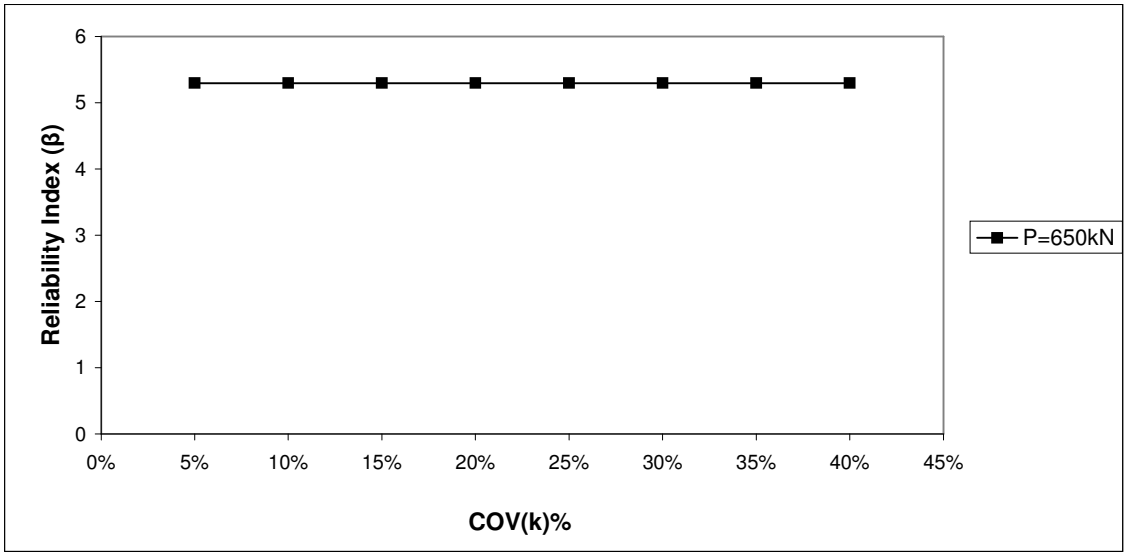


Fig. C.129 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.164 Reliability Index(β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 950kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
0.00E+00	10696.73	5%	103.4250	4.3635
2.50E-03	10696.73	10%	103.4250	4.3635
1.00E-02	10696.73	15%	103.4250	4.3635
1.00E-02	10696.73	20%	103.4250	4.3635
2.25E-02	10696.73	25%	103.4251	4.3635
9.00E-02	10696.73	30%	103.4254	4.3635
2.50E-01	10696.73	35%	103.4262	4.3635
3.60E-01	10696.73	40%	103.4267	4.3635

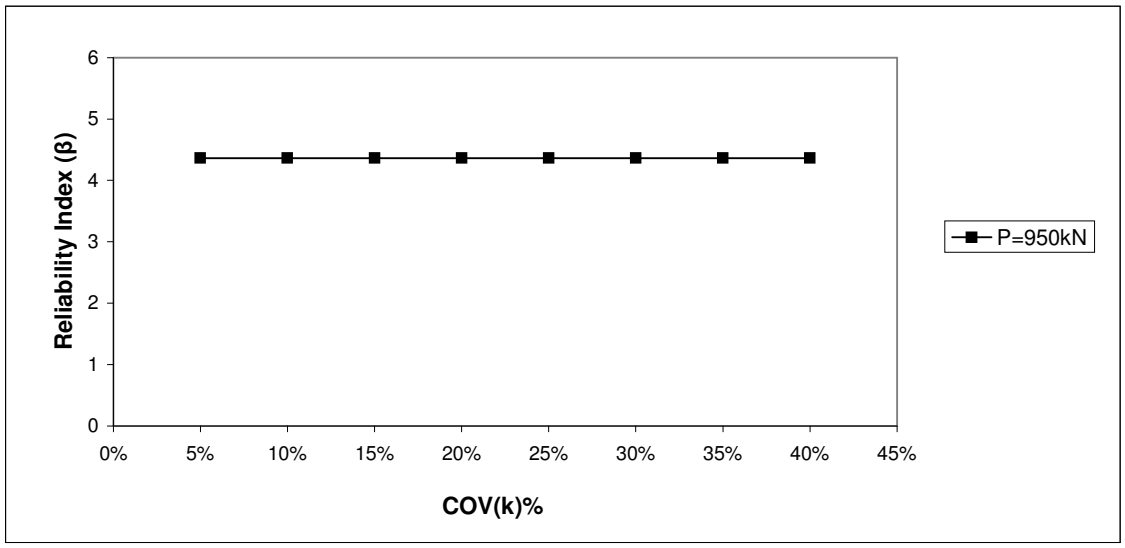


Fig. C.130 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.165 Reliability Index(β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 1025kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-03	10696.73	5%	103.4250	3.8269
0.00E+00	10696.73	10%	103.4250	3.8269
2.50E-03	10696.73	15%	103.4250	3.8269
1.00E-02	10696.73	20%	103.4250	3.8269
2.50E-03	10696.73	25%	103.4250	3.8269
0.00E+00	10696.73	30%	103.4250	3.8269
1.00E-02	10696.73	35%	103.4250	3.8269
2.25E-02	10696.73	40%	103.4251	3.8269

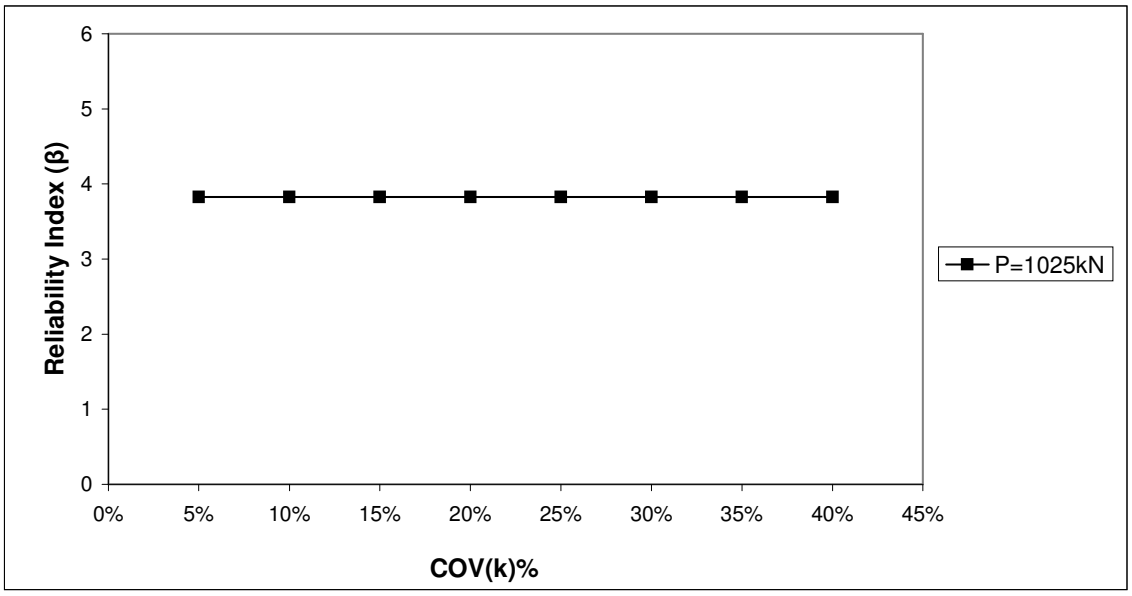


Fig. C.131 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force 1025kN.

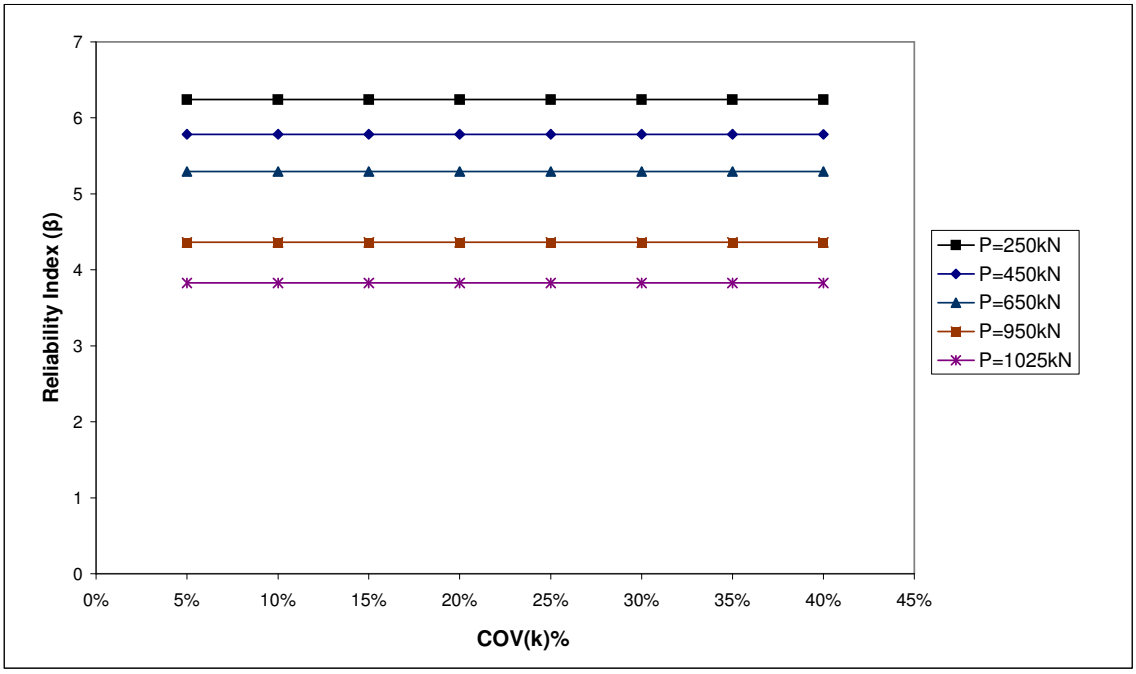


Fig. C.132 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table C.166 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'B' applied lateral load 250kN .

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.22E-01	10696.73	5%	103.4270	6.2415
1.60E+00	10696.73	10%	103.4327	6.2412
3.37E+00	10696.73	15%	103.4413	6.2406
5.64E+00	10696.73	20%	103.4523	6.2400
8.79E+00	10696.73	25%	103.4675	6.2391
1.19E+01	10696.73	30%	103.4825	6.2382
1.44E+01	10696.73	35%	103.4946	6.2374
1.60E+01	10696.73	40%	103.5025	6.2369

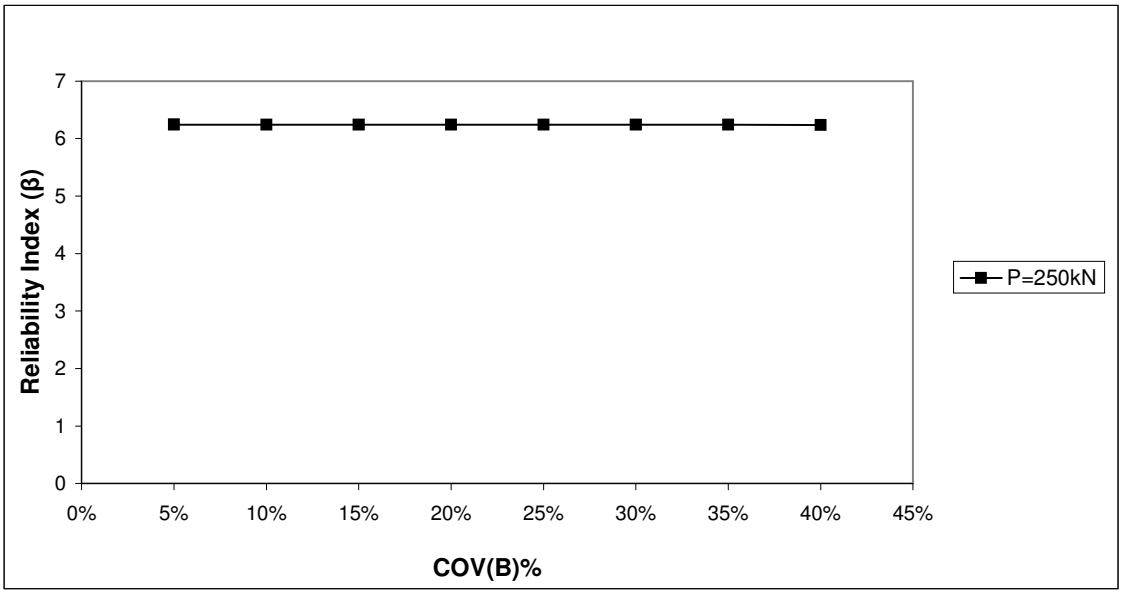


Fig. C.133 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.167 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'B' subjected to lateral load 450kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.25E-02	10696.73	5%	103.4251	5.7837
9.03E-01	10696.73	10%	103.4294	5.7835
1.82E+00	10696.73	15%	103.4338	5.7832
3.06E+00	10696.73	20%	103.4398	5.7829
5.06E+00	10696.73	25%	103.4495	5.7823
6.76E+00	10696.73	30%	103.4577	5.7819
8.23E+00	10696.73	35%	103.4648	5.7815
1.06E+01	10696.73	40%	103.4761	5.7809

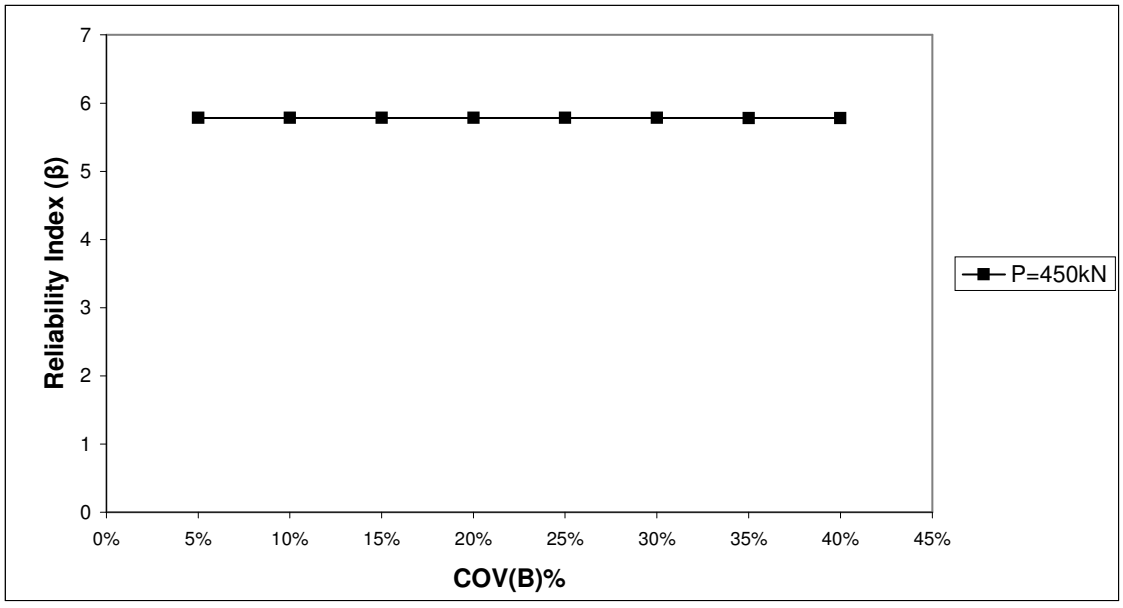


Fig. C.134 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.168 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'B' subjected to lateral load 650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
9.00E-02	10696.73	5%	103.4254	5.2956
1.10E+00	10696.73	10%	103.4303	5.2954
1.96E+00	10696.73	15%	103.4345	5.2951
3.80E+00	10696.73	20%	103.4434	5.2947
7.02E+00	10696.73	25%	103.4589	5.2939
1.19E+01	10696.73	30%	103.4825	5.2927
1.66E+01	10696.73	35%	103.5053	5.2915
2.21E+01	10696.73	40%	103.5317	5.2902

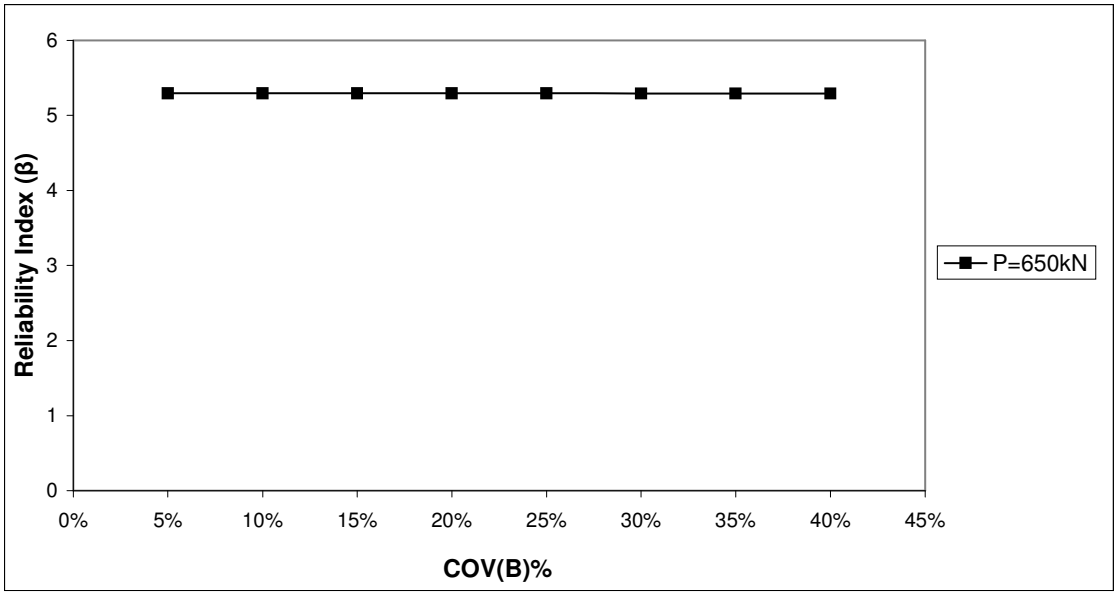


Fig. C.135 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.169 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'B' subjected to lateral load 950kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.10E+00	10696.73	5%	103.4303	4.3633
4.00E+00	10696.73	10%	103.4443	4.3627
9.92E+00	10696.73	15%	103.4730	4.3615
1.76E+01	10696.73	20%	103.5102	4.3600
2.76E+01	10696.73	25%	103.5582	4.3579
3.97E+01	10696.73	30%	103.6167	4.3555
5.70E+01	10696.73	35%	103.7000	4.3520
7.92E+01	10696.73	40%	103.8072	4.3475

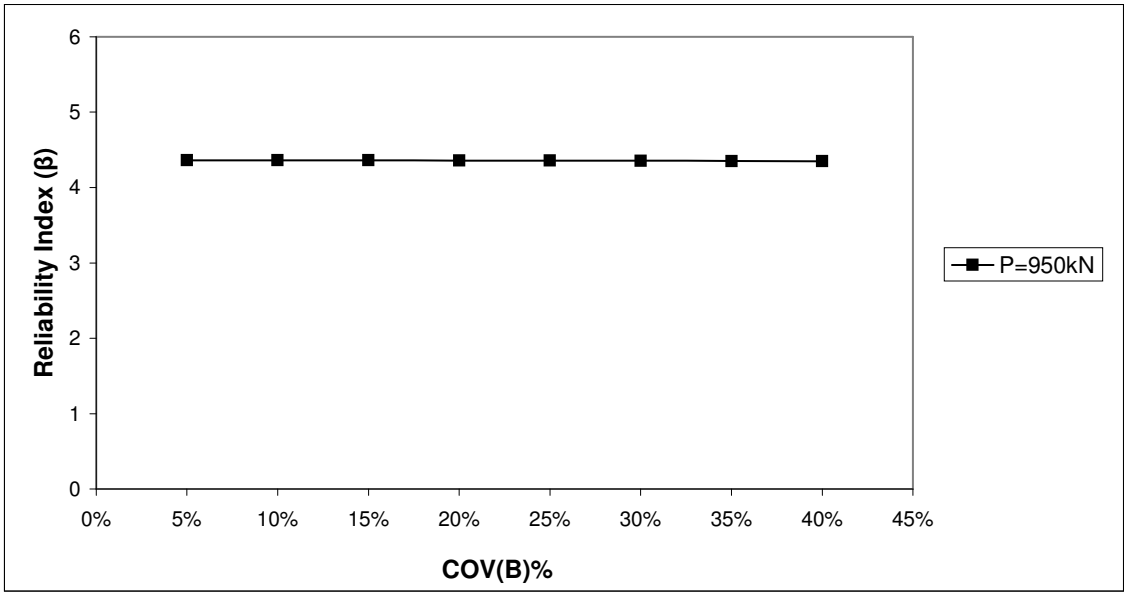


Fig. C.136 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.170 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'B' subjected to lateral load 1025kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.00E+00	10696.73	5%	103.4443	3.8262
1.16E+01	10696.73	10%	103.4809	3.8249
2.45E+01	10696.73	15%	103.5434	3.8226
4.16E+01	10696.73	20%	103.6259	3.8195
6.48E+01	10696.73	25%	103.7378	3.8154
9.31E+01	10696.73	30%	103.8742	3.8104
1.34E+02	10696.73	35%	104.0705	3.8032
1.77E+02	10696.73	40%	104.2767	3.7957

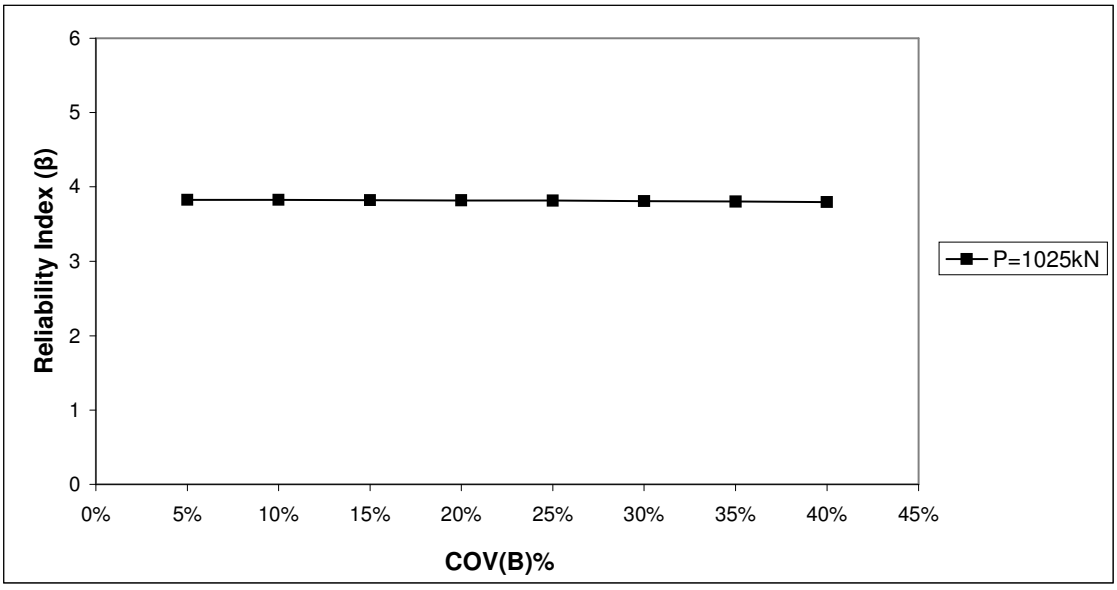


Fig. C.137 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force 1025kN.

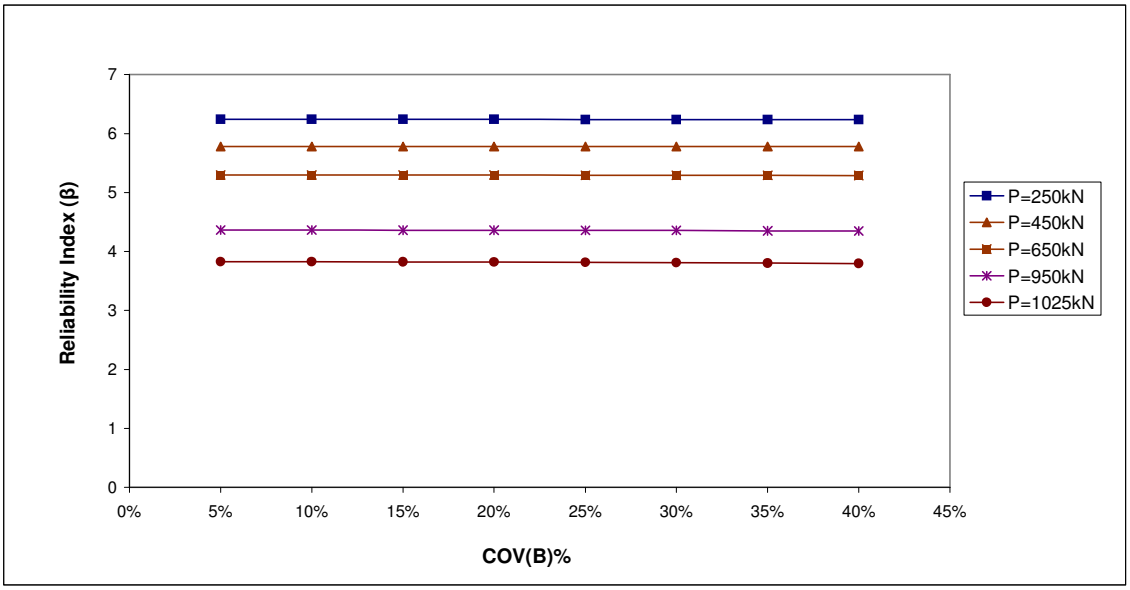


Fig. C.138 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table C.171 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 250kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.81E-02	10696.73	5%	103.4251	6.2416
1.12E-01	10696.73	10%	103.4255	6.2416
2.55E-01	10696.73	15%	103.4262	6.2415
4.66E-01	10696.73	20%	103.4273	6.2415
3.28E-01	10696.73	25%	103.4266	6.2415
1.10E+00	10696.73	30%	103.4303	6.2413
1.56E+00	10696.73	35%	103.4325	6.2412
2.12E+00	10696.73	40%	103.4353	6.2410

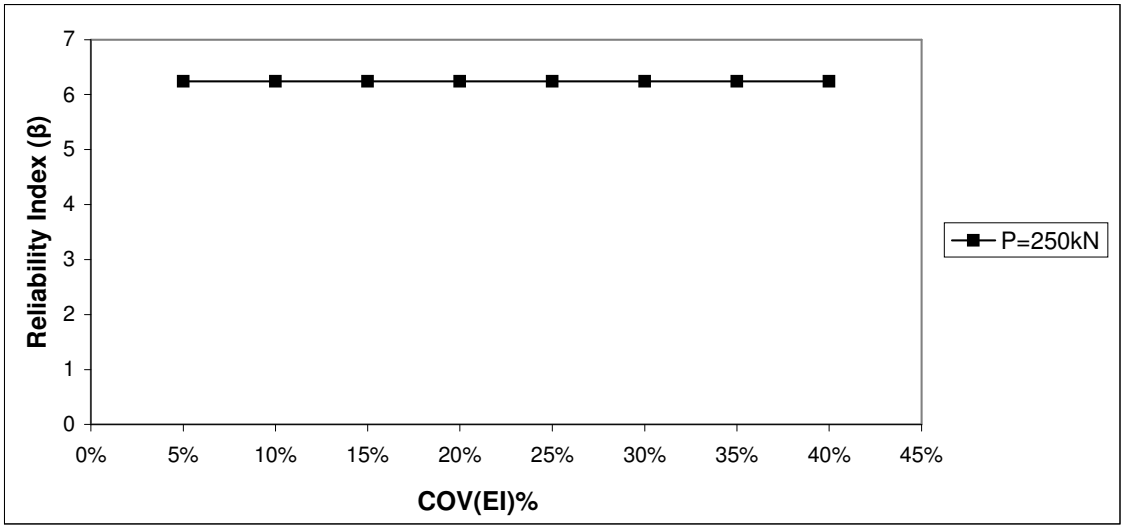


Fig. C.139 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.172 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 450kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.41E-01	10696.73	5%	103.4257	5.7837
6.01E-01	10696.73	10%	103.4279	5.7835
1.32E+00	10696.73	15%	103.4314	5.7834
2.10E+00	10696.73	20%	103.4352	5.7831
1.39E+00	10696.73	25%	103.4317	5.7833
4.41E+00	10696.73	30%	103.4463	5.7825
5.64E+00	10696.73	35%	103.4523	5.7822
7.29E+00	10696.73	40%	103.4602	5.7817

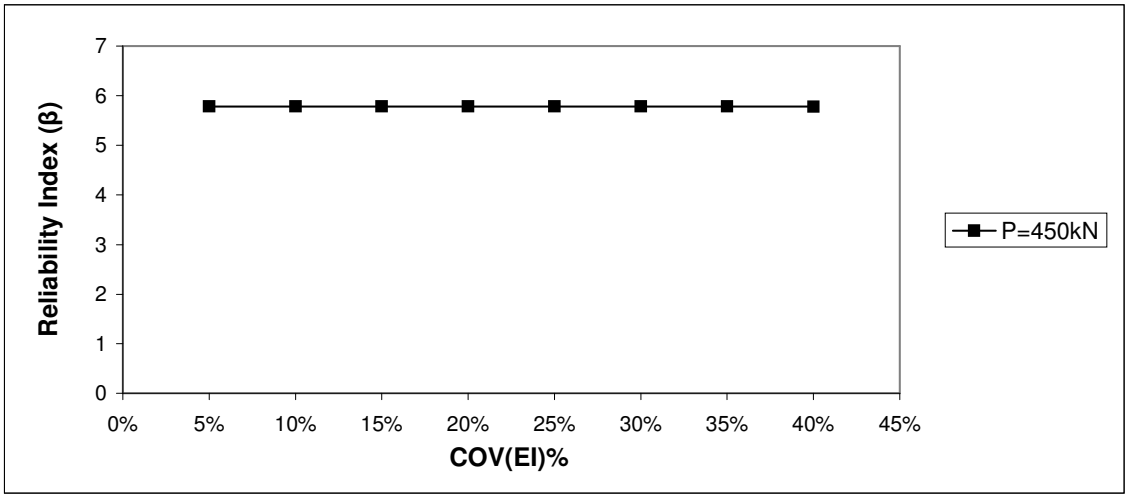


Fig. C.140 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.173 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.41E-01	10696.73	5%	103.4257	5.2956
6.01E-01	10696.73	10%	103.4279	5.2955
1.50E+00	10696.73	15%	103.4323	5.2953
2.72E+00	10696.73	20%	103.4382	5.2950
1.94E+00	10696.73	25%	103.4344	5.2951
6.25E+00	10696.73	30%	103.4552	5.2941
8.41E+00	10696.73	35%	103.4656	5.2935
1.07E+01	10696.73	40%	103.4768	5.2930

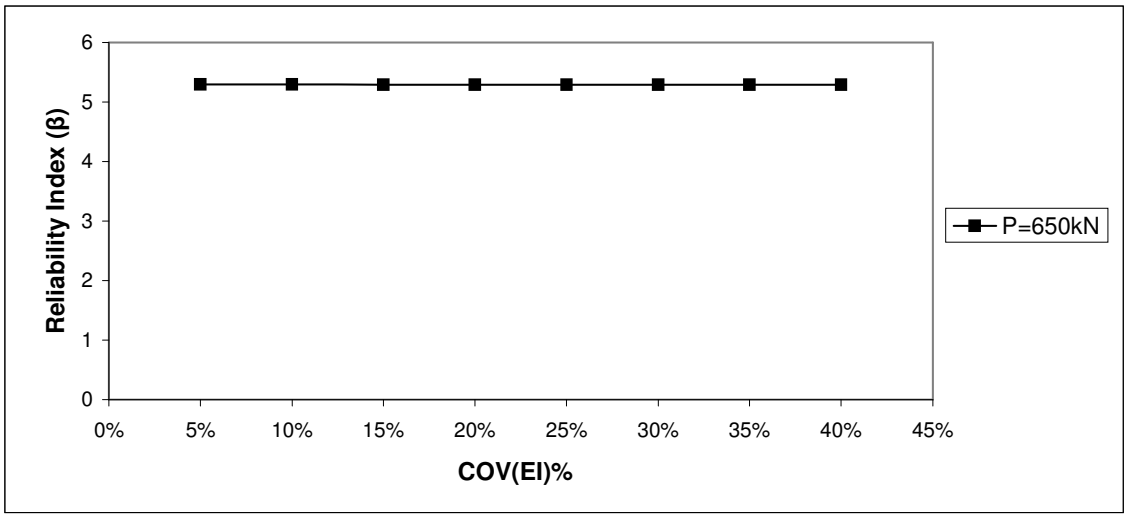


Fig. C.141 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 650kN.

Table C.174 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 950kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.06E-01	10696.73	5%	103.4255	4.3635
3.91E-01	10696.73	10%	103.4269	4.3635
7.66E-01	10696.73	15%	103.4287	4.3634
1.27E+00	10696.73	20%	103.4311	4.3633
7.74E-01	10696.73	25%	103.4287	4.3634
2.48E+00	10696.73	30%	103.4370	4.3630
3.33E+00	10696.73	35%	103.4411	4.3629
4.52E+00	10696.73	40%	103.4468	4.3626

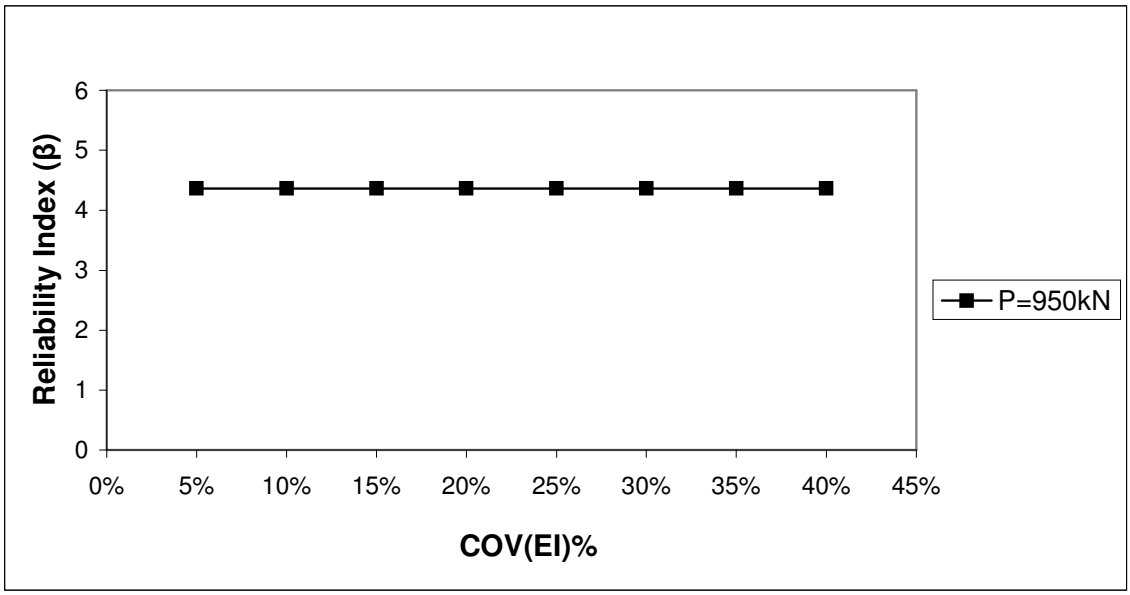


Fig. C.142 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.175 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 1025kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.56E-02	10696.73	5%	103.4251	3.8269
4.00E-02	10696.73	10%	103.4252	3.8269
7.57E-02	10696.73	15%	103.4254	3.8269
1.60E-01	10696.73	20%	103.4258	3.8269
1.21E-01	10696.73	25%	103.4256	3.8269
5.63E-01	10696.73	30%	103.4277	3.8268
9.02E-01	10696.73	35%	103.4294	3.8268
1.38E+00	10696.73	40%	103.4317	3.8267

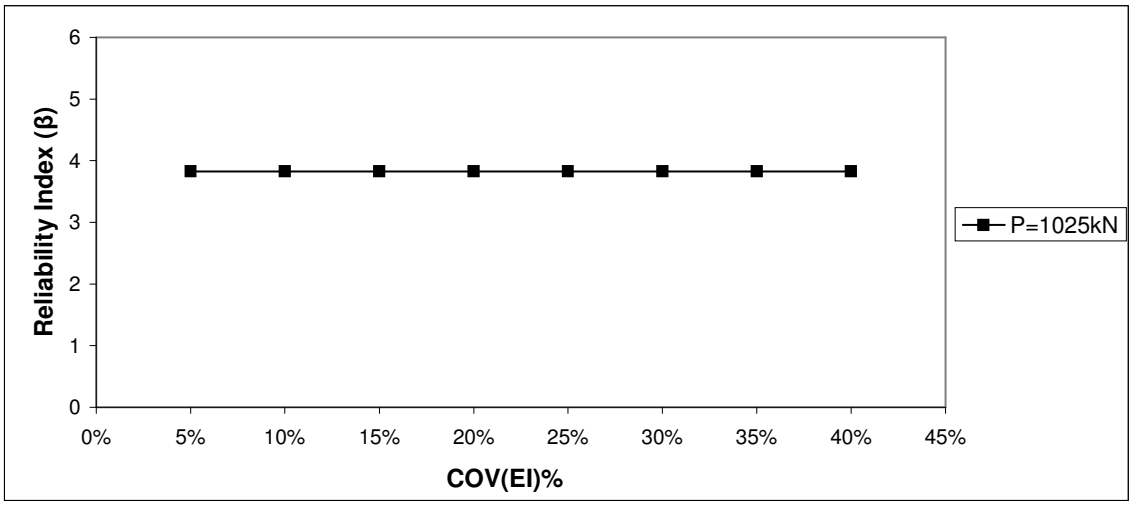


Fig. C.143 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 1025kN.

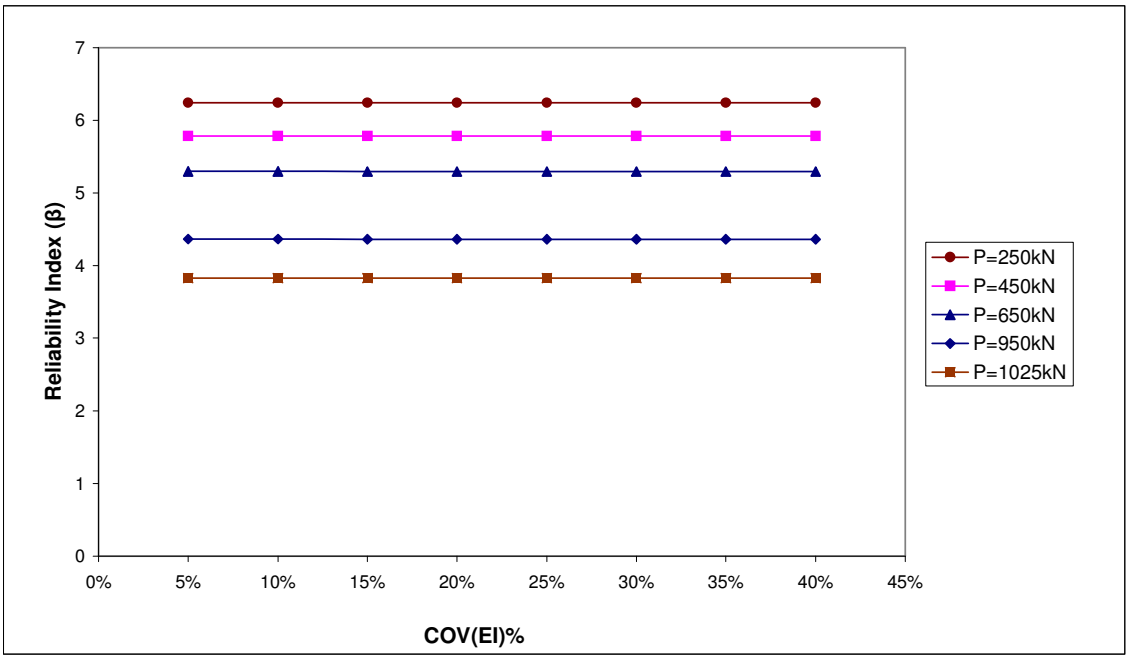


Fig. C.144 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table C.176 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'P' subjected to lateral load 250kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.26E+01	10696.73	5%	103.5340	6.2351
9.03E+01	10696.73	10%	103.8604	6.2155
2.03E+02	10696.73	15%	104.4041	6.1831
3.66E+02	10696.73	20%	105.1802	6.1375
5.76E+02	10696.73	25%	106.1720	6.0801
8.27E+02	10696.73	30%	107.3479	6.0135
1.11E+03	10696.73	35%	108.6813	5.9398
1.46E+03	10696.73	40%	110.2541	5.8550

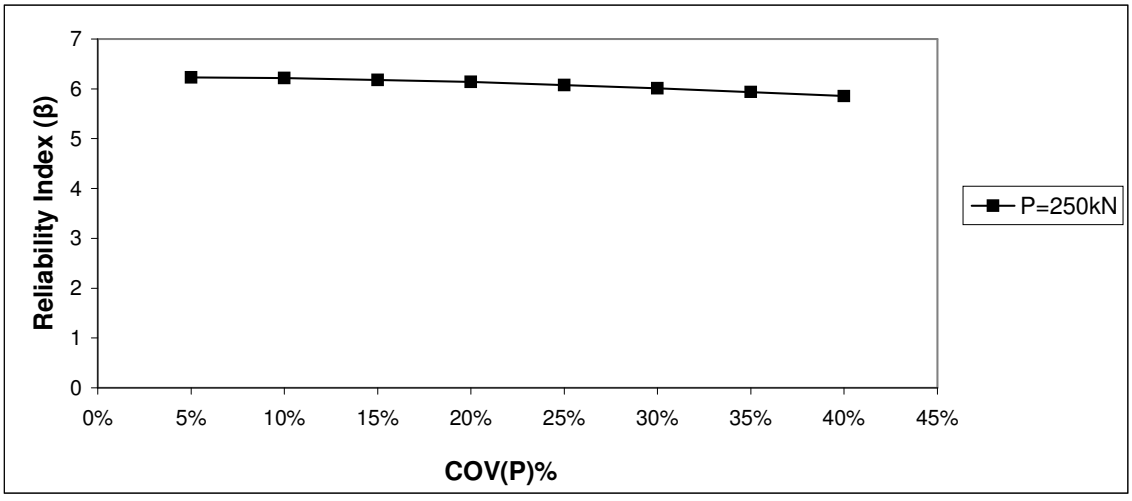


Fig. C.145 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force 250kN.

Table C.177 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'P' subjected to lateral load 450kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\ m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
5.85E+01	10696.73	5%	103.7075	5.7680
2.34E+02	10696.73	10%	104.5506	5.7214
5.22E+02	10696.73	15%	105.9191	5.6475
9.32E+02	10696.73	20%	107.8370	5.5471
1.46E+03	10696.73	25%	110.2645	5.4250
2.11E+03	10696.73	30%	113.1588	5.2862
2.88E+03	10696.73	35%	116.5282	5.1334
3.76E+03	10696.73	40%	120.2418	4.9748

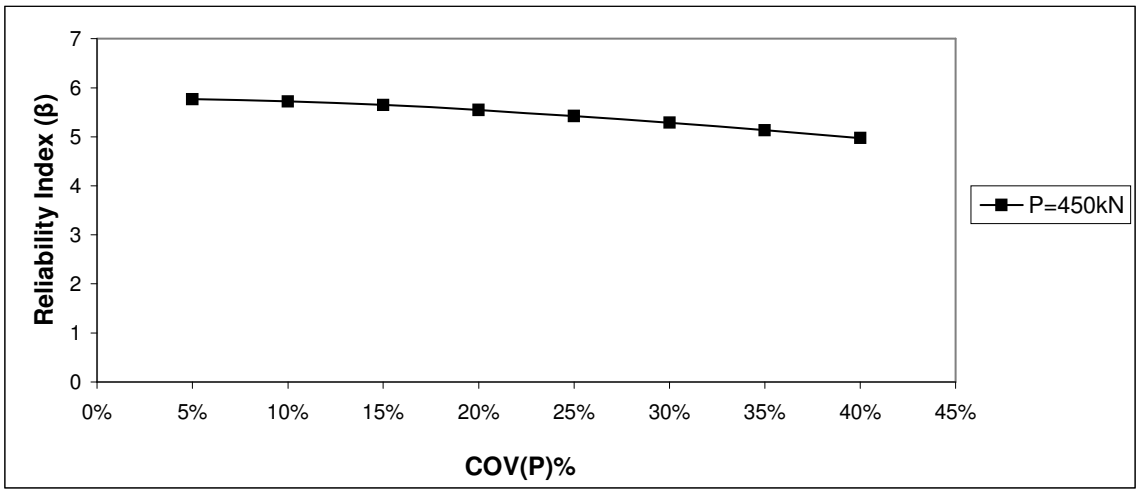


Fig. C.146 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.178 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'P' subjected to lateral load 650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.22E+02	10696.73	5%	104.0136	5.2657
4.82E+02	10696.73	10%	105.7286	5.1802
1.09E+03	10696.73	15%	108.5773	5.0443
1.94E+03	10696.73	20%	112.4346	4.8713
3.05E+03	10696.73	25%	117.2338	4.6719
4.38E+03	10696.73	30%	122.7973	4.4602
5.99E+03	10696.73	35%	129.1801	4.2398
7.87E+03	10696.73	40%	136.2708	4.0192

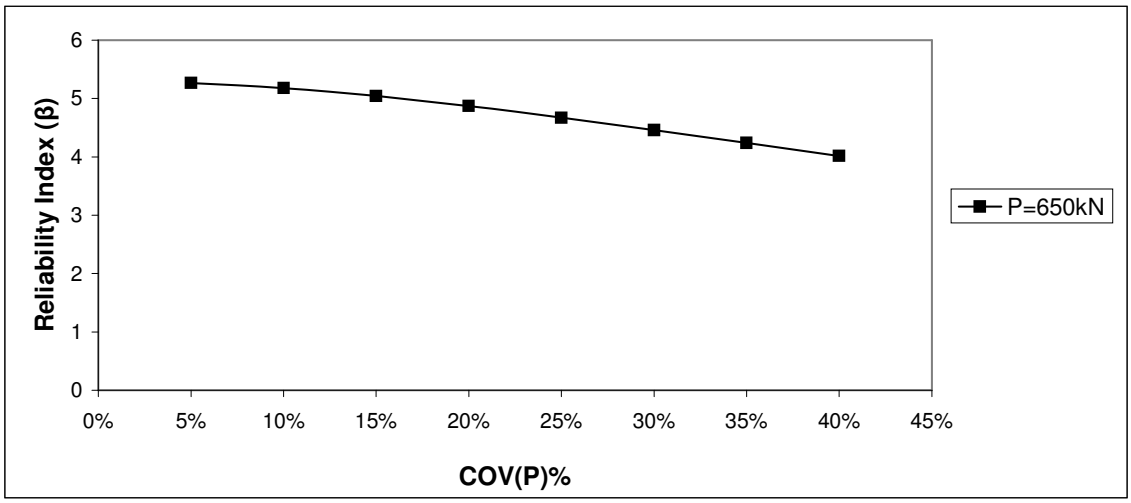


Fig. C.147 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force 450kN.

Table C.179 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'P' subjected to lateral load 950kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.24E+02	10696.73	5%	104.4999	4.3187
9.15E+02	10696.73	10%	107.7580	4.1881
2.04E+03	10696.73	15%	112.8506	3.9991
3.60E+03	10696.73	20%	119.5689	3.7744
5.66E+03	10696.73	25%	127.8740	3.5293
8.13E+03	10696.73	30%	137.1997	3.2894
1.12E+04	10696.73	35%	147.8110	3.0532
1.46E+04	10696.73	40%	159.1783	2.8352

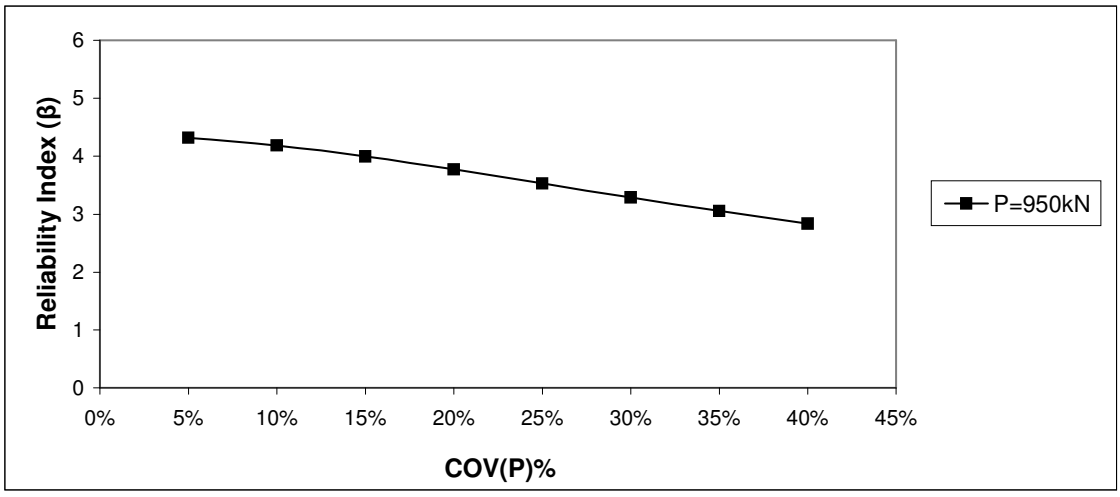


Fig. C.148 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force 950kN.

Table C.180 Reliability Index (β) connected to M_{max} for free head long(10T) group with spacing (3D) and with varying 'P' subjected to lateral load 1025kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.82E+02	10696.73	5%	105.2565	3.7603
1.54E+03	10696.73	10%	110.6046	3.5785
3.51E+03	10696.73	15%	119.1944	3.3206
6.28E+03	10696.73	20%	130.2969	3.0377
9.92E+03	10696.73	25%	143.5858	2.7565
1.42E+04	10696.73	30%	157.8521	2.5074
1.93E+04	10696.73	35%	173.2161	2.2850
2.52E+04	10696.73	40%	189.5103	2.0885

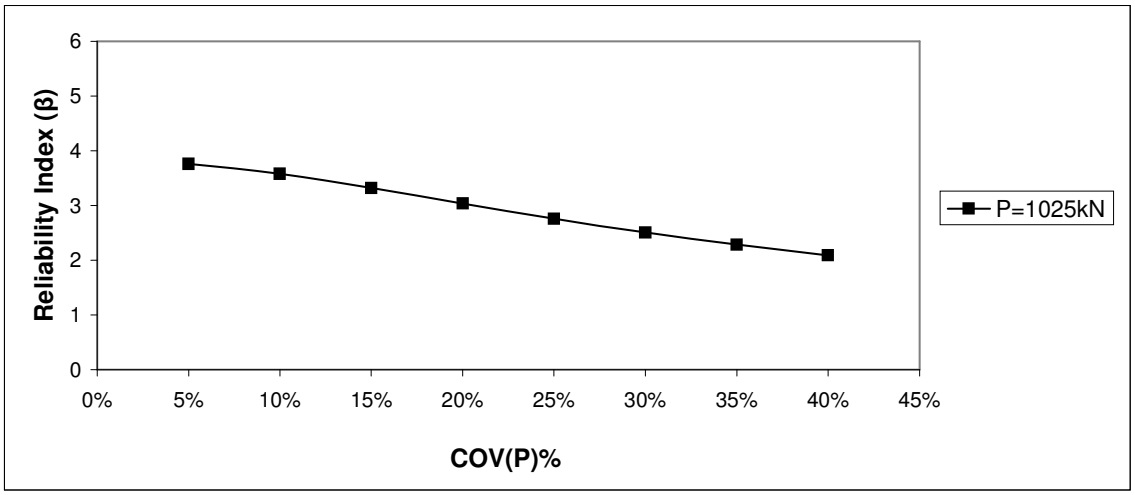


Fig. C.149 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force 1025kN.

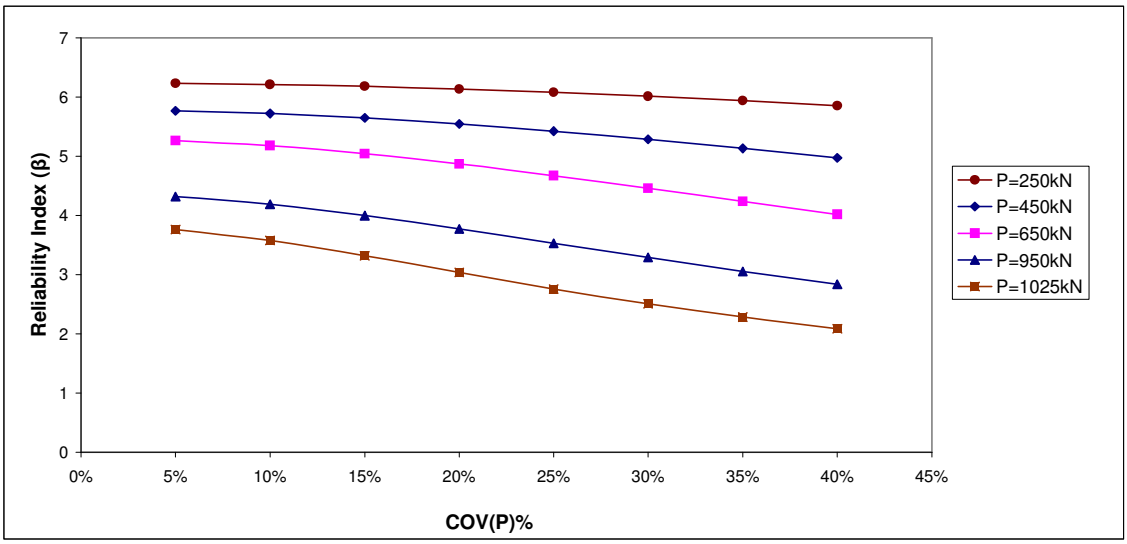


Fig. C.150 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force of discrete variability.

C.6 Probability of Failure, p_f . (M_{max})of bending moment vs. COV (Variables).

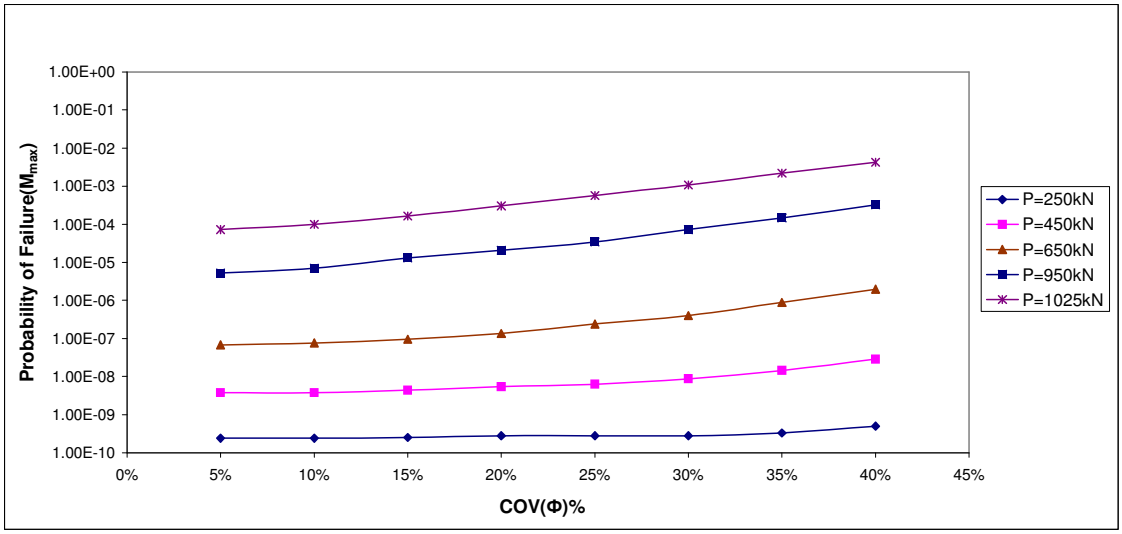


Fig. C.151 Probability of failure of bending moment p_f . (M_{max})vs. COV (Φ) for free head long pile group of length 10T.

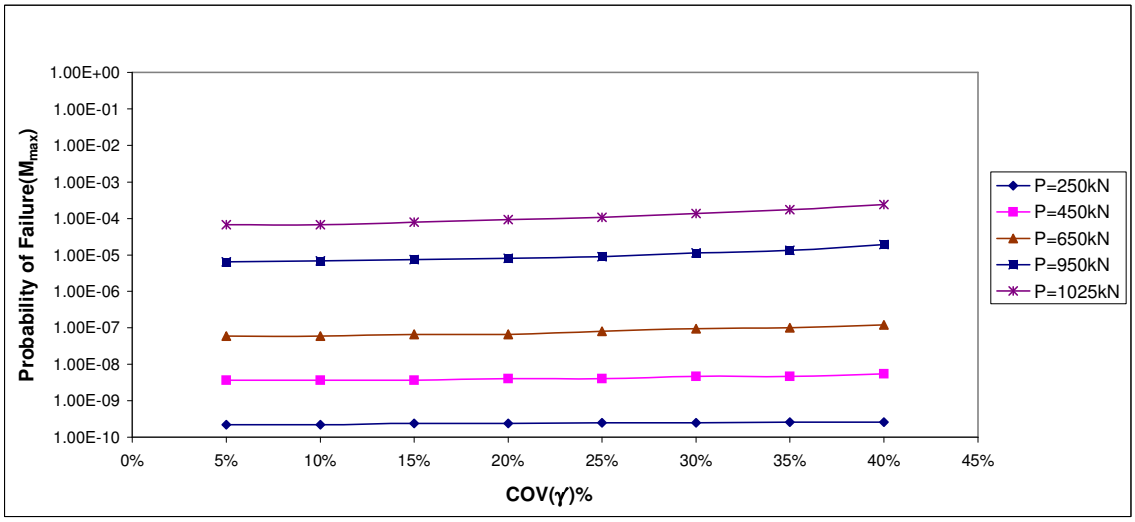


Fig. C.152 Probability of failure of bending moment p_f . (M_{max}) vs. COV (γ) for free head long pile group of length 10T.

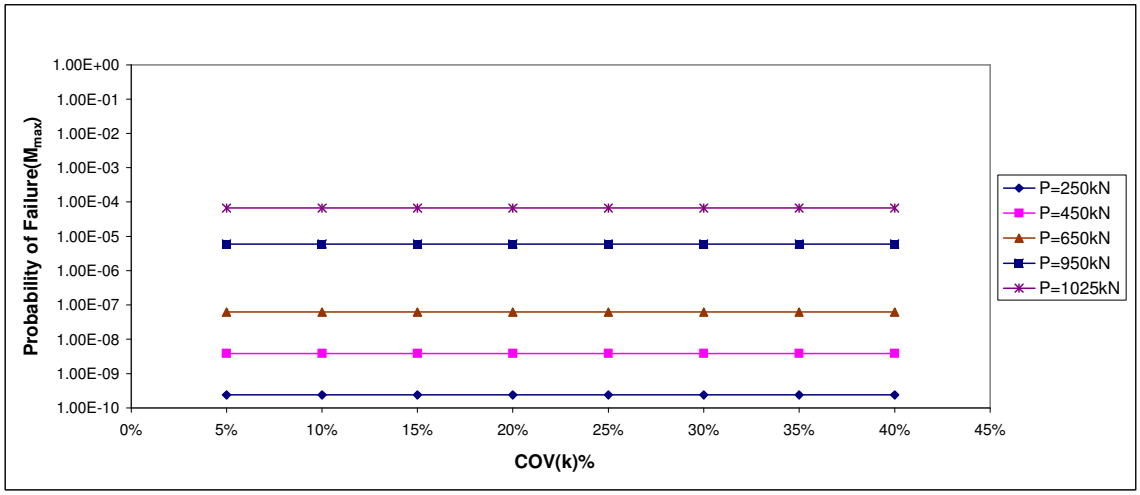


Fig. C.153 Probability of failure of bending moment p_f. (M_{max}) vs. COV (k) for free head long pile group of length 10T.

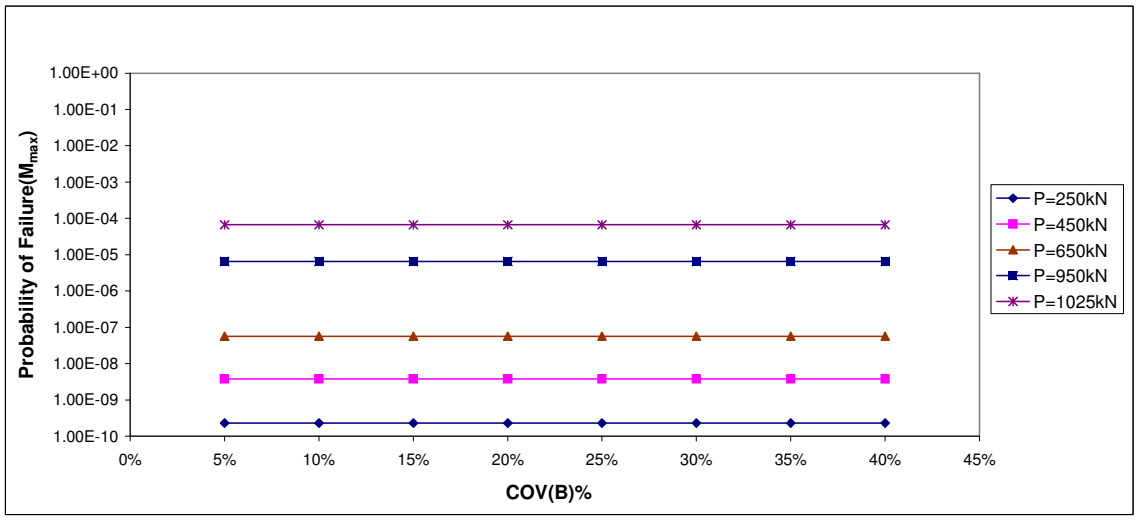


Fig. C.154 Probability of failure of bending moment p_f. (M_{max}) vs. COV (B) for free head long pile group of length 10T.

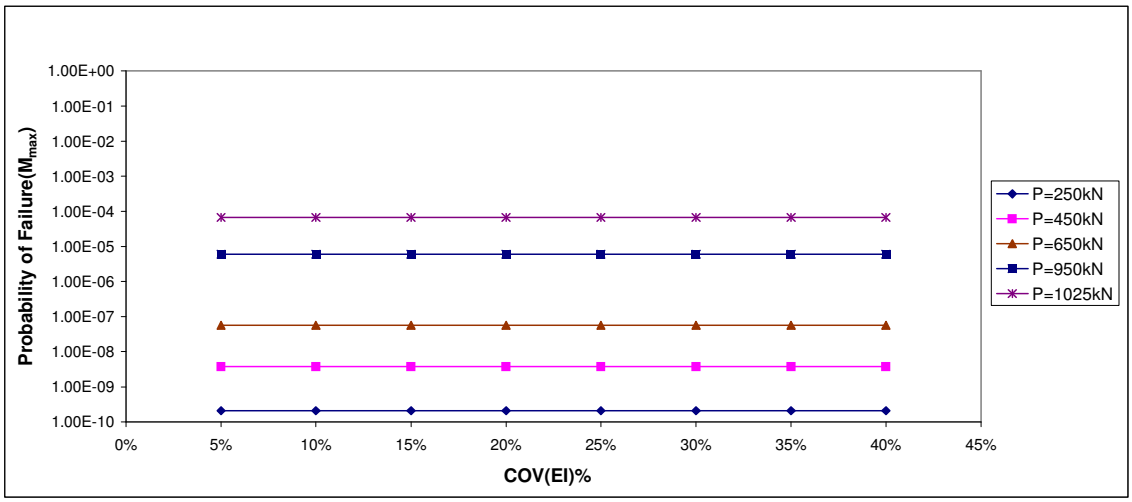


Fig. C.155 Probability of failure of bending moment p_f. (M_{max}) vs. COV (EI) for free head long pile group of length 10T.

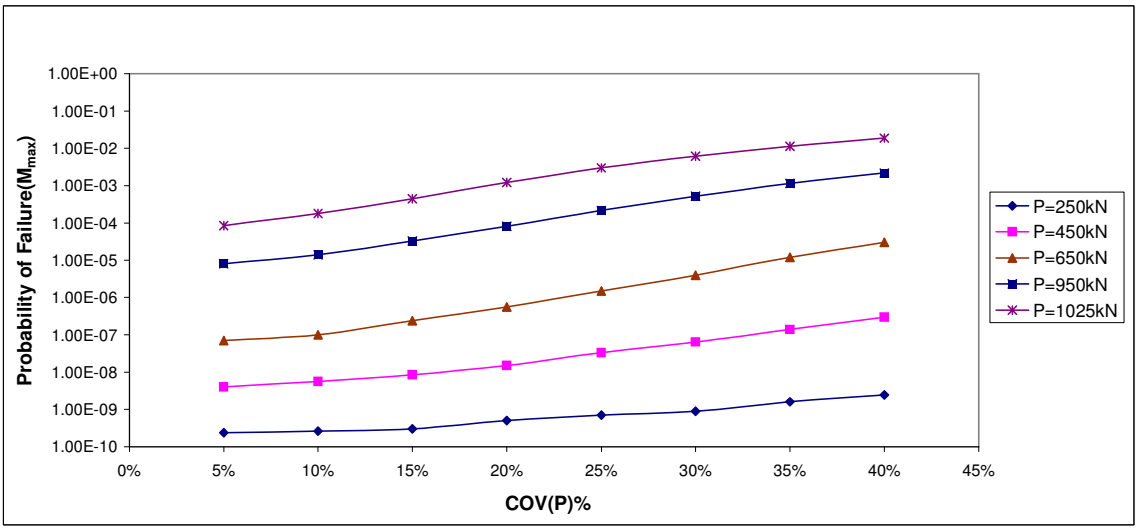


Fig. C.156 Probability of failure of bending moment p_f. (M_{max}) vs. COV (P) for free head long pile group of length 10T.

APPENDIX D

LATERALLY LOADED FIXED HEAD LONG (10T) PILE GROUP WITH (3D) SPACING

D-1 Deflection of fixed head long pile group (Y_{Top}) and COV (Y_{Top}) vs. COV (Variables)

Table D.1 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (Φ) and load 1000kN.

P=1000kN

COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.50	1.03E-02				
5%	30			2.25E+00	8.28E-07	6.22E-03	8.12%
		28.50	1.22E-02				
		33.00	9.56E-03				
10%	30			9.00E+00	3.30E-06	6.22E-03	16.23%
		27.00	1.32E-02				
		34.50	8.86E-03				
15%	30			2.03E+01	7.49E-06	6.22E-03	24.44%
		25.50	1.43E-02				
		36.00	8.21E-03				
20%	30			3.60E+01	1.37E-05	6.22E-03	33.04%
		24.00	1.56E-02				
		37.50	7.65E-03				
25%	30			5.63E+01	2.22E-05	6.22E-03	42.03%
		22.50	1.71E-02				
		39.00	7.14E-03				
30%	30			8.10E+01	3.37E-05	6.22E-03	51.86%
		21.00	1.88E-02				
		40.50	6.67E-03				
35%	30			1.10E+02	4.97E-05	6.22E-03	62.93%
		19.50	2.08E-02				
		42.00	6.29E-03				
40%	30			1.44E+02	7.21E-05	6.22E-03	75.79%
		18.00	2.33E-02				

Table D.2 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (Φ) and load 1375kN.

P=1375kN

COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.50	1.65E-02				
5%	30			2.25E+00	2.06E-06	7.40E-03	8.05%
		28.50	1.93E-02				
		33.00	1.52E-02				
10%	30			9.00E+00	8.35E-06	7.40E-03	16.22%
		27.00	2.10E-02				
		34.50	1.41E-02				
15%	30			2.03E+01	1.93E-05	7.40E-03	24.66%
		25.50	2.29E-02				
		36.00	1.31E-02				
20%	30			3.60E+01	3.63E-05	7.40E-03	33.81%
		24.00	2.51E-02				
		37.50	1.22E-02				
25%	30			5.63E+01	6.11E-05	7.40E-03	43.86%
		22.50	2.78E-02				
		39.00	1.13E-02				
30%	30			8.10E+01	9.70E-05	7.40E-03	55.27%
		21.00	3.10E-02				
		40.50	1.06E-02				
35%	30			1.10E+02	1.50E-04	7.40E-03	68.74%
		19.50	3.51E-02				
		42.00	9.90E-03				
40%	30			1.44E+02	2.30E-04	7.40E-03	85.12%
		18.00	4.02E-02				

Table D.3 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (Φ) and load 1750kN.

P=1750kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.50	2.35E-02				
5%	30			2.25E+00	1.20E-05	1.65E-02	13.30%
		28.50	2.80E-02				
		33.00	2.16E-02				
10%	30			9.00E+00	4.96E-05	1.65E-02	22.80%
		27.00	3.07E-02				
		34.50	2.00E-02				
15%	30			2.03E+01	9.71E-05	1.65E-02	32.90%
		25.50	3.39E-02				
		36.00	1.85E-02				
20%	30			3.60E+01	1.45E-04	1.65E-02	43.00%
		24.00	3.76E-02				
		37.50	1.71E-02				
25%	30			5.63E+01	1.88E-04	1.65E-02	54.80%
		22.50	4.22E-02				
		39.00	1.59E-02				
30%	30			8.10E+01	2.71E-04	1.65E-02	69.30%
		21.00	4.80E-02				
		40.50	1.49E-02				
35%	30			1.10E+02	3.70E-04	1.65E-02	81.60%
		19.50	5.55E-02				
		42.00	1.39E-02				
40%	30			1.44E+02	4.60E-04	1.65E-02	94.47%
		18.00	6.57E-02				

Table D.4 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (Φ) and load 2125kN.

P=2125kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.50	3.21E-02				
5%	30			2.25E+00	1.38E-04	2.98E-02	14.00%
		28.50	3.91E-02				
		33.00	2.93E-02				
10%	30			9.00E+00	1.01E-05	2.98E-02	21.80%
		27.00	4.34E-02				
		34.50	2.68E-02				
15%	30			2.03E+01	2.87E-05	2.98E-02	31.70%
		25.50	4.86E-02				
		36.00	2.47E-02				
20%	30			3.60E+01	5.91E-05	2.98E-02	43.70%
		24.00	5.49E-02				
		37.50	2.28E-02				
25%	30			5.63E+01	1.05E-04	2.98E-02	55.70%
		22.50	6.31E-02				
		39.00	2.11E-02				
30%	30			8.10E+01	1.73E-04	2.98E-02	70.64%
		21.00	7.41E-02				
		40.50	1.95E-02				
35%	30			1.10E+02	4.66E-04	2.98E-02	84.90%
		19.50	8.95E-02				
		42.00	1.82E-02				
40%	30			1.44E+02	6.67E-04	2.98E-02	97.55%
		18.00	1.12E-01				

Table D.5 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D)with varying (Φ) and load 2500kN.

P=2500kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.50	4.36E-02				
5%	30			2.25E+00	3.16E-05	4.77E-02	14.90%
		28.50	5.49E-02				
		33.00	4.07E-02				
10%	30			9.00E+00	1.16E-04	4.77E-02	23.40%
		27.00	6.22E-02				
		34.50	3.90E-02				
15%	30			2.03E+01	2.63E-04	4.77E-02	33.00%
		25.50	7.14E-02				
		36.00	3.76E-02				
20%	30			3.60E+01	5.23E-04	4.77E-02	45.50%
		24.00	8.33E-02				
		37.50	3.57E-02				
25%	30			5.63E+01	1.02E-03	4.77E-02	58.40%
		22.50	9.94E-02				
		39.00	3.18E-02				
30%	30			8.10E+01	1.16E-03	4.77E-02	71.49%
		21.00	1.00E-01				
		40.50	2.85E-02				
35%	30			1.10E+02	2.14E-03	4.77E-02	87.70%
		19.50	1.21E-01				
		42.00	2.46E-02				
40%	30			1.44E+02	2.47E-03	4.77E-02	105.30%
		18.00	1.24E-01				

Table D.6 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 1000kN.

P=1000kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	8.28E-07	8.12%
10%	9.00E+00	3.30E-06	16.23%
15%	2.03E+01	7.49E-06	24.44%
20%	3.60E+01	1.37E-05	33.04%
25%	5.63E+01	2.22E-05	42.03%
30%	8.10E+01	3.37E-05	51.86%
35%	1.10E+02	4.97E-05	62.93%
40%	1.44E+02	7.21E-05	75.79%

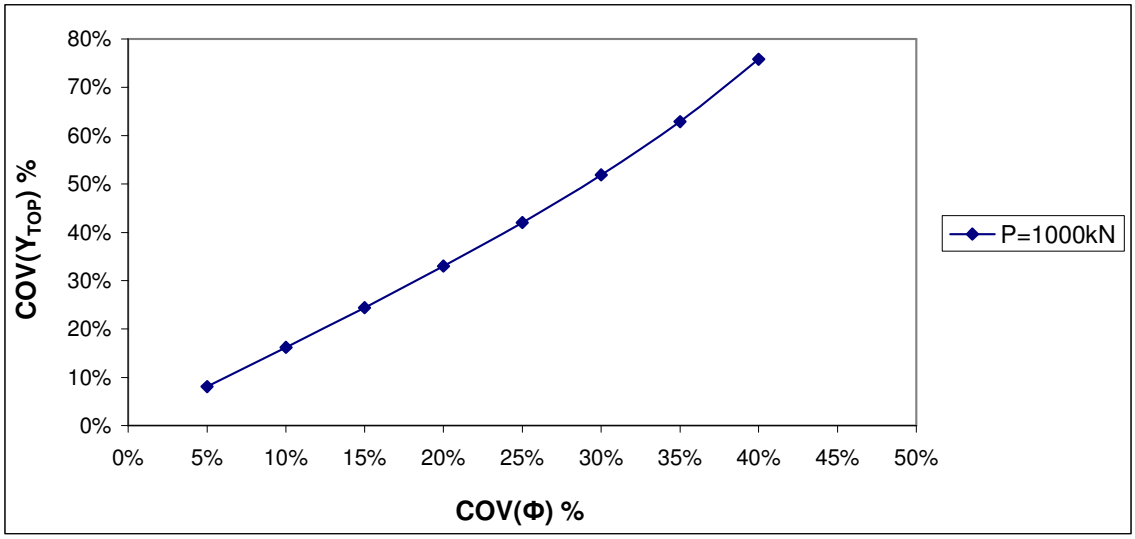


Fig. D.1 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.7 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 1375kN.

P=1375kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	2.06E-06	8.05%
10%	9.00E+00	8.35E-06	16.22%
15%	2.03E+01	1.93E-05	24.66%
20%	3.60E+01	3.63E-05	33.81%
25%	5.63E+01	6.11E-05	43.86%
30%	8.10E+01	9.70E-05	55.27%
35%	1.10E+02	1.50E-04	68.74%
40%	1.44E+02	2.30E-04	85.12%

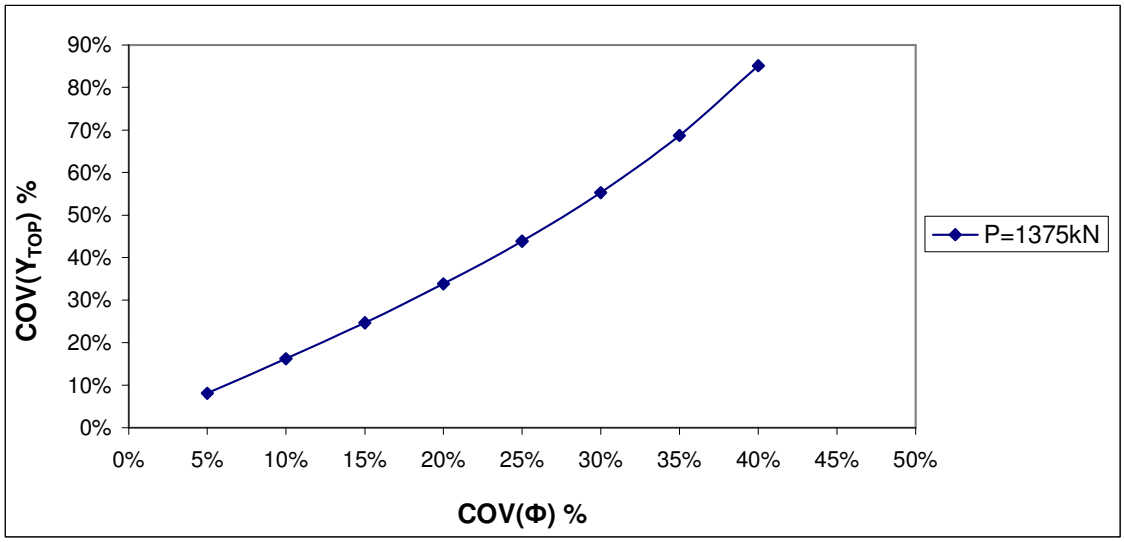


Fig. D.2 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.8 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 1750kN.

P=1750kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	5.06E-06	14.00%
10%	9.00E+00	2.06E-05	22.80%
15%	2.03E+01	4.83E-05	32.90%
20%	3.60E+01	9.18E-05	43.00%
25%	5.63E+01	1.58E-04	54.80%
30%	8.10E+01	2.58E-04	69.30%
35%	1.10E+02	4.14E-04	81.60%
40%	1.44E+02	6.73E-04	94.47%

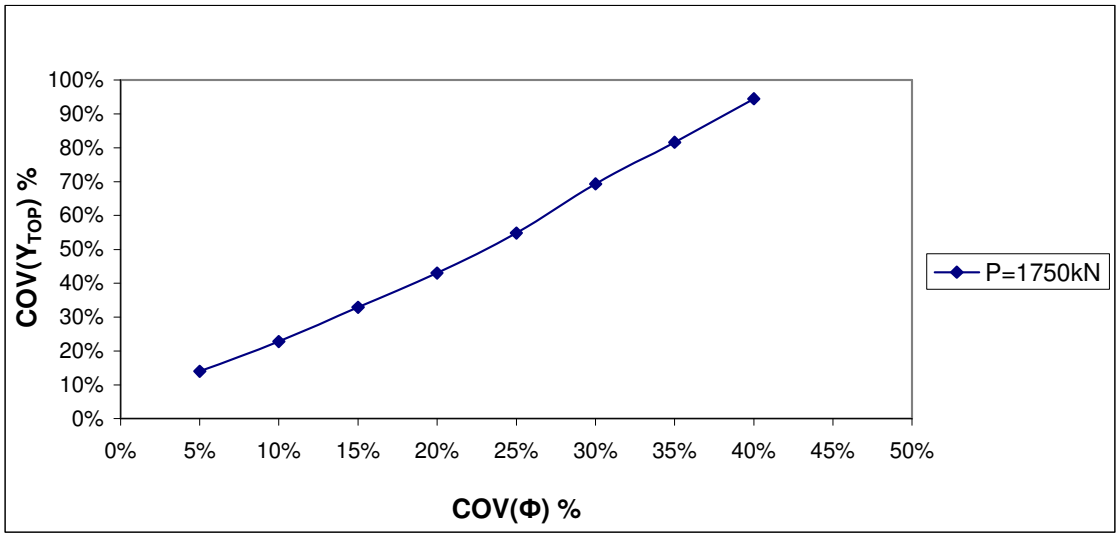


Fig. D.3 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.9 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 2125kN.

P=2125kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	1.20E-05	14.00%
10%	9.00E+00	4.96E-05	21.80%
15%	2.03E+01	1.18E-04	31.70%
20%	3.60E+01	2.29E-04	43.70%
25%	5.63E+01	4.06E-04	55.70%
30%	8.10E+01	7.04E-04	70.64%
35%	1.10E+02	1.22E-03	84.90%
40%	1.44E+02	2.19E-03	97.55%

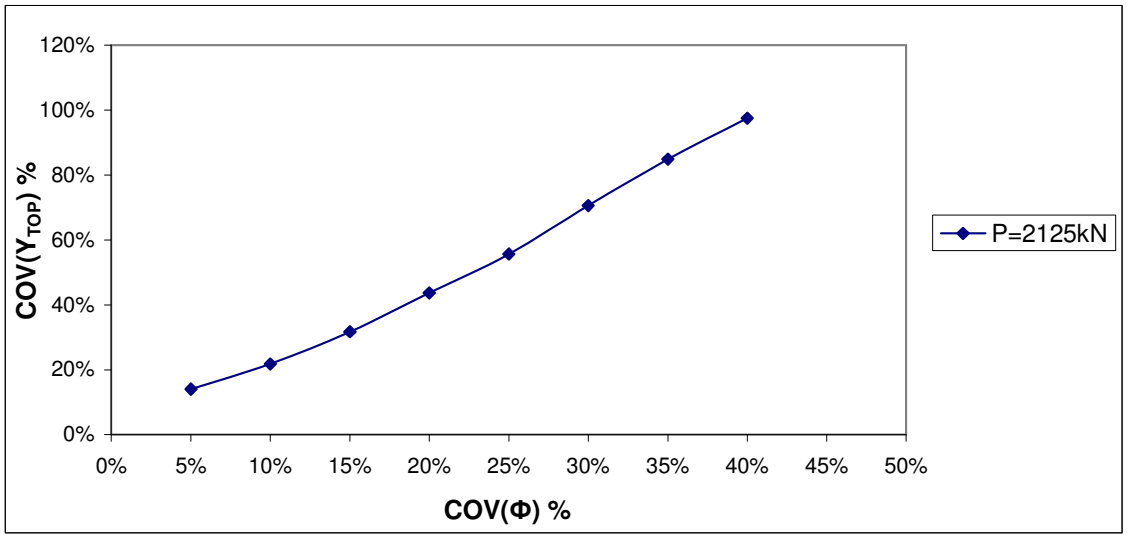


Fig. D.4 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.10 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 2500kN.

P=2500kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	3.16E-05	14.90%
10%	9.00E+00	1.31E-04	23.40%
15%	2.03E+01	3.22E-04	33.00%
20%	3.60E+01	6.51E-04	45.50%
25%	5.63E+01	1.22E-03	58.40%
30%	8.10E+01	2.24E-03	71.49%
35%	1.10E+02	4.04E-03	87.70%
40%	1.44E+02	7.37E-03	105.30%

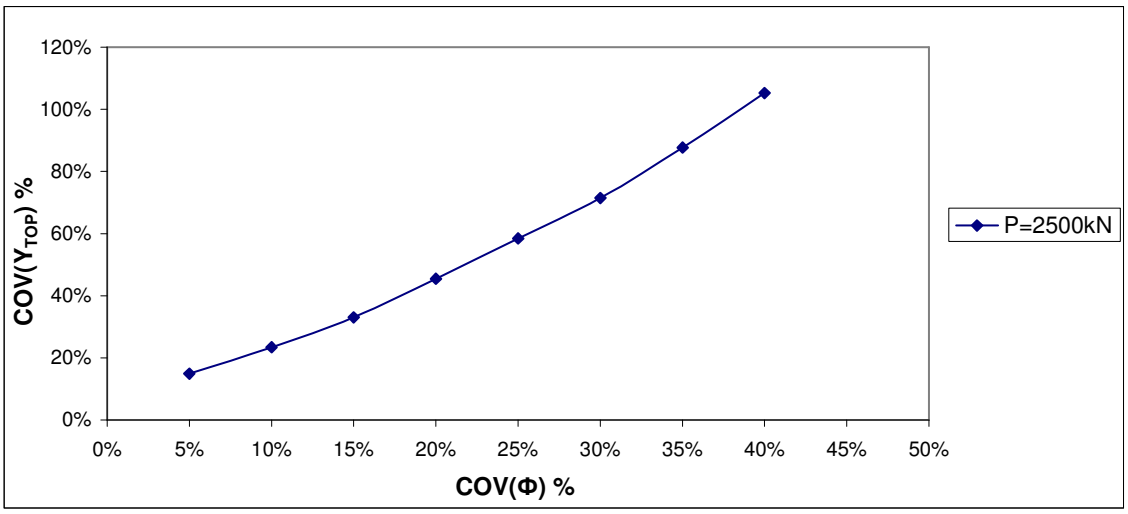


Fig. D.5 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

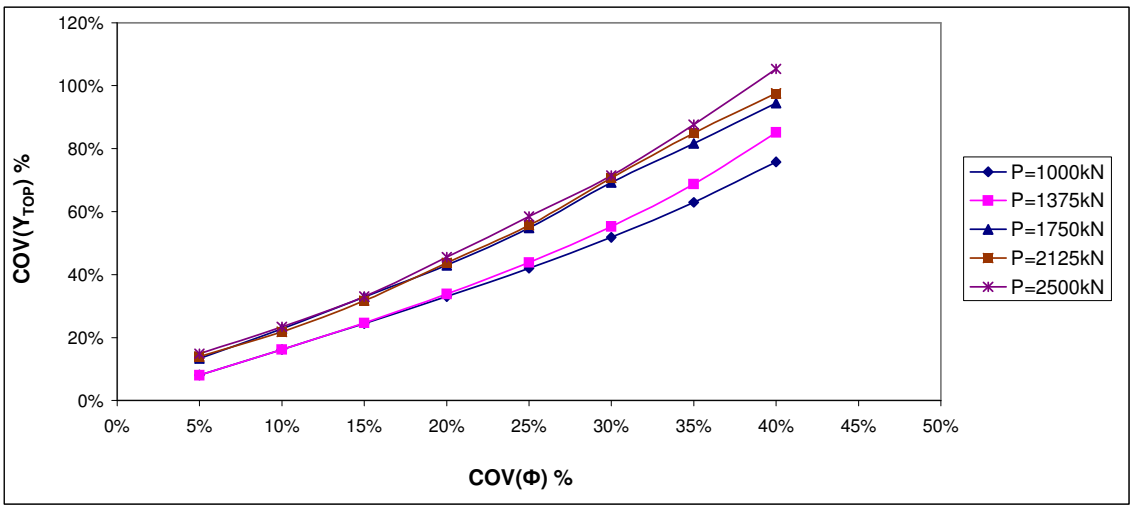


Fig. D.6 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table D.11 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (γ') and load 1000kN.

P=1000kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^{o} (m)	COV(Y_{TOP}) (%)
		11.03	1.08E-02				
5%	10.5			2.76E-01	1.37E-07	6.22E-03	3.30%
		9.98	1.16E-02				
		11.55	1.05E-02				
10%	10.5			1.10E+00	5.62E-07	6.22E-03	6.70%
		9.45	1.20E-02				
		12.08	1.02E-02				
15%	10.5			2.48E+00	1.30E-06	6.22E-03	10.18%
		8.93	1.25E-02				
		12.60	9.92E-03				
20%	10.5			4.41E+00	2.35E-06	6.22E-03	13.69%
		8.40	1.30E-02				
		13.13	9.66E-03				
25%	10.5			6.89E+00	3.80E-06	6.22E-03	17.41%
		7.88	1.36E-02				
		13.65	9.41E-03				
30%	10.5	3.15		9.92E+00	5.74E-06	6.22E-03	21.39%
		7.35	1.42E-02				
		14.18	9.18E-03				
35%	10.5			1.35E+01	8.21E-06	6.22E-03	25.59%
		6.83	1.49E-02				
		14.70	8.97E-03				
40%	10.5			1.76E+01	1.14E-05	6.22E-03	30.10%
		6.30	1.57E-02				

Table D.12 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (γ') and load 1375kN.

P=1375kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^{o} (m)	COV(Y_{TOP}) (%)
		11.03	1.73E-02				
5%	10.5			2.76E-01	3.42E-07	7.40E-03	3.28%
		9.98	1.84E-02				
		11.55	1.67E-02				
10%	10.5			1.10E+00	1.39E-06	7.40E-03	6.62%
		9.45	1.91E-02				
		12.08	1.63E-02				
15%	10.5			2.48E+00	3.22E-06	7.40E-03	10.07%
		8.93	1.99E-02				
		12.60	1.58E-02				
20%	10.5			4.41E+00	5.88E-06	7.40E-03	13.61%
		8.40	2.07E-02				
		13.13	1.54E-02				
25%	10.5			6.89E+00	9.58E-06	7.40E-03	17.37%
		7.88	2.16E-02				
		13.65	1.50E-02				
30%	10.5			9.92E+00	1.45E-05	7.40E-03	21.38%
		7.35	2.26E-02				
		14.18	1.47E-02				
35%	10.5			1.35E+01	2.11E-05	7.40E-03	25.79%
		6.83	2.39E-02				
		14.70	1.43E-02				
40%	10.5			1.76E+01	2.97E-05	7.40E-03	30.58%
		6.30	2.52E-02				

Table D.13 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (γ') and load 1750kN.

P=1750kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^{o} (m)	COV(Y_{TOP}) (%)
		11.03	2.47E-02				
5%	10.5			2.76E-01	8.37E-07	1.65E-02	4.03%
		9.98	2.65E-02				
		11.55	2.39E-02				
10%	10.5			1.10E+00	3.42E-06	1.65E-02	8.15%
		9.45	2.76E-02				
		12.08	2.32E-02				
15%	10.5			2.48E+00	7.90E-06	1.65E-02	12.38%
		8.93	2.88E-02				
		12.60	2.25E-02				
20%	10.5			4.41E+00	1.44E-05	1.65E-02	16.72%
		8.40	3.01E-02				
		13.13	2.19E-02				
25%	10.5			6.89E+00	2.37E-05	1.65E-02	21.43%
		7.88	3.16E-02				
		13.65	2.13E-02				
30%	10.5			9.92E+00	3.62E-05	1.65E-02	26.50%
		7.35	3.33E-02				
		14.18	2.08E-02				
35%	10.5			1.35E+01	5.26E-05	1.65E-02	31.96%
		6.83	3.53E-02				
		14.70	2.03E-02				
40%	10.5			1.76E+01	7.48E-05	1.65E-02	38.11%
		6.30	3.76E-02				

Table D.14 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (γ') and load 2125kN.

P=2125kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^{o} (m)	COV(Y_{TOP}) (%)
		11.03	3.40E-02				
5%	10.5			2.76E-01	2.00E-06	2.98E-02	4.75%
		9.98	3.69E-02				
		11.55	3.28E-02				
10%	10.5			1.10E+00	8.04E-06	2.98E-02	9.51%
		9.45	3.85E-02				
		12.08	3.17E-02				
15%	10.5			2.48E+00	1.86E-05	2.98E-02	14.48%
		8.93	4.04E-02				
		12.60	3.07E-02				
20%	10.5			4.41E+00	3.43E-05	2.98E-02	19.66%
		8.40	4.24E-02				
		13.13	2.98E-02				
25%	10.5	2.63		6.89E+00	5.66E-05	2.98E-02	25.25%
		7.88	4.48E-02				
		13.65	2.89E-02				
30%	10.5			9.92E+00	8.70E-05	2.98E-02	31.31%
		7.35	4.76E-02				
		14.18	2.80E-02				
35%	10.5			1.35E+01	1.29E-04	2.98E-02	38.12%
		6.83	5.07E-02				
		14.70	2.74E-02				
40%	10.5			1.76E+01	1.84E-04	2.98E-02	45.49%
		6.30	5.45E-02				

Table D.15 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (γ) and load 2500kN.

P=2500kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^o (m)	COV(Y_{TOP}) (%)
		11.03	4.67E-02				
5%	10.5			2.76E-01	5.09E-06	4.77E-02	4.73%
		9.98	5.12E-02				
		11.55	4.47E-02				
10%	10.5			1.10E+00	2.10E-05	4.77E-02	9.60%
		9.45	5.39E-02				
		12.08	4.30E-02				
15%	10.5			2.48E+00	4.87E-05	4.77E-02	14.63%
		8.93	5.69E-02				
		12.60	4.14E-02				
20%	10.5			4.41E+00	9.05E-05	4.77E-02	19.95%
		8.40	6.05E-02				
		13.13	4.00E-02				
25%	10.5			6.89E+00	1.51E-04	4.77E-02	25.72%
		7.88	6.46E-02				
		13.65	3.87E-02				
30%	10.5			9.92E+00	2.35E-04	4.77E-02	32.13%
		7.35	6.94E-02				
		14.18	3.75E-02				
35%	10.5			1.35E+01	3.52E-04	4.77E-02	39.35%
		6.83	7.50E-02				
		14.70	3.64E-02				
40%	10.5			1.76E+01	5.17E-04	4.77E-02	47.66%
		6.30	8.19E-02				

Table D.16 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 1000kN.

P=1000kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	1.37E-07	3.30%
10%	1.10E+00	5.62E-07	6.70%
15%	2.48E+00	1.30E-06	10.18%
20%	4.41E+00	2.35E-06	13.69%
25%	6.89E+00	3.80E-06	17.41%
30%	9.92E+00	5.74E-06	21.39%
35%	1.35E+01	8.21E-06	25.59%
40%	1.76E+01	1.14E-05	30.10%

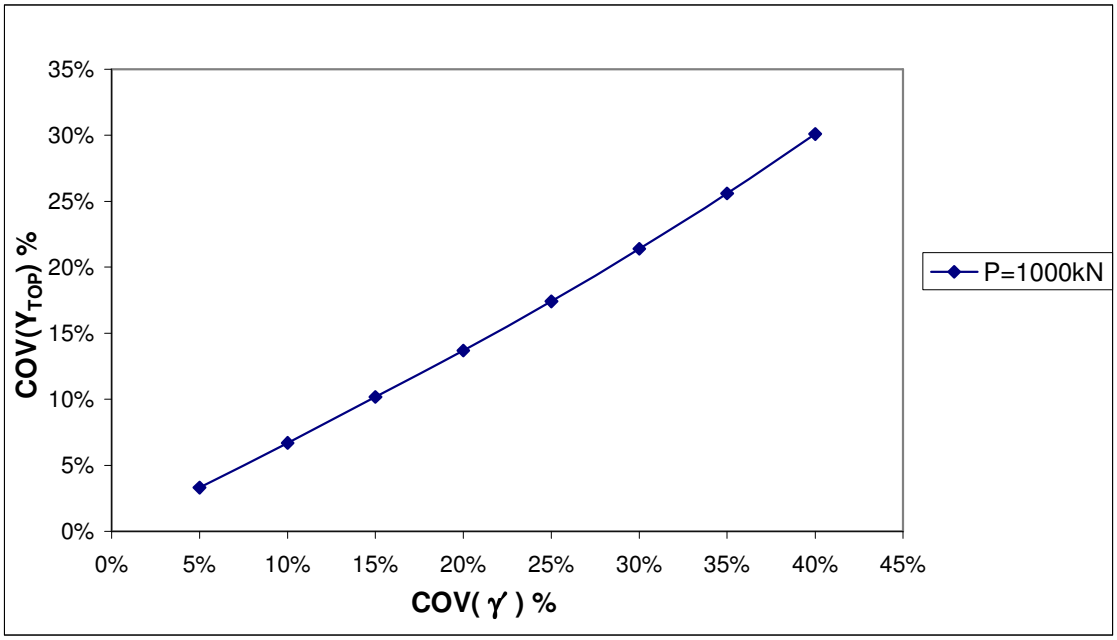


Fig. D.7 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.17 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 1375kN.

P=1375kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	3.42E-07	3.28%
10%	1.10E+00	1.39E-06	6.62%
15%	2.48E+00	3.22E-06	10.07%
20%	4.41E+00	5.88E-06	13.61%
25%	6.89E+00	9.58E-06	17.37%
30%	9.92E+00	1.45E-05	21.38%
35%	1.35E+01	2.11E-05	25.79%
40%	1.76E+01	2.97E-05	30.58%

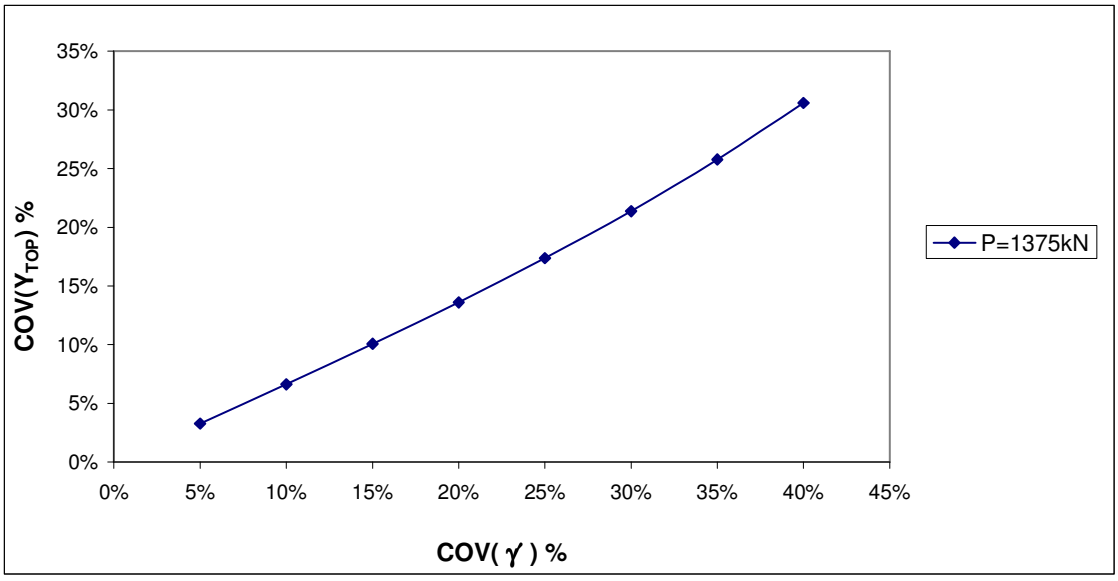


Fig. D.8 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1357kN.

Table D.18 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 1750kN.

P=1750kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	8.37E-07	4.03%
10%	1.10E+00	3.42E-06	8.15%
15%	2.48E+00	7.90E-06	12.38%
20%	4.41E+00	1.44E-05	16.72%
25%	6.89E+00	2.37E-05	21.43%
30%	9.92E+00	3.62E-05	26.50%
35%	1.35E+01	5.26E-05	31.96%
40%	1.76E+01	7.48E-05	38.11%

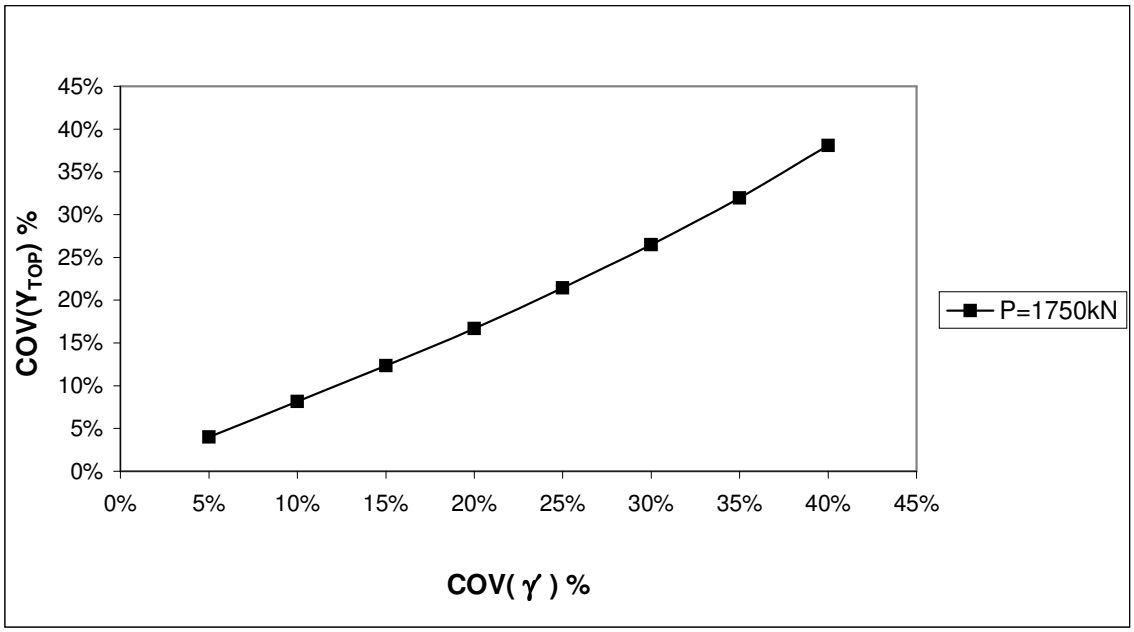


Fig. D.9 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.19 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 2125kN.

P=2125kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	2.00E-06	4.75%
10%	1.10E+00	8.04E-06	9.51%
15%	2.48E+00	1.86E-05	14.48%
20%	4.41E+00	3.43E-05	19.66%
25%	6.89E+00	5.66E-05	25.25%
30%	9.92E+00	8.70E-05	31.31%
35%	1.35E+01	1.29E-04	38.12%
40%	1.76E+01	1.84E-04	45.49%

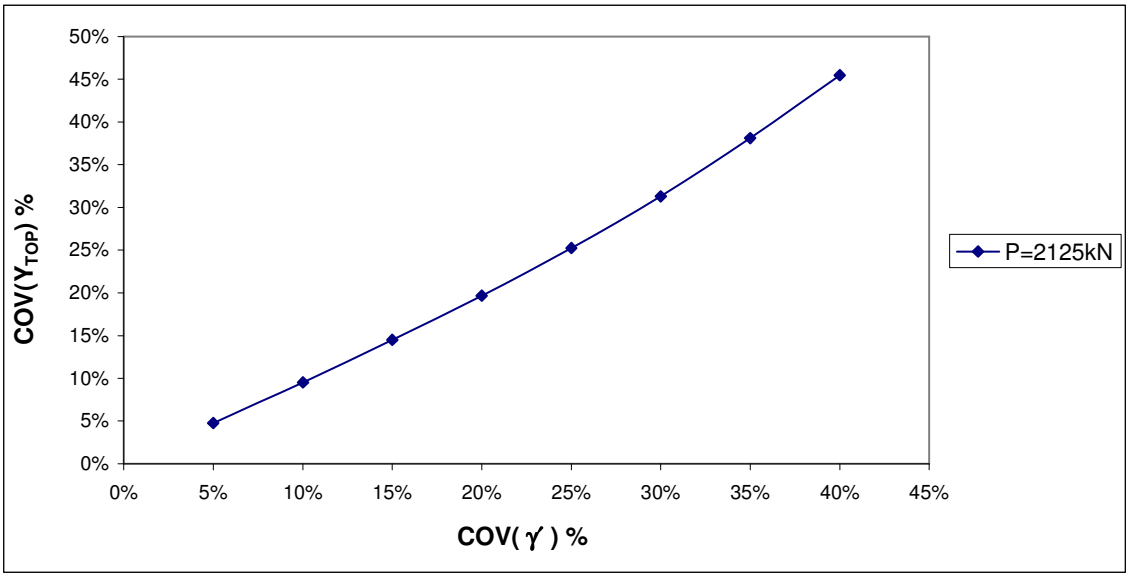


Fig. D.10 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.20 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 2500kN.

P=2500kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	5.09E-06	4.73%
10%	1.10E+00	2.10E-05	9.60%
15%	2.48E+00	4.87E-05	14.63%
20%	4.41E+00	9.05E-05	19.95%
25%	6.89E+00	1.51E-04	25.72%
30%	9.92E+00	2.35E-04	32.13%
35%	1.35E+01	3.52E-04	39.35%
40%	1.76E+01	5.17E-04	47.66%

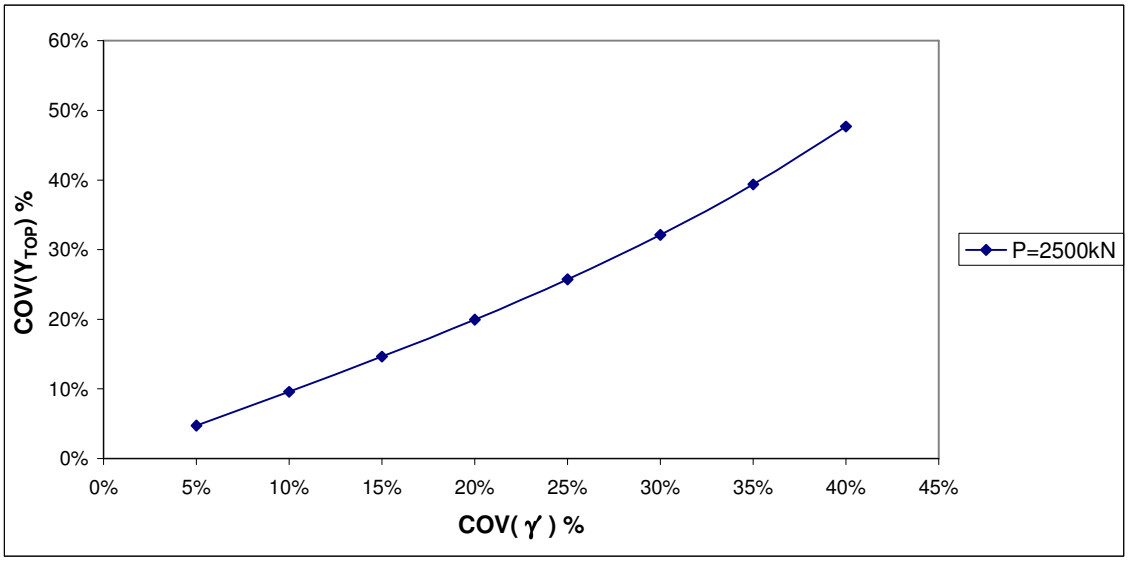


Fig. D.11 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

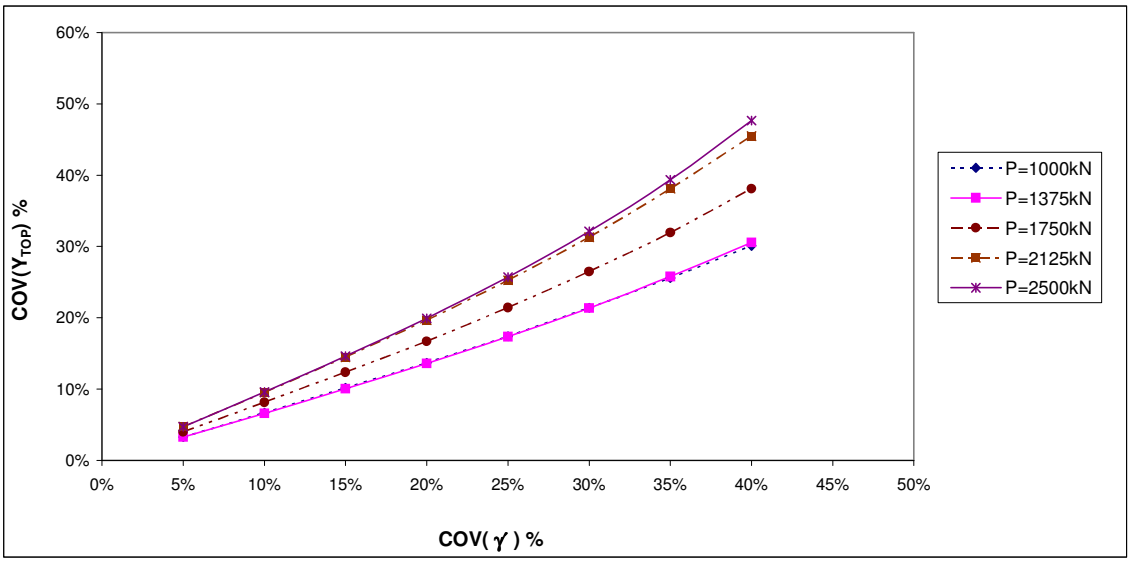


Fig. D.12 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table D.21 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (k) and load 1000kN.

P=1000kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	1.14E-02				
5%	16300			6.64E+05	9.00E-10	6.22E-03	0.27%
		15485	1.12E-02				
		17930	1.12E-02				
10%	16300			2.66E+06	3.02E-09	6.22E-03	0.49%
		14670	1.13E-02				
		18745	1.11E-02				
15%	16300			5.98E+06	5.62E-09	6.22E-03	0.67%
		13855	1.13E-02				
		19560	1.11E-02				
20%	16300			1.06E+07	1.10E-08	6.22E-03	0.94%
		13040	1.13E-02				
		20375	1.11E-02				
25%	16300			1.66E+07	1.82E-08	6.22E-03	1.21%
		12225	1.14E-02				
		21190	1.11E-02				
30%	16300			2.39E+07	3.06E-08	6.22E-03	1.56%
		11410	1.15E-02				
		22005	1.11E-02				
35%	16300			3.25E+07	4.62E-08	6.22E-03	1.92%
		10595	1.15E-02				
		22820	1.11E-02				
40%	16300			4.25E+07	7.02E-08	6.22E-03	2.37%
		9780	1.16E-02				

Table D.22 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (k) and load 1375kN.

P=1375kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	1.78E-02				
5%	16300			6.64E+05	9.00E-10	7.40E-03	0.18%
		15485	1.79E-02				
		17930	1.78E-02				
10%	16300			2.66E+06	3.02E-09	7.40E-03	0.33%
		14670	1.79E-02				
		18745	1.78E-02				
15%	16300			5.98E+06	6.40E-09	7.40E-03	0.48%
		13855	1.79E-02				
		19560	1.77E-02				
20%	16300			1.06E+07	1.21E-08	7.40E-03	0.67%
		13040	1.80E-02				
		20375	1.77E-02				
25%	16300			1.66E+07	2.10E-08	7.40E-03	0.88%
		12225	1.80E-02				
		21190	1.77E-02				
30%	16300			2.39E+07	3.42E-08	7.40E-03	1.12%
		11410	1.81E-02				
		22005	1.77E-02				
35%	16300			3.25E+07	5.52E-08	7.40E-03	1.42%
		10595	1.82E-02				
		22820	1.77E-02				
40%	16300			4.25E+07	7.84E-08	7.40E-03	1.70%
		9780	1.83E-02				

Table D.23 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (k) and load 1750kN.

P=1750kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	2.57E-02				
5%	16300			6.64E+05	9.00E-10	1.65E-02	0.13%
		15485	2.56E-02				
		17930	2.55E-02				
10%	16300			2.66E+06	4.22E-09	1.65E-02	0.29%
		14670	2.57E-02				
		18745	2.55E-02				
15%	16300			5.98E+06	9.03E-09	1.65E-02	0.42%
		13855	2.57E-02				
		19560	2.55E-02				
20%	16300			1.06E+07	1.82E-08	1.65E-02	0.59%
		13040	2.58E-02				
		20375	2.55E-02				
25%	16300			1.66E+07	2.89E-08	1.65E-02	0.75%
		12225	2.58E-02				
		21190	2.55E-02				
30%	16300			2.39E+07	4.84E-08	1.65E-02	0.97%
		11410	2.59E-02				
		22005	2.54E-02				
35%	16300			3.25E+07	7.29E-08	1.65E-02	1.19%
		10595	2.60E-02				
		22820	2.54E-02				
40%	16300			4.25E+07	1.12E-07	1.65E-02	1.48%
		9780	2.61E-02				

Table D.24 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (k) and load 2125kN.

P=2125kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	3.53E-02				
5%	16300			6.64E+05	1.60E-09	2.98E-02	0.13%
		15485	3.54E-02				
		17930	3.53E-02				
10%	16300			2.66E+06	5.62E-09	2.98E-02	0.25%
		14670	3.55E-02				
		18745	3.53E-02				
15%	16300			5.98E+06	1.44E-08	2.98E-02	0.40%
		13855	3.55E-02				
		19560	3.53E-02				
20%	16300			1.06E+07	2.89E-08	2.98E-02	0.57%
		13040	3.56E-02				
		20375	3.52E-02				
25%	16300			1.66E+07	4.84E-08	2.98E-02	0.74%
		12225	3.57E-02				
		21190	3.52E-02				
30%	16300			2.39E+07	7.56E-08	2.98E-02	0.92%
		11410	3.58E-02				
		22005	3.52E-02				
35%	16300			3.25E+07	1.19E-07	2.98E-02	1.16%
		10595	3.59E-02				
		22820	3.52E-02				
40%	16300			4.25E+07	1.81E-07	2.98E-02	1.43%
		9780	3.60E-02				

Table D.25 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (k) and load 2500kN.

P=2500kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	4.87E-02				
5%	16300			6.64E+05	3.02E-09	4.77E-02	0.12%
		15485	4.88E-02				
		17930	4.87E-02				
10%	16300			2.66E+06	1.00E-08	4.77E-02	0.21%
		14670	4.89E-02				
		18745	4.86E-02				
15%	16300			5.98E+06	2.56E-08	4.77E-02	0.34%
		13855	4.90E-02				
		19560	4.86E-02				
20%	16300			1.06E+07	4.84E-08	4.77E-02	0.46%
		13040	4.90E-02				
		20375	4.86E-02				
25%	16300			1.66E+07	8.41E-08	4.77E-02	0.61%
		12225	4.91E-02				
		21190	4.85E-02				
30%	16300			2.39E+07	1.37E-07	4.77E-02	0.78%
		11410	4.93E-02				
		22005	4.85E-02				
35%	16300			3.25E+07	2.12E-07	4.77E-02	0.96%
		10595	4.94E-02				
		22820	4.85E-02				
40%	16300			4.25E+07	3.31E-07	4.77E-02	1.21%
		9780	4.96E-02				

Table D.26 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 1000kN.

P=1000kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	9.00E-10	0.27%
10%	2.66E+06	3.02E-09	0.49%
15%	5.98E+06	5.62E-09	0.67%
20%	1.06E+07	1.10E-08	0.94%
25%	1.66E+07	1.82E-08	1.21%
30%	2.39E+07	3.06E-08	1.56%
35%	3.25E+07	4.62E-08	1.92%
40%	4.25E+07	7.02E-08	2.37%

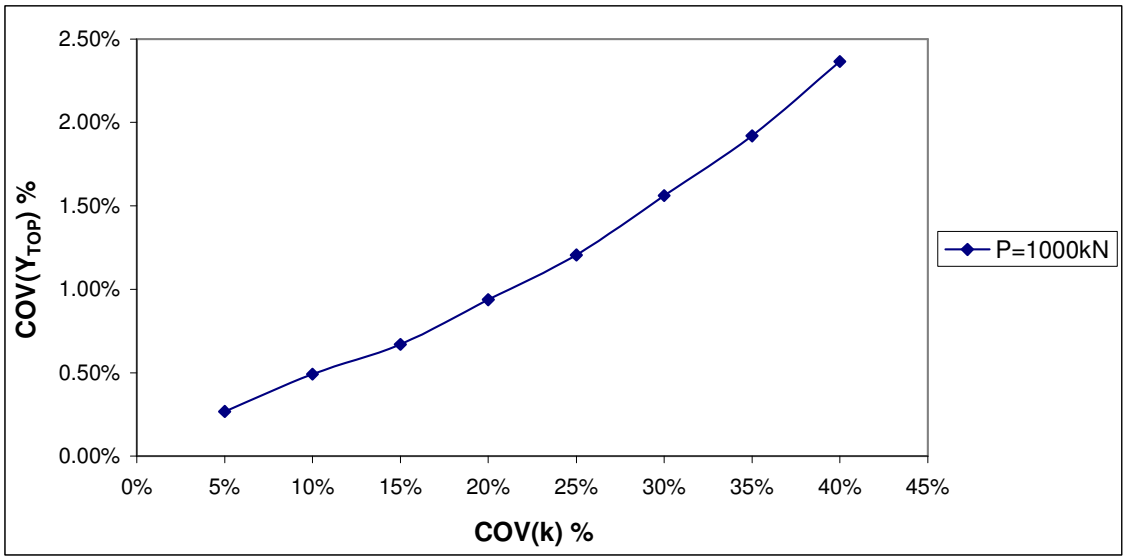


Fig. D.13 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.27 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 1375kN.

P=1375kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	9.00E-10	0.18%
10%	2.66E+06	3.02E-09	0.33%
15%	5.98E+06	6.40E-09	0.48%
20%	1.06E+07	1.21E-08	0.67%
25%	1.66E+07	2.10E-08	0.88%
30%	2.39E+07	3.42E-08	1.12%
35%	3.25E+07	5.52E-08	1.42%
40%	4.25E+07	7.84E-08	1.70%

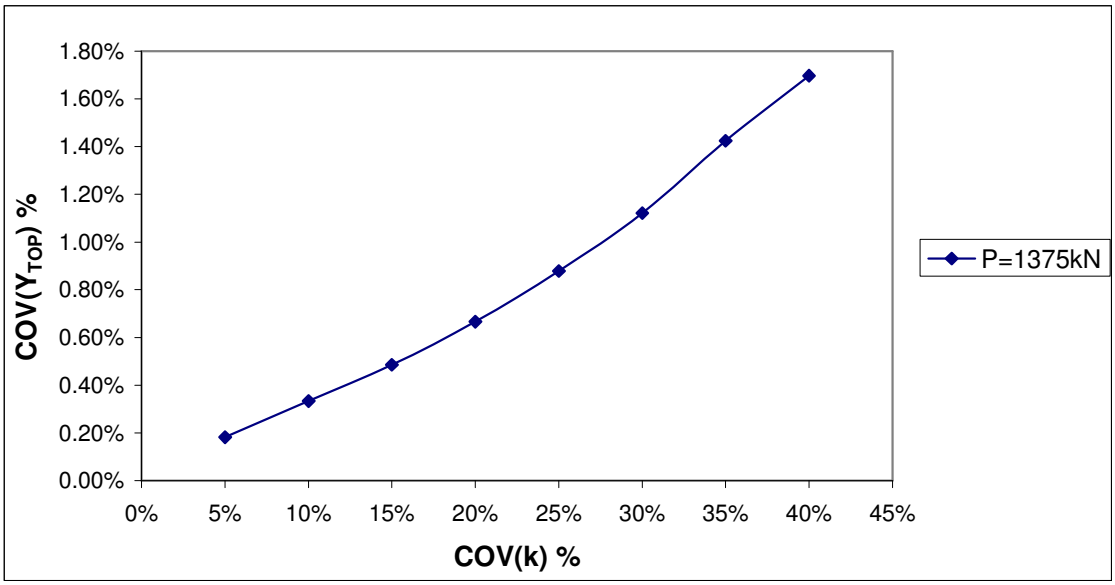


Fig. D.14 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.28 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 1750kN.

P=1750kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	9.00E-10	0.13%
10%	2.66E+06	4.22E-09	0.29%
15%	5.98E+06	9.03E-09	0.42%
20%	1.06E+07	1.82E-08	0.59%
25%	1.66E+07	2.89E-08	0.75%
30%	2.39E+07	4.84E-08	0.97%
35%	3.25E+07	7.29E-08	1.19%
40%	4.25E+07	1.12E-07	1.48%

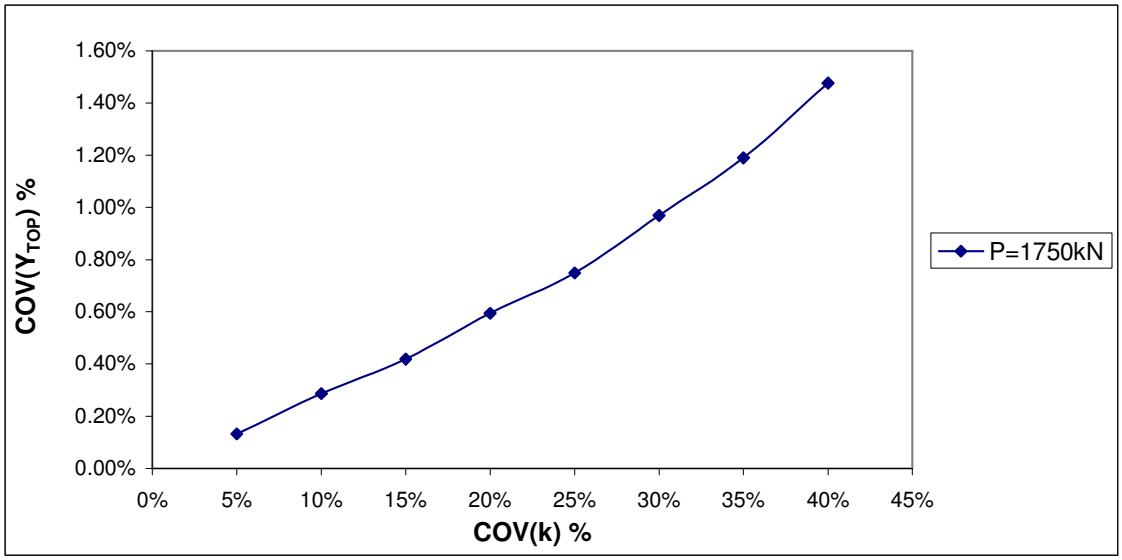


Fig. D.15 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.29 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 2125kN.

P=2125kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	1.60E-09	0.13%
10%	2.66E+06	5.62E-09	0.25%
15%	5.98E+06	1.44E-08	0.40%
20%	1.06E+07	2.89E-08	0.57%
25%	1.66E+07	4.84E-08	0.74%
30%	2.39E+07	7.56E-08	0.92%
35%	3.25E+07	1.19E-07	1.16%
40%	4.25E+07	1.81E-07	1.43%

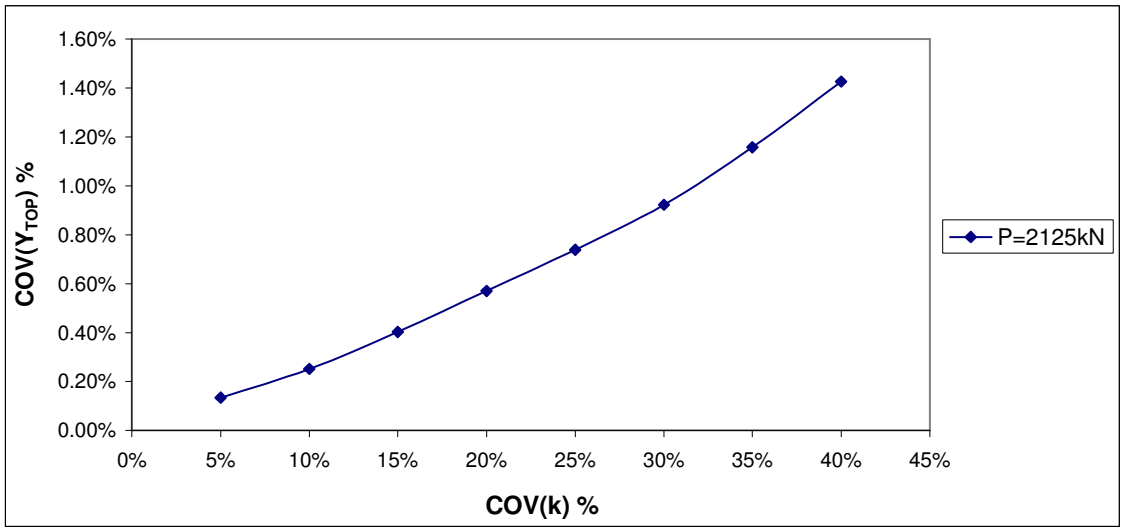


Fig. D.16 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.30 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 2500kN.

P=2500kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	3.02E-09	0.12%
10%	2.66E+06	1.00E-08	0.21%
15%	5.98E+06	2.56E-08	0.34%
20%	1.06E+07	4.84E-08	0.46%
25%	1.66E+07	8.41E-08	0.61%
30%	2.39E+07	1.37E-07	0.78%
35%	3.25E+07	2.12E-07	0.96%
40%	4.25E+07	3.31E-07	1.21%

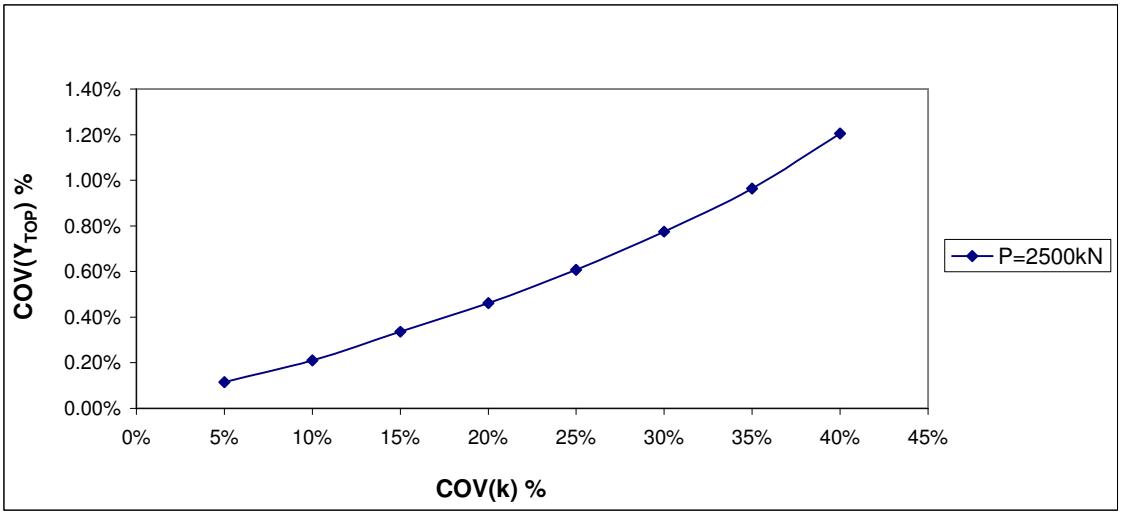


Fig. D.17 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

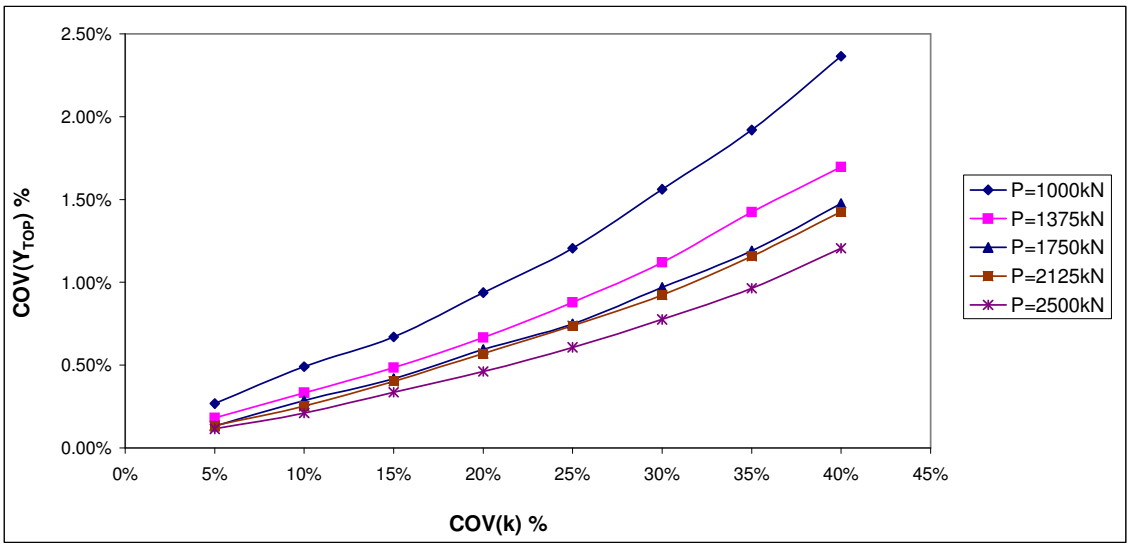


Fig. D.18 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table D.31 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (B) and load 1000kN.

P=1000kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.4263	8.23E-03				
5%	0.406			4.12E-04	1.82E-08	6.22E-03	1.17%
		0.3857	8.50E-03				
		0.4466	8.15E-03				
10%	0.406			1.65E-03	3.80E-08	6.22E-03	1.56%
		0.3654	8.54E-03				
		0.4669	8.05E-03				
15%	0.406			3.71E-03	7.45E-08	6.22E-03	2.22%
		0.3451	8.60E-03				
		0.4872	8.05E-03				
20%	0.406			6.59E-03	8.97E-08	6.22E-03	2.57%
		0.3248	8.65E-03				
		0.5075	7.97E-03				
25%	0.406			1.03E-02	1.34E-07	6.22E-03	3.27%
		0.3045	8.70E-03				
		0.5278	7.84E-03				
30%	0.406			1.48E-02	2.16E-07	6.22E-03	4.15%
		0.2842	8.77E-03				
		0.5472	7.71E-03				
35%	0.406			2.02E-02	3.36E-07	6.22E-03	5.18%
		0.2648	8.86E-03				
		0.5684	7.59E-03				
40%	0.406			2.64E-02	4.75E-07	6.22E-03	6.15%
		0.2436	8.97E-03				

Table D.32 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (B) and load 1375kN.

P=1375kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.4263	1.35E-02				
5%	0.406			4.12E-04	1.23E-09	7.40E-03	0.21%
		0.3857	1.36E-02				
		0.4466	1.34E-02				
10%	0.406			1.65E-03	7.23E-09	7.40E-03	0.52%
		0.3654	1.36E-02				
		0.4669	1.33E-02				
15%	0.406			3.71E-03	1.82E-08	7.40E-03	0.82%
		0.3451	1.36E-02				
		0.4872	1.32E-02				
20%	0.406			6.59E-03	4.20E-08	7.40E-03	1.05%
		0.3248	1.36E-02				
		0.5075	1.31E-02				
25%	0.406			1.03E-02	6.76E-08	7.40E-03	1.58%
		0.3045	1.37E-02				
		0.5278	1.30E-02				
30%	0.406			1.48E-02	1.41E-07	7.40E-03	2.27%
		0.2842	1.38E-02				
		0.5472	1.29E-02				
35%	0.406			2.02E-02	2.79E-07	7.40E-03	3.20%
		0.2648	1.39E-02				
		0.5684	1.28E-02				
40%	0.406			2.64E-02	5.70E-07	7.40E-03	4.58%
		0.2436	1.43E-02				

Table D.33 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (B) and load 1750kN.

P=1750kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	1.91E-02				
5%	0.406			4.12E-04	2.50E-09	1.65E-02	0.22%
		0.3857	1.90E-02				
		0.4466	1.90E-02				
10%	0.406			1.65E-03	2.50E-09	1.65E-02	0.22%
		0.3654	1.91E-02				
		0.4669	1.89E-02				
15%	0.406			3.71E-03	2.40E-08	1.65E-02	0.68%
		0.3451	1.92E-02				
		0.4872	1.89E-02				
20%	0.406			6.59E-03	4.41E-08	1.65E-02	0.93%
		0.3248	1.93E-02				
		0.5075	1.88E-02				
25%	0.406			1.03E-02	1.12E-07	1.65E-02	1.48%
		0.3045	1.95E-02				
		0.5278	1.88E-02				
30%	0.406			1.48E-02	3.14E-07	1.65E-02	2.47%
		0.2842	1.99E-02				
		0.5472	1.87E-02				
35%	0.406			2.02E-02	8.67E-07	1.65E-02	4.10%
		0.2648	2.05E-02				
		0.5684	1.86E-02				
40%	0.406			2.64E-02	2.87E-06	1.65E-02	7.47%
		0.2436	2.20E-02				

Table D.34 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (B) and load 2125kN.

P=2125kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	2.53E-02				
5%	0.406			4.12E-04	2.50E-09	2.98E-02	0.17%
		0.3857	2.54E-02				
		0.4466	2.52E-02				
10%	0.406			1.65E-03	4.00E-08	2.98E-02	0.67%
		0.3654	2.56E-02				
		0.4669	2.51E-02				
15%	0.406			3.71E-03	1.68E-07	2.98E-02	1.38%
		0.3451	2.59E-02				
		0.4872	2.51E-02				
20%	0.406			6.59E-03	3.60E-07	2.98E-02	2.01%
		0.3248	2.63E-02				
		0.5075	2.50E-02				
25%	0.406			1.03E-02	8.19E-07	2.98E-02	3.04%
		0.3045	2.68E-02				
		0.5278	2.50E-02				
30%	0.406			1.48E-02	2.36E-06	2.98E-02	5.15%
		0.2842	2.80E-02				
		0.5472	2.49E-02				
35%	0.406			2.02E-02	8.78E-06	2.98E-02	9.95%
		0.2648	3.08E-02				
		0.5684	2.48E-02				
40%	0.406			2.64E-02	3.49E-05	2.98E-02	19.82%
		0.2436	3.66E-02				

Table D.35 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (B) and load 2500kN.

P=2500kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	3.23E-02				
5%	0.406			4.12E-04	6.43E-07	4.77E-02	1.66%
		0.3857	3.39E-02				
		0.4466	3.23E-02				
10%	0.406			1.65E-03	6.43E-07	4.77E-02	1.66%
		0.3654	3.39E-02				
		0.4669	3.21E-02				
15%	0.406			3.71E-03	8.93E-07	4.77E-02	1.98%
		0.3451	3.40E-02				
		0.4872	3.20E-02				
20%	0.406			6.59E-03	2.09E-06	4.77E-02	3.03%
		0.3248	3.49E-02				
		0.5075	3.19E-02				
25%	0.406			1.03E-02	6.08E-06	4.77E-02	5.17%
		0.3045	3.69E-02				
		0.5278	3.18E-02				
30%	0.406			1.48E-02	2.23E-05	4.77E-02	9.91%
		0.2842	4.13E-02				
		0.5472	3.18E-02				
35%	0.406			2.02E-02	7.65E-05	4.77E-02	18.33%
		0.2648	4.91E-02				
		0.5684	3.17E-02				
40%	0.406			2.64E-02	1.96E-04	4.77E-02	29.37%
		0.2436	5.97E-02				

Table D.36 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 1000kN.

P=1000kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.82E-08	1.17%
10%	1.65E-03	3.80E-08	1.56%
15%	3.71E-03	7.45E-08	2.22%
20%	6.59E-03	8.97E-08	2.57%
25%	1.03E-02	1.34E-07	3.27%
30%	1.48E-02	2.16E-07	4.15%
35%	2.02E-02	3.36E-07	5.18%
40%	2.64E-02	4.75E-07	6.15%

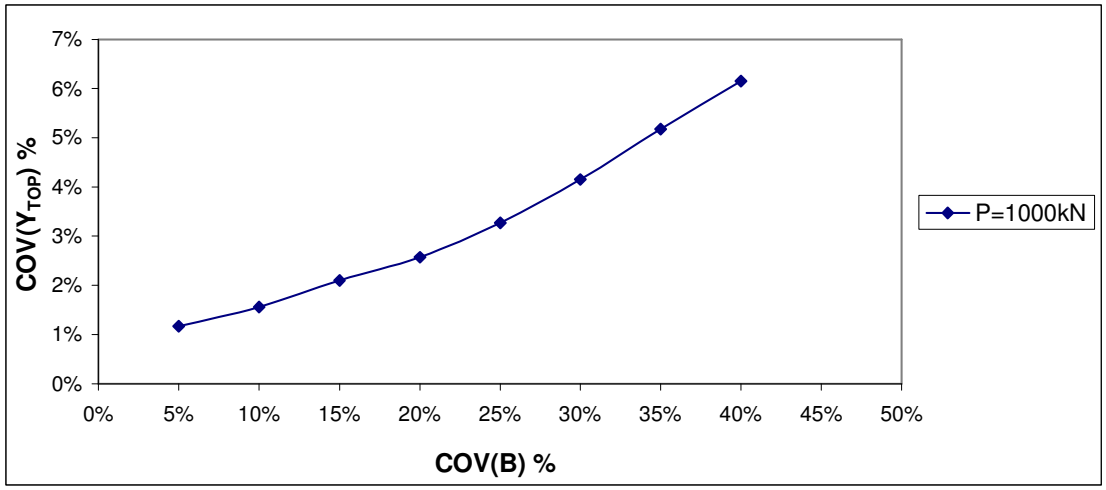


Fig. D.19 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.37 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load1375kN.

P=1375kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.23E-09	0.21%
10%	1.65E-03	7.23E-09	0.52%
15%	3.71E-03	1.82E-08	0.82%
20%	6.59E-03	4.20E-08	1.05%
25%	1.03E-02	6.76E-08	1.58%
30%	1.48E-02	1.41E-07	2.27%
35%	2.02E-02	2.79E-07	3.20%
40%	2.64E-02	5.70E-07	4.58%

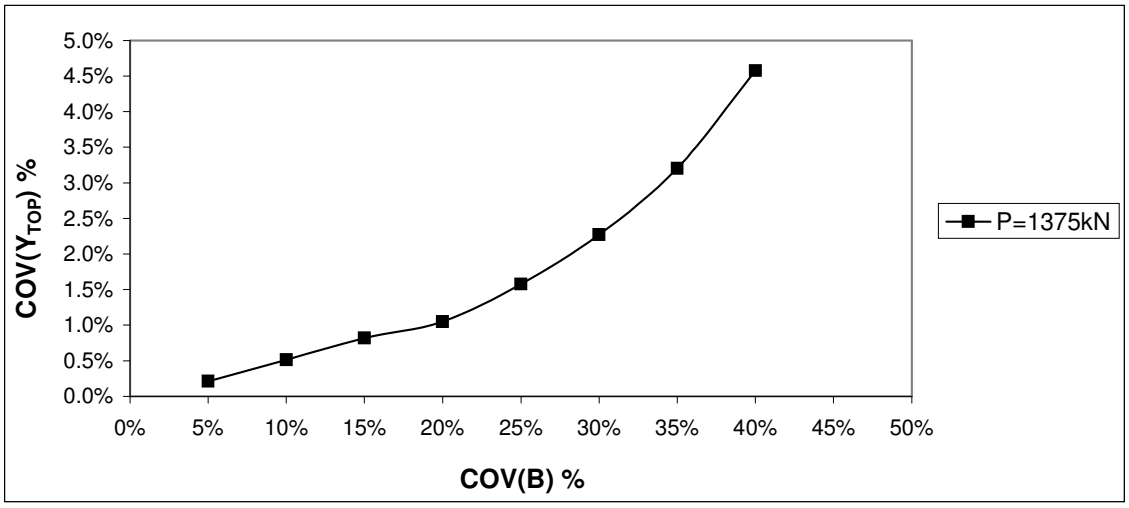


Fig. D.20 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.38 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 1750kN.

P=1750kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	2.50E-09	0.22%
10%	1.65E-03	2.50E-09	0.22%
15%	3.71E-03	2.40E-08	0.68%
20%	6.59E-03	4.41E-08	0.93%
25%	1.03E-02	1.12E-07	1.48%
30%	1.48E-02	3.14E-07	2.47%
35%	2.02E-02	8.67E-07	4.10%
40%	2.64E-02	2.87E-06	7.47%

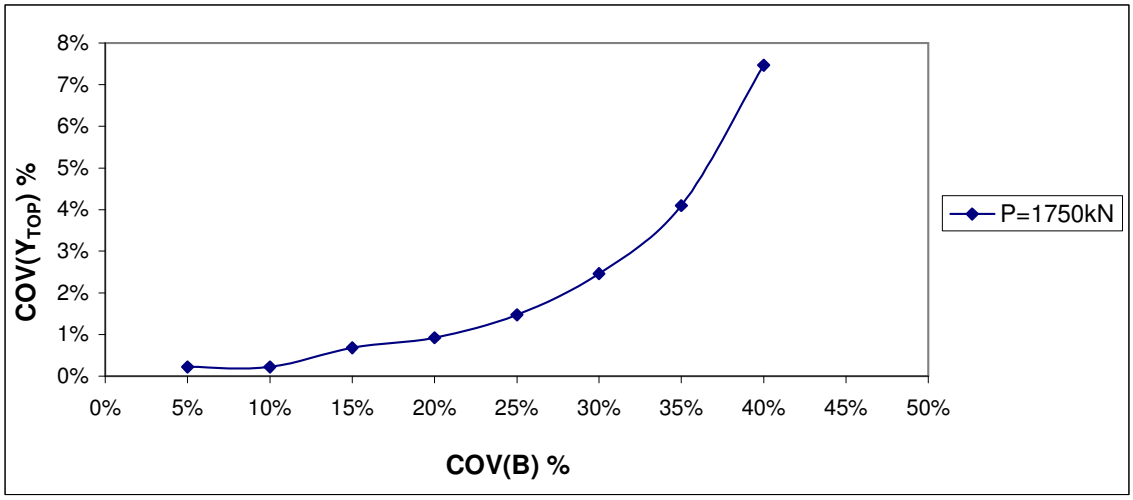


Fig. D.21 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.39 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 2125kN.

P=2125kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	2.50E-09	0.17%
10%	1.65E-03	4.00E-08	0.67%
15%	3.71E-03	1.68E-07	1.38%
20%	6.59E-03	3.60E-07	2.01%
25%	1.03E-02	8.19E-07	3.04%
30%	1.48E-02	2.36E-06	5.15%
35%	2.02E-02	8.78E-06	9.95%
40%	2.64E-02	3.49E-05	19.82%

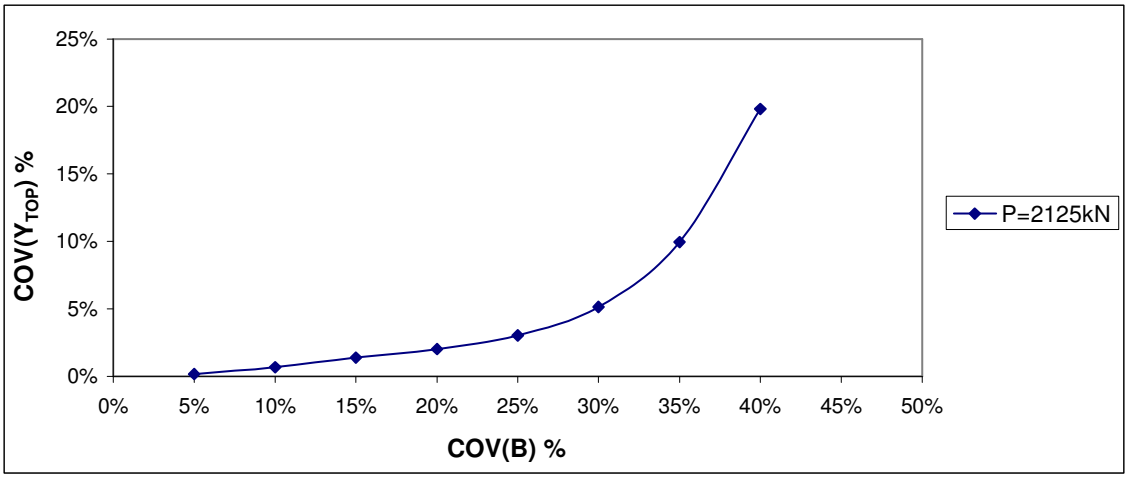


Fig. D.22 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.40 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 2500kN.

P=2500kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	6.43E-07	1.66%
10%	1.65E-03	6.43E-07	1.66%
15%	3.71E-03	8.93E-07	1.98%
20%	6.59E-03	2.09E-06	3.03%
25%	1.03E-02	6.08E-06	5.17%
30%	1.48E-02	2.23E-05	9.91%
35%	2.02E-02	7.65E-05	18.33%
40%	2.64E-02	1.96E-04	29.37%

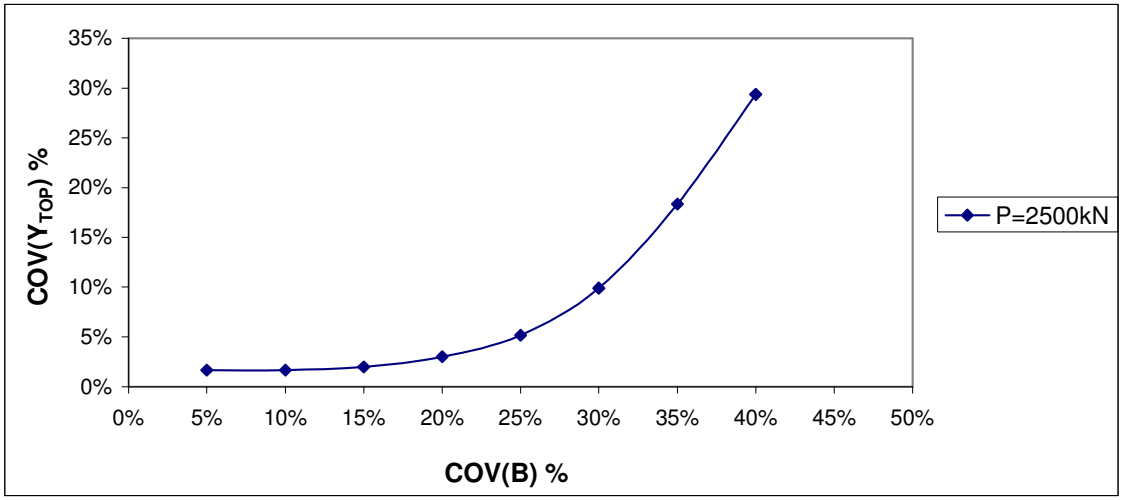


Fig. D.23 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

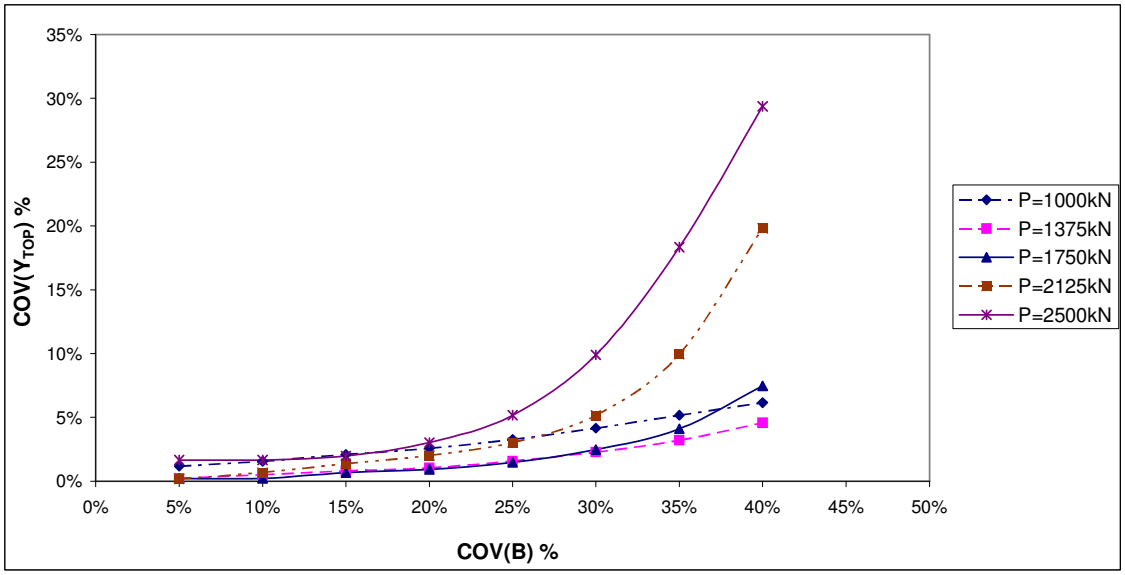


Fig. D.24 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table D.41 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (EI) and load 1000kN.

P=1000kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) ($kN-m^2$)	Y_{TOP} (m)	VAR(EI) $(kN-m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	1.05E-02				
5%	61000			9.30E+06	9.61E-08	6.22E-03	2.77%
		57950	1.12E-02				
		67100	1.03E-02				
10%	61000			3.72E+07	3.78E-07	6.22E-03	5.49%
		54900	1.15E-02				
		70150	1.00E-02				
15%	61000			8.37E+07	8.74E-07	6.22E-03	8.35%
		51850	1.19E-02				
		73200	9.77E-03				
20%	61000			1.49E+08	1.60E-06	6.22E-03	11.29%
		48800	1.23E-02				
		76250	9.55E-03				
25%	61000			2.33E+08	2.59E-06	6.22E-03	14.36%
		45750	1.28E-02				
		79300	9.35E-03				
30%	61000			3.35E+08	3.88E-06	6.22E-03	17.59%
		42700	1.33E-02				
		82350	9.16E-03				
35%	61000			4.56E+08	5.57E-06	6.22E-03	21.08%
		39650	1.39E-02				
		85400	8.98E-03				
40%	61000			5.95E+08	7.76E-06	6.22E-03	24.87%
		36600	1.46E-02				

Table D.42 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (EI) and load 1375kN.

P=1375kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) ($kN-m^2$)	Y_{TOP} (m)	VAR(EI) $(kN-m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	1.68E-02				
5%	61000			9.30E+06	2.40E-07	7.40E-03	2.97%
		57950	1.77E-02				
		67100	1.63E-02				
10%	61000			3.72E+07	9.51E-07	7.40E-03	5.91%
		54900	1.83E-02				
		70150	1.59E-02				
15%	61000			8.37E+07	2.19E-06	7.40E-03	8.97%
		51850	1.89E-02				
		73200	1.56E-02				
20%	61000			1.49E+08	4.00E-06	7.40E-03	12.12%
		48800	1.96E-02				
		76250	1.52E-02				
25%	61000			2.33E+08	6.50E-06	7.40E-03	15.45%
		45750	2.03E-02				
		79300	1.49E-02				
30%	61000			3.35E+08	9.83E-06	7.40E-03	19.00%
		42700	2.12E-02				
		82350	1.46E-02				
35%	61000			4.56E+08	1.43E-05	7.40E-03	22.91%
		39650	2.22E-02				
		85400	1.43E-02				
40%	61000			5.95E+08	2.01E-05	7.40E-03	27.18%
		36600	2.33E-02				

Table D.43 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (EI) and load 1750kN.

P=1750kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) ($kN-m^2$)	Y_{TOP} (m)	VAR(EI) $(kN-m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	2.40E-02				
5%	61000			9.30E+06	5.63E-07	1.65E-02	3.30%
		57950	2.55E-02				
		67100	2.33E-02				
10%	61000			3.72E+07	2.25E-06	1.65E-02	6.61%
		54900	2.63E-02				
		70150	2.27E-02				
15%	61000			8.37E+07	5.13E-06	1.65E-02	9.98%
		51850	2.73E-02				
		73200	2.22E-02				
20%	61000			1.49E+08	9.39E-06	1.65E-02	13.50%
		48800	2.83E-02				
		76250	2.17E-02				
25%	61000			2.33E+08	1.54E-05	1.65E-02	17.29%
		45750	2.95E-02				
		79300	2.12E-02				
30%	61000			3.35E+08	2.35E-05	1.65E-02	25.79%
		42700	3.09E-02				
		82350	2.08E-02				
35%	61000			4.56E+08	3.43E-05	1.65E-02	25.79%
		39650	3.25E-02				
		85400	2.04E-02				
40%	61000			5.95E+08	4.85E-05	1.65E-02	30.68%
		36600	3.43E-02				

Table D.44 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (EI) and load 2125kN.

P=2125kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) ($kN-m^2$)	Y_{TOP} (m)	VAR(EI) $(kN-m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	3.30E-02				
5%	61000			9.30E+06	1.21E-06	2.98E-02	3.69%
		57950	3.52E-02				
		67100	3.20E-02				
10%	61000			3.72E+07	4.88E-06	2.98E-02	5.70%
		54900	3.65E-02				
		70150	3.12E-02				
15%	61000			8.37E+07	1.12E-05	2.98E-02	8.60%
		51850	3.79E-02				
		73200	3.04E-02				
20%	61000			1.49E+08	1.45E-05	2.98E-02	12.50%
		48800	3.80E-02				
		76250	2.97E-02				
25%	61000			2.33E+08	3.34E-05	2.98E-02	16.67%
		45750	4.12E-02				
		79300	2.90E-02				
30%	61000			3.35E+08	5.11E-05	2.98E-02	21.64%
		42700	4.33E-02				
		82350	2.83E-02				
35%	61000			4.56E+08	7.46E-05	2.98E-02	27.89%
		39650	4.56E-02				
		85400	2.77E-02				
40%	61000			5.95E+08	1.06E-04	2.98E-02	34.60%
		36600	4.84E-02				

Table D.45 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (EI) and load 2500kN.

P=2500kN							
COV(EI) (%)	EI^o (kN-m^2)	EI(current) (kN-m^2)	Y_{TOP} (m)	VAR(EI) (kN-m^2)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^o (m)	COV(Y_{TOP}) (%)
		64050	4.54E-02				
5%	61000			9.30E+06	2.37E-06	4.77E-02	3.23%
		57950	4.85E-02				
		67100	4.41E-02				
10%	61000			3.72E+07	9.67E-06	4.77E-02	6.52%
		54900	5.03E-02				
		70150	4.28E-02				
15%	61000			8.37E+07	2.24E-05	4.77E-02	9.92%
		51850	5.23E-02				
		73200	4.17E-02				
20%	61000			1.49E+08	4.12E-05	4.77E-02	13.45%
		48800	5.45E-02				
		76250	4.06E-02				
25%	61000			2.33E+08	6.77E-05	4.77E-02	17.25%
		45750	5.71E-02				
		79300	3.97E-02				
30%	61000			3.35E+08	1.03E-04	4.77E-02	22.20%
		42700	6.00E-02				
		82350	3.88E-02				
35%	61000			4.56E+08	1.86E-04	4.77E-02	28.56%
		39650	6.60E-02				
		85400	3.79E-02				
40%	61000			5.95E+08	2.91E-04	4.77E-02	35.73%
		36600	7.20E-02				

Table D.46 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 1000kN.

P=1000kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	9.61E-08	2.77%
10%	3.72E+07	3.78E-07	5.49%
15%	8.37E+07	8.74E-07	8.35%
20%	1.49E+08	1.60E-06	11.29%
25%	2.33E+08	2.59E-06	14.36%
30%	3.35E+08	3.88E-06	17.59%
35%	4.56E+08	5.57E-06	21.08%
40%	5.95E+08	7.76E-06	24.87%

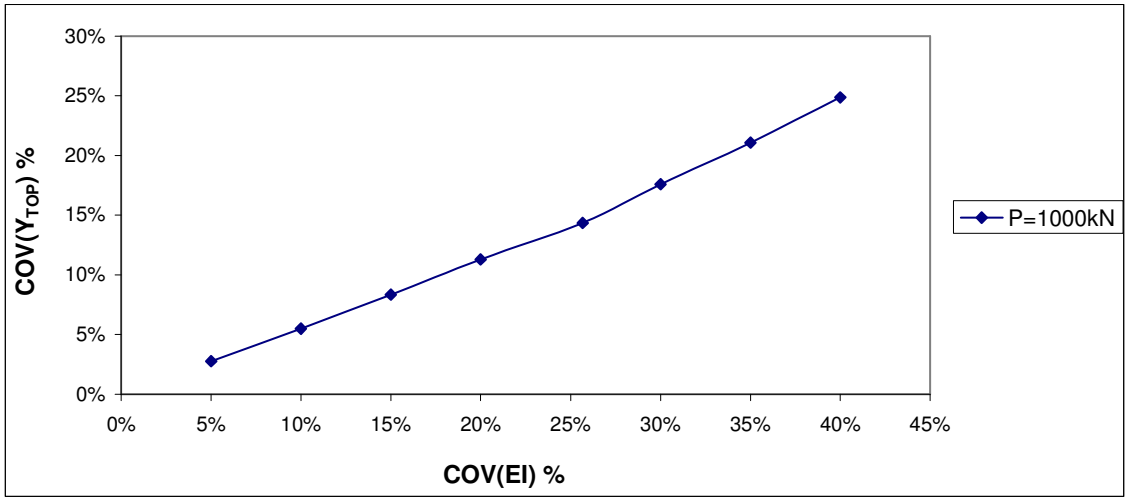


Fig. D.25 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.47 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 1375kN.

P=1375kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	2.40E-07	2.97%
10%	3.72E+07	9.51E-07	5.91%
15%	8.37E+07	2.19E-06	8.97%
20%	1.49E+08	4.00E-06	12.12%
25%	2.33E+08	6.50E-06	15.45%
30%	3.35E+08	9.83E-06	19.00%
35%	4.56E+08	1.43E-05	22.91%
40%	5.95E+08	2.01E-05	27.18%

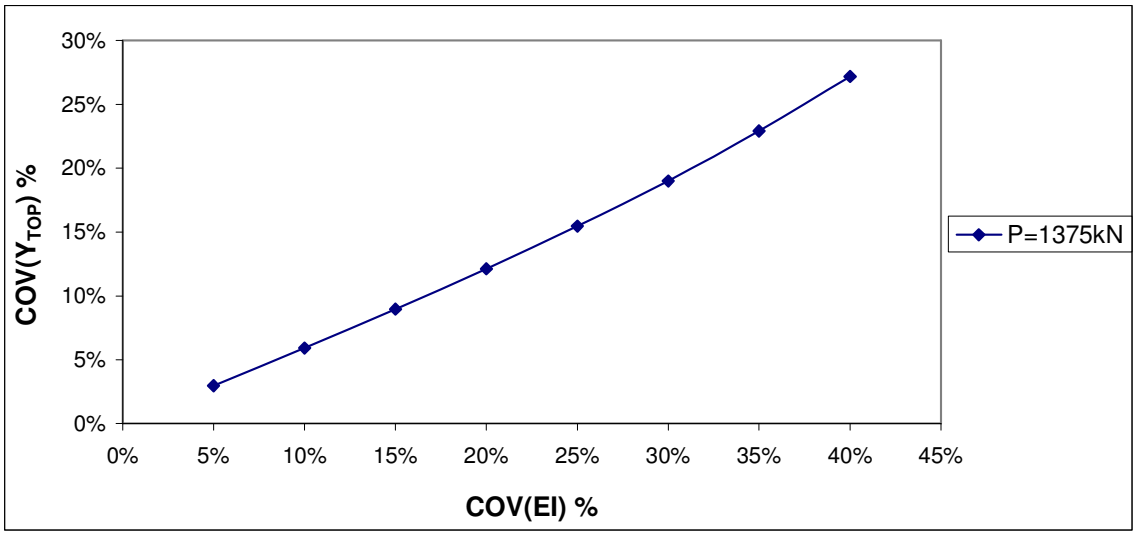


Fig. D.26 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.48 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 1750kN.

P=1750kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	5.63E-07	3.30%
10%	3.72E+07	2.25E-06	6.61%
15%	8.37E+07	5.13E-06	9.98%
20%	1.49E+08	9.39E-06	13.50%
25%	2.33E+08	1.54E-05	17.29%
30%	3.35E+08	2.35E-05	21.37%
35%	4.56E+08	3.43E-05	25.79%
40%	5.95E+08	4.85E-05	30.68%

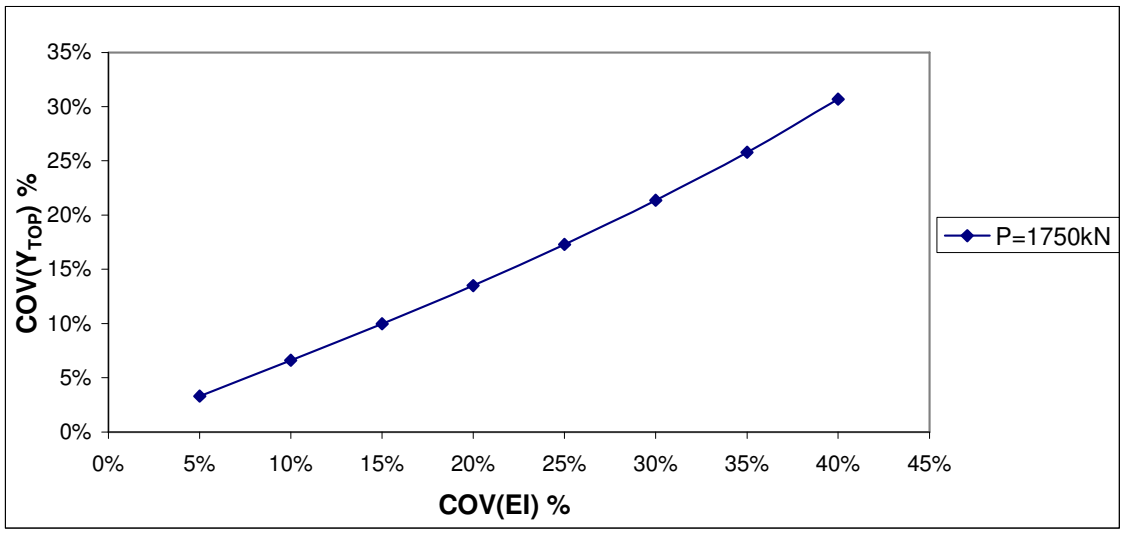


Fig. D.27 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.49 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 2125kN.

P=2125kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	1.21E-06	3.69%
10%	3.72E+07	4.88E-06	5.70%
15%	8.37E+07	1.12E-05	8.60%
20%	1.49E+08	1.45E-05	12.50%
25%	2.33E+08	3.34E-05	16.67%
30%	3.35E+08	5.11E-05	21.64%
35%	4.56E+08	7.46E-05	27.89%
40%	5.95E+08	1.06E-04	34.60%

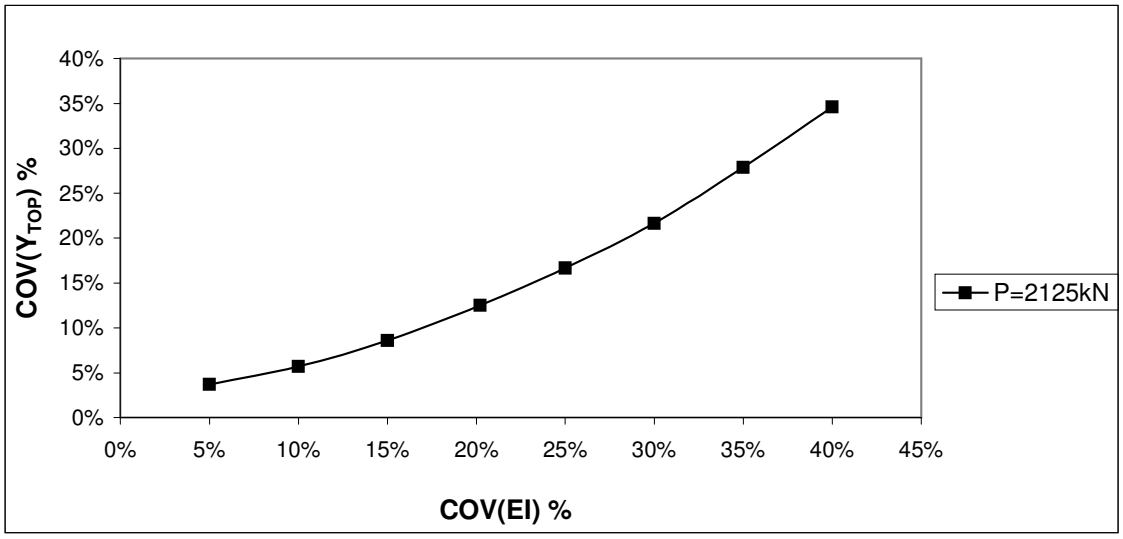


Fig. D.28 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.50 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 2500kN.

P=2500kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	2.37E-06	3.23%
10%	3.72E+07	9.67E-06	6.52%
15%	8.37E+07	2.24E-05	9.92%
20%	1.49E+08	4.12E-05	13.45%
25%	2.33E+08	6.77E-05	17.25%
30%	3.35E+08	1.03E-04	22.20%
35%	4.56E+08	1.86E-04	28.56%
40%	5.95E+08	2.91E-04	35.73%

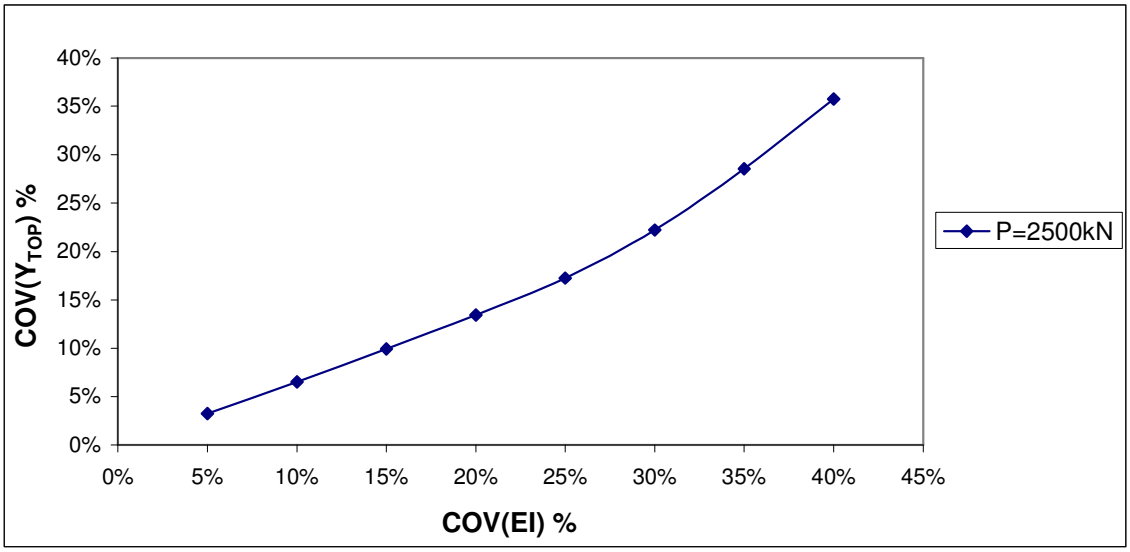


Fig. D.29 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

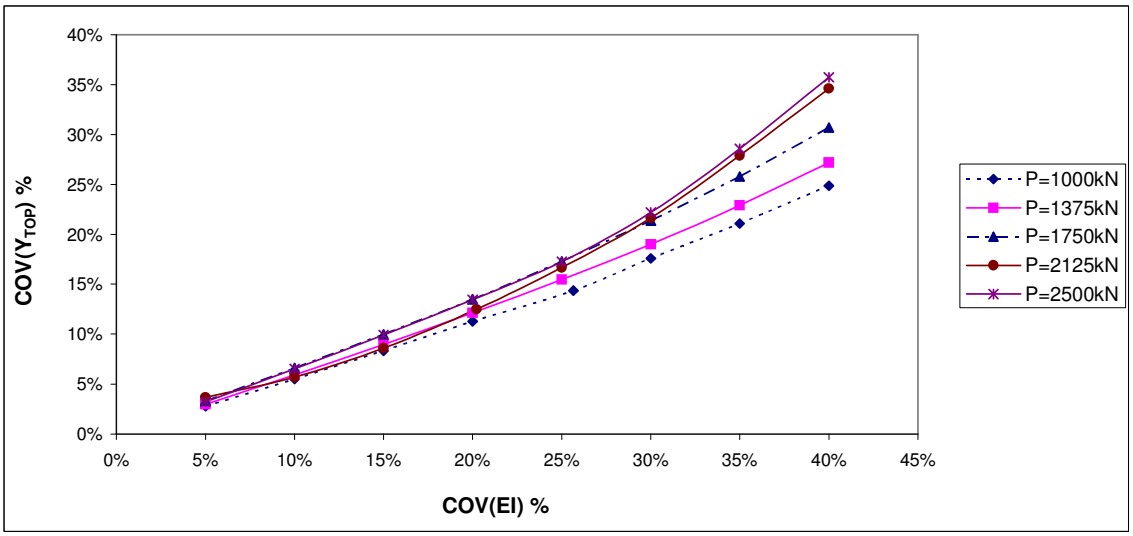


Fig. D.30 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table D.51 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (P) and load 1000kN.

P=1000kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		1050	1.16E-02				
5%	1000			2.50E+03	5.70E-07	6.22E-03	6.74%
		950	1.01E-02				
		1100	1.24E-02				
10%	1000			1.00E+04	2.28E-06	6.22E-03	13.49%
		900	9.34E-03				
		1150	1.32E-02				
15%	1000			2.25E+04	5.15E-06	6.22E-03	20.25%
		850	8.61E-03				
		1200	1.39E-02				
20%	1000			4.00E+04	9.10E-06	6.22E-03	28.00%
		800	7.91E-03				
		1250	1.48E-02				
25%	1000			6.25E+04	1.68E-05	6.22E-03	36.60%
		750	6.55E-03				
		1300	1.56E-02				
30%	1000			9.00E+04	2.33E-05	6.22E-03	43.13%
		700	5.90E-03				
		1350	1.64E-02				
35%	1000			1.23E+05	3.05E-05	6.22E-03	49.28%
		650	5.35E-03				
		1400	1.72E-02				
40%	1000			1.60E+05	3.58E-05	6.22E-03	54.10%
		600	5.26E-03				

Table D.52 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (P) and load 1375kN.

P=1375kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		1443.75	1.84E-02				
5%	1375			4.73E+03	1.40E-06	7.40E-03	7.18%
		1306.25	1.61E-02				
		1512.5	1.97E-02				
10%	1375			1.89E+04	5.66E-06	7.40E-03	14.42%
		1237.5	1.49E-02				
		1581.25	2.13E-02				
15%	1375			4.25E+04	1.41E-05	7.40E-03	21.50%
		1168.75	1.38E-02				
		1650	2.23E-02				
20%	1375			7.56E+04	2.31E-05	7.40E-03	29.12%
		1100	1.27E-02				
		1718.75	2.36E-02				
25%	1375			1.18E+05	3.99E-05	7.40E-03	37.20%
		1031.25	1.10E-02				
		1787.5	2.51E-02				
30%	1375			1.70E+05	5.31E-05	7.40E-03	44.15%
		962.5	1.05E-02				
		1856.25	2.66E-02				
35%	1375			2.32E+05	7.31E-05	7.40E-03	51.82%
		893.75	9.47E-03				
		1925	2.75E-02				
40%	1375			3.03E+05	8.52E-05	7.40E-03	57.00%
		825	9.00E-03				

Table D.53 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (P) and load 1750kN.

P=1750kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		1837.5	2.66E-02				
5%	1750			7.66E+03	3.46E-06	1.65E-02	7.10%
		1662.5	2.29E-02				
		1925	2.86E-02				
10%	1750			3.06E+04	1.39E-05	1.65E-02	16.41%
		1575	2.11E-02				
		2012.5	3.30E-02				
15%	1750			6.89E+04	4.54E-05	1.65E-02	28.00%
		1487.5	1.95E-02				
		2100	3.54E-02				
20%	1750			1.23E+05	7.65E-05	1.65E-02	38.52%
		1400	1.79E-02				
		2187.5	3.80E-02				
25%	1750			1.91E+05	1.33E-04	1.65E-02	50.10%
		1312.5	1.49E-02				
		2275	4.08E-02				
30%	1750			2.76E+05	1.86E-04	1.65E-02	60.15%
		1225	1.35E-02				
		2362.5	4.39E-02				
35%	1750			3.75E+05	2.49E-04	1.65E-02	69.49%
		1137.5	1.23E-02				
		2450	4.42E-02				
40%	1750			4.90E+05	2.59E-04	1.65E-02	77.10%
		1050	1.21E-02				

Table D.54 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (P) and load 2125kN.

P=2125kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		2231.25	3.37E-02				
5%	2125			1.13E+04	1.59E-06	2.98E-02	8.30%
		2018.75	3.12E-02				
		2337.5	3.71E-02				
10%	2125			4.52E+04	1.81E-05	2.98E-02	17.70%
		1912.5	2.86E-02				
		2443.75	4.05E-02				
15%	2125			1.02E+05	5.12E-05	2.98E-02	29.10%
		1806.25	2.61E-02				
		2550	4.85E-02				
20%	2125			1.81E+05	1.51E-04	2.98E-02	41.29%
		1700	2.38E-02				
		2656.25	5.34E-02				
25%	2125			2.82E+05	2.84E-04	2.98E-02	56.53%
		1593.75	1.97E-02				
		2762.5	5.89E-02				
30%	2125			4.06E+05	4.23E-04	2.98E-02	68.98%
		1487.5	1.77E-02				
		2868.75	6.51E-02				
35%	2125			5.53E+05	5.98E-04	2.98E-02	82.03%
		1381.25	1.62E-02				
		2975	7.21E-02				
40%	2125			7.23E+05	7.89E-04	2.98E-02	94.28%
		1275	1.59E-02				

Table D.55 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (P) and load 2500kN.

P=2500kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		2625	5.24E-02				
5%	2500			1.56E+04	2.65E-05	4.77E-02	10.55%
		2375	4.21E-02				
		2750	5.89E-02				
10%	2500			6.25E+04	1.09E-04	4.77E-02	21.42%
		2250	3.80E-02				
		2875	6.50E-02				
15%	2500			1.41E+05	2.36E-04	4.77E-02	31.50%
		2125	3.43E-02				
		3000	7.48E-02				
20%	2500			2.50E+05	4.79E-04	4.77E-02	44.91%
		2000	3.10E-02				
		3125	8.40E-02				
25%	2500			3.91E+05	8.69E-04	4.77E-02	60.46%
		1875	2.51E-02				
		3250	9.42E-02				
30%	2500			5.63E+05	1.29E-03	4.77E-02	73.57%
		1750	2.25E-02				
		3375	1.05E-01				
35%	2500			7.66E+05	1.79E-03	4.77E-02	88.77%
		1625	2.04E-02				
		3500	1.17E-01				
40%	2500			1.00E+06	2.34E-03	4.77E-02	99.25%
		1500	2.00E-02				

Table D.56 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 1000kN.

P=1000kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.50E+03	5.70E-07	6.74%
10%	1.00E+04	2.28E-06	13.49%
15%	2.25E+04	5.15E-06	20.25%
20%	4.00E+04	9.10E-06	28.00%
25%	6.25E+04	1.68E-05	36.60%
30%	9.00E+04	2.33E-05	43.13%
35%	1.23E+05	3.05E-05	49.28%
40%	1.60E+05	3.58E-05	54.10%

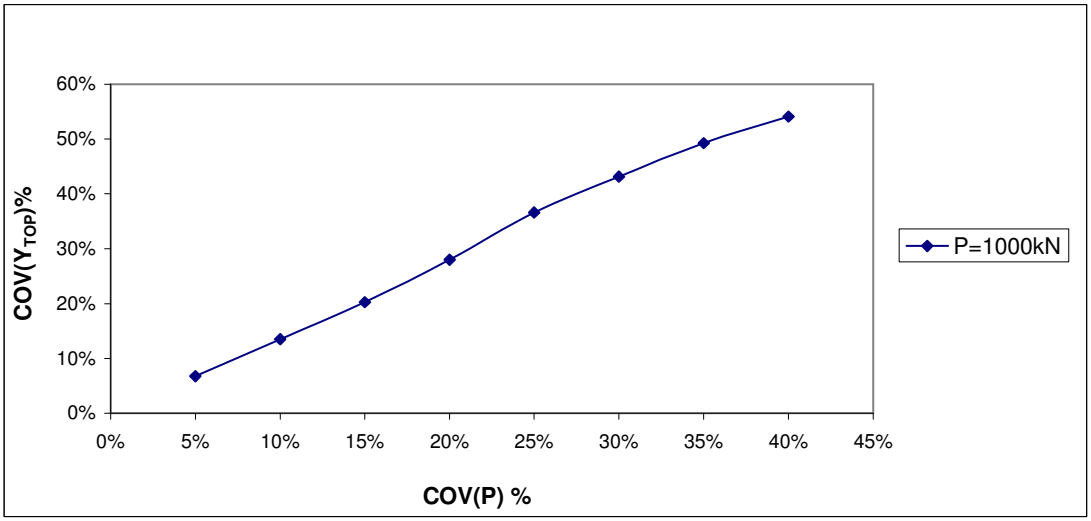


Fig. D.31 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.57 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 1357kN.

P=1375kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.73E+03	1.40E-06	7.18%
10%	1.89E+04	5.66E-06	14.42%
15%	4.25E+04	1.41E-05	21.50%
20%	7.56E+04	2.31E-05	29.12%
25%	1.18E+05	3.99E-05	37.20%
30%	1.70E+05	5.31E-05	44.15%
35%	2.32E+05	7.31E-05	51.82%
40%	3.03E+05	8.52E-05	57.00%

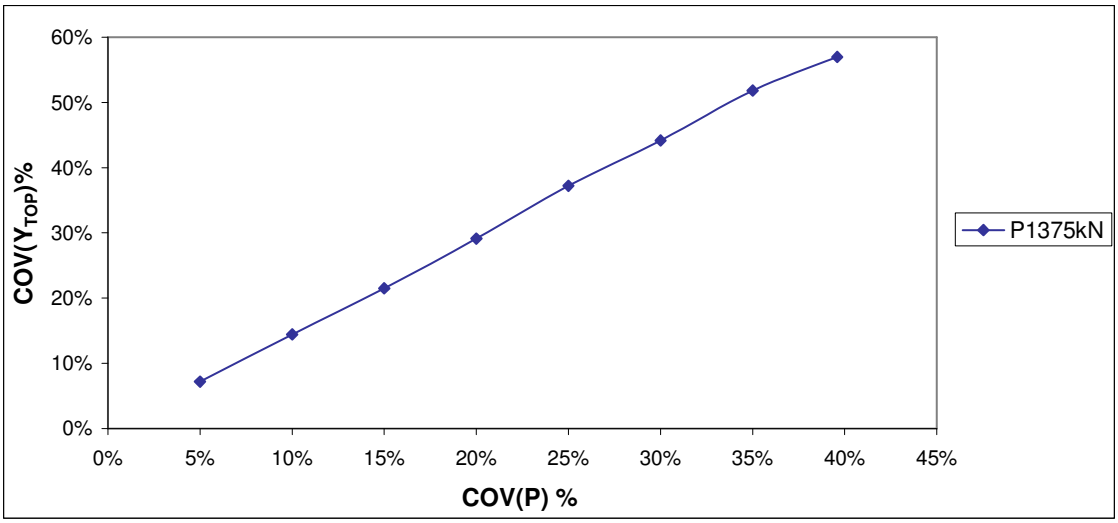


Fig. D.32 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.58 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 1750kN.

P=1750kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	7.66E+03	3.46E-06	7.10%
10%	3.06E+04	1.39E-05	16.41%
15%	6.89E+04	4.54E-05	28.00%
20%	1.23E+05	7.65E-05	38.52%
25%	1.91E+05	1.33E-04	50.10%
30%	2.76E+05	1.86E-04	60.15%
35%	3.75E+05	2.49E-04	69.49%
40%	4.90E+05	2.59E-04	77.10%

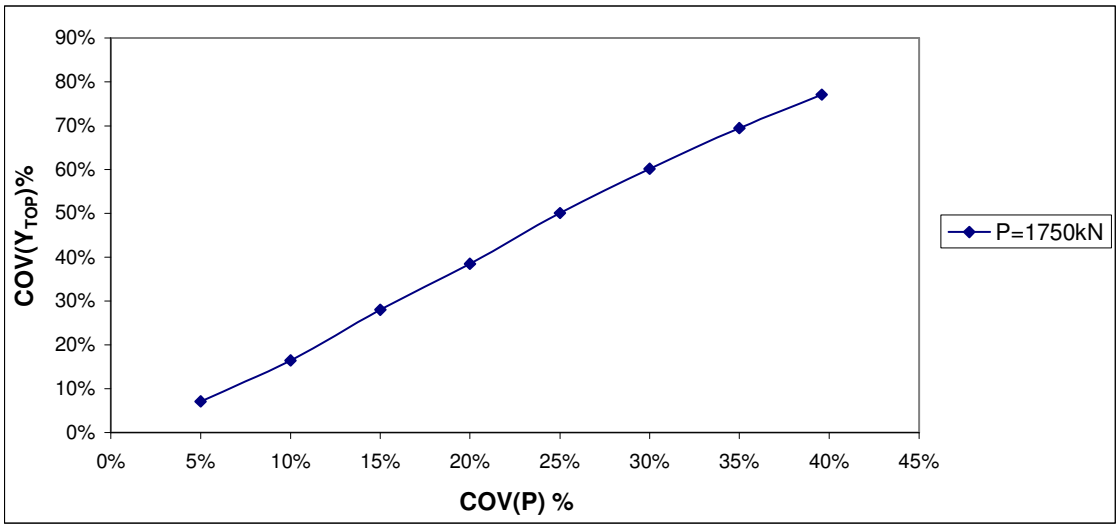


Fig. D.33 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.59 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 2125kN.

P=2125kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	1.13E+04	1.59E-06	8.30%
10%	4.52E+04	1.81E-05	17.70%
15%	1.02E+05	5.12E-05	29.10%
20%	1.81E+05	1.51E-04	41.29%
25%	2.82E+05	2.84E-04	56.53%
30%	4.06E+05	4.23E-04	68.98%
35%	5.53E+05	5.98E-04	82.03%
40%	7.23E+05	7.89E-04	94.28%

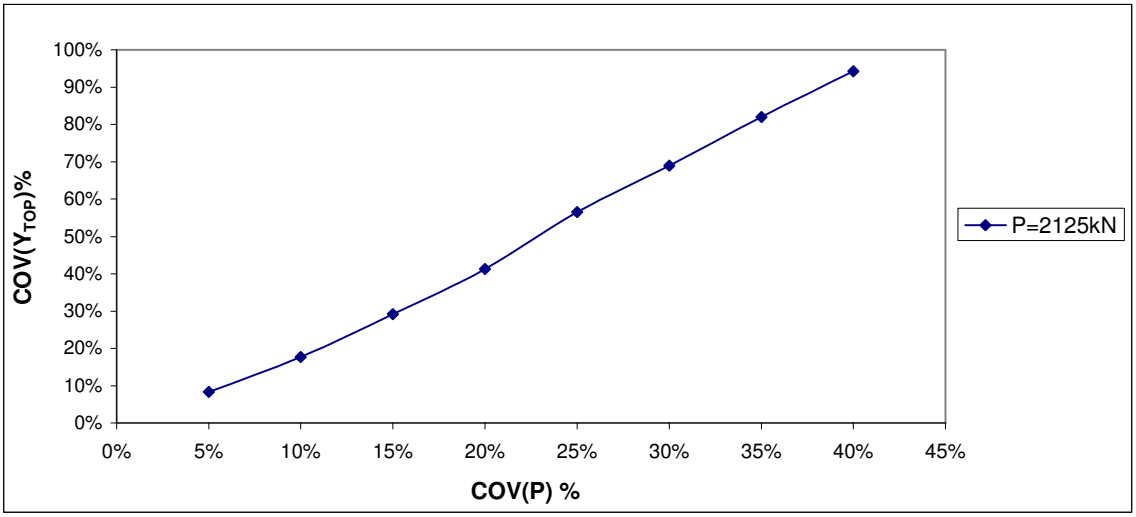


Fig. D.34 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.61 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 2500kN.

P=2500kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	1.56E+04	2.65E-05	10.55%
10%	6.25E+04	1.09E-04	21.42%
15%	1.41E+05	2.36E-04	31.50%
20%	2.50E+05	4.79E-04	44.91%
25%	3.91E+05	8.69E-04	60.46%
30%	5.63E+05	1.29E-03	73.57%
35%	7.66E+05	1.79E-03	86.86%
40%	1.00E+06	2.34E-03	99.25%

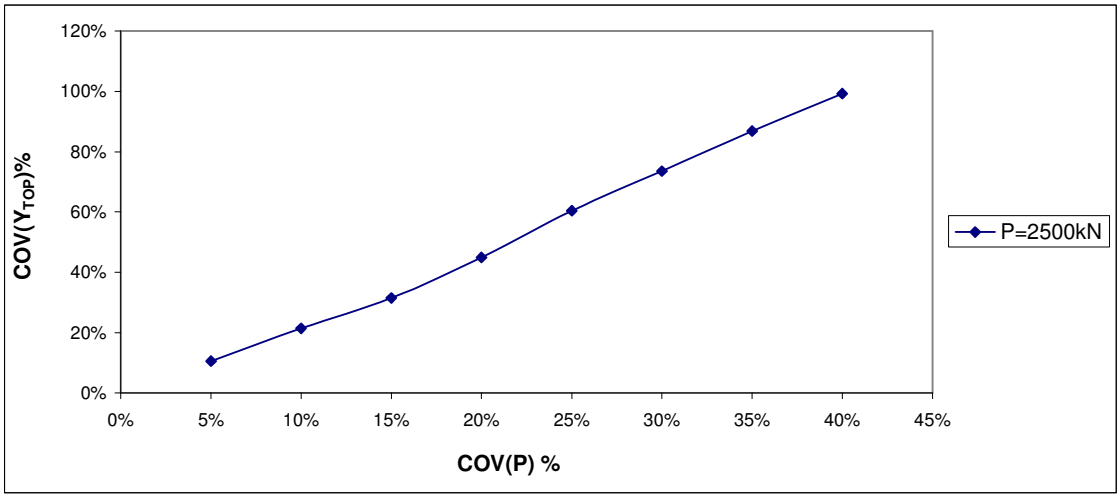


Fig. D.35 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

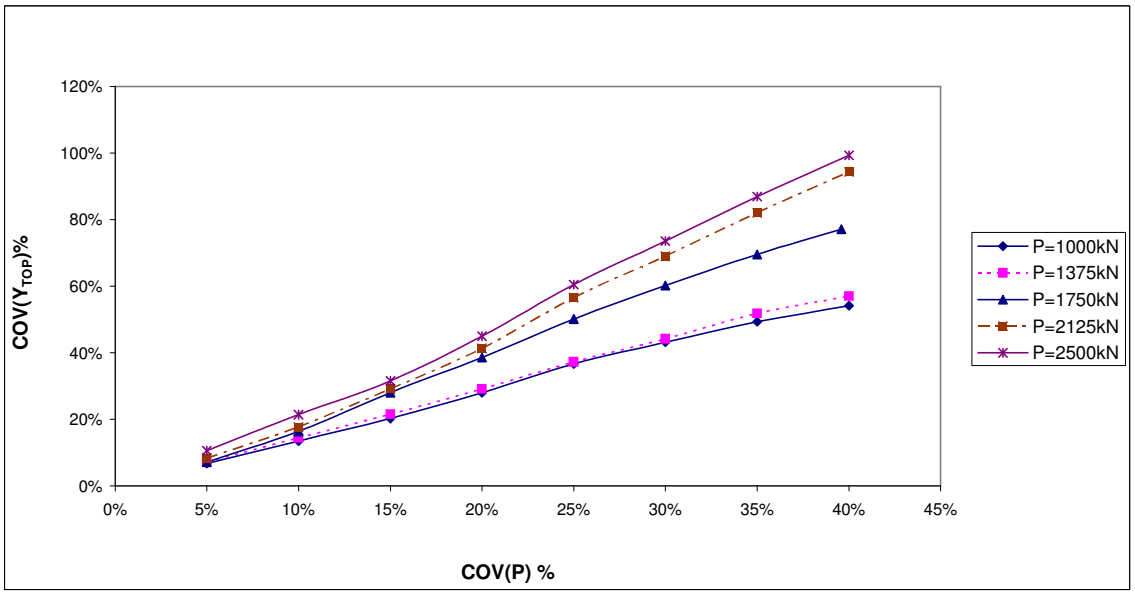


Fig. D.36 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

D-2 Reliability Index of top deflection vs. COV (Variables)

Table D.61 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
8.28E-07	0.000225	5%	0.0150	5.9091
3.30E-06	0.000225	10%	0.0151	5.8770
7.49E-06	0.000225	15%	0.0152	5.8238
1.37E-05	0.000225	20%	0.0154	5.7477
2.22E-05	0.000225	25%	0.0157	5.6484
3.37E-05	0.000225	30%	0.0161	5.5205
4.97E-05	0.000225	35%	0.0166	5.3580
7.21E-05	0.000225	40%	0.0172	5.1522

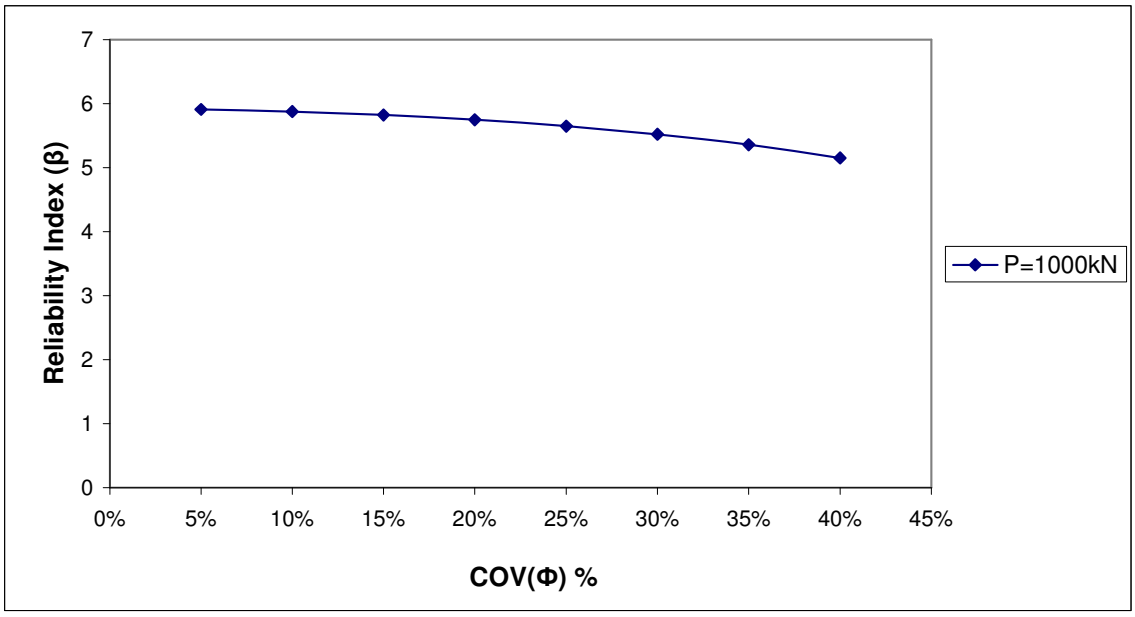


Fig. D.37 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.62 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 1375kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.06E-06	0.000225	5%	0.0151	5.5414
8.35E-06	0.000225	10%	0.0153	5.4661
1.93E-05	0.000225	15%	0.0156	5.3421
3.63E-05	0.000225	20%	0.0162	5.1655
6.11E-05	0.000225	25%	0.0169	4.9368
9.70E-05	0.000225	30%	0.0179	4.6531
1.50E-04	0.000225	35%	0.0194	4.3116
2.30E-04	0.000225	40%	0.0213	3.9141

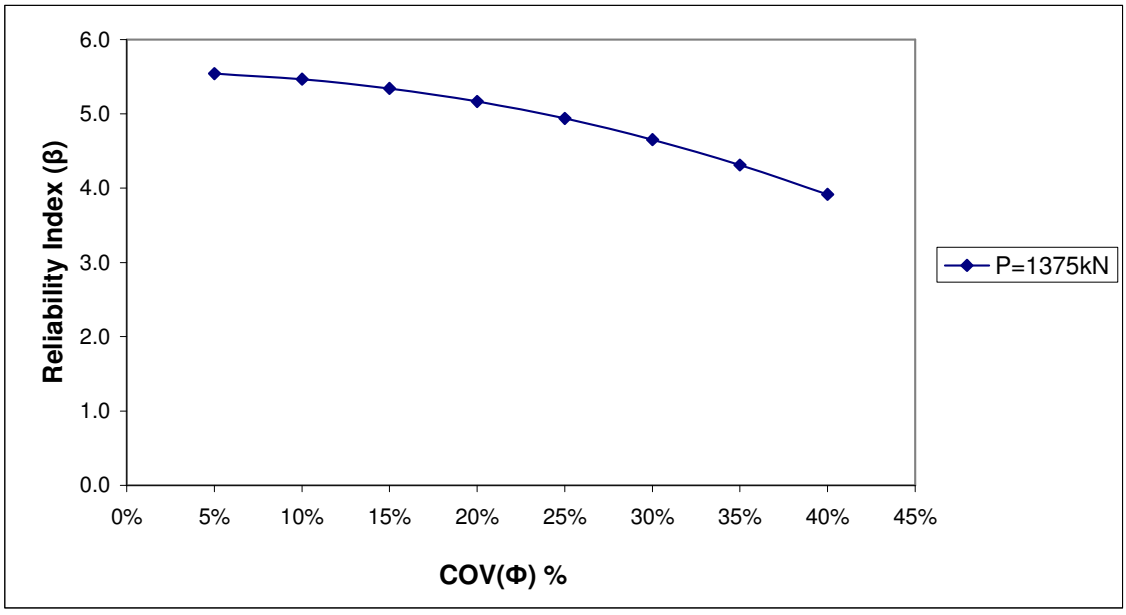


Fig. D.38 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.63 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 1750kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.06E-06	0.000225	5%	0.0152	5.0963
2.06E-05	0.000225	10%	0.0157	4.9328
4.83E-05	0.000225	15%	0.0165	4.6758
9.18E-05	0.000225	20%	0.0178	4.3431
1.58E-04	0.000225	25%	0.0196	3.9518
2.58E-04	0.000225	30%	0.0220	3.5187
4.14E-04	0.000225	35%	0.0253	3.0591
6.73E-04	0.000225	40%	0.0300	2.5801

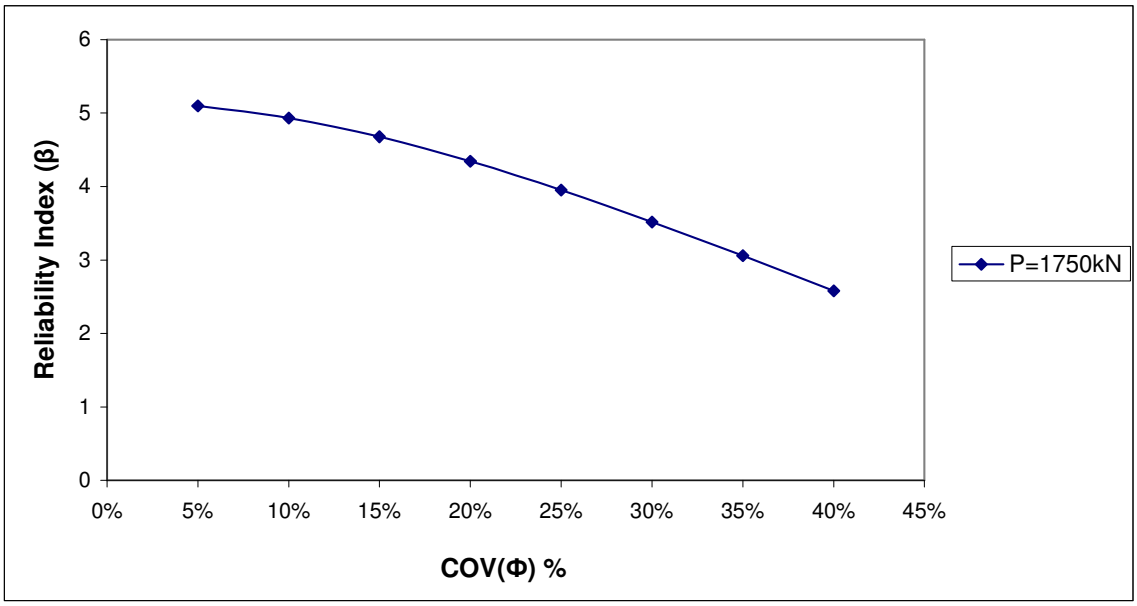


Fig. D.39 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.64 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 2125kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.20E-05	0.000225	5%	0.0154	4.5599
4.96E-05	0.000225	10%	0.0166	4.2366
1.18E-04	0.000225	15%	0.0185	3.7914
2.29E-04	0.000225	20%	0.0213	3.2955
4.06E-04	0.000225	25%	0.0251	2.7946
7.04E-04	0.000225	30%	0.0305	2.3037
1.22E-03	0.000225	35%	0.0381	1.8440
2.19E-03	0.000225	40%	0.0491	1.4299

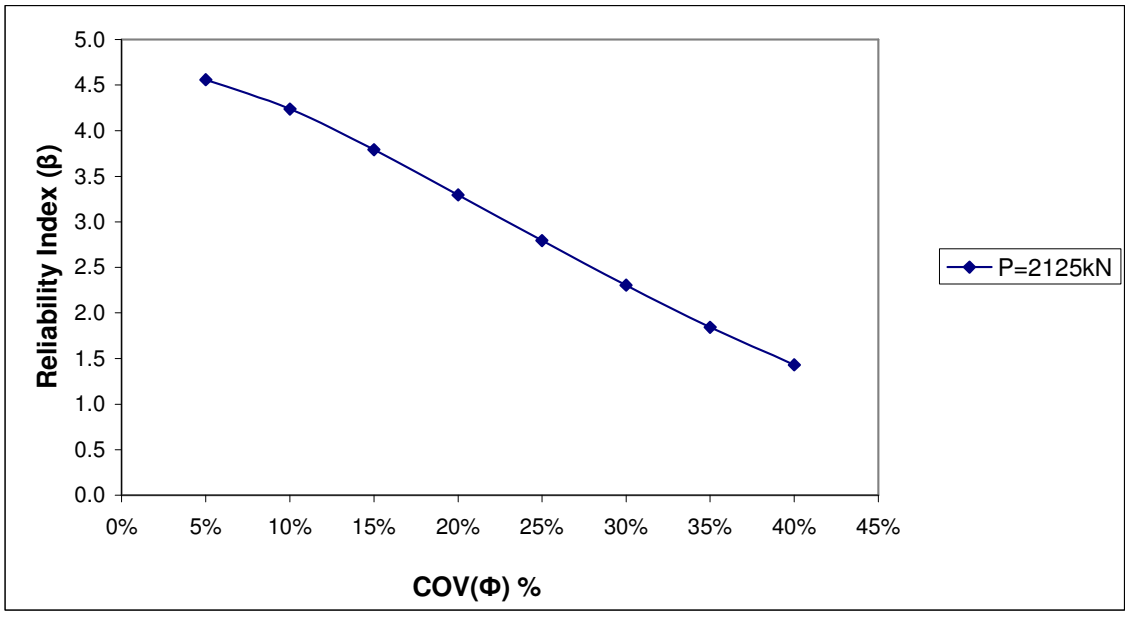


Fig. D.40 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.65 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 2500kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.16E-05	0.000225	5%	0.0160	3.2650
1.31E-04	0.000225	10%	0.0189	2.7702
3.22E-04	0.000225	15%	0.0234	2.2365
6.51E-04	0.000225	20%	0.0296	1.7676
1.22E-03	0.000225	25%	0.0380	1.3746
2.24E-03	0.000225	30%	0.0496	1.0535
4.04E-03	0.000225	35%	0.0653	0.8007
7.37E-03	0.000225	40%	0.0871	0.6002

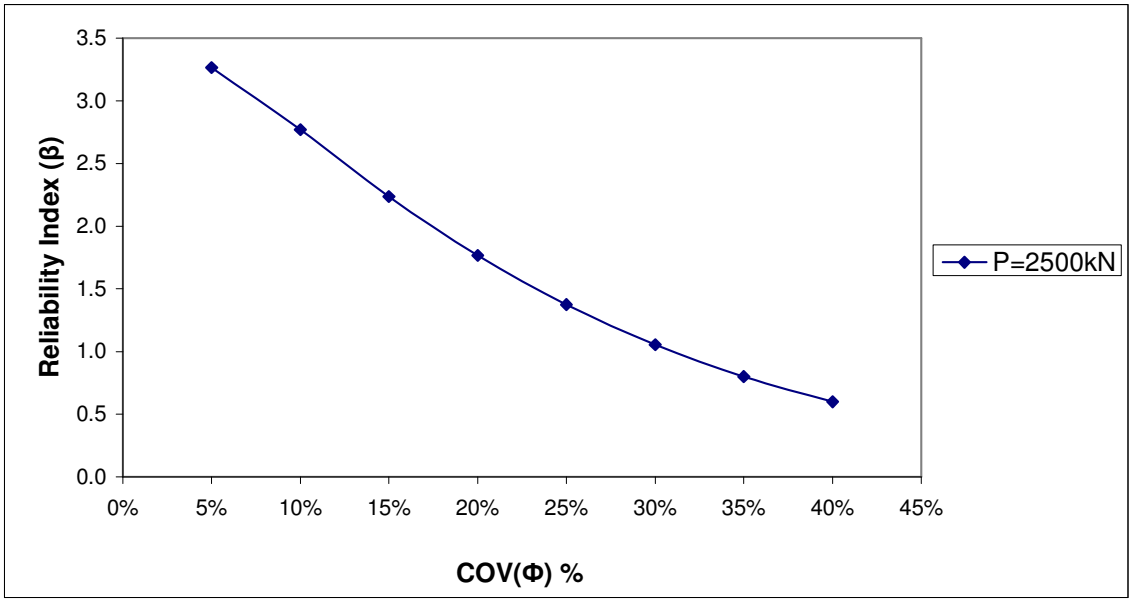


Fig. D.41 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force 2500kN.

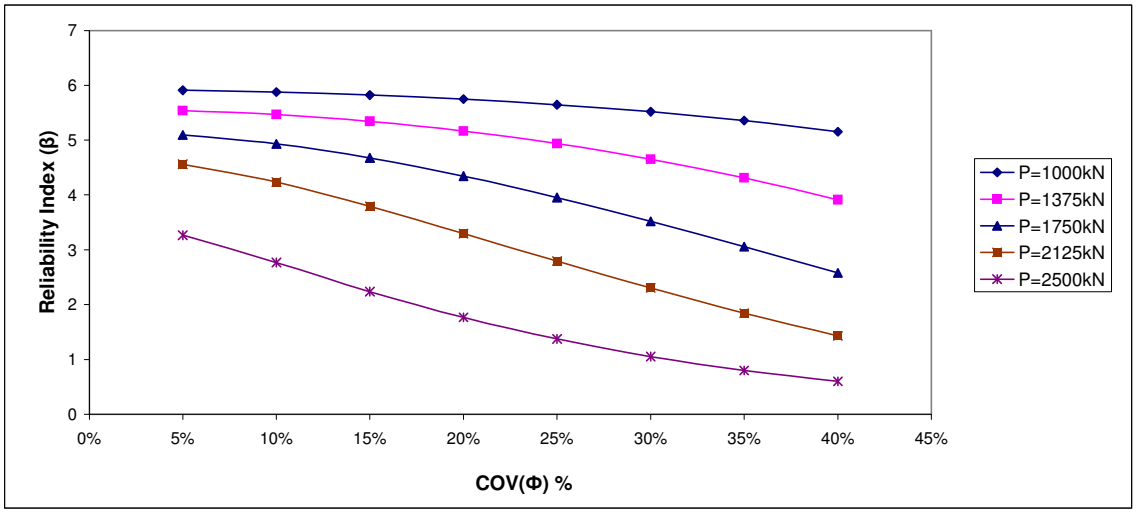


Fig. D.42 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table D.66 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.37E-07	0.000225	5%	0.0150	5.9182
5.62E-07	0.000225	10%	0.0150	5.9126
1.30E-06	0.000225	15%	0.0150	5.9030
2.35E-06	0.000225	20%	0.0151	5.8893
3.80E-06	0.000225	25%	0.0151	5.8706
5.74E-06	0.000225	30%	0.0152	5.8459
8.21E-06	0.000225	35%	0.0153	5.8148
1.14E-05	0.000225	40%	0.0154	5.7759

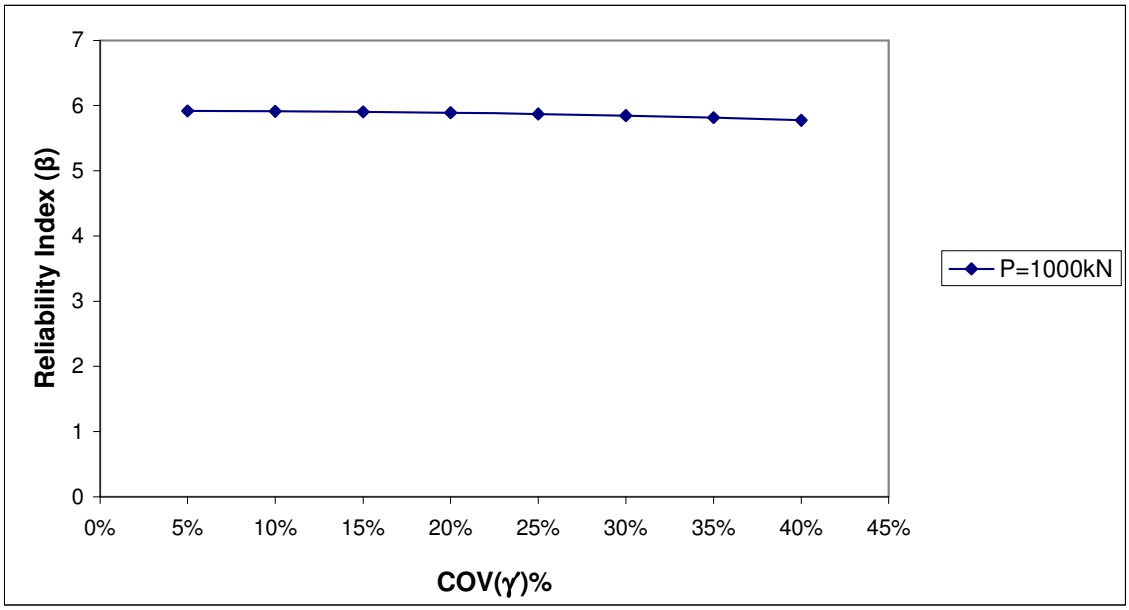


Fig. D.43 Reliability Index (β) of Y_{TOP} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.67 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 1375kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.42E-07	0.000225	5%	0.0150	5.5624
1.39E-06	0.000225	10%	0.0150	5.5495
3.22E-06	0.000225	15%	0.0151	5.5272
5.88E-06	0.000225	20%	0.0152	5.4953
9.58E-06	0.000225	25%	0.0153	5.4518
1.45E-05	0.000225	30%	0.0155	5.3953
2.11E-05	0.000225	35%	0.0157	5.3225
2.97E-05	0.000225	40%	0.0160	5.2320

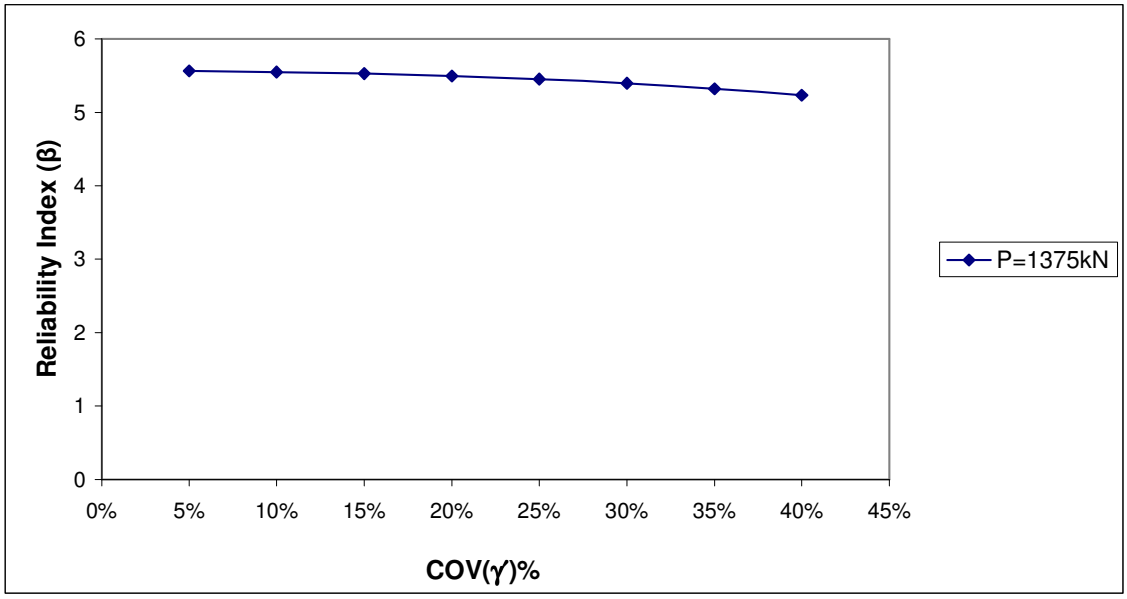


Fig. D.44 Reliability Index (β) of Y_{TOP} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.68 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 1750kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
8.37E-07	0.000225	5%	0.0150	5.1438
3.42E-06	0.000225	10%	0.0151	5.1146
7.90E-06	0.000225	15%	0.0153	5.0652
1.44E-05	0.000225	20%	0.0155	4.9959
2.37E-05	0.000225	25%	0.0158	4.9020
3.62E-05	0.000225	30%	0.0162	4.7831
5.26E-05	0.000225	35%	0.0167	4.6392
7.48E-05	0.000225	40%	0.0173	4.4642

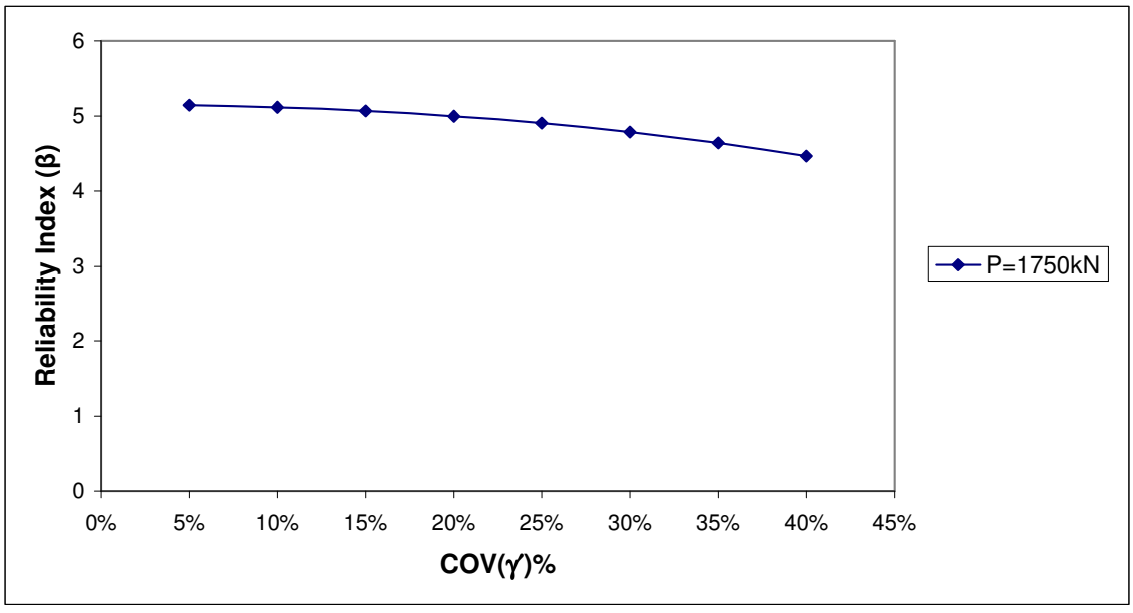


Fig. D.45 Reliability Index (β) of Y_{TOP} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.69 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 2125kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.00E-06	0.000225	5%	0.0151	4.6593
8.04E-06	0.000225	10%	0.0153	4.5986
1.86E-05	0.000225	15%	0.0156	4.4976
3.43E-05	0.000225	20%	0.0161	4.3592
5.66E-05	0.000225	25%	0.0168	4.1831
8.70E-05	0.000225	30%	0.0177	3.9740
1.29E-04	0.000225	35%	0.0188	3.7308
1.84E-04	0.000225	40%	0.0202	3.4723

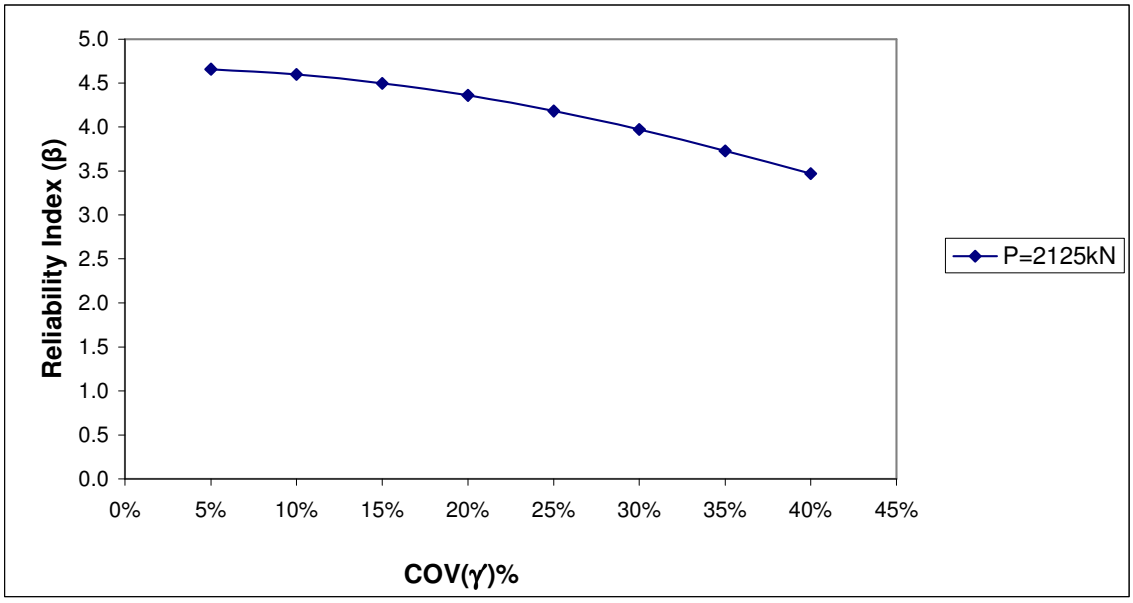


Fig. D.46 Reliability Index (β) of Y_{TOP} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.70 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 2500kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.09E-06	0.000225	5%	0.0152	3.4479
2.10E-05	0.000225	10%	0.0157	3.3347
4.87E-05	0.000225	15%	0.0165	3.1612
9.05E-05	0.000225	20%	0.0178	2.9443
1.51E-04	0.000225	25%	0.0194	2.6988
2.35E-04	0.000225	30%	0.0214	2.4389
3.52E-04	0.000225	35%	0.0240	2.1767
5.17E-04	0.000225	40%	0.0272	1.9201

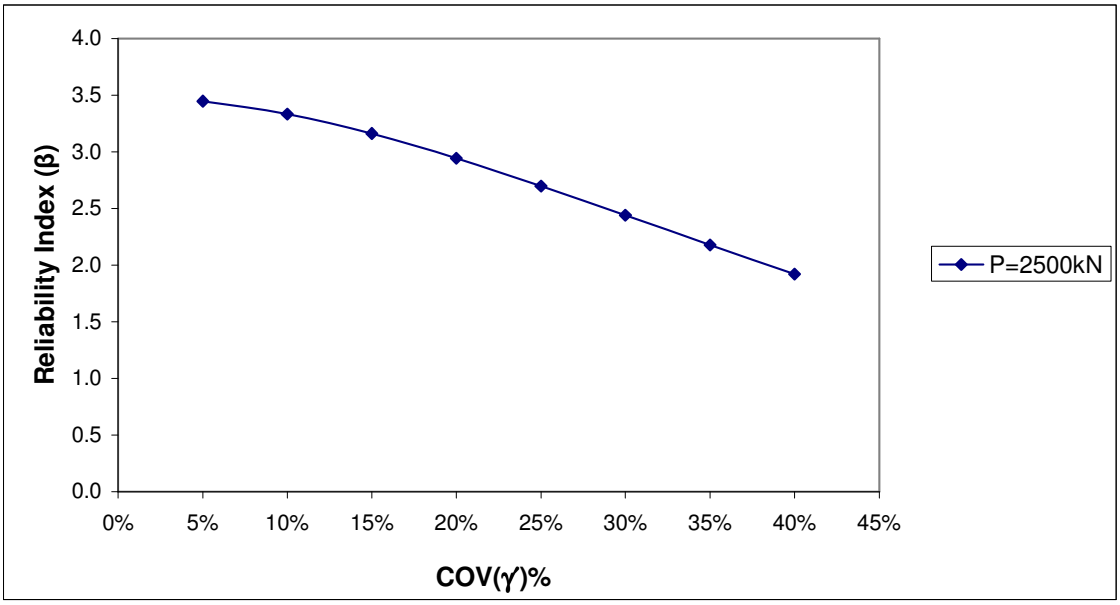


Fig. D.47 Reliability Index (β) of Y_{TOP} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force 2500kN.

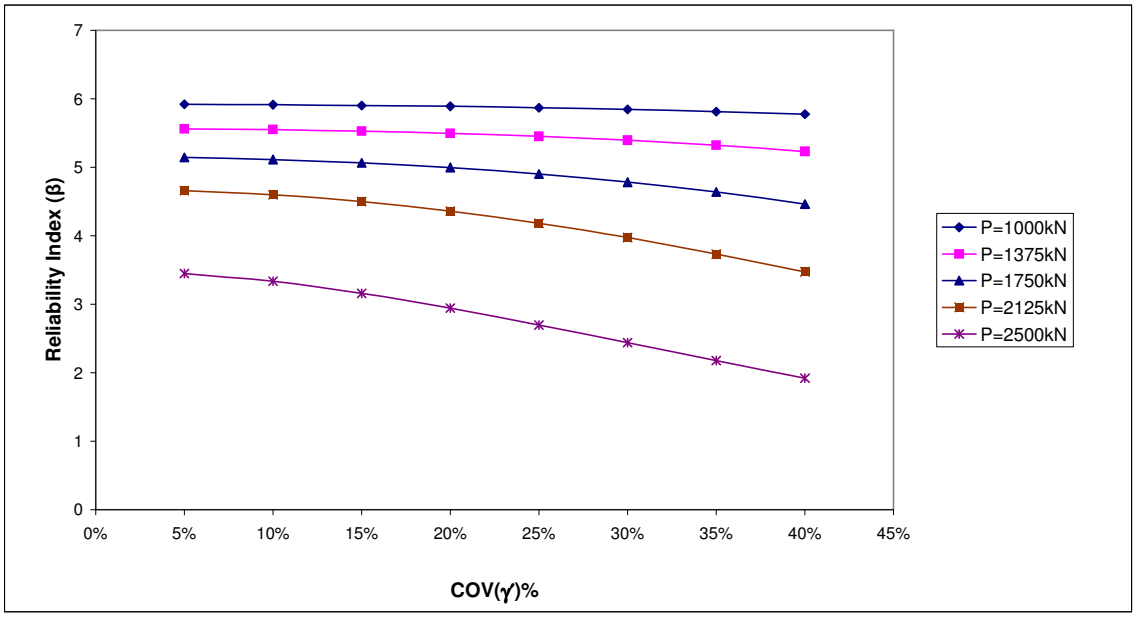


Fig. D.48 Reliability Index (β) of Y_{TOP} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table D.71 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
9.00E-10	0.000225	5%	0.0150	5.9200
3.02E-09	0.000225	10%	0.0150	5.9200
5.62E-09	0.000225	15%	0.0150	5.9199
1.10E-08	0.000225	20%	0.0150	5.9199
1.82E-08	0.000225	25%	0.0150	5.9198
3.06E-08	0.000225	30%	0.0150	5.9196
4.62E-08	0.000225	35%	0.0150	5.9194
7.02E-08	0.000225	40%	0.0150	5.9191

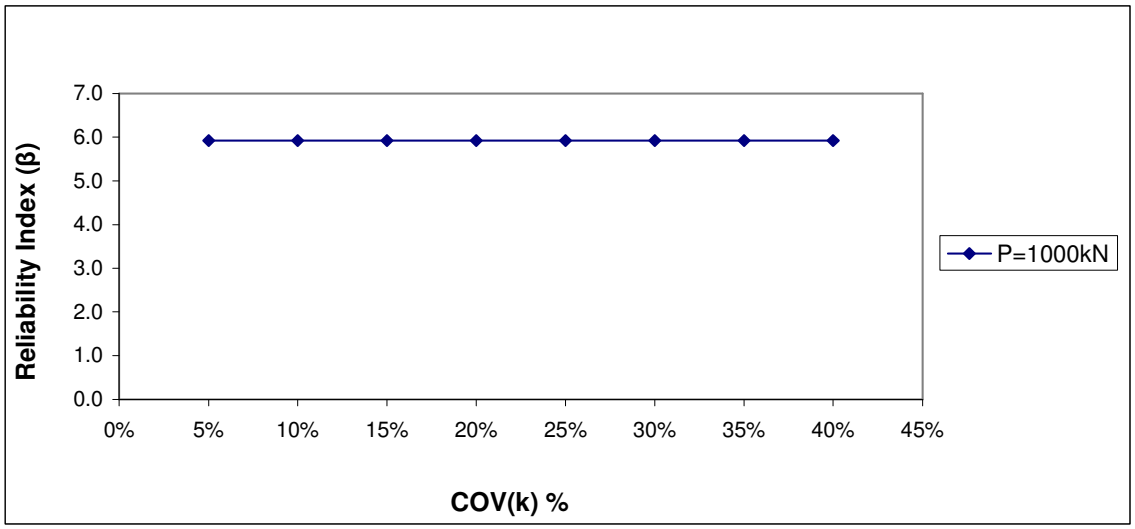


Fig. D.49 Reliability Index (β) of Y_{TOP} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.72 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 1375kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
9.00E-10	0.000225	5%	0.0150	5.5667
3.02E-09	0.000225	10%	0.0150	5.5666
6.40E-09	0.000225	15%	0.0150	5.5666
1.21E-08	0.000225	20%	0.0150	5.5665
2.10E-08	0.000225	25%	0.0150	5.5664
3.42E-08	0.000225	30%	0.0150	5.5662
5.52E-08	0.000225	35%	0.0150	5.5660
7.84E-08	0.000225	40%	0.0150	5.5657

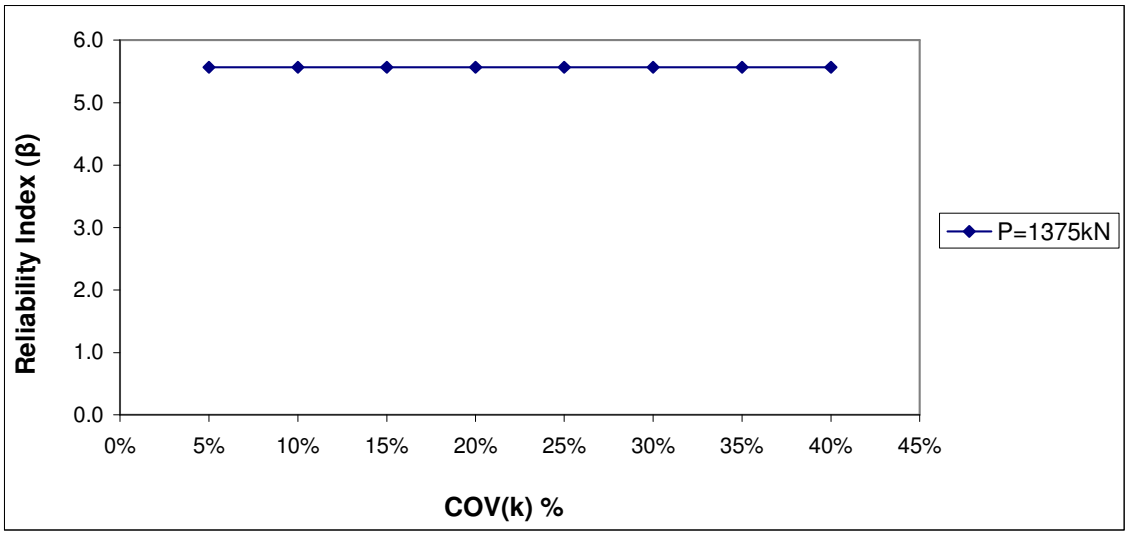


Fig. D.50 Reliability Index (β) of Y_{TOP} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.73 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 1750kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
9.00E-10	0.000225	5%	0.0150	5.1533
4.22E-09	0.000225	10%	0.0150	5.1533
9.03E-09	0.000225	15%	0.0150	5.1532
1.82E-08	0.000225	20%	0.0150	5.1531
2.89E-08	0.000225	25%	0.0150	5.1530
4.84E-08	0.000225	30%	0.0150	5.1528
7.29E-08	0.000225	35%	0.0150	5.1525
1.12E-07	0.000225	40%	0.0150	5.1520

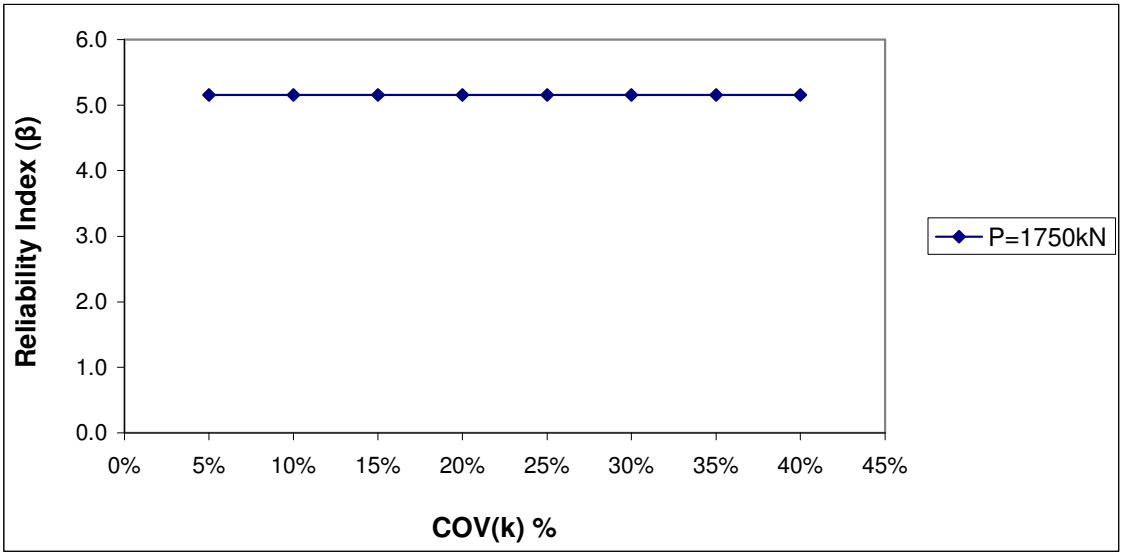


Fig. D.51 Reliability Index (β) of Y_{TOP} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.74 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 2125kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.60E-09	0.000225	5%	0.0150	4.6800
5.62E-09	0.000225	10%	0.0150	4.6799
1.44E-08	0.000225	15%	0.0150	4.6799
2.89E-08	0.000225	20%	0.0150	4.6797
4.84E-08	0.000225	25%	0.0150	4.6795
7.56E-08	0.000225	30%	0.0150	4.6792
1.19E-07	0.000225	35%	0.0150	4.6788
1.81E-07	0.000225	40%	0.0150	4.6781

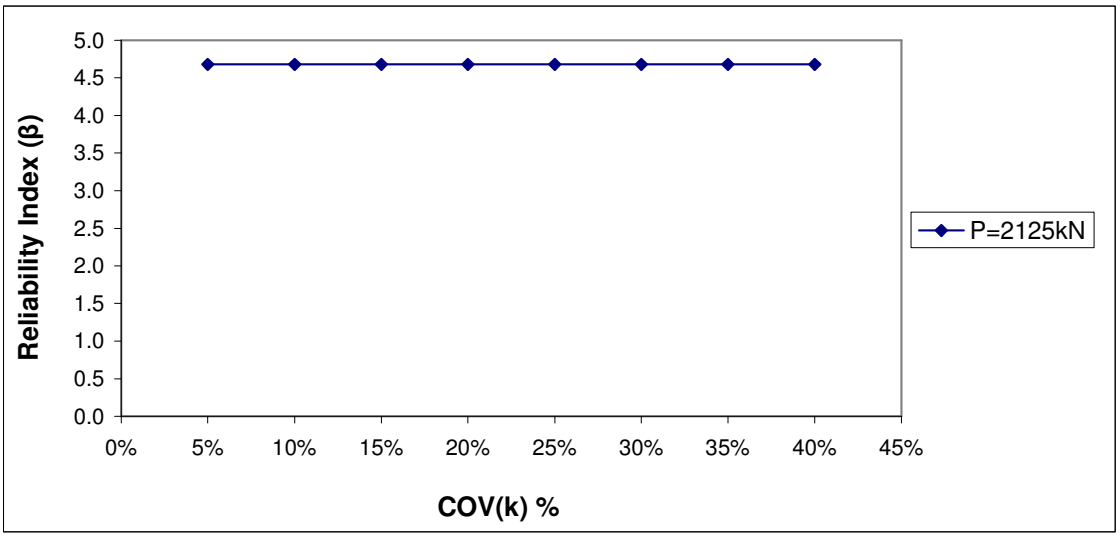


Fig. D.52 Reliability Index (β) of Y_{TOP} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.75 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'k' subjected to lateral load 2500kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.02E-09	0.000225	5%	0.0150	3.4866
1.00E-08	0.000225	10%	0.0150	3.4866
2.56E-08	0.000225	15%	0.0150	3.4865
4.84E-08	0.000225	20%	0.0150	3.4863
8.41E-08	0.000225	25%	0.0150	3.4860
1.37E-07	0.000225	30%	0.0150	3.4856
2.12E-07	0.000225	35%	0.0150	3.4850
3.31E-07	0.000225	40%	0.0150	3.4841

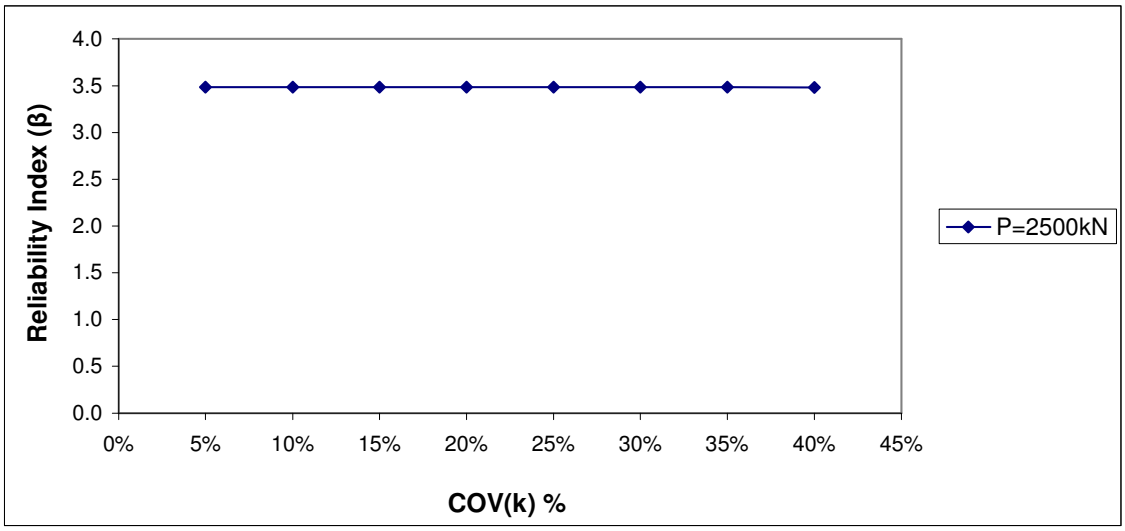


Fig. D.53 Reliability Index (β) of Y_{TOP} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 2500kN.

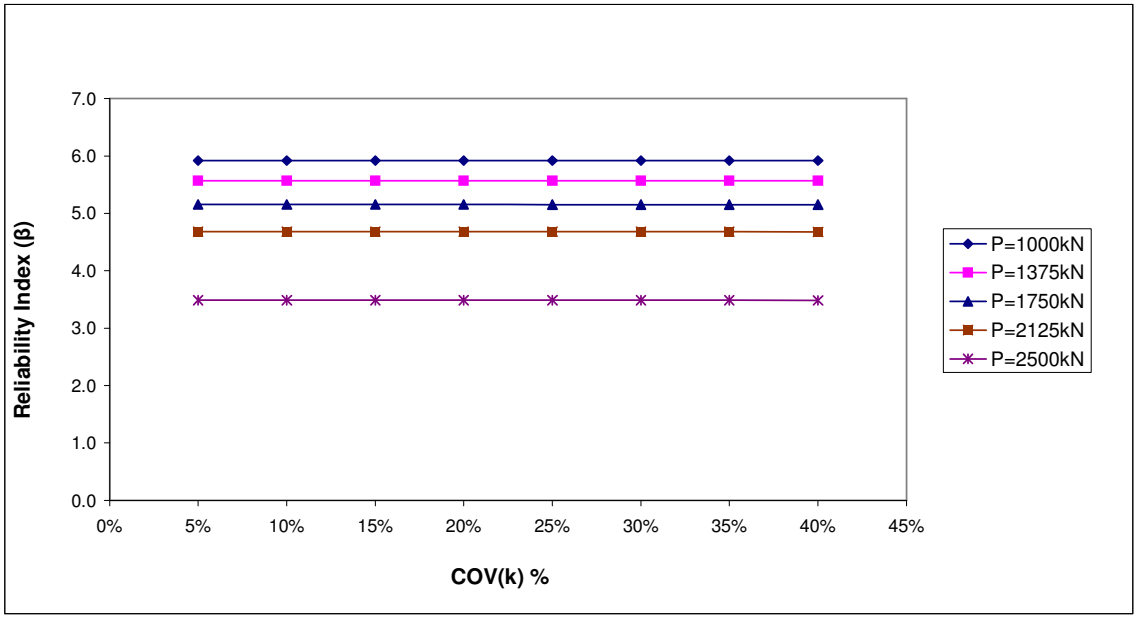


Fig. D.54 Reliability Index (β) of Y_{TOP} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table D.76 Reliability Index (β) connected to Y_{TOP} for fixed head long(10T) group with spacing (3D) and with varying 'B' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.82E-08	0.000225	5%	0.0150	5.9198
3.80E-08	0.000225	10%	0.0150	5.9195
7.45E-08	0.000225	15%	0.0150	5.9190
8.97E-08	0.000225	20%	0.0150	5.9188
1.34E-07	0.000225	25%	0.0150	5.9182
2.16E-07	0.000225	30%	0.0150	5.9172
3.36E-07	0.000225	35%	0.0150	5.9156
4.75E-07	0.000225	40%	0.0150	5.9138

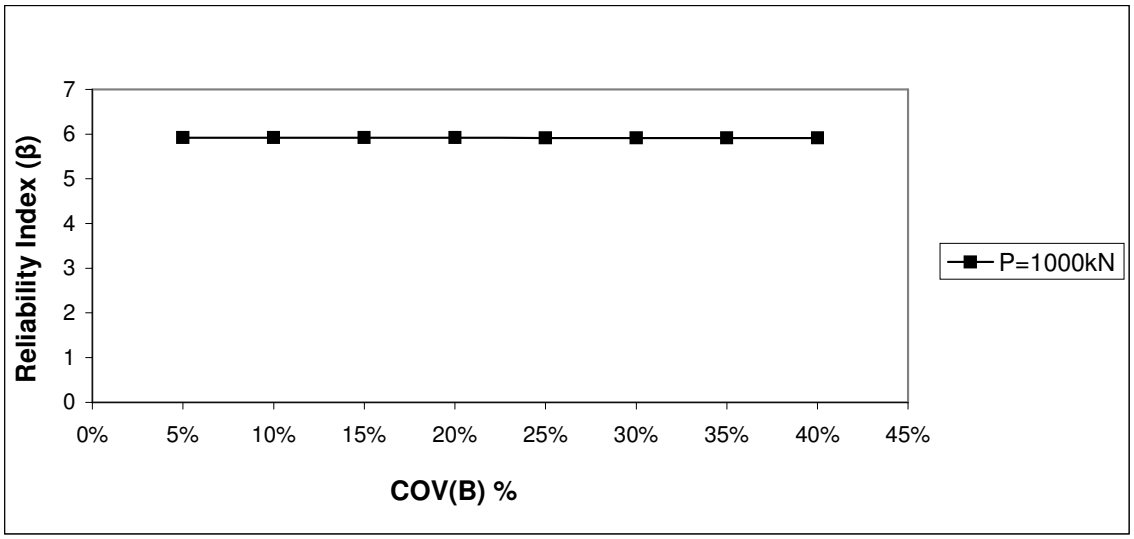


Fig. D.55 Reliability Index (β) of Y_{TOP} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.77 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'B' subjected to lateral load 1375kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.61E-08	0.000225	5%	0.0150	5.5662
1.68E-07	0.000225	10%	0.0150	5.5646
4.36E-07	0.000225	15%	0.0150	5.5613
9.60E-07	0.000225	20%	0.0150	5.5548
1.97E-06	0.000225	25%	0.0151	5.5424
4.35E-06	0.000225	30%	0.0151	5.5137
1.02E-05	0.000225	35%	0.0153	5.4449
2.35E-05	0.000225	40%	0.0158	5.2967

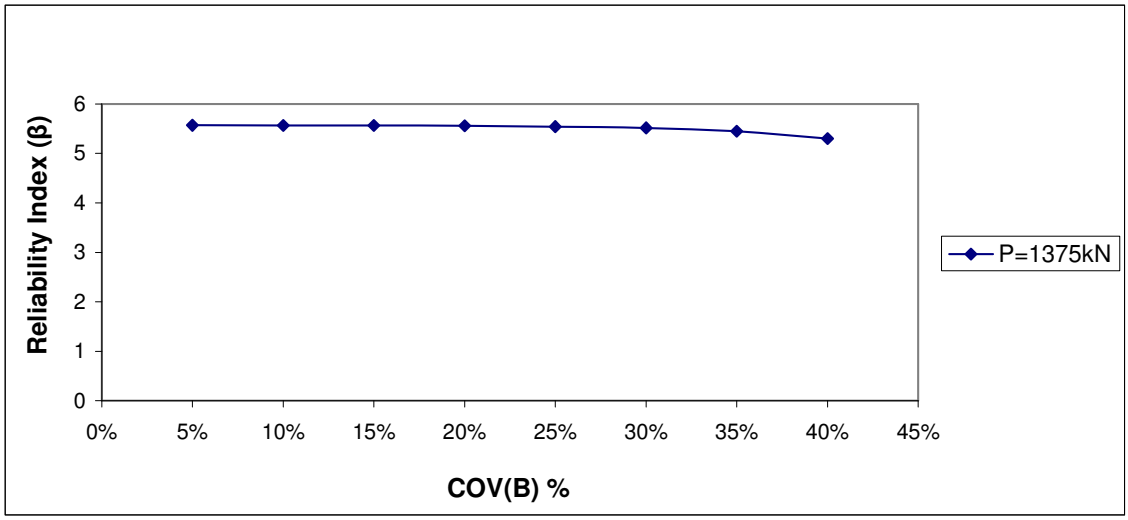


Fig. D.56 Reliability Index (β) of Y_{TOP} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.78 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'B' subjected to lateral load 1750kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.89E-07	0.000225	5%	0.0150	5.1512
8.84E-07	0.000225	10%	0.0150	5.1432
2.54E-06	0.000225	15%	0.0151	5.1244
6.43E-06	0.000225	20%	0.0152	5.0813
1.69E-05	0.000225	25%	0.0156	4.9701
4.27E-05	0.000225	30%	0.0164	4.7244
9.60E-05	0.000225	35%	0.0179	4.3146
1.84E-04	0.000225	40%	0.0202	3.8228

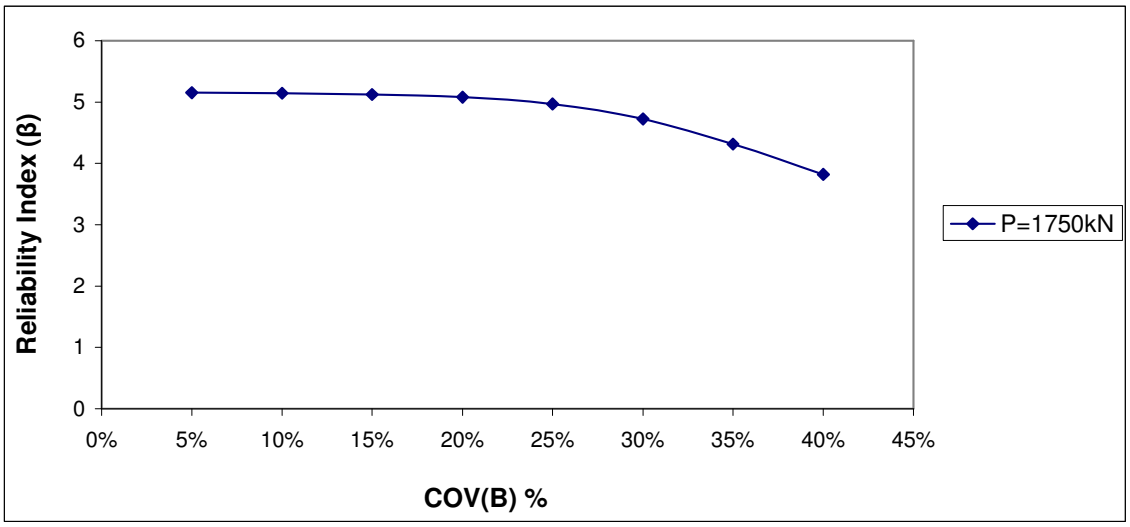


Fig. D.57 Reliability Index (β) of Y_{TOP} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.79 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'B' subjected to lateral load 2125kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.23E-06	0.000225	5%	0.0150	4.6672
6.33E-06	0.000225	10%	0.0152	4.6156
2.15E-05	0.000225	15%	0.0157	4.4710
5.85E-05	0.000225	20%	0.0168	4.3400
1.34E-04	0.000225	25%	0.0189	4.2000
2.60E-04	0.000225	30%	0.0220	3.8600
4.65E-04	0.000225	35%	0.0263	3.4600
7.61E-04	0.000225	40%	0.0314	2.9000

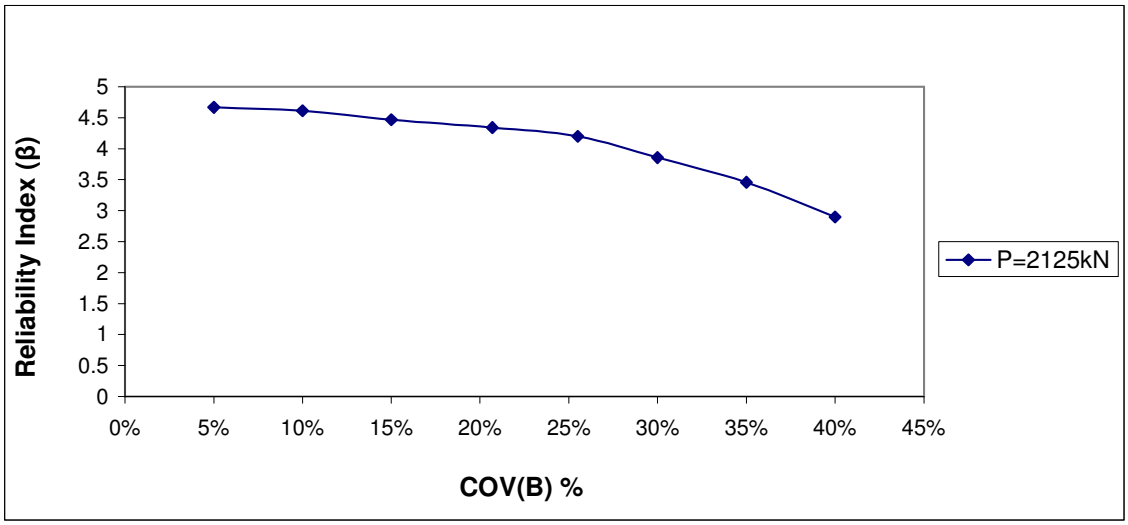


Fig. D.58 Reliability Index (β) of Y_{TOP} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.80 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'B' subjected to lateral load 2500kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.43E-07	0.000225	5%	0.0150	3.4817
6.43E-07	0.000225	10%	0.0150	3.4817
8.93E-07	0.000225	15%	0.0150	3.4798
2.09E-06	0.000225	20%	0.0151	3.4706
6.08E-06	0.000225	25%	0.0152	3.4405
2.23E-05	0.000225	30%	0.0157	3.3256
7.65E-05	0.000225	35%	0.0174	3.0121
1.96E-04	0.000225	40%	0.0205	2.5481

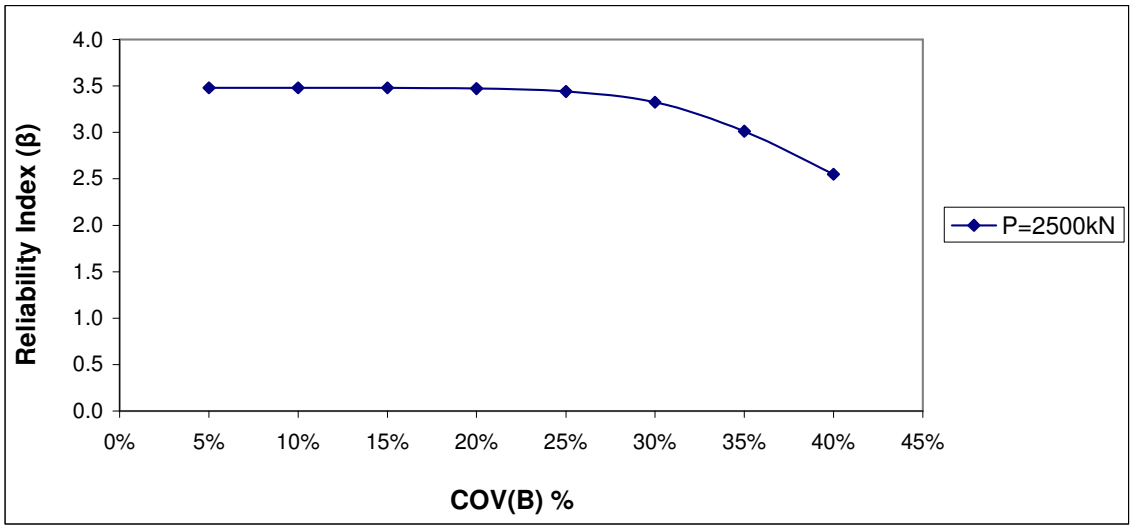


Fig. D.59 Reliability Index (β) of Y_{TOP} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 2500kN.

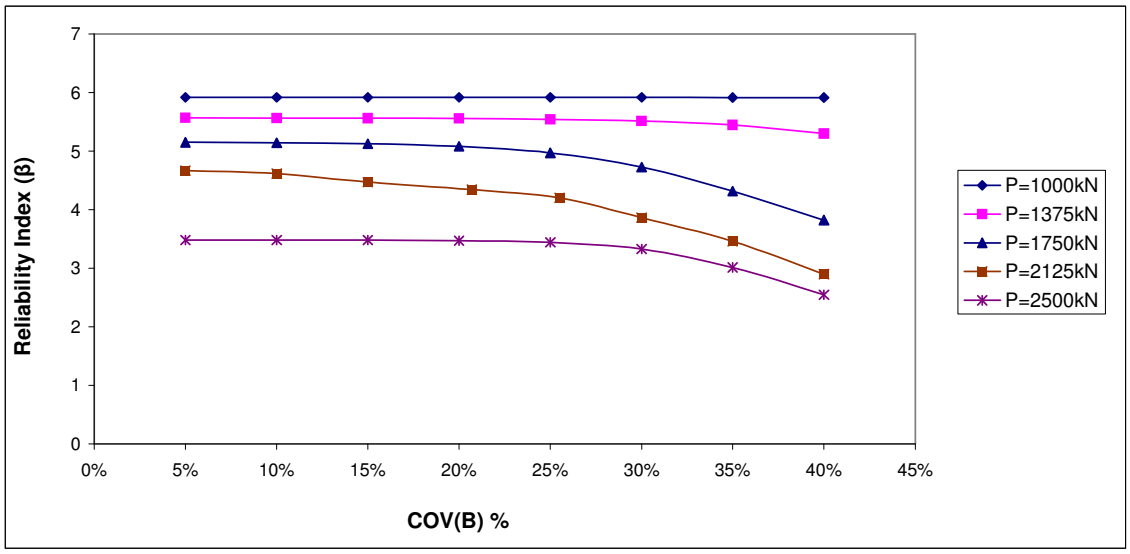


Fig. D.60 Reliability Index (β) of Y_{TOP} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table D.81 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
9.61E-08	0.000225	5%	0.0150	5.9187
3.78E-07	0.000225	10%	0.0150	5.9150
8.74E-07	0.000225	15%	0.0150	5.9085
1.60E-06	0.000225	20%	0.0151	5.8991
2.59E-06	0.000225	25%	0.0151	5.8863
3.88E-06	0.000225	30%	0.0151	5.8696
5.57E-06	0.000225	35%	0.0152	5.8480
7.76E-06	0.000225	40%	0.0153	5.8205

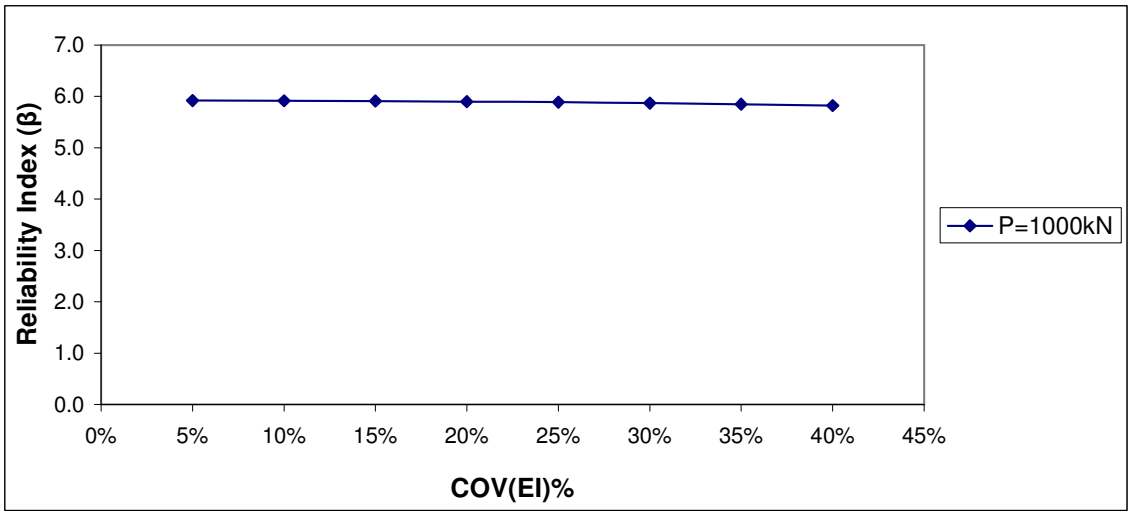


Fig. D.61 Reliability Index (β) of Y_{TOP} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.82 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 1375kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.40E-07	0.000225	5%	0.0150	5.5637
9.51E-07	0.000225	10%	0.0150	5.5549
2.19E-06	0.000225	15%	0.0151	5.5398
4.00E-06	0.000225	20%	0.0151	5.5178
6.50E-06	0.000225	25%	0.0152	5.4879
9.83E-06	0.000225	30%	0.0153	5.4489
1.43E-05	0.000225	35%	0.0155	5.3979
2.01E-05	0.000225	40%	0.0157	5.3334

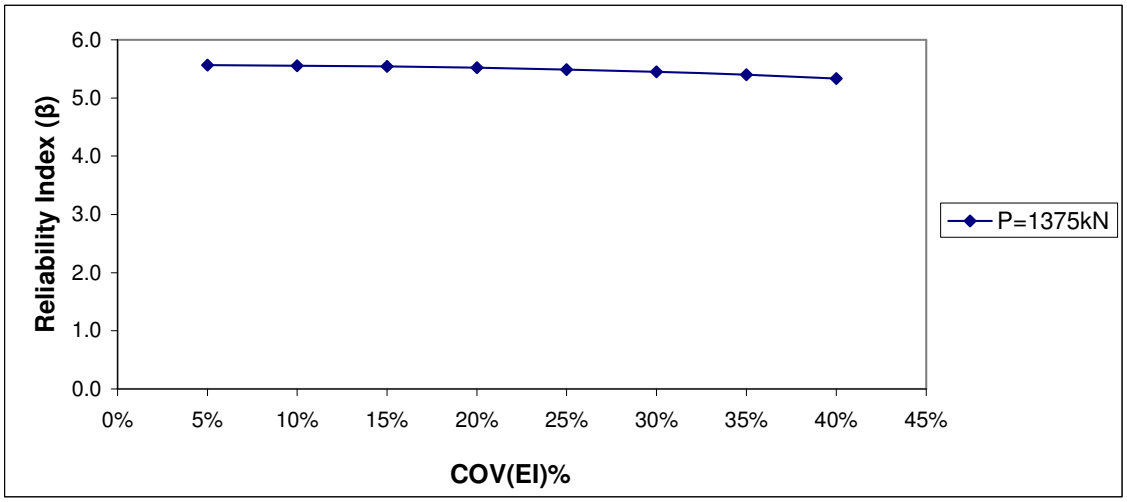


Fig. D.62 Reliability Index (β) of Y_{TOP} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.83 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 1750kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.63E-07	0.000225	5%	0.0150	5.1469
2.25E-06	0.000225	10%	0.0151	5.1278
5.13E-06	0.000225	15%	0.0152	5.0956
9.39E-06	0.000225	20%	0.0153	5.0490
1.54E-05	0.000225	25%	0.0155	4.9855
2.35E-05	0.000225	30%	0.0158	4.9034
3.43E-05	0.000225	35%	0.0161	4.8006
4.85E-05	0.000225	40%	0.0165	4.6740

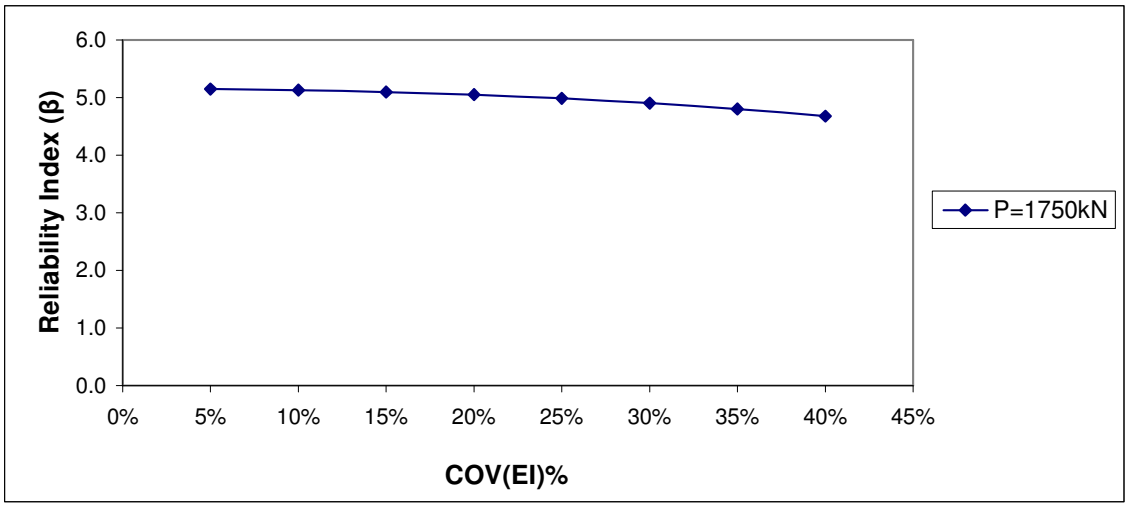


Fig. D.63 Reliability Index (β) of Y_{TOP} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.84 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 2125kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.21E-06	0.000225	5%	0.0150	4.6675
4.88E-06	0.000225	10%	0.0152	4.6300
1.12E-05	0.000225	15%	0.0154	4.5678
1.45E-05	0.000225	20%	0.0155	4.4800
3.34E-05	0.000225	25%	0.0161	4.3670
5.11E-05	0.000225	30%	0.0166	4.2252
7.46E-05	0.000225	35%	0.0173	4.0554
1.06E-04	0.000225	40%	0.0182	3.8568

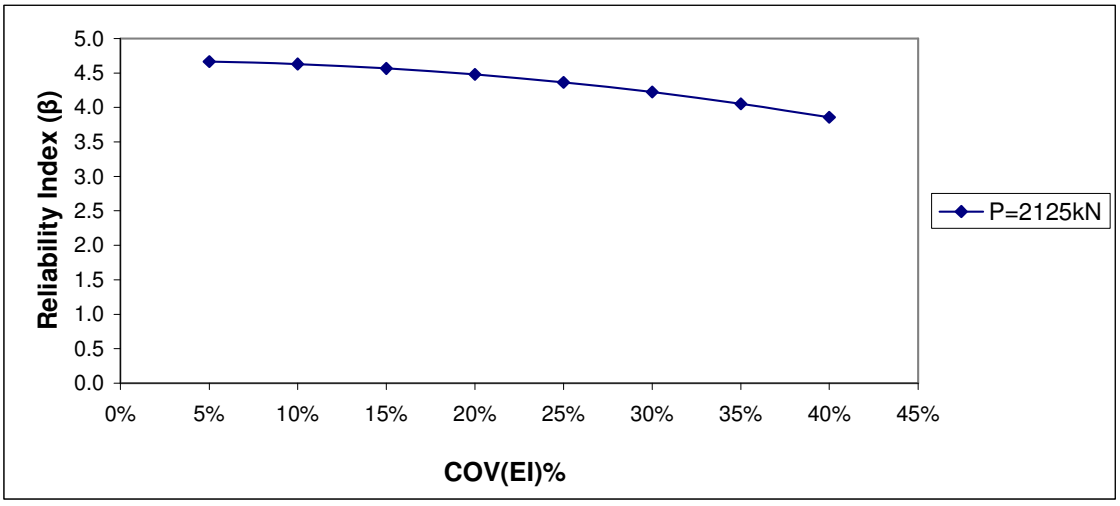


Fig. D.64 Reliability Index (β) of Y_{TOP} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.85 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 2500kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.37E-06	0.000225	5%	0.0151	3.4684
9.67E-06	0.000225	10%	0.0153	3.4141
2.24E-05	0.000225	15%	0.0157	3.3253
4.12E-05	0.000225	20%	0.0163	3.2058
6.77E-05	0.000225	25%	0.0171	3.0568
1.03E-04	0.000225	30%	0.0181	2.8859
1.86E-04	0.000225	35%	0.0203	2.5809
2.91E-04	0.000225	40%	0.0227	2.3034

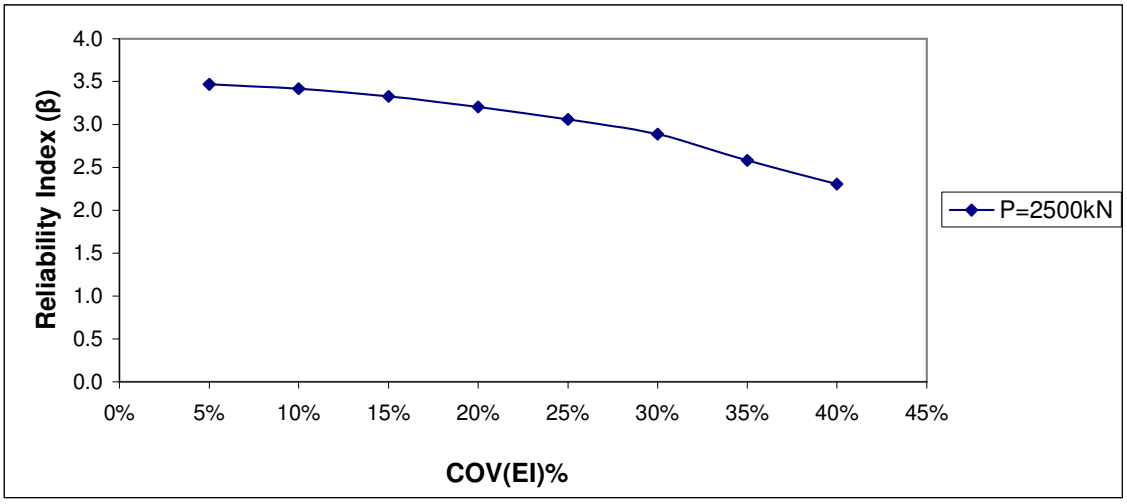


Fig. D.65 Reliability Index (β) of Y_{TOP} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 2500kN.

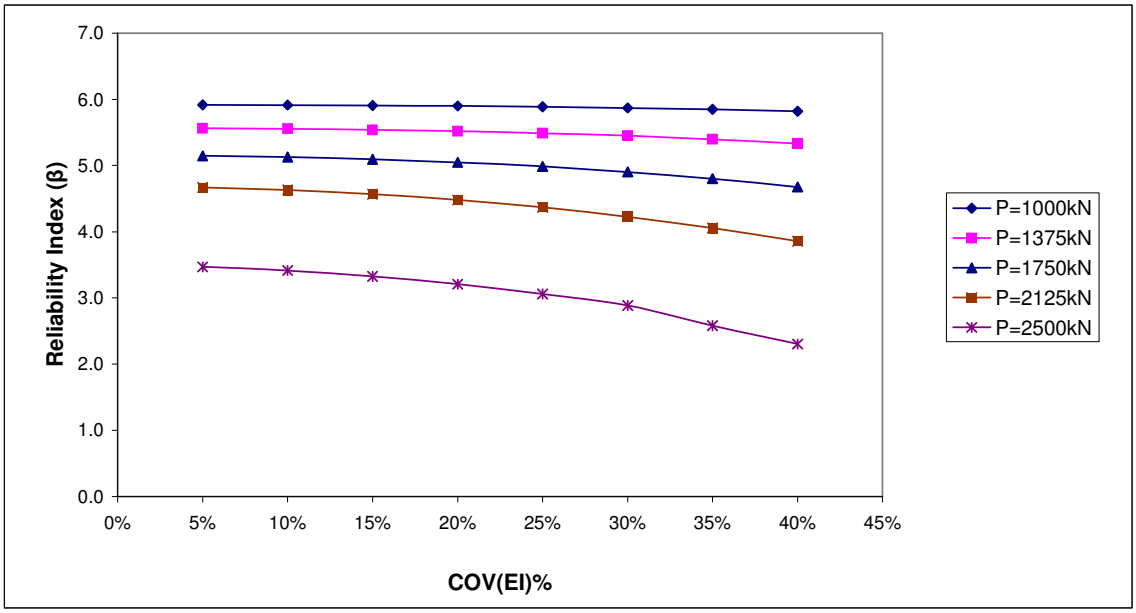


Fig. D.66 Reliability Index (β) of Y_{TOP} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table D.86 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'P' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.70E-07	0.000225	5%	0.0150	5.9125
2.28E-06	0.000225	10%	0.0151	5.8902
5.15E-06	0.000225	15%	0.0152	5.8534
9.10E-06	0.000225	20%	0.0153	5.8038
1.68E-05	0.000225	25%	0.0155	5.7106
2.33E-05	0.000225	30%	0.0158	5.6350
3.05E-05	0.000225	35%	0.0160	5.5559
3.58E-05	0.000225	40%	0.0161	5.4986

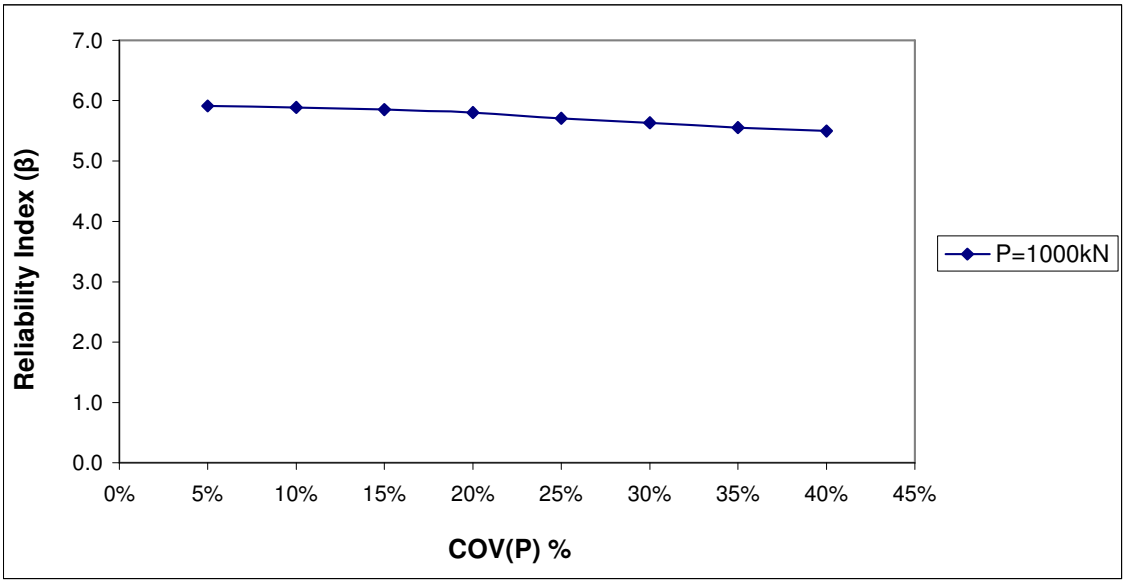


Fig. D.67 Reliability Index (β) of Y_{TOP} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.87 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'P' subjected to lateral load 1375kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.40E-06	0.000225	5%	0.0150	5.5494
5.66E-06	0.000225	10%	0.0152	5.4979
1.41E-05	0.000225	15%	0.0155	5.3996
2.31E-05	0.000225	20%	0.0158	5.3013
3.99E-05	0.000225	25%	0.0163	5.1299
5.31E-05	0.000225	30%	0.0167	5.0074
7.31E-05	0.000225	35%	0.0173	4.8362
8.52E-05	0.000225	40%	0.0176	4.7410

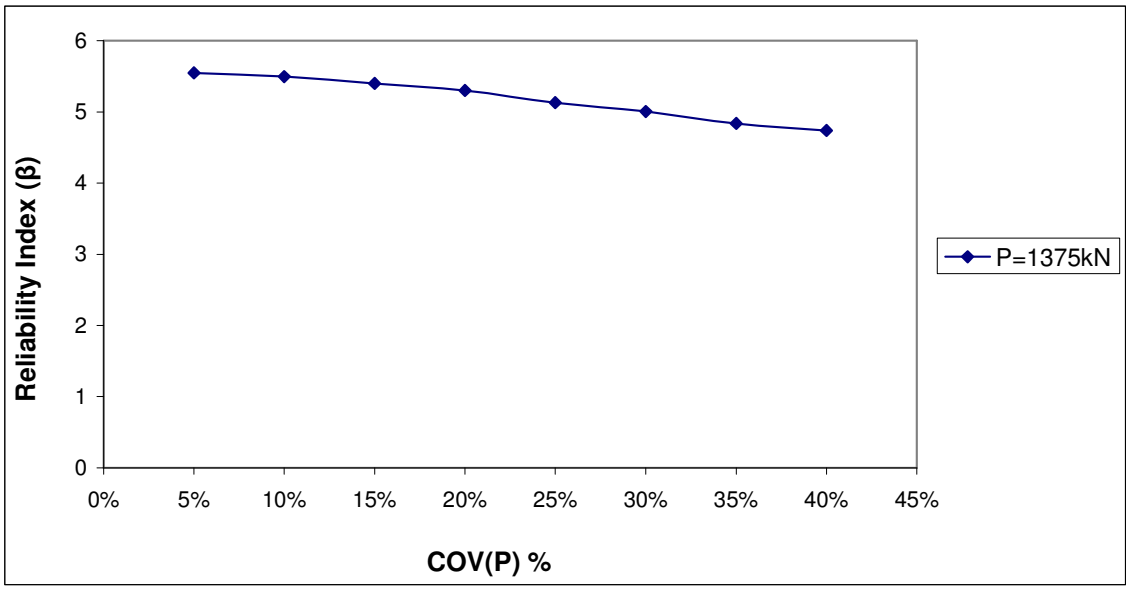


Fig. D.68 Reliability Index (β) of Y_{TOP} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.88 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'P' subjected to lateral load 1750kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.46E-06	0.000225	5%	0.0151	5.1142
1.39E-05	0.000225	10%	0.0155	5.0014
4.54E-05	0.000225	15%	0.0164	4.7006
7.65E-05	0.000225	20%	0.0174	4.4520
1.33E-04	0.000225	25%	0.0189	4.0858
1.86E-04	0.000225	30%	0.0203	3.8108
2.49E-04	0.000225	35%	0.0218	3.5511
2.59E-04	0.000225	40%	0.0220	3.5140

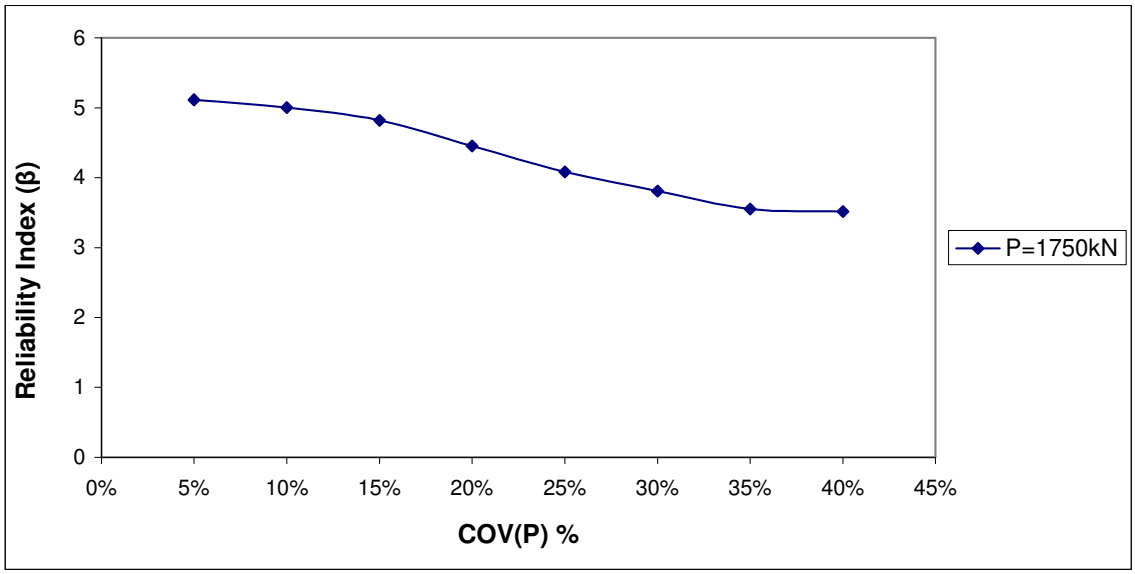


Fig. D.69 Reliability Index (β) of Y_{TOP} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.89 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'P' subjected to lateral load 2125kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.59E-06	0.000225	5%	0.0151	4.6636
1.81E-05	0.000225	10%	0.0156	4.5020
5.12E-05	0.000225	15%	0.0166	4.2241
1.51E-04	0.000225	20%	0.0194	3.6183
2.84E-04	0.000225	25%	0.0226	3.1123
4.23E-04	0.000225	30%	0.0254	2.7588
5.98E-04	0.000225	35%	0.0287	2.4477
7.89E-04	0.000225	40%	0.0318	2.2042

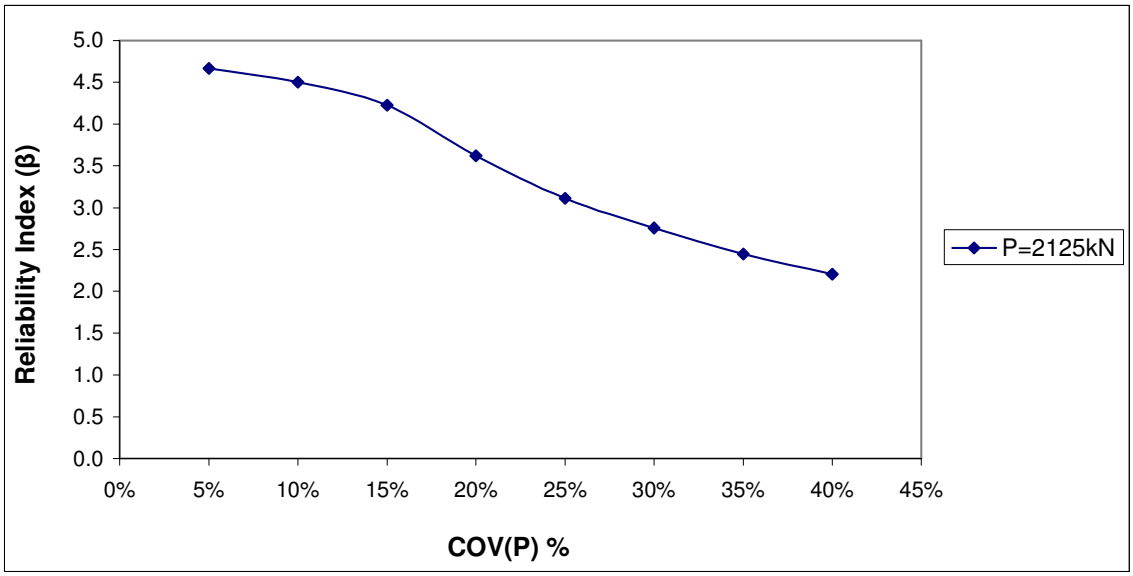


Fig. D.70 Reliability Index (β) of Y_{TOP} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.90 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (3D) and with varying 'P' subjected to lateral load 2500kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.65E-05	0.000225	5%	0.0159	3.2981
1.09E-04	0.000225	10%	0.0183	2.8618
2.36E-04	0.000225	15%	0.0215	2.4364
4.79E-04	0.000225	20%	0.0265	1.9706
8.69E-04	0.000225	25%	0.0331	1.5814
1.29E-03	0.000225	30%	0.0389	1.3453
1.79E-03	0.000225	35%	0.0449	1.1642
2.34E-03	0.000225	40%	0.0507	1.0324

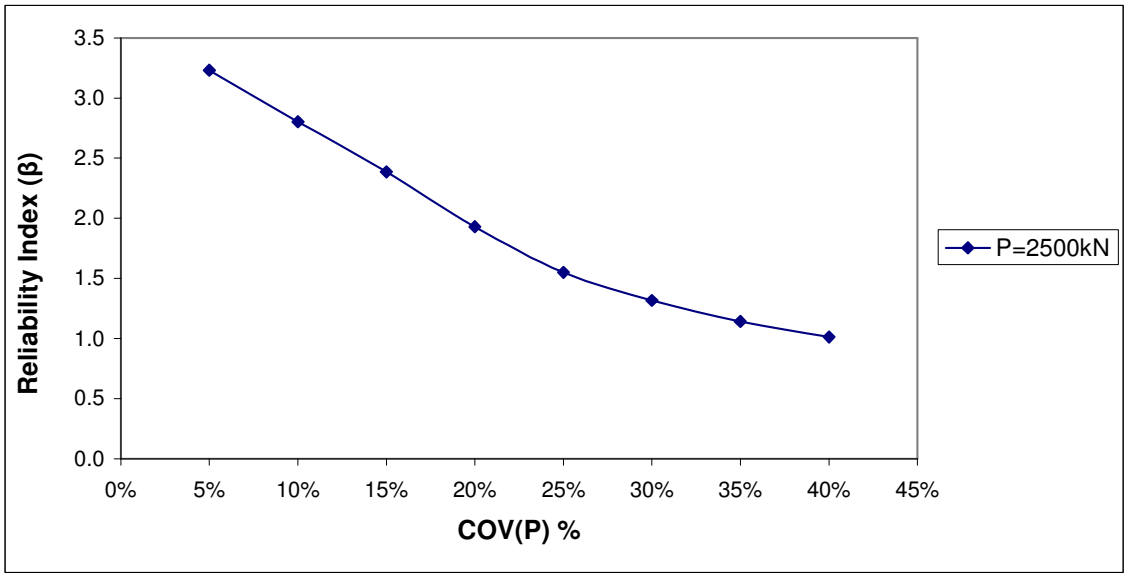


Fig. D.71 Reliability Index (β) of Y_{TOP} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 2500kN.

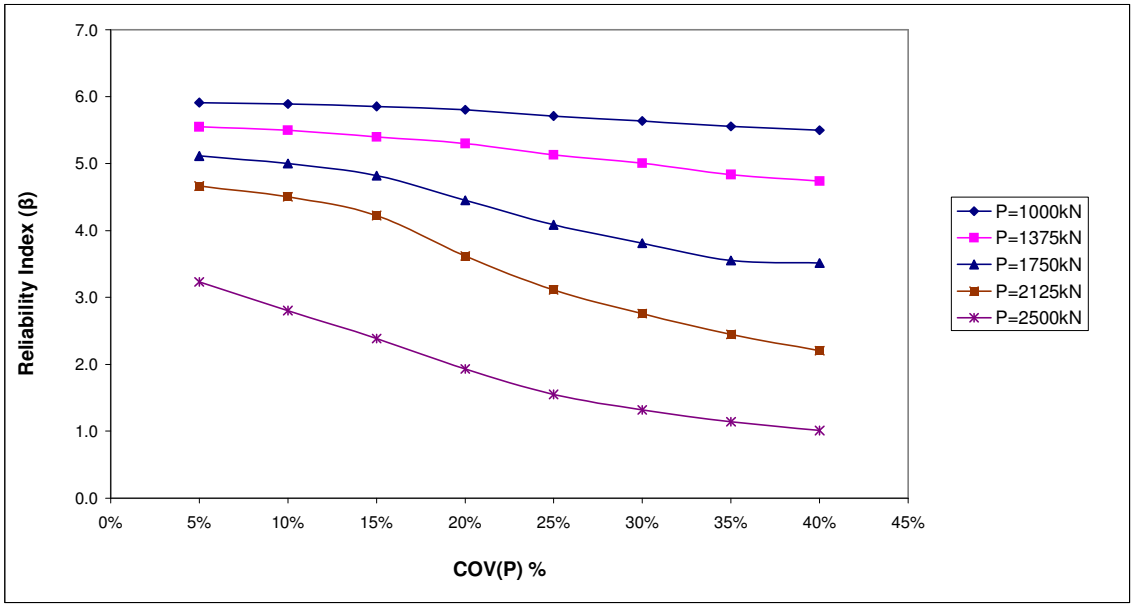


Fig. D.72 Reliability Index (β) of Y_{TOP} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

D.3 Probability of failure, p_f (Y_{TOP})of top deflection vs. COV (Variables).

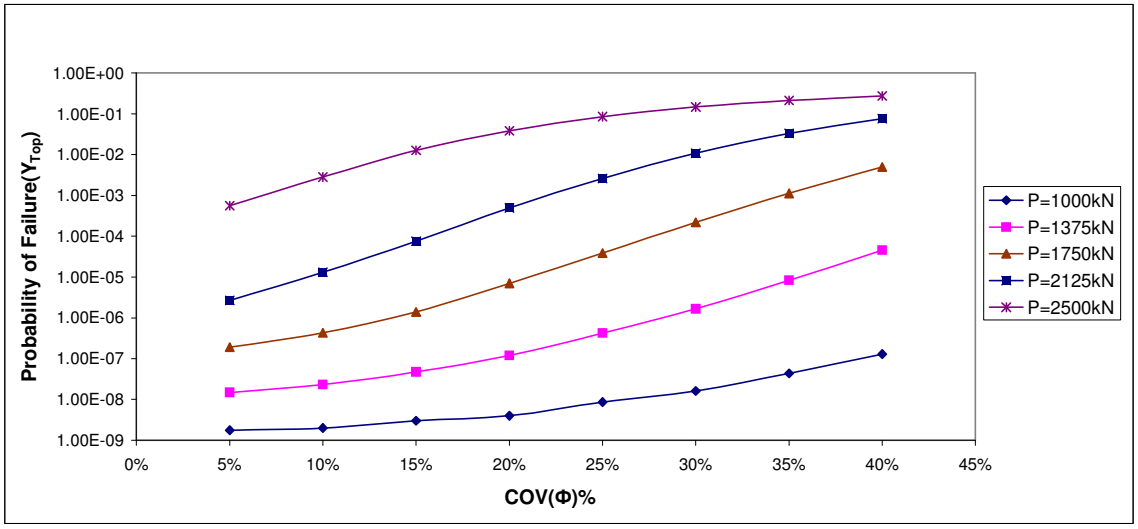


Fig. D.73 Probability of failure of top deflection p_f (Y_{TOP}) vs. COV (Φ) for fixed head long pile group of length 10T.

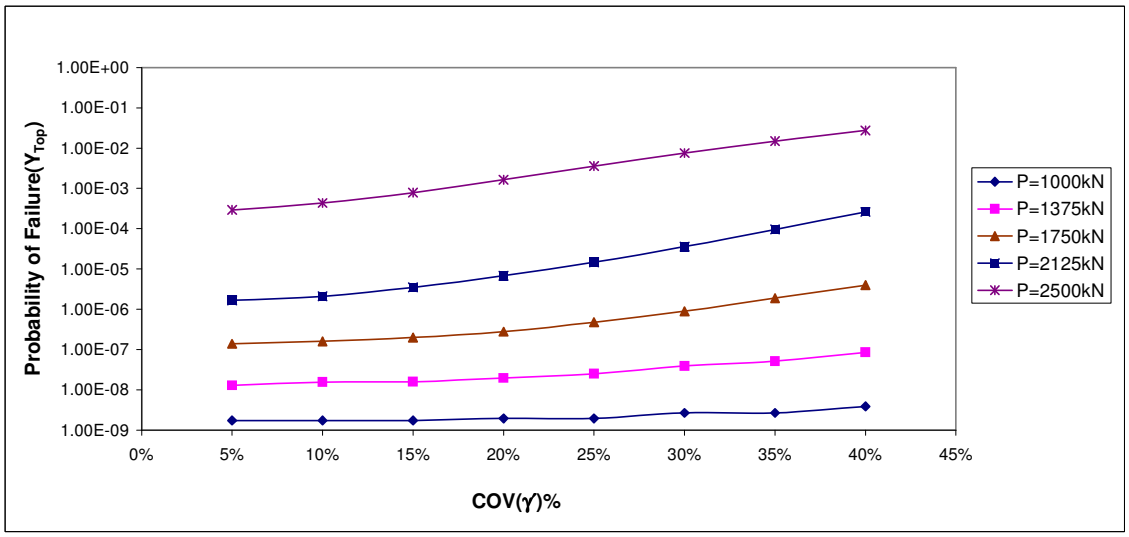


Fig. D.74 Probability of failure of top deflection p_f (Y_{TOP})vs. COV (γ') for fixed head long pile group of length 10T.

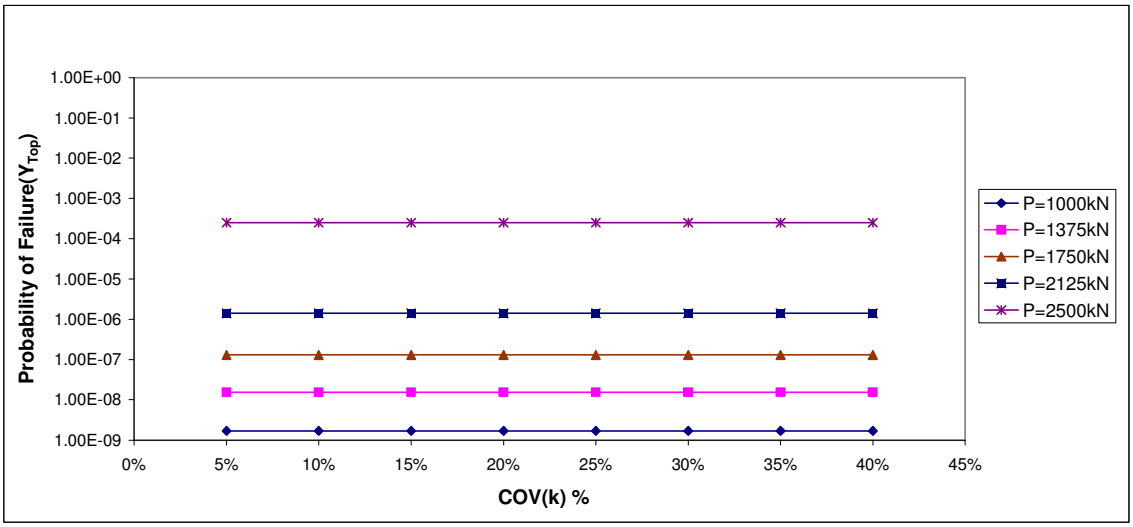


Fig. D.75 Probability of failure of top deflection p_f (Y_{TOP})vs. COV (k) for fixed head long pile group of length 10T.

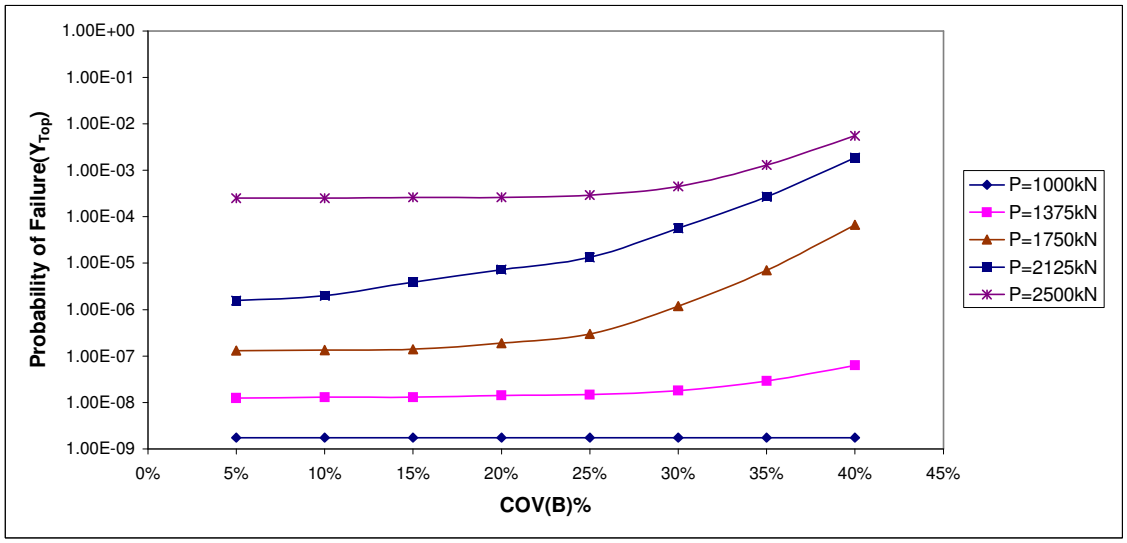


Fig. D.76 Probability of failure of top deflection p_f (Y_{TOP})vs. COV (B) for fixed head long pile group of length 10T.

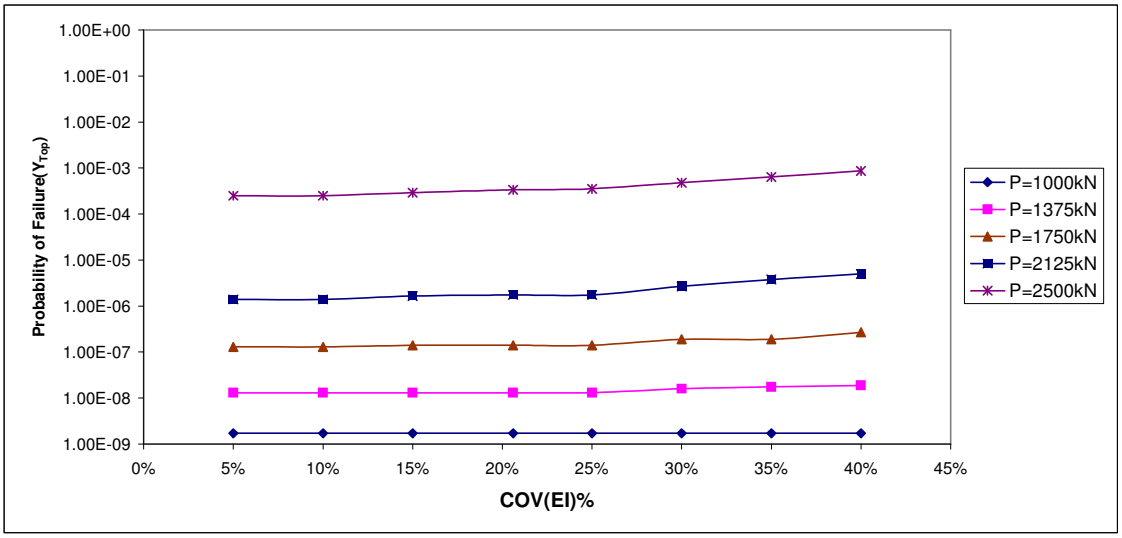


Fig. D.77 Probability of failure of top deflection p_f (Y_{TOP}) vs. COV (EI) for fixed head long pile group of length 10T.

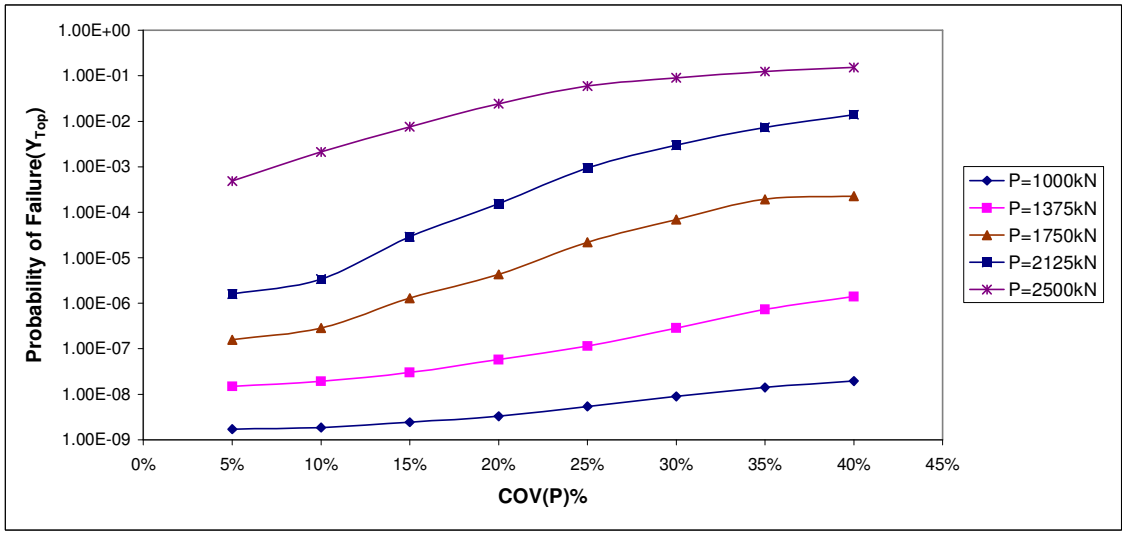


Fig. D.78 Probability of failure of top deflection p_f (Y_{TOP})vs. COV (P) for fixed head long pile group of length 10T.

D.4 Moment of fixed head long pile group and coefficient of (M_{max}) vs. COV (Variables)

Table D.91 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (Φ) and load 1000kN.

P=1000kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-1.91E+02				
5%	30			2.25E+00	3.91E+01	1.98E+02	3.16%
		28.5	-2.04E+02				
		33.0	-1.86E+02				
10%	30			9.00E+00	1.50E+02	1.98E+02	6.20%
		27.0	-2.10E+02				
		34.5	-1.80E+02				
15%	30			2.03E+01	3.40E+02	1.98E+02	9.34%
		25.5	-2.17E+02				
		36.0	-1.74E+02				
20%	30			3.60E+01	6.13E+02	1.98E+02	12.53%
		24.0	-2.24E+02				
		37.5	-1.69E+02				
25%	30			5.63E+01	9.58E+02	1.98E+02	15.67%
		22.5	-2.31E+02				
		39.0	-1.64E+02				
30%	30			8.10E+01	1.41E+03	1.98E+02	19.01%
		21.0	-2.39E+02				
		40.5	-1.59E+02				
35%	30			1.10E+02	1.97E+03	1.98E+02	22.48%
		19.5	-2.48E+02				
		42.0	-1.55E+02				
40%	30			1.44E+02	2.68E+03	1.98E+02	26.23%
		18.0	-2.59E+02				

Table D.92 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (Φ) and load 1375kN.

P=1375kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-2.81E+02				
5%	30			2.25E+00	7.83E+01	2.89E+02	3.06%
		28.5	-2.98E+02				
		33.0	-2.73E+02				
10%	30			9.00E+00	3.06E+02	2.89E+02	6.05%
		27.0	-3.08E+02				
		34.5	-2.65E+02				
15%	30			2.03E+01	7.08E+02	2.89E+02	9.19%
		25.5	-3.18E+02				
		36.0	-2.57E+02				
20%	30			3.60E+01	1.31E+03	2.89E+02	12.51%
		24.0	-3.29E+02				
		37.5	-2.50E+02				
25%	30			5.63E+01	2.12E+03	2.89E+02	15.92%
		22.5	-3.42E+02				
		39.0	-2.42E+02				
30%	30			8.10E+01	3.23E+03	2.89E+02	19.63%
		21.0	-3.56E+02				
		40.5	-2.35E+02				
35%	30			1.10E+02	4.70E+03	2.89E+02	23.70%
		19.5	-3.72E+02				
		42.0	-2.28E+02				
40%	30			1.44E+02	6.60E+03	2.89E+02	28.09%
		18.0	-3.91E+02				

Table D.93 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (Φ) and load 1750kN.

P=1750kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-3.73E+02				
5%	30			2.25E+00	1.68E+02	3.86E+02	3.35%
		28.5	-3.99E+02				
		33.0	-3.62E+02				
10%	30			9.00E+00	6.48E+02	3.86E+02	6.59%
		27.0	-4.13E+02				
		34.5	-3.52E+02				
15%	30			2.03E+01	1.48E+03	3.86E+02	9.96%
		25.5	-4.28E+02				
		36.0	-3.41E+02				
20%	30			3.60E+01	2.73E+03	3.86E+02	13.53%
		24.0	-4.45E+02				
		37.5	-3.31E+02				
25%	30			5.63E+01	4.46E+03	3.86E+02	17.29%
		22.5	-4.64E+02				
		39.0	-3.22E+02				
30%	30			8.10E+01	6.72E+03	3.86E+02	21.23%
		21.0	-4.86E+02				
		40.5	-3.12E+02				
35%	30			1.10E+02	9.79E+03	3.86E+02	25.63%
		19.5	-5.10E+02				
		42.0	-3.03E+02				
40%	30			1.44E+02	1.40E+04	3.86E+02	30.61%
		18.0	-5.40E+02				

Table D.94 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (Φ) and load 2125kN.

P=2125kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-4.72E+02				
5%	30			2.25E+00	2.89E+02	4.89E+02	3.48%
		28.5	-5.06E+02				
		33.0	-4.57E+02				
10%	30			9.00E+00	1.16E+03	4.89E+02	6.97%
		27.0	-5.25E+02				
		34.5	-4.42E+02				
15%	30			2.03E+01	2.66E+03	4.89E+02	10.55%
		25.5	-5.45E+02				
		36.0	-4.28E+02				
20%	30			3.60E+01	4.82E+03	4.89E+02	14.20%
		24.0	-5.67E+02				
		37.5	-4.15E+02				
25%	30			5.63E+01	7.80E+03	4.89E+02	18.05%
		22.5	-5.92E+02				
		39.0	-4.02E+02				
30%	30			8.10E+01	1.18E+04	4.89E+02	22.18%
		21.0	-6.19E+02				
		40.5	-3.91E+02				
35%	30			1.10E+02	1.68E+04	4.89E+02	26.53%
		19.5	-6.51E+02				
		42.0	-3.80E+02				
40%	30			1.44E+02	2.33E+04	4.89E+02	31.20%
		18.0	-6.85E+02				

Table D.95 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (Φ) and load 2500kN.

P=2500kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-5.73E+02				
5%	30			2.25E+00	3.80E+02	5.92E+02	3.30%
		28.5	-6.12E+02				
		33.0	-5.54E+02				
10%	30			9.00E+00	1.56E+03	5.92E+02	6.69%
		27.0	-6.33E+02				
		34.5	-5.35E+02				
15%	30			2.03E+01	3.61E+03	5.92E+02	10.15%
		25.5	-6.56E+02				
		36.0	-5.18E+02				
20%	30			3.60E+01	6.50E+03	5.92E+02	13.62%
		24.0	-6.79E+02				
		37.5	-5.02E+02				
25%	30			5.63E+01	1.04E+04	5.92E+02	17.27%
		22.5	-7.06E+02				
		39.0	-4.86E+02				
30%	30			8.10E+01	1.57E+04	5.92E+02	27.30%
		21.0	-7.37E+02				
		40.5	-4.71E+02				
35%	30			1.10E+02	2.26E+04	5.92E+02	32.60%
		19.5	-7.72E+02				
		42.0	-4.57E+02				
40%	30			1.44E+02	3.15E+04	5.92E+02	38.00%
		18.0	-8.12E+02				

Table D.96 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 1000kN.

P=1000kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	3.91E+01	3.16%
10%	9.00E+00	1.50E+02	6.20%
15%	2.03E+01	3.40E+02	9.34%
20%	3.60E+01	6.13E+02	12.53%
25%	5.63E+01	9.58E+02	15.67%
30%	8.10E+01	1.41E+03	19.01%
35%	1.10E+02	1.97E+03	22.48%
40%	1.44E+02	2.68E+03	26.23%

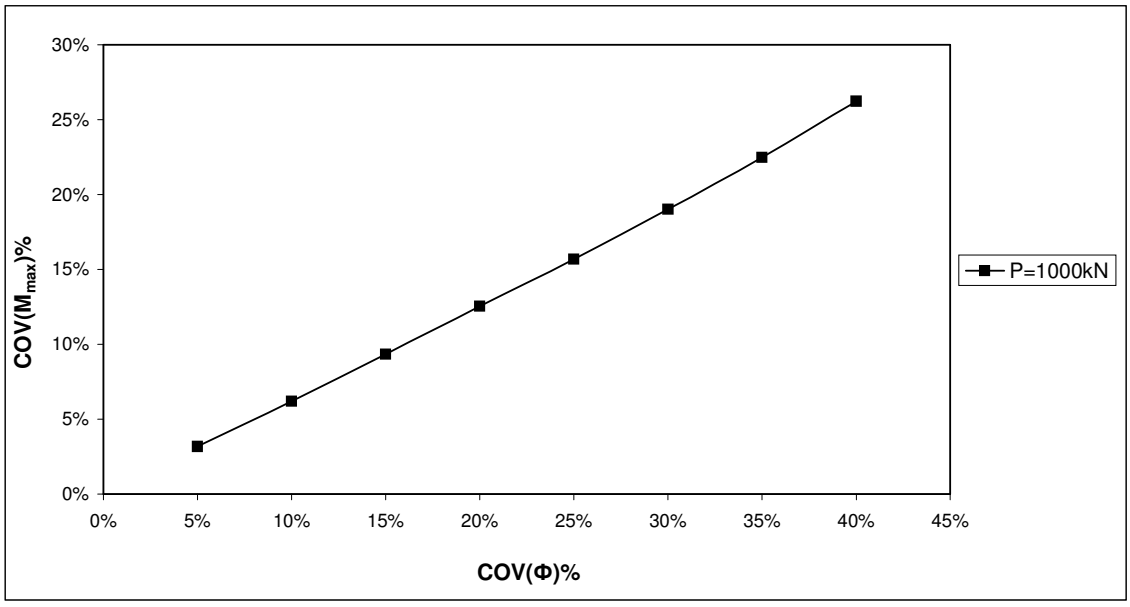


Fig. D.79 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.97 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 1375kN.

P=1375kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	7.83E+01	3.06%
10%	9.00E+00	3.06E+02	6.05%
15%	2.03E+01	7.08E+02	9.19%
20%	3.60E+01	1.31E+03	12.51%
25%	5.63E+01	2.12E+03	15.92%
30%	8.10E+01	3.23E+03	19.63%
35%	1.10E+02	4.70E+03	23.70%
40%	1.44E+02	6.60E+03	28.09%

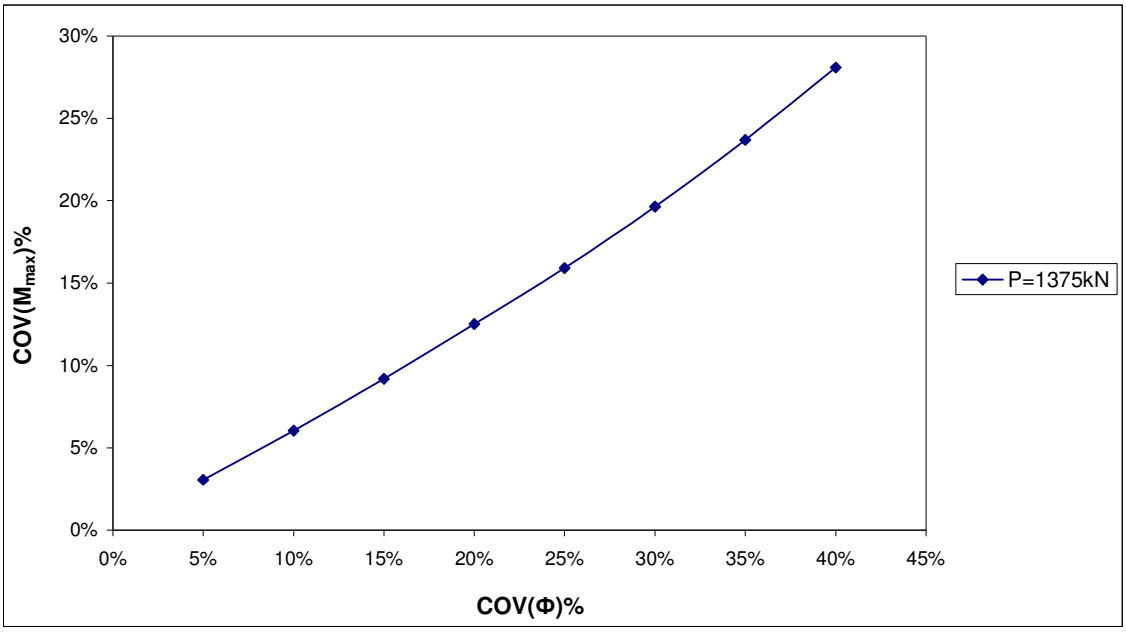


Fig. D.80 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.98 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 1750kN.

P=1750kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	1.68E+02	3.35%
10%	9.00E+00	6.48E+02	6.59%
15%	2.03E+01	1.48E+03	9.96%
20%	3.60E+01	2.73E+03	13.53%
25%	5.63E+01	4.46E+03	17.29%
30%	8.10E+01	6.72E+03	21.23%
35%	1.10E+02	9.79E+03	25.63%
40%	1.44E+02	1.40E+04	30.61%

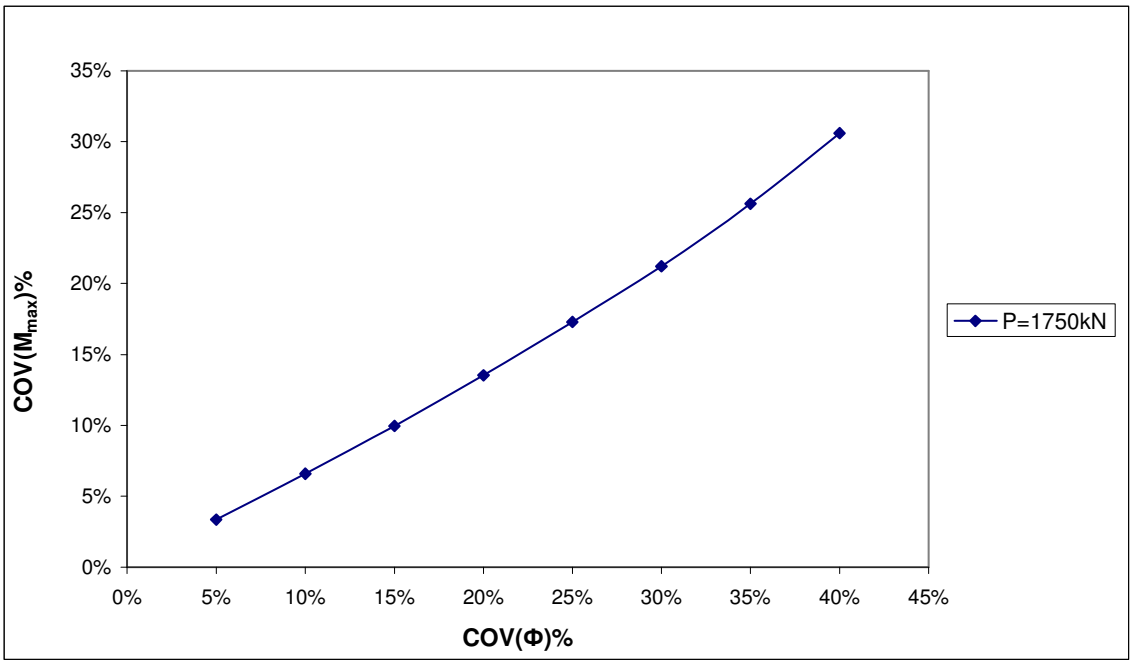


Fig. D.81 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.99 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 2125kN.

P=2125kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	2.89E+02	3.48%
10%	9.00E+00	1.16E+03	6.97%
15%	2.03E+01	2.66E+03	10.55%
20%	3.60E+01	4.82E+03	14.20%
25%	5.63E+01	7.80E+03	18.05%
30%	8.10E+01	1.18E+04	22.18%
35%	1.10E+02	1.68E+04	26.53%
40%	1.44E+02	2.33E+04	31.20%

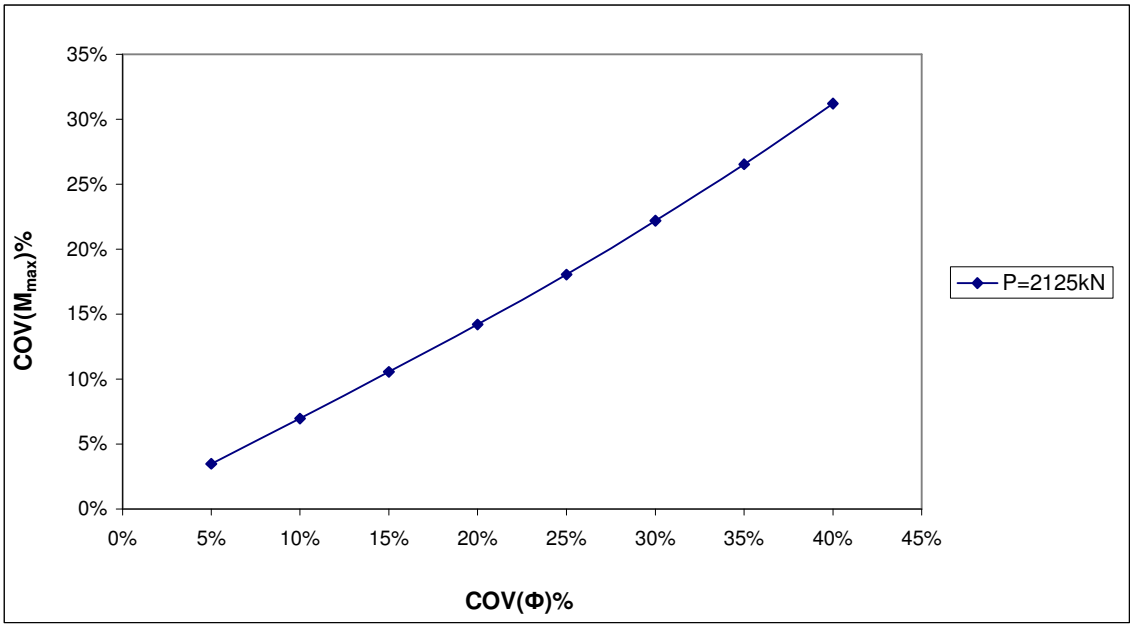


Fig. D.82 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.100 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(Φ) and lateral load 2500kN.

P=2500kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	3.80E+02	3.30%
10%	9.00E+00	1.56E+03	6.69%
15%	2.03E+01	3.61E+03	10.15%
20%	3.60E+01	6.50E+03	13.62%
25%	5.63E+01	1.04E+04	17.27%
30%	8.10E+01	1.57E+04	27.30%
35%	1.10E+02	2.26E+04	32.60%
40%	1.44E+02	3.15E+04	38.00%

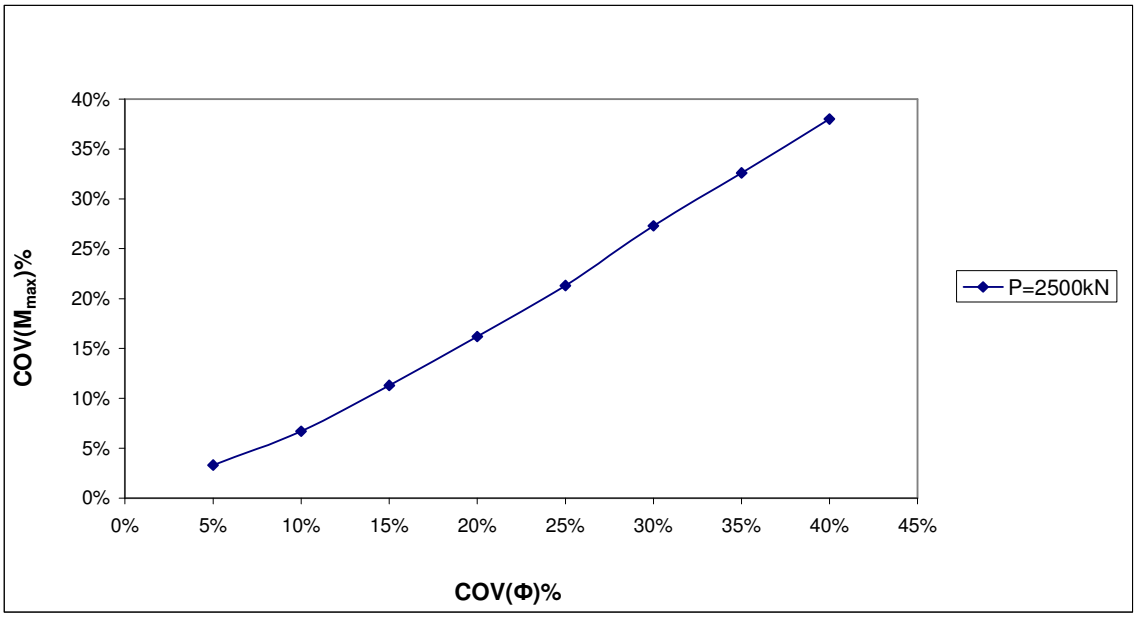


Fig. D.83 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

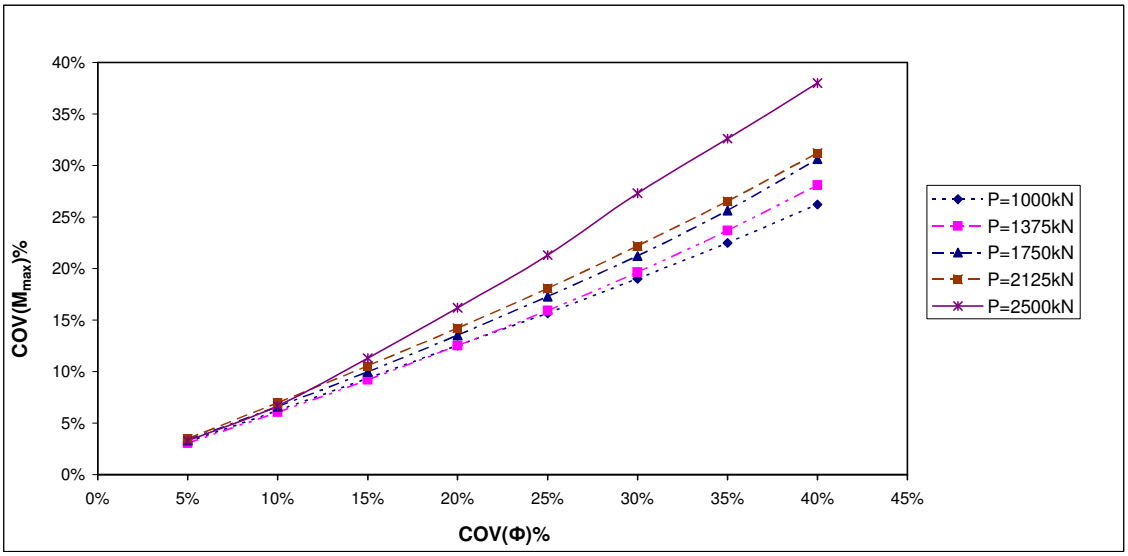


Fig. D.84 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table D.101 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (γ) and load 1000kN.

P=1000kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^o (kN-m)	COV(M_{max}) (%)
		11.03	-1.95E+02				
5%	10.5			2.76E-01	6.25E+00	1.98E+02	1.27%
		9.98	-2.00E+02				
		11.55	-1.93E+02				
10%	10.5			1.10E+00	2.70E+01	1.98E+02	2.63%
		9.45	-2.03E+02				
		12.08	-1.90E+02				
15%	10.5			2.48E+00	6.24E+01	1.98E+02	4.00%
		8.93	-2.06E+02				
		12.60	-1.88E+02				
20%	10.5			4.41E+00	1.09E+02	1.98E+02	5.29%
		8.40	-2.09E+02				
		13.13	-1.86E+02				
25%	10.5			6.89E+00	1.74E+02	1.98E+02	6.68%
		7.88	-2.13E+02				
		13.65	-1.85E+02				
30%	10.5			9.92E+00	2.53E+02	1.98E+02	8.05%
		7.35	-2.16E+02				
		14.18	-1.82E+02				
35%	10.5			1.35E+01	3.61E+02	1.98E+02	9.62%
		6.83	-2.20E+02				
		14.70	-1.81E+02				
40%	10.5			1.76E+01	4.86E+02	1.98E+02	11.10%
		6.30	-2.25E+02				

Table D.102 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (γ) and load 1375kN.

P=1375kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^o (kN-m)	COV(M_{max}) (%)
		11.03	-2.86E+02				
5%	10.5			2.76E-01	1.26E+01	2.89E+02	1.23%
		9.98	-2.93E+02				
		11.55	-2.83E+02				
10%	10.5			1.10E+00	5.40E+01	2.89E+02	2.54%
		9.45	-2.97E+02				
		12.08	-2.79E+02				
15%	10.5			2.48E+00	1.22E+02	2.89E+02	3.82%
		8.93	-3.01E+02				
		12.60	-2.76E+02				
20%	10.5			4.41E+00	2.21E+02	2.89E+02	5.13%
		8.40	-3.06E+02				
		13.13	-2.74E+02				
25%	10.5			6.89E+00	3.55E+02	2.89E+02	6.52%
		7.88	-3.11E+02				
		13.65	-2.71E+02				
30%	10.5			9.92E+00	5.20E+02	2.89E+02	8.06%
		7.35	-3.17E+02				
		14.18	-2.68E+02				
35%	10.5			1.35E+01	7.54E+02	2.89E+02	9.77%
		6.83	-3.23E+02				
		14.70	-2.66E+02				
40%	10.5			1.76E+01	1.03E+03	2.89E+02	11.58%
		6.30	-3.30E+02				

Table D.103 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (γ) and load 1750kN.

P=1750kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^o (kN-m)	COV(M_{max}) (%)
		11.03	-3.81E+02				
5%	10.5			2.76E-01	2.55E+01	3.86E+02	1.31%
		9.98	-3.91E+02				
		11.55	-3.76E+02				
10%	10.5			1.10E+00	1.14E+02	3.86E+02	2.77%
		9.45	-3.97E+02				
		12.08	-3.72E+02				
15%	10.5			2.48E+00	2.59E+02	3.86E+02	4.17%
		8.93	-4.04E+02				
		12.60	-3.68E+02				
20%	10.5			4.41E+00	4.54E+02	3.86E+02	5.52%
		8.40	-4.10E+02				
		13.13	-3.64E+02				
25%	10.5			6.89E+00	7.37E+02	3.86E+02	7.03%
		7.88	-4.18E+02				
		13.65	-3.60E+02				
30%	10.5			9.92E+00	1.11E+03	3.86E+02	8.62%
		7.35	-4.26E+02				
		14.18	-3.56E+02				
35%	10.5			1.35E+01	1.56E+03	3.86E+02	10.53%
		6.83	-4.35E+02				
		14.70	-3.53E+02				
40%	10.5			1.76E+01	2.14E+03	3.86E+02	12.75%
		6.30	-4.46E+02				

Table D.104 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (γ) and load 2125kN.

P=2125kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^o (kN-m)	COV(M_{max}) (%)
		11.03	-4.82E+02				
5%	10.5			2.76E-01	4.90E+01	4.89E+02	1.43%
		9.98	-4.96E+02				
		11.55	-4.76E+02				
10%	10.5			1.10E+00	1.96E+02	4.89E+02	2.86%
		9.45	-5.04E+02				
		12.08	-4.70E+02				
15%	10.5			2.48E+00	4.49E+02	4.89E+02	4.33%
		8.93	-5.12E+02				
		12.60	-4.64E+02				
20%	10.5			4.41E+00	8.04E+02	4.89E+02	5.80%
		8.40	-5.21E+02				
		13.13	-4.59E+02				
25%	10.5			6.89E+00	1.29E+03	4.89E+02	7.34%
		7.88	-5.31E+02				
		13.65	-4.54E+02				
30%	10.5			9.92E+00	1.94E+03	4.89E+02	9.20%
		7.35	-5.42E+02				
		14.18	-4.49E+02				
35%	10.5			1.35E+01	2.68E+03	4.89E+02	11.42%
		6.83	-5.53E+02				
		14.70	-4.45E+02				
40%	10.5			1.76E+01	3.68E+03	4.89E+02	13.78%
		6.30	-5.66E+02				

Table D.105 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (γ) and load 2500kN.

P=2500kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^o (kN-m)	COV(M_{max}) (%)
		11.03	-5.84E+02				
5%	10.5			2.76E-01	6.89E+01	5.92E+02	1.40%
		9.98	-6.01E+02				
		11.55	-5.77E+02				
10%	10.5			1.10E+00	2.54E+02	5.92E+02	2.85%
		9.45	-6.09E+02				
		12.08	-5.70E+02				
15%	10.5			2.48E+00	6.20E+02	5.92E+02	5.00%
		8.93	-6.20E+02				
		12.60	-5.62E+02				
20%	10.5			4.41E+00	1.14E+03	5.92E+02	7.37%
		8.40	-6.29E+02				
		13.13	-5.57E+02				
25%	10.5			6.89E+00	1.93E+03	5.92E+02	10.18%
		7.88	-6.45E+02				
		13.65	-5.51E+02				
30%	10.5			9.92E+00	2.84E+03	5.92E+02	12.84%
		7.35	-6.58E+02				
		14.18	-5.45E+02				
35%	10.5			1.35E+01	4.01E+03	5.92E+02	16.49%
		6.83	-6.72E+02				
		14.70	-5.35E+02				
40%	10.5			1.76E+01	5.74E+03	5.92E+02	20.35%
		6.30	-6.87E+02				

Table D.106 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 1000kN.

P=1000kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	6.25E+00	1.27%
10%	1.10E+00	2.70E+01	2.63%
15%	2.48E+00	6.24E+01	4.00%
20%	4.41E+00	1.09E+02	5.29%
25%	6.89E+00	1.74E+02	6.68%
30%	9.92E+00	2.53E+02	8.05%
35%	1.35E+01	3.61E+02	9.62%
40%	1.76E+01	4.86E+02	11.10%

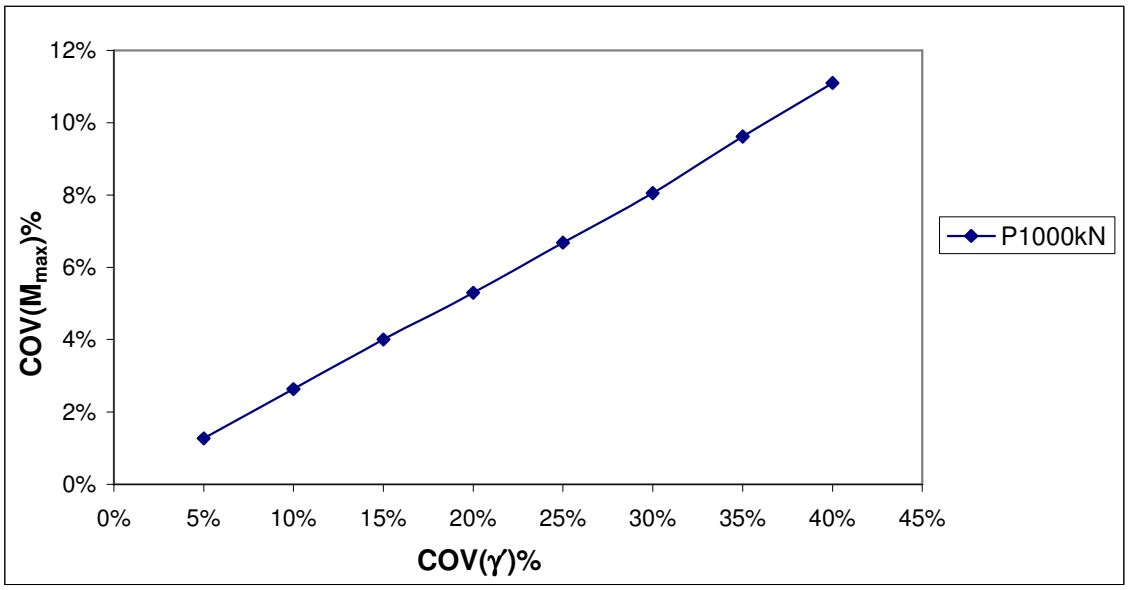


Fig. D.85 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.107 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 1375kN.

P=1375kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	1.26E+01	1.23%
10%	1.10E+00	5.40E+01	2.54%
15%	2.48E+00	1.22E+02	3.82%
20%	4.41E+00	2.21E+02	5.13%
25%	6.89E+00	3.55E+02	6.52%
30%	9.92E+00	5.20E+02	8.06%
35%	1.35E+01	7.54E+02	9.77%
40%	1.76E+01	1.03E+03	11.58%

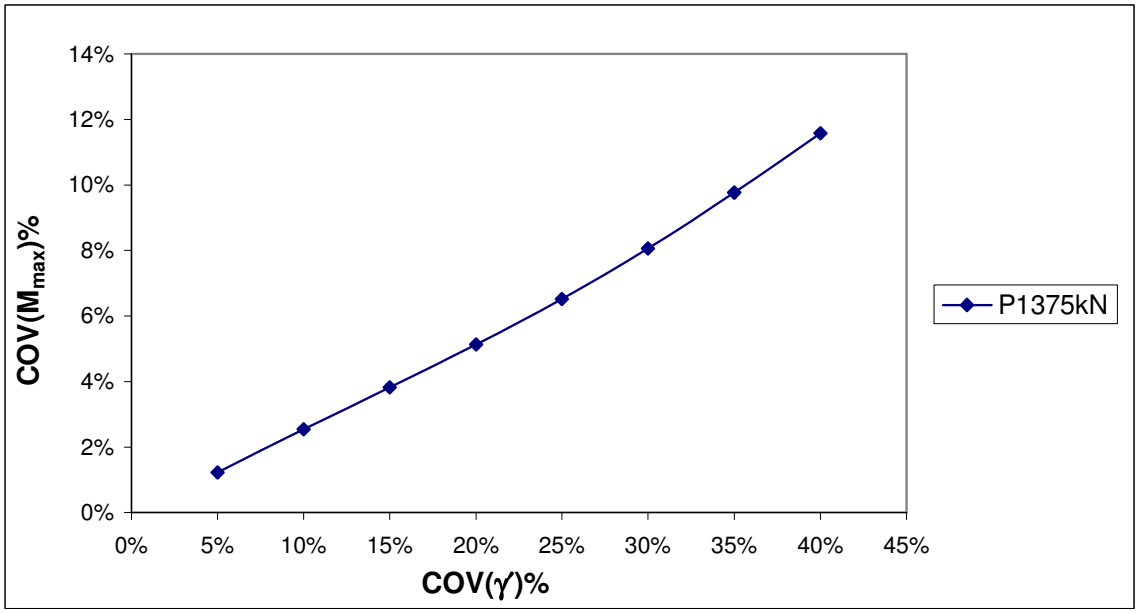


Fig. D.86 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.108 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 1750kN.

P=1750kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.55E+01	1.31%
10%	2.66E+06	1.14E+02	2.77%
15%	5.98E+06	2.59E+02	4.17%
20%	1.06E+07	4.54E+02	5.52%
25%	1.66E+07	7.37E+02	7.03%
30%	2.39E+07	1.11E+03	8.62%
35%	3.25E+07	1.56E+03	10.53%
40%	4.25E+07	2.14E+03	12.75%

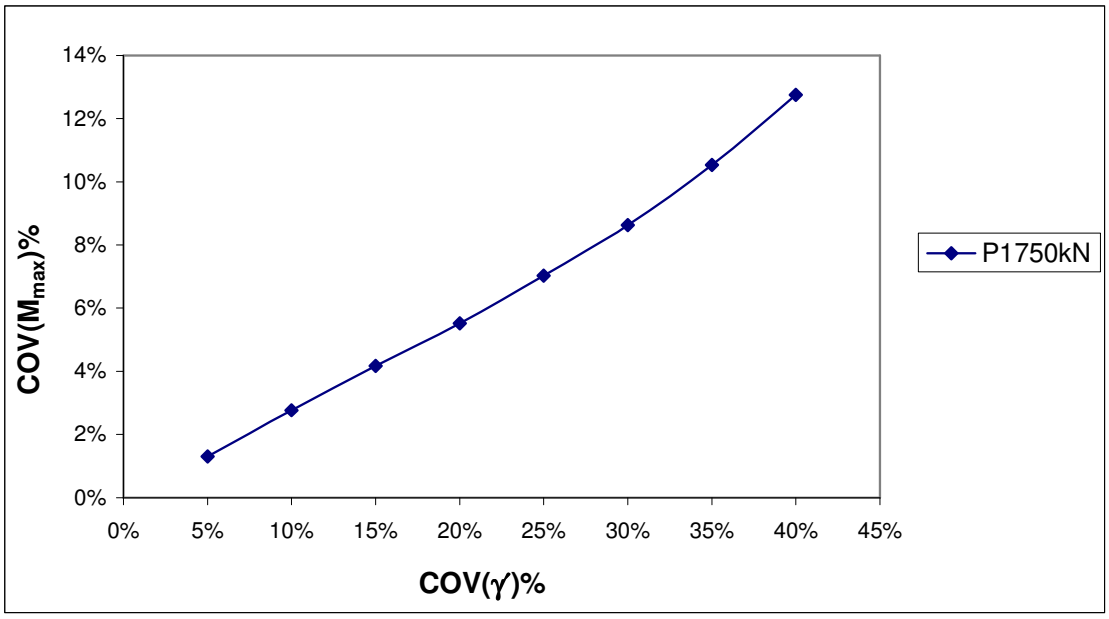


Fig. D.87 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.109 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 2125kN.

P=2125kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	4.90E+01	1.43%
10%	2.66E+06	1.96E+02	2.86%
15%	5.98E+06	4.49E+02	4.33%
20%	1.06E+07	8.04E+02	5.80%
25%	1.66E+07	1.29E+03	7.34%
30%	2.39E+07	1.94E+03	9.20%
35%	3.25E+07	2.68E+03	11.42%
40%	4.25E+07	3.68E+03	13.78%

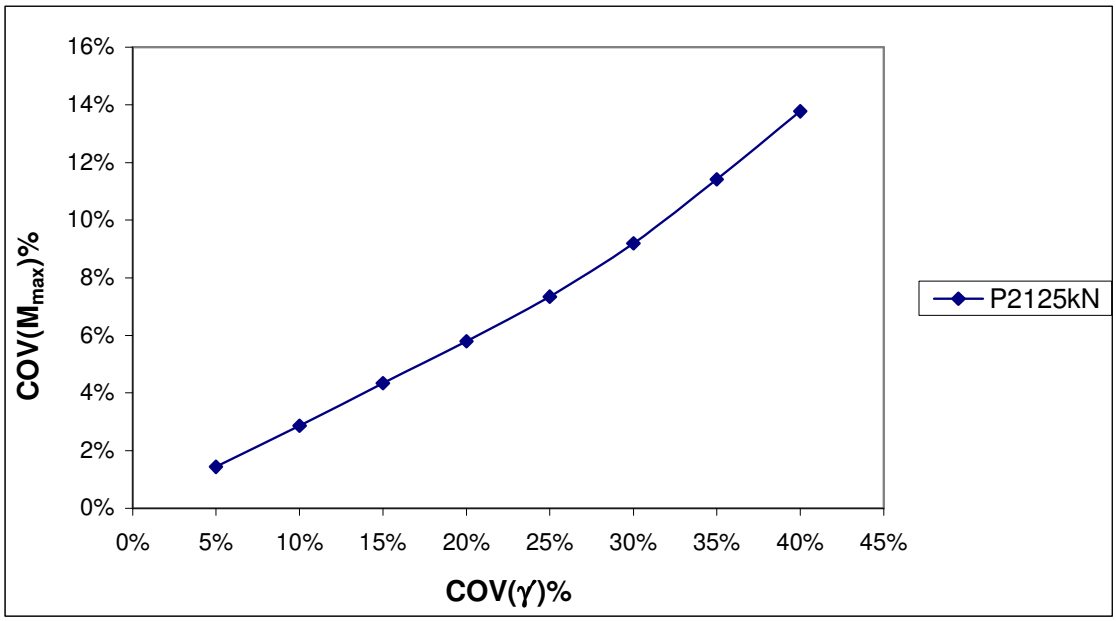


Fig. D.88 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.110 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(γ) and lateral load 2500kN.

P=2500kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	6.89E+01	1.40%
10%	2.66E+06	2.54E+02	2.85%
15%	5.98E+06	6.20E+02	5.00%
20%	1.06E+07	1.14E+03	7.37%
25%	1.66E+07	1.93E+03	10.18%
30%	2.39E+07	2.84E+03	12.84%
35%	3.25E+07	4.01E+03	16.49%
40%	4.25E+07	5.74E+03	20.35%

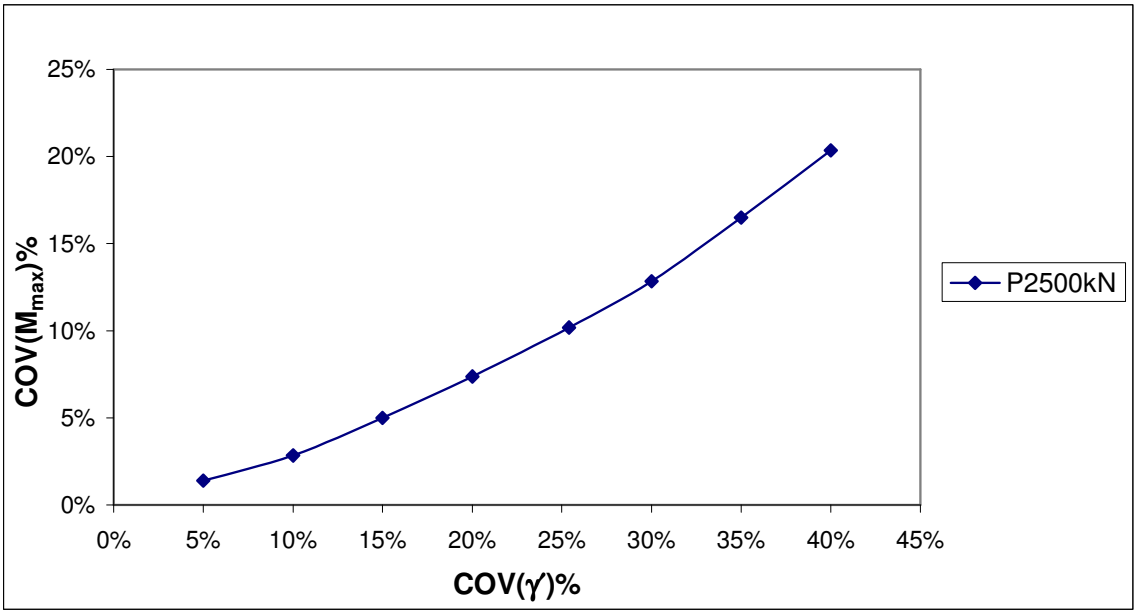


Fig. D.89 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

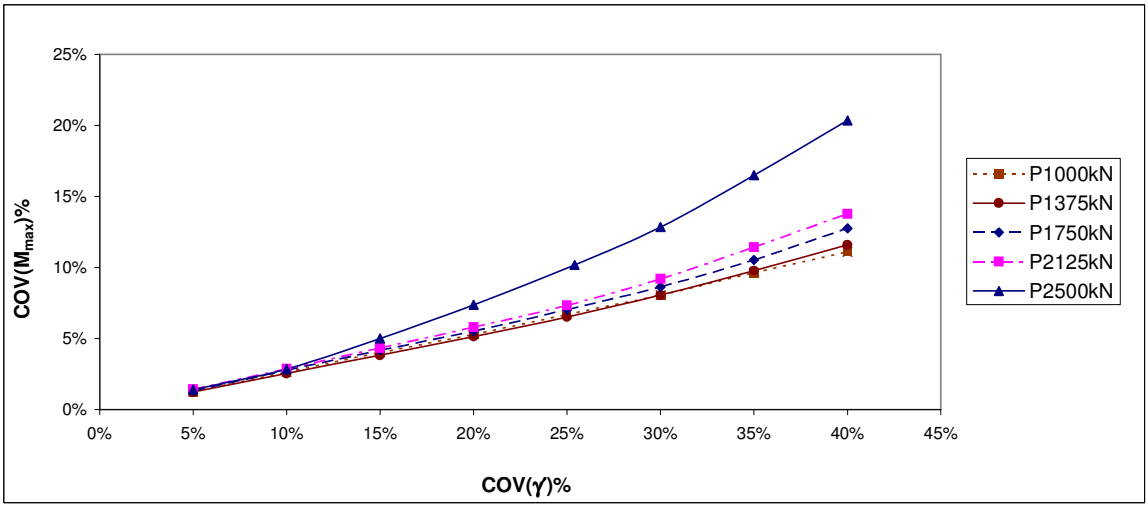


Fig. D.90 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table D.111 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (k) and load 1000kN.

P=1000kN							
COV(k) (%)	k ° (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		17115	-1.97E+02				
5%	16300			6.64E+05	2.25E-02	1.98E+02	0.07%
		15485	-1.98E+02				
		17930	-1.97E+02				
10%	16300			2.66E+06	6.25E-02	1.98E+02	0.11%
		14670	-1.98E+02				
		18745	-1.97E+02				
15%	16300			5.98E+06	9.00E-02	1.98E+02	0.14%
		13855	-1.98E+02				
		19560	-1.97E+02				
20%	16300			1.06E+07	9.00E-02	1.98E+02	0.20%
		13040	-1.98E+02				
		20375	-1.97E+02				
25%	16300			1.66E+07	9.00E-02	1.98E+02	0.23%
		12225	-1.98E+02				
		21190	-1.97E+02				
30%	16300			2.39E+07	2.50E-01	1.98E+02	0.29%
		11410	-1.98E+02				
		22005	-1.97E+02				
35%	16300			3.25E+07	4.90E-01	1.98E+02	0.35%
		10595	-1.99E+02				
		22820	-1.97E+02				
40%	16300			4.25E+07	8.10E-01	1.98E+02	0.41%
		9780	-1.99E+02				

Table D.112 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (k) and load 1375kN.

P=1375kN							
COV(k) (%)	k ° (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		17115	-2.89E+02				
5%	16300			6.64E+05	1.00E-02	2.89E+02	0.03%
		15485	-2.89E+02				
		17930	-2.89E+02				
10%	16300			2.66E+06	6.25E-02	2.89E+02	0.07%
		14670	-2.90E+02				
		18745	-2.89E+02				
15%	16300			5.98E+06	1.22E-01	2.89E+02	0.12%
		13855	-2.90E+02				
		19560	-2.89E+02				
20%	16300			1.06E+07	1.22E-01	2.89E+02	0.16%
		13040	-2.90E+02				
		20375	-2.89E+02				
25%	16300			1.66E+07	9.00E-02	2.89E+02	0.20%
		12225	-2.90E+02				
		21190	-2.89E+02				
30%	16300			2.39E+07	2.02E-01	2.89E+02	0.26%
		11410	-2.90E+02				
		22005	-2.89E+02				
35%	16300			3.25E+07	4.90E-01	2.89E+02	0.32%
		10595	-2.90E+02				
		22820	-2.89E+02				
40%	16300			4.25E+07	8.10E-01	2.89E+02	0.39%
		9780	-2.91E+02				

Table D.113 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (k) and load 1750kN.

P=1750kN							
COV(k) (%)	k ° (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		17115	-3.86E+02				
5%	16300			6.64E+05	4.00E-02	3.86E+02	0.02%
		15485	-3.86E+02				
		17930	-3.86E+02				
10%	16300			2.66E+06	1.22E-01	3.86E+02	0.05%
		14670	-3.86E+02				
		18745	-3.86E+02				
15%	16300			5.98E+06	1.60E-01	3.86E+02	0.09%
		13855	-3.86E+02				
		19560	-3.86E+02				
20%	16300			1.06E+07	1.60E-01	3.86E+02	0.13%
		13040	-3.86E+02				
		20375	-3.86E+02				
25%	16300			1.66E+07	3.03E-01	3.86E+02	0.17%
		12225	-3.87E+02				
		21190	-3.86E+02				
30%	16300			2.39E+07	5.63E-01	3.86E+02	0.22%
		11410	-3.87E+02				
		22005	-3.86E+02				
35%	16300			3.25E+07	1.00E+00	3.86E+02	0.29%
		10595	-3.88E+02				
		22820	-3.86E+02				
40%	16300			4.25E+07	1.10E+00	3.86E+02	0.36%
		9780	-3.88E+02				

Table D.114 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (k) and load 2125kN.

P=2125kN							
COV(k) (%)	k ° (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		17115	-4.89E+02				
5%	16300			6.64E+05	0.00E+00	4.89E+02	0.02%
		15485	-4.89E+02				
		17930	-4.89E+02				
10%	16300			2.66E+06	1.00E-02	4.89E+02	0.04%
		14670	-4.89E+02				
		18745	-4.89E+02				
15%	16300			5.98E+06	9.00E-02	4.89E+02	0.07%
		13855	-4.89E+02				
		19560	-4.89E+02				
20%	16300			1.06E+07	3.03E-01	4.89E+02	0.10%
		13040	-4.90E+02				
		20375	-4.88E+02				
25%	16300			1.66E+07	7.23E-01	4.89E+02	0.13%
		12225	-4.90E+02				
		21190	-4.88E+02				
30%	16300			2.39E+07	1.21E+00	4.89E+02	0.18%
		11410	-4.91E+02				
		22005	4.88E+02				
35%	16300			3.25E+07	1.44E+00	4.89E+02	0.23%
		10595	-4.91E+02				
		22820	-4.88E+02				
40%	16300			4.25E+07	1.82E+00	4.89E+02	0.30%
		9780	-4.91E+02				

Table D.115 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (k) and load 2500kN.

P=2500kN							
COV(k) (%)	k ° (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		17115	-5.92E+02				
5%	16300			6.64E+05	2.25E-02	5.92E+02	0.01%
		15485	-5.92E+02				
		17930	-5.91E+02				
10%	16300			2.66E+06	1.23E-01	5.92E+02	0.02%
		14670	-5.92E+02				
		18745	-5.91E+02				
15%	16300			5.98E+06	3.03E-01	5.92E+02	0.05%
		13855	-5.93E+02				
		19560	-5.91E+02				
20%	16300			1.06E+07	6.40E-01	5.92E+02	0.07%
		13040	-5.93E+02				
		20375	-5.91E+02				
25%	16300			1.66E+07	8.10E-01	5.92E+02	0.11%
		12225	-5.93E+02				
		21190	-5.91E+02				
30%	16300			2.39E+07	1.10E+00	5.92E+02	0.16%
		11410	-5.93E+02				
		22005	-5.91E+02				
35%	16300			3.25E+07	1.69E+00	5.92E+02	0.21%
		10595	-5.94E+02				
		22820	-5.91E+02				
40%	16300			4.25E+07	3.42E+00	5.92E+02	0.26%
		9780	-5.95E+02				

Table D.116 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 1000kN.

P=1000kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.25E-02	0.07%
10%	2.66E+06	6.25E-02	0.11%
15%	5.98E+06	9.00E-02	0.14%
20%	1.06E+07	9.00E-02	0.20%
25%	1.66E+07	9.00E-02	0.23%
30%	2.39E+07	2.50E-01	0.29%
35%	3.25E+07	4.90E-01	0.35%
40%	4.25E+07	8.10E-01	0.41%

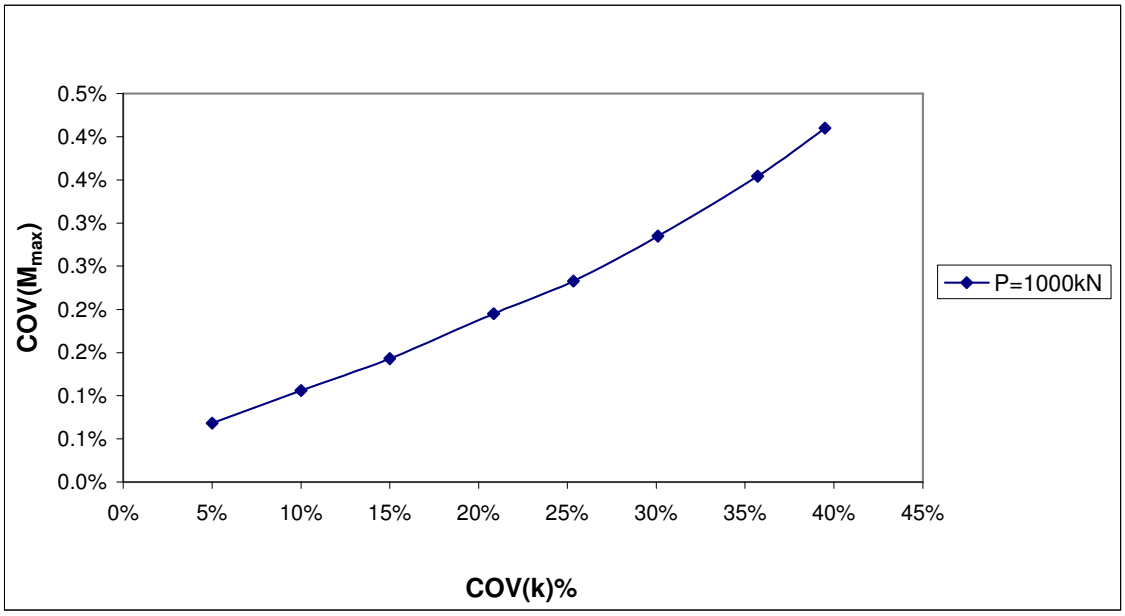


Fig. D.91 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.117 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 1375kN.

P=1375kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.00E-02	0.03%
10%	2.66E+06	6.25E-02	0.07%
15%	5.98E+06	1.22E-01	0.12%
20%	1.06E+07	1.22E-01	0.16%
25%	1.66E+07	9.00E-02	0.20%
30%	2.39E+07	2.02E-01	0.26%
35%	3.25E+07	4.90E-01	0.32%
40%	4.25E+07	8.10E-01	0.39%

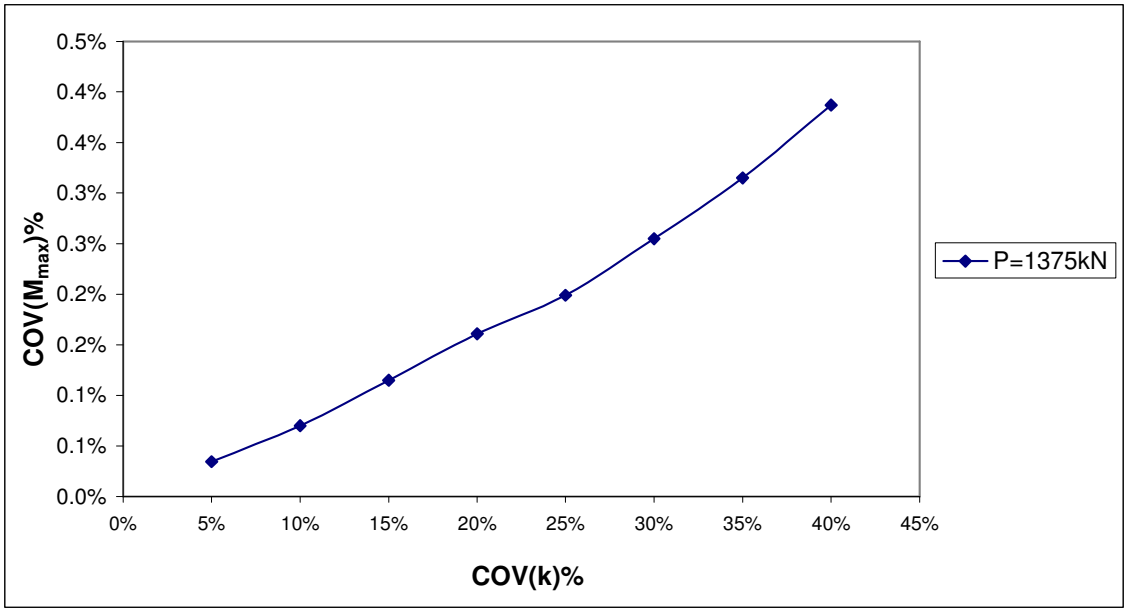


Fig. D.92 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.118 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 1750kN.

P=1750kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	4.00E-02	0.02%
10%	2.66E+06	1.22E-01	0.05%
15%	5.98E+06	1.60E-01	0.09%
20%	1.06E+07	1.60E-01	0.13%
25%	1.66E+07	3.03E-01	0.17%
30%	2.39E+07	5.63E-01	0.22%
35%	3.25E+07	1.00E+00	0.29%
40%	4.25E+07	1.10E+00	0.36%

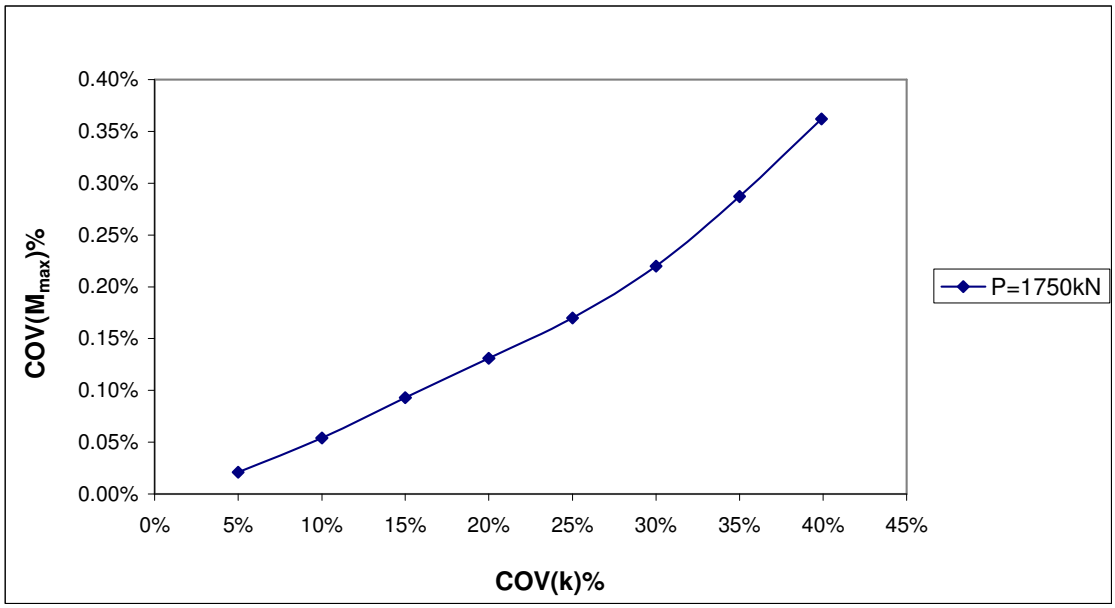


Fig. D.93 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.119 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 2125kN.

P=2125kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	0.00E+00	0.02%
10%	2.66E+06	1.00E-02	0.04%
15%	5.98E+06	9.00E-02	0.07%
20%	1.06E+07	3.03E-01	0.10%
25%	1.66E+07	7.23E-01	0.13%
30%	2.39E+07	1.21E+00	0.18%
35%	3.25E+07	1.44E+00	0.23%
40%	4.25E+07	1.82E+00	0.30%

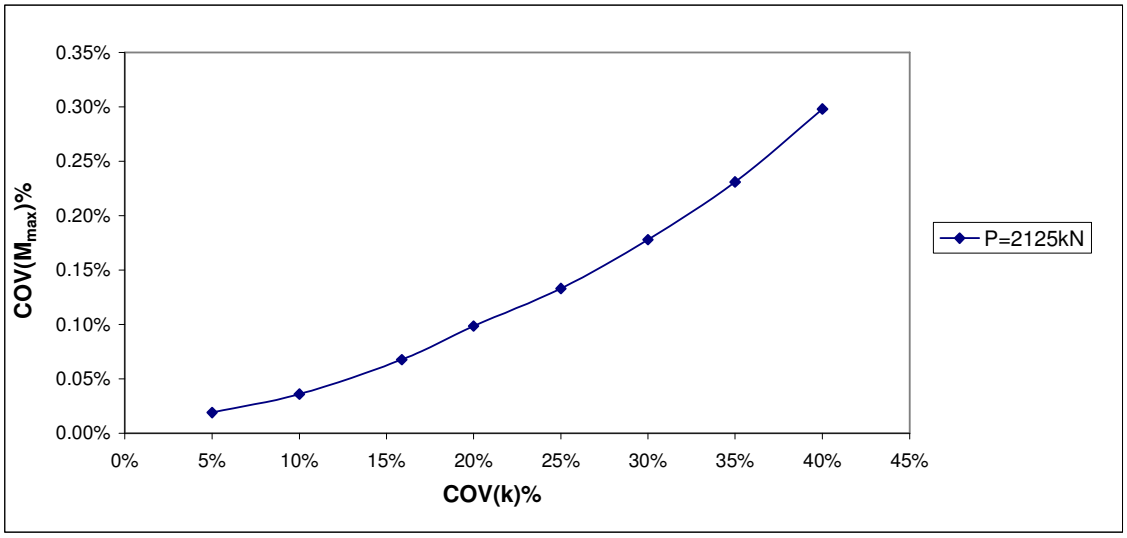


Fig. D.94 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.120 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(k) and lateral load 2500kN.

P=2500kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.25E-02	0.01%
10%	2.66E+06	1.23E-01	0.02%
15%	5.98E+06	3.03E-01	0.05%
20%	1.06E+07	6.40E-01	0.07%
25%	1.66E+07	8.10E-01	0.11%
30%	2.39E+07	1.10E+00	0.16%
35%	3.25E+07	1.69E+00	0.21%
40%	4.25E+07	3.42E+00	0.26%

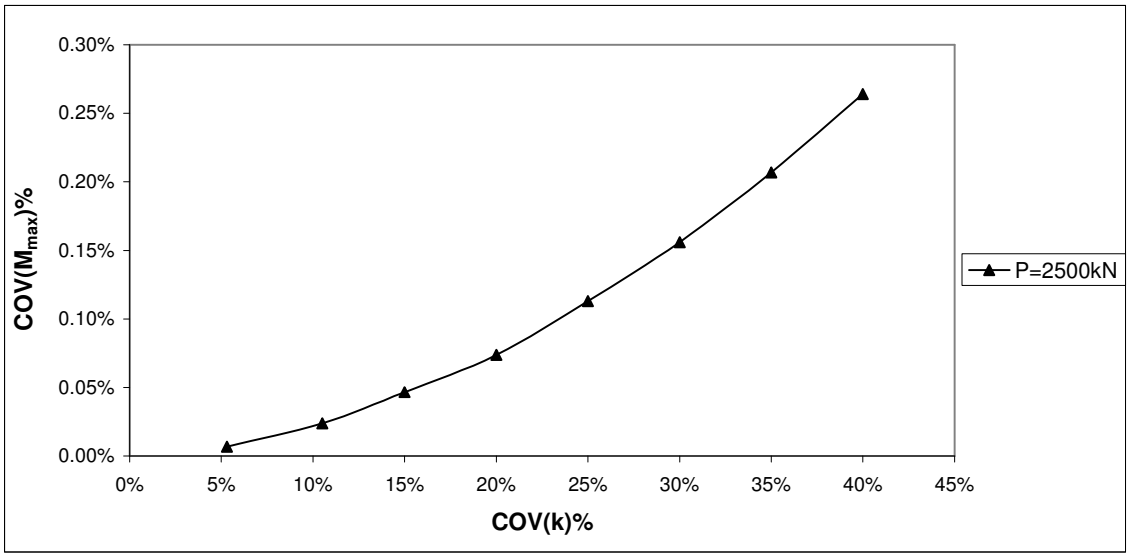


Fig. D.95 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

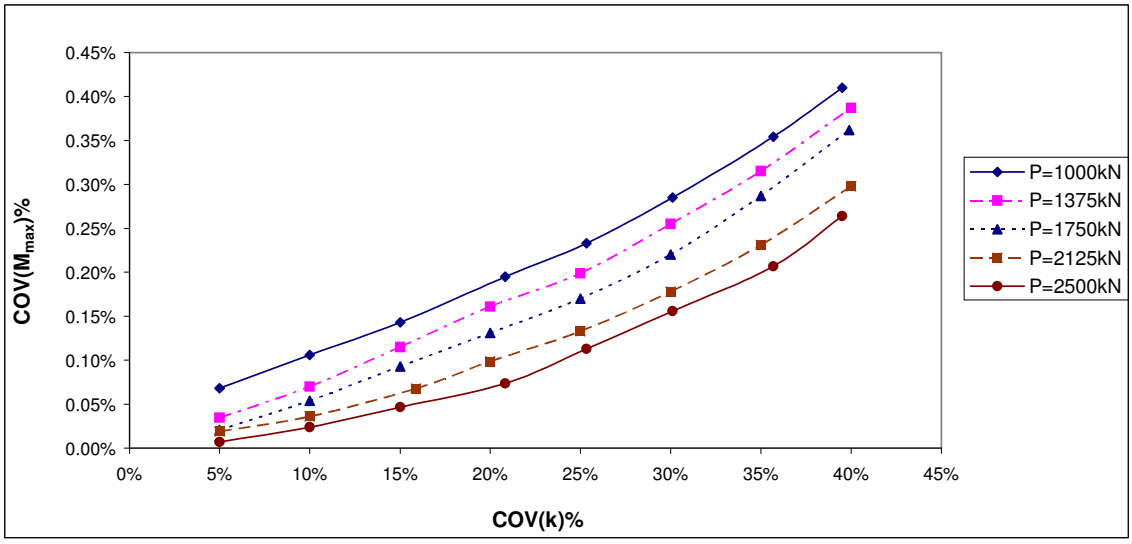


Fig. D.96 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table D.121 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (B) and load 1000kN.

P=1000kN							
COV(B) (%)	B° (m)	B(current) (m)	Mmax (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	-1.99E+02				
5%	0.406			4.12E-04	1.32E+00	1.98E+02	0.58%
		0.3857	-1.96E+02				
		0.4466	-1.99E+02				
10%	0.406			1.65E-03	4.84E+00	1.98E+02	1.11%
		0.3654	-1.95E+02				
		0.4669	-1.99E+02				
15%	0.406			3.71E-03	1.12E+01	1.98E+02	1.70%
		0.3451	-1.93E+02				
		0.4872	-2.00E+02				
20%	0.406			6.59E-03	2.35E+01	1.98E+02	2.46%
		0.3248	-1.90E+02				
		0.5075	-2.00E+02				
25%	0.406			1.03E-02	4.42E+01	1.98E+02	3.37%
		0.3045	-1.87E+02				
		0.5278	-2.00E+02				
30%	0.406			1.48E-02	7.66E+01	1.98E+02	4.43%
		0.2842	-1.82E+02				
		0.5472	-1.99E+02				
35%	0.406			2.02E-02	1.30E+02	1.98E+02	5.78%
		0.2648	-1.77E+02				
		0.5684	-1.99E+02				
40%	0.406			2.64E-02	2.15E+02	1.98E+02	7.42%
		0.2436	-1.70E+02				

Table D.122 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (B) and load 1375kN.

P=1375kN							
COV(B) (%)	B° (m)	B(current) (m)	Mmax (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	-2.91E+02				
5%	0.406			4.12E-04	5.06E+00	2.89E+02	0.78%
		0.3857	-2.87E+02				
		0.4466	-2.93E+02				
10%	0.406			1.65E-03	2.03E+01	2.89E+02	1.56%
		0.3654	-2.84E+02				
		0.4669	-2.94E+02				
15%	0.406			3.71E-03	4.76E+01	2.89E+02	2.39%
		0.3451	-2.80E+02				
		0.4872	-2.95E+02				
20%	0.406			6.59E-03	9.51E+01	2.89E+02	3.37%
		0.3248	-2.76E+02				
		0.5075	-2.96E+02				
25%	0.406			1.03E-02	1.74E+02	2.89E+02	4.56%
		0.3045	-2.70E+02				
		0.5278	-2.97E+02				
30%	0.406			1.48E-02	3.13E+02	2.89E+02	6.12%
		0.2842	-2.61E+02				
		0.5472	-2.97E+02				
35%	0.406			2.02E-02	5.83E+02	2.89E+02	8.35%
		0.2648	-2.49E+02				
		0.5684	-2.97E+02				
40%	0.406			2.64E-02	1.11E+03	2.89E+02	11.51%
		0.2436	-2.31E+02				

Table D.123 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (B) and load 1750kN.

P=1750kN							
COV(B) (%)	B° (m)	B(current) (m)	Mmax (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	-3.89E+02				
5%	0.406			4.12E-04	8.70E+00	3.86E+02	0.76%
		0.3857	-3.83E+02				
		0.4466	-3.91E+02				
10%	0.406			1.65E-03	3.54E+01	3.86E+02	1.54%
		0.3654	-3.79E+02				
		0.4669	-3.93E+02				
15%	0.406			3.71E-03	9.90E+01	3.86E+02	2.58%
		0.3451	-3.73E+02				
		0.4872	-3.94E+02				
20%	0.406			6.59E-03	2.39E+02	3.86E+02	4.00%
		0.3248	-3.63E+02				
		0.5075	-3.95E+02				
25%	0.406			1.03E-02	5.62E+02	3.86E+02	5.78%
		0.3045	-3.48E+02				
		0.5278	-3.96E+02				
30%	0.406			1.48E-02	1.24E+03	3.86E+02	7.43%
		0.2842	-3.26E+02				
		0.5472	-3.97E+02				
35%	0.406			2.02E-02	2.47E+03	3.86E+02	9.92%
		0.2648	-2.98E+02				
		0.5684	-3.98E+02				
40%	0.406			2.64E-02	2.52E+03	3.86E+02	12.46%
		0.2436	-2.97E+02				

Table D.124 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (B) and load 2125kN.

P=2125kN							
COV(B) (%)	B° (m)	B(current) (m)	Mmax (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	-4.93E+02				
5%	0.406			4.12E-04	2.45E+01	4.89E+02	1.01%
		0.3857	-4.83E+02				
		0.4466	-4.95E+02				
10%	0.406			1.65E-03	1.19E+02	4.89E+02	2.23%
		0.3654	-4.74E+02				
		0.4669	-4.98E+02				
15%	0.406			3.71E-03	3.98E+02	4.89E+02	4.08%
		0.3451	-4.58E+02				
		0.4872	-4.99E+02				
20%	0.406			6.59E-03	7.65E+02	4.89E+02	5.65%
		0.3248	-4.44E+02				
		0.5075	-5.01E+02				
25%	0.406			1.03E-02	1.11E+03	4.89E+02	6.81%
		0.3045	-4.34E+02				
		0.5278	-5.02E+02				
30%	0.406			1.48E-02	2.34E+03	4.89E+02	9.90%
		0.2842	-4.05E+02				
		0.5472	-5.02E+02				
35%	0.406			2.02E-02	2.67E+03	4.89E+02	10.56%
		0.2648	-4.00E+02				
		0.5684	-5.03E+02				
40%	0.406			2.64E-02	4.26E+03	4.89E+02	13.35%
		0.2436	-3.73E+02				

Table D.125 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (B) and load 2500kN.

P=2500kN							
COV(B) (%)	B^o (m)	B(current) (m)	Mmax (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	-6.01E+02				
5%	0.406			4.12E-04	1.36E+02	5.92E+02	1.97%
		0.3857	-5.77E+02				
		0.4466	-6.06E+02				
10%	0.406			1.65E-03	3.71E+02	5.92E+02	3.25%
		0.3654	-5.67E+02				
		0.4669	-6.09E+02				
15%	0.406			3.71E-03	7.73E+02	5.92E+02	4.70%
		0.3451	-5.53E+02				
		0.4872	-6.11E+02				
20%	0.406			6.59E-03	1.40E+03	5.92E+02	6.32%
		0.3248	-5.36E+02				
		0.5075	-6.13E+02				
25%	0.406			1.03E-02	2.43E+03	5.92E+02	8.33%
		0.3045	-5.14E+02				
		0.5278	-6.14E+02				
30%	0.406			1.48E-02	3.84E+03	5.92E+02	10.48%
		0.2842	-4.90E+02				
		0.5472	-6.15E+02				
35%	0.406			2.02E-02	6.11E+03	5.92E+02	13.22%
		0.2648	-4.59E+02				
		0.5684	-6.15E+02				
40%	0.406			2.64E-02	9.57E+03	5.92E+02	16.54%
		0.2436	-4.19E+02				

Table D.126 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 1000kN.

P=1000kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	1.32E+00	0.58%
10%	1.65E-03	4.84E+00	1.11%
15%	3.71E-03	1.12E+01	1.70%
20%	6.59E-03	2.35E+01	2.46%
25%	1.03E-02	4.42E+01	3.37%
30%	1.48E-02	7.66E+01	4.43%
35%	2.02E-02	1.30E+02	5.78%
40%	2.64E-02	2.15E+02	7.42%

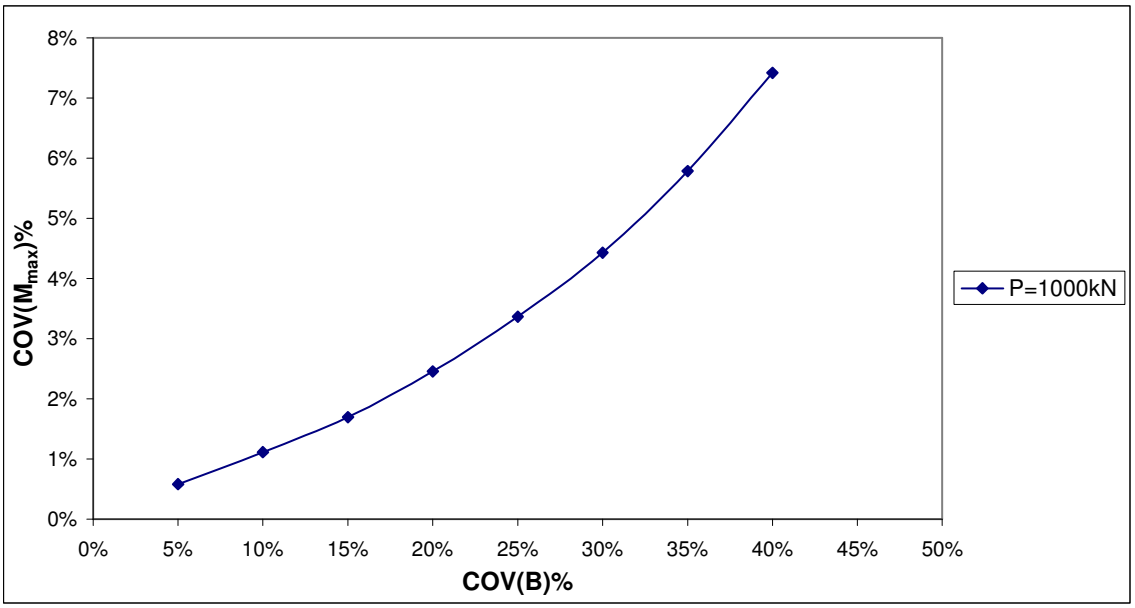


Fig. D.97 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.127 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 1375kN.

P=1375kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	5.06E+00	0.78%
10%	1.65E-03	2.03E+01	1.56%
15%	3.71E-03	4.76E+01	2.39%
20%	6.59E-03	9.51E+01	3.37%
25%	1.03E-02	1.74E+02	4.56%
30%	1.48E-02	3.13E+02	6.12%
35%	2.02E-02	5.83E+02	8.35%
40%	2.64E-02	1.11E+03	11.51%

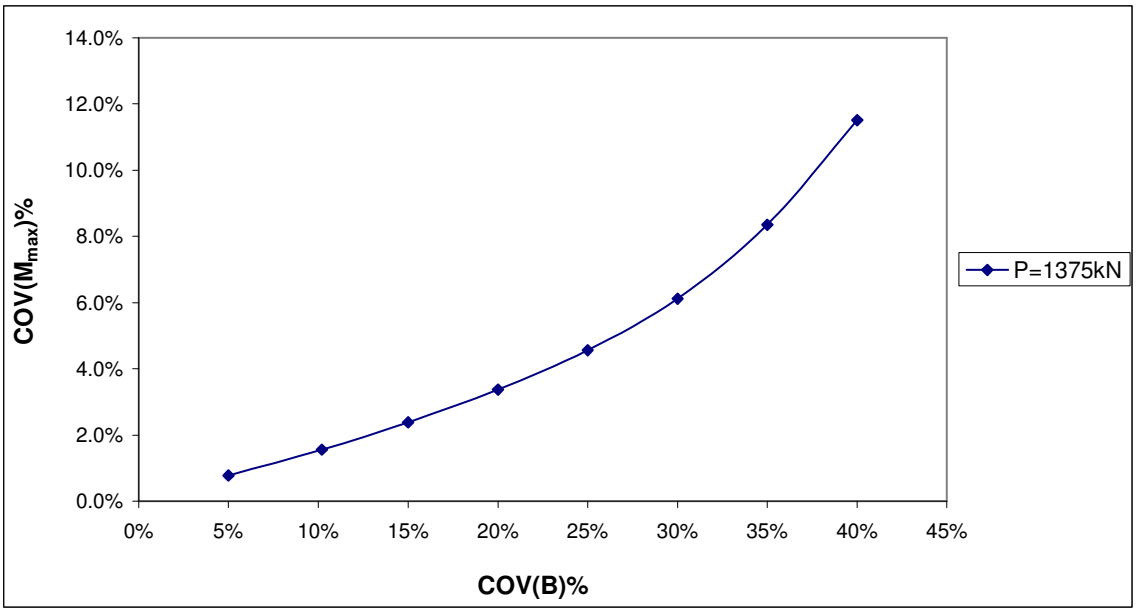


Fig. D.98 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.128 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 1750kN.

P=1750kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	8.70E+00	0.76%
10%	1.65E-03	3.54E+01	1.54%
15%	3.71E-03	9.90E+01	2.58%
20%	6.59E-03	2.39E+02	4.00%
25%	1.03E-02	5.62E+02	5.78%
30%	1.48E-02	1.24E+03	7.43%
35%	2.02E-02	2.47E+03	9.92%
40%	2.64E-02	2.52E+03	12.46%

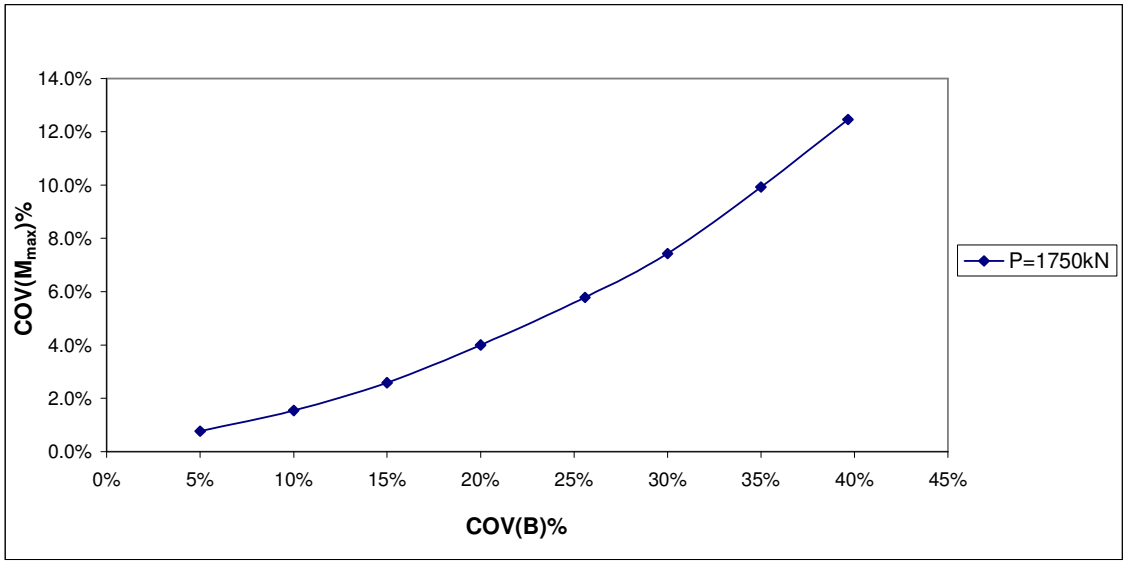


Fig. D.99 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.129 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 2125kN.

P=2125kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	2.45E+01	1.01%
10%	1.65E-03	1.19E+02	2.23%
15%	3.71E-03	3.98E+02	3.49%
20%	6.59E-03	7.65E+02	5.20%
25%	1.03E-02	1.11E+03	6.81%
30%	1.48E-02	2.34E+03	8.51%
35%	2.02E-02	2.67E+03	10.56%
40%	2.64E-02	4.26E+03	13.35%

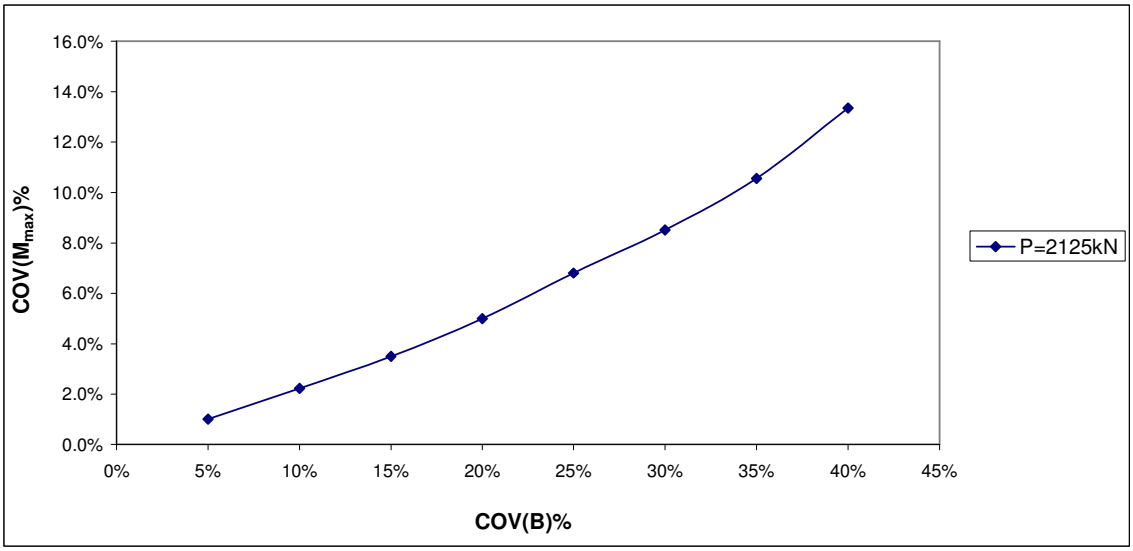


Fig. D.100 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.130 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(B) and lateral load 2500kN.

P=2500kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	1.36E+02	1.97%
10%	1.65E-03	3.71E+02	3.26%
15%	3.71E-03	7.73E+02	4.70%
20%	6.59E-03	1.40E+03	6.30%
25%	1.03E-02	2.43E+03	8.33%
30%	1.48E-02	3.84E+03	10.48%
35%	2.02E-02	6.11E+03	13.22%
40%	2.64E-02	9.57E+03	16.54%

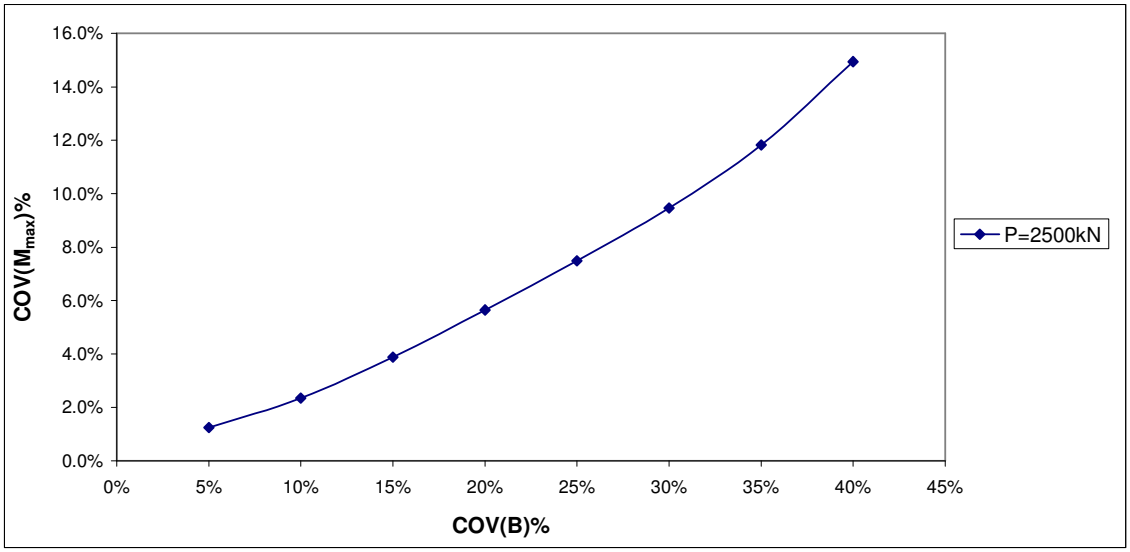


Fig. D.101 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

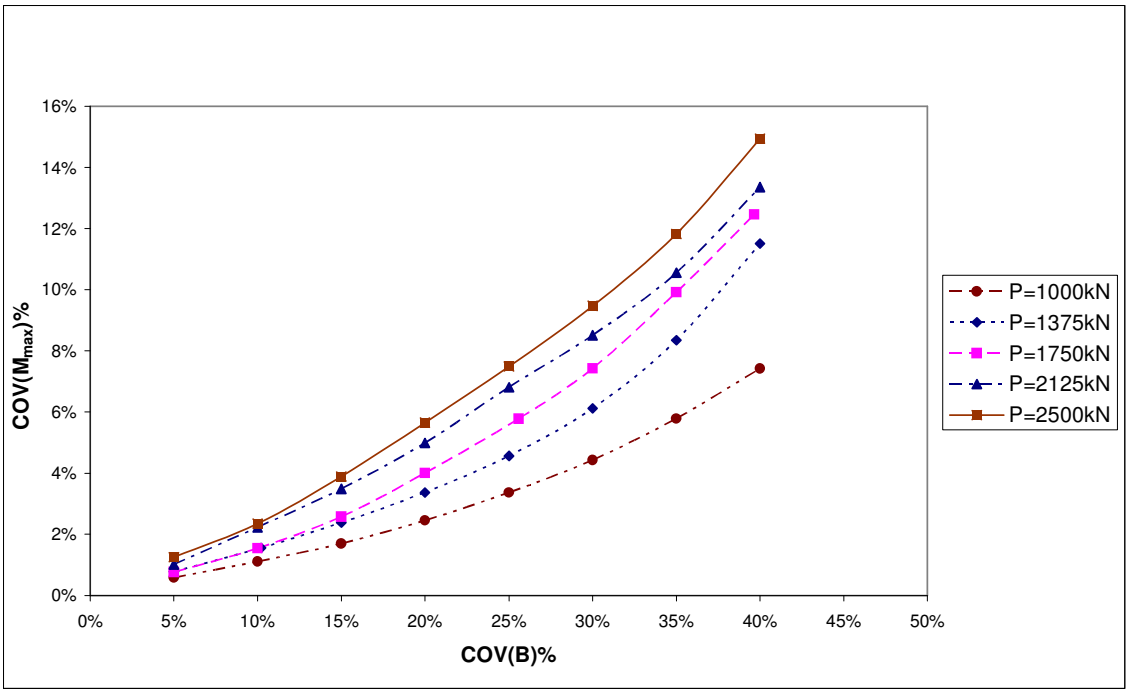


Fig. D.102 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table D.131 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (EI) and load 1000kN.

P=1000kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN-m^2)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		64050	-1.99E+02				
5%	61000			9.30E+06	1.00E-02	1.98E+02	0.05%
		57950	-1.98E+02				
		67100	-2.00E+02				
10%	61000			3.72E+07	3.06E-02	1.98E+02	0.09%
		54900	-1.97E+02				
		70150	-2.01E+02				
15%	61000			8.37E+07	6.25E-02	1.98E+02	0.13%
		51850	-1.96E+02				
		73200	-2.01E+02				
20%	61000			1.49E+08	7.56E-02	1.98E+02	0.06%
		48800	-1.95E+02				
		76250	-2.02E+02				
25%	61000			2.33E+08	7.96E-02	1.98E+02	0.07%
		45750	-1.94E+02				
		79300	-2.02E+02				
30%	61000			3.35E+08	3.02E-01	1.98E+02	0.28%
		42700	-1.92E+02				
		82350	-2.03E+02				
35%	61000			4.56E+08	4.55E-01	1.98E+02	0.34%
		39650	-1.91E+02				
		85400	-2.03E+02				
40%	61000			5.95E+08	6.01E-01	1.98E+02	0.39%
		36600	-1.90E+02				

Table D.132 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (EI) and load 1375kN.

P=1375kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN-m^2)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		64050	-2.92E+02				
5%	61000			9.30E+06	1.23E-01	2.89E+02	0.07%
		57950	-2.89E+02				
		67100	-2.93E+02				
10%	61000			3.72E+07	5.26E-01	2.89E+02	0.15%
		54900	-2.88E+02				
		70150	-2.94E+02				
15%	61000			8.37E+07	1.27E+00	2.89E+02	0.23%
		51850	-2.87E+02				
		73200	-2.95E+02				
20%	61000			1.49E+08	2.48E+00	2.89E+02	0.32%
		48800	-2.85E+02				
		76250	-2.96E+02				
25%	61000			2.33E+08	1.76E+00	2.89E+02	0.40%
		45750	-2.84E+02				
		79300	-2.97E+02				
30%	61000			3.35E+08	5.52E+00	2.89E+02	0.48%
		42700	-2.82E+02				
		82350	-2.97E+02				
35%	61000			4.56E+08	7.42E+00	2.89E+02	0.56%
		39650	-2.81E+02				
		85400	-2.98E+02				
40%	61000			5.95E+08	9.92E+00	2.89E+02	0.64%
		36600	-2.79E+02				

Table D.133 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (EI) and load 1750kN.

P=1750kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	-3.88E+02				
5%	61000			9.30E+06	1.60E-01	3.86E+02	0.14%
		57950	-3.86E+02				
		67100	-3.89E+02				
10%	61000			3.72E+07	6.40E-01	3.86E+02	0.28%
		54900	-3.85E+02				
		70150	-3.90E+02				
15%	61000			8.37E+07	1.44E+00	3.86E+02	0.43%
		51850	-3.83E+02				
		73200	-3.91E+02				
20%	61000			1.49E+08	2.56E+00	3.86E+02	0.58%
		48800	-3.82E+02				
		76250	-3.92E+02				
25%	61000			2.33E+08	1.81E+00	3.86E+02	0.70%
		45750	-3.81E+02				
		79300	-3.93E+02				
30%	61000			3.35E+08	6.13E+00	3.86E+02	0.85%
		42700	-3.80E+02				
		82350	-3.94E+02				
35%	61000			4.56E+08	8.55E+00	3.86E+02	1.00%
		39650	-3.78E+02				
		85400	-3.95E+02				
40%	61000			5.95E+08	1.17E+01	3.86E+02	1.16%
		36600	-3.77E+02				

Table D.134 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (EI) and load 2125kN.

P=2125kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	-4.90E+02				
5%	61000			9.30E+06	3.03E-01	4.89E+02	0.20%
		57950	-4.89E+02				
		67100	-4.91E+02				
10%	61000			3.72E+07	1.16E+00	4.89E+02	0.40%
		54900	-4.88E+02				
		70150	-4.91E+02				
15%	61000			8.37E+07	2.72E+00	4.89E+02	0.59%
		51850	-4.87E+02				
		73200	-4.92E+02				
20%	61000			1.49E+08	4.95E+00	4.89E+02	0.78%
		48800	-4.86E+02				
		76250	-4.93E+02				
25%	61000			2.33E+08	3.27E+00	4.89E+02	1.00%
		45750	-4.85E+02				
		79300	-4.94E+02				
30%	61000			3.35E+08	1.09E+01	4.89E+02	1.24%
		42700	-4.84E+02				
		82350	-4.94E+02				
35%	61000			4.56E+08	1.50E+01	4.89E+02	1.45%
		39650	-4.83E+02				
		85400	-4.95E+02				
40%	61000			5.95E+08	2.00E+01	4.89E+02	1.67%
		36600	-4.82E+02				

Table D.135 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (EI) and load 2500kN.

P=2500kN							
COV(EI) (%)	EI^o (kN-m^2)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) (kN-m^2)^2	VAR (M_{max}) (kN-m)^2	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		64050	-5.91E+02				
5%	61000			9.30E+06	3.31E-01	5.92E+02	0.20%
		57950	-5.91E+02				
		67100	-5.92E+02				
10%	61000			3.72E+07	1.44E+00	5.92E+02	0.41%
		54900	-5.91E+02				
		70150	-5.92E+02				
15%	61000			8.37E+07	3.15E+00	5.92E+02	0.61%
		51850	-5.91E+02				
		73200	-5.92E+02				
20%	61000			1.49E+08	5.64E+00	5.92E+02	0.81%
		48800	-5.91E+02				
		76250	-5.92E+02				
25%	61000			2.33E+08	3.97E+00	5.92E+02	1.02%
		45750	-5.91E+02				
		79300	-5.92E+02				
30%	61000			3.35E+08	1.30E+01	5.92E+02	1.25%
		42700	-5.90E+02				
		82350	-5.92E+02				
35%	61000			4.56E+08	1.76E+01	5.92E+02	1.48%
		39650	-5.90E+02				
		85400	-5.92E+02				
40%	61000			5.95E+08	2.33E+01	5.92E+02	1.73%
		36600	-5.89E+02				

Table D.136 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 1000kN.

P=1000kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.00E-02	0.02%
10%	3.72E+07	3.06E-02	0.03%
15%	8.37E+07	6.25E-02	0.04%
20%	1.49E+08	7.56E-02	0.06%
25%	2.33E+08	7.96E-02	0.07%
30%	3.35E+08	3.02E-01	0.09%
35%	4.56E+08	4.55E-01	0.11%
40%	5.95E+08	6.01E-01	0.13%

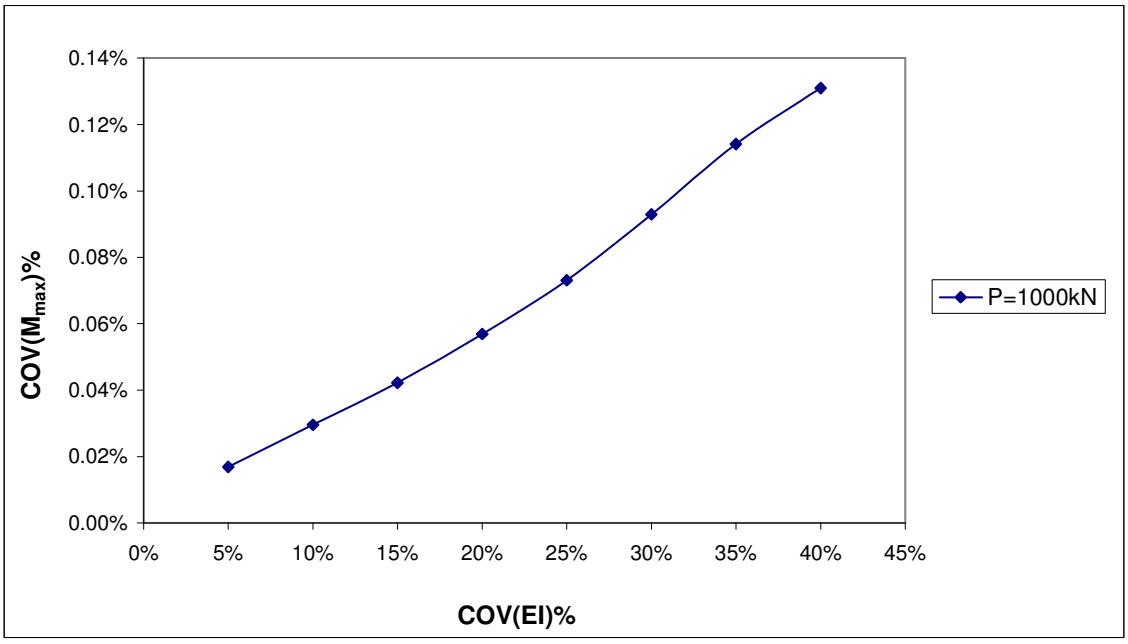


Fig. D.103 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.137 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 1375kN.

P=1375kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.23E-01	0.07%
10%	3.72E+07	5.26E-01	0.15%
15%	8.37E+07	1.27E+00	0.23%
20%	1.49E+08	2.48E+00	0.32%
25%	2.33E+08	1.76E+00	0.40%
30%	3.35E+08	5.52E+00	0.48%
35%	4.56E+08	7.42E+00	0.56%
40%	5.95E+08	9.92E+00	0.64%

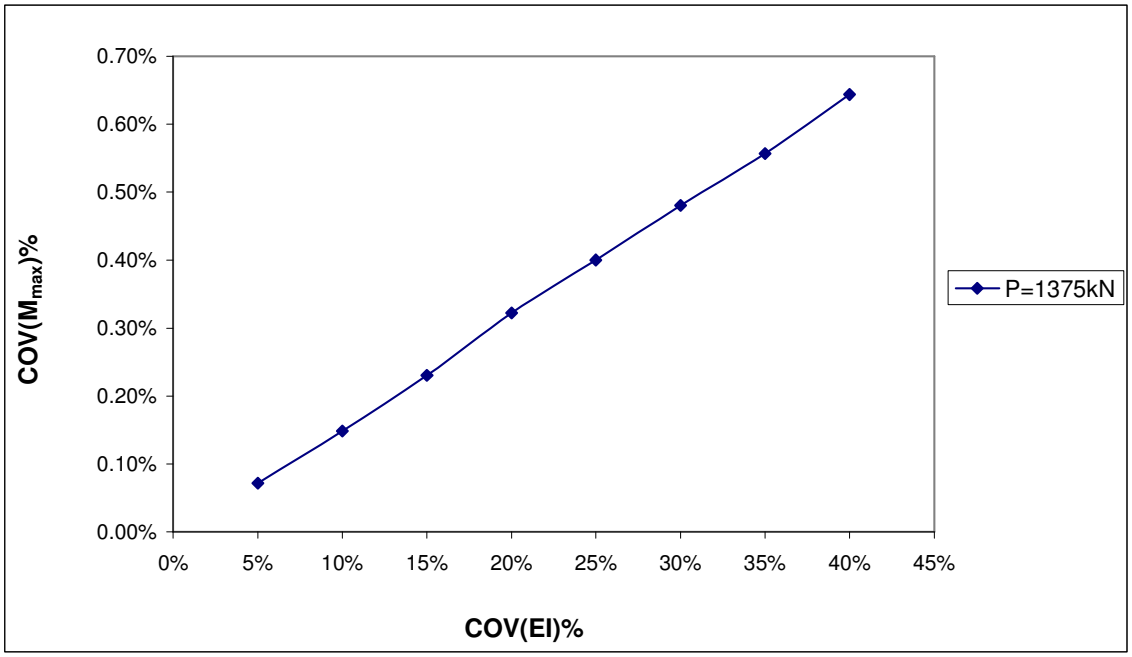


Fig. D.104 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.138 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 1750kN.

P=1750kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.60E-01	0.14%
10%	3.72E+07	6.40E-01	0.28%
15%	8.37E+07	1.44E+00	0.43%
20%	1.49E+08	2.56E+00	0.58%
25%	2.33E+08	1.81E+00	0.70%
30%	3.35E+08	6.13E+00	0.85%
35%	4.56E+08	8.55E+00	1.00%
40%	5.95E+08	1.17E+01	1.16%

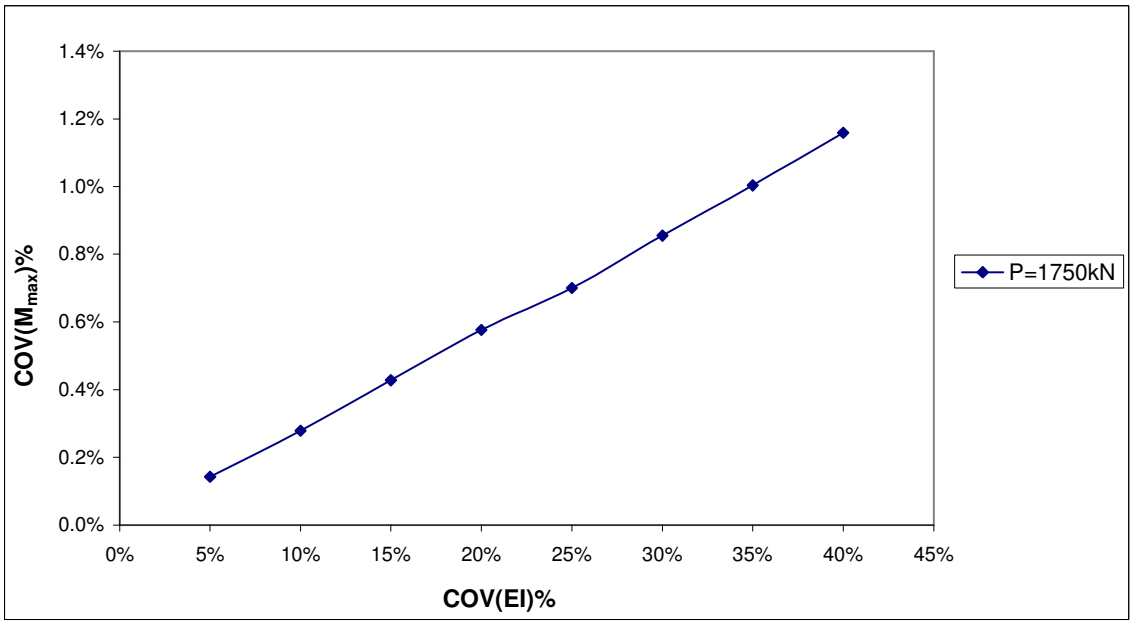


Fig. D.105 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.139 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 2125kN.

P=2125kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	3.03E-01	0.20%
10%	3.72E+07	1.16E+00	0.40%
15%	8.37E+07	2.72E+00	0.59%
20%	1.49E+08	4.95E+00	0.78%
25%	2.33E+08	3.27E+00	1.00%
30%	3.35E+08	1.09E+01	1.24%
35%	4.56E+08	1.50E+01	1.45%
40%	5.95E+08	2.00E+01	1.67%

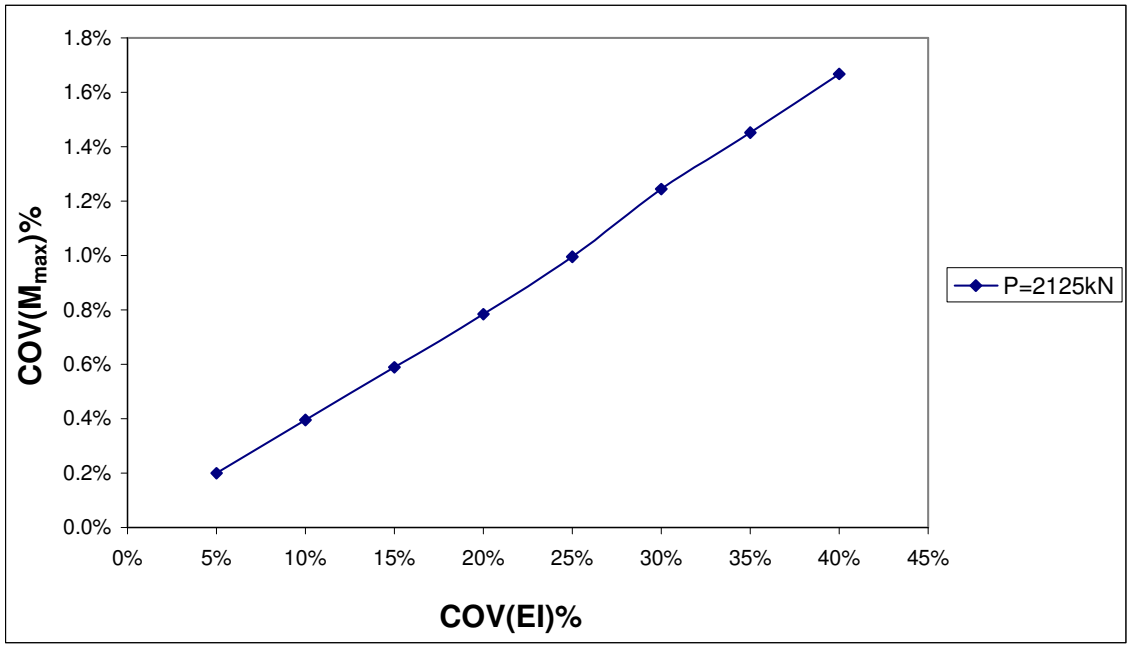


Fig. D.106 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.140 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(EI) and lateral load 2500kN.

P=2500kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	(M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	3.31E-01	0.20%
10%	3.72E+07	1.44E+00	0.41%
15%	8.37E+07	3.15E+00	0.61%
20%	1.49E+08	5.64E+00	0.81%
25%	2.33E+08	3.97E+00	1.02%
30%	3.35E+08	1.30E+01	1.25%
35%	4.56E+08	1.76E+01	1.48%
40%	5.95E+08	2.33E+01	1.73%

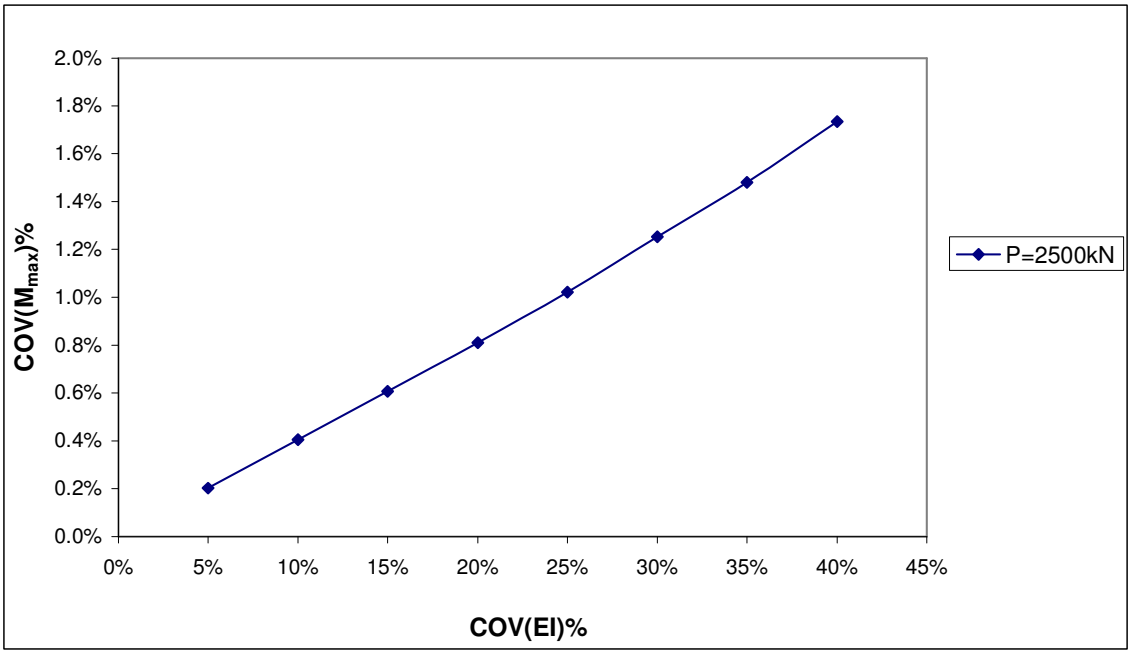


Fig. D.107 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

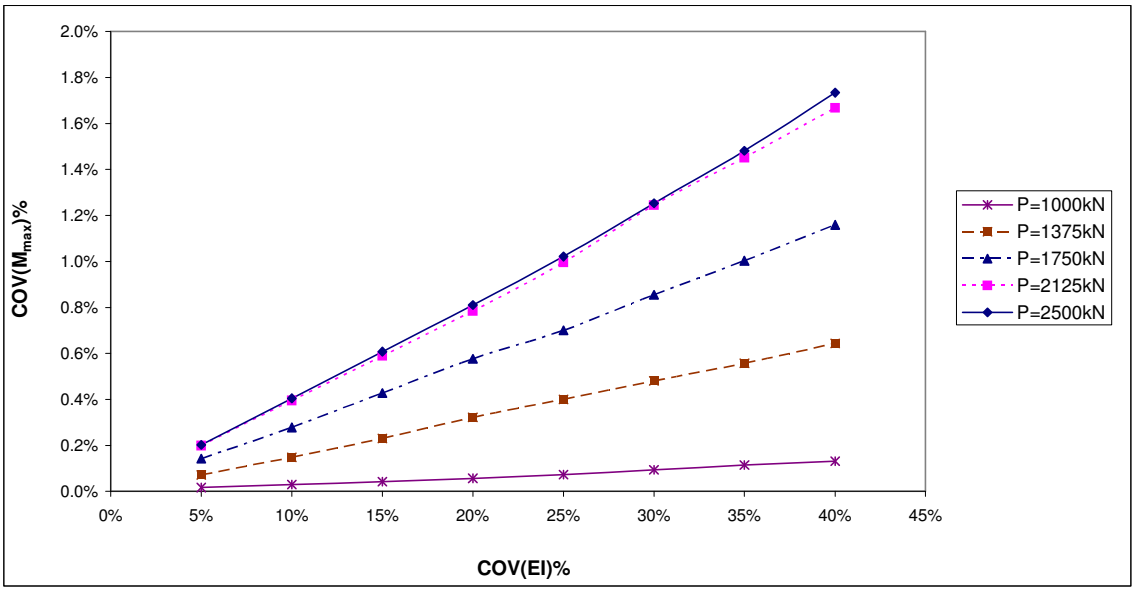


Fig. D.108 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

Table D.141 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (P) and load 1000kN.

P=1000kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		1050	-2.10E+02				
5%	1000			2.50E+03	1.29E+02	1.98E+02	5.75%
		950	-1.87E+02				
		1100	-2.21E+02				
10%	1000			1.00E+04	5.15E+02	1.98E+02	11.49%
		900	-1.76E+02				
		1150	-2.33E+02				
15%	1000			2.25E+04	1.17E+03	1.98E+02	17.29%
		850	-1.65E+02				
		1200	-2.44E+02				
20%	1000			4.00E+04	2.08E+03	1.98E+02	23.11%
		800	-1.53E+02				
		1250	-2.56E+02				
25%	1000			6.25E+04	3.21E+03	1.98E+02	28.70%
		750	-1.43E+02				
		1300	-2.67E+02				
30%	1000			9.00E+04	4.64E+03	1.98E+02	34.48%
		700	-1.31E+02				
		1350	-2.79E+02				
35%	1000			1.23E+05	6.29E+03	1.98E+02	40.15%
		650	-1.20E+02				
		1400	-2.90E+02				
40%	1000			1.60E+05	8.19E+03	1.98E+02	45.82%
		600	-1.09E+02				

Table D.142 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (P) and load 1375kN.

P=1375kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		1443.75	-3.07E+02				
5%	1375			4.73E+03	2.66E+02	2.89E+02	5.63%
		1306.25	-2.74E+02				
		1512.5	-3.24E+02				
10%	1375			1.89E+04	1.07E+03	2.89E+02	11.29%
		1237.5	-2.58E+02				
		1581.25	-3.40E+02				
15%	1375			4.25E+04	2.42E+03	2.89E+02	16.99%
		1168.75	-2.42E+02				
		1650	-3.58E+02				
20%	1375			7.56E+04	4.34E+03	2.89E+02	22.76%
		1100	-2.26E+02				
		1718.75	-3.75E+02				
25%	1375			1.18E+05	6.70E+03	2.89E+02	28.30%
		1031.25	-2.11E+02				
		1787.5	-3.92E+02				
30%	1375			1.70E+05	9.82E+03	2.89E+02	34.26%
		962.5	-1.94E+02				
		1856.25	-4.09E+02				
35%	1375			2.32E+05	1.34E+04	2.89E+02	39.98%
		893.75	-1.78E+02				
		1925	-4.27E+02				
40%	1375			3.03E+05	1.76E+04	2.89E+02	45.82%
		825	-1.62E+02				

Table D.143 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (P) and load 1750kN.

P=1750kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		1837.5	-4.09E+02				
5%	1750			7.66E+03	4.97E+02	3.86E+02	5.78%
		1662.5	-3.65E+02				
		1925	-4.32E+02				
10%	1750			3.06E+04	2.01E+03	3.86E+02	11.60%
		1575	-3.43E+02				
		2012.5	-4.55E+02				
15%	1750			6.89E+04	4.51E+03	3.86E+02	17.39%
		1487.5	-3.21E+02				
		2100	-4.79E+02				
20%	1750			1.23E+05	8.02E+03	3.86E+02	23.19%
		1400	-3.00E+02				
		2187.5	-5.03E+02				
25%	1750			1.91E+05	1.25E+04	3.86E+02	29.00%
		1312.5	-2.79E+02				
		2275	-5.26E+02				
30%	1750			2.76E+05	1.79E+04	3.86E+02	34.62%
		1225	-2.58E+02				
		2362.5	-5.49E+02				
35%	1750			3.75E+05	2.43E+04	3.86E+02	40.35%
		1137.5	-2.37E+02				
		2450	-5.72E+02				
40%	1750			4.90E+05	3.15E+04	3.86E+02	45.99%
		1050	-2.17E+02				

Table D.144 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (P) and load 2125kN.

P=2125kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		2231.25	-5.18E+02				
5%	2125			1.13E+04	8.24E+02	4.89E+02	5.87%
		2018.75	-4.61E+02				
		2337.5	-5.46E+02				
10%	2125			4.52E+04	3.25E+03	4.89E+02	11.65%
		1912.5	-4.32E+02				
		2443.75	-5.74E+02				
15%	2125			1.02E+05	7.21E+03	4.89E+02	17.30%
		1806.25	-4.04E+02				
		2550	-6.01E+02				
20%	2125			1.81E+05	1.36E+04	4.89E+02	23.80%
		1700	-3.68E+02				
		2656.25	-6.28E+02				
25%	2125			2.82E+05	2.30E+04	4.89E+02	29.00%
		1593.75	-3.24E+02				
		2762.5	-6.52E+02				
30%	2125			4.06E+05	2.69E+04	4.89E+02	34.80%
		1487.5	-3.24E+02				
		2868.75	-6.76E+02				
35%	2125			5.53E+05	3.57E+04	4.89E+02	42.70%
		1381.25	-2.97E+02				
		2975	-6.97E+02				
40%	2125			7.23E+05	4.53E+04	4.89E+02	49.30%
		1275	-2.72E+02				

Table D.145 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (3D) with varying (P) and load 2500kN.

P=2500kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		2625	-6.23E+02				
5%	2500			1.56E+04	1.01E+03	5.92E+02	5.50%
		2375	-5.59E+02				
		2750	-6.52E+02				
10%	2500			6.25E+04	3.99E+03	5.92E+02	10.40%
		2250	-5.26E+02				
		2875	-6.80E+02				
15%	2500			1.41E+05	8.80E+03	5.92E+02	16.40%
		2125	-4.92E+02				
		3000	-7.05E+02				
20%	2500			2.50E+05	1.53E+04	5.92E+02	23.40%
		2000	-4.58E+02				
		3125	-7.30E+02				
25%	2500			3.91E+05	2.86E+04	5.92E+02	29.40%
		1875	-3.92E+02				
		3250	-7.55E+02				
30%	2500			5.63E+05	3.29E+04	5.92E+02	36.00%
		1750	-3.92E+02				
		3375	-7.78E+02				
35%	2500			7.66E+05	4.38E+04	5.92E+02	43.30%
		1625	-3.60E+02				
		3500	-8.03E+02				
40%	2500			1.00E+06	5.63E+04	5.92E+02	50.70%
		1500	-3.28E+02				

Table D.146 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 1000kN.

P=1000kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.50E+03	1.29E+02	5.75%
10%	1.00E+04	5.15E+02	11.49%
15%	2.25E+04	1.17E+03	17.29%
20%	4.00E+04	2.08E+03	23.11%
25%	6.25E+04	3.21E+03	28.70%
30%	9.00E+04	4.64E+03	34.48%
35%	1.23E+05	6.29E+03	40.15%
40%	1.60E+05	8.19E+03	45.82%

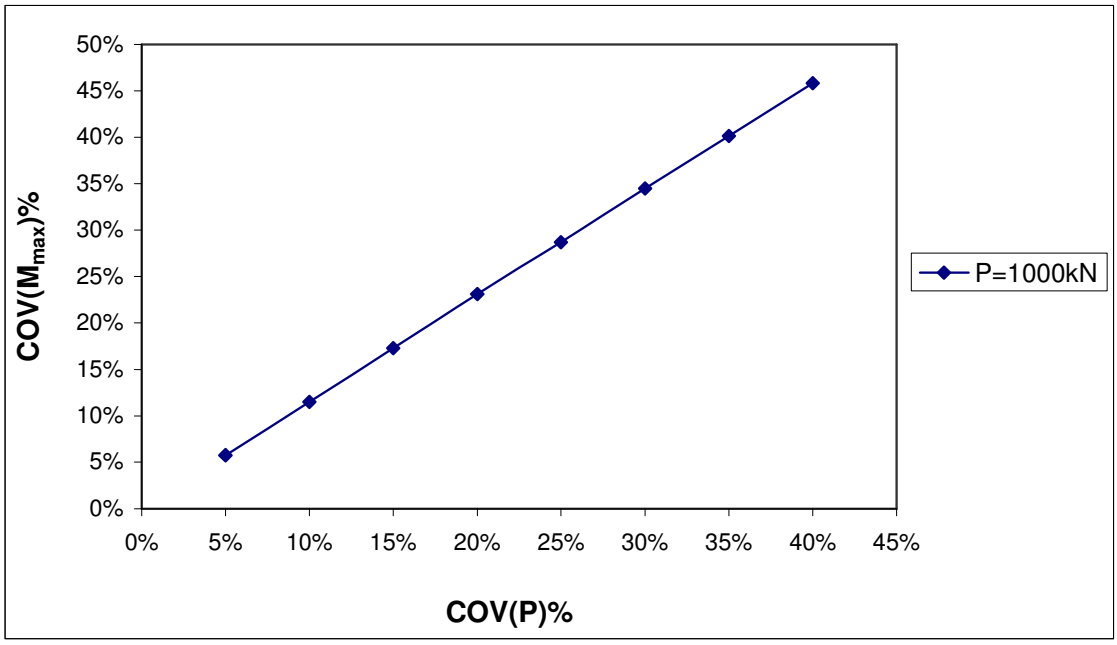


Fig. D.109 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1000kN.

Table D.147 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 1375kN.

P=1375kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.73E+03	2.66E+02	5.63%
10%	1.89E+04	1.07E+03	11.29%
15%	4.25E+04	2.42E+03	16.99%
20%	7.56E+04	4.34E+03	22.76%
25%	1.18E+05	6.70E+03	28.30%
30%	1.70E+05	9.82E+03	34.26%
35%	2.32E+05	1.34E+04	39.98%
40%	3.03E+05	1.76E+04	45.82%

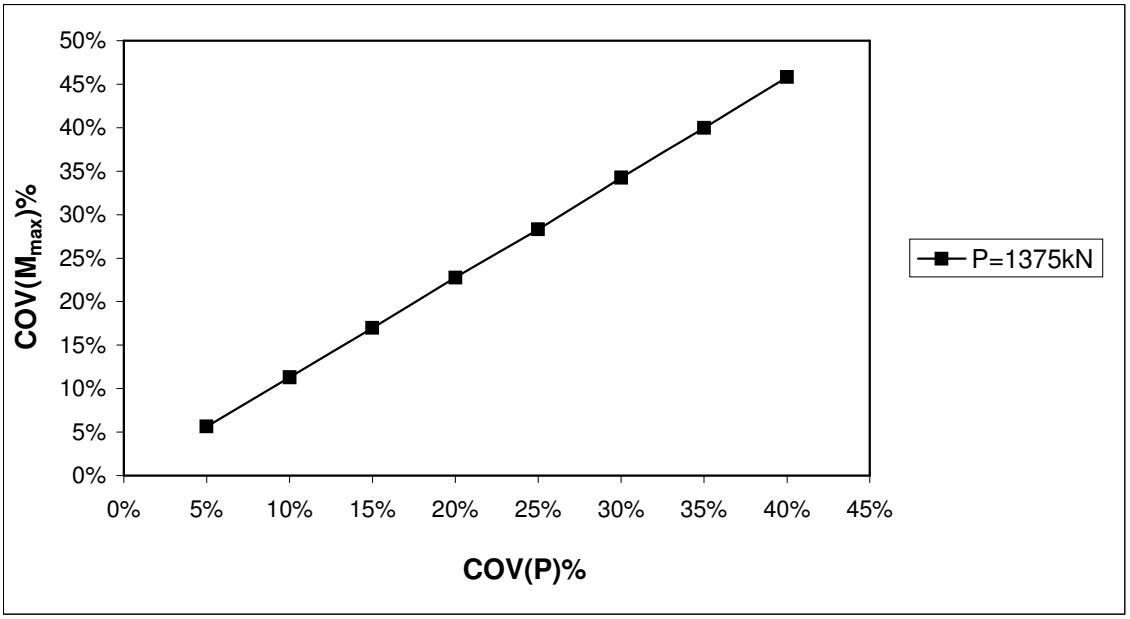


Fig. D.110 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1375kN.

Table D.148 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 1750kN.

P=1750kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	7.66E+03	4.97E+02	5.78%
10%	3.06E+04	2.01E+03	11.60%
15%	6.89E+04	4.51E+03	17.39%
20%	1.23E+05	8.02E+03	23.19%
25%	1.91E+05	1.25E+04	29.00%
30%	2.76E+05	1.79E+04	34.62%
35%	3.75E+05	2.43E+04	40.35%
40%	3.75E+05	3.15E+04	45.99%

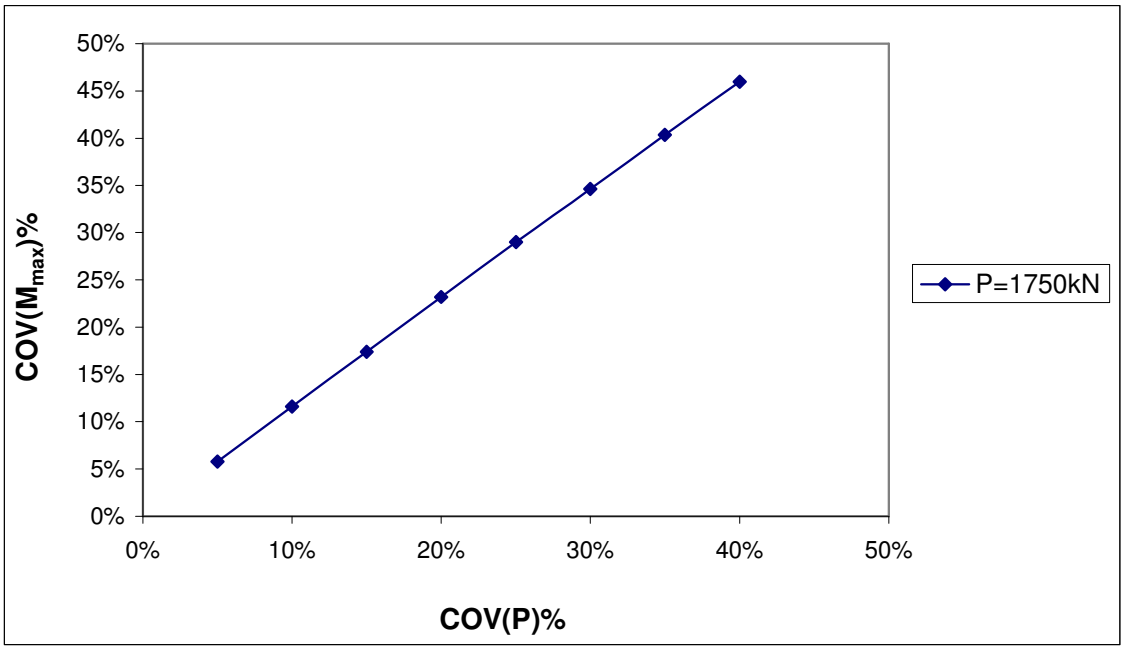


Fig. D.111 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 1750kN.

Table D.149 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 2125kN.

P=2125kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	1.13E+04	8.24E+02	5.87%
10%	4.52E+04	3.25E+03	11.40%
15%	1.02E+05	7.21E+03	17.10%
20%	1.81E+05	1.36E+04	22.80%
25%	2.82E+05	2.30E+04	28.70%
30%	4.06E+05	2.69E+04	34.80%
35%	5.53E+05	3.57E+04	42.20%
40%	7.23E+05	4.53E+04	49.30%

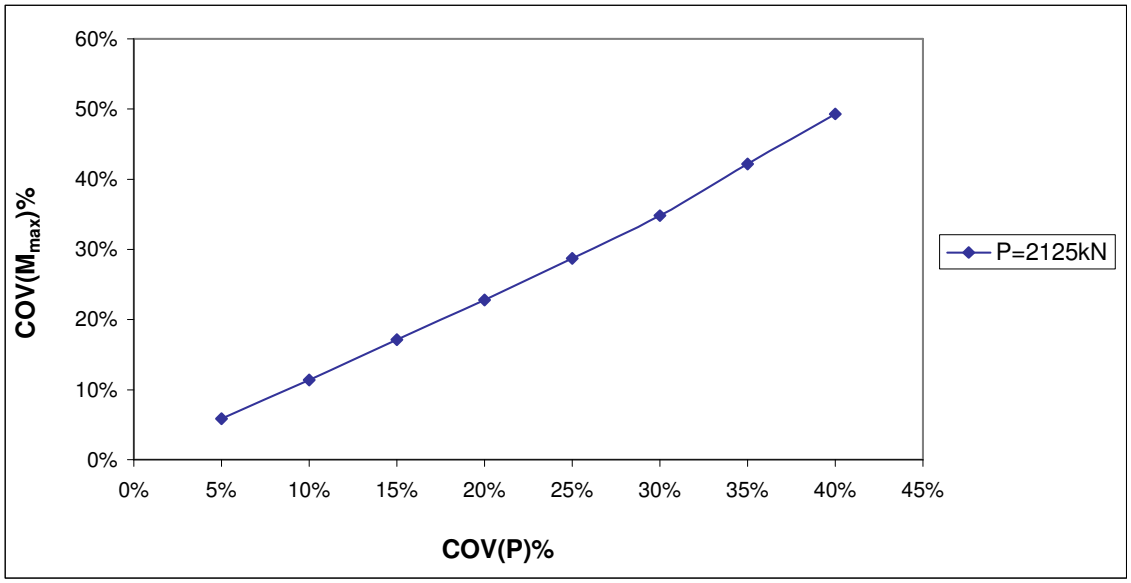


Fig. D.112 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2125kN.

Table D.150 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (3D) with varying COV(P) and lateral load 2500kN.

P=2500kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	1.56E+04	1.01E+03	5.50%
10%	6.25E+04	3.99E+03	10.40%
15%	1.41E+05	8.80E+03	16.40%
20%	2.50E+05	1.53E+04	23.40%
25%	3.91E+05	2.86E+04	29.40%
30%	5.63E+05	3.29E+04	36.00%
35%	7.66E+05	4.38E+04	43.30%
40%	1.00E+06	5.63E+04	50.70%

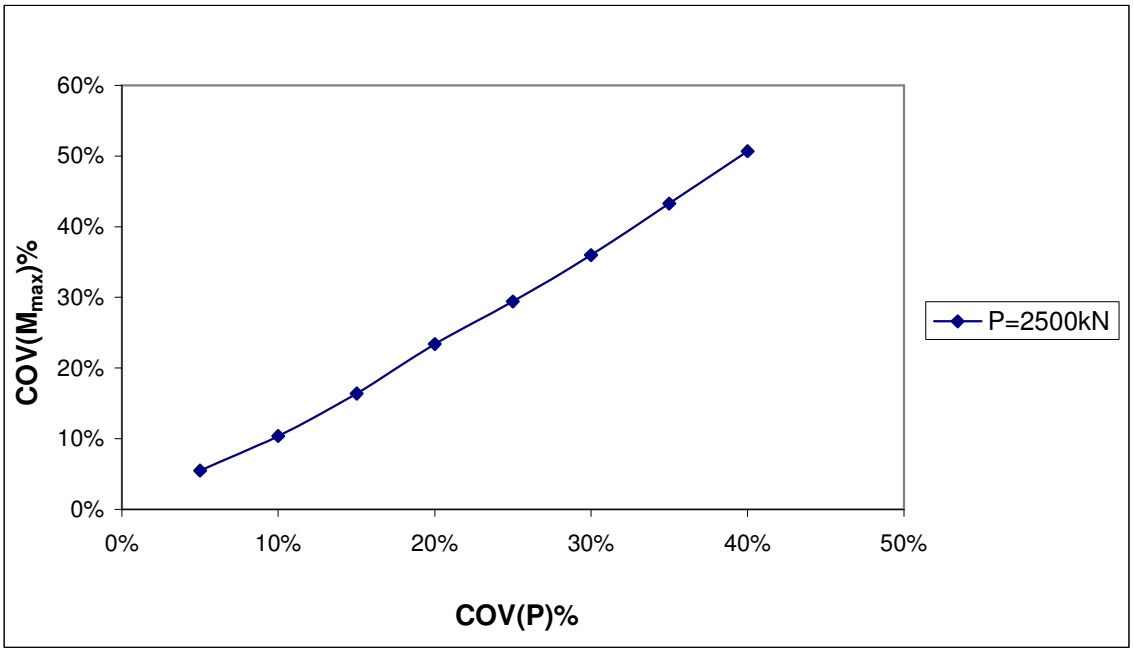


Fig. D.113 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force 2500kN.

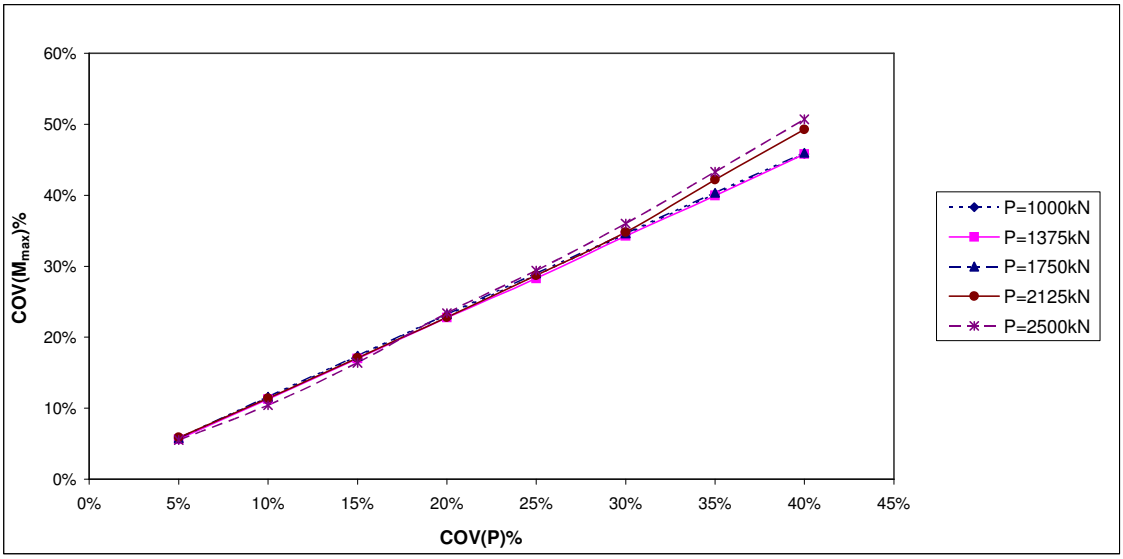


Fig. D.114 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (3D) subjected to lateral force of discrete variability.

D.5 Reliability Index (β) of bending moment vs. COV (Variables)

Table D.151 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.91E+01	10696.73	5%	103.6137	4.7484
1.50E+02	10696.73	10%	104.1479	4.7240
3.40E+02	10696.73	15%	105.0578	4.6831
6.13E+02	10696.73	20%	106.3452	4.6264
9.58E+02	10696.73	25%	107.9566	4.5574
1.41E+03	10696.73	30%	110.0306	4.4715
1.97E+03	10696.73	35%	112.5526	4.3713
2.68E+03	10696.73	40%	115.6718	4.2534

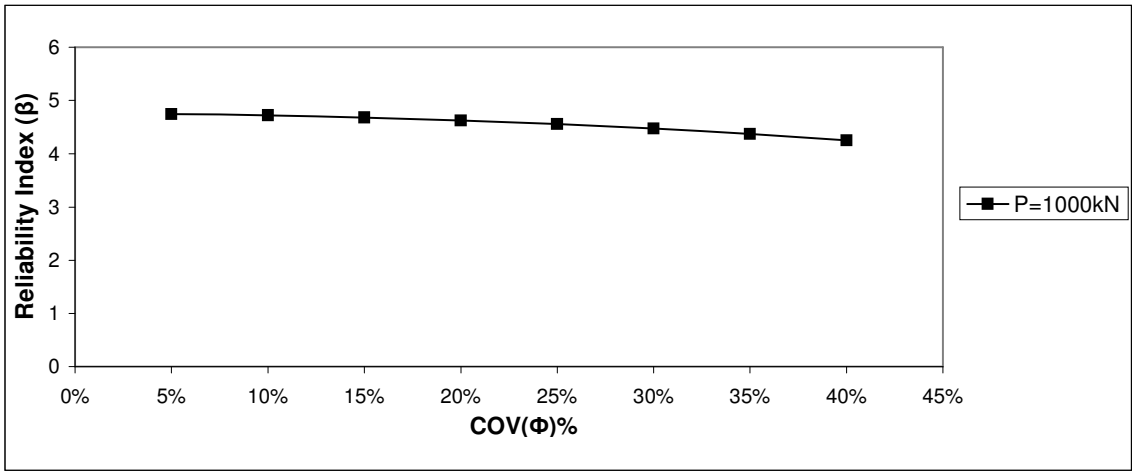


Fig. D.115 Reliability Index (β) of M_{max} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.152 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 1375kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
7.83E+01	10696.73	5%	103.8030	3.8554
3.06E+02	10696.73	10%	104.8951	3.8152
7.08E+02	10696.73	15%	106.7909	3.7475
1.31E+03	10696.73	20%	109.5772	3.6522
2.12E+03	10696.73	25%	113.2137	3.5349
3.23E+03	10696.73	30%	117.9956	3.3917
4.70E+03	10696.73	35%	124.0799	3.2253
6.60E+03	10696.73	40%	131.5230	3.0428

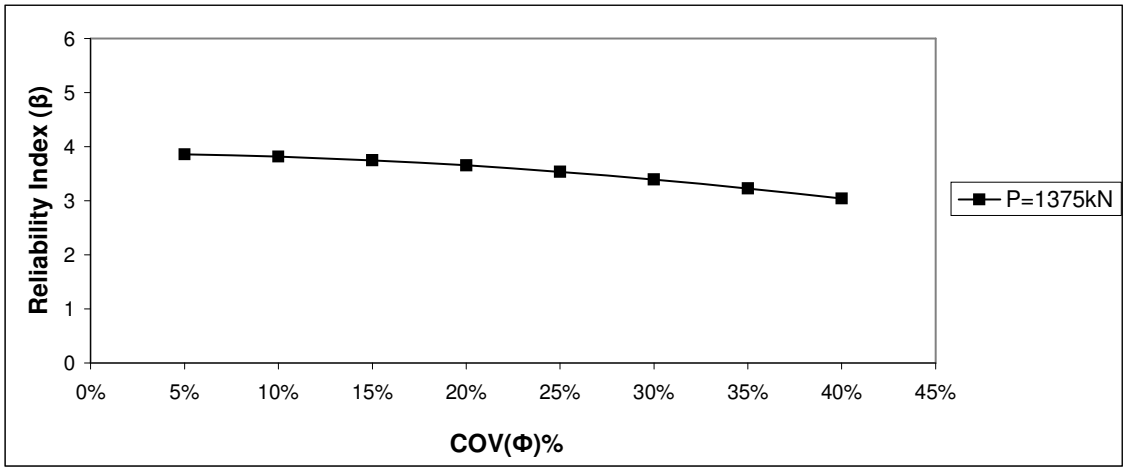


Fig. D.116 Reliability Index (β) of M_{max} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.153 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 1750kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.68E+02	10696.73	5%	104.2326	2.9108
6.48E+02	10696.73	10%	106.5102	2.8486
1.48E+03	10696.73	15%	110.3410	2.7497
2.73E+03	10696.73	20%	115.8740	2.6184
4.46E+03	10696.73	25%	123.0947	2.4648
6.72E+03	10696.73	30%	131.9566	2.2992
9.79E+03	10696.73	35%	143.1357	2.1197
1.40E+04	10696.73	40%	157.0604	1.9317

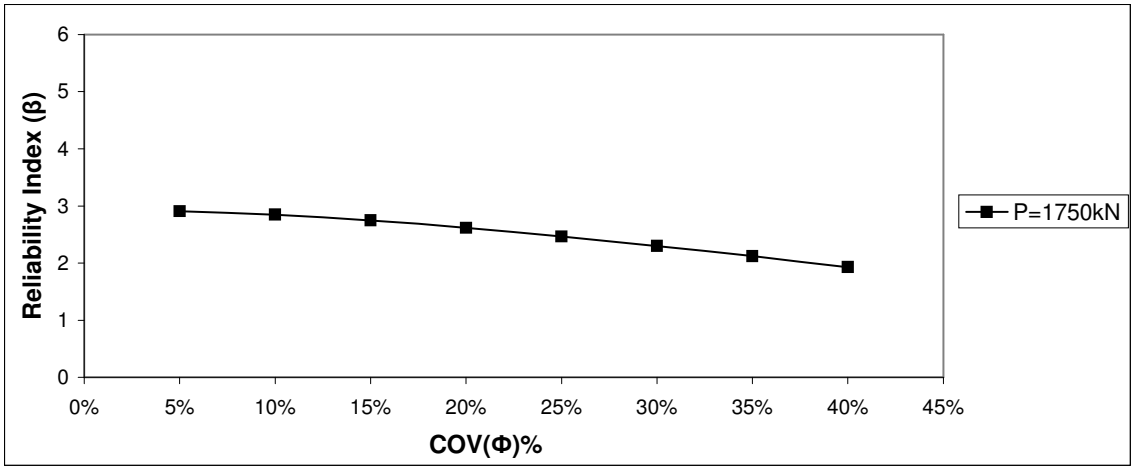


Fig. D.117 Reliability Index (β) of M_{max} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.154 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 2125kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.89E+02	10696.73	5%	104.8128	1.9120
1.16E+03	10696.73	10%	108.9015	1.8402
2.66E+03	10696.73	15%	115.5824	1.7338
4.82E+03	10696.73	20%	124.5794	1.6086
7.80E+03	10696.73	25%	135.9913	1.4736
1.18E+04	10696.73	30%	149.8966	1.3369
1.68E+04	10696.73	35%	165.9271	1.2078
2.33E+04	10696.73	40%	184.3461	1.0871

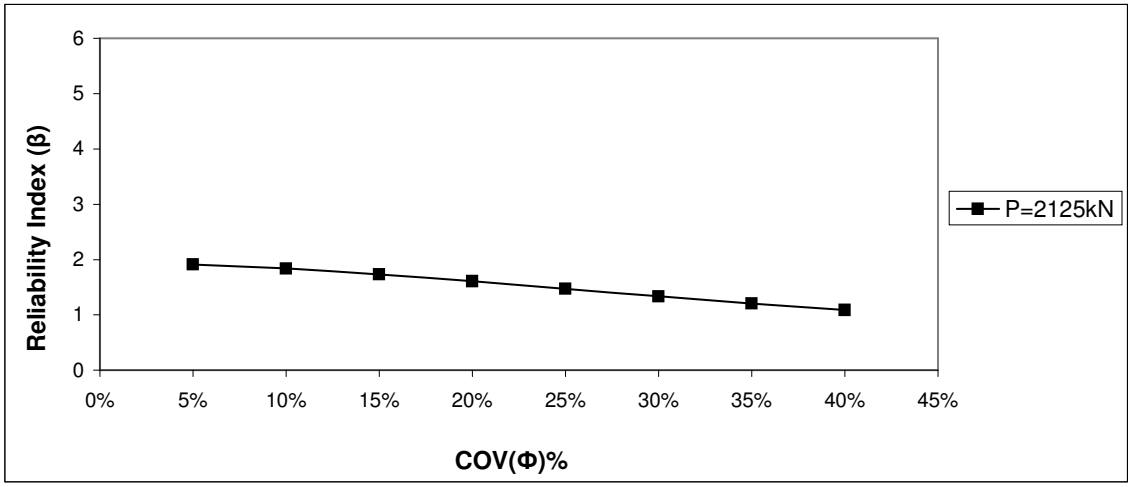


Fig. D.118 Reliability Index (β) of M_{max} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.155 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'Φ' subjected to lateral load 2500kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.80E+02	10696.73	5%	105.2472	0.9302
1.56E+03	10696.73	10%	110.7291	0.8841
3.61E+03	10696.73	15%	119.5940	0.8186
6.50E+03	10696.73	20%	131.1224	0.7466
1.04E+04	10696.73	25%	145.3663	0.6735
1.57E+04	10696.73	30%	162.3939	0.6029
2.26E+04	10696.73	35%	182.4468	0.5366
3.15E+04	10696.73	40%	205.5200	0.4764

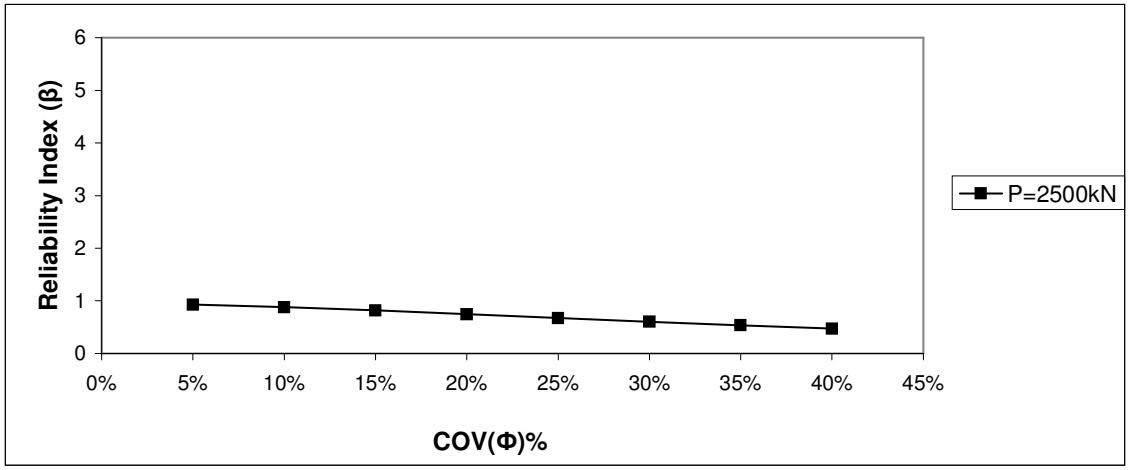


Fig. D.119 Reliability Index (β) of M_{max} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force 2500kN.

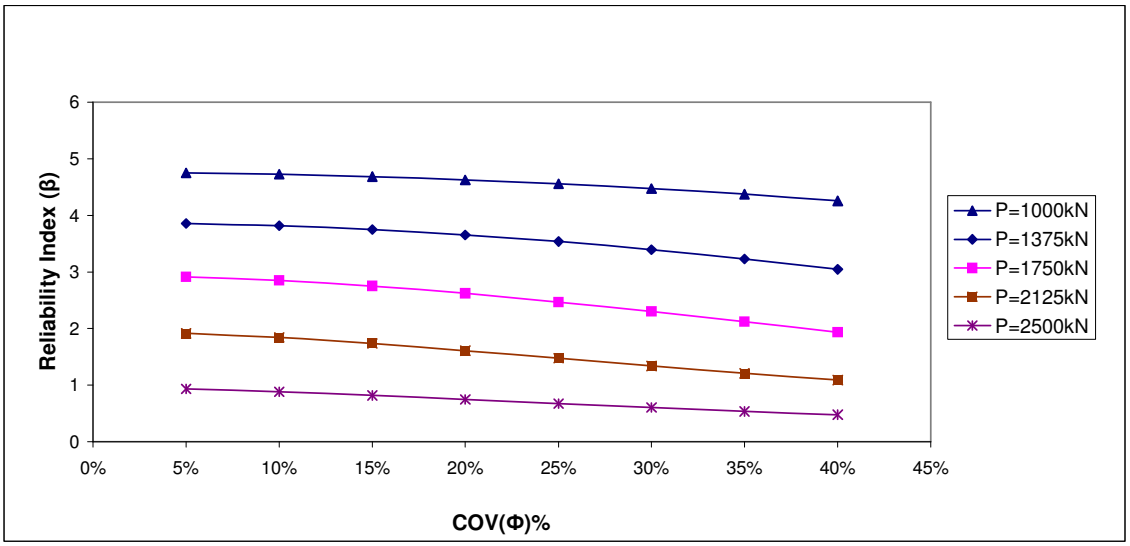


Fig. D.120 Reliability Index (β) of M_{max} vs. COV (Φ) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table D.156 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
6.25E+00	10696.73	5%	103.4552	4.7557
2.70E+01	10696.73	10%	103.5556	4.7511
6.24E+01	10696.73	15%	103.7263	4.7433
1.09E+02	10696.73	20%	103.9516	4.7330
1.74E+02	10696.73	25%	104.2639	4.7188
2.53E+02	10696.73	30%	104.6401	4.7018
3.61E+02	10696.73	35%	105.1557	4.6788
4.86E+02	10696.73	40%	105.7494	4.6525

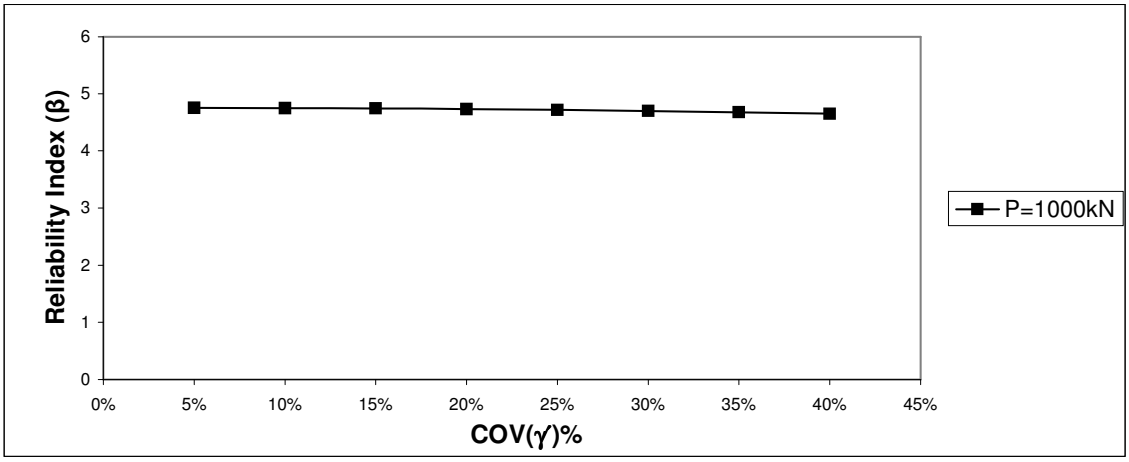


Fig. D.121 Reliability Index (β) of M_{max} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.157 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 1375kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.26E+01	10696.73	5%	103.4859	3.8672
5.40E+01	10696.73	10%	103.6858	3.8597
1.22E+02	10696.73	15%	104.0136	3.8476
2.21E+02	10696.73	20%	104.4857	3.8302
3.55E+02	10696.73	25%	105.1287	3.8068
5.20E+02	10696.73	30%	105.9083	3.7787
7.54E+02	10696.73	35%	107.0058	3.7400
1.03E+03	10696.73	40%	108.2919	3.6300

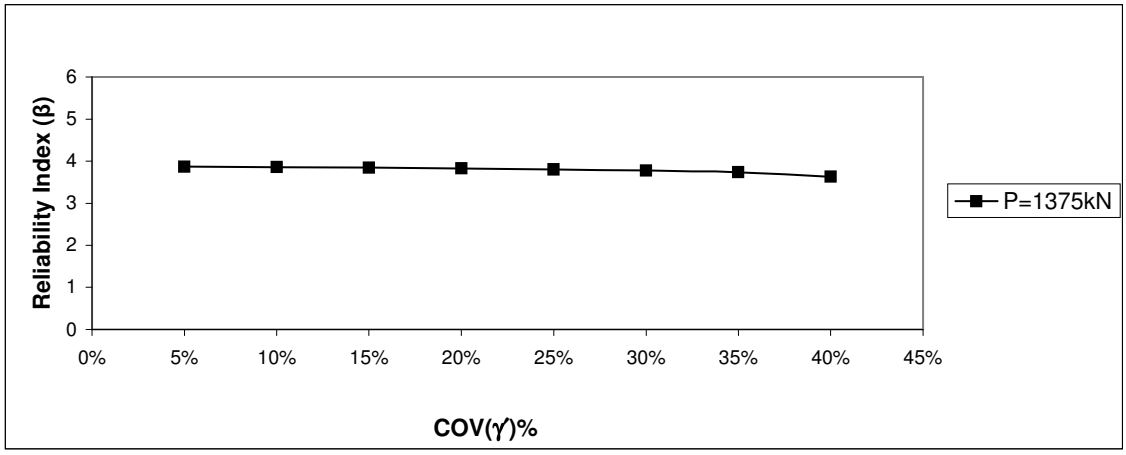


Fig. D.122 Reliability Index (β) of M_{max} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.158 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 1750kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
2.55E+01	10696.73	5%	103.5482	2.9300
1.14E+02	10696.73	10%	103.9770	2.9180
2.59E+02	10696.73	15%	104.6706	2.8986
4.54E+02	10696.73	20%	105.5956	2.8732
7.37E+02	10696.73	25%	106.9292	2.8374
1.11E+03	10696.73	30%	108.6537	2.7000
1.56E+03	10696.73	35%	110.7291	2.5395
2.14E+03	10696.73	40%	113.3156	2.3860

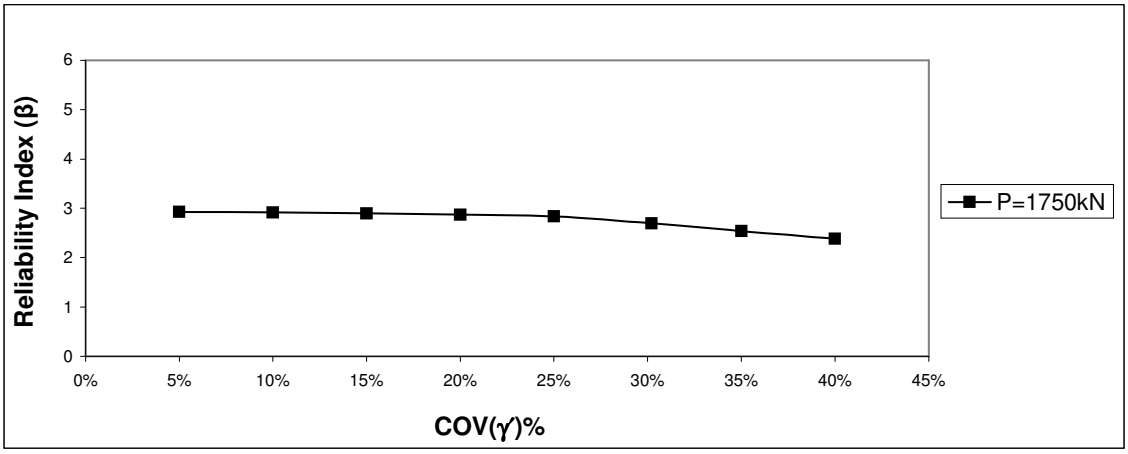


Fig. D.123 Reliability Index (β) of M_{max} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.159 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 2125kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
4.90E+01	10696.73	5%	103.6616	1.9332
1.96E+02	10696.73	10%	104.3682	1.9201
4.49E+02	10696.73	15%	105.5754	1.8982
8.04E+02	10696.73	20%	107.2402	1.8687
1.29E+03	10696.73	25%	109.4785	1.8305
1.94E+03	10696.73	30%	112.4150	1.7827
2.68E+03	10696.73	35%	115.6718	1.7325
3.68E+03	10696.73	40%	119.8964	1.6124

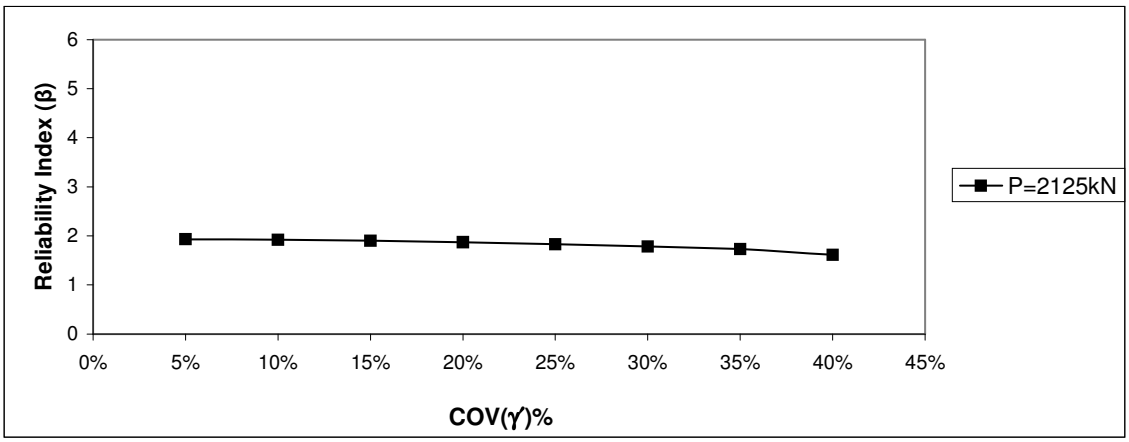


Fig. D.124 Reliability Index (β) of M_{max} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.160 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'γ' subjected to lateral load 2500kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
6.89E+01	10696.73	5%	103.7575	0.9400
2.54E+02	10696.73	10%	104.6477	0.9302
6.20E+02	10696.73	15%	106.3778	0.9141
1.14E+03	10696.73	20%	108.8080	0.8720
1.93E+03	10696.73	25%	112.3759	0.8414
2.84E+03	10696.73	30%	116.3284	0.7800
4.01E+03	10696.73	35%	121.2846	0.7000
5.74E+03	10696.73	40%	128.1983	0.5866

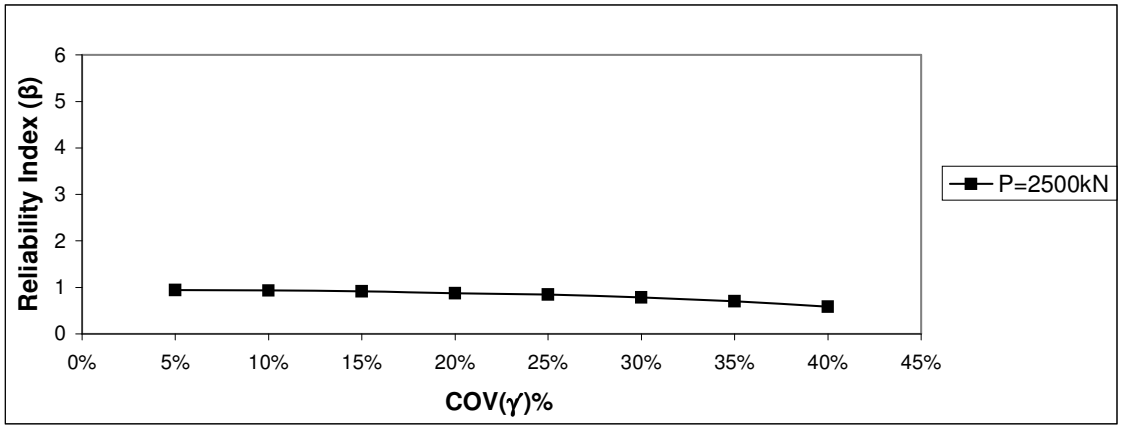


Fig. D.125 Reliability Index (β) of M_{max} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force 2500kN.

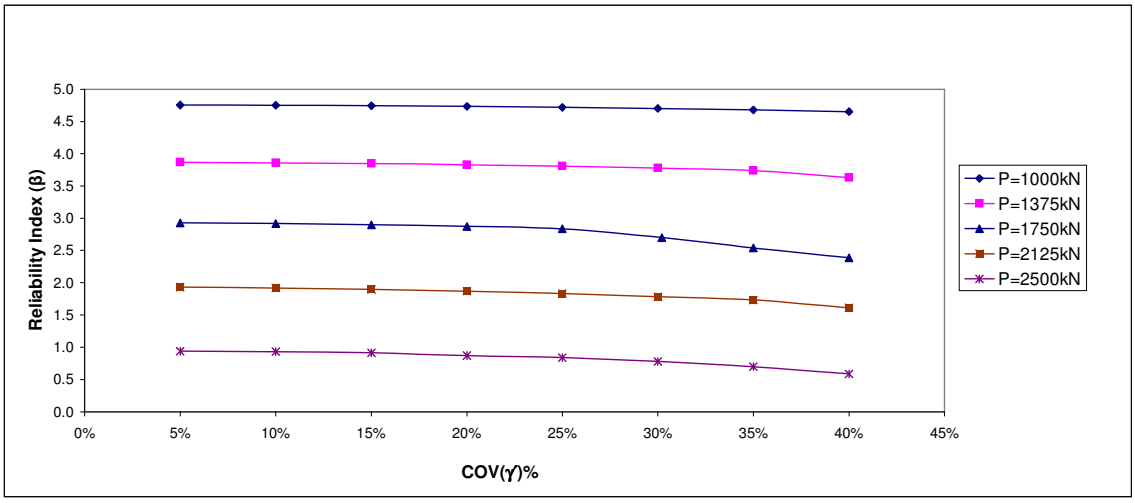


Fig. D.126 Reliability Index (β) of M_{max} vs. COV (γ) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table D.161 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'k' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.25E-02	10696.73	5%	103.4251	4.7571
6.25E-02	10696.73	10%	103.4253	4.7571
9.00E-02	10696.73	15%	103.4254	4.7571
9.00E-02	10696.73	20%	103.4254	4.7571
9.00E-02	10696.73	25%	103.4254	4.7571
2.50E-01	10696.73	30%	103.4262	4.7570
4.90E-01	10696.73	35%	103.4274	4.7570
8.10E-01	10696.73	40%	103.4289	4.7569

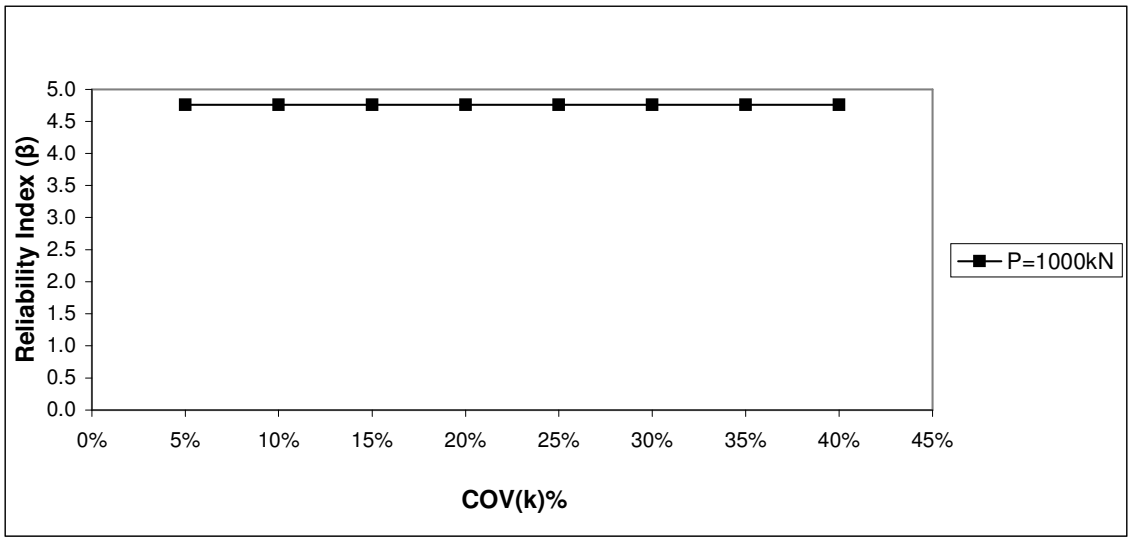


Fig. D.127 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.162 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'k' subjected to lateral load 1375kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E-02	10696.73	5%	103.4250	3.8695
6.25E-02	10696.73	10%	103.4253	3.8695
1.22E-01	10696.73	15%	103.4256	3.8694
1.22E-01	10696.73	20%	103.4256	3.8694
9.00E-02	10696.73	25%	103.4254	3.8695
2.02E-01	10696.73	30%	103.4260	3.8694
4.90E-01	10696.73	35%	103.4274	3.8694
8.10E-01	10696.73	40%	103.4289	3.8693

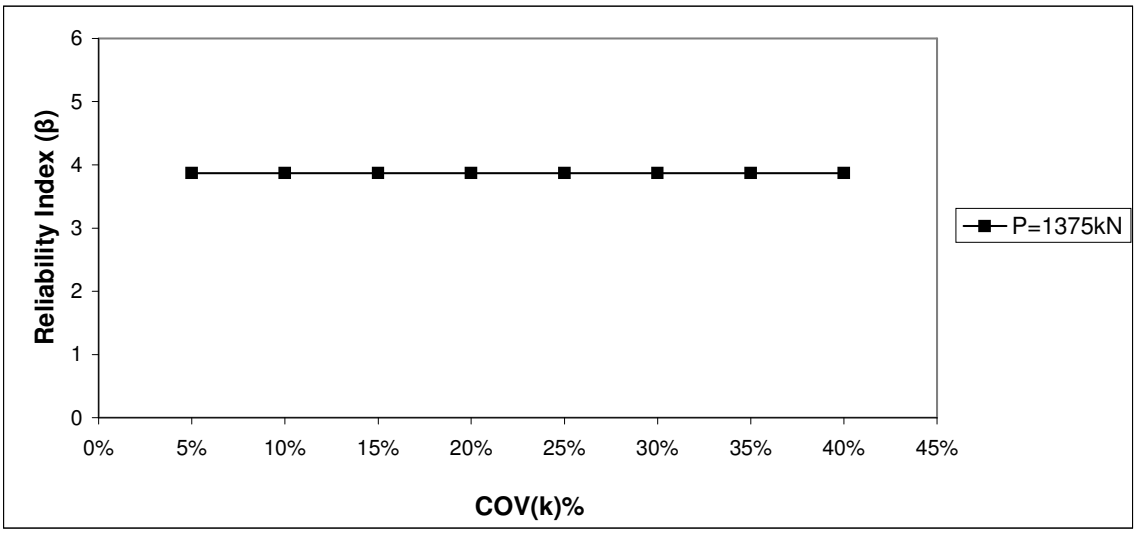


Fig. D.128 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.163 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'k' subjected to lateral load 1750kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.00E-02	10696.73	5%	103.4252	2.9335
1.22E-01	10696.73	10%	103.4256	2.9335
1.60E-01	10696.73	15%	103.4258	2.9335
1.60E-01	10696.73	20%	103.4258	2.9335
3.03E-01	10696.73	25%	103.4265	2.9335
5.63E-01	10696.73	30%	103.4277	2.9334
1.00E+00	10696.73	35%	103.4298	2.9334
1.10E+00	10696.73	40%	103.4303	2.9334

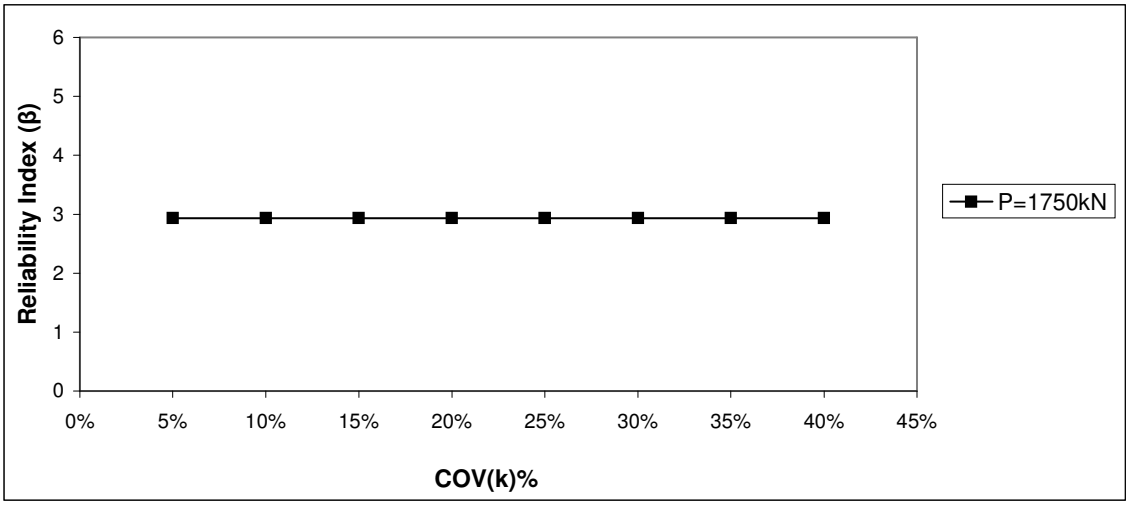


Fig. D.129 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.164 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'k' subjected to lateral load 2125kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
0.00E+00	10696.73	5%	103.4250	1.9376
1.00E-02	10696.73	10%	103.4250	1.9376
9.00E-02	10696.73	15%	103.4254	1.9376
3.03E-01	10696.73	20%	103.4265	1.9376
7.23E-01	10696.73	25%	103.4285	1.9376
1.21E+00	10696.73	30%	103.4308	1.9375
1.44E+00	10696.73	35%	103.4320	1.9375
1.82E+00	10696.73	40%	103.4338	1.9375

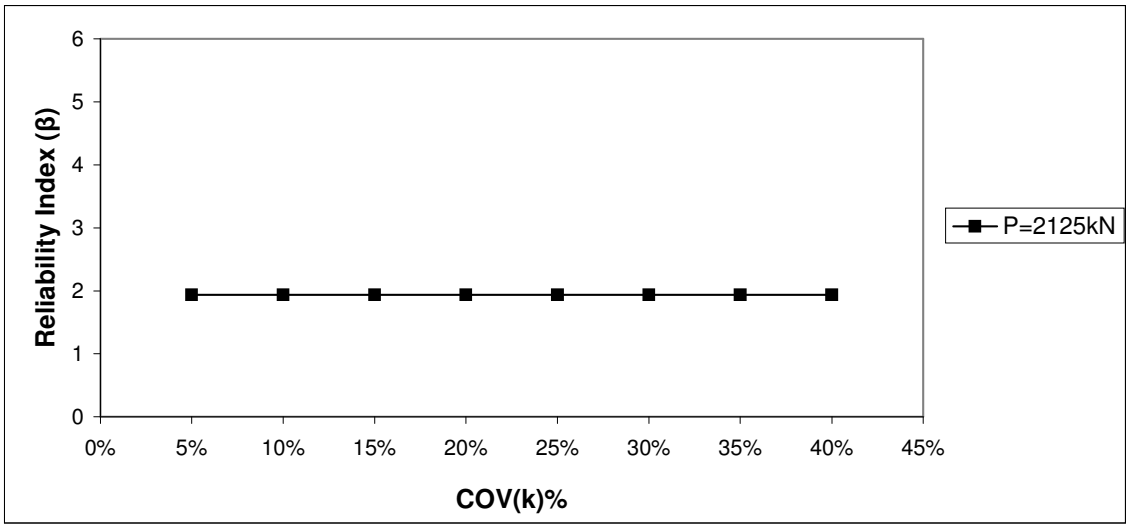


Fig. D.130 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.165 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'k' subjected to lateral load 2500kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.25E-02	10696.73	5%	103.4251	0.9466
1.23E-01	10696.73	10%	103.4256	0.9466
3.03E-01	10696.73	15%	103.4265	0.9466
6.40E-01	10696.73	20%	103.4281	0.9466
8.10E-01	10696.73	25%	103.4289	0.9465
1.10E+00	10696.73	30%	103.4303	0.9465
1.69E+00	10696.73	35%	103.4332	0.9465
3.42E+00	10696.73	40%	103.4415	0.9464

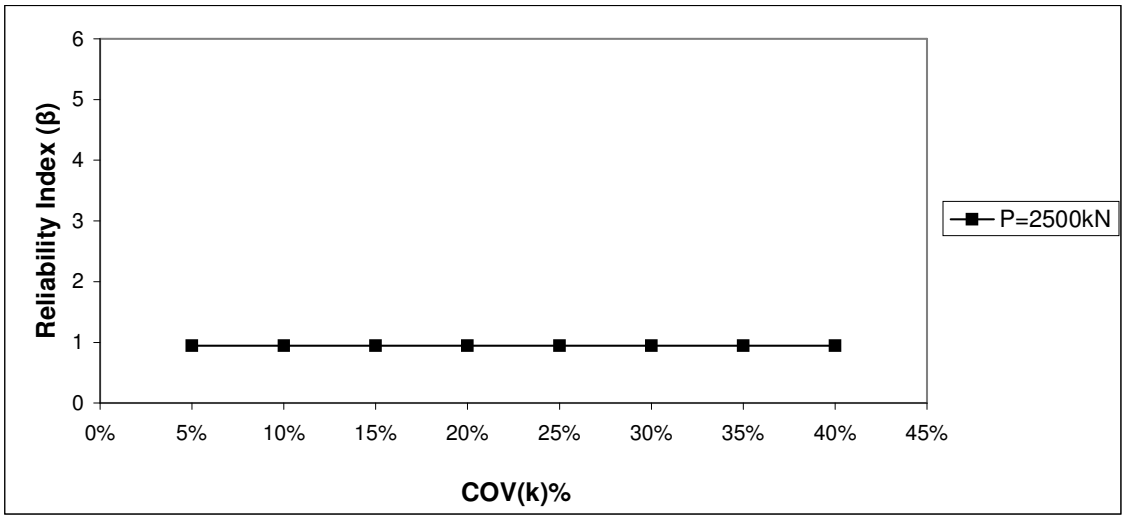


Fig. D.131 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 2500kN.

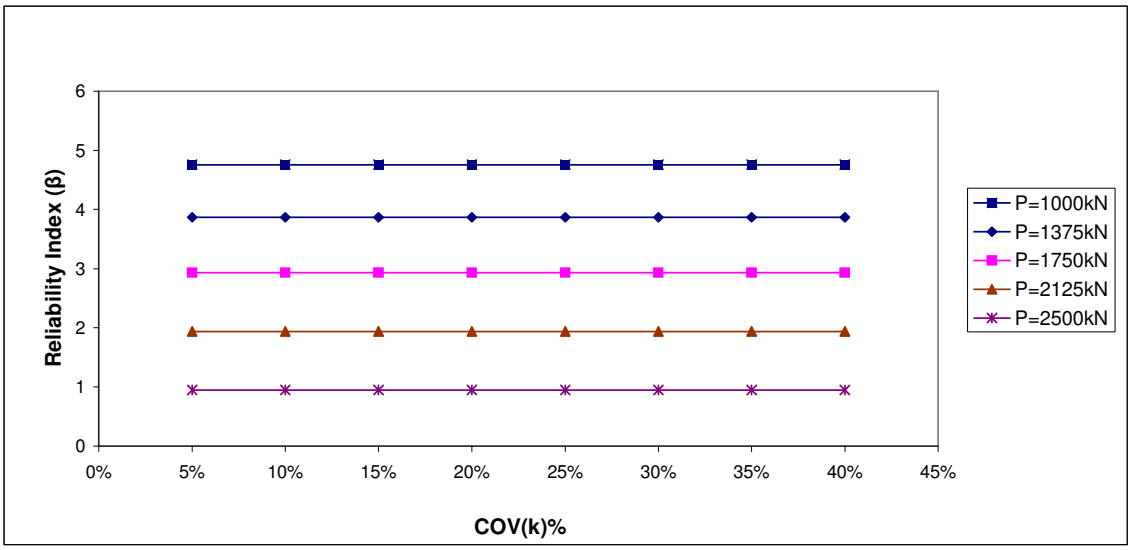


Fig. D.132 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table D.166 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'B' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.32E+00	10696.73	5%	103.4314	4.7568
4.84E+00	10696.73	10%	103.4484	4.7560
1.12E+01	10696.73	15%	103.4792	4.7546
2.35E+01	10696.73	20%	103.5387	4.7518
4.42E+01	10696.73	25%	103.6386	4.7473
7.66E+01	10696.73	30%	103.7945	4.7401
1.30E+02	10696.73	35%	104.0538	4.7283
2.15E+02	10696.73	40%	104.4574	4.7101

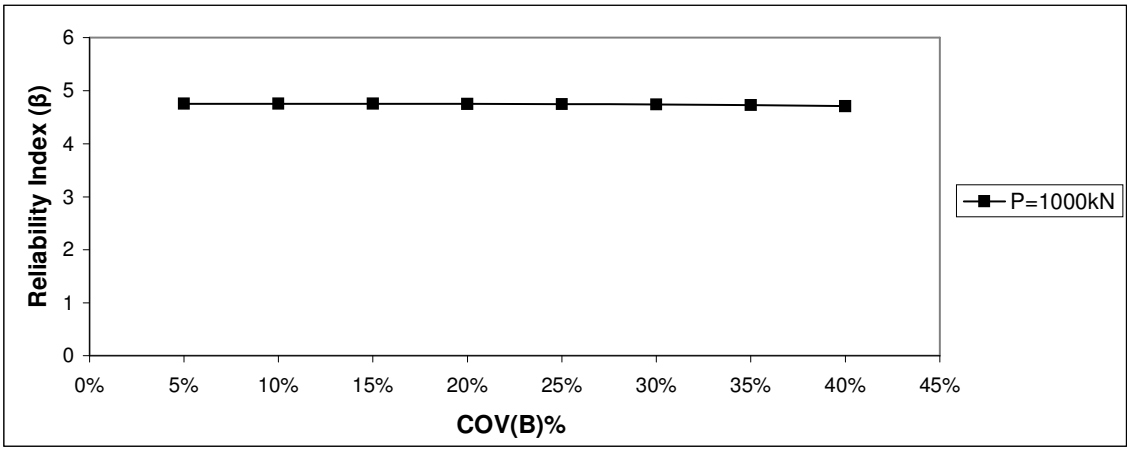


Fig. D.133 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.167 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'B' subjected to lateral load 1375kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
5.06E+00	10696.73	5%	103.4495	3.8686
2.03E+01	10696.73	10%	103.5229	3.8658
4.76E+01	10696.73	15%	103.6549	3.8609
9.51E+01	10696.73	20%	103.8836	3.8524
1.74E+02	10696.73	25%	104.2639	3.8383
3.13E+02	10696.73	30%	104.9286	3.8140
5.83E+02	10696.73	35%	106.2078	3.7681
1.11E+03	10696.73	40%	108.6537	3.6833

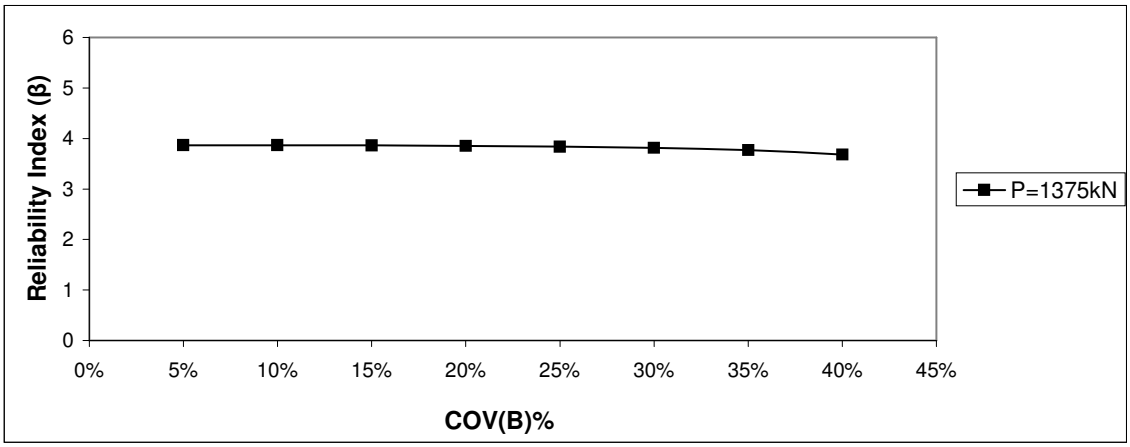


Fig. D.134 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.168 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'B' subjected to lateral load 1750kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
8.70E+00	10696.73	5%	103.4671	2.9323
3.54E+01	10696.73	10%	103.5960	2.9287
9.90E+01	10696.73	15%	103.9025	2.9200
2.39E+02	10696.73	20%	104.5726	2.9013
5.62E+02	10696.73	25%	106.1057	2.8594
1.24E+03	10696.73	30%	109.2510	2.7771
2.47E+03	10696.73	35%	114.7532	2.6439
2.52E+03	10696.73	40%	114.9642	2.6391

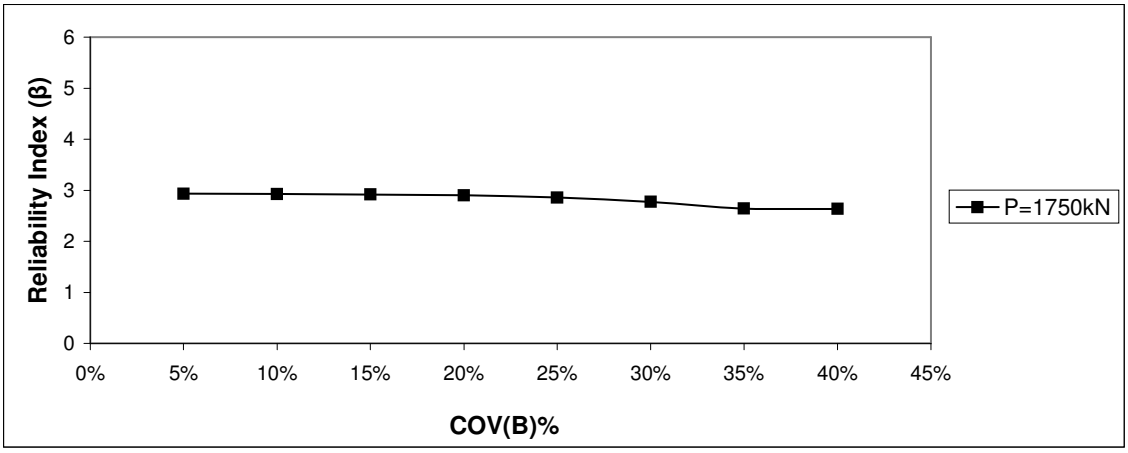


Fig. D.135 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.169 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'B' subjected to lateral load 2125kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.45E+01	10696.73	5%	103.5434	1.9354
1.19E+02	10696.73	10%	103.9978	1.9270
3.98E+02	10696.73	15%	105.3315	1.9026
7.65E+02	10696.73	20%	107.0572	1.8719
1.11E+03	10696.73	25%	108.6537	1.8444
2.34E+03	10696.73	30%	114.1897	1.7550
2.67E+03	10696.73	35%	115.5944	1.7336
4.26E+03	10696.73	40%	122.3144	1.6384

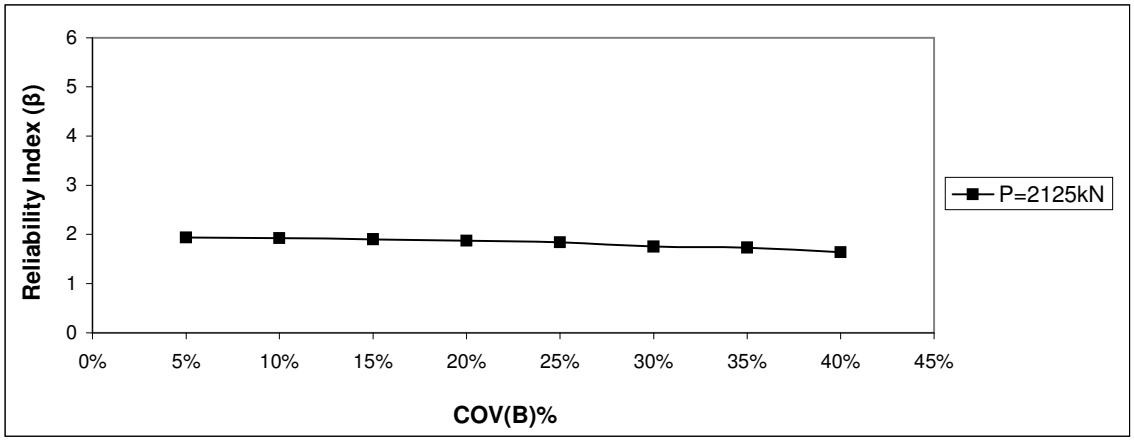


Fig. D.136 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.170 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'B' subjected to lateral load 2500kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.36E+02	10696.73	5%	104.0791	0.9406
3.71E+02	10696.73	10%	105.2012	0.9306
7.73E+02	10696.73	15%	107.0961	0.9141
1.40E+03	10696.73	20%	109.9797	0.8902
2.43E+03	10696.73	25%	114.5745	0.8545
3.84E+03	10696.73	30%	120.5850	0.8119
6.11E+03	10696.73	35%	129.6581	0.7551
9.57E+03	10696.73	40%	142.3775	0.6876

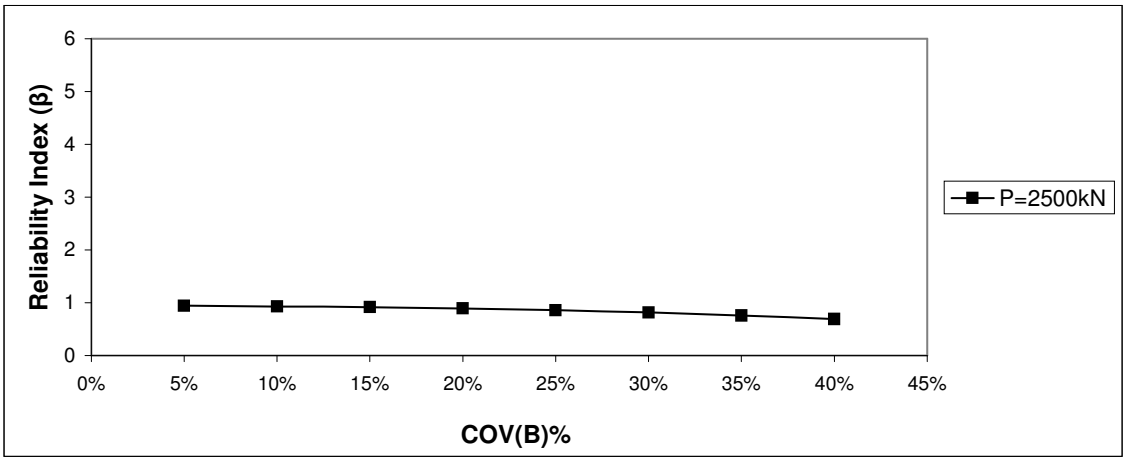


Fig. D.137 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 2500kN.

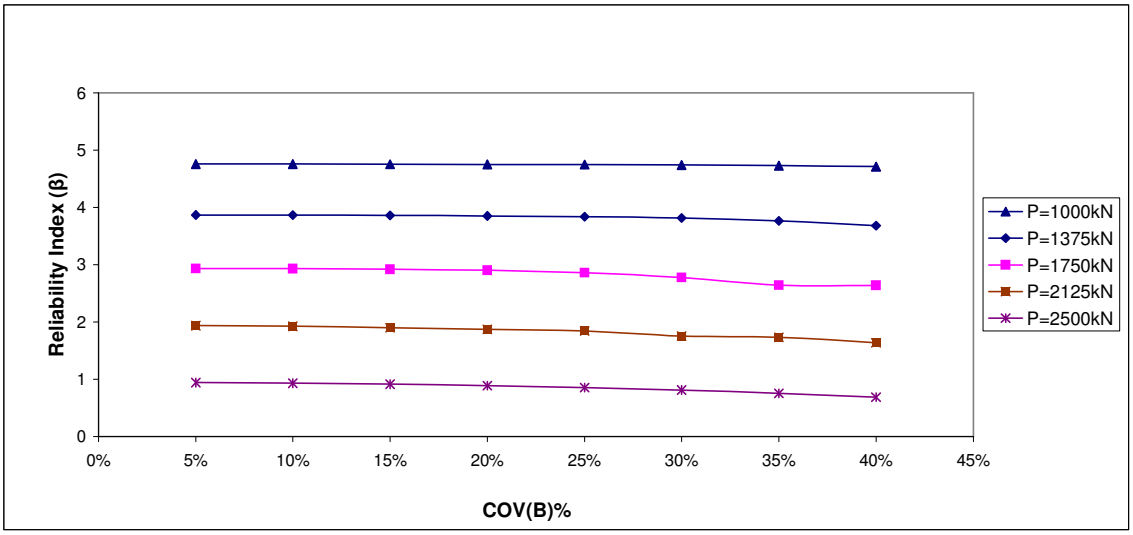


Fig.D.138 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table D.171 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E-02	10696.73	5%	103.4250	4.7571
3.06E-02	10696.73	10%	103.4251	4.7571
6.25E-02	10696.73	15%	103.4253	4.7571
7.56E-02	10696.73	20%	103.4254	4.7571
7.96E-02	10696.73	25%	103.4254	4.7571
3.02E-01	10696.73	30%	103.4265	4.7570
4.55E-01	10696.73	35%	103.4272	4.7570
6.01E-01	10696.73	40%	103.4279	4.7569

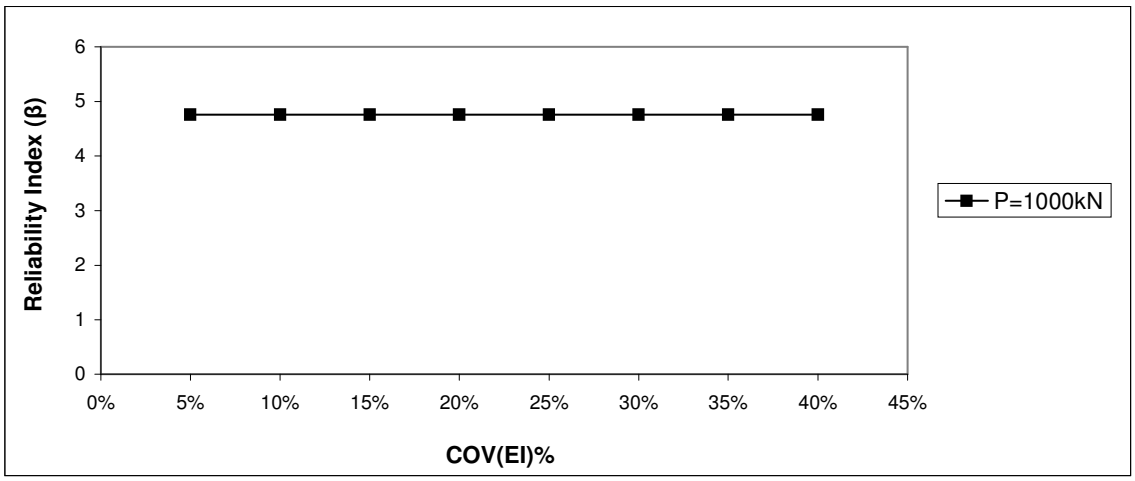


Fig. D.139 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.172 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 1375kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.23E-01	10696.73	5%	103.4256	3.8694
5.26E-01	10696.73	10%	103.4275	3.8694
1.27E+00	10696.73	15%	103.4311	3.8692
2.48E+00	10696.73	20%	103.4370	3.8690
1.76E+00	10696.73	25%	103.4335	3.8692
5.52E+00	10696.73	30%	103.4517	3.8685
7.42E+00	10696.73	35%	103.4609	3.8681
9.92E+00	10696.73	40%	103.4730	3.8677

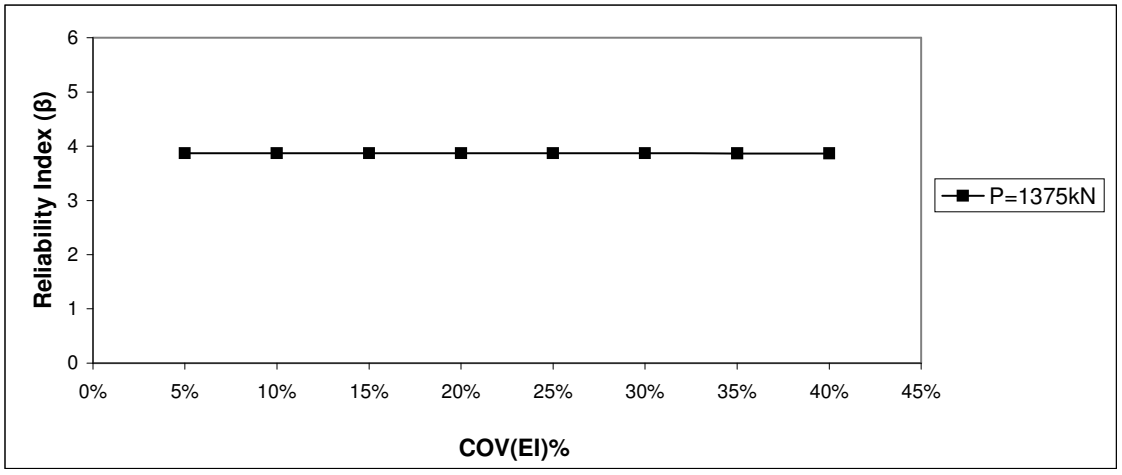


Fig. D.140 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.173 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 1750kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.60E-01	10696.73	5%	103.4258	2.9335
6.40E-01	10696.73	10%	103.4281	2.9334
1.44E+00	10696.73	15%	103.4320	2.9333
2.56E+00	10696.73	20%	103.4374	2.9332
1.81E+00	10696.73	25%	103.4337	2.9333
6.13E+00	10696.73	30%	103.4546	2.9327
8.55E+00	10696.73	35%	103.4663	2.9324
1.17E+01	10696.73	40%	103.4817	2.9319

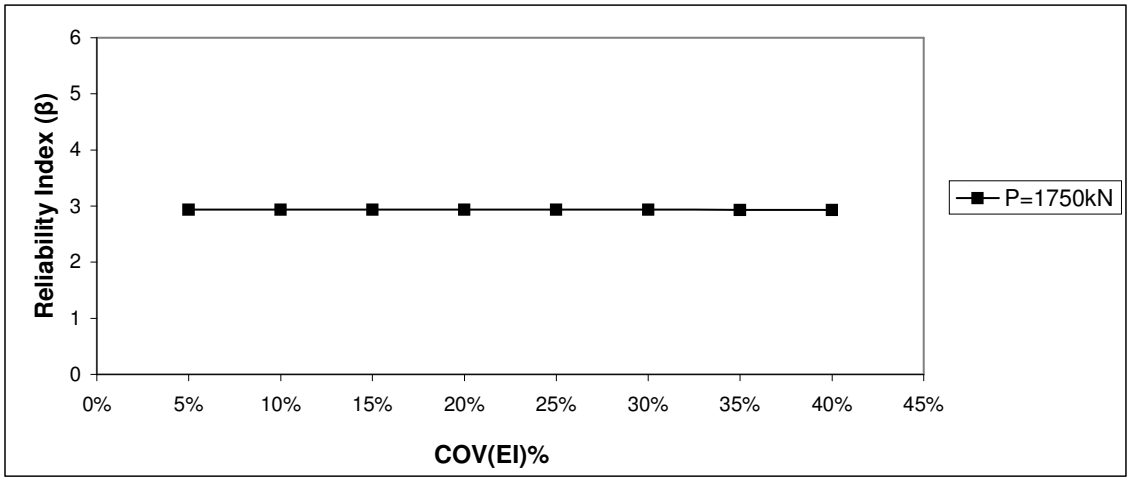


Fig. D.141 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.174 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 2125kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.03E-01	10696.73	5%	103.4265	1.9376
1.16E+00	10696.73	10%	103.4306	1.9375
2.72E+00	10696.73	15%	103.4382	1.9374
4.95E+00	10696.73	20%	103.4489	1.9372
3.27E+00	10696.73	25%	103.4408	1.9373
1.09E+01	10696.73	30%	103.4776	1.9367
1.50E+01	10696.73	35%	103.4975	1.9363
2.00E+01	10696.73	40%	103.5218	1.9358

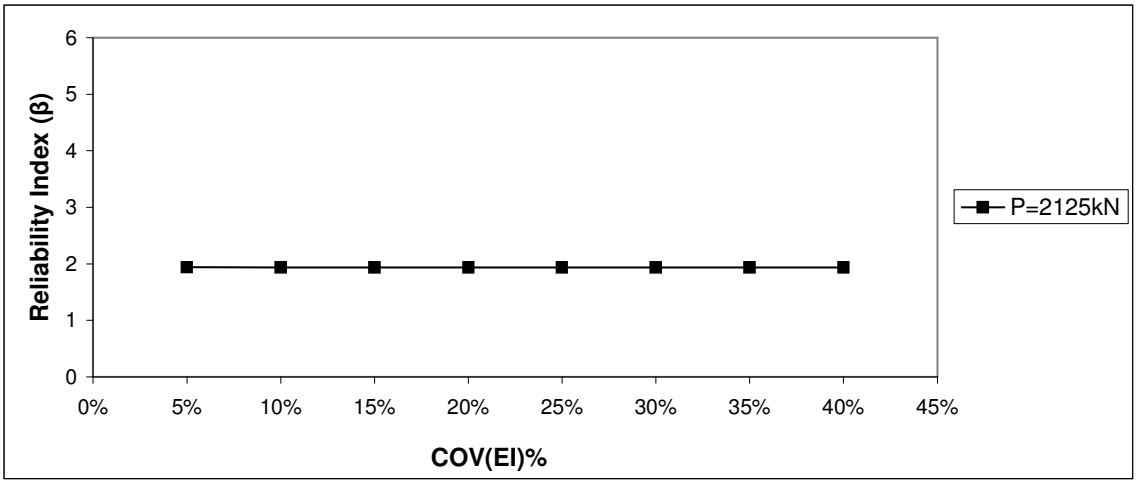


Fig. D.142 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.175 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'EI' subjected to lateral load 2500kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.31E-01	10696.73	5%	103.4266	0.9466
1.44E+00	10696.73	10%	103.4320	0.9465
3.15E+00	10696.73	15%	103.4402	0.9464
5.64E+00	10696.73	20%	103.4523	0.9463
3.97E+00	10696.73	25%	103.4442	0.9464
1.30E+01	10696.73	30%	103.4876	0.9460
1.76E+01	10696.73	35%	103.5102	0.9458
2.33E+01	10696.73	40%	103.5375	0.9456

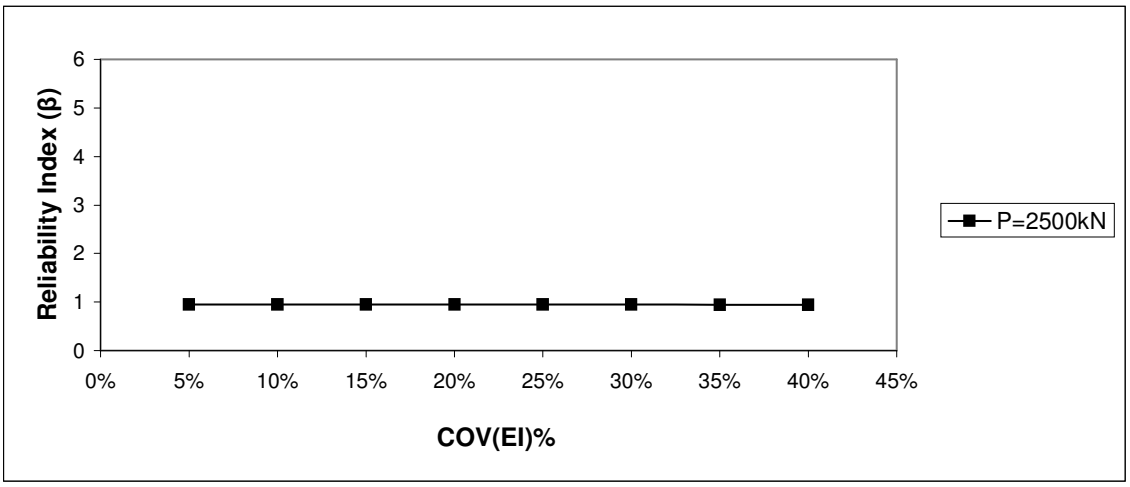


Fig. D.143 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 2500kN.

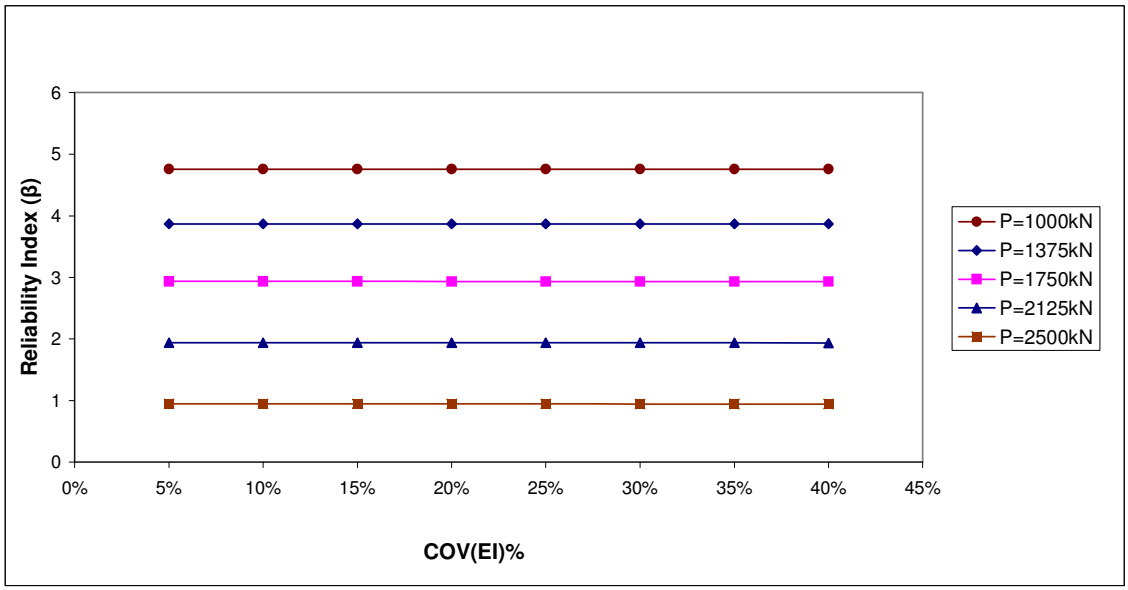


Fig. D.144 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table D.176 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'P' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.29E+02	10696.73	5%	104.0459	4.7287
5.15E+02	10696.73	10%	105.8868	4.6465
1.17E+03	10696.73	15%	108.9172	4.5172
2.08E+03	10696.73	20%	113.0516	4.3520
3.21E+03	10696.73	25%	117.9403	4.1716
4.64E+03	10696.73	30%	123.8319	3.9731
6.29E+03	10696.73	35%	130.3274	3.7751
8.19E+03	10696.73	40%	137.4299	3.5800

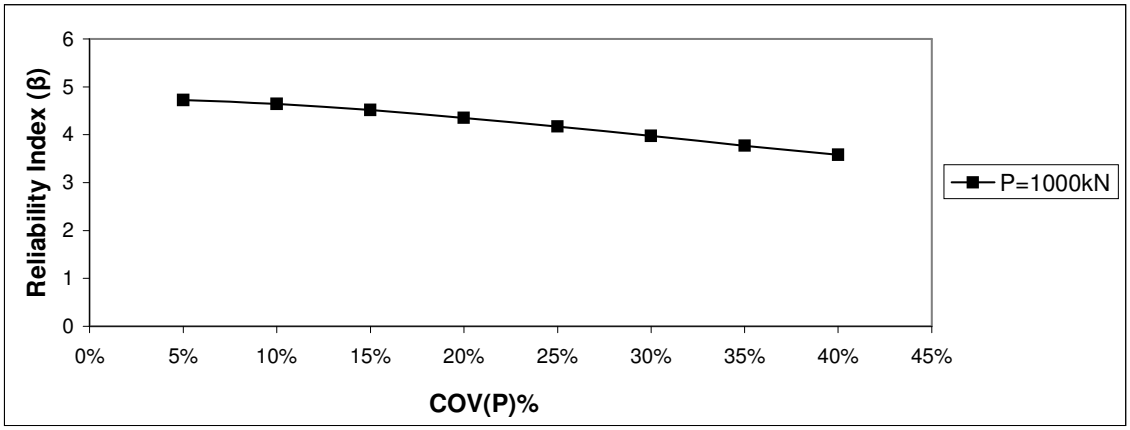


Fig. D.145 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table D.177 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'P' subjected to lateral load 1375kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.66E+02	10696.73	5%	104.7016	3.8223
1.07E+03	10696.73	10%	108.4562	3.6900
2.42E+03	10696.73	15%	114.5096	3.4949
4.34E+03	10696.73	20%	122.6089	3.2640
6.70E+03	10696.73	25%	131.9100	3.0339
9.82E+03	10696.73	30%	143.2395	2.7939
1.34E+04	10696.73	35%	155.1504	2.5794
1.76E+04	10696.73	40%	168.1256	2.3804

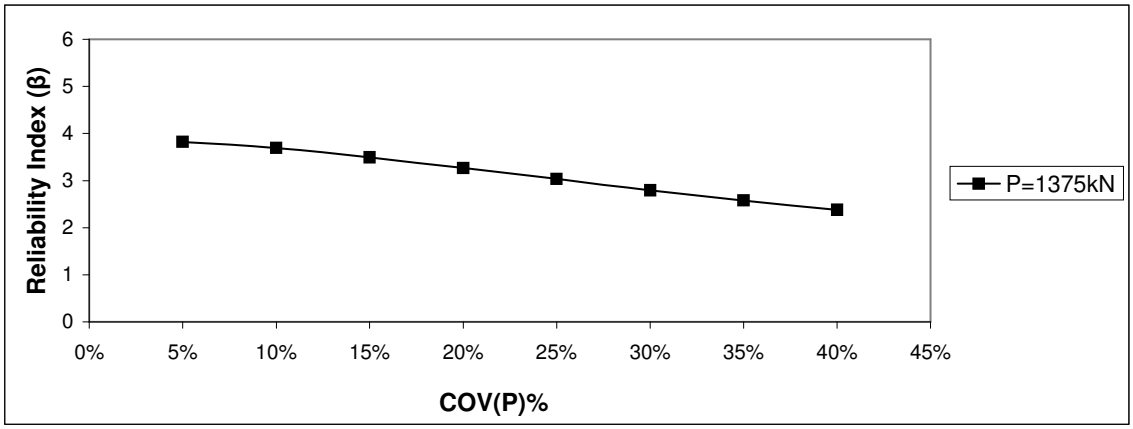


Fig. D.146 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 1375kN.

Table D.178 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'P' subjected to lateral load 1750kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.97E+02	10696.73	5%	105.8018	2.8676
2.01E+03	10696.73	10%	112.7110	2.6918
4.51E+03	10696.73	15%	123.3120	2.4604
8.02E+03	10696.73	20%	136.8062	2.2177
1.25E+04	10696.73	25%	152.4124	1.9907
1.79E+04	10696.73	30%	168.9942	1.7953
2.43E+04	10696.73	35%	187.0037	1.6224
3.15E+04	10696.73	40%	205.4768	1.4766

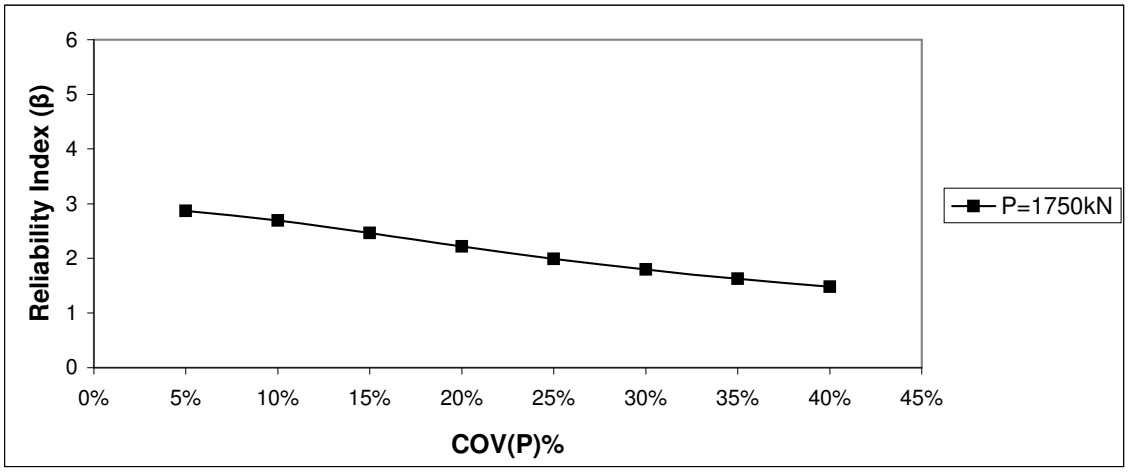


Fig. D.147 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 1750kN.

Table D.179 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'P' subjected to lateral load 2125kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
8.24E+02	10696.73	5%	107.3332	1.8671
3.25E+03	10696.73	10%	118.0920	1.6970
7.21E+03	10696.73	15%	133.8086	1.4977
1.36E+04	10696.73	20%	155.7477	1.2867
2.30E+04	10696.73	25%	183.6844	1.1700
2.69E+04	10696.73	30%	194.0153	1.0329
3.57E+04	10696.73	35%	215.4916	0.9300
4.53E+04	10696.73	40%	236.5572	0.8472

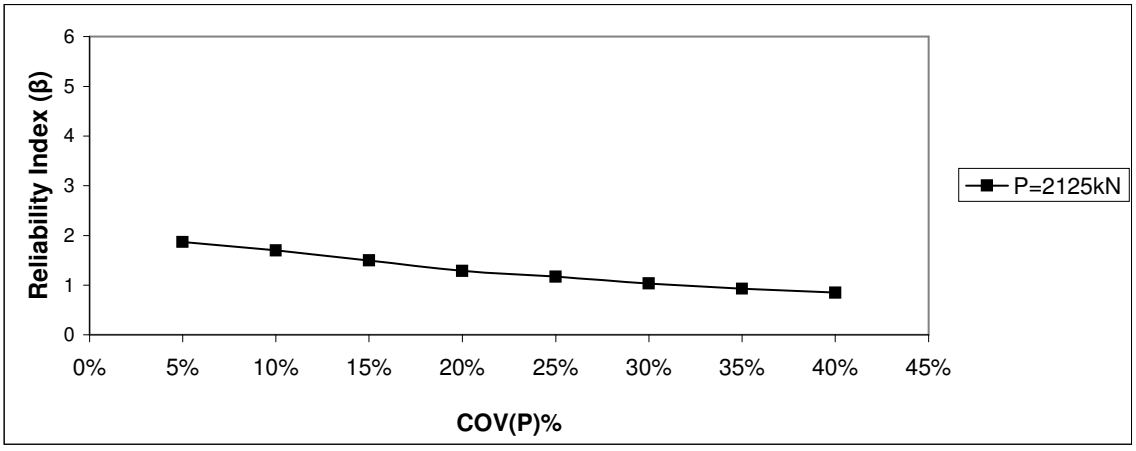


Fig. D.148 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 2125kN.

Table D.180 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (3D) and with varying 'P' subjected to lateral load 2500kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.01E+03	10696.73	5%	108.2181	0.9047
3.99E+03	10696.73	10%	121.1803	0.8079
8.80E+03	10696.73	15%	139.6251	0.7012
1.53E+04	10696.73	20%	161.0869	0.6077
2.86E+04	10696.73	25%	198.2636	0.5240
3.29E+04	10696.73	30%	208.8995	0.4686
4.38E+04	10696.73	35%	233.4144	0.4194
5.63E+04	10696.73	40%	258.9049	0.3781

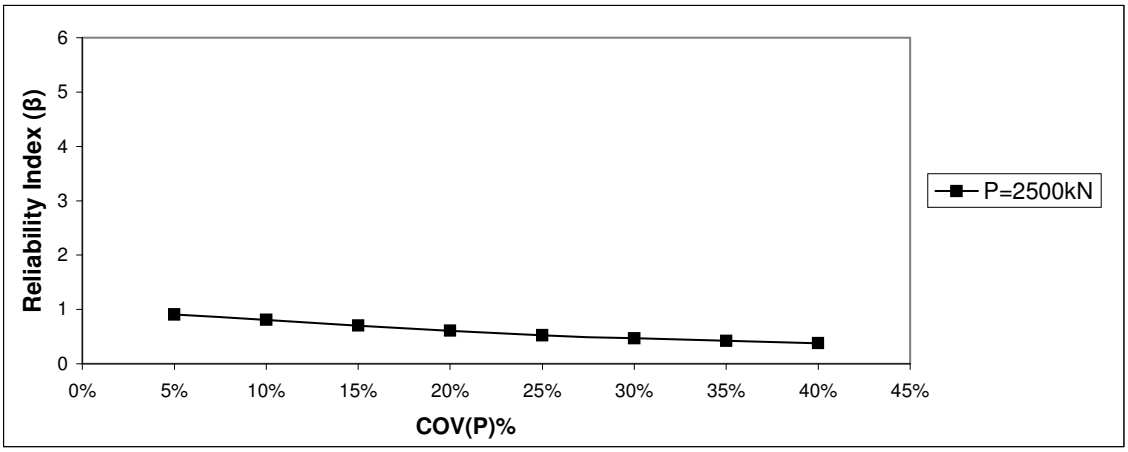


Fig. D.149 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 2500kN.

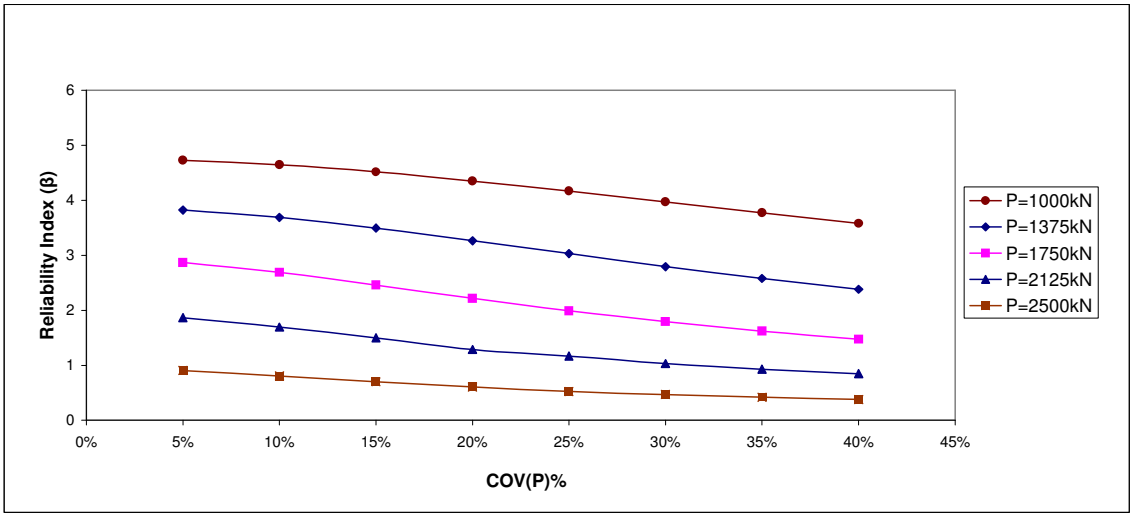


Fig.D.150 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

D.6 Probability of failure, $p_f(M_{max})$ of bending moment vs. COV (Variables).

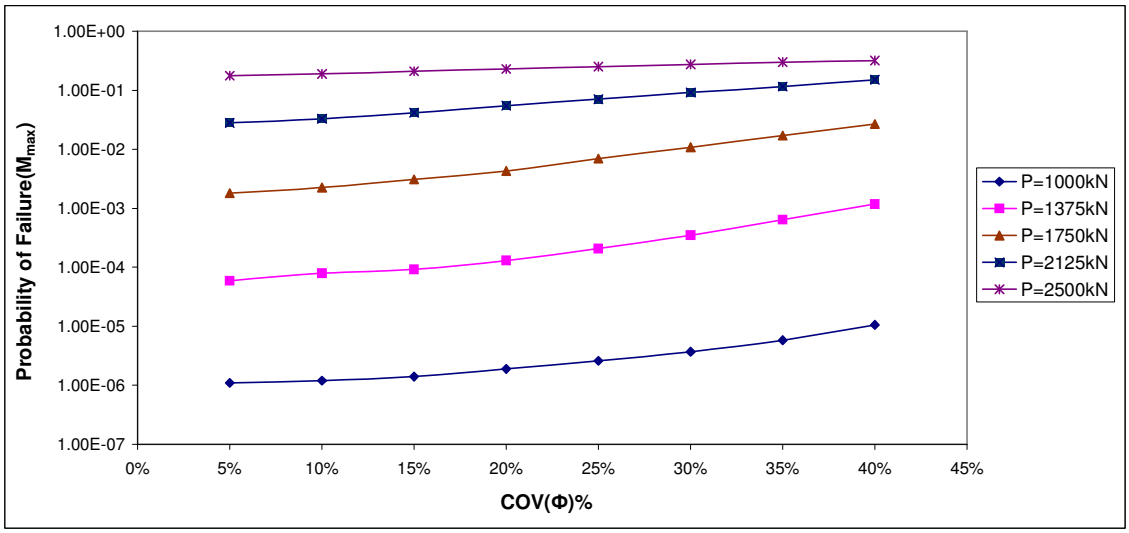


Fig. D.151 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (Φ) for fixed head long pile group of length 10T.

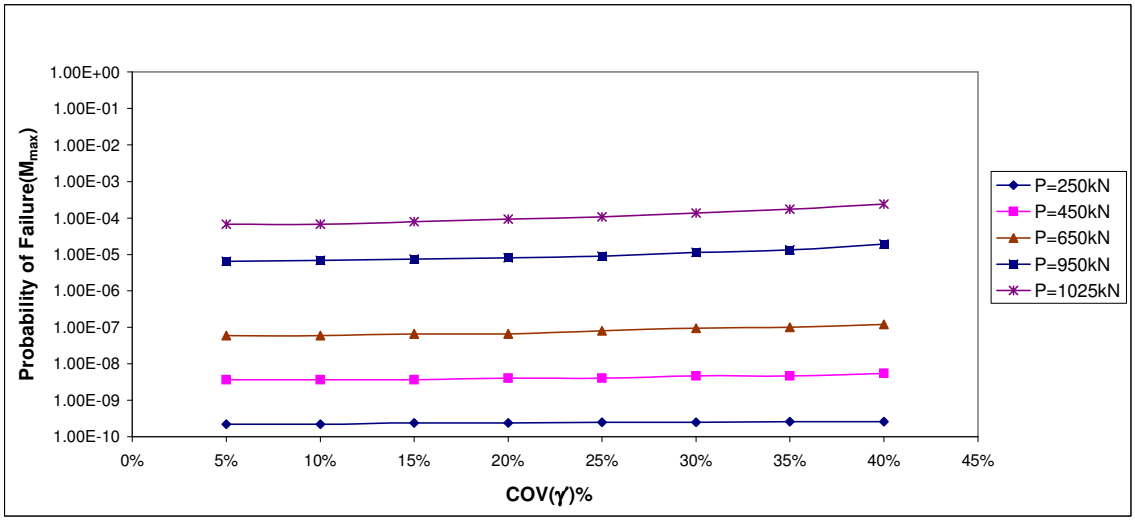


Fig. D.152 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (γ) for fixed head long pile group of length 10T.

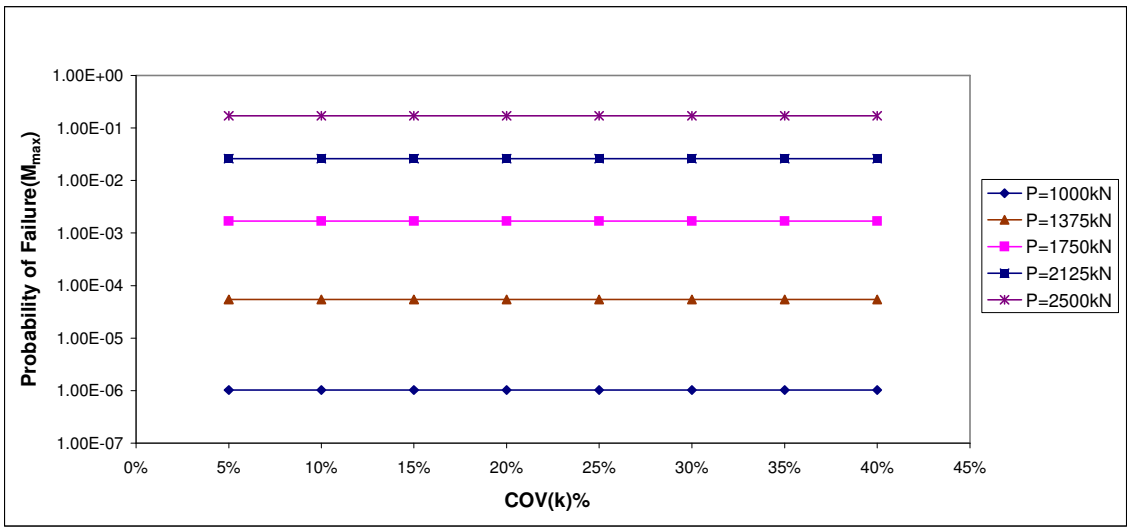


Fig. D.153 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (k) for fixed head long pile group of length 10T.

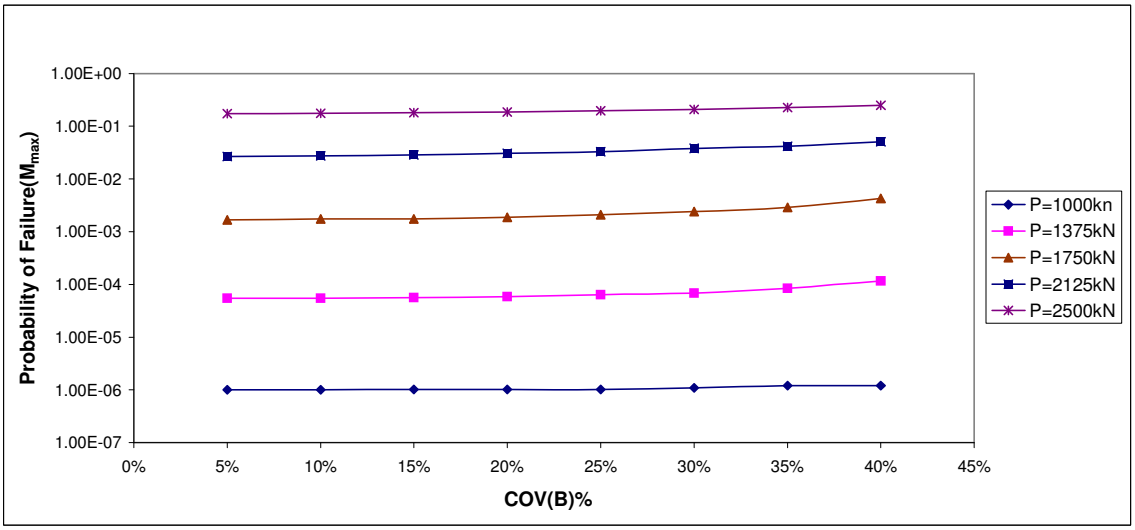


Fig. D.154 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (B) for fixed head long pile group of length 10T.

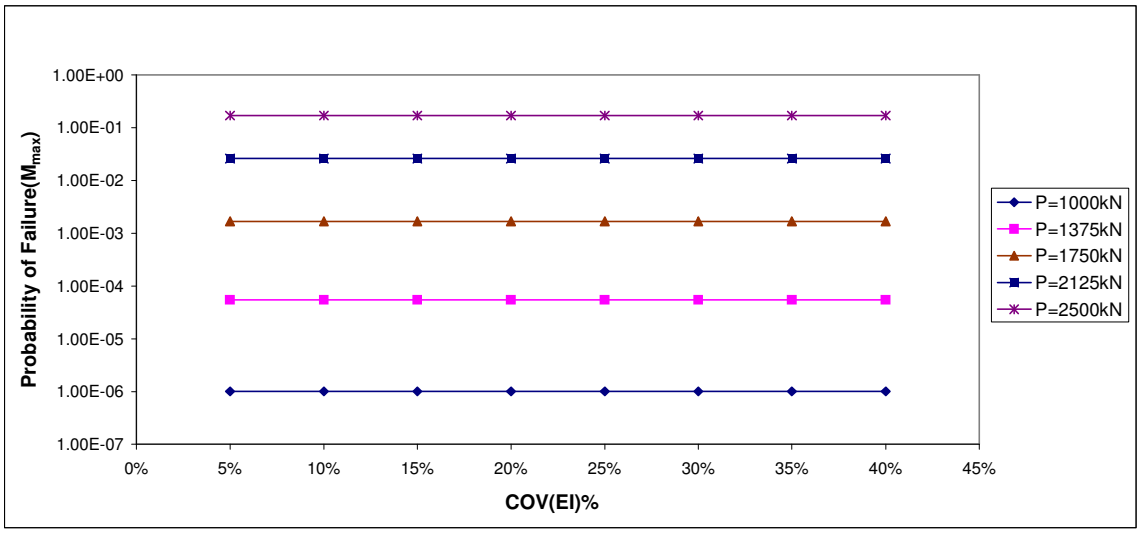


Fig. D.155 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (EI) for fixed head long pile group of length 10T .

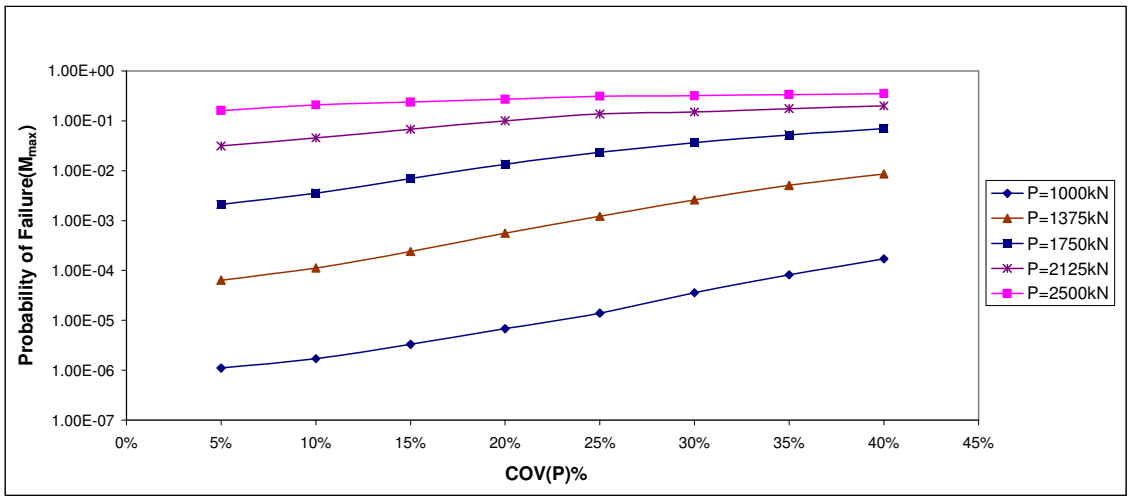


Fig. D.156 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (P) for fixed head long pile group of length 10T.

APPENDIX E

LATERALLY LOADED FREE HEAD LONG (10T) PILE GROUP WITH (5D) SPACING

E-1 Deflection of free head long pile group (Y_{Top}) and COV (Y_{Top}) vs. COV(Variables).

Table E.1 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (Φ) and load 285kN.

P=285kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	7.16E-03				
5%	30			2.25E+00	4.99E-07	4.13E-03	8.70%
		28.5	8.57E-03				
		33	6.53E-03				
10%	30			9.00E+00	1.04E-06	4.13E-03	14.60%
		27	8.57E-03				
		34.5	6.01E-03				
15%	30			2.03E+01	4.62E-06	4.13E-03	22.30%
		25.5	1.03E-02				
		36	5.49E-03				
20%	30			3.60E+01	8.49E-06	4.13E-03	30.60%
		24	1.13E-02				
		37.5	5.08E-03				
25%	30			5.63E+01	1.36E-05	4.13E-03	41.80%
		22.5	1.25E-02				
		39	4.73E-03				
30%	30			8.10E+01	2.03E-05	4.13E-03	53.30%
		21	1.37E-02				
		40.5	4.59E-03				
35%	30			1.10E+02	2.81E-05	4.13E-03	66.20%
		19.5	1.52E-02				
		42	4.45E-03				
40%	30			1.44E+02	3.86E-05	4.13E-03	81.50%
		18	1.69E-02				

Table E.2 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (Φ) and load 530kN.

P=530kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	1.31E-02				
5%	30			2.25E+00	1.55E-06	7.40E-03	8.76%
		28.5	1.55E-02				
		33	1.20E-02				
10%	30			9.00E+00	3.22E-06	7.40E-03	17.36%
		27	1.55E-02				
		34.5	1.10E-02				
15%	30			2.03E+01	1.43E-05	7.40E-03	26.24%
		25.5	1.85E-02				
		36	1.01E-02				
20%	30			3.60E+01	2.60E-05	7.40E-03	35.26%
		24	2.03E-02				
		37.5	9.30E-03				
25%	30			5.63E+01	4.20E-05	7.40E-03	45.17%
		22.5	2.23E-02				
		39	8.53E-03				
30%	30			8.10E+01	6.36E-05	7.40E-03	55.99%
		21	2.45E-02				
		40.5	7.92E-03				
35%	30			1.10E+02	9.24E-05	7.40E-03	68.73%
		19.5	2.71E-02				
		42	7.29E-03				
40%	30			1.44E+02	1.33E-04	7.40E-03	82.88%
		18	3.03E-02				

Table E.3 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (Φ) and load 775kN.

P=775kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	1.97E-02				
5%	30			2.25E+00	3.46E-06	1.63E-02	8.86%
		28.5	2.34E-02				
		33	1.81E-02				
10%	30			9.00E+00	6.97E-06	1.63E-02	17.85%
		27	2.34E-02				
		34.5	1.66E-02				
15%	30			2.03E+01	3.23E-05	1.63E-02	26.99%
		25.5	2.80E-02				
		36	1.53E-02				
20%	30			3.60E+01	5.87E-05	1.63E-02	36.98%
		24	3.07E-02				
		37.5	1.41E-02				
25%	30			5.63E+01	9.82E-05	1.63E-02	47.74%
		22.5	3.39E-02				
		39	1.30E-02				
30%	30			8.10E+01	1.51E-04	1.63E-02	60.27%
		21	3.76E-02				
		40.5	1.20E-02				
35%	30			1.10E+02	2.29E-04	1.63E-02	74.55%
		19.5	4.22E-02				
		42	1.11E-02				
40%	30			1.44E+02	3.39E-04	1.63E-02	91.87%
		18	4.80E-02				

Table E.4 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (Φ) and load 1000kN.

P=1000kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	0.00E+00				
5%	30			2.25E+00	1.83E-04	3.23E-02	9.49%
		28.5	2.71E-02				
		33	3.23E-02				
10%	30			9.00E+00	1.40E-05	3.23E-02	19.02%
		27	2.48E-02				
		34.5	3.23E-02				
15%	30			2.03E+01	2.24E-05	3.23E-02	29.13%
		25.5	2.29E-02				
		36	3.91E-02				
20%	30			3.60E+01	8.18E-05	3.23E-02	39.73%
		24	2.10E-02				
		37.5	4.33E-02				
25%	30			5.63E+01	1.43E-04	3.23E-02	51.87%
		22.5	1.94E-02				
		39	4.81E-02				
30%	30			8.10E+01	2.29E-04	3.23E-02	65.57%
		21	1.78E-02				
		40.5	5.41E-02				
35%	30			1.10E+02	3.53E-04	3.23E-02	82.24%
		19.5	1.65E-02				
		42	6.15E-02				
40%	30			1.44E+02	5.35E-04	3.23E-02	102.65%
		18	1.52E-02				

Table E.5 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (Φ) and load 1300kN.

P=1300kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	3.54E-02				
5%	30			2.25E+00	1.35E-05	4.55E-02	14.50%
		28.5	4.28E-02				
		33	3.24E-02				
10%	30			9.00E+00	2.66E-05	4.55E-02	27.40%
		27	4.28E-02				
		34.5	2.97E-02				
15%	30			2.03E+01	1.29E-04	4.55E-02	40.00%
		25.5	5.24E-02				
		36	2.73E-02				
20%	30			3.60E+01	2.41E-04	4.55E-02	53.30%
		24	5.84E-02				
		37.5	2.51E-02				
25%	30			5.63E+01	4.10E-04	4.55E-02	67.50%
		22.5	6.56E-02				
		39	2.31E-02				
30%	30			8.10E+01	6.50E-04	4.55E-02	84.20%
		21	7.41E-02				
		40.5	2.13E-02				
35%	30			1.10E+02	1.02E-03	4.55E-02	101.10%
		19.5	8.51E-02				
		42	1.97E-02				
40%	30			1.44E+02	1.58E-03	4.55E-02	118.40%
		18	9.92E-02				

Table E.6 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV(Φ) and lateral load 285kN.

P=285kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	4.99E-07	8.70%
10%	9.00E+00	1.04E-06	14.60%
15%	2.03E+01	4.62E-06	22.30%
20%	3.60E+01	8.49E-06	30.60%
25%	5.63E+01	1.36E-05	41.80%
30%	8.10E+01	2.03E-05	53.30%
35%	1.10E+02	2.81E-05	66.20%
40%	1.44E+02	3.86E-05	81.50%

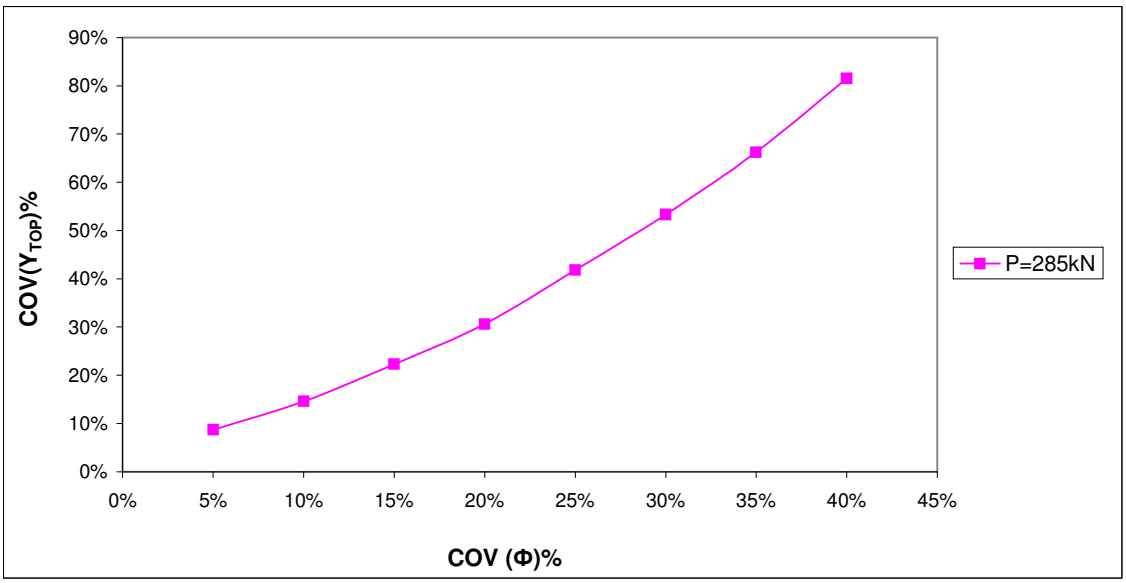


Fig. E.1 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.7 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 530kN.

P=530kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	1.55E-06	8.76%
10%	9.00E+00	3.22E-06	17.36%
15%	2.03E+01	1.43E-05	26.24%
20%	3.60E+01	2.60E-05	35.26%
25%	5.63E+01	4.20E-05	45.17%
30%	8.10E+01	6.36E-05	55.99%
35%	1.10E+02	9.24E-05	68.73%
40%	1.44E+02	1.33E-04	82.88%

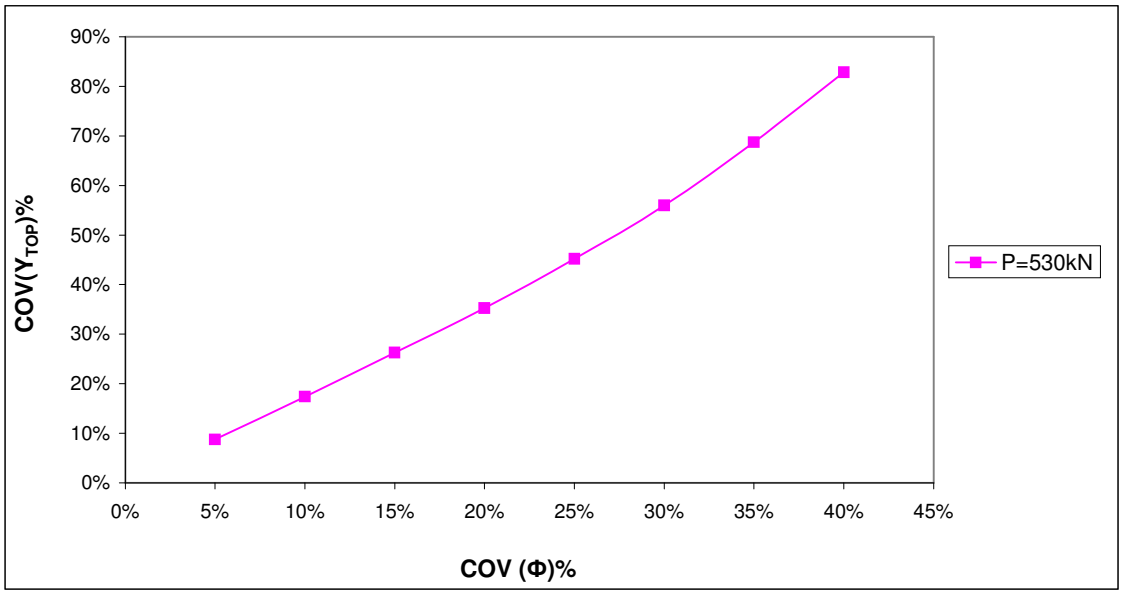


Fig. E.2 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.8 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 775kN.

P=775kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	3.46E-06	8.86%
10%	9.00E+00	6.97E-06	17.85%
15%	2.03E+01	3.23E-05	26.99%
20%	3.60E+01	5.87E-05	36.98%
25%	5.63E+01	9.82E-05	47.74%
30%	8.10E+01	1.51E-04	60.27%
35%	1.10E+02	2.29E-04	74.55%
40%	1.44E+02	3.39E-04	91.87%

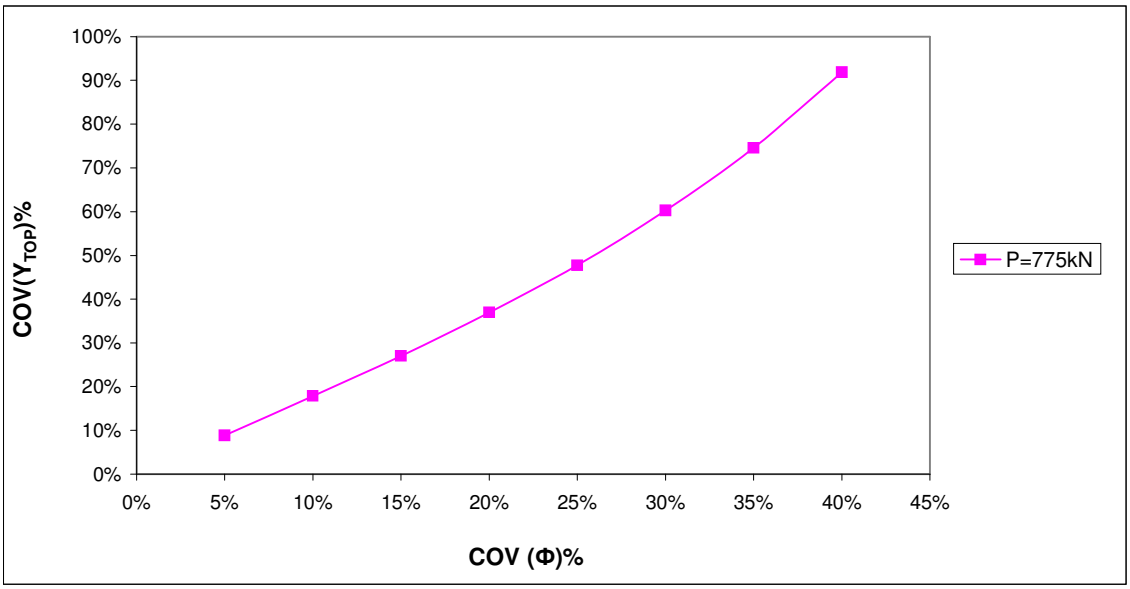


Fig. E.3 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.9 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 1000kN.

P=1000kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	6.86E-06	9.49%
10%	9.00E+00	1.40E-05	19.02%
15%	2.03E+01	6.56E-05	29.13%
20%	3.60E+01	1.25E-04	39.73%
25%	5.63E+01	2.06E-04	51.87%
30%	8.10E+01	3.29E-04	65.57%
35%	1.10E+02	5.05E-04	82.24%
40%	1.44E+02	7.68E-04	102.65%

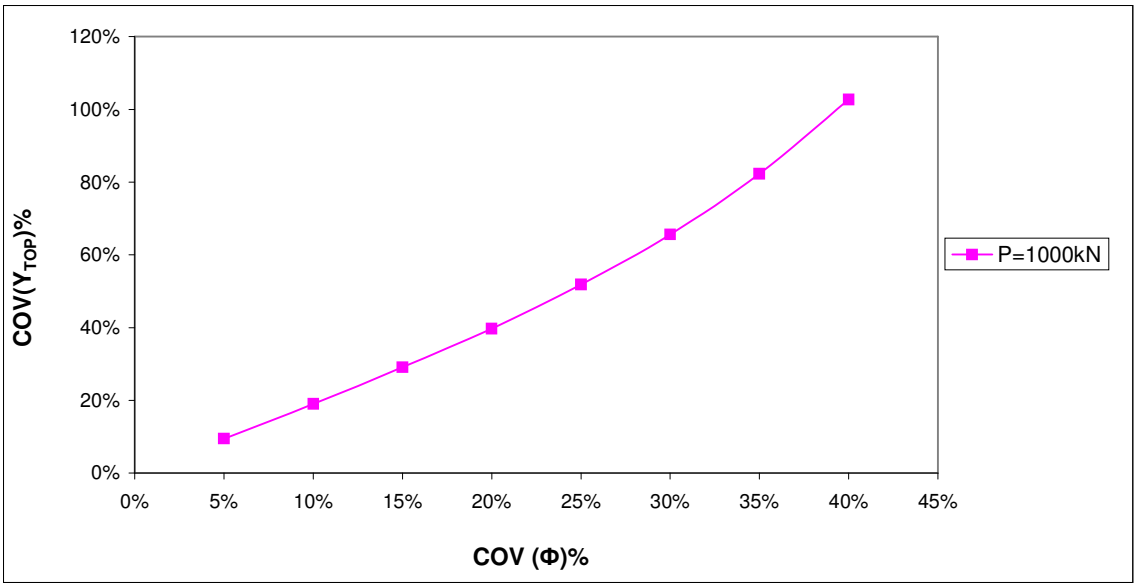


Fig. E.4 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.10 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 1300kN.

P=1300kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	1.35E-05	14.50%
10%	9.00E+00	2.66E-05	27.40%
15%	2.03E+01	1.29E-04	40.00%
20%	3.60E+01	2.41E-04	53.30%
25%	5.63E+01	4.10E-04	67.50%
30%	8.10E+01	6.50E-04	84.20%
35%	1.10E+02	1.02E-03	101.10%
40%	1.44E+02	1.58E-03	118.40%

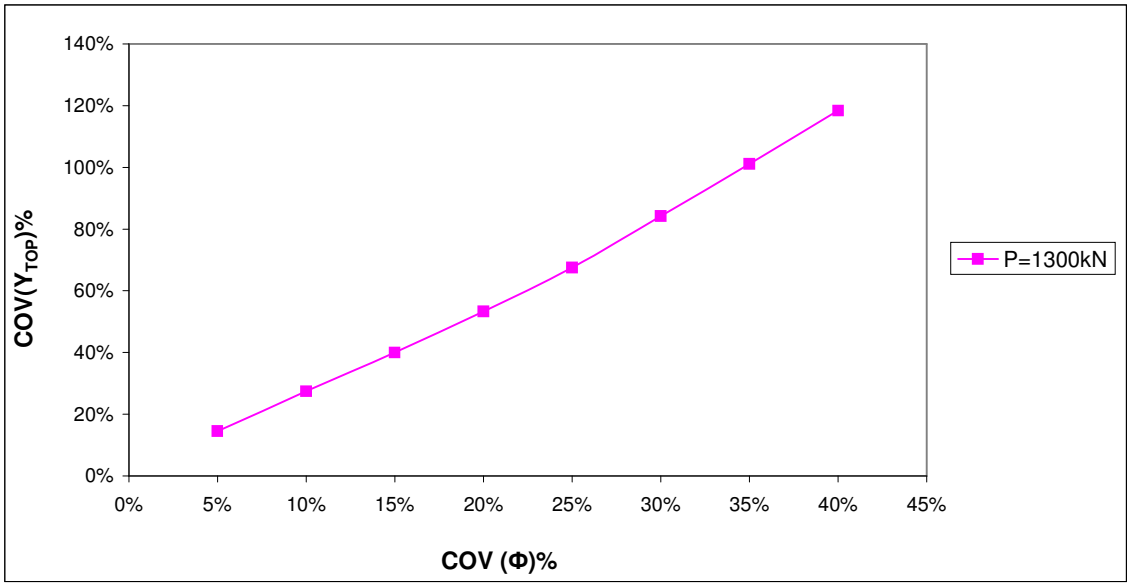


Fig. E.5 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force e 1300kN.

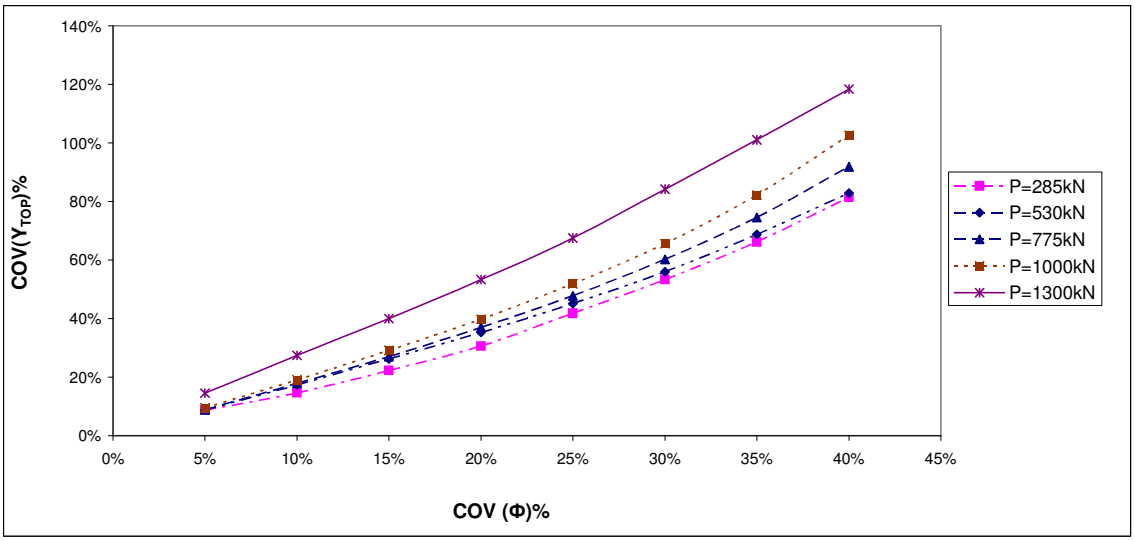


Fig. E.6 Variability of COV (Y_{TOP}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table E.11 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (γ) and load 285kN.

P=285kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^o (m)	COV(Y_{TOP}) (%)
		11.03	7.53E-03				
5%	10.5			2.76E-01	8.76E-08	4.13E-03	3.30%
		9.98	8.13E-03				
		11.55	7.27E-03				
10%	10.5			1.10E+00	3.66E-07	4.13E-03	6.64%
		9.45	8.48E-03				
		12.08	7.03E-03				
15%	10.5			2.48E+00	8.48E-07	4.13E-03	10.36%
		8.93	8.87E-03				
		12.60	6.79E-03				
20%	10.5			4.41E+00	1.55E-06	4.13E-03	14.01%
		8.40	9.28E-03				
		13.13	6.57E-03				
25%	10.5			6.89E+00	2.52E-06	4.13E-03	17.74%
		7.88	9.75E-03				
		13.65	6.39E-03				
30%	10.5			9.92E+00	3.79E-06	4.13E-03	21.78%
		7.35	1.03E-02				
		14.18	6.22E-03				
35%	10.5			1.35E+01	5.41E-06	4.13E-03	26.53%
		6.83	1.09E-02				
		14.70	6.05E-03				
40%	10.5			1.76E+01	7.50E-06	4.13E-03	31.56%
		6.30	1.15E-02				

Table E.12 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (γ) and load 530kN.

P=530kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^o (m)	COV(Y_{TOP}) (%)
		11.03	1.37E-02				
5%	10.5			2.76E-01	2.65E-07	7.40E-03	3.42%
		9.98	1.48E-02				
		11.55	1.33E-02				
10%	10.5			1.10E+00	1.11E-06	7.40E-03	6.80%
		9.45	1.54E-02				
		12.08	1.28E-02				
15%	10.5			2.48E+00	2.54E-06	7.40E-03	10.29%
		8.93	1.60E-02				
		12.60	1.24E-02				
20%	10.5			4.41E+00	4.67E-06	7.40E-03	14.04%
		8.40	1.67E-02				
		13.13	1.20E-02				
25%	10.5			6.89E+00	7.54E-06	7.40E-03	18.03%
		7.88	1.75E-02				
		13.65	1.17E-02				
30%	10.5			9.92E+00	1.13E-05	7.40E-03	22.20%
		7.35	1.84E-02				
		14.18	1.14E-02				
35%	10.5			1.35E+01	1.62E-05	7.40E-03	26.72%
		6.83	1.95E-02				
		14.70	1.11E-02				
40%	10.5			1.76E+01	2.25E-05	7.40E-03	31.93%
		6.30	2.06E-02				

Table E.13 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (γ) and load 775kN.

P=775kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.03	2.07E-02				
5%	10.5			2.76E-01	6.01E-07	1.63E-02	3.66%
		9.98	2.23E-02				
		11.55	2.00E-02				
10%	10.5			1.10E+00	2.42E-06	1.63E-02	7.33%
		9.45	2.31E-02				
		12.08	1.94E-02				
15%	10.5			2.48E+00	5.66E-06	1.63E-02	11.23%
		8.93	2.41E-02				
		12.60	1.88E-02				
20%	10.5			4.41E+00	1.02E-05	1.63E-02	15.09%
		8.40	2.52E-02				
		13.13	1.83E-02				
25%	10.5			6.89E+00	1.66E-05	1.63E-02	19.20%
		7.88	2.64E-02				
		13.65	1.78E-02				
30%	10.5			9.92E+00	2.50E-05	1.63E-02	23.58%
		7.35	2.78E-02				
		14.18	1.73E-02				
35%	10.5			1.35E+01	3.62E-05	1.63E-02	28.40%
		6.83	2.93E-02				
		14.70	1.68E-02				
40%	10.5			1.76E+01	5.06E-05	1.63E-02	33.56%
		6.30	3.11E-02				

Table E.14 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (γ) and load 1000kN.

P=1000kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.03	2.85E-02				
5%	10.5			2.76E-01	1.22E-06	3.23E-02	4.36%
		9.98	3.07E-02				
		11.55	2.76E-02				
10%	10.5			1.10E+00	4.82E-06	3.23E-02	8.94%
		9.45	3.20E-02				
		12.08	2.67E-02				
15%	10.5			2.48E+00	1.11E-05	3.23E-02	13.52%
		8.93	3.34E-02				
		12.60	2.59E-02				
20%	10.5			4.41E+00	2.06E-05	3.23E-02	18.31%
		8.40	3.50E-02				
		13.13	2.51E-02				
25%	10.5			6.89E+00	3.39E-05	3.23E-02	23.26%
		7.88	3.68E-02				
		13.65	2.44E-02				
30%	10.5			9.92E+00	5.14E-05	3.23E-02	28.47%
		7.35	3.87E-02				
		14.18	2.38E-02				
35%	10.5			1.35E+01	7.45E-05	3.23E-02	34.11%
		6.83	4.10E-02				
		14.70	2.32E-02				
40%	10.5			1.76E+01	1.06E-04	3.23E-02	40.17%
		6.30	4.38E-02				

Table E.15 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (γ) and load 1300kN.

P=1300kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.03	3.75E-02				
5%	10.5			2.76E-01	2.25E-06	4.55E-02	7.17%
		9.98	4.05E-02				
		11.55	3.61E-02				
10%	10.5			1.10E+00	9.12E-06	4.55E-02	14.65%
		9.45	4.22E-02				
		12.08	3.48E-02				
15%	10.5			2.48E+00	2.22E-05	4.55E-02	22.30%
		8.93	4.43E-02				
		12.60	3.38E-02				
20%	10.5			4.41E+00	4.06E-05	4.55E-02	30.11%
		8.40	4.65E-02				
		13.13	3.28E-02				
25%	10.5			6.89E+00	6.51E-05	4.55E-02	38.47%
		7.88	4.90E-02				
		13.65	3.19E-02				
30%	10.5			9.92E+00	9.82E-05	4.55E-02	47.12%
		7.35	5.17E-02				
		14.18	3.10E-02				
35%	10.5			1.35E+01	1.46E-04	4.55E-02	56.33%
		6.83	5.51E-02				
		14.70	3.01E-02				
40%	10.5			1.76E+01	2.06E-04	4.55E-02	66.33%
		6.30	5.89E-02				

Table E.16 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 285kN.

P=285kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	8.76E-08	3.30%
10%	1.10E+00	3.66E-07	6.64%
15%	2.48E+00	8.48E-07	10.36%
20%	4.41E+00	1.55E-06	14.01%
25%	6.89E+00	2.52E-06	17.74%
30%	9.92E+00	3.79E-06	21.78%
35%	1.35E+01	5.41E-06	26.53%
40%	1.76E+01	7.50E-06	31.56%

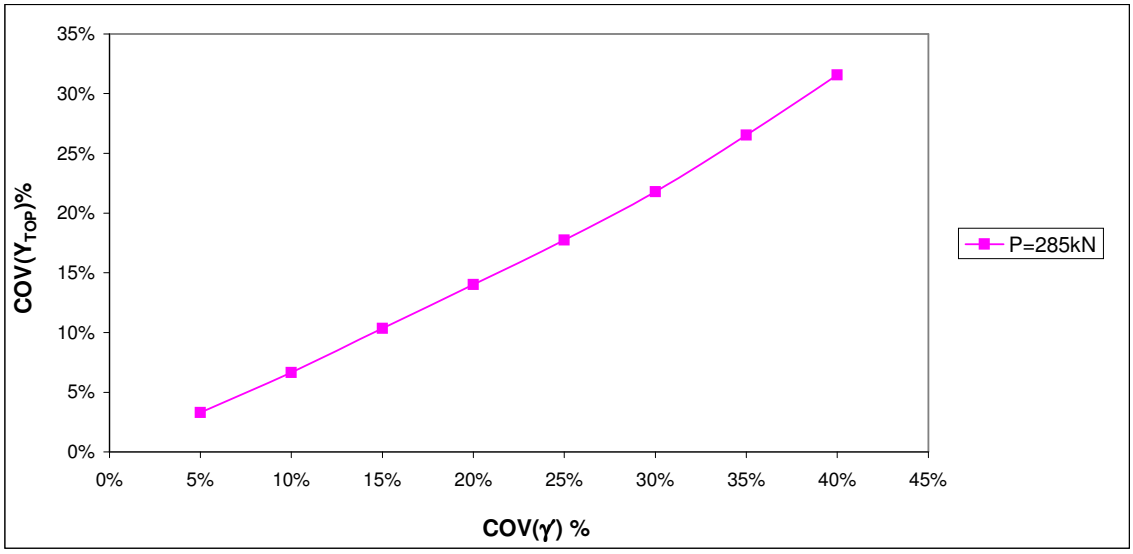


Fig. E.7 Variability of COV (Y_{TOP}) vs. COV (γ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.17 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 530kN.

P=530kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	2.65E-07	3.42%
10%	1.10E+00	1.11E-06	6.80%
15%	2.48E+00	2.54E-06	10.29%
20%	4.41E+00	4.67E-06	14.04%
25%	6.89E+00	7.54E-06	18.03%
30%	9.92E+00	1.13E-05	22.20%
35%	1.35E+01	1.62E-05	26.72%
40%	1.76E+01	2.25E-05	31.93%

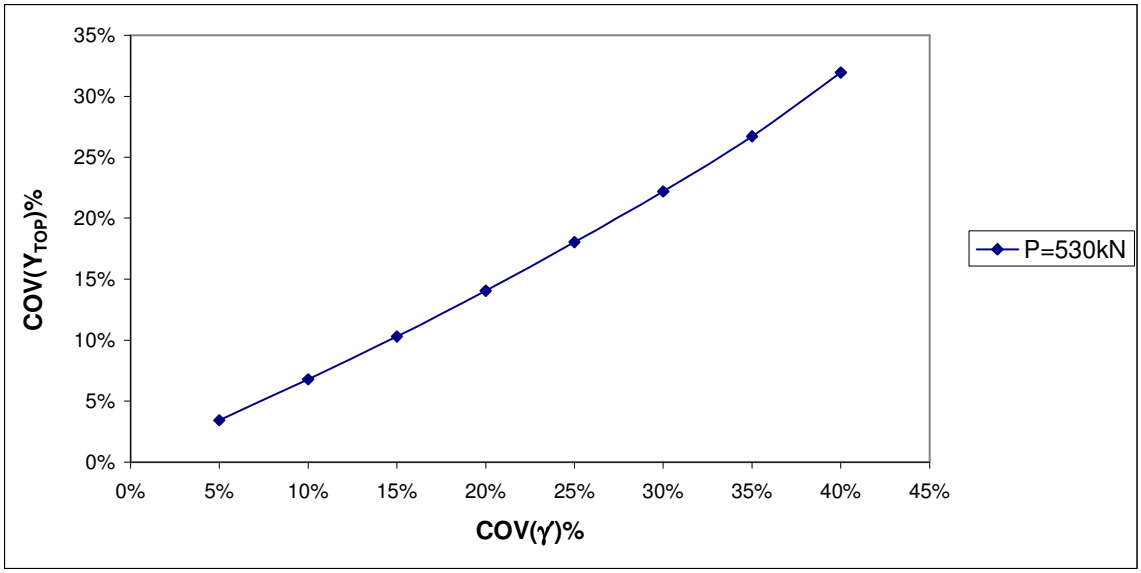


Fig. E.8 Variability of COV (Y_{TOP}) vs. COV (γ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.18 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (γ') and lateral load 775kN.

P=775kN			
COV(γ') (%)	VAR(γ') $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	6.01E-07	3.66%
10%	1.10E+00	2.42E-06	7.33%
15%	2.48E+00	5.66E-06	11.23%
20%	4.41E+00	1.02E-05	15.09%
25%	6.89E+00	1.66E-05	19.20%
30%	9.92E+00	2.50E-05	23.58%
35%	1.35E+01	3.62E-05	28.40%
40%	1.76E+01	5.06E-05	33.56%

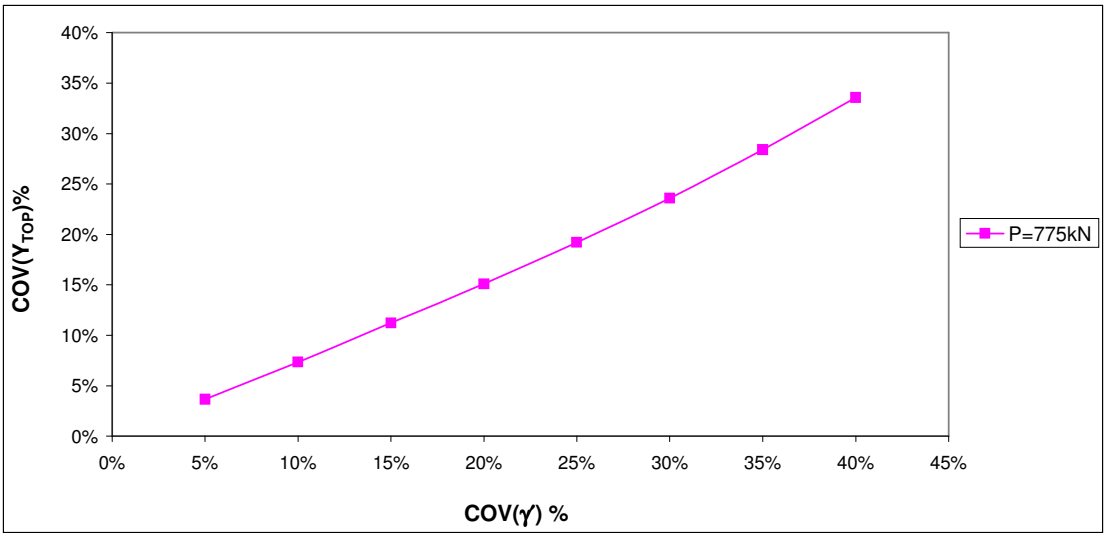


Fig. E.9 Variability of COV (Y_{TOP}) vs. COV (γ') for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.19 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 1000kN.

P=1000kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	1.22E-06	4.36%
10%	1.10E+00	4.82E-06	8.94%
15%	2.48E+00	1.11E-05	13.52%
20%	4.41E+00	2.06E-05	18.31%
25%	6.89E+00	3.39E-05	23.26%
30%	9.92E+00	5.14E-05	28.47%
35%	1.35E+01	7.45E-05	34.11%
40%	1.76E+01	1.06E-04	40.17%

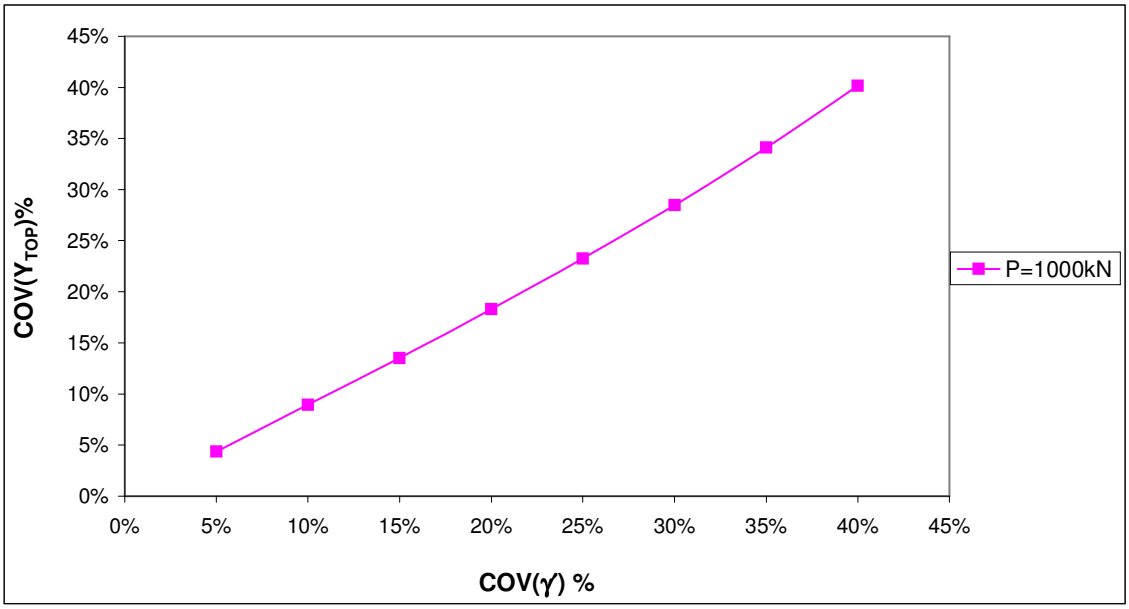


Fig. E.10 Variability of COV (Y_{TOP}) vs. COV (γ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.20 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (γ') and lateral load 1300kN.

P=1300kN			
COV(γ') (%)	VAR(γ') $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	2.25E-06	7.17%
10%	1.10E+00	9.12E-06	14.65%
15%	2.48E+00	2.22E-05	22.30%
20%	4.41E+00	4.06E-05	30.11%
25%	6.89E+00	6.51E-05	38.47%
30%	9.92E+00	9.82E-05	47.12%
35%	1.35E+01	1.46E-04	56.33%
40%	1.76E+01	2.06E-04	66.33%

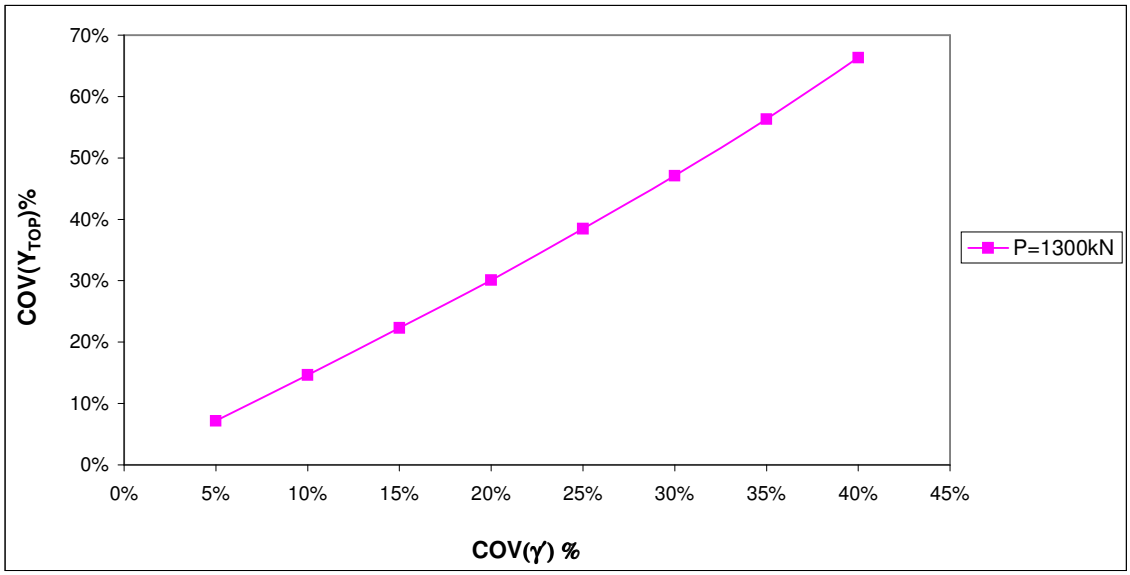


Fig. E.11 Variability of COV (Y_{TOP}) vs. COV (γ') for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

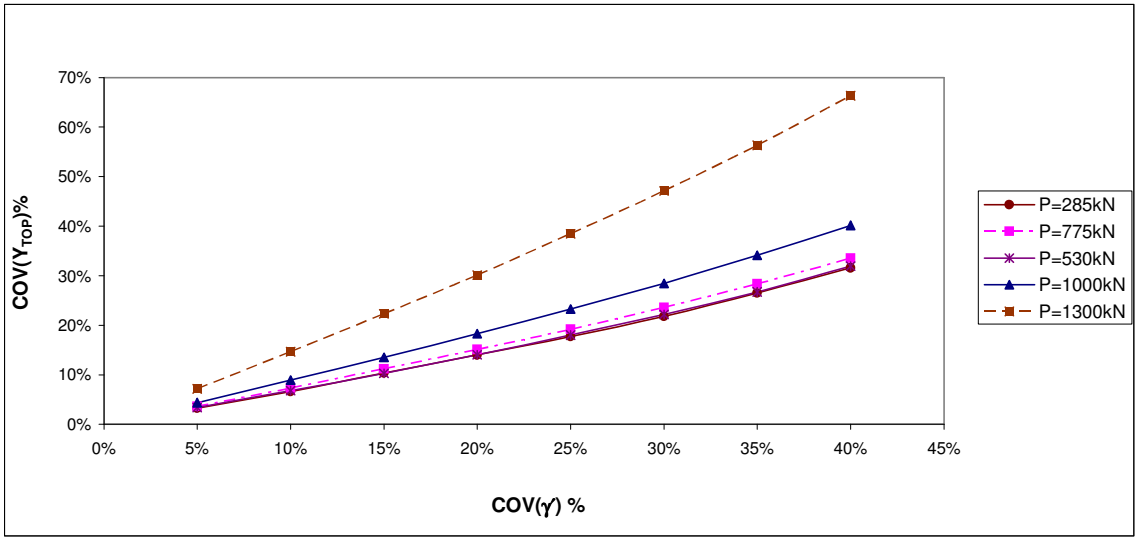


Fig. E.12 Variability of COV (Y_{TOP}) vs. COV (γ') for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table E.21 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (k) and load 285kN.

P=285kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	7.78E-03				
5%	16300			6.64E+05	1.02E-09	4.13E-03	0.77%
		15485	7.84E-03				
		17930	7.76E-03				
10%	16300			2.66E+06	3.48E-09	4.13E-03	1.43%
		14670	7.88E-03				
		18745	7.75E-03				
15%	16300			5.98E+06	4.29E-09	4.13E-03	2.01%
		13855	7.88E-03				
		19560	7.74E-03				
20%	16300			1.06E+07	1.30E-08	4.13E-03	2.76%
		13040	7.97E-03				
		20375	7.73E-03				
25%	16300			1.66E+07	2.06E-08	4.13E-03	3.47%
		12225	8.01E-03				
		21190	7.71E-03				
30%	16300			2.39E+07	3.01E-08	4.13E-03	4.20%
		11410	8.06E-03				
		22005	7.70E-03				
35%	16300			3.25E+07	4.26E-08	4.13E-03	5.00%
		10595	8.11E-03				
		22820	7.69E-03				
40%	16300			4.25E+07	7.00E-08	4.13E-03	6.40%
		9780	8.22E-03				

Table E.22 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (k) and load 530kN.

P=530kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	1.42E-02				
5%	16300			6.64E+05	1.60E-09	7.40E-03	0.34%
		15485	1.43E-02				
		17930	1.42E-02				
10%	16300			2.66E+06	5.62E-09	7.40E-03	0.64%
		14670	1.43E-02				
		18745	1.41E-02				
15%	16300			5.98E+06	7.23E-09	7.40E-03	0.89%
		13855	1.43E-02				
		19560	1.41E-02				
20%	16300			1.06E+07	1.82E-08	7.40E-03	1.14%
		13040	1.44E-02				
		20375	1.41E-02				
25%	16300			1.66E+07	3.06E-08	7.40E-03	1.48%
		12225	1.45E-02				
		21190	1.41E-02				
30%	16300			2.39E+07	4.20E-08	7.40E-03	1.74%
		11410	1.45E-02				
		22005	1.41E-02				
35%	16300			3.25E+07	6.00E-08	7.40E-03	2.08%
		10595	1.46E-02				
		22820	1.41E-02				
40%	16300			4.25E+07	1.02E-07	7.40E-03	2.71%
		9780	1.47E-02				

Table E.23 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (k) and load 775kN.

P=775kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	2.14E-02				
5%	16300	815		6.64E+05	1.11E-11	1.63E-02	0.02%
			2.15E-02				
		17930	2.14E-02				
10%	16300			2.66E+06	5.63E-09	1.63E-02	0.35%
		14670	2.15E-02				
		18745	2.14E-02				
15%	16300			5.98E+06	8.10E-09	1.63E-02	0.51%
		13855	2.15E-02				
		19560	2.13E-02				
20%	16300			1.06E+07	2.10E-08	1.63E-02	0.68%
		13040	2.16E-02				
		20375	2.13E-02				
25%	16300			1.66E+07	3.42E-08	1.63E-02	0.87%
		12225	2.17E-02				
		21190	2.13E-02				
30%	16300			2.39E+07	6.00E-08	1.63E-02	1.16%
		11410	2.18E-02				
		22005	2.13E-02				
35%	16300			3.25E+07	9.61E-08	1.63E-02	1.46%
		10595	2.19E-02				
		22820	2.13E-02				
40%	16300			4.25E+07	1.44E-07	1.63E-02	1.79%
		9780	2.20E-02				

Table E.24 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (k) and load 1000kN.

P=1000kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	2.96E-02				
5%	16300			6.64E+05	9.00E-10	3.23E-02	0.09%
		15485	2.96E-02				
		17930	2.95E-02				
10%	16300			2.66E+06	5.63E-09	3.23E-02	0.23%
		14670	2.97E-02				
		18745	2.95E-02				
15%	16300			5.98E+06	8.10E-09	3.23E-02	0.36%
		13855	2.97E-02				
		19560	2.95E-02				
20%	16300			1.06E+07	3.06E-08	3.23E-02	0.54%
		13040	2.98E-02				
		20375	2.95E-02				
25%	16300			1.66E+07	5.52E-08	3.23E-02	0.73%
		12225	2.99E-02				
		21190	2.94E-02				
30%	16300			2.39E+07	8.12E-08	3.23E-02	0.88%
		11410	3.00E-02				
		22005	2.94E-02				
35%	16300			3.25E+07	1.19E-07	3.23E-02	1.11%
		10595	3.01E-02				
		22820	3.87E-02				
40%	16300			4.25E+07	1.79E-05	3.23E-02	1.46%
		9780	3.02E-02				

Table E.25 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (k) and load 1300kN.

P=1300kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	3.89E-02				
5%	16300			6.64E+05	2.50E-09	4.55E-02	0.11%
		15485	3.90E-02				
		17930	3.89E-02				
10%	16300			2.66E+06	1.10E-08	4.55E-02	0.23%
		14670	3.91E-02				
		18745	3.88E-02				
15%	16300			5.98E+06	2.25E-08	4.55E-02	0.31%
		13855	3.91E-02				
		19560	3.88E-02				
20%	16300			1.06E+07	4.20E-08	4.55E-02	0.45%
		13040	3.92E-02				
		20375	3.87E-02				
25%	16300			1.66E+07	6.76E-08	4.55E-02	0.57%
		12225	3.93E-02				
		21190	3.87E-02				
30%	16300			2.39E+07	1.19E-07	4.55E-02	0.76%
		11410	3.94E-02				
		22005	3.87E-02				
35%	16300			3.25E+07	1.89E-07	4.55E-02	0.92%
		10595	3.95E-02				
		22820	3.87E-02				
40%	16300			4.25E+07	2.86E-07	4.55E-02	1.10%
		9780	3.97E-02				

Table E.26 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 285kN.

P=285kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	1.02E-09	0.77%
10%	2.66E+06	3.48E-09	1.43%
15%	5.98E+06	4.29E-09	2.01%
20%	1.06E+07	1.30E-08	2.76%
25%	1.66E+07	2.06E-08	3.47%
30%	2.39E+07	3.01E-08	4.20%
35%	3.25E+07	4.26E-08	5.00%
40%	4.25E+07	7.00E-08	6.40%

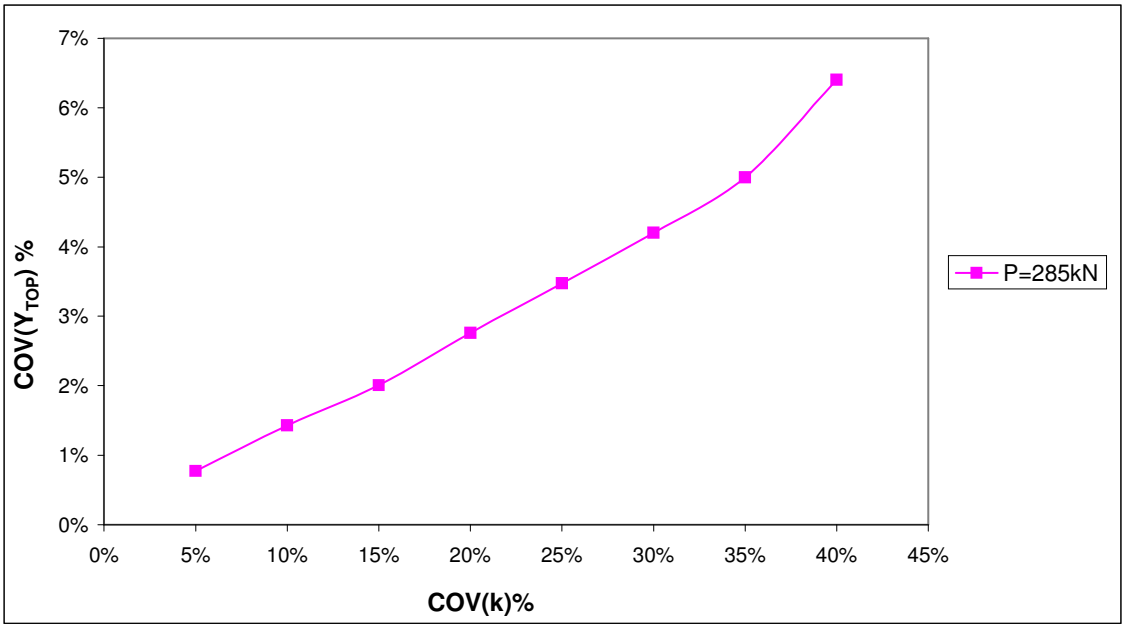


Fig. E.13 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.27 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 530kN.

P=530kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	1.60E-09	3.39E-03
10%	2.66E+06	5.62E-09	6.36E-03
15%	5.98E+06	7.23E-09	8.89E-03
20%	1.06E+07	1.82E-08	1.14E-02
25%	1.66E+07	3.06E-08	1.48E-02
30%	2.39E+07	4.20E-08	1.74E-02
35%	3.25E+07	6.00E-08	2.08E-02
40%	4.25E+07	1.02E-07	2.71E-02

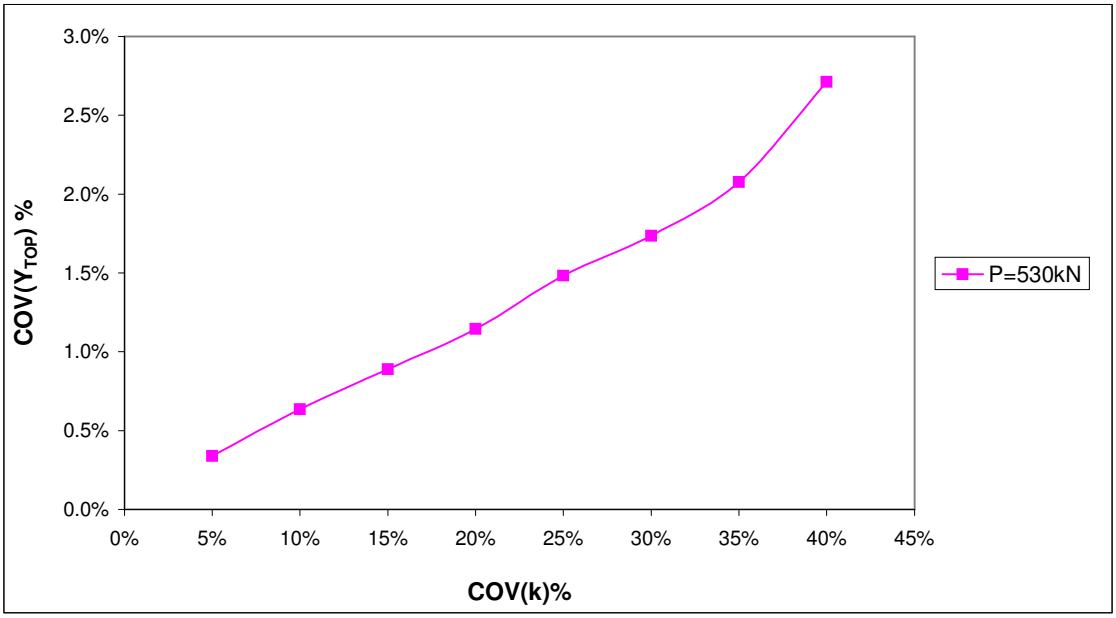


Fig. E.14 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.28 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 775kN.

P=775kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	1.22E-09	0.17%
10%	2.66E+06	5.63E-09	0.35%
15%	5.98E+06	8.10E-09	0.51%
20%	1.06E+07	2.10E-08	0.68%
25%	1.66E+07	3.42E-08	0.87%
30%	2.39E+07	6.00E-08	1.16%
35%	3.25E+07	9.61E-08	1.46%
40%	4.25E+07	1.44E-07	1.79%

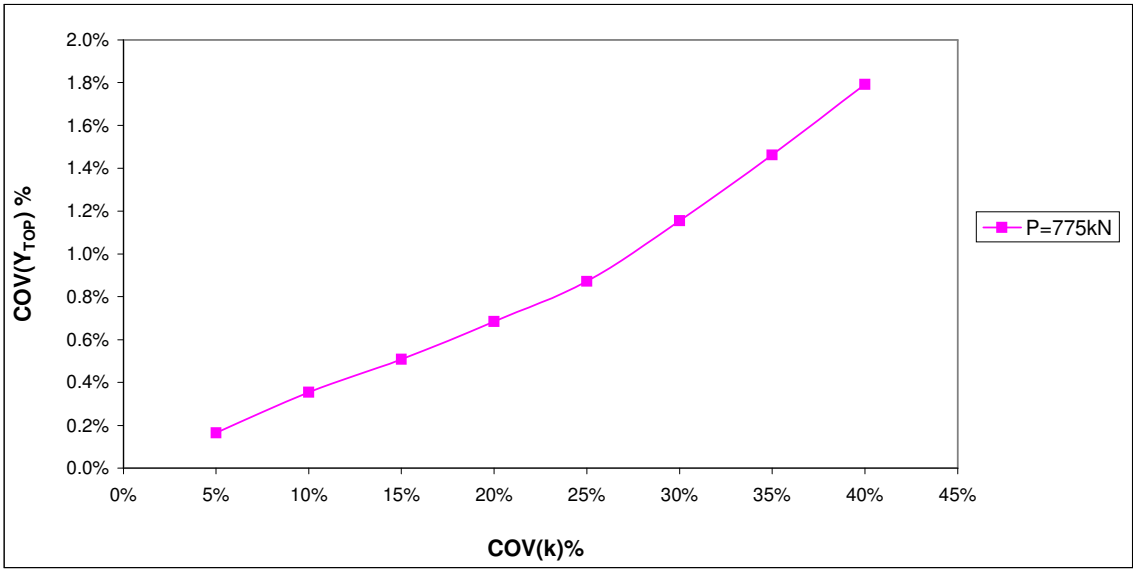


Fig. E.15 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.29 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 1000kN.

P=1000kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	9.00E-10	0.09%
10%	2.66E+06	5.63E-09	0.23%
15%	5.98E+06	8.10E-09	0.36%
20%	1.06E+07	3.06E-08	0.54%
25%	1.66E+07	5.52E-08	0.73%
30%	2.39E+07	8.12E-08	0.88%
35%	3.25E+07	1.19E-07	1.11%
40%	4.25E+07	1.79E-05	1.46%

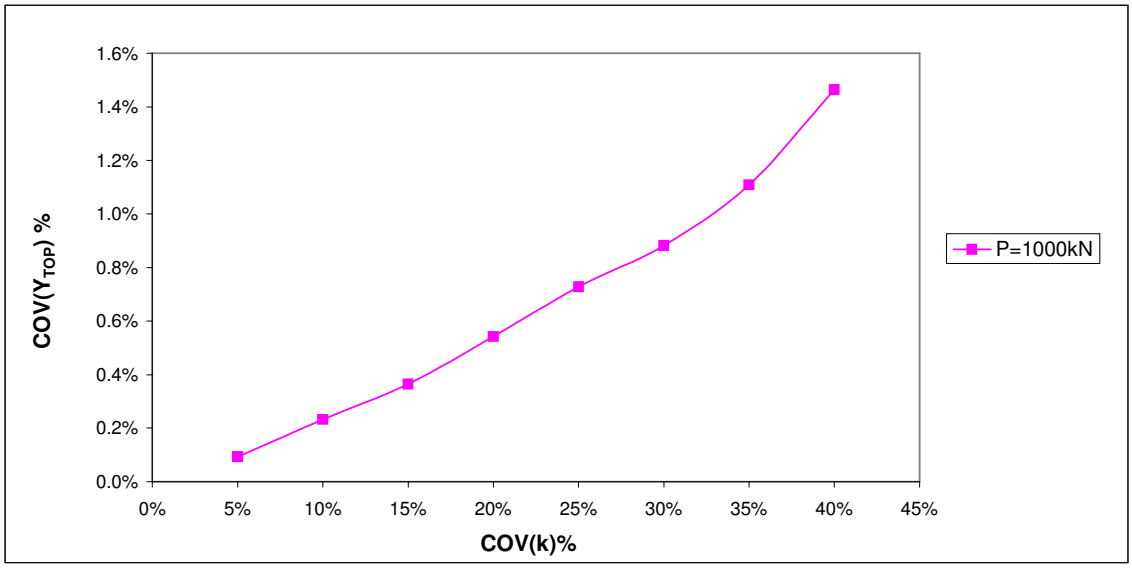


Fig. E.16 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.30 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 1300kN.

P=1300kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	2.50E-09	0.11%
10%	2.66E+06	1.10E-08	0.23%
15%	5.98E+06	2.25E-08	0.31%
20%	1.06E+07	4.20E-08	0.45%
25%	1.66E+07	6.76E-08	0.57%
30%	2.39E+07	1.19E-07	0.76%
35%	3.25E+07	1.89E-07	0.92%
40%	4.25E+07	2.86E-07	1.10%

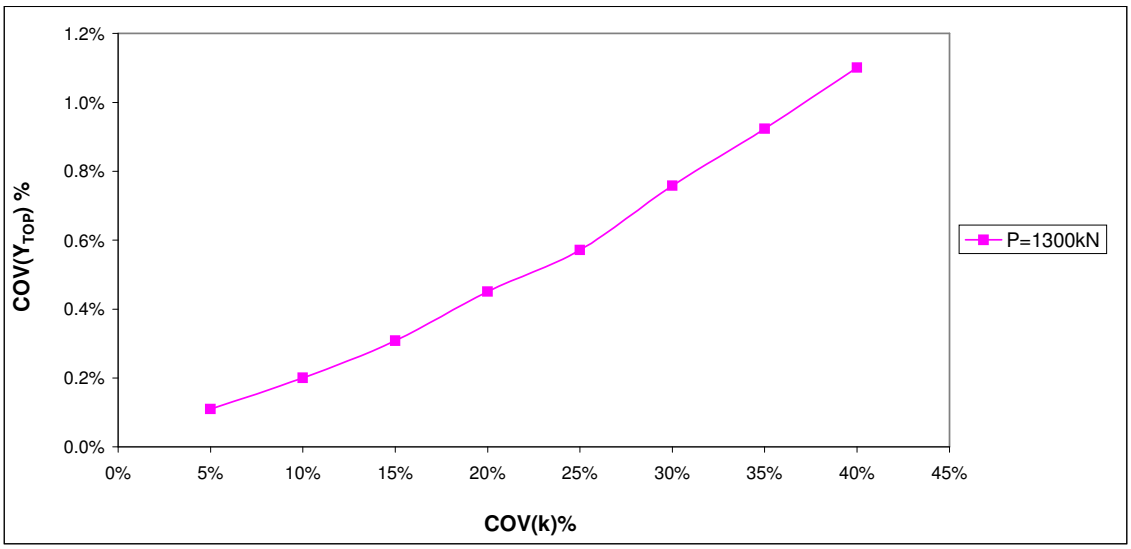


Fig. E.17 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

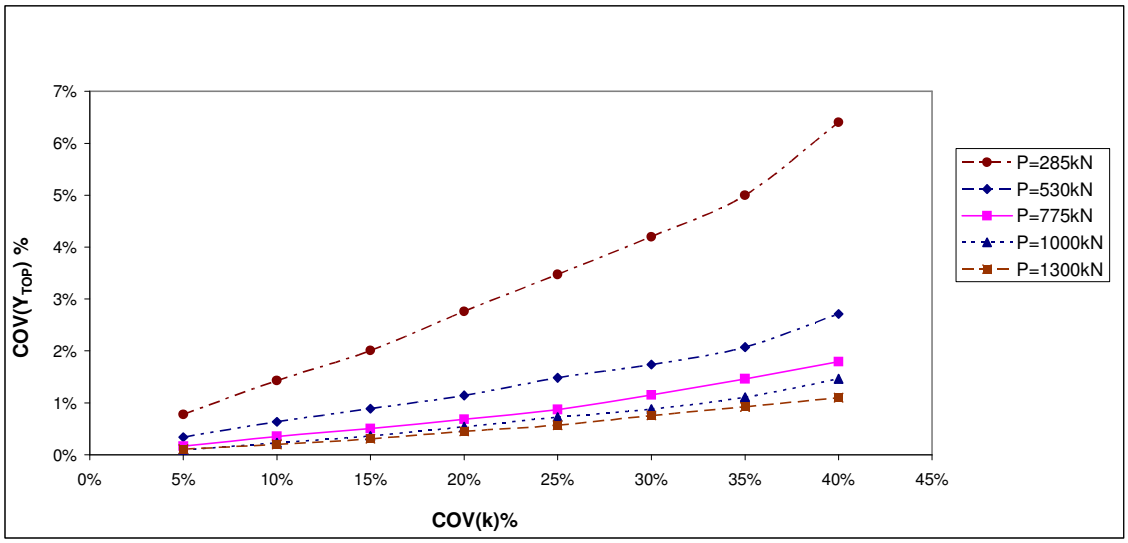


Fig. E.18 Variability of COV (Y_{TOP}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table E.31 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (B) and load 285kN.

P=285kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.43	7.67E-03				
5%	0.406			4.12E-04	6.25E-10	4.13E-03	0.72%
		0.39	7.90E-03				
		0.45	7.54E-03				
10%	0.406			1.65E-03	4.23E-09	4.13E-03	1.14%
		0.37	7.96E-03				
		0.47	7.41E-03				
15%	0.406			3.71E-03	1.10E-08	4.13E-03	1.57%
		0.35	8.01E-03				
		0.49	7.29E-03				
20%	0.406			6.59E-03	7.23E-09	4.13E-03	2.05%
		0.32	8.05E-03				
		0.51	7.13E-03				
25%	0.406			1.03E-02	2.50E-09	4.13E-03	2.50%
		0.30	8.10E-03				
		0.53	6.93E-03				
30%	0.406			1.48E-02	1.00E-10	4.13E-03	3.01%
		0.28	8.10E-03				
		0.55	6.76E-03				
35%	0.406			2.02E-02	2.53E-11	4.13E-03	3.38%
		0.26	8.05E-03				
		0.57	6.59E-03				
40%	0.406			2.64E-02	6.25E-10	4.13E-03	3.65%
		0.24	8.00E-03				

Table E.32 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (B) and load 530kN.

P=530kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.43	1.41E-02				
5%	0.406			4.12E-04	3.60E-09	7.40E-03	1.02%
		0.39	1.43E-02				
		0.45	1.40E-02				
10%	0.406			1.65E-03	2.02E-09	7.40E-03	1.80%
		0.37	1.43E-02				
		0.47	1.39E-02				
15%	0.406			3.71E-03	2.50E-11	7.40E-03	2.44%
		0.35	1.42E-02				
		0.49	1.38E-02				
20%	0.406			6.59E-03	1.23E-09	7.40E-03	2.87%
		0.32	1.42E-02				
		0.51	1.36E-02				
25%	0.406			1.03E-02	6.25E-10	7.40E-03	3.40%
		0.30	1.42E-02				
		0.53	1.33E-02				
30%	0.406			1.48E-02	4.00E-10	7.40E-03	3.90%
		0.28	1.41E-02				
		0.55	1.31E-02				
35%	0.406			2.02E-02	6.33E-10	7.40E-03	4.30%
		0.26	1.39E-02				
		0.57	1.29E-02				
40%	0.406			2.64E-02	6.25E-10	7.40E-03	4.54%
		0.24	1.38E-02				

Table E.33 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (B) and load 775kN.

P=775kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.43	2.14E-02				
5%	0.406			4.12E-04	4.00E-10	1.63E-02	2.34%
		0.39	2.13E-02				
		0.45	2.13E-02				
10%	0.406			1.65E-03	2.50E-11	1.63E-02	3.60%
		0.37	2.14E-02				
		0.47	2.13E-02				
15%	0.406			3.71E-03	4.22E-09	1.63E-02	4.44%
		0.35	2.13E-02				
		0.49	2.12E-02				
20%	0.406			6.59E-03	1.69E-08	1.63E-02	4.80%
		0.32	2.12E-02				
		0.51	2.11E-02				
25%	0.406			1.03E-02	2.56E-08	1.63E-02	5.64%
		0.30	2.10E-02				
		0.53	2.09E-02				
30%	0.406			1.48E-02	3.80E-08	1.63E-02	6.60%
		0.28	2.09E-02				
		0.55	2.07E-02				
35%	0.406			2.02E-02	4.05E-08	1.63E-02	7.44%
		0.26	2.07E-02				
		0.57	2.05E-02				
40%	0.406			2.64E-02	9.61E-08	1.63E-02	8.00%
		0.24	2.06E-02				

Table E.34 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (B) and load 1000kN.

P=1000kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.43	2.96E-02				
5%	0.406			4.12E-04	7.22E-09	3.23E-02	2.82%
		0.39	2.95E-02				
		0.45	2.95E-02				
10%	0.406			1.65E-03	1.82E-08	3.23E-02	5.08%
		0.37	2.94E-02				
		0.47	2.95E-02				
15%	0.406			3.71E-03	3.42E-08	3.23E-02	7.26%
		0.35	2.93E-02				
		0.49	2.95E-02				
20%	0.406			6.59E-03	4.84E-08	3.23E-02	9.23%
		0.32	2.93E-02				
		0.51	2.94E-02				
25%	0.406			1.03E-02	8.70E-08	3.23E-02	11.82%
		0.30	2.93E-02				
		0.53	2.92E-02				
30%	0.406			1.48E-02	1.26E-07	3.23E-02	14.12%
		0.28	2.92E-02				
		0.55	2.90E-02				
35%	0.406			2.02E-02	1.46E-07	3.23E-02	15.67%
		0.26	2.90E-02				
		0.57	2.88E-02				
40%	0.406			2.64E-02	1.64E-07	3.23E-02	16.99%
		0.24	2.89E-02				

Table E.35 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (B) and load 1300kN.

P=1300kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	3.89E-02				
5%	0.406			4.12E-04	1.36E-08	4.55E-02	3.40%
		0.3857	3.90E-02				
		0.4466	3.89E-02				
10%	0.406			1.65E-03	4.41E-08	4.55E-02	6.20%
		0.3654	3.89E-02				
		0.4669	3.88E-02				
15%	0.406			3.71E-03	9.00E-08	4.55E-02	9.30%
		0.3451	3.89E-02				
		0.4872	3.87E-02				
20%	0.406			6.59E-03	1.45E-07	4.55E-02	11.90%
		0.3248	3.90E-02				
		0.5075	3.86E-02				
25%	0.406			1.03E-02	2.38E-07	4.55E-02	15.50%
		0.3045	3.90E-02				
		0.5278	3.85E-02				
30%	0.406			1.48E-02	3.40E-07	4.55E-02	18.20%
		0.2842	3.89E-02				
		0.5472	3.84E-02				
35%	0.406			2.02E-02	4.19E-07	4.55E-02	20.60%
		0.2648	3.88E-02				
		0.5684	3.82E-02				
40%	0.406			2.64E-02	4.92E-07	4.55E-02	22.90%
		0.2436	3.88E-02				

Table E.36 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 285kN.

P=285kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	6.25E-10	0.72%
10%	1.65E-03	4.23E-09	1.14%
15%	3.71E-03	1.10E-08	1.57%
20%	6.59E-03	7.23E-09	2.05%
25%	1.03E-02	2.50E-09	2.50%
30%	1.48E-02	1.00E-10	3.01%
35%	2.02E-02	2.53E-11	3.38%
40%	2.64E-02	6.25E-10	3.65%

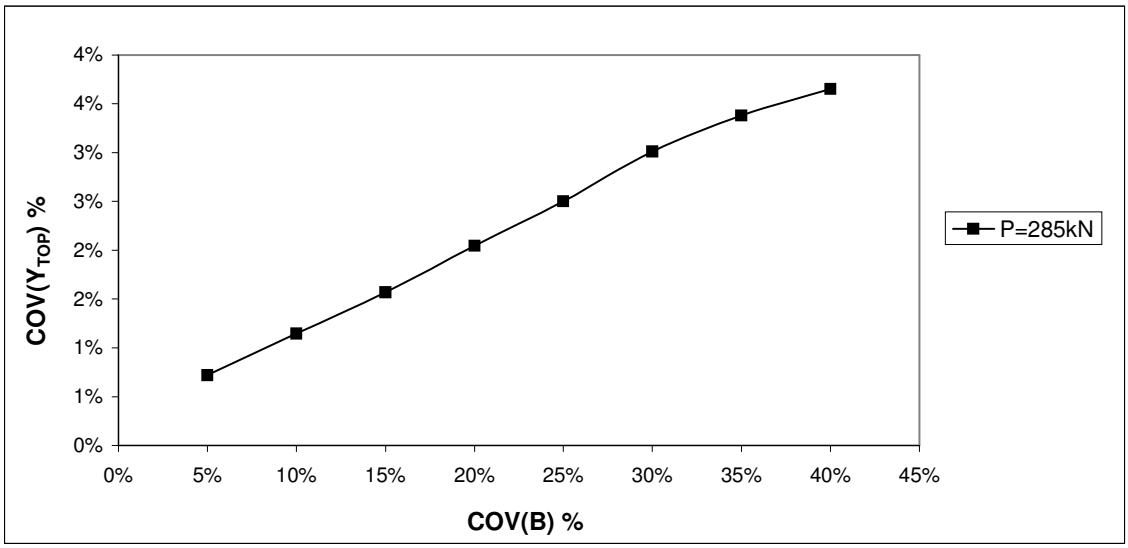


Fig. E.19 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.37 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 530kN.

P=530kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	3.60E-09	1.02%
10%	1.65E-03	2.02E-09	1.80%
15%	3.71E-03	2.50E-11	2.44%
20%	6.59E-03	1.23E-09	2.87%
25%	1.03E-02	6.25E-10	3.40%
30%	1.48E-02	4.00E-10	3.90%
35%	2.02E-02	6.33E-10	4.30%
40%	2.64E-02	6.25E-10	4.54%

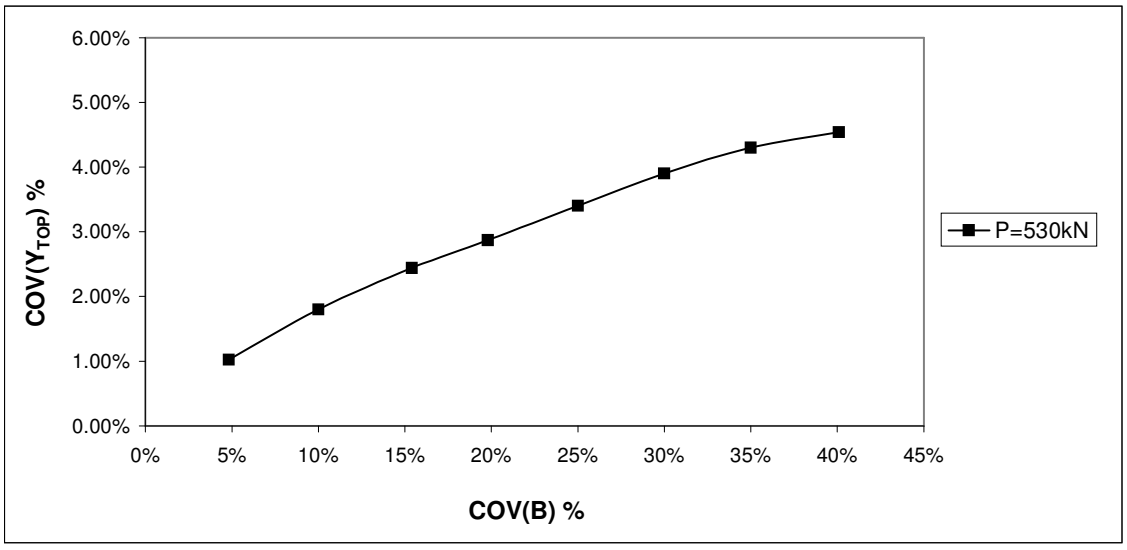


Fig. E.20 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.38 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 775kN.

P=775kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	4.00E-10	2.34%
10%	1.65E-03	2.50E-11	3.60%
15%	3.71E-03	4.22E-09	4.44%
20%	6.59E-03	1.69E-08	4.80%
25%	1.03E-02	2.56E-08	5.64%
30%	1.48E-02	3.80E-08	6.60%
35%	2.02E-02	4.05E-08	7.44%
40%	2.64E-02	9.61E-08	8.00%

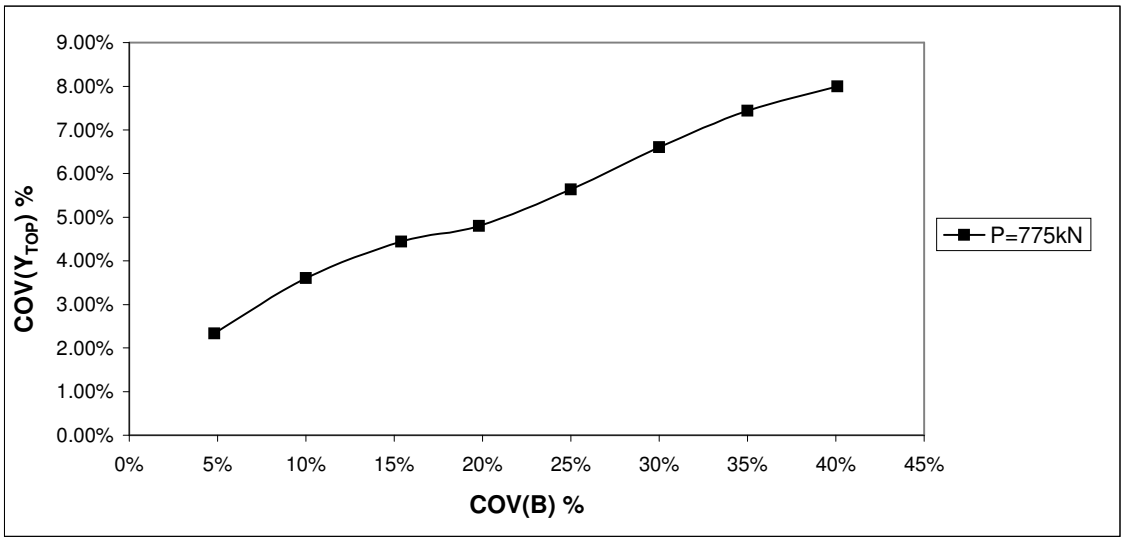


Fig. E.21 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.39 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 1000kN.

P=1000kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	7.22E-09	2.82%
10%	1.65E-03	1.82E-08	5.08%
15%	3.71E-03	3.42E-08	7.26%
20%	6.59E-03	4.84E-08	9.23%
25%	1.03E-02	8.70E-08	11.82%
30%	1.48E-02	1.26E-07	14.12%
35%	2.02E-02	1.46E-07	15.67%
40%	2.64E-02	1.64E-07	16.99%

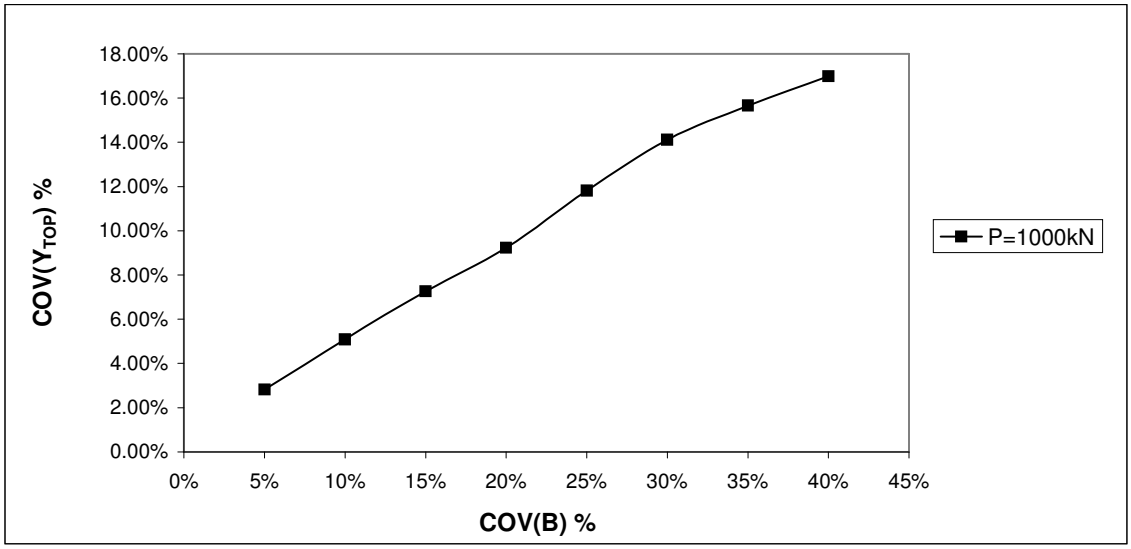


Fig. E.22 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.40 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 1300kN.

P=1300kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.36E-08	3.40%
10%	1.65E-03	4.41E-08	6.20%
15%	3.71E-03	9.00E-08	9.30%
20%	6.59E-03	1.45E-07	11.90%
25%	1.03E-02	2.38E-07	15.50%
30%	1.48E-02	3.40E-07	18.20%
35%	2.02E-02	4.19E-07	20.60%
40%	2.64E-02	4.92E-07	22.90%

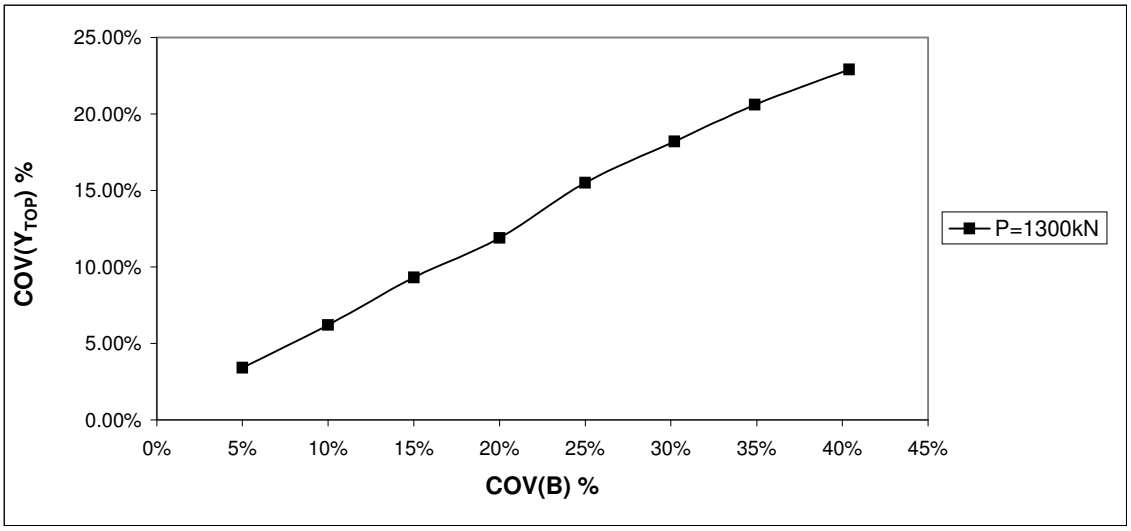


Fig. E.23 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

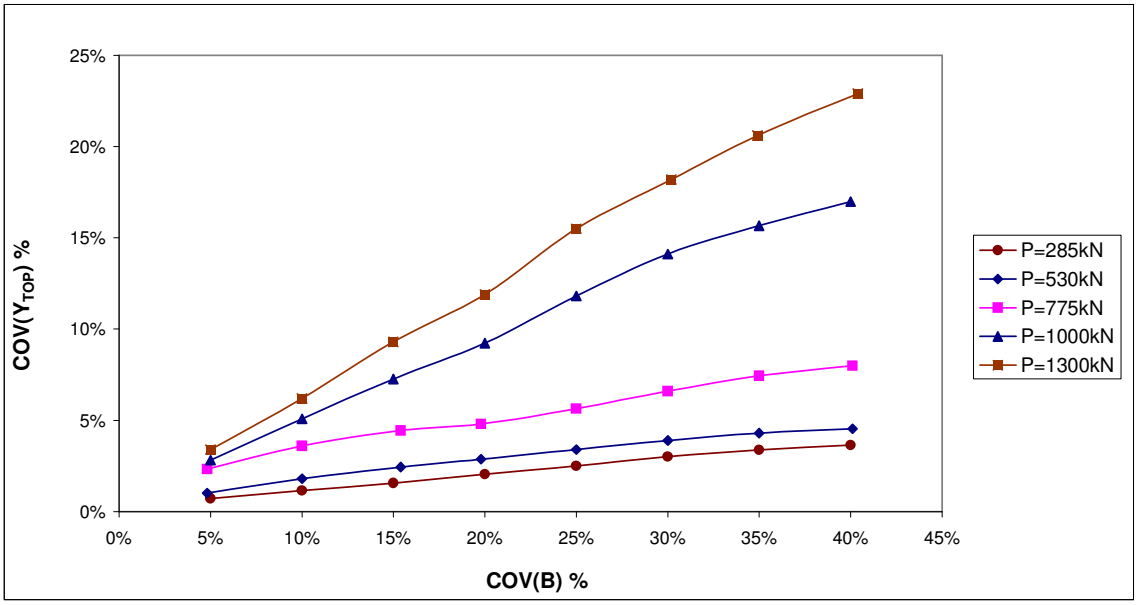


Fig. E.24 Variability of COV (Y_{TOP}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table E.41 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (EI) and load 285kN.

P=285kN							
COV(EI) (%)	EI° ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	7.54E-03				
5%	61000			9.30E+06	7.05E-08	4.13E-03	3.11%
		57950	8.07E-03				
		67100	7.34E-03				
10%	61000			3.72E+07	2.60E-07	4.13E-03	6.23%
		54900	8.36E-03				
		70150	7.13E-03				
15%	61000			8.37E+07	5.98E-07	4.13E-03	9.43%
		51850	8.68E-03				
		73200	6.94E-03				
20%	61000			1.49E+08	1.09E-06	4.13E-03	12.86%
		48800	9.03E-03				
		76250	6.76E-03				
25%	61000			2.33E+08	1.77E-06	4.13E-03	16.55%
		45750	9.42E-03				
		79300	6.59E-03				
30%	61000			3.35E+08	2.66E-06	4.13E-03	20.20%
		42700	9.86E-03				
		82350	6.44E-03				
35%	61000			4.56E+08	3.83E-06	4.13E-03	24.53%
		39650	1.04E-02				
		85400	6.29E-03				
40%	61000			5.95E+08	5.34E-06	4.13E-03	29.20%
		36600	1.09E-02				

Table E.42 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (EI) and load 530kN.

P=530kN							
COV(EI) (%)	EI° ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	1.39E-02				
5%	61000			9.30E+06	1.60E-07	7.40E-03	4.07%
		57950	1.47E-02				
		67100	1.34E-02				
10%	61000			3.72E+07	8.74E-07	7.40E-03	6.32%
		54900	1.52E-02				
		70150	1.30E-02				
15%	61000			8.37E+07	1.99E-06	7.40E-03	9.55%
		51850	1.58E-02				
		73200	1.26E-02				
20%	61000			1.49E+08	3.65E-06	7.40E-03	12.89%
		48800	1.64E-02				
		76250	1.23E-02				
25%	61000			2.33E+08	5.90E-06	7.40E-03	16.52%
		45750	1.72E-02				
		79300	1.20E-02				
30%	61000			3.35E+08	8.85E-06	7.40E-03	20.45%
		42700	1.79E-02				
		82350	1.17E-02				
35%	61000			4.56E+08	1.27E-05	7.40E-03	24.69%
		39650	1.88E-02				
		85400	1.14E-02				
40%	61000			5.95E+08	1.78E-05	7.40E-03	29.37%
		36600	1.99E-02				

Table E.43 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (EI) and load 775kN.

P=775kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	2.10E-02				
5%	61000			9.30E+06	3.54E-07	1.63E-02	2.81%
		57950	2.22E-02				
		67100	2.02E-02				
10%	61000			3.72E+07	2.02E-06	1.63E-02	6.70%
		54900	2.30E-02				
		70150	1.96E-02				
15%	61000			8.37E+07	4.67E-06	1.63E-02	10.19%
		51850	2.39E-02				
		73200	1.91E-02				
20%	61000			1.49E+08	8.53E-06	1.63E-02	13.77%
		48800	2.49E-02				
		76250	1.86E-02				
25%	61000			2.33E+08	1.38E-05	1.63E-02	17.52%
		45750	2.60E-02				
		79300	1.81E-02				
30%	61000			3.35E+08	2.08E-05	1.63E-02	21.51%
		42700	2.72E-02				
		82350	1.77E-02				
35%	61000			4.56E+08	3.01E-05	1.63E-02	25.87%
		39650	2.86E-02				
		85400	1.72E-02				
40%	61000			5.95E+08	4.24E-05	1.63E-02	30.73%
		36600	3.03E-02				

Table E.44 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (EI) and load 1000kN.

P=1000kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	2.80E-02				
5%	61000			9.30E+06	1.73E-06	3.23E-02	3.39%
		57950	3.06E-02				
		67100	2.77E-02				
10%	61000			3.72E+07	4.16E-06	3.23E-02	7.92%
		54900	3.18E-02				
		70150	2.69E-02				
15%	61000			8.37E+07	9.52E-06	3.23E-02	11.95%
		51850	3.31E-02				
		73200	2.61E-02				
20%	61000			1.49E+08	1.73E-05	3.23E-02	16.19%
		48800	3.44E-02				
		76250	2.54E-02				
25%	61000			2.33E+08	2.85E-05	3.23E-02	20.59%
		45750	3.61E-02				
		79300	2.48E-02				
30%	61000			3.35E+08	4.36E-05	3.23E-02	25.21%
		42700	3.80E-02				
		82350	2.42E-02				
35%	61000			4.56E+08	6.36E-05	3.23E-02	30.25%
		39650	4.01E-02				
		85400	2.36E-02				
40%	61000			5.95E+08	9.00E-05	3.23E-02	35.72%
		36600	4.26E-02				

Table E.45 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (EI) and load 1300kN.

P=1300kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		64050	3.76E-02				
5%	61000			9.30E+06	2.00E-06	4.55E-02	6.43%
		57950	4.04E-02				
		67100	3.64E-02				
10%	61000			3.72E+07	8.04E-06	4.55E-02	12.35%
		54900	4.20E-02				
		70150	3.52E-02				
15%	61000			8.37E+07	1.84E-05	4.55E-02	18.73%
		51850	4.38E-02				
		73200	3.42E-02				
20%	61000			1.49E+08	3.42E-05	4.55E-02	25.30%
		48800	4.59E-02				
		76250	3.32E-02				
25%	61000			2.33E+08	5.67E-05	4.55E-02	32.20%
		45750	4.82E-02				
		79300	3.22E-02				
30%	61000			3.35E+08	8.70E-05	4.55E-02	39.52%
		42700	5.09E-02				
		82350	3.14E-02				
35%	61000			4.56E+08	1.27E-04	4.55E-02	47.40%
		39650	5.39E-02				
		85400	3.07E-02				
40%	61000			5.95E+08	1.79E-04	4.55E-02	55.97%
		36600	5.74E-02				

Table E.46 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 285kN.

P=285kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	7.05E-08	3.11%
10%	3.72E+07	2.60E-07	6.23%
15%	8.37E+07	5.98E-07	9.43%
20%	1.49E+08	1.09E-06	12.86%
25%	2.33E+08	1.77E-06	16.55%
30%	3.35E+08	2.66E-06	20.20%
35%	4.56E+08	3.83E-06	24.53%
40%	5.95E+08	5.34E-06	29.20%

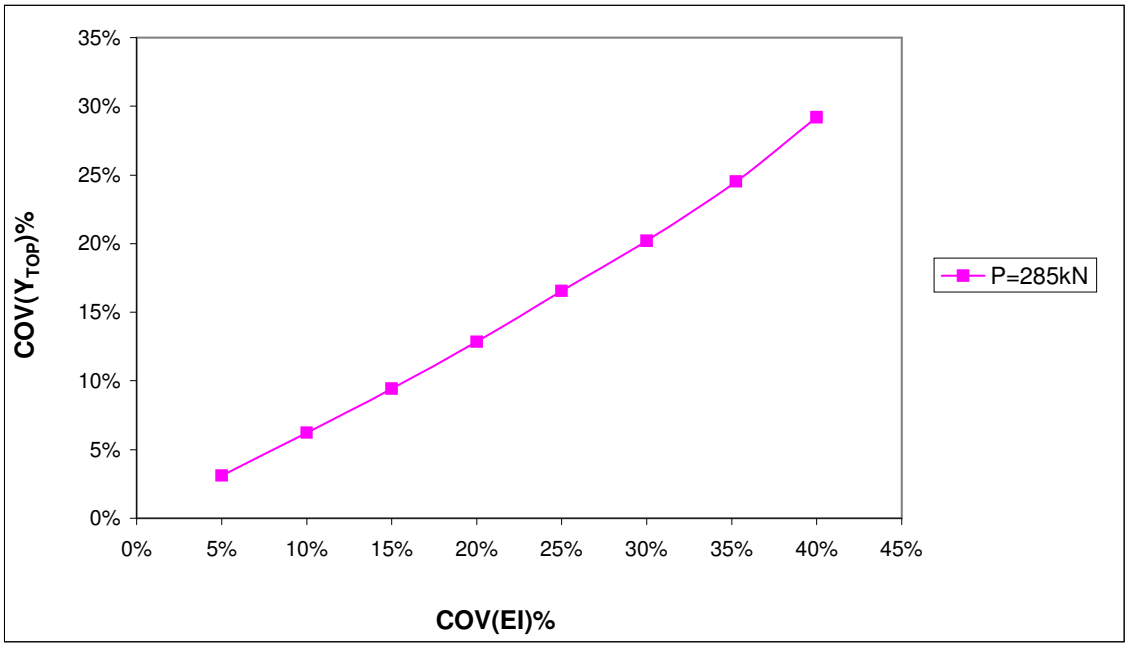


Fig. E.25 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.47 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 530kN.

P=530kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	1.60E-07	4.07%
10%	3.72E+07	8.74E-07	6.32%
15%	8.37E+07	1.99E-06	9.55%
20%	1.49E+08	3.65E-06	12.89%
25%	2.33E+08	5.90E-06	16.52%
30%	3.35E+08	8.85E-06	20.45%
35%	4.56E+08	1.27E-05	24.69%
40%	5.95E+08	1.78E-05	29.37%

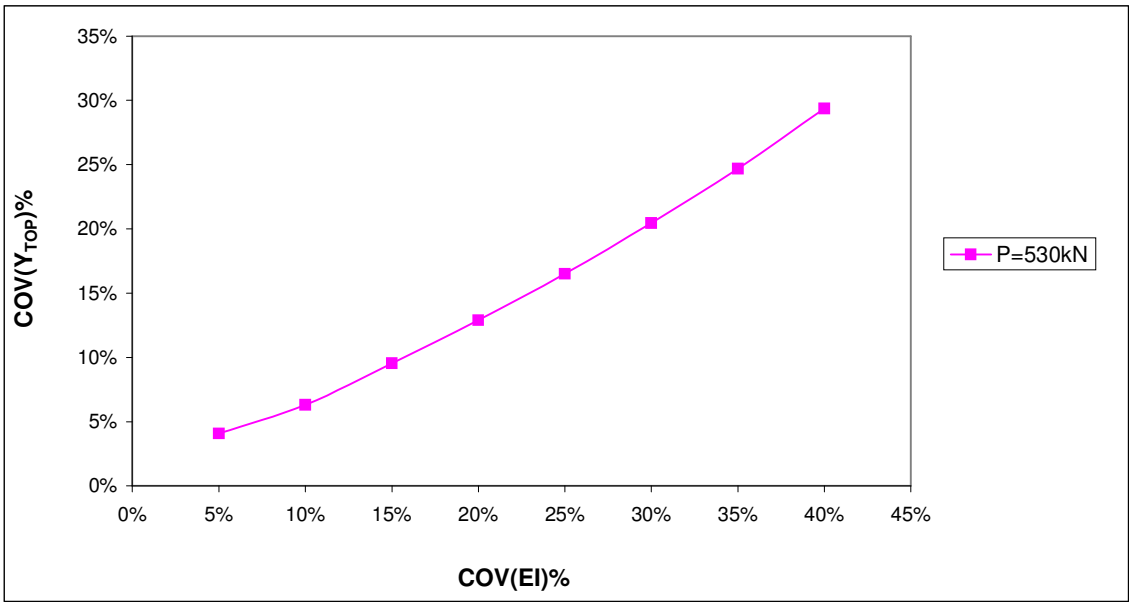


Fig. E.26 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.48 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 775kN.

P=775kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	3.54E-07	2.81%
10%	3.72E+07	2.02E-06	6.70%
15%	8.37E+07	4.67E-06	10.19%
20%	1.49E+08	8.53E-06	13.77%
25%	2.33E+08	1.38E-05	17.52%
30%	3.35E+08	2.08E-05	21.51%
35%	4.56E+08	3.01E-05	25.87%
40%	5.95E+08	4.24E-05	30.73%

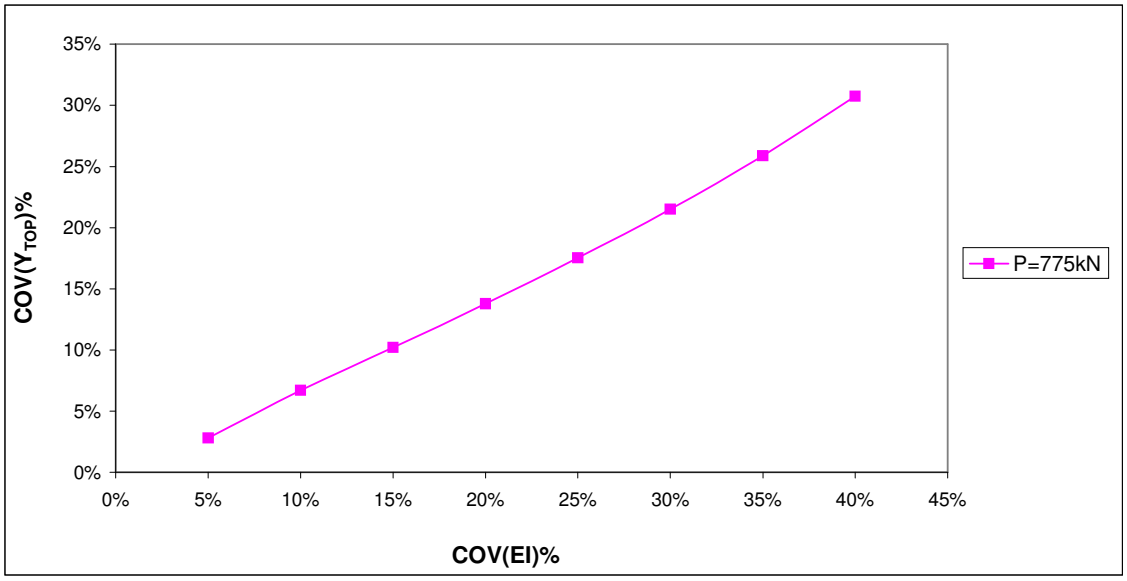


Fig. E.27 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.49 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 1000kN.

P=1000kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	1.73E-06	3.39%
10%	3.72E+07	4.16E-06	7.92%
15%	8.37E+07	9.52E-06	11.95%
20%	1.49E+08	1.73E-05	16.19%
25%	2.33E+08	2.85E-05	20.59%
30%	3.35E+08	4.36E-05	25.21%
35%	4.56E+08	6.36E-05	30.25%
40%	5.95E+08	9.00E-05	35.72%

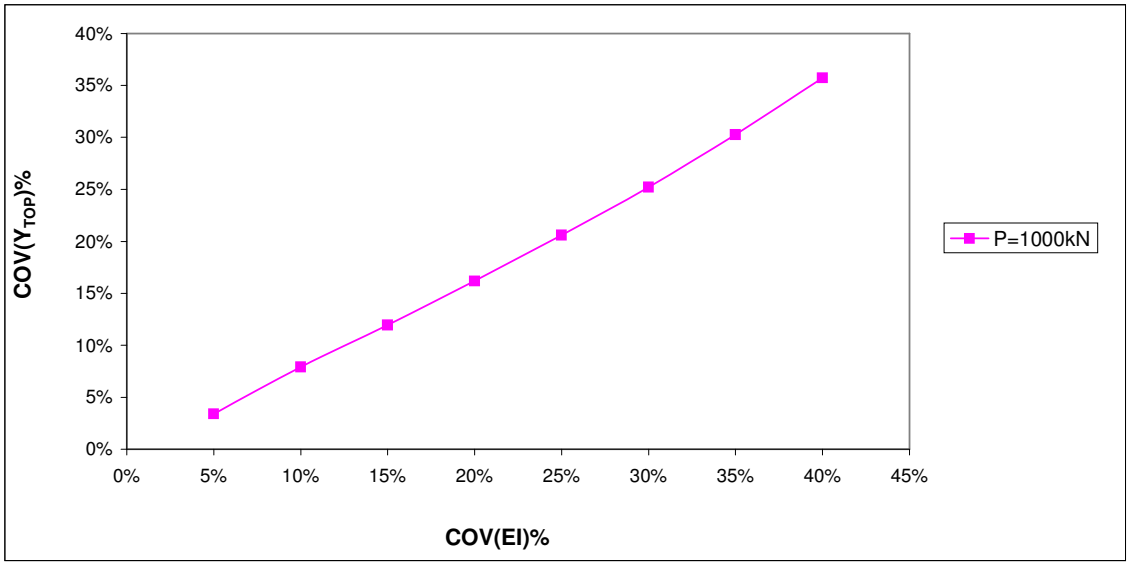


Fig. E.28 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.50 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 1300kN.

P=1300kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	2.00E-06	6.43%
10%	3.72E+07	8.04E-06	12.35%
15%	8.37E+07	1.84E-05	18.73%
20%	1.49E+08	3.42E-05	25.30%
25%	2.33E+08	5.67E-05	32.20%
30%	3.35E+08	8.70E-05	39.52%
35%	4.56E+08	1.27E-04	47.40%
40%	5.95E+08	1.79E-04	55.97%

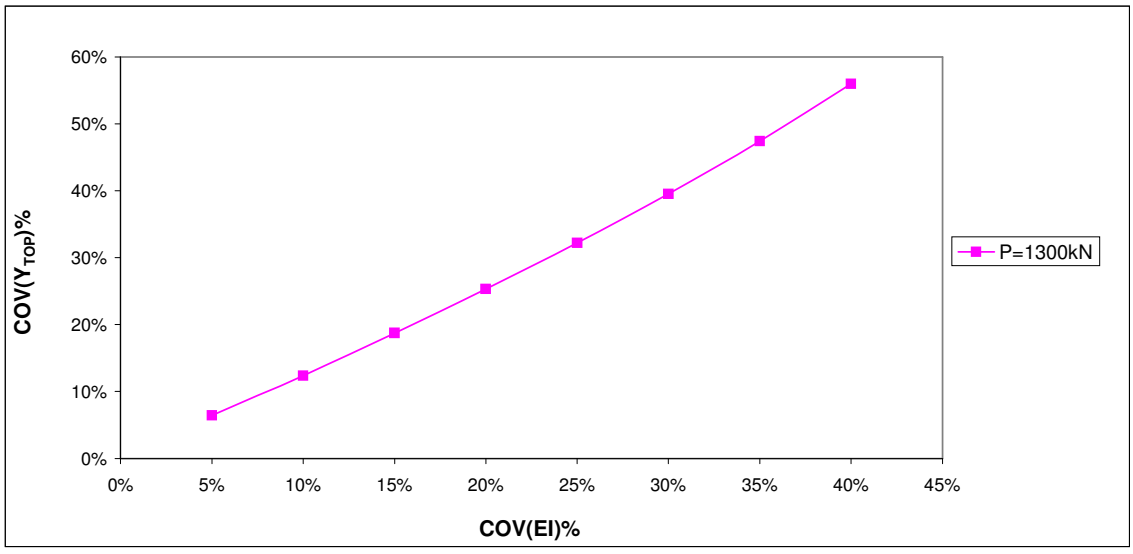


Fig. E.29 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

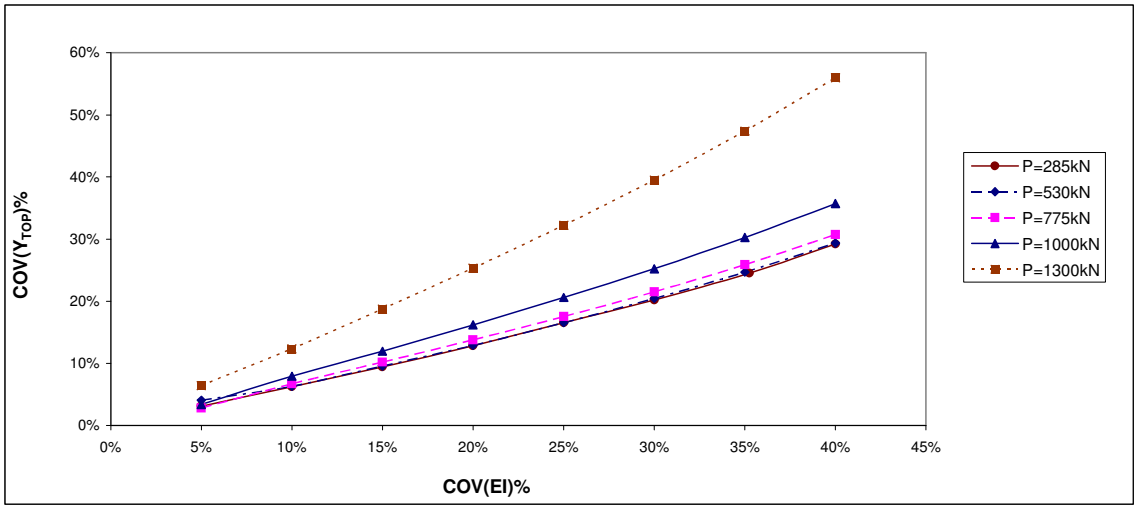


Fig. E.30 Variability of COV (Y_{TOP}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table E.51 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (P) and load 285kN.

P=285kN							
COV(P) (%)	P° (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		299.3	8.40E-03				
5%	285			2.03E+02	3.36E-07	4.13E-03	6.55%
		270.8	7.24E-03				
		313.5	9.01E-03				
10%	285			8.12E+02	1.36E-06	4.13E-03	13.30%
		256.5	6.68E-03				
		327.8	9.64E-03				
15%	285			1.83E+03	3.08E-06	4.13E-03	19.90%
		242.3	6.13E-03				
		342.0	1.03E-02				
20%	285			3.25E+03	5.49E-06	4.13E-03	26.56%
		228.0	5.59E-03				
		356.3	1.09E-02				
25%	285			5.08E+03	8.57E-06	4.13E-03	33.12%
		213.8	5.06E-03				
		370.5	1.16E-02				
30%	285			7.31E+03	1.23E-05	4.13E-03	40.03%
		199.5	4.54E-03				
		384.8	1.22E-02				
35%	285			9.95E+03	1.66E-05	4.13E-03	46.96%
		185.3	4.05E-03				
		399.0	1.29E-02				
40%	285			1.30E+04	2.16E-05	4.13E-03	53.81%
		171.0	3.59E-03				

Table E.52 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (P) and load 530kN.

P=530kN							
COV(P) (%)	P° (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	(Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		556.5	1.52E-02				
5%	530			7.02E+02	1.03E-06	7.40E-03	6.75%
		503.5	1.32E-02				
		583.0	1.63E-02				
10%	530			2.81E+03	4.18E-06	7.40E-03	13.39%
		477.0	1.22E-02				
		609.5	1.74E-02				
15%	530			6.32E+03	9.46E-06	7.40E-03	20.23%
		450.5	1.12E-02				
		636.0	1.85E-02				
20%	530			1.12E+04	1.68E-05	7.40E-03	27.11%
		424.0	1.03E-02				
		662.5	1.96E-02				
25%	530			1.76E+04	2.63E-05	7.40E-03	33.85%
		397.5	9.32E-03				
		689.0	2.07E-02				
30%	530			2.53E+04	3.79E-05	7.40E-03	40.77%
		371.0	8.40E-03				
		715.5	2.18E-02				
35%	530			3.44E+04	5.13E-05	7.40E-03	47.88%
		344.5	7.52E-03				
		742.0	2.30E-02				
40%	530			4.49E+04	6.67E-05	7.40E-03	54.94%
		318.0	6.68E-03				

Table E.53 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (P) and load 775kN.

P=775kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		813.8	2.30E-02				
5%	775			1.50E+03	2.34E-06	1.63E-02	7.22%
		736.3	2.00E-02				
		852.5	2.46E-02				
10%	775			6.01E+03	9.36E-06	1.63E-02	14.43%
		697.5	1.85E-02				
		891.3	2.62E-02				
15%	775			1.35E+04	2.09E-05	1.63E-02	21.58%
		658.8	1.70E-02				
		930.0	2.78E-02				
20%	775			2.40E+04	3.75E-05	1.63E-02	28.89%
		620.0	1.56E-02				
		968.8	2.96E-02				
25%	775			3.75E+04	5.90E-05	1.63E-02	36.23%
		581.3	1.42E-02				
		1007.5	3.13E-02				
30%	775			5.41E+04	8.51E-05	1.63E-02	43.51%
		542.5	1.29E-02				
		1046.3	3.31E-02				
35%	775			7.36E+04	1.16E-04	1.63E-02	50.78%
		503.8	1.16E-02				
		1085.0	3.50E-02				
40%	775			9.61E+04	1.53E-04	1.63E-02	58.33%
		465.0	1.03E-02				

Table E.54 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (P) and load 1000kN.

P=1000kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		1050	3.18E-02				
5%	1000			2.50E+03	4.75E-06	3.23E-02	8.60%
		950	2.74E-02				
		1100	3.40E-02				
10%	1000			1.00E+04	1.87E-05	3.23E-02	17.33%
		900	2.54E-02				
		1150	3.65E-02				
15%	1000			2.25E+04	4.27E-05	3.23E-02	26.06%
		850	2.34E-02				
		1200	3.90E-02				
20%	1000			4.00E+04	7.67E-05	3.23E-02	34.75%
		800	2.15E-02				
		1250	4.15E-02				
25%	1000			6.25E+04	1.20E-04	3.23E-02	43.47%
		750	1.96E-02				
		1300	4.41E-02				
30%	1000			9.00E+04	1.73E-04	3.23E-02	52.14%
		700	1.77E-02				
		1350	4.69E-02				
35%	1000			1.23E+05	2.39E-04	3.23E-02	60.68%
		650	1.60E-02				
		1400	4.97E-02				
40%	1000			1.60E+05	3.15E-04	3.23E-02	69.21%
		600	1.42E-02				

Table E.55 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (P) and load 1300kN.

P=1300kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		1365	4.20E-02				
5%	1300			4.23E+03	8.88E-06	4.55E-02	14.03%
		1235	3.60E-02				
		1430	4.52E-02				
10%	1300			1.69E+04	3.66E-05	4.55E-02	28.24%
		1170	3.31E-02				
		1495	4.86E-02				
15%	1300			3.80E+04	8.20E-05	4.55E-02	42.49%
		1105	3.05E-02				
		1560	5.20E-02				
20%	1300			6.76E+04	1.46E-04	4.55E-02	56.72%
		1040	2.78E-02				
		1625	5.55E-02				
25%	1300			1.06E+05	2.27E-04	4.55E-02	70.88%
		975	2.54E-02				
		1690	5.94E-02				
30%	1300			1.52E+05	3.32E-04	4.55E-02	85.01%
		910	2.30E-02				
		1755	6.34E-02				
35%	1300			2.07E+05	4.56E-04	4.55E-02	98.74%
		845	2.07E-02				
		1820	6.74E-02				
40%	1300			2.70E+05	6.00E-04	4.55E-02	112.48%
		780	1.85E-02				

Table E.56 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 285kN.

P=285kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.03E+02	3.36E-07	6.55%
10%	8.12E+02	1.36E-06	13.30%
15%	1.83E+03	3.08E-06	19.90%
20%	3.25E+03	5.49E-06	26.56%
25%	5.08E+03	8.57E-06	33.12%
30%	7.31E+03	1.23E-05	40.03%
35%	9.95E+03	1.66E-05	46.96%
40%	1.30E+04	2.16E-05	53.81%

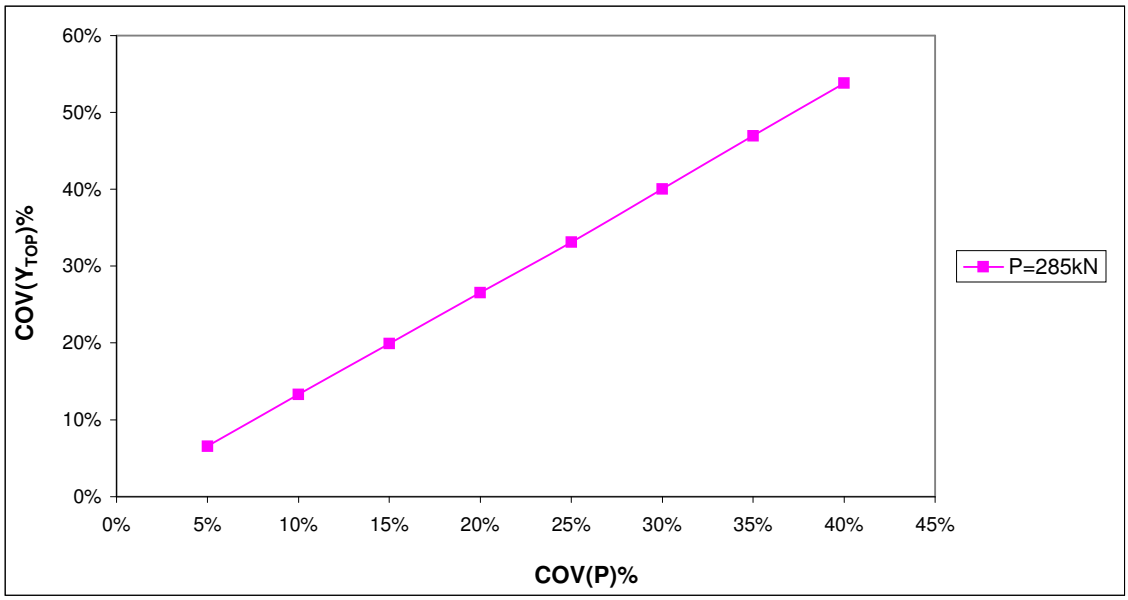


Fig. E.31 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.57 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 530kN.

P=530kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	7.02E+02	1.03E-06	6.75%
10%	2.81E+03	4.18E-06	13.39%
15%	6.32E+03	9.46E-06	20.23%
20%	1.12E+04	1.68E-05	27.11%
25%	1.76E+04	2.63E-05	33.85%
30%	2.53E+04	3.79E-05	40.77%
35%	3.44E+04	5.13E-05	47.88%
40%	4.49E+04	6.67E-05	54.94%

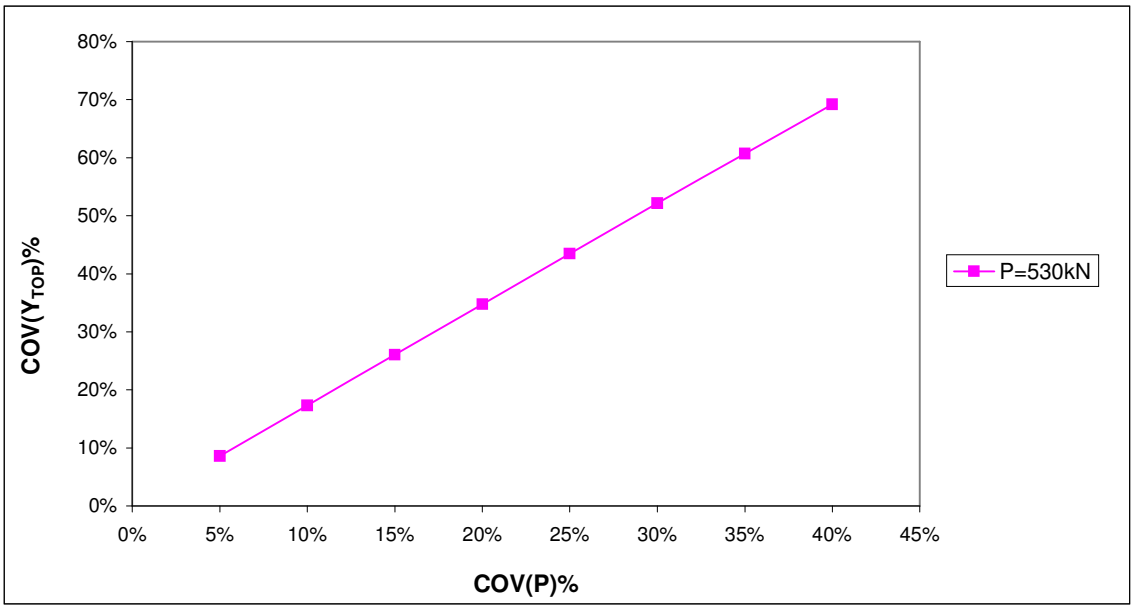


Fig. E.32 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.58 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 775kN.

P=775kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	1.50E+03	2.34E-06	7.22%
10%	6.01E+03	9.36E-06	14.43%
15%	1.35E+04	2.09E-05	21.58%
20%	2.40E+04	3.75E-05	28.89%
25%	3.75E+04	5.90E-05	36.23%
30%	5.41E+04	8.51E-05	43.51%
35%	7.36E+04	1.16E-04	50.78%
40%	9.61E+04	1.53E-04	58.33%

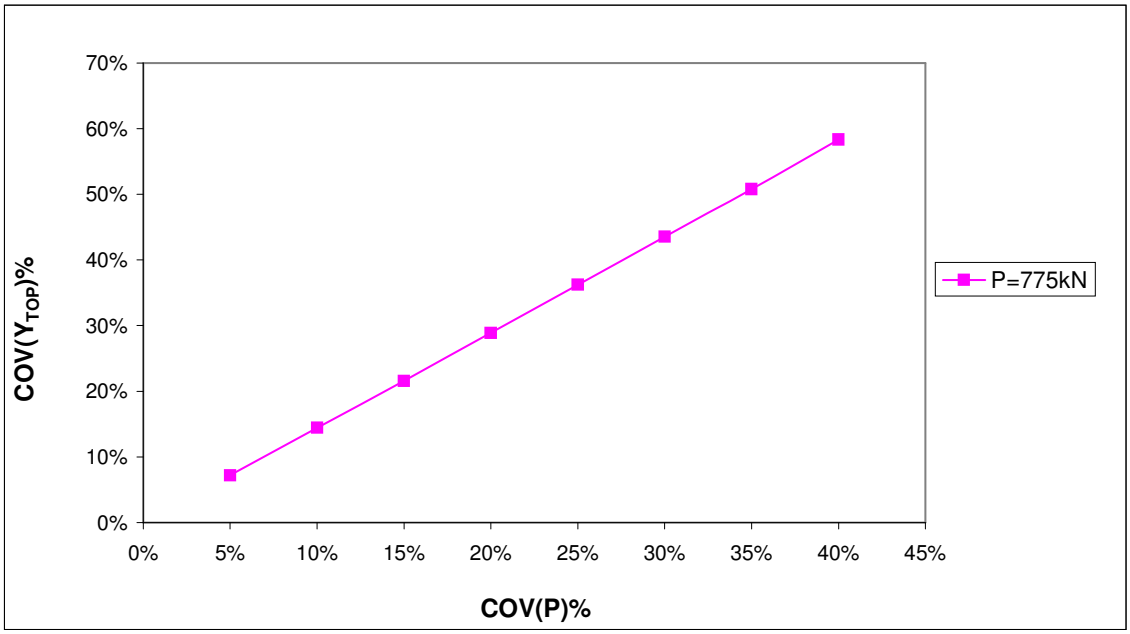


Fig. E.33 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.59 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 1000kN.

P=1000kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.50E+03	4.75E-06	8.60%
10%	1.00E+04	1.87E-05	17.33%
15%	2.25E+04	4.27E-05	26.06%
20%	4.00E+04	7.67E-05	34.75%
25%	6.25E+04	1.20E-04	43.47%
30%	9.00E+04	1.73E-04	52.14%
35%	1.23E+05	2.39E-04	60.68%
40%	1.60E+05	3.15E-04	69.21%

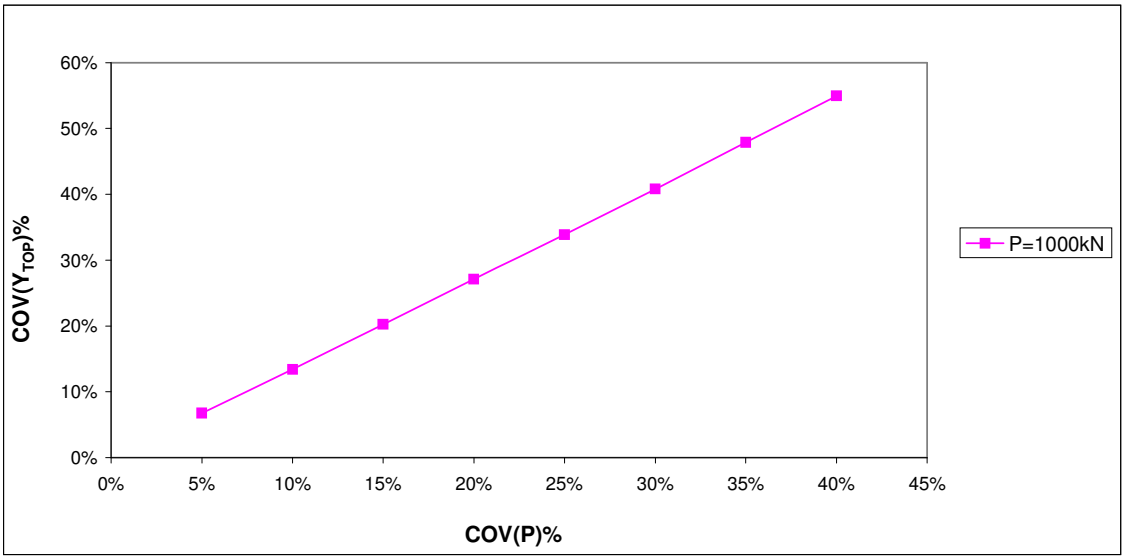


Fig. E.34 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.60 Value of COV (Y_{TOP}) for free head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 1300kN.

P=1300kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.23E+03	8.88E-06	14.03%
10%	1.69E+04	3.66E-05	28.24%
15%	3.80E+04	8.20E-05	42.49%
20%	6.76E+04	1.46E-04	56.72%
25%	1.06E+05	2.27E-04	70.88%
30%	1.52E+05	3.32E-04	85.01%
35%	2.07E+05	4.56E-04	98.74%
40%	2.70E+05	6.00E-04	112.48%

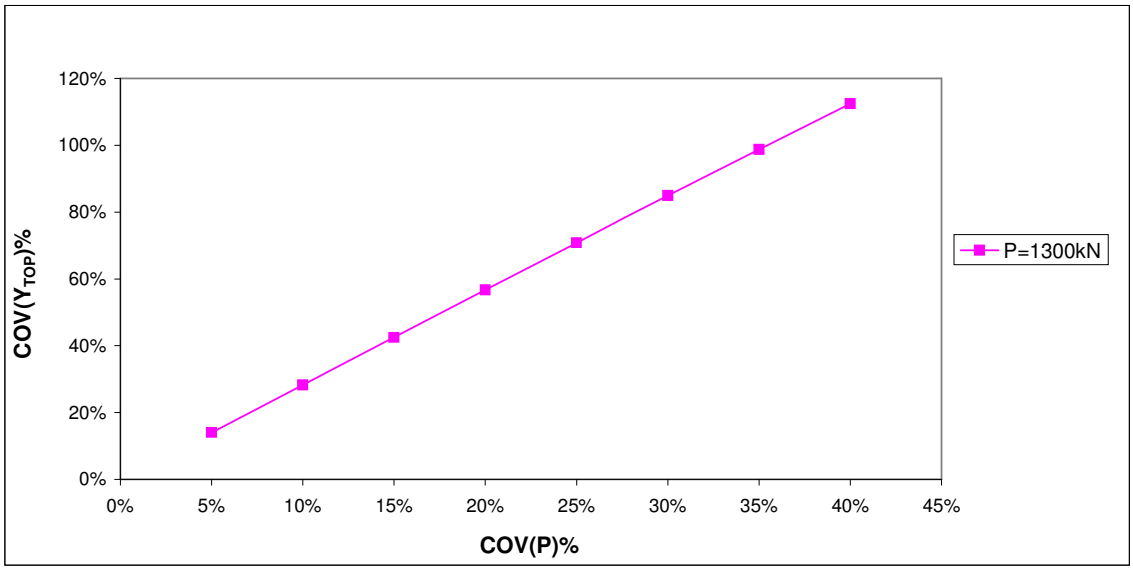


Fig. E.35 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

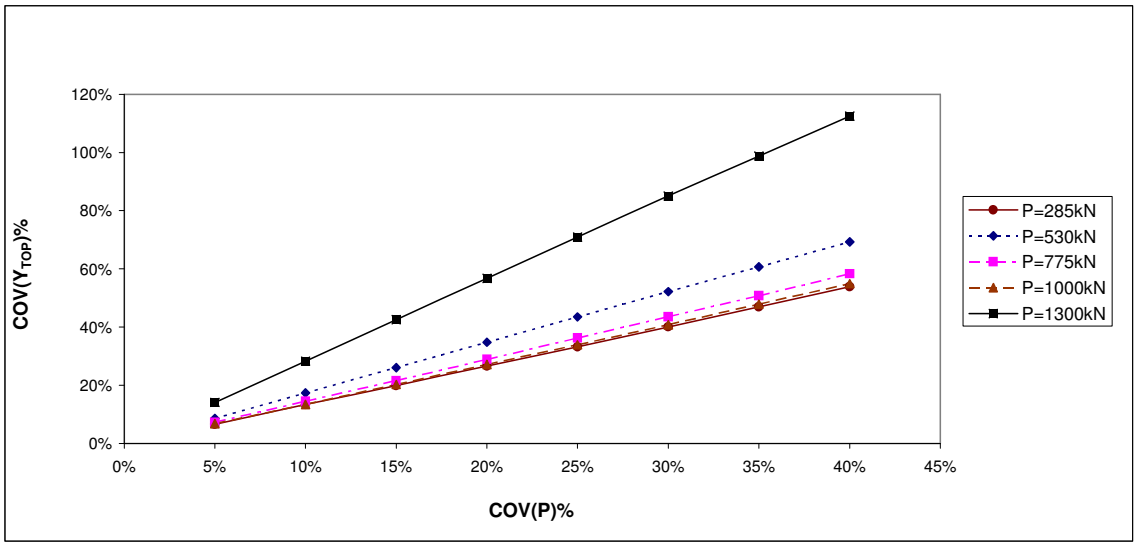


Fig. E.36 Variability of COV (Y_{TOP}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

E-2 Reliability Index (β) of top deflection vs. COV (Variables).

Table E.61 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 285kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.99E-07	0.000225	5%	0.0150	6.3843
1.04E-06	0.000225	10%	0.0150	6.3767
4.62E-06	0.000225	15%	0.0152	6.3267
8.49E-06	0.000225	20%	0.0153	6.2741
1.36E-05	0.000225	25%	0.0154	6.2059
2.03E-05	0.000225	30%	0.0157	6.1213
2.81E-05	0.000225	35%	0.0159	6.0260
3.86E-05	0.000225	40%	0.0162	5.9048

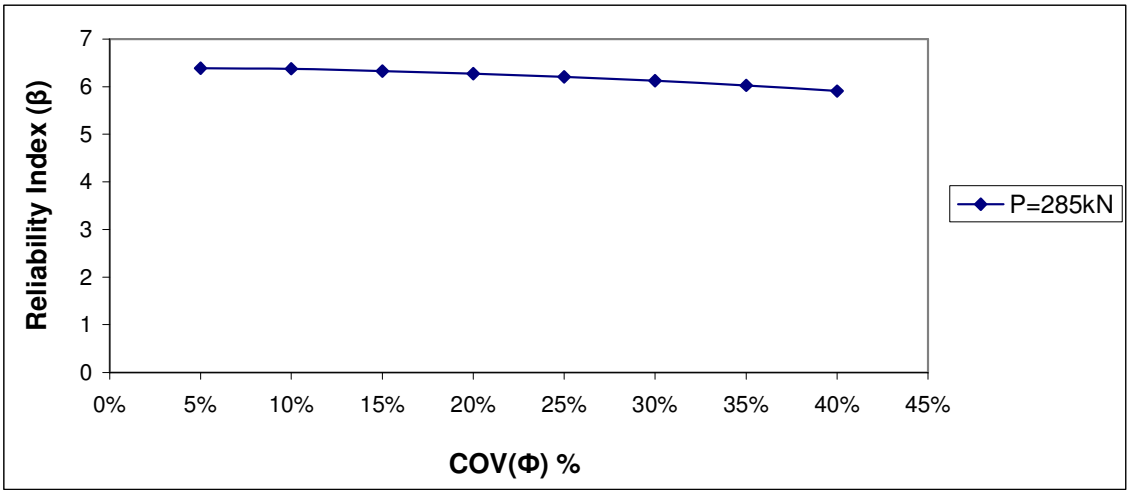


Fig. E.37 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 285kN.

Table E.62 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 530kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.55E-06	0.000225	5%	0.0151	5.8599
3.22E-06	0.000225	10%	0.0151	5.8383
1.43E-05	0.000225	15%	0.0155	5.7022
2.60E-05	0.000225	20%	0.0158	5.5676
4.20E-05	0.000225	25%	0.0163	5.3977
6.36E-05	0.000225	30%	0.0170	5.1919
9.24E-05	0.000225	35%	0.0178	4.9507
1.33E-04	0.000225	40%	0.0189	4.6627

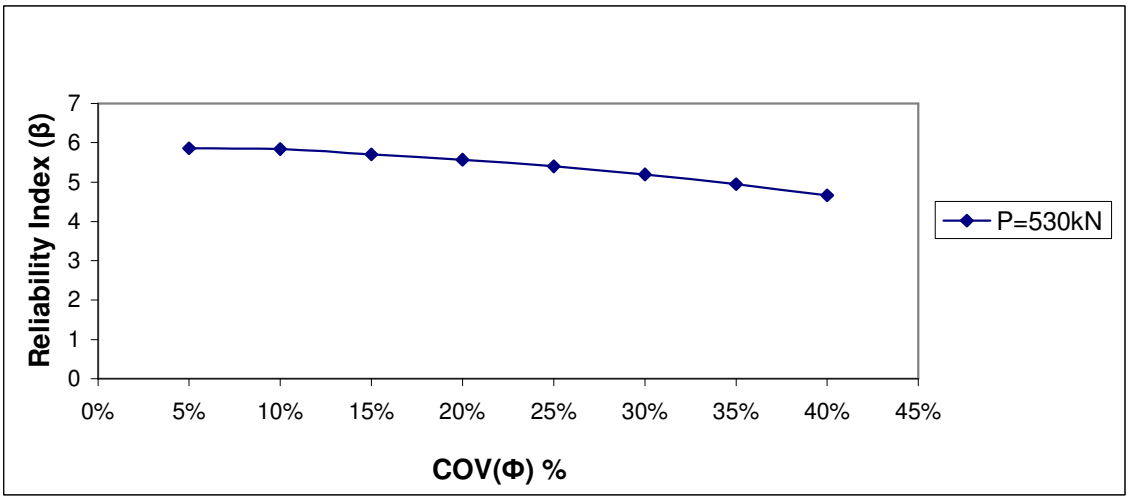


Fig. E.38 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.63 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 775kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.46E-06	0.000225	5%	0.0151	5.2134
6.97E-06	0.000225	10%	0.0152	5.1738
3.23E-05	0.000225	15%	0.0160	4.9124
5.87E-05	0.000225	20%	0.0168	4.6786
9.82E-05	0.000225	25%	0.0180	4.3831
1.51E-04	0.000225	30%	0.0194	4.0649
2.29E-04	0.000225	35%	0.0213	3.6992
3.39E-04	0.000225	40%	0.0237	3.3183

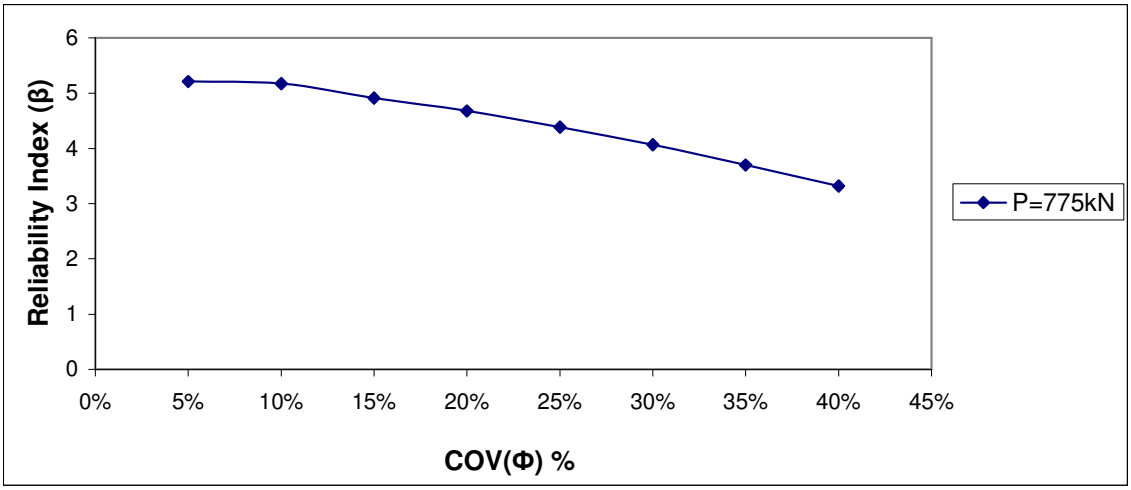


Fig. E.39 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.64 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.86E-06	0.000225	5%	0.0152	4.4460
1.40E-05	0.000225	10%	0.0155	4.3789
6.56E-05	0.000225	15%	0.0170	3.9713
1.25E-04	0.000225	20%	0.0187	3.6199
2.06E-04	0.000225	25%	0.0208	3.2618
3.29E-04	0.000225	30%	0.0235	2.8752
5.05E-04	0.000225	35%	0.0270	2.5051
7.68E-04	0.000225	40%	0.0315	2.1489

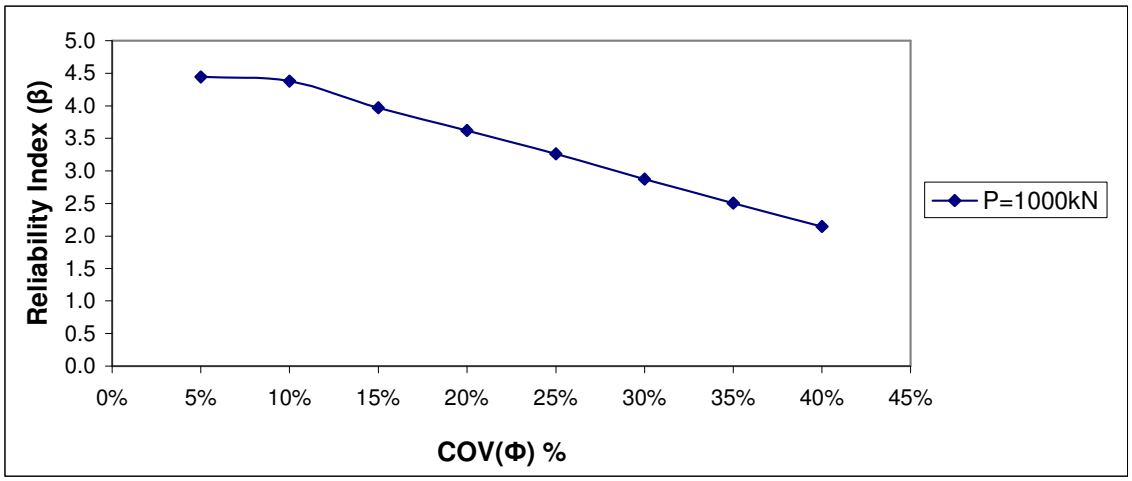


Fig. E.40 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.65 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 1300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.35E-05	0.000225	5%	0.0154	3.5290
2.66E-05	0.000225	10%	0.0159	3.3000
1.29E-04	0.000225	15%	0.0188	2.8974
2.41E-04	0.000225	20%	0.0216	2.5242
4.10E-04	0.000225	25%	0.0252	2.1620
6.50E-04	0.000225	30%	0.0296	1.8424
1.02E-03	0.000225	35%	0.0353	1.5457
1.58E-03	0.000225	40%	0.0425	1.2838

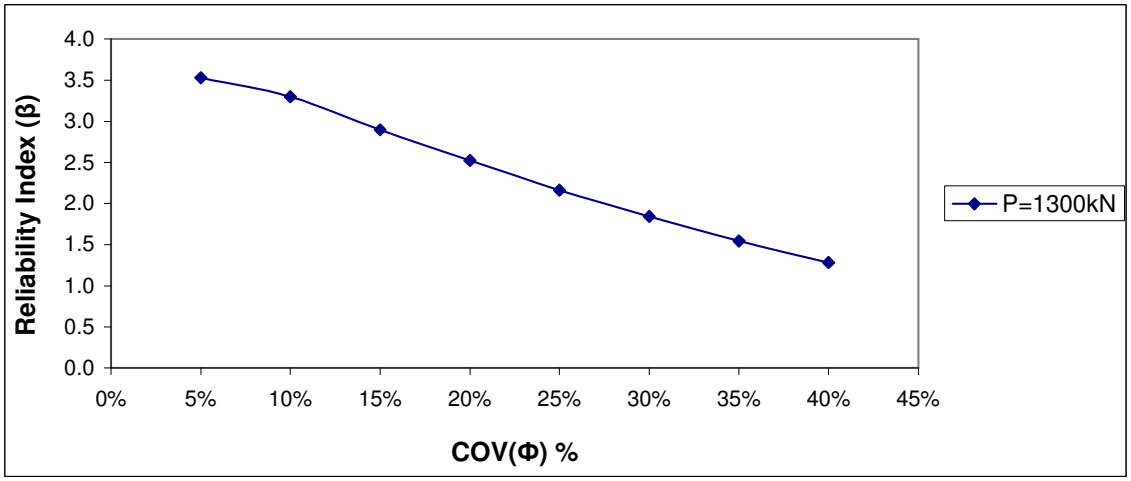


Fig. E.41 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 1300kN.

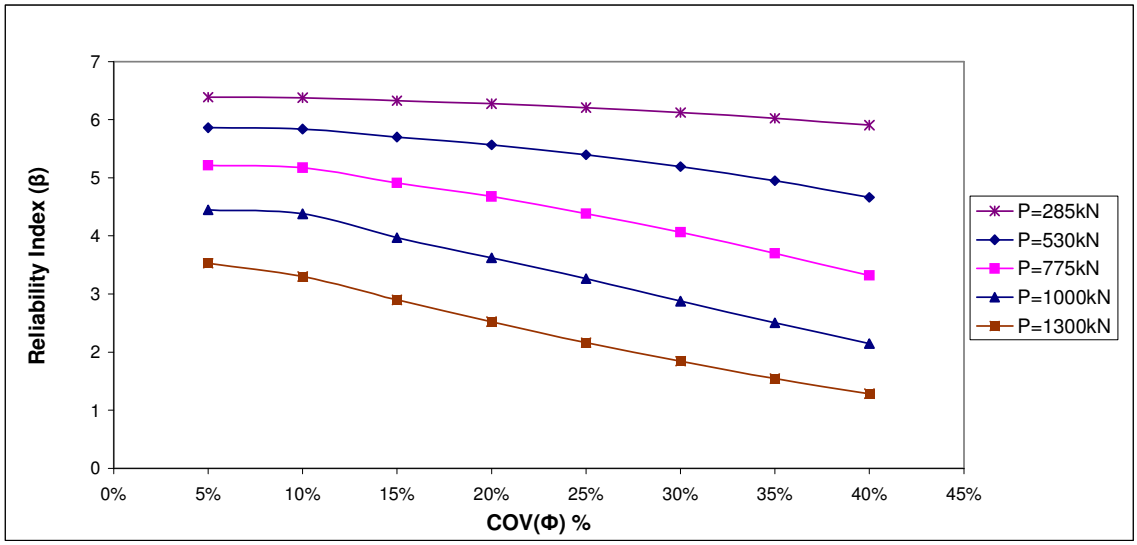


Fig. E.42 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table E.66 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D)and with varying 'γ' subjected to lateral load 285kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
8.76E-08	0.000225	5%	0.0150	6.3901
3.66E-07	0.000225	10%	0.0150	6.3861
8.48E-07	0.000225	15%	0.0150	6.3793
1.55E-06	0.000225	20%	0.0151	6.3695
2.52E-06	0.000225	25%	0.0151	6.3558
3.79E-06	0.000225	30%	0.0151	6.3382
5.41E-06	0.000225	35%	0.0152	6.3158
7.50E-06	0.000225	40%	0.0152	6.2873

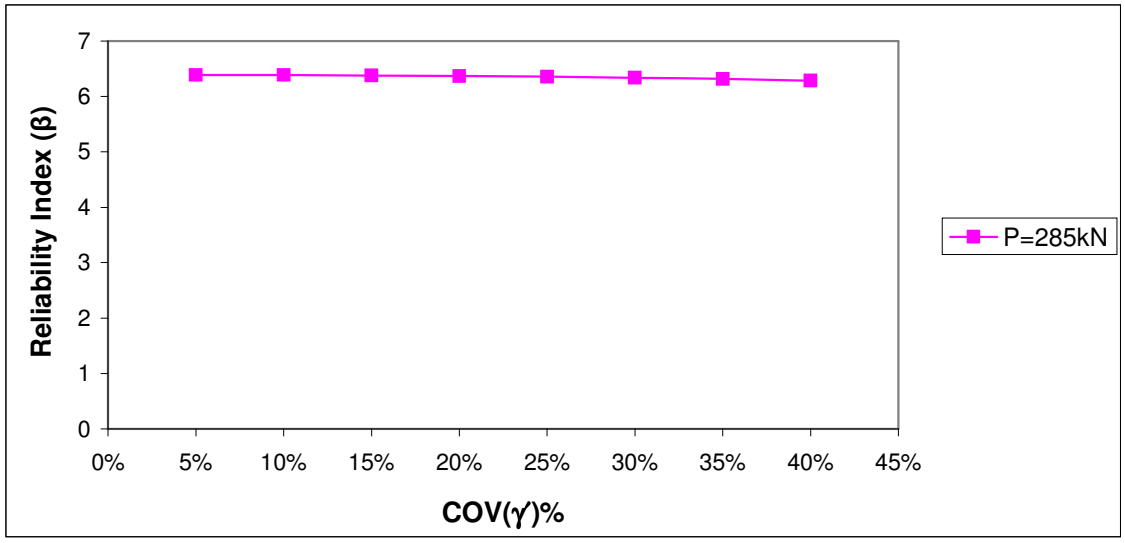


Fig. E.43 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 285kN.

Table E.67 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 530kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.65E-07	0.000225	5%	0.0150	5.8765
1.11E-06	0.000225	10%	0.0150	5.8655
2.54E-06	0.000225	15%	0.0151	5.8470
4.67E-06	0.000225	20%	0.0152	5.8200
7.54E-06	0.000225	25%	0.0152	5.7839
1.13E-05	0.000225	30%	0.0154	5.7378
1.62E-05	0.000225	35%	0.0155	5.6791
2.25E-05	0.000225	40%	0.0157	5.6067

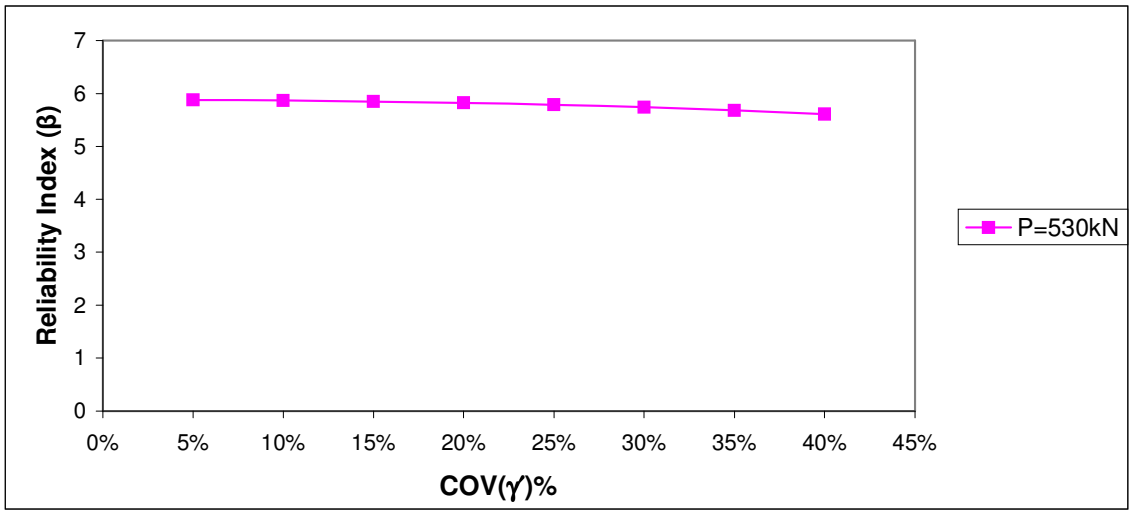


Fig. E.44 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.68 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D)and with varying 'γ' subjected to lateral load 775kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.01E-07	0.000225	5%	0.0150	5.2463
2.42E-06	0.000225	10%	0.0151	5.2253
5.66E-06	0.000225	15%	0.0152	5.1884
1.02E-05	0.000225	20%	0.0153	5.1377
1.66E-05	0.000225	25%	0.0155	5.0700
2.50E-05	0.000225	30%	0.0158	4.9837
3.62E-05	0.000225	35%	0.0162	4.8754
5.06E-05	0.000225	40%	0.0166	4.7464

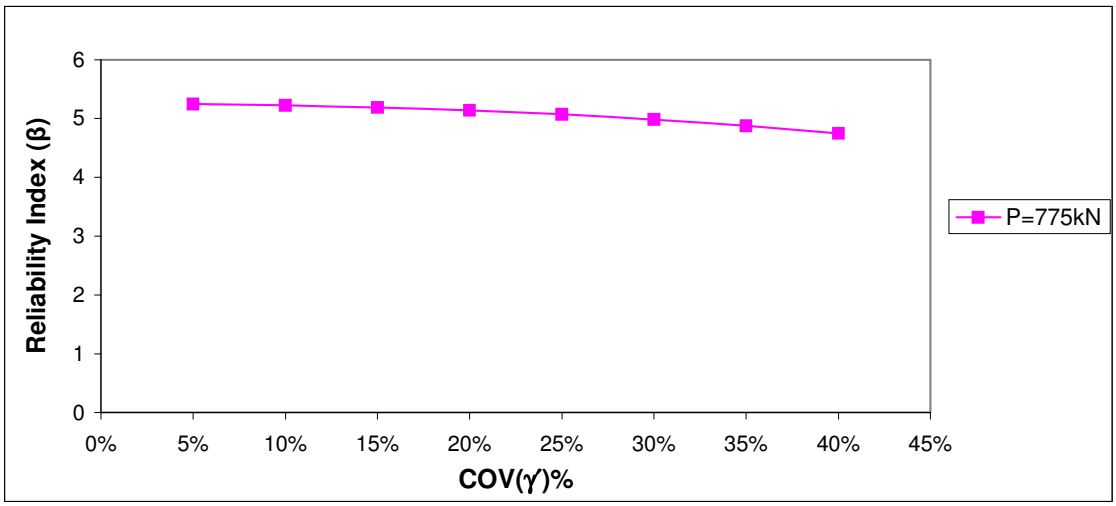


Fig. E.45 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.69 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.22E-06	0.000225	5%	0.0150	4.5011
4.82E-06	0.000225	10%	0.0152	4.4658
1.11E-05	0.000225	15%	0.0154	4.4064
2.06E-05	0.000225	20%	0.0157	4.3202
3.39E-05	0.000225	25%	0.0161	4.2072
5.14E-05	0.000225	30%	0.0166	4.0720
7.45E-05	0.000225	35%	0.0173	3.9121
1.06E-04	0.000225	40%	0.0182	3.7189

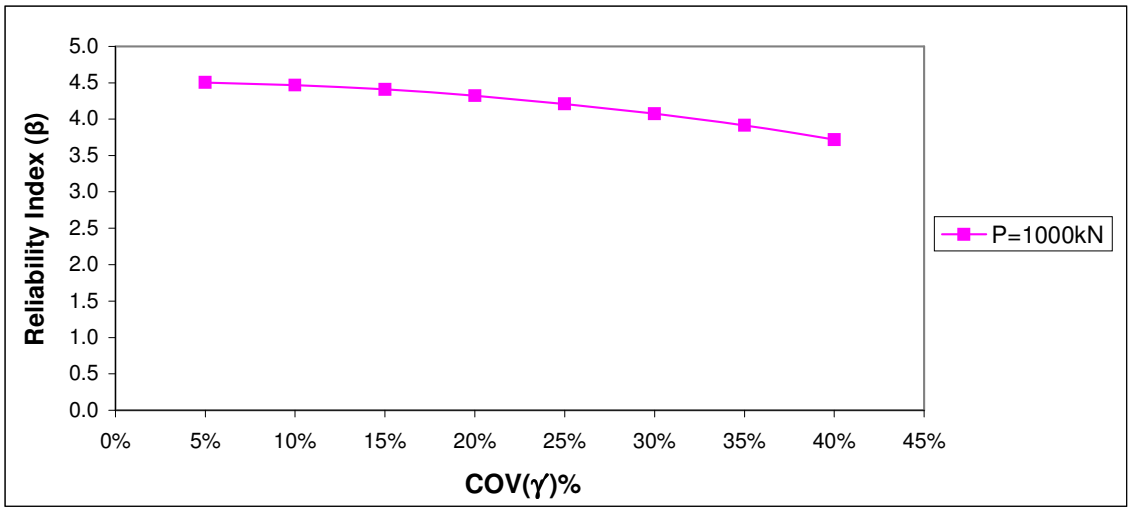


Fig. E.46 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.70 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D)and with varying 'γ' subjected to lateral load 1300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.25E-06	0.000225	5%	0.0151	3.6153
9.12E-06	0.000225	10%	0.0153	3.5619
2.22E-05	0.000225	15%	0.0157	3.4661
4.06E-05	0.000225	20%	0.0163	3.3439
6.51E-05	0.000225	25%	0.0170	3.1997
9.82E-05	0.000225	30%	0.0180	3.0315
1.46E-04	0.000225	35%	0.0193	2.8307
2.06E-04	0.000225	40%	0.0208	2.6245

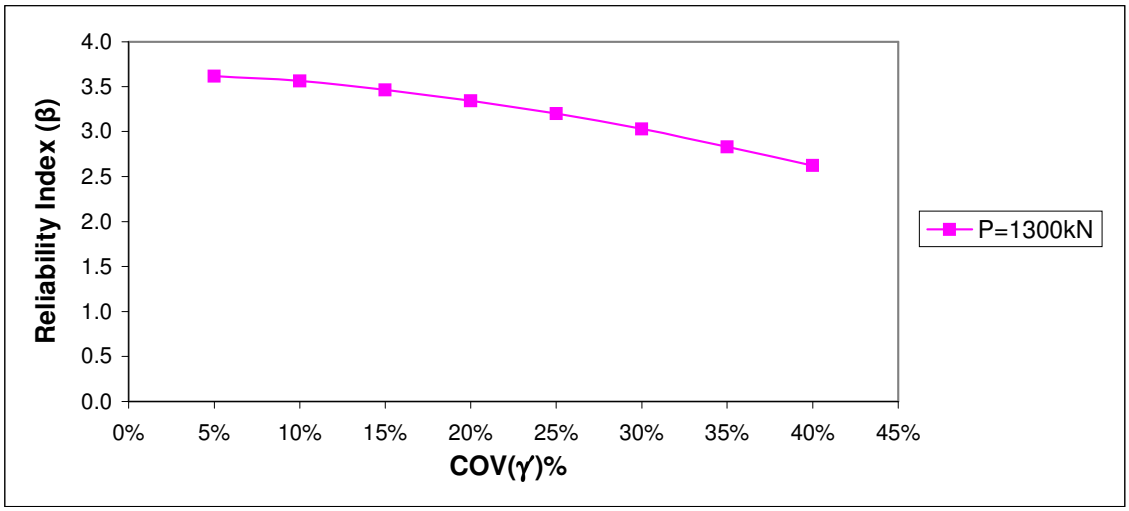


Fig. E.47 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 1300kN.

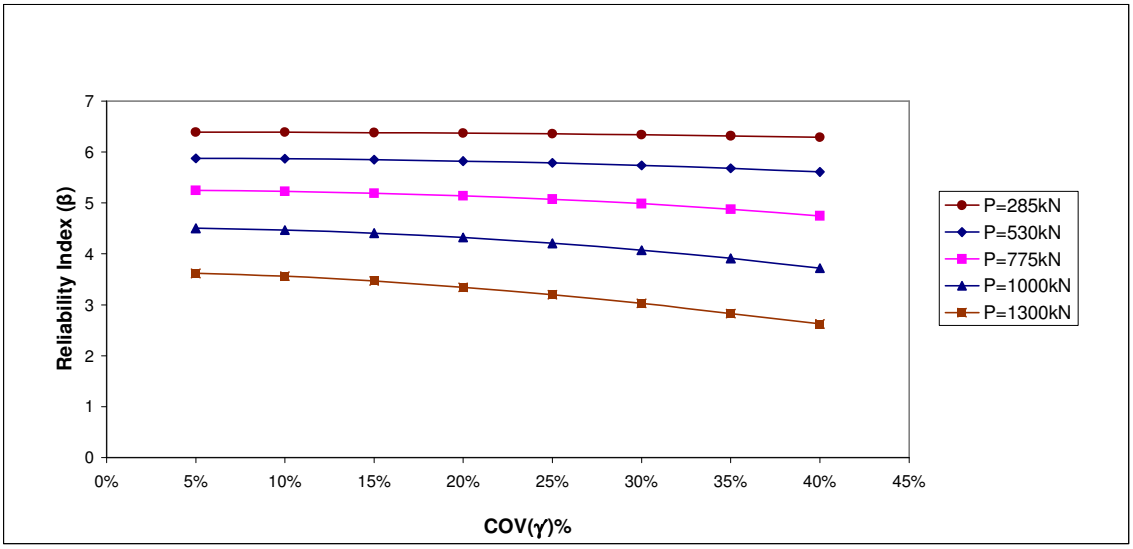


Fig. E.48 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table E.71 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 285kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.02E-09	0.000225	5%	0.0150	6.3913
3.48E-09	0.000225	10%	0.0150	6.3913
4.29E-09	0.000225	15%	0.0150	6.3913
1.30E-08	0.000225	20%	0.0150	6.3911
2.06E-08	0.000225	25%	0.0150	6.3910
3.01E-08	0.000225	30%	0.0150	6.3909
4.26E-08	0.000225	35%	0.0150	6.3907
7.00E-08	0.000225	40%	0.0150	6.3903

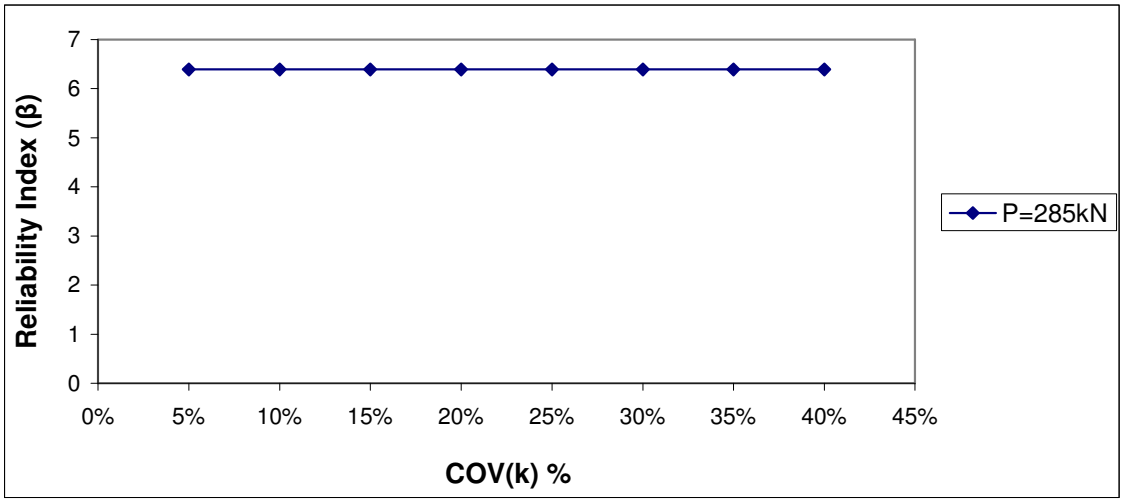


Fig. E.49 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 285kN.

Table E.72 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 530kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.60E-09	0.000225	5%	0.0150	5.8800
5.62E-09	0.000225	10%	0.0150	5.8799
7.23E-09	0.000225	15%	0.0150	5.8799
1.82E-08	0.000225	20%	0.0150	5.8798
3.06E-08	0.000225	25%	0.0150	5.8796
4.20E-08	0.000225	30%	0.0150	5.8795
6.00E-08	0.000225	35%	0.0150	5.8792
1.02E-07	0.000225	40%	0.0150	5.8787

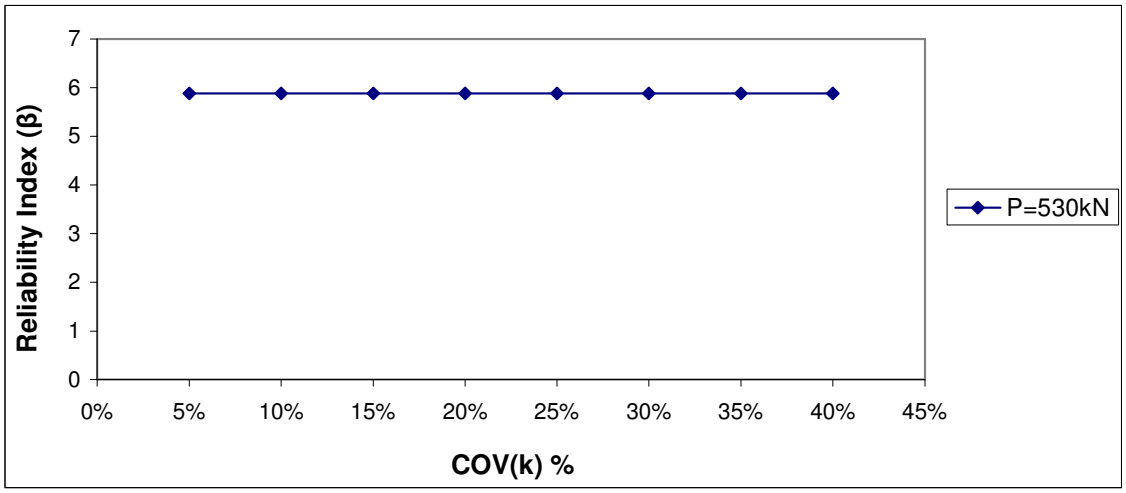


Fig. E.50 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.73 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D)and with varying 'k' subjected to lateral load 775kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.22E-09	0.000225	5%	0.0150	5.2533
5.63E-09	0.000225	10%	0.0150	5.2533
8.10E-09	0.000225	15%	0.0150	5.2532
2.10E-08	0.000225	20%	0.0150	5.2531
3.42E-08	0.000225	25%	0.0150	5.2529
6.00E-08	0.000225	30%	0.0150	5.2526
9.61E-08	0.000225	35%	0.0150	5.2522
1.44E-07	0.000225	40%	0.0150	5.2516

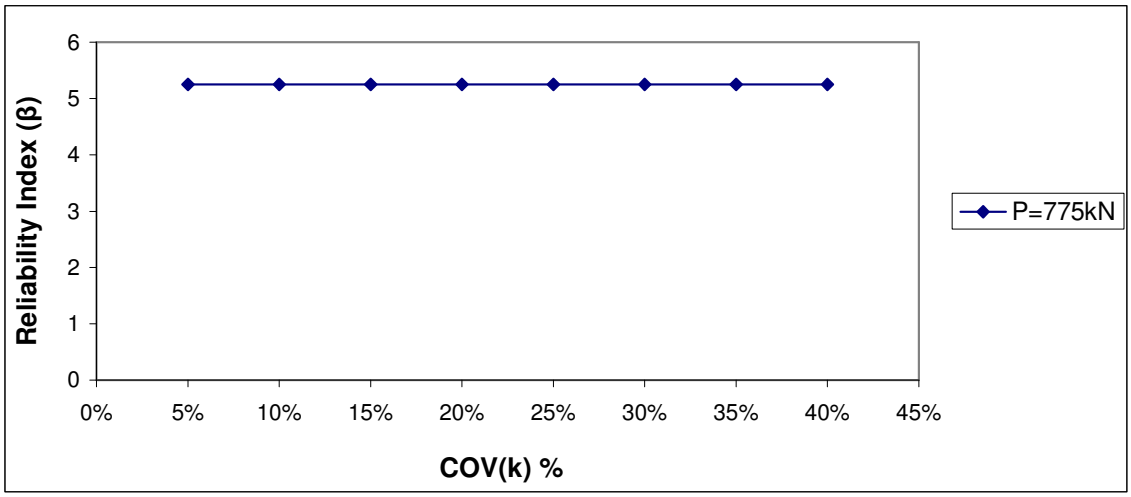


Fig. E.51 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.74 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D)and with varying 'k' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
9.00E-10	0.000225	5%	0.0150	4.5133
5.63E-09	0.000225	10%	0.0150	4.5133
8.10E-09	0.000225	15%	0.0150	4.5133
3.06E-08	0.000225	20%	0.0150	4.5130
5.52E-08	0.000225	25%	0.0150	4.5128
8.12E-08	0.000225	30%	0.0150	4.5125
1.19E-07	0.000225	35%	0.0150	4.5121
1.79E-05	0.000225	40%	0.0156	4.4900

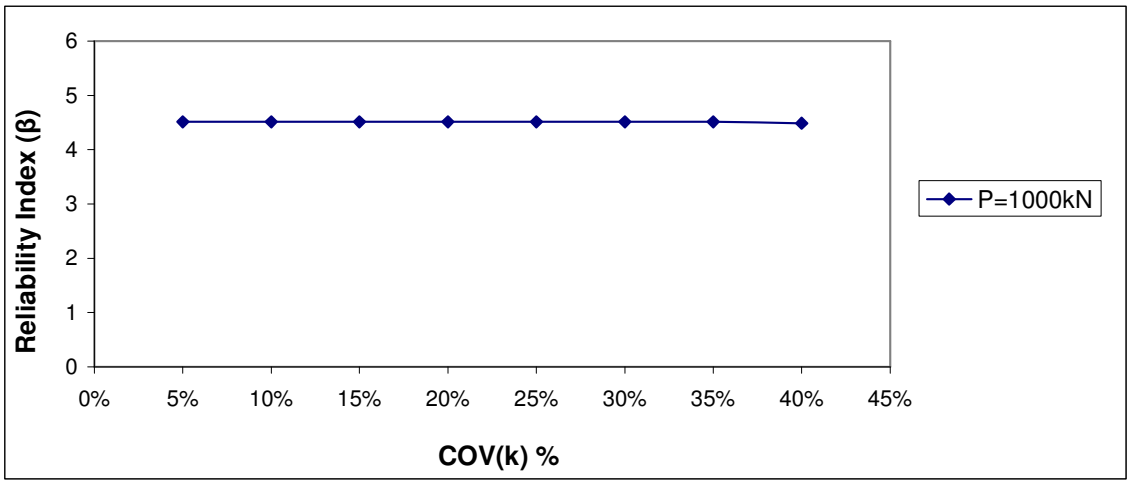


Fig. E.52 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.75 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 1300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.50E-09	0.000225	5%	0.0150	3.6333
1.10E-08	0.000225	10%	0.0150	3.6332
2.25E-08	0.000225	15%	0.0150	3.6332
4.20E-08	0.000225	20%	0.0150	3.6330
6.76E-08	0.000225	25%	0.0150	3.6328
1.19E-07	0.000225	30%	0.0150	3.6324
1.89E-07	0.000225	35%	0.0150	3.6318
2.86E-07	0.000225	40%	0.0150	3.6310

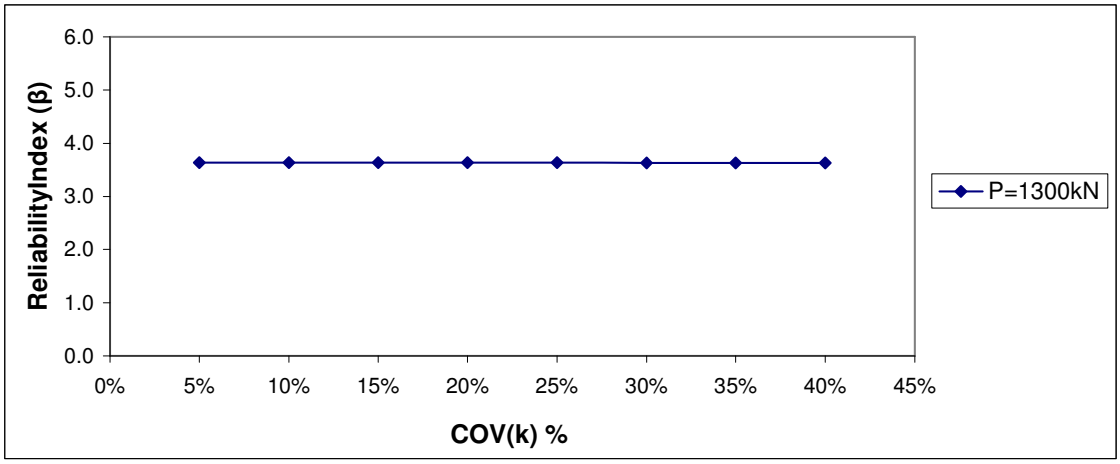


Fig. E.53 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 1300kN.

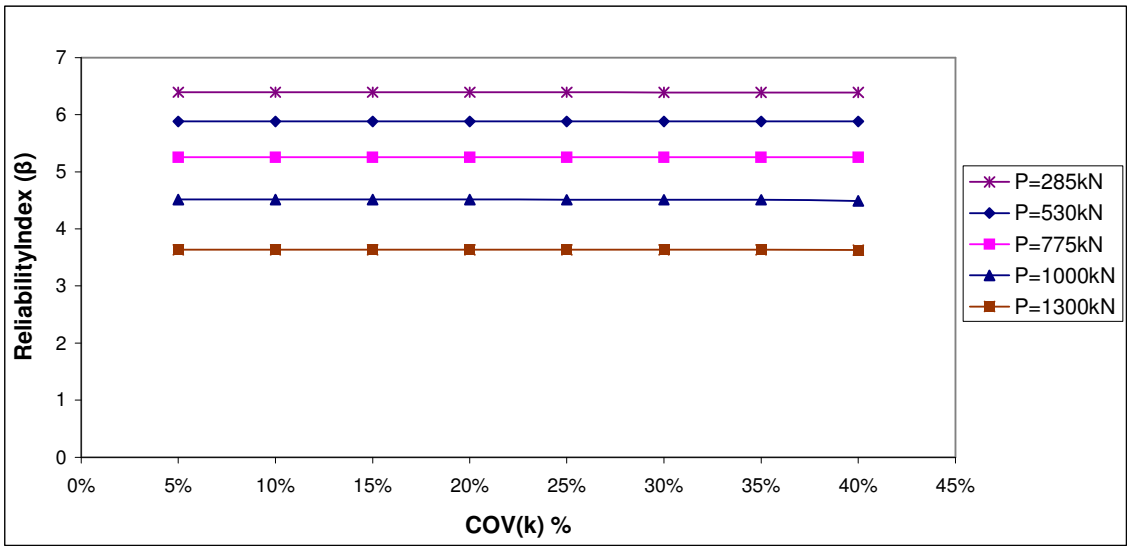


Fig. E.54 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table E.76 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 285kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.25E-10	0.000225	5%	0.0150	6.39132
4.23E-09	0.000225	10%	0.0150	6.39127
1.10E-08	0.000225	15%	0.0150	6.39118
7.23E-09	0.000225	20%	0.0150	6.39123
2.50E-09	0.000225	25%	0.0150	6.39130
1.00E-10	0.000225	30%	0.0150	6.39133
2.53E-11	0.000225	35%	0.0150	6.39133
6.25E-10	0.000225	40%	0.0150	6.39132

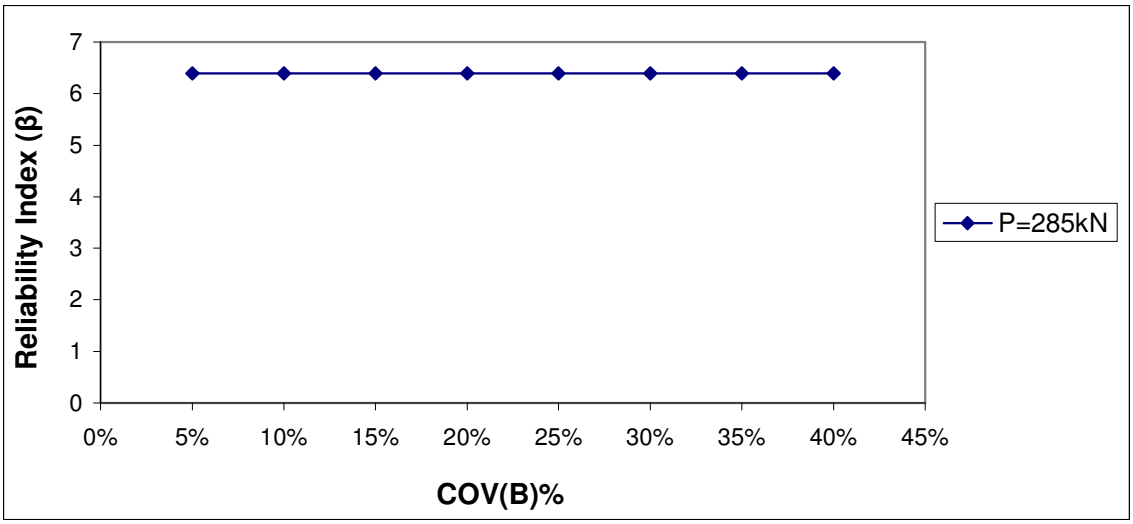


Fig. E.55 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 285kN.

Table E.77 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D)and with varying 'B' subjected to lateral load 530kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.60E-09	0.000225	5%	0.0150	5.87995
2.02E-09	0.000225	10%	0.0150	5.87997
2.50E-11	0.000225	15%	0.0150	5.88000
1.23E-09	0.000225	20%	0.0150	5.87998
6.25E-10	0.000225	25%	0.0150	5.87999
4.00E-10	0.000225	30%	0.0150	5.87999
6.33E-10	0.000225	35%	0.0150	5.87999
6.25E-10	0.000225	40%	0.0150	5.87999

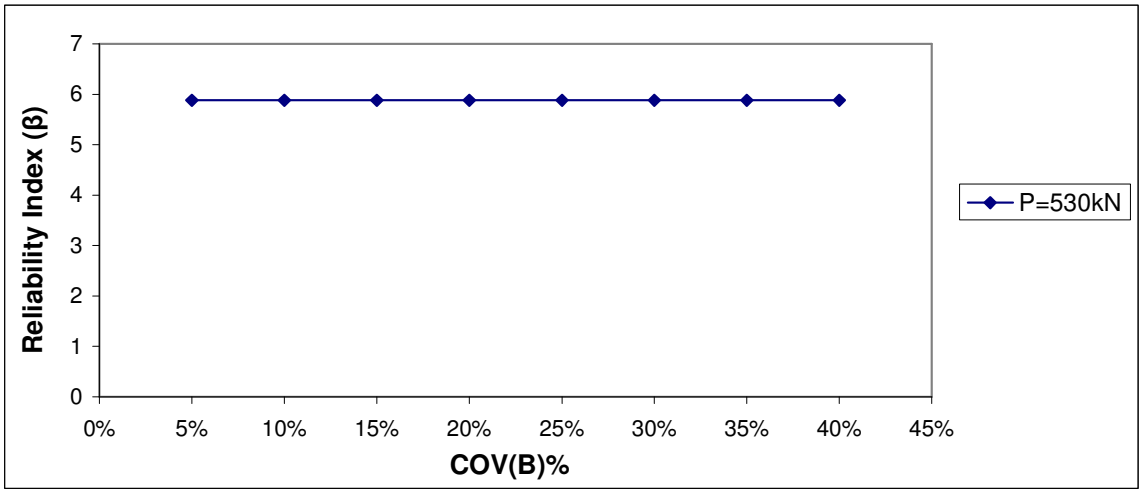


Fig. E.56 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.78 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 775kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.00E-10	0.000225	5%	0.0150	5.2533
2.50E-11	0.000225	10%	0.0150	5.2533
4.22E-09	0.000225	15%	0.0150	5.2533
1.69E-08	0.000225	20%	0.0150	5.2531
2.56E-08	0.000225	25%	0.0150	5.2530
3.80E-08	0.000225	30%	0.0150	5.2529
4.05E-08	0.000225	35%	0.0150	5.2529
9.61E-08	0.000225	40%	0.0150	5.2522

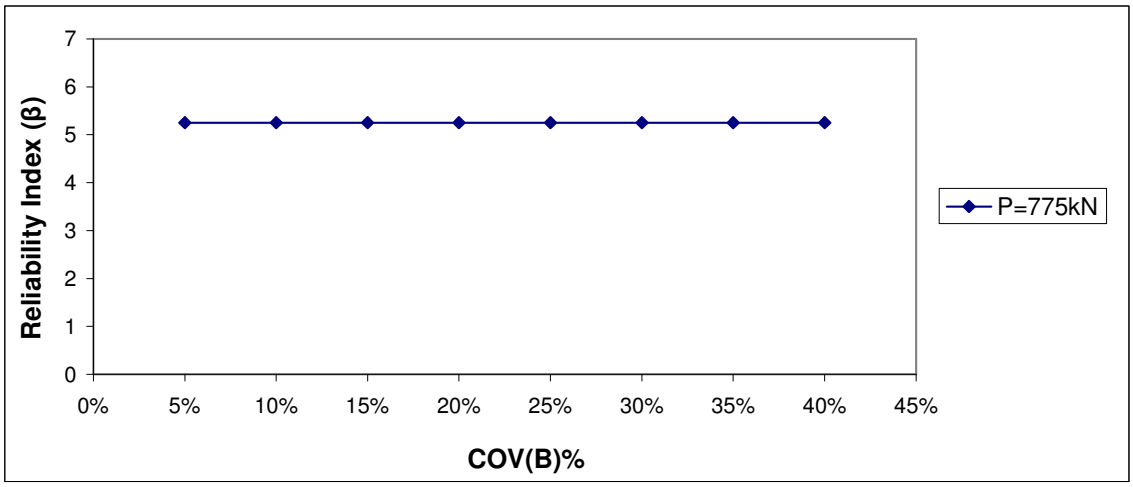


Fig. E.57 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.79 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
7.22E-09	0.000225	5%	0.01500	4.51326
1.82E-08	0.000225	10%	0.01500	4.5132
3.42E-08	0.000225	15%	0.01500	4.5130
4.84E-08	0.000225	20%	0.01500	4.5128
8.70E-08	0.000225	25%	0.01500	4.5125
1.26E-07	0.000225	30%	0.01500	4.5121
1.46E-07	0.000225	35%	0.01500	4.5119
1.64E-07	0.000225	40%	0.01501	4.5117

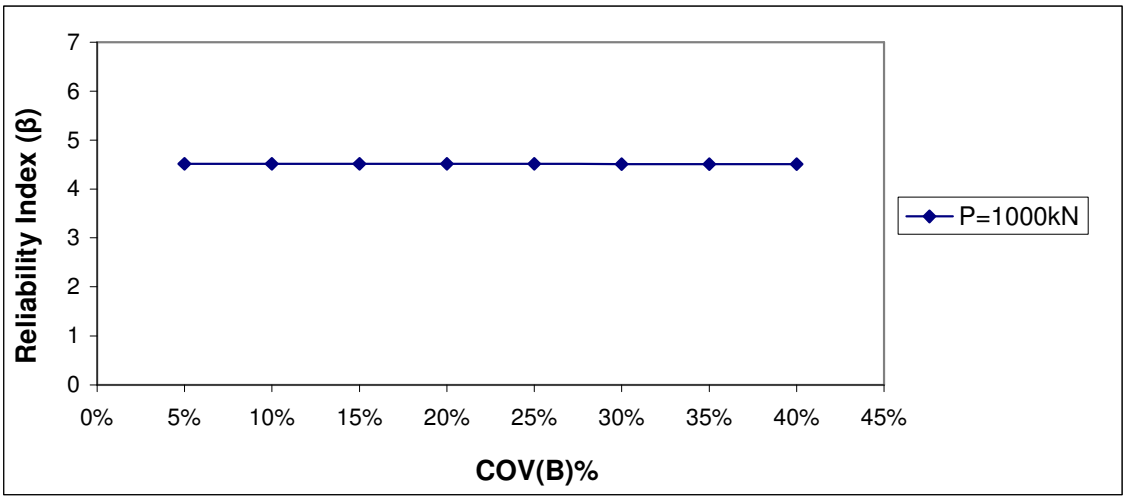


Fig. E.58 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.80 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 1300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.36E-08	0.000225	5%	0.0150	3.6332
4.41E-08	0.000225	10%	0.0150	3.6330
9.00E-08	0.000225	15%	0.0150	3.6326
1.45E-07	0.000225	20%	0.0150	3.6322
2.38E-07	0.000225	25%	0.0150	3.6314
3.40E-07	0.000225	30%	0.0150	3.6306
4.19E-07	0.000225	35%	0.0150	3.6300
4.92E-07	0.000225	40%	0.0150	3.6294

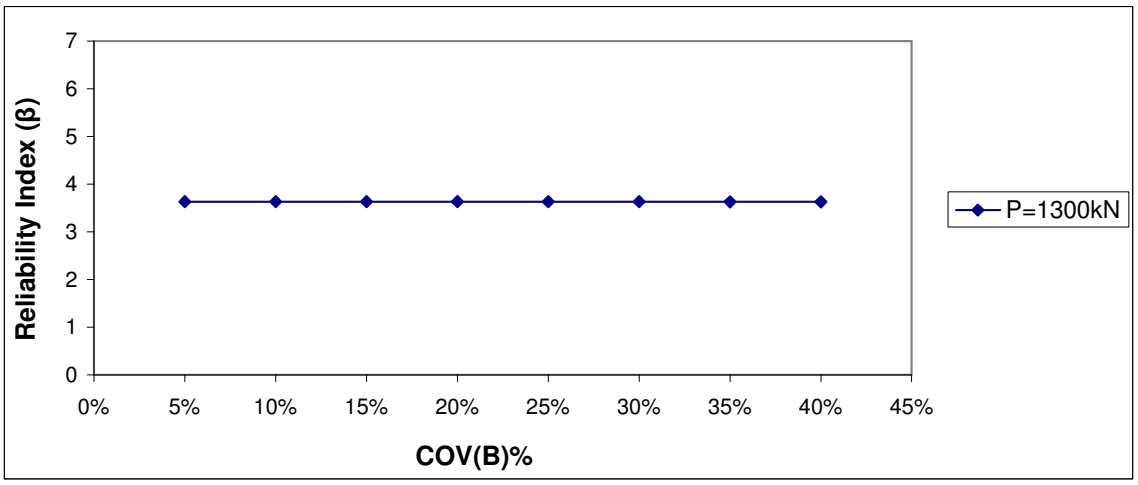


Fig. E.59 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 1300kN.

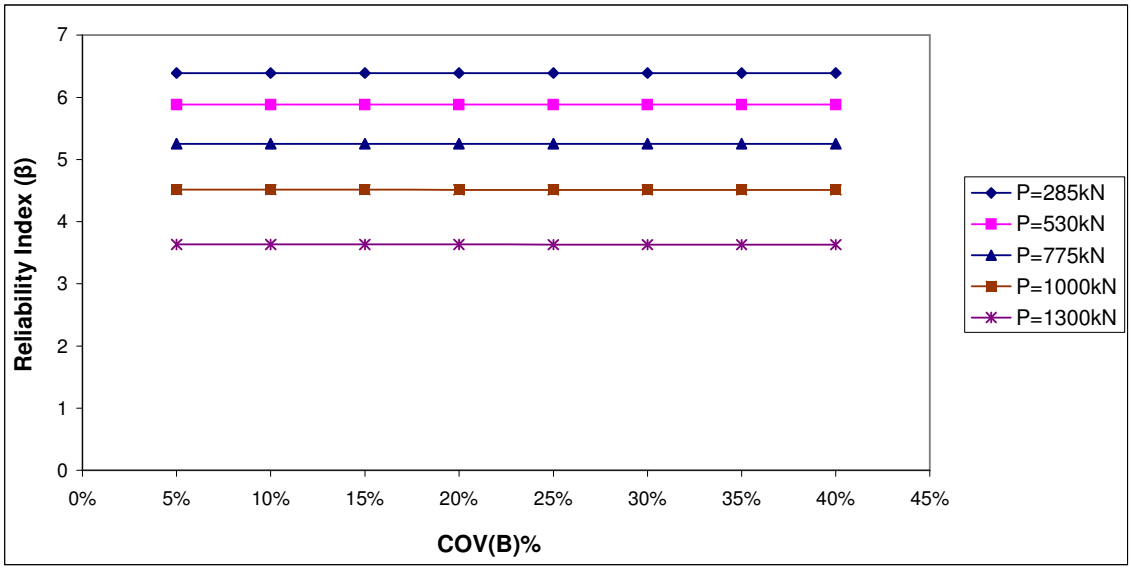


Fig. E. 60 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 1300kN.

Table E.81 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 285kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
7.05E-08	0.000225	5%	0.0150	6.4000
2.60E-07	0.000225	10%	0.0150	6.3876
5.98E-07	0.000225	15%	0.0150	6.3829
1.09E-06	0.000225	20%	0.0150	6.3759
1.77E-06	0.000225	25%	0.0151	6.3664
2.66E-06	0.000225	30%	0.0151	6.3538
3.83E-06	0.000225	35%	0.0151	6.3376
5.34E-06	0.000225	40%	0.0152	6.3168

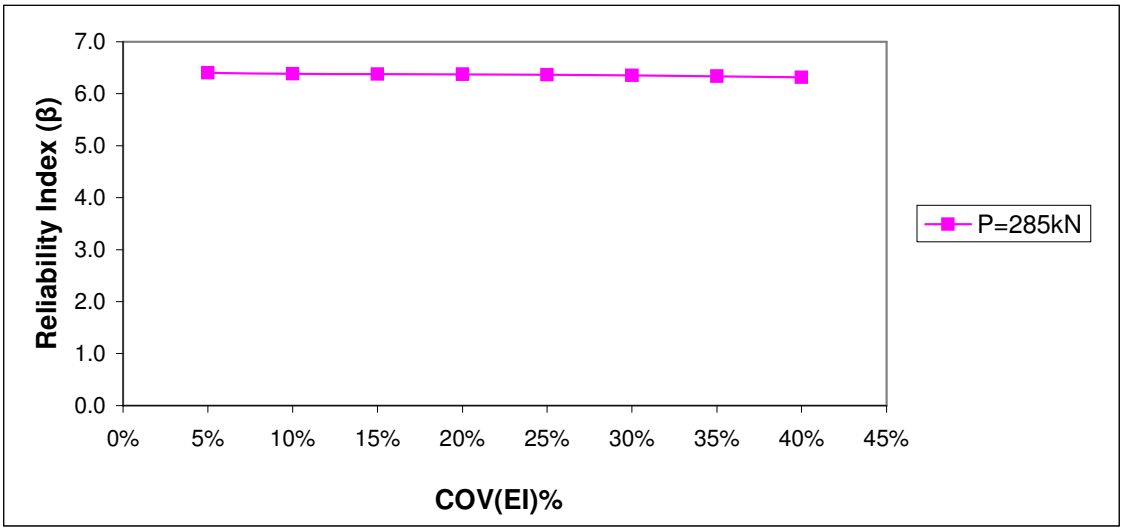


Fig. E. 61 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 285kN.

Table E.82 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 530kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.60E-07	0.000225	5%	0.0150	5.8779
8.74E-07	0.000225	10%	0.0150	5.8686
1.99E-06	0.000225	15%	0.0151	5.8542
3.65E-06	0.000225	20%	0.0151	5.8329
5.90E-06	0.000225	25%	0.0152	5.8043
8.85E-06	0.000225	30%	0.0153	5.7677
1.27E-05	0.000225	35%	0.0154	5.7202
1.78E-05	0.000225	40%	0.0156	5.6608

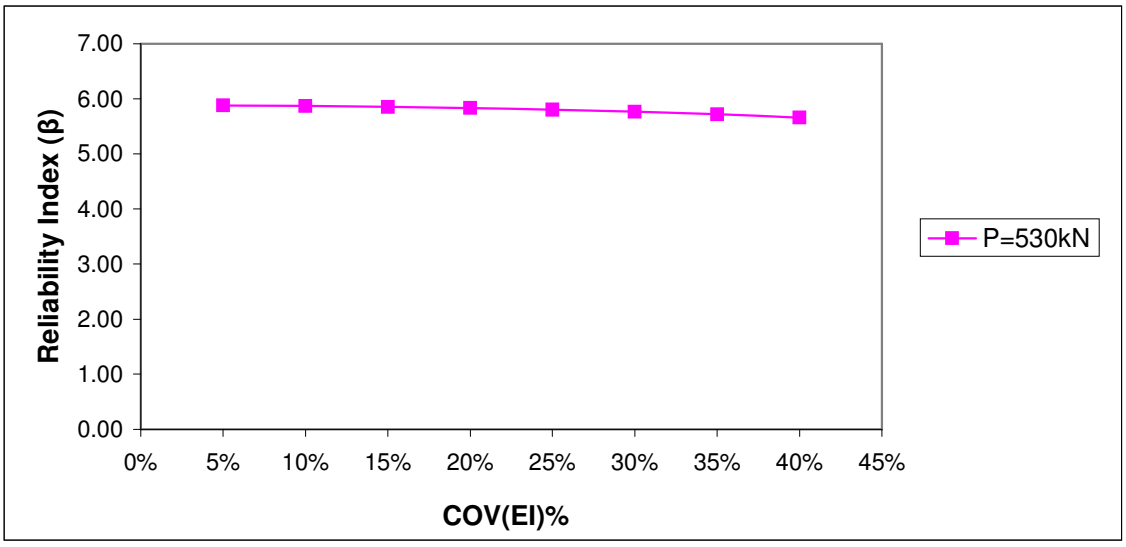


Fig. E. 62 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.83 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 775kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.54E-07	0.000225	5%	0.0150	5.2492
2.02E-06	0.000225	10%	0.0151	5.2300
4.67E-06	0.000225	15%	0.0152	5.1997
8.53E-06	0.000225	20%	0.0153	5.1565
1.38E-05	0.000225	25%	0.0155	5.0993
2.08E-05	0.000225	30%	0.0157	5.0262
3.01E-05	0.000225	35%	0.0160	4.9338
4.24E-05	0.000225	40%	0.0164	4.8185

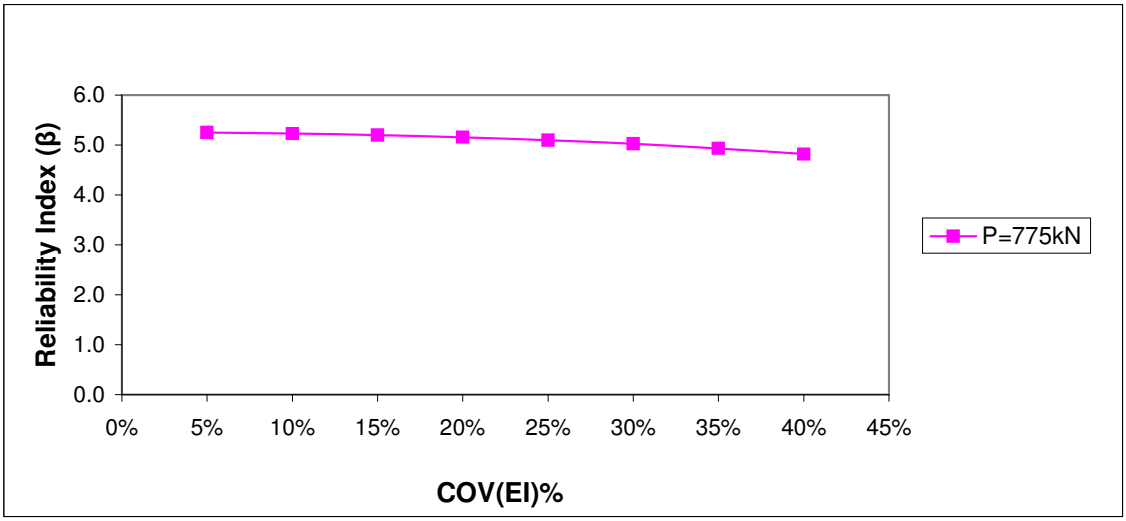


Fig. E. 63 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.84 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.73E-06	0.000225	5%	0.0151	4.4961
4.16E-06	0.000225	10%	0.0151	4.4722
9.52E-06	0.000225	15%	0.0153	4.4208
1.73E-05	0.000225	20%	0.0156	4.3488
2.85E-05	0.000225	25%	0.0159	4.2524
4.36E-05	0.000225	30%	0.0164	4.1306
6.36E-05	0.000225	35%	0.0170	3.9851
9.00E-05	0.000225	40%	0.0177	3.8147

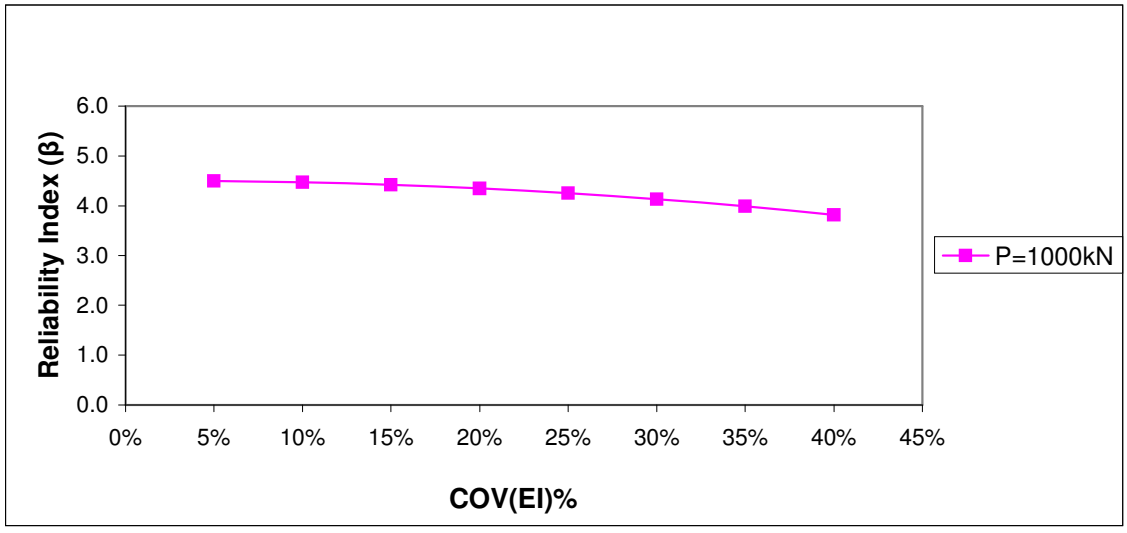


Fig. E. 64 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.85 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 1300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.00E-06	0.000225	5%	0.0151	3.6173
8.04E-06	0.000225	10%	0.0153	3.5701
1.84E-05	0.000225	15%	0.0156	3.4933
3.42E-05	0.000225	20%	0.0161	3.3850
5.67E-05	0.000225	25%	0.0168	3.2472
8.70E-05	0.000225	30%	0.0177	3.0852
1.27E-04	0.000225	35%	0.0188	2.9057
1.79E-04	0.000225	40%	0.0201	2.7109

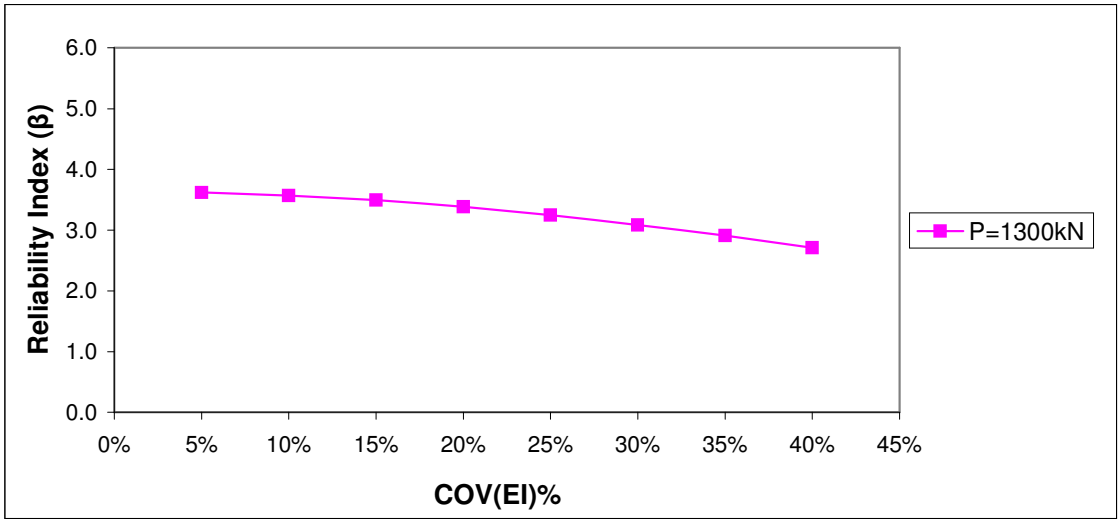


Fig. E. 65 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 1300kN.

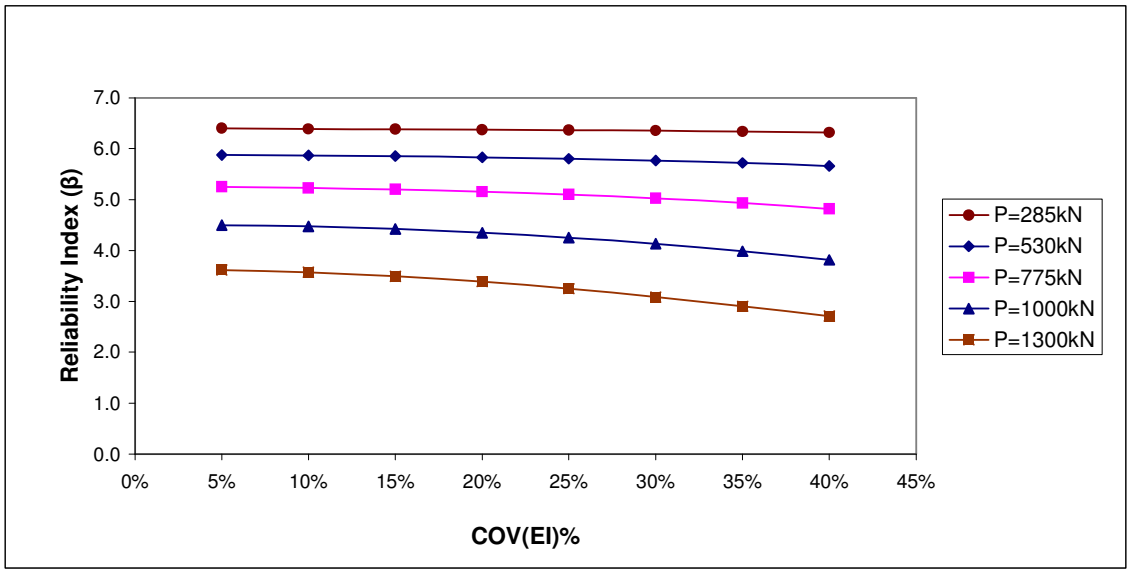


Fig. E. 66 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table E.86 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 285kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.36E-07	0.000225	5%	0.0150	6.3866
1.36E-06	0.000225	10%	0.0150	6.3721
3.08E-06	0.000225	15%	0.0151	6.3480
5.49E-06	0.000225	20%	0.0152	6.3148
8.57E-06	0.000225	25%	0.0153	6.2730
1.23E-05	0.000225	30%	0.0154	6.2231
1.66E-05	0.000225	35%	0.0155	6.1675
2.16E-05	0.000225	40%	0.0157	6.1052

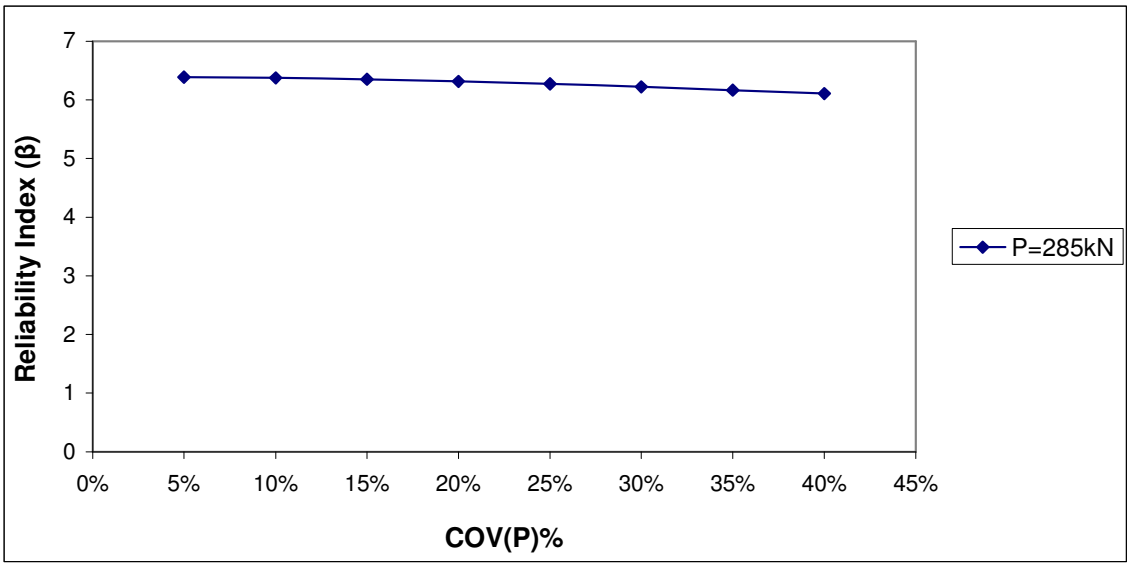


Fig. E. 67 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 285kN.

Table E.87 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 530kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.03E-06	0.000225	5%	0.0150	5.8666
4.18E-06	0.000225	10%	0.0151	5.8261
9.46E-06	0.000225	15%	0.0153	5.7602
1.68E-05	0.000225	20%	0.0156	5.6719
2.63E-05	0.000225	25%	0.0159	5.5637
3.79E-05	0.000225	30%	0.0162	5.4402
5.13E-05	0.000225	35%	0.0166	5.3065
6.67E-05	0.000225	40%	0.0171	5.1642

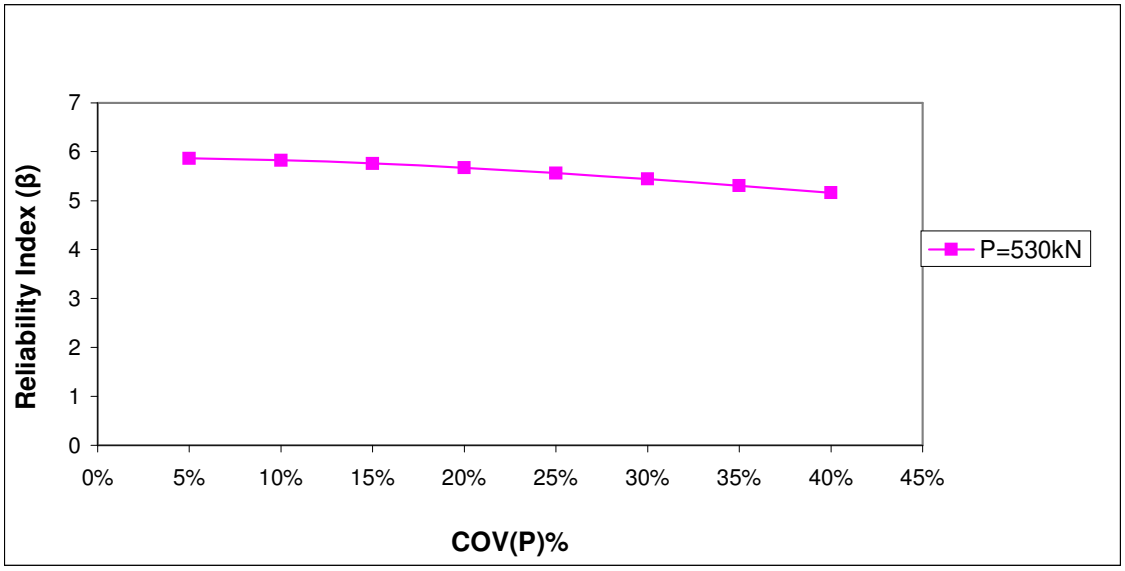


Fig. E. 68 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.88 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 775kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.34E-06	0.000225	5%	0.0151	5.2262
9.36E-06	0.000225	10%	0.0153	5.1473
2.09E-05	0.000225	15%	0.0157	5.0248
3.75E-05	0.000225	20%	0.0162	4.8635
5.90E-05	0.000225	25%	0.0169	4.6761
8.51E-05	0.000225	30%	0.0176	4.4748
1.16E-04	0.000225	35%	0.0185	4.2680
1.53E-04	0.000225	40%	0.0194	4.0536

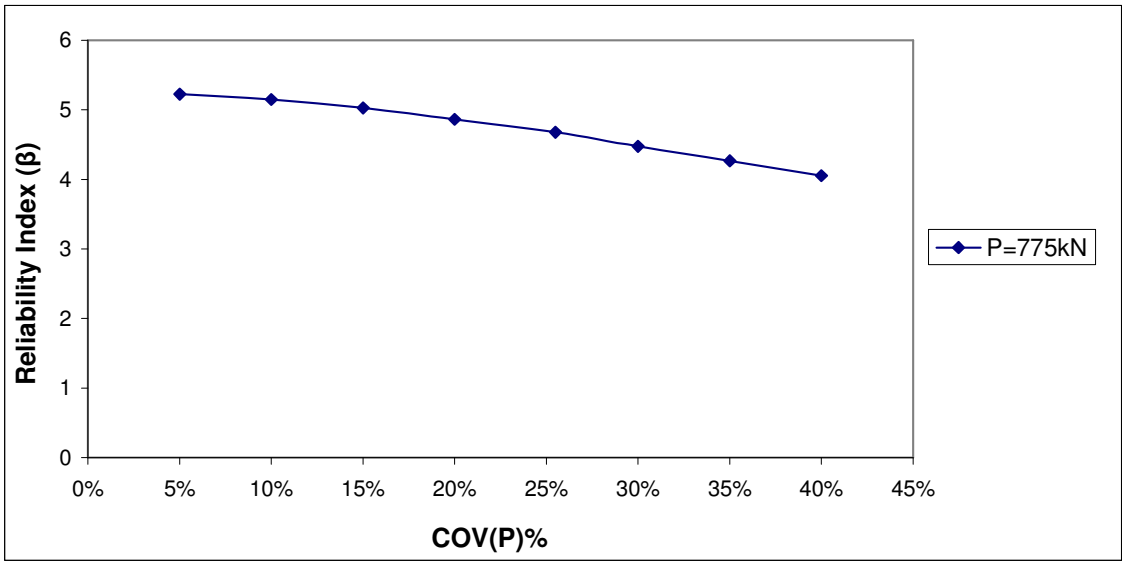


Fig. E. 69 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.89 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.75E-06	0.000225	5%	0.0152	4.4664
1.87E-05	0.000225	10%	0.0156	4.3367
4.27E-05	0.000225	15%	0.0164	4.1377
7.67E-05	0.000225	20%	0.0174	3.8980
1.20E-04	0.000225	25%	0.0186	3.6471
1.73E-04	0.000225	30%	0.0200	3.3916
2.39E-04	0.000225	35%	0.0215	3.1423
3.15E-04	0.000225	40%	0.0232	2.9137

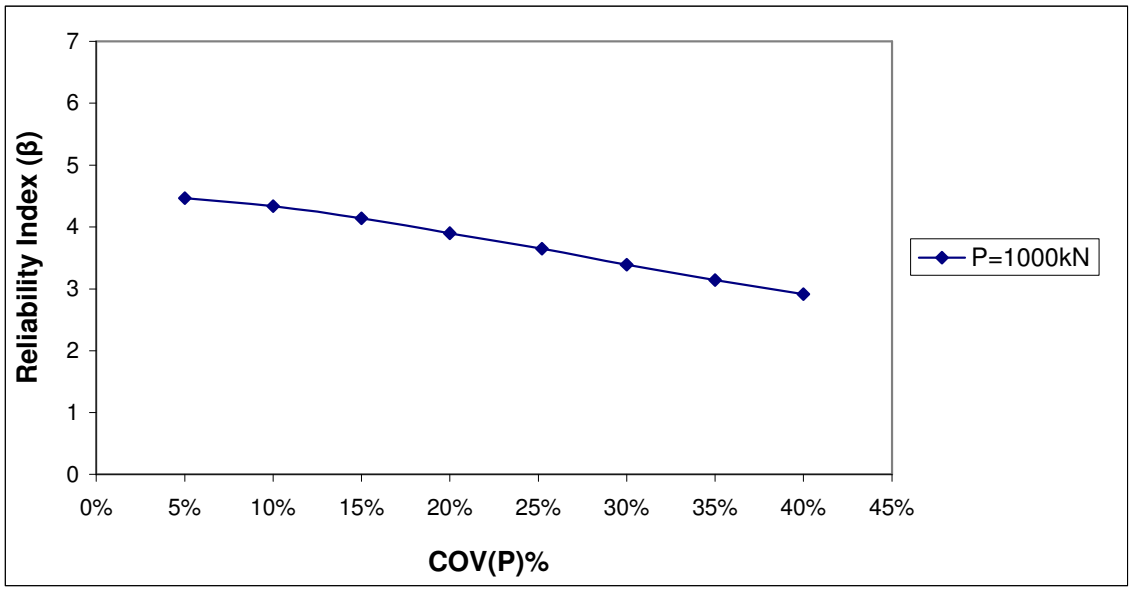


Fig. E. 70 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.90 Reliability Index (β) connected to Y_{TOP} for free head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 1300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
8.88E-06	0.000225	5%	0.0153	3.5637
3.66E-05	0.000225	10%	0.0162	3.3696
8.20E-05	0.000225	15%	0.0175	3.1105
1.46E-04	0.000225	20%	0.0193	2.8293
2.27E-04	0.000225	25%	0.0213	2.5632
3.32E-04	0.000225	30%	0.0236	2.3097
4.56E-04	0.000225	35%	0.0261	2.0877
6.00E-04	0.000225	40%	0.0287	1.8980

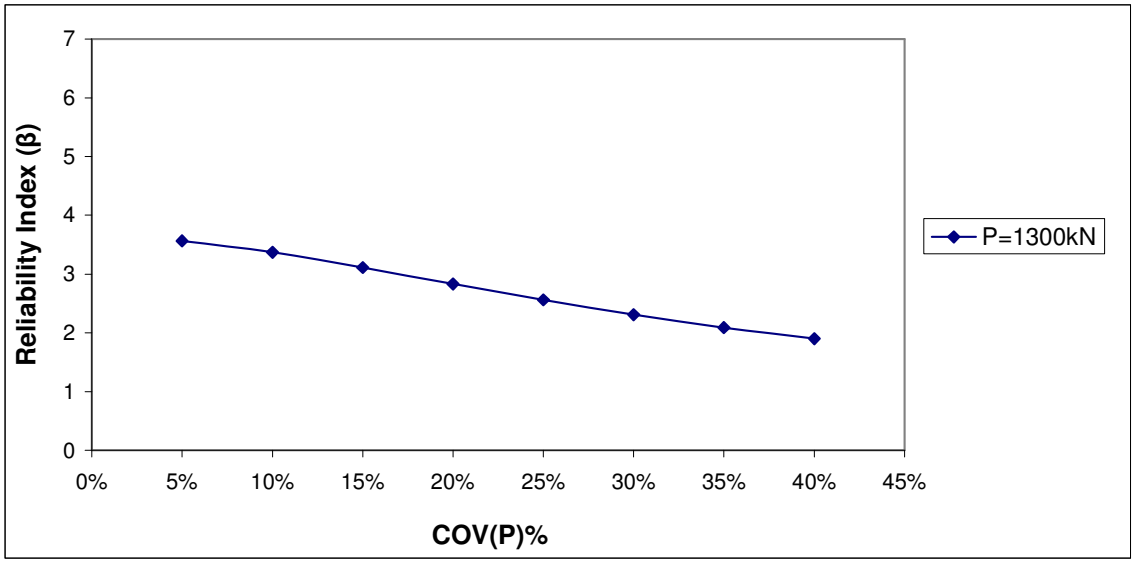


Fig. E. 71 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 1300kN.

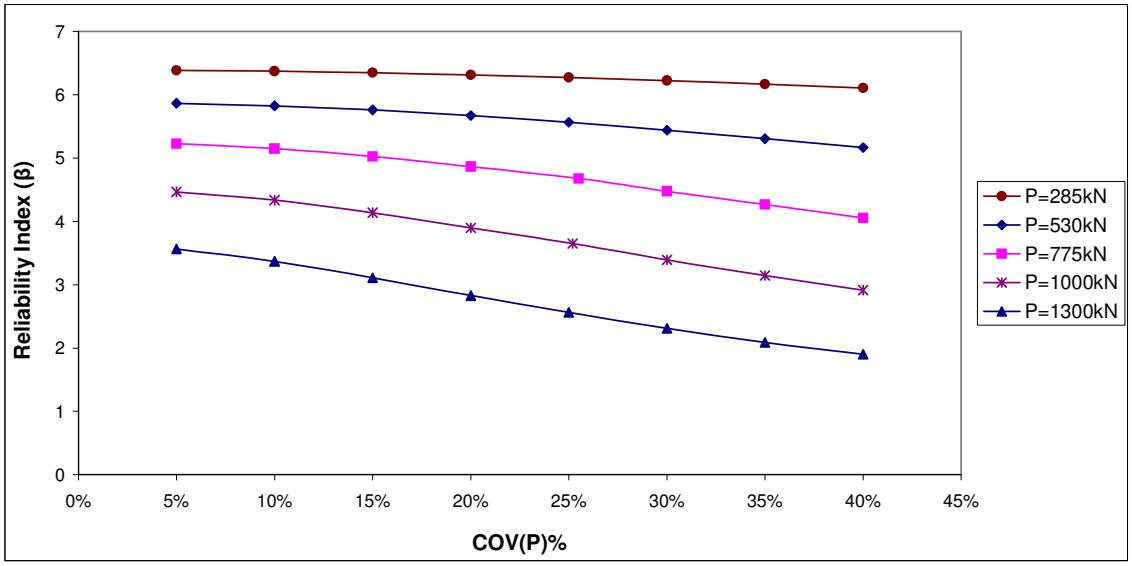


Fig. E. 72 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force of discrete variability.

E.3 Probability of failure, $p_f(Y_{TOP})$ of top deflection vs. COV (Variables).

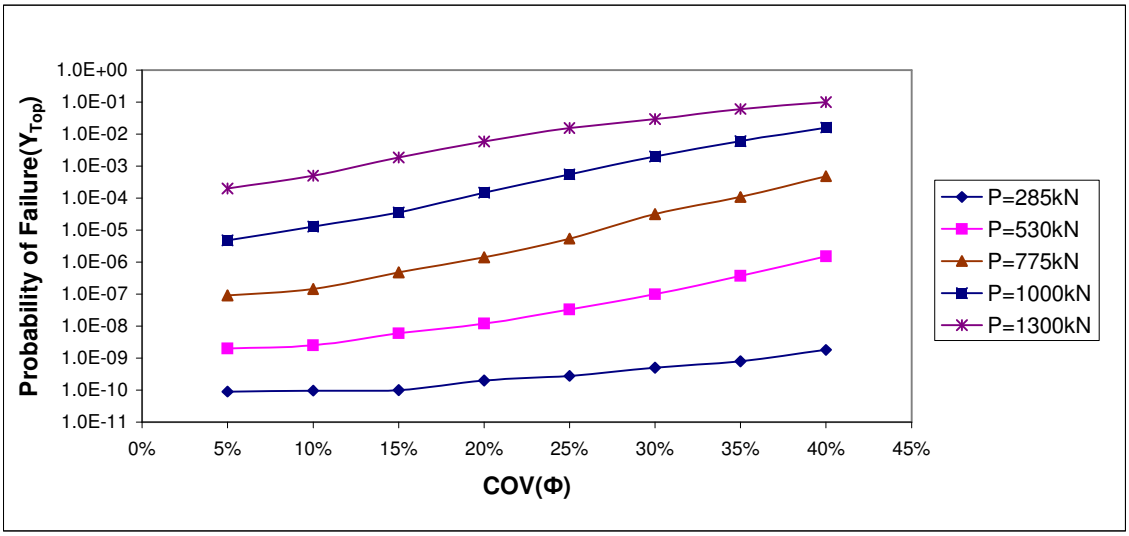


Fig. E.73 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (Φ) for free head long pile group of length 10T.

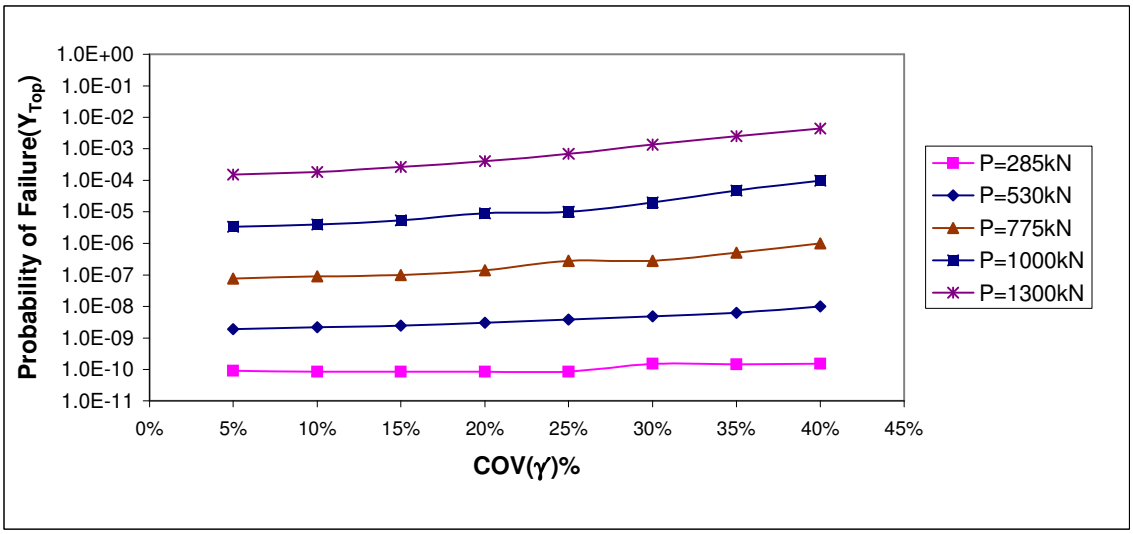


Fig. E.74 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (γ) for free head long pile group of length 10T.

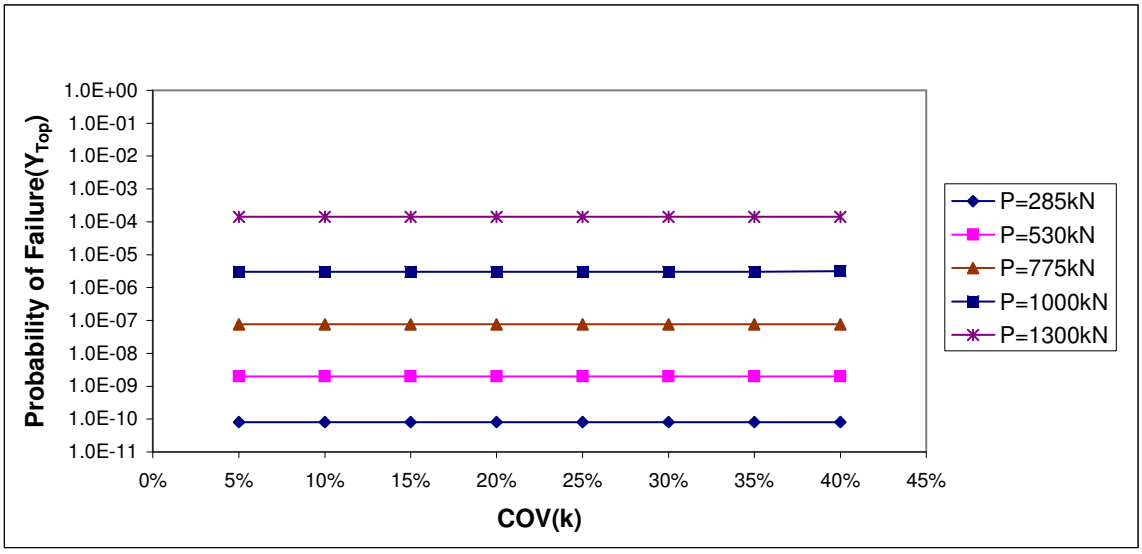


Fig. E.75 Probability of failure of top deflection p_f (Y_{TOP}) vs. COV (k) for free head long pile group of length 10T.

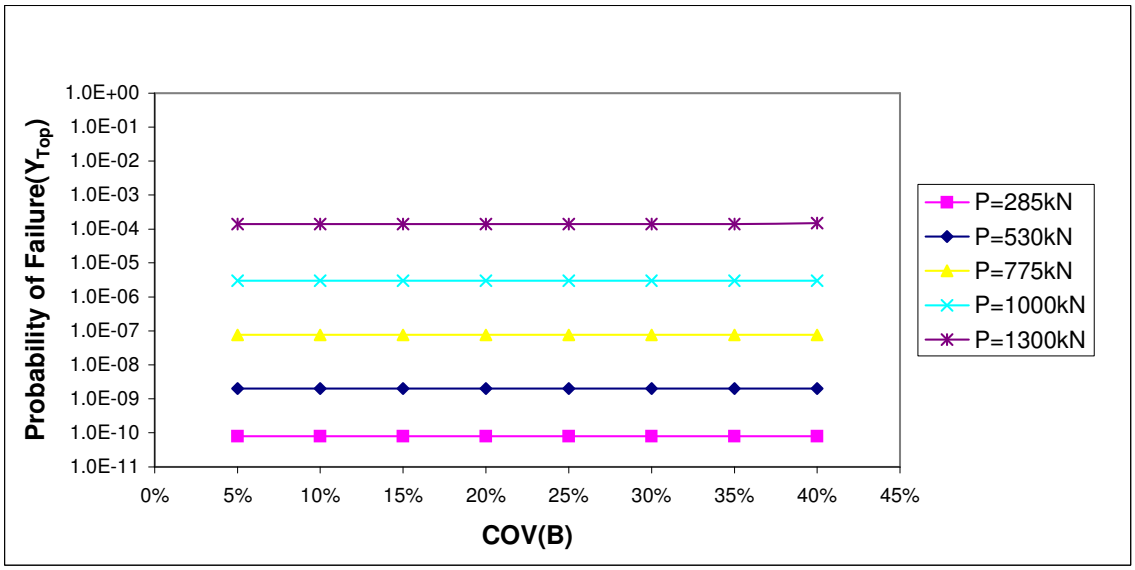


Fig. E.76 Probability of failure of top deflection p_f (Y_{TOP}) vs. COV (B) for free head long pile group of length 10T.

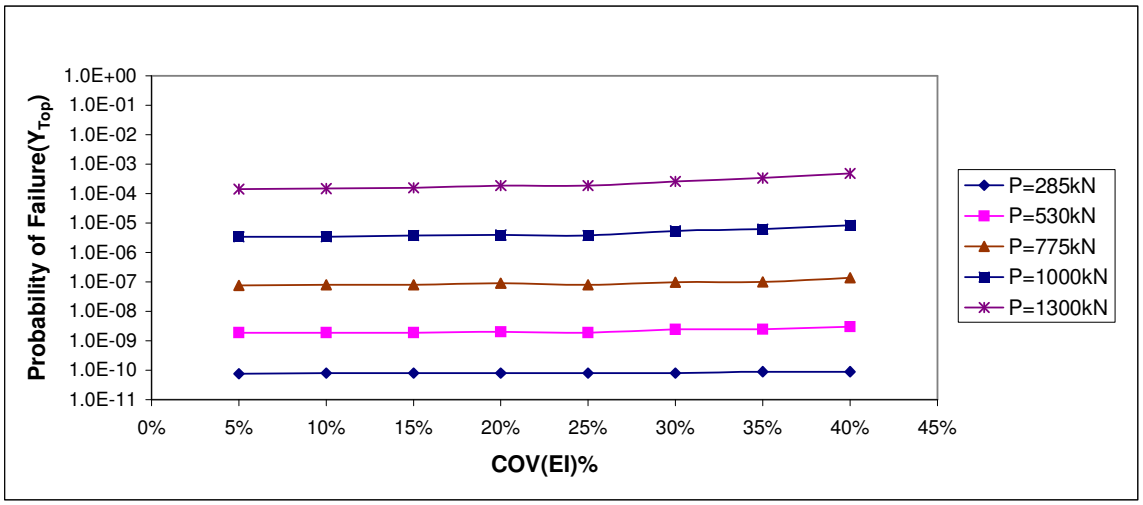


Fig. E.77 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (EI) for free head long pile group of length 10T.

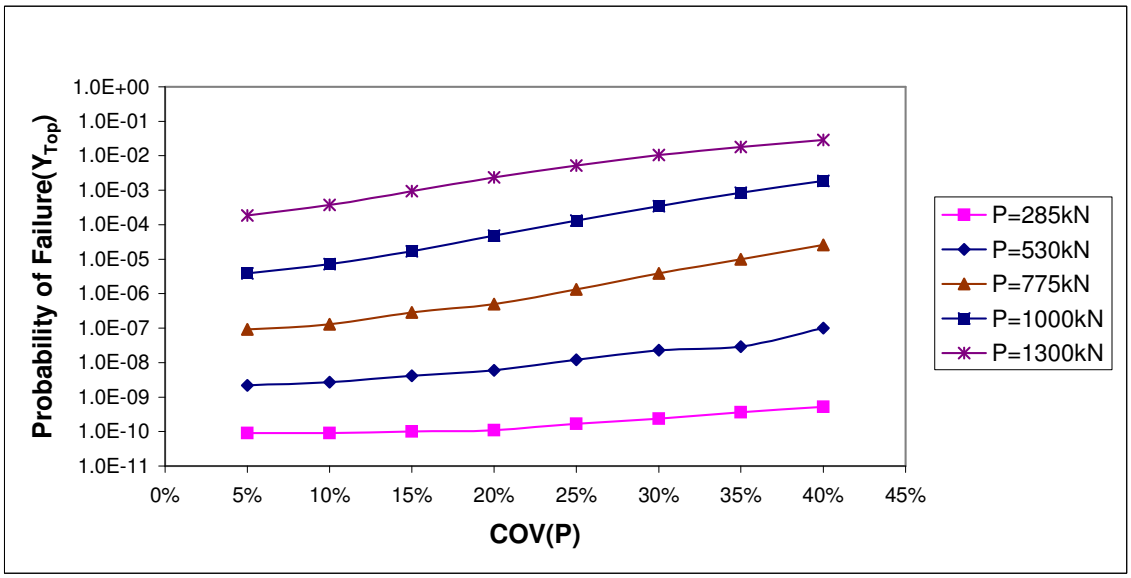


Fig. C.78 Probability of failure of top deflection $p_f(Y_{TOP})$ vs. COV (P) for free head long pile group of length 10T.

E. 4 Moment of free head long pile group and coefficient of (M_{max}) vs. COV (Variables).

Table E.91 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (Φ) and load 285kN.

P=285kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	6.63E+01				
5%	30			2.25E+00	8.47E+00	6.39E+01	3.16%
		28.5	7.21E+01				
		33	6.33E+01				
10%	30			9.00E+00	3.26E+01	6.39E+01	6.38%
		27	7.47E+01				
		34.5	6.11E+01				
15%	30			2.03E+01	6.70E+01	6.39E+01	9.84%
		25.5	7.74E+01				
		36	5.86E+01				
20%	30			3.60E+01	1.24E+02	6.39E+01	13.17%
		24	8.08E+01				
		37.5	5.57E+01				
25%	30			5.63E+01	1.98E+02	6.39E+01	17.12%
		22.5	8.39E+01				
		39	5.33E+01				
30%	30			8.10E+01	2.82E+02	6.39E+01	21.17%
		21	8.69E+01				
		40.5	5.19E+01				
35%	30			1.10E+02	3.58E+02	6.39E+01	25.59%
		19.5	8.97E+01				
		42	5.05E+01				
40%	30			1.44E+02	4.56E+02	6.39E+01	29.46%
		18	9.33E+01				

Table E.92 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (Φ) and load 530kN.

P=530kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	1.10E+02				
5%	30			2.25E+00	1.33E+01	1.08E+02	3.65%
		28.5	1.18E+02				
		33	1.06E+02				
10%	30			9.00E+00	6.40E+01	1.08E+02	7.16%
		27	1.22E+02				
		34.5	1.02E+02				
15%	30			2.03E+01	1.53E+02	1.08E+02	10.36%
		25.5	1.27E+02				
		36	9.73E+01				
20%	30			3.60E+01	2.81E+02	1.08E+02	14.00%
		24	1.31E+02				
		37.5	9.40E+01				
25%	30			5.63E+01	4.14E+02	1.08E+02	18.11%
		22.5	1.35E+02				
		39	9.03E+01				
30%	30			8.10E+01	6.10E+02	1.08E+02	22.16%
		21	1.40E+02				
		40.5	8.62E+01				
35%	30			1.10E+02	8.69E+02	1.08E+02	26.40%
		19.5	1.45E+02				
		42	8.18E+01				
40%	30			1.44E+02	1.18E+03	1.08E+02	30.63%
		18	1.50E+02				

Table E.93 Probabilistic modeling of laterally loaded free head long (10T) pile group with

spacing (5D) with varying (Φ) and load 775kN.

P=775kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	1.55E+02				
5%	30			2.25E+00	3.31E+01	1.54E+02	3.73%
		28.5	1.67E+02				
		33	1.50E+02				
10%	30			9.00E+00	1.19E+02	1.54E+02	7.08%
		27	1.72E+02				
		34.5	1.46E+02				
15%	30			2.03E+01	2.61E+02	1.54E+02	10.49%
		25.5	1.78E+02				
		36	1.40E+02				
20%	30			3.60E+01	4.67E+02	1.54E+02	14.03%
		24	1.83E+02				
		37.5	1.34E+02				
25%	30			5.63E+01	8.12E+02	1.54E+02	18.20%
		22.5	1.91E+02				
		39	1.29E+02				
30%	30			8.10E+01	1.23E+03	1.54E+02	22.34%
		21	1.99E+02				
		40.5	1.25E+02				
35%	30			1.10E+02	1.71E+03	1.54E+02	26.85%
		19.5	2.07E+02				
		42	1.19E+02				
40%	30			1.44E+02	2.37E+03	1.54E+02	31.62%
		18	2.17E+02				

Table E.94 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (Φ) and load 1000kN.

P=1000kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	2.03E+02				
5%	30			2.25E+00	5.93E+01	2.11E+02	3.38%
		28.5	2.18E+02				
		33	1.96E+02				
10%	30			9.00E+00	2.28E+02	2.11E+02	7.41%
		27	2.26E+02				
		34.5	1.90E+02				
15%	30			2.03E+01	4.77E+02	2.11E+02	11.44%
		25.5	2.33E+02				
		36	1.84E+02				
20%	30			3.60E+01	9.24E+02	2.11E+02	15.52%
		24	2.45E+02				
		37.5	1.77E+02				
25%	30			5.63E+01	1.53E+03	2.11E+02	19.82%
		22.5	2.55E+02				
		39	1.70E+02				
30%	30			8.10E+01	2.32E+03	2.11E+02	24.00%
		21	2.66E+02				
		40.5	1.63E+02				
35%	30			1.10E+02	3.36E+03	2.11E+02	28.00%
		19.5	2.79E+02				
		42	1.58E+02				
40%	30			1.44E+02	4.64E+03	2.11E+02	32.43%
		18	2.94E+02				

Table E.95 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (Φ) and load 1300kN.

P=1300kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	2.54E+02				
5%	30			2.25E+00	9.90E+01	3.15E+02	4.55%
		28.5	2.74E+02				
		33	2.44E+02				
10%	30			9.00E+00	4.04E+02	3.15E+02	8.94%
		27	2.85E+02				
		34.5	2.36E+02				
15%	30			2.03E+01	9.61E+02	3.15E+02	12.81%
		25.5	2.98E+02				
		36	2.29E+02				
20%	30			3.60E+01	1.72E+03	3.15E+02	17.42%
		24	3.12E+02				
		37.5	2.21E+02				
25%	30			5.63E+01	2.70E+03	3.15E+02	21.44%
		22.5	3.25E+02				
		39	2.12E+02				
30%	30			8.10E+01	4.15E+03	3.15E+02	26.28%
		21	3.41E+02				
		40.5	2.03E+02				
35%	30			1.10E+02	6.03E+03	3.15E+02	30.80%
		19.5	3.59E+02				
		42	1.96E+02				
40%	30			1.44E+02	8.16E+03	3.15E+02	34.30%
		18	3.77E+02				

Table E.96 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 285kN.

P=285kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) (kN-m)^2	COV(M_{max}) (%)
5%	2.25E+00	8.47E+00	3.16%
10%	9.00E+00	3.26E+01	6.38%
15%	2.03E+01	6.70E+01	9.84%
20%	3.60E+01	1.24E+02	13.17%
25%	5.63E+01	1.98E+02	17.12%
30%	8.10E+01	2.82E+02	21.17%
35%	1.10E+02	3.58E+02	25.59%
40%	1.44E+02	4.56E+02	29.46%

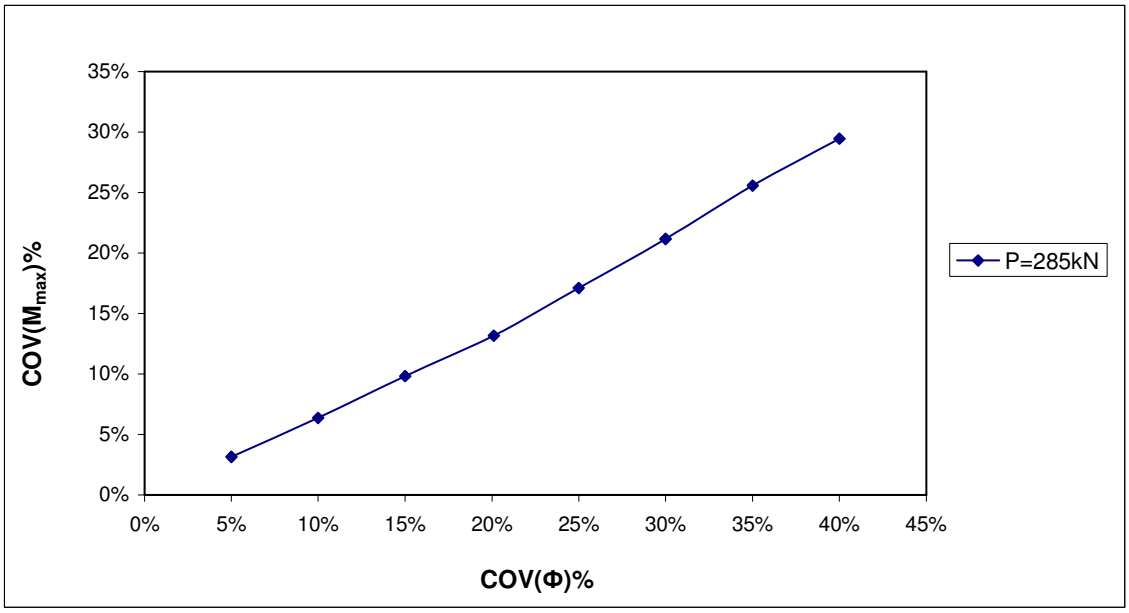


Fig. E.79 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.97 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 530kN.

P=530kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	1.33E+01	3.65%
10%	9.00E+00	6.40E+01	7.16%
15%	2.03E+01	1.53E+02	10.36%
20%	3.60E+01	2.81E+02	14.00%
25%	5.63E+01	4.14E+02	18.11%
30%	8.10E+01	6.10E+02	22.16%
35%	1.10E+02	8.69E+02	26.40%
40%	1.44E+02	1.18E+03	30.63%

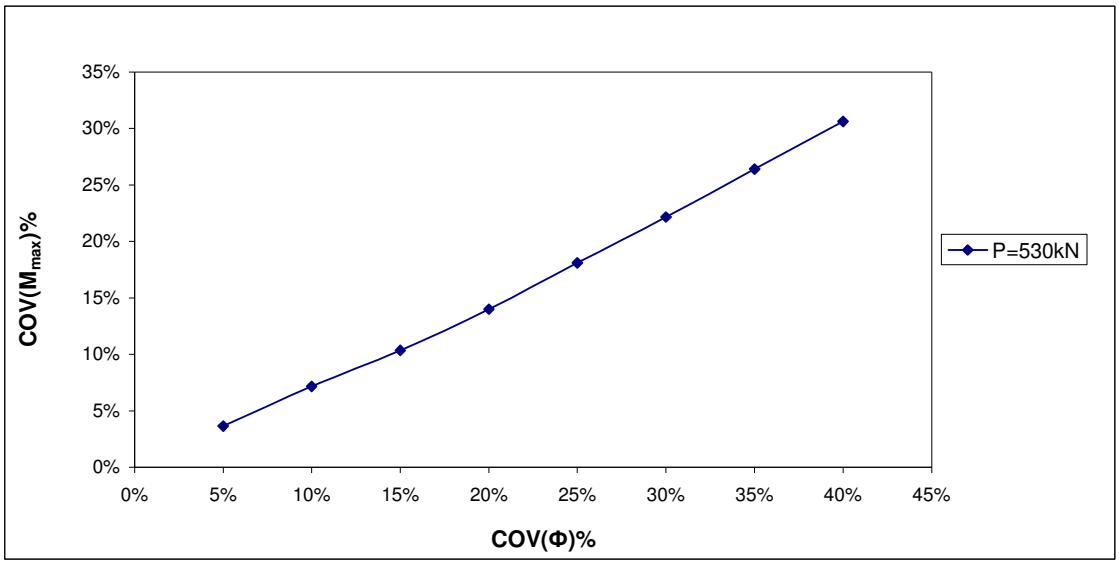


Fig. E.80 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.98 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 775kN.

P=775kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	3.31E+01	3.73%
10%	9.00E+00	1.19E+02	7.08%
15%	2.03E+01	2.61E+02	10.49%
20%	3.60E+01	4.67E+02	14.30%
25%	5.63E+01	8.12E+02	18.20%
30%	8.10E+01	1.23E+03	22.34%
35%	1.10E+02	1.71E+03	26.85%
40%	1.44E+02	2.37E+03	31.62%

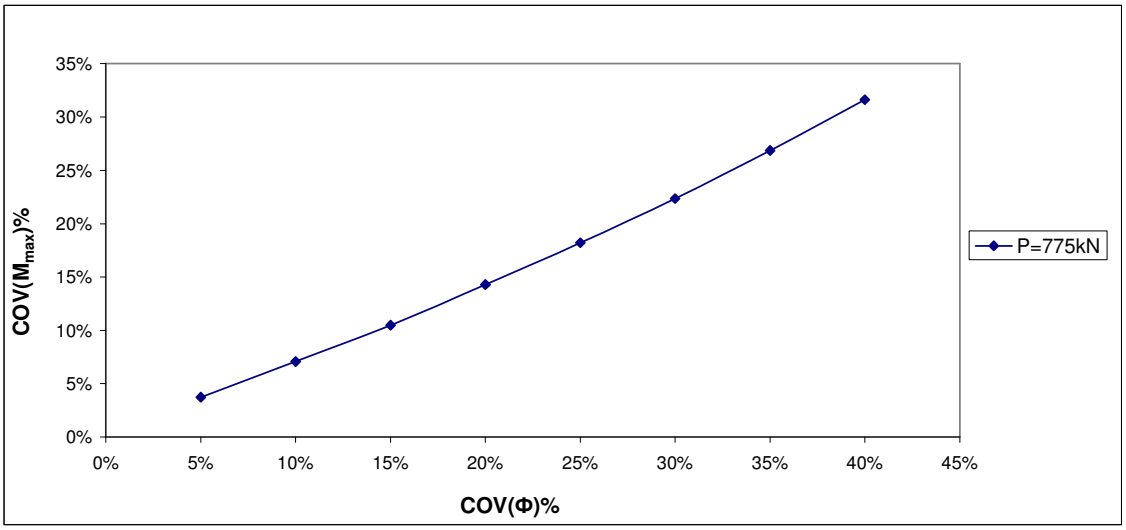


Fig. E.81 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.99 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 1000kN.

P=1000kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	5.93E+01	3.38%
10%	9.00E+00	2.28E+02	7.41%
15%	2.03E+01	4.77E+02	11.44%
20%	3.60E+01	9.24E+02	15.52%
25%	5.63E+01	1.53E+03	19.82%
30%	8.10E+01	2.32E+03	24.00%
35%	1.10E+02	3.36E+03	28.00%
40%	1.44E+02	4.64E+03	32.43%

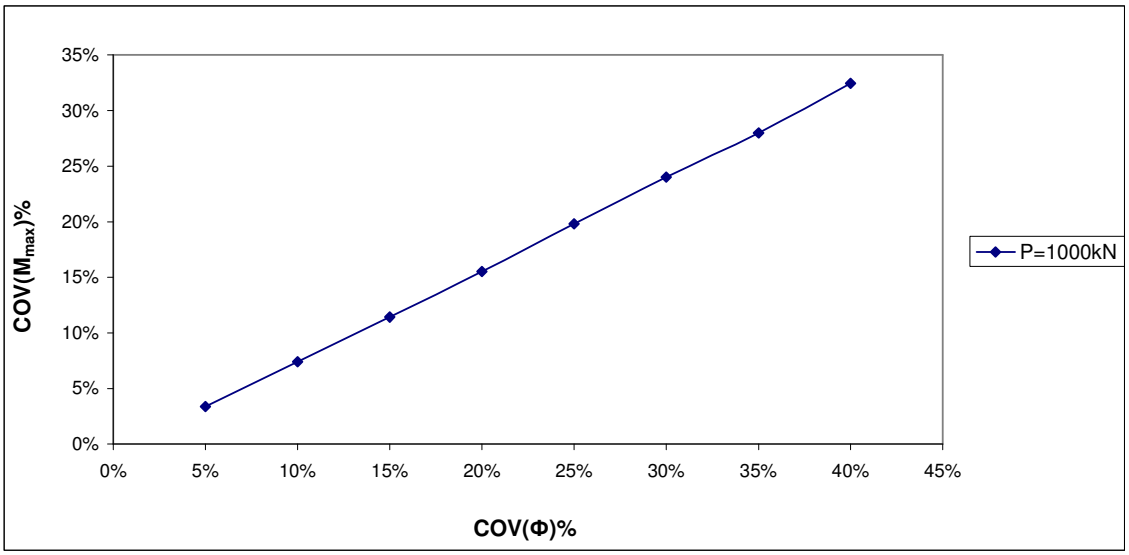


Fig. E.82 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.100 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 1300kN.

P=1300kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	9.90E+01	4.55%
10%	9.00E+00	4.04E+02	8.94%
15%	2.03E+01	9.61E+02	12.81%
20%	3.60E+01	1.72E+03	17.42%
25%	5.63E+01	2.70E+03	21.44%
30%	8.10E+01	4.15E+03	26.28%
35%	1.10E+02	6.03E+03	30.80%
40%	1.44E+02	8.16E+03	34.30%

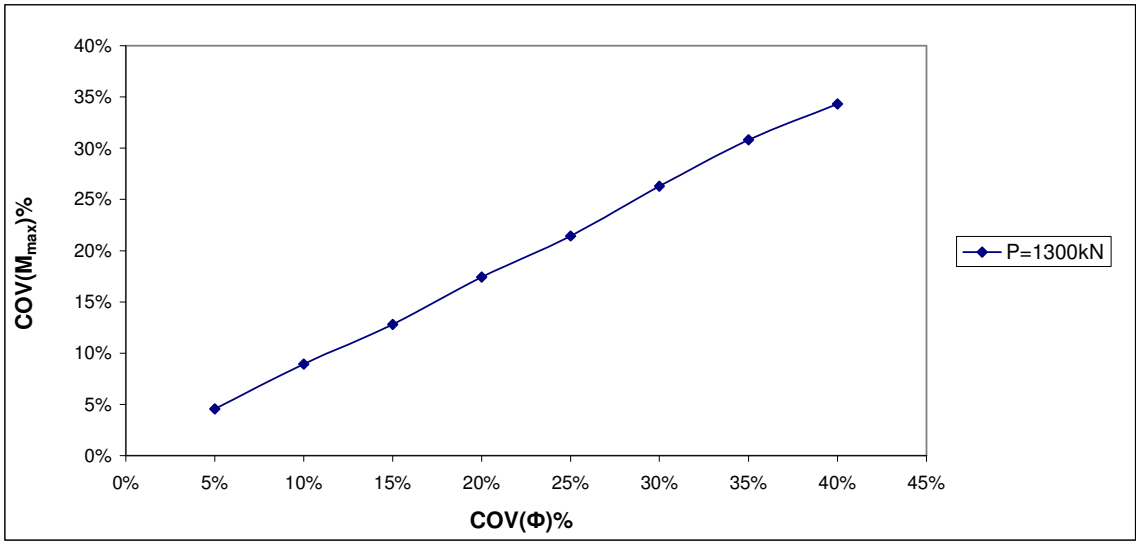


Fig. E.83 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

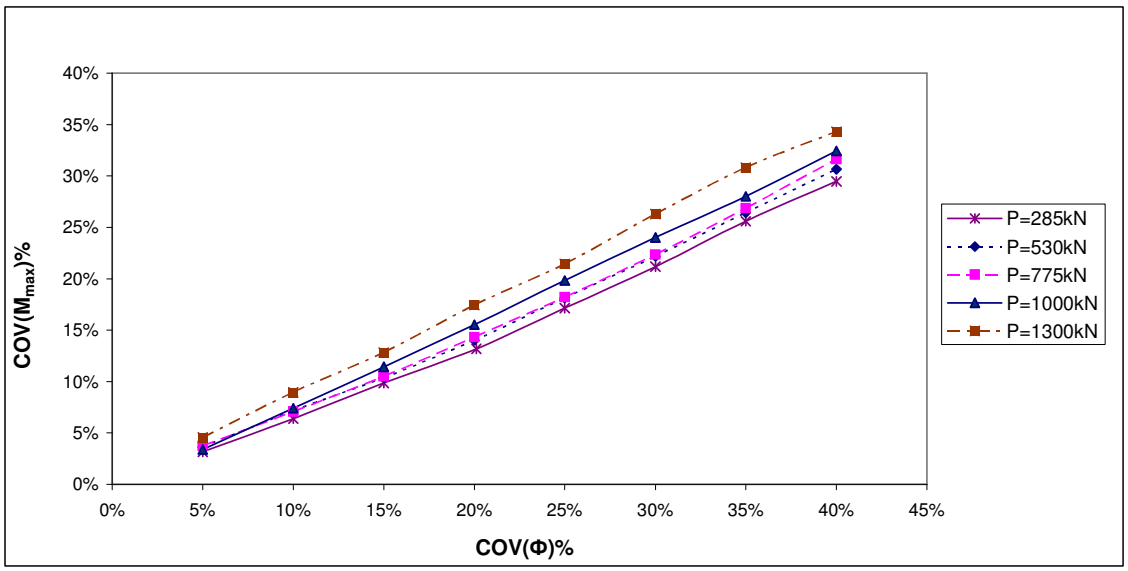


Fig. E.84 Variability of COV (M_{max}) vs. COV (Φ) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table E.101 Probabilistic modeling of laterally loaded free head long (10T) pile group with

spacing (5D) with varying (γ') and load 285kN.

P=285kN							
COV(γ') (%)	γ'o (kN/m^3)	γ'(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ') (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}° (kN-m)	COV(M_{max}) (%)
		11.025	6.81E+01				
5%	10.5			2.76E-01	1.76E+00	6.39E+01	1.30%
		9.975	7.07E+01				
		11.55	6.68E+01				
10%	10.5			1.10E+00	6.66E+00	6.39E+01	2.65%
		9.45	7.20E+01				
		12.075	6.56E+01				
15%	10.5			2.48E+00	1.47E+01	6.39E+01	4.14%
		8.925	7.33E+01				
		12.6	6.44E+01				
20%	10.5			4.41E+00	2.61E+01	6.39E+01	5.52%
		8.4	7.46E+01				
		13.125	6.33E+01				
25%	10.5			6.89E+00	4.05E+01	6.39E+01	7.10%
		7.875	7.61E+01				
		13.65	6.25E+01				
30%	10.5			9.92E+00	5.72E+01	6.39E+01	8.81%
		7.35	7.77E+01				
		14.175	6.18E+01				
35%	10.5			1.35E+01	8.09E+01	6.39E+01	10.63%
		6.825	7.98E+01				
		14.7	6.10E+01				
40%	10.5			1.76E+01	1.10E+02	6.39E+01	12.30%
		6.3	8.20E+01				

Table E.102 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (γ') and load 530kN.

P=530kN							
COV(γ') (%)	γ'o (kN/m^3)	γ'(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ') (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}° (kN-m)	COV(M_{max}) (%)
		11.025	1.12E+02				
5%	10.5			2.76E-01	2.40E+00	1.08E+02	1.44%
		9.975	1.16E+02				
		11.55	1.11E+02				
10%	10.5			1.10E+00	9.92E+00	1.08E+02	2.92%
		9.45	1.17E+02				
		12.075	1.09E+02				
15%	10.5			2.48E+00	2.55E+01	1.08E+02	4.68%
		8.925	1.20E+02				
		12.6	1.08E+02				
20%	10.5			4.41E+00	4.83E+01	1.08E+02	6.44%
		8.4	1.22E+02				
		13.125	1.06E+02				
25%	10.5			6.89E+00	8.19E+01	1.08E+02	8.38%
		7.875	1.25E+02				
		13.65	1.05E+02				
30%	10.5			9.92E+00	1.20E+02	1.08E+02	10.14%
		7.35	1.27E+02				
		14.175	1.04E+02				
35%	10.5			1.35E+01	1.69E+02	1.08E+02	12.04%
		6.825	1.30E+02				
		14.7	1.02E+02				
40%	10.5			1.76E+01	2.28E+02	1.08E+02	13.98%
		6.3	1.32E+02				

Table E.103 Probabilistic modeling of laterally loaded free head long (10T) pile group with

spacing (5D) with varying (γ) and load 775kN.

P=775kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^o (kN-m)	COV(M_{max}) (%)
		11.025	1.58E+02				
5%	10.5			2.76E-01	7.02E+00	1.54E+02	1.59%
		9.975	1.63E+02				
		11.55	1.56E+02				
10%	10.5			1.10E+00	2.70E+01	1.54E+02	3.15%
		9.45	1.66E+02				
		12.075	1.54E+02				
15%	10.5			2.48E+00	5.55E+01	1.54E+02	4.82%
		8.925	1.69E+02				
		12.6	1.52E+02				
20%	10.5			4.41E+00	9.60E+01	1.54E+02	6.65%
		8.4	1.72E+02				
		13.125	1.50E+02				
25%	10.5			6.89E+00	1.49E+02	1.54E+02	8.59%
		7.875	1.75E+02				
		13.65	1.49E+02				
30%	10.5			9.92E+00	2.16E+02	1.54E+02	10.43%
		7.35	1.78E+02				
		14.175	1.47E+02				
35%	10.5			1.35E+01	2.92E+02	1.54E+02	12.31%
		6.825	1.82E+02				
		14.7	1.46E+02				
40%	10.5			1.76E+01	3.90E+02	1.54E+02	14.32%
		6.3	1.85E+02				

Table E.104 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (γ) and load 1000kN.

P=1000kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^o (kN-m)	COV(M_{max}) (%)
		11.025	2.07E+02				
5%	10.5			2.76E-01	1.12E+01	2.11E+02	1.72%
		9.975	2.14E+02				
		11.55	2.04E+02				
10%	10.5			1.10E+00	4.42E+01	2.11E+02	3.38%
		9.45	2.17E+02				
		12.075	2.01E+02				
15%	10.5			2.48E+00	1.01E+02	2.11E+02	5.03%
		8.925	2.21E+02				
		12.6	1.98E+02				
20%	10.5			4.41E+00	1.85E+02	2.11E+02	6.95%
		8.4	2.25E+02				
		13.125	1.96E+02				
25%	10.5			6.89E+00	2.79E+02	2.11E+02	8.96%
		7.875	2.29E+02				
		13.65	1.94E+02				
30%	10.5			9.92E+00	3.92E+02	2.11E+02	10.96%
		7.35	2.33E+02				
		14.175	1.92E+02				
35%	10.5			1.35E+01	5.78E+02	2.11E+02	12.76%
		6.825	2.40E+02				
		14.7	1.90E+02				
40%	10.5			1.76E+01	8.12E+02	2.11E+02	14.69%
		6.3	2.47E+02				

Table E.105 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (γ) and load 1300kN.

P=1300kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		11.025	2.61E+02				
5%	10.5			2.76E-01	1.68E+01	3.15E+02	2.07%
		9.975	2.69E+02				
		11.55	2.56E+02				
10%	10.5			1.10E+00	6.97E+01	3.15E+02	4.04%
		9.45	2.73E+02				
		12.075	2.52E+02				
15%	10.5			2.48E+00	1.70E+02	3.15E+02	6.00%
		8.925	2.78E+02				
		12.6	2.48E+02				
20%	10.5			4.41E+00	3.03E+02	3.15E+02	7.99%
		8.4	2.83E+02				
		13.125	2.45E+02				
25%	10.5			6.89E+00	5.00E+02	3.15E+02	9.96%
		7.875	2.90E+02				
		13.65	2.42E+02				
30%	10.5			9.92E+00	7.70E+02	3.15E+02	12.11%
		7.35	2.97E+02				
		14.175	2.39E+02				
35%	10.5			1.35E+01	1.12E+03	3.15E+02	14.08%
		6.825	3.06E+02				
		14.7	2.37E+02				
40%	10.5			1.76E+01	1.50E+03	3.15E+02	16.41%
		6.3	3.14E+02				

Table E.106 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (γ') and lateral load 285kN.

P=285kN			
COV(γ') (%)	VAR(γ') $(kN/m^3)^2$	VAR (M_{max}) $(kN m)^2$	COV(M_{max}) (%)
5%	2.76E-01	1.76E+00	1.30%
10%	1.10E+00	6.66E+00	2.65%
15%	2.48E+00	1.47E+01	4.14%
20%	4.41E+00	2.61E+01	5.52%
25%	6.89E+00	4.05E+01	7.16%
30%	9.92E+00	5.72E+01	8.81%
35%	1.35E+01	8.09E+01	10.63%
40%	1.76E+01	1.10E+02	12.30%

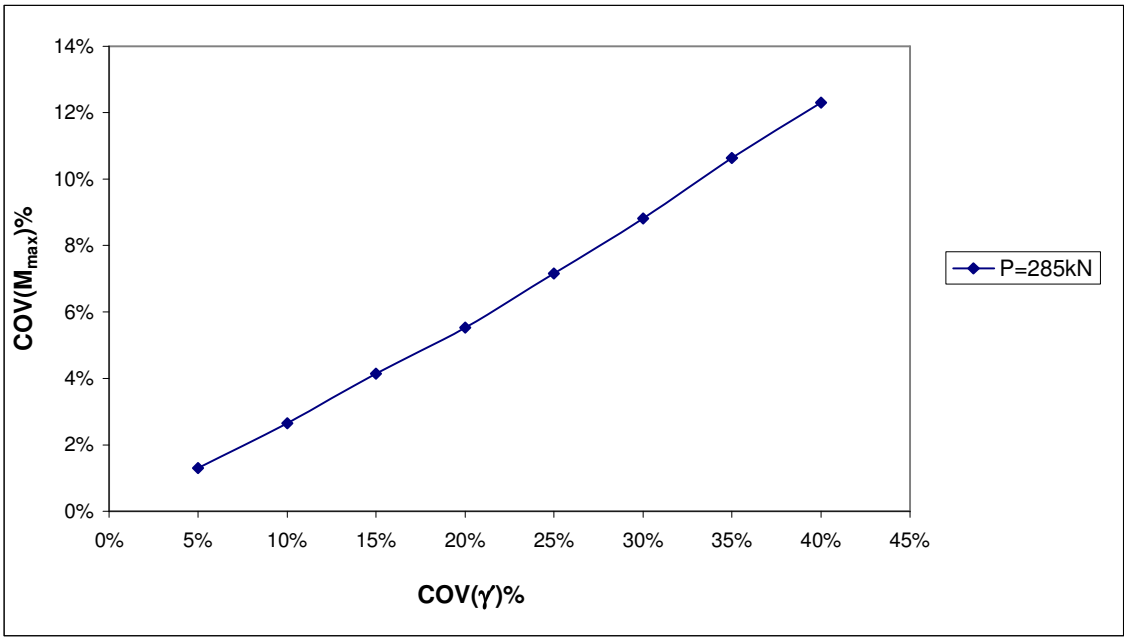


Fig. E.85 Variability of COV (M_{max}) vs. COV (γ') for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.107 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (γ') and lateral load 530kN.

P=530kN			
COV(γ') (%)	VAR(γ') $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	2.40E+00	1.44%
10%	1.10E+00	9.92E+00	2.92%
15%	2.48E+00	2.55E+01	4.68%
20%	4.41E+00	4.83E+01	6.44%
25%	6.89E+00	8.19E+01	8.38%
30%	9.92E+00	1.20E+02	10.14%
35%	1.35E+01	1.69E+02	12.04%
40%	1.76E+01	2.28E+02	13.98%

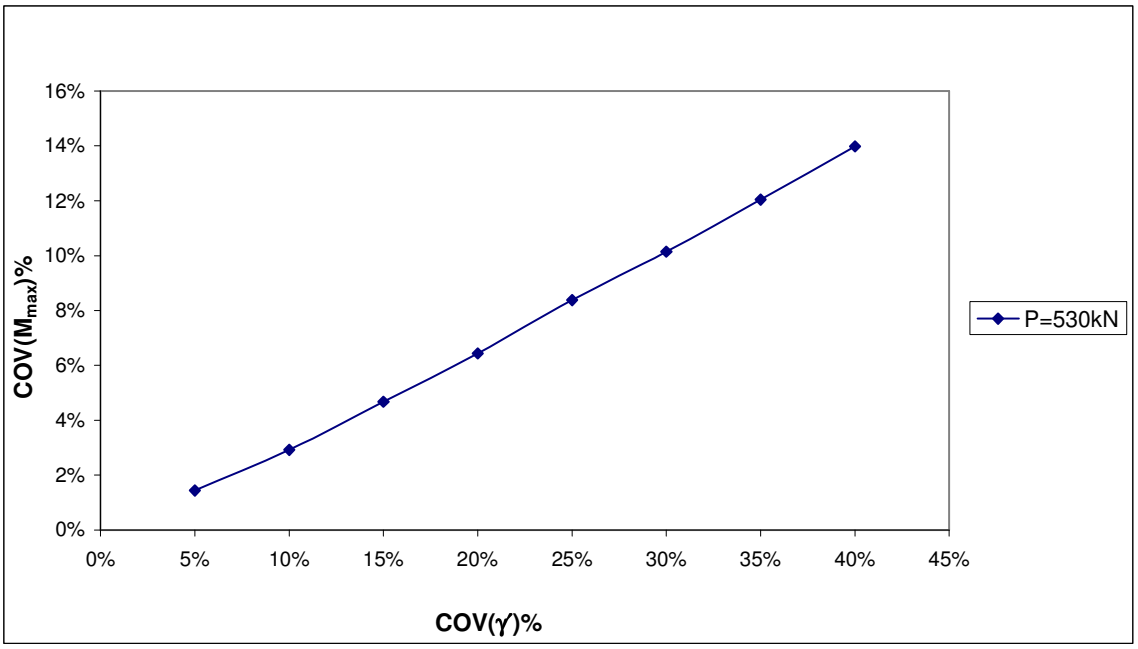


Fig. E.86 Variability of COV (M_{max}) vs. COV (γ') for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.108 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 775kN.

P=775kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	7.02E+00	1.59%
10%	2.66E+06	2.70E+01	3.15%
15%	5.98E+06	5.55E+01	4.82%
20%	1.06E+07	9.60E+01	6.65%
25%	1.66E+07	1.49E+02	8.59%
30%	2.39E+07	2.16E+02	10.43%
35%	3.25E+07	2.92E+02	12.31%
40%	4.25E+07	3.90E+02	14.32%

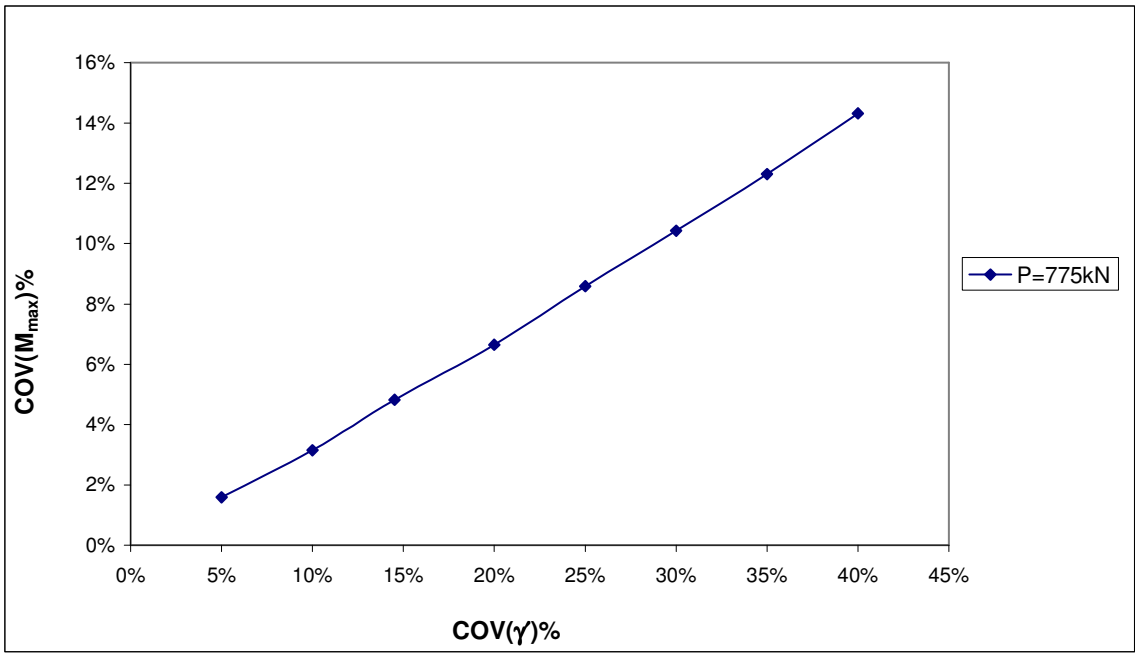


Fig. E.87 Variability of COV (M_{max}) vs. COV (γ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.109 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 1000kN.

P=1000kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.12E+01	1.72%
10%	2.66E+06	4.42E+01	3.38%
15%	5.98E+06	1.01E+02	5.03%
20%	1.06E+07	1.85E+02	6.95%
25%	1.66E+07	2.79E+02	8.96%
30%	2.39E+07	3.92E+02	10.96%
35%	3.25E+07	5.78E+02	12.76%
40%	4.25E+07	8.12E+02	14.69%

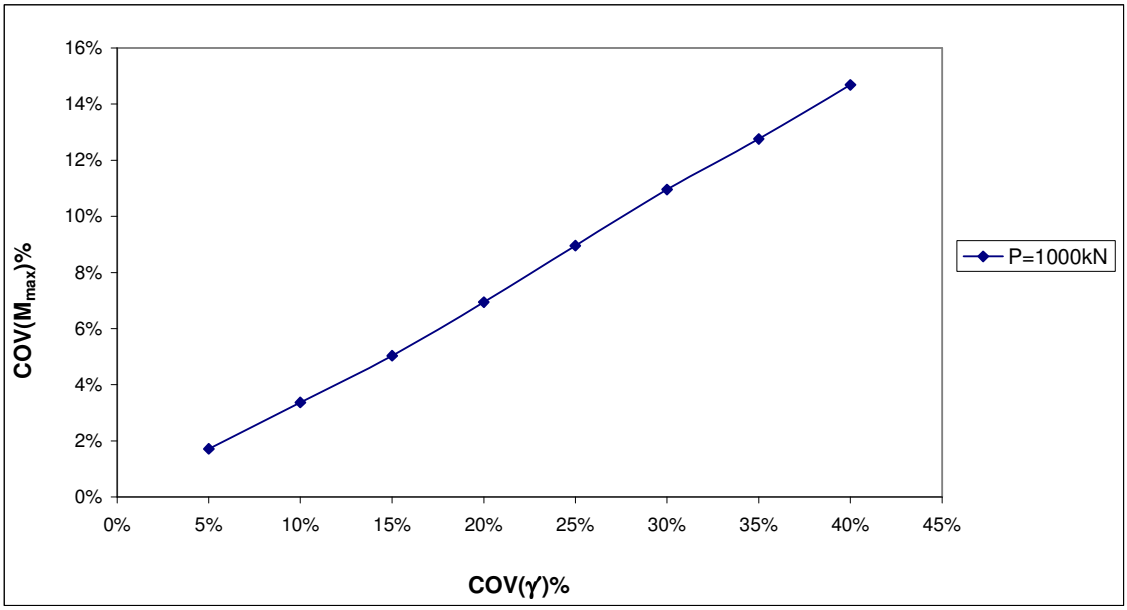


Fig. E.88 Variability of COV (M_{max}) vs. COV (γ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.110 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 1300kN.

P=1300kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.68E+01	2.07%
10%	2.66E+06	6.97E+01	4.04%
15%	5.98E+06	1.70E+02	6.00%
20%	1.06E+07	3.03E+02	7.99%
25%	1.66E+07	5.00E+02	9.96%
30%	2.39E+07	7.70E+02	12.11%
35%	3.25E+07	1.12E+03	14.08%
40%	4.25E+07	1.50E+03	16.41%

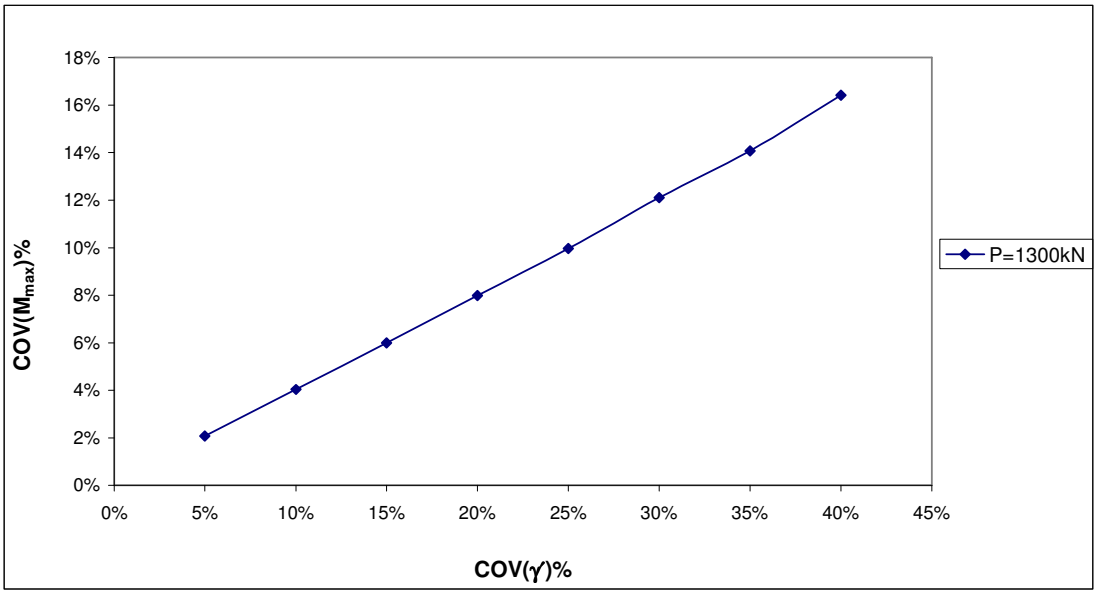


Fig. E.89 Variability of COV (M_{max}) vs. COV (γ) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

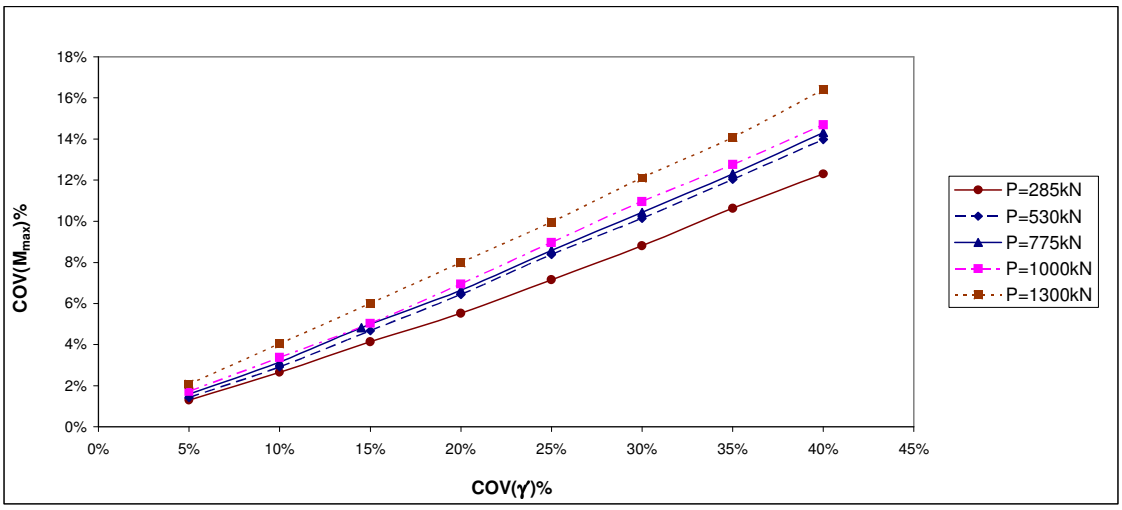


Fig. E.90 Variability of COV (M_{max}) vs. COV (γ) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table E.111 Probabilistic modeling of laterally loaded free head long (10T) pile group with

spacing (5D) with varying (k) and load 285kN.

P=285kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	6.95E+01				
5%	16300			6.64E+05	1.10E-02	6.39E+01	0.16%
		15485	6.93E+01				
		17930	6.95E+01				
10%	16300			2.66E+06	2.89E-02	6.39E+01	0.27%
		14670	6.92E+01				
		18745	6.95E+01				
15%	16300			5.98E+06	5.06E-02	6.39E+01	0.35%
		13855	6.91E+01				
		19560	6.96E+01				
20%	16300			1.06E+07	7.56E-02	6.39E+01	0.43%
		13040	6.90E+01				
		20375	6.96E+01				
25%	16300			1.66E+07	1.12E-01	6.39E+01	0.52%
		12225	6.89E+01				
		21190	6.96E+01				
30%	16300			2.39E+07	1.56E-01	6.39E+01	0.62%
		11410	6.88E+01				
		22005	6.96E+01				
35%	16300			3.25E+07	2.40E-01	6.39E+01	0.77%
		10595	6.87E+01				
		22820	6.97E+01				
40%	16300			4.25E+07	4.10E-01	6.39E+01	1.00%
		9780	6.84E+01				

Table E.112 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (k) and load 530kN.

P=530kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	1.14E+02				
5%	16300			6.64E+05	1.00E-02	1.08E+02	0.09%
		15485	1.14E+02				
		17930	1.14E+02				
10%	16300			2.66E+06	2.25E-02	1.08E+02	0.14%
		14670	1.14E+02				
		18745	1.14E+02				
15%	16300			5.98E+06	4.00E-02	1.08E+02	0.19%
		13855	1.14E+02				
		19560	1.14E+02				
20%	16300			1.06E+07	6.25E-02	1.08E+02	0.23%
		13040	1.14E+02				
		20375	1.14E+02				
25%	16300			1.66E+07	9.00E-02	1.08E+02	0.28%
		12225	1.14E+02				
		21190	1.14E+02				
30%	16300			2.39E+07	1.23E-01	1.08E+02	0.32%
		11410	1.14E+02				
		22005	1.14E+02				
35%	16300			3.25E+07	2.03E-01	1.08E+02	0.42%
		10595	1.13E+02				
		22820	1.14E+02				
40%	16300			4.25E+07	3.03E-01	1.08E+02	0.51%
		9780	1.13E+02				

Table E.113 Probabilistic modeling of laterally loaded free head long (10T) pile group with

spacing (5D) with varying (k) and load 775kN.

P=775kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		17115	1.60E+02				
5%	16300			6.64E+05	2.50E-03	1.54E+02	0.03%
		15485	1.60E+02				
		17930	1.60E+02				
10%	16300			2.66E+06	2.25E-02	1.54E+02	0.10%
		14670	1.60E+02				
		18745	1.61E+02				
15%	16300			5.98E+06	6.25E-02	1.54E+02	0.16%
		13855	1.60E+02				
		19560	1.61E+02				
20%	16300			1.06E+07	1.22E-01	1.54E+02	0.23%
		13040	1.60E+02				
		20375	1.61E+02				
25%	16300			1.66E+07	2.03E-01	1.54E+02	0.29%
		12225	1.60E+02				
		21190	1.61E+02				
30%	16300			2.39E+07	4.90E-01	1.54E+02	0.45%
		11410	1.59E+02				
		22005	1.61E+02				
35%	16300			3.25E+07	7.23E-01	1.54E+02	0.55%
		10595	1.59E+02				
		22820	1.61E+02				
40%	16300			4.25E+07	1.10E+00	1.54E+02	0.68%
		9780	1.59E+02				

Table E.114 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (k) and load 1000kN.

P=1000kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		17115	2.11E+02				
5%	16300			6.64E+05	2.50E-03	2.11E+02	0.02%
		15485	2.11E+02				
		17930	2.11E+02				
10%	16300			2.66E+06	2.25E-02	2.11E+02	0.07%
		14670	2.10E+02				
		18745	2.11E+02				
15%	16300			5.98E+06	6.25E-02	2.11E+02	0.12%
		13855	2.10E+02				
		19560	2.11E+02				
20%	16300			1.06E+07	1.23E-01	2.11E+02	0.17%
		13040	2.10E+02				
		20375	2.11E+02				
25%	16300			1.66E+07	1.60E-01	2.11E+02	0.19%
		12225	2.10E+02				
		21190	2.11E+02				
30%	16300			2.39E+07	2.03E-01	2.11E+02	0.21%
		11410	2.10E+02				
		22005	2.11E+02				
35%	16300			3.25E+07	3.02E-01	2.11E+02	0.26%
		10595	2.10E+02				
		22820	2.11E+02				
40%	16300			4.25E+07	4.23E-01	2.11E+02	0.31%
		9780	2.10E+02				

Table E.115 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (k) and load 1300kN.

P=1300kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	2.65E+02				
5%	16300			6.64E+05	2.50E-03	3.15E+02	0.02%
		15485	2.65E+02				
		17930	2.65E+02				
10%	16300			2.66E+06	2.50E-03	3.15E+02	0.02%
		14670	2.65E+02				
		18745	2.65E+02				
15%	16300			5.98E+06	2.50E-03	3.15E+02	0.02%
		13855	2.65E+02				
		19560	2.65E+02				
20%	16300			1.06E+07	1.00E-02	3.15E+02	0.03%
		13040	2.64E+02				
		20375	2.65E+02				
25%	16300			1.66E+07	4.00E-02	3.15E+02	0.06%
		12225	2.64E+02				
		21190	2.65E+02				
30%	16300			2.39E+07	9.00E-02	3.15E+02	0.10%
		11410	2.64E+02				
		22005	2.65E+02				
35%	16300			3.25E+07	2.50E-01	3.15E+02	0.16%
		10595	2.64E+02				
		22820	2.65E+02				
40%	16300			4.25E+07	3.02E-01	3.15E+02	0.17%
		9780	2.64E+02				

Table E.116 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 285kN.

P=285kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.10E-02	0.16%
10%	2.66E+06	2.89E-02	0.27%
15%	5.98E+06	5.06E-02	0.35%
20%	1.06E+07	7.56E-02	0.43%
25%	1.66E+07	1.12E-01	0.52%
30%	2.39E+07	1.56E-01	0.62%
35%	3.25E+07	2.40E-01	0.77%
40%	4.25E+07	4.10E-01	1.00%

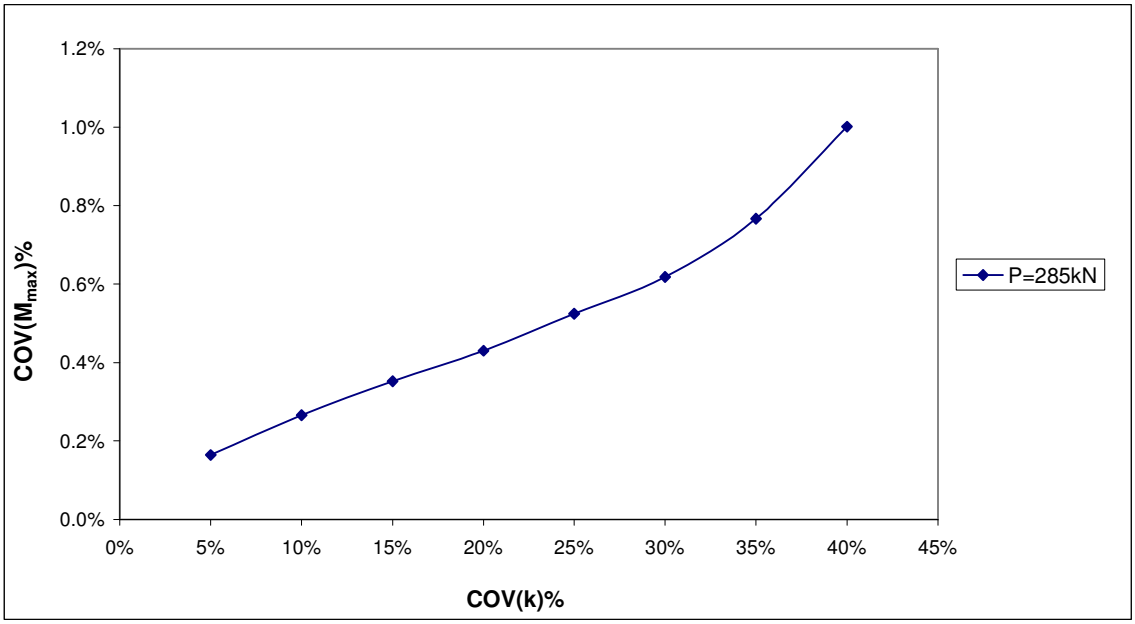


Fig. E.91 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.117 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 530kN.

P=530kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.00E-02	0.09%
10%	2.66E+06	2.25E-02	0.14%
15%	5.98E+06	4.00E-02	0.19%
20%	1.06E+07	6.25E-02	0.23%
25%	1.66E+07	9.00E-02	0.28%
30%	2.39E+07	1.23E-01	0.32%
35%	3.25E+07	2.03E-01	0.42%
40%	4.25E+07	3.03E-01	0.51%

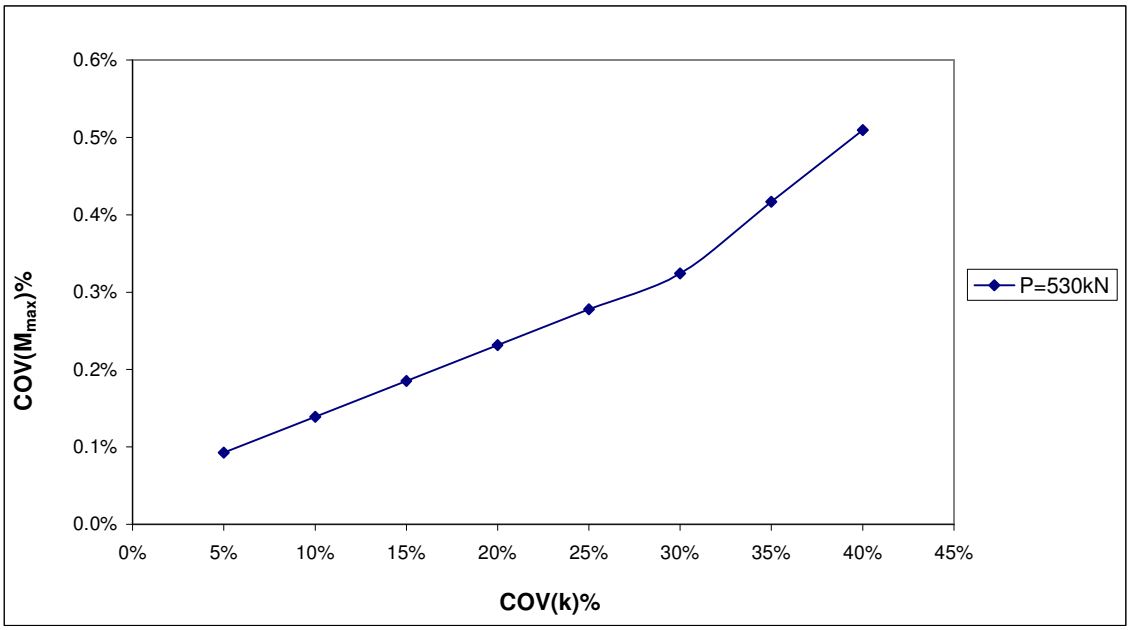


Fig. E.92 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.118 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 775kN.

P=775kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.50E-03	0.03%
10%	2.66E+06	2.25E-02	0.10%
15%	5.98E+06	6.25E-02	0.16%
20%	1.06E+07	1.22E-01	0.23%
25%	1.66E+07	2.03E-01	0.29%
30%	2.39E+07	4.90E-01	0.45%
35%	3.25E+07	7.23E-01	0.55%
40%	4.25E+07	1.10E+00	0.68%

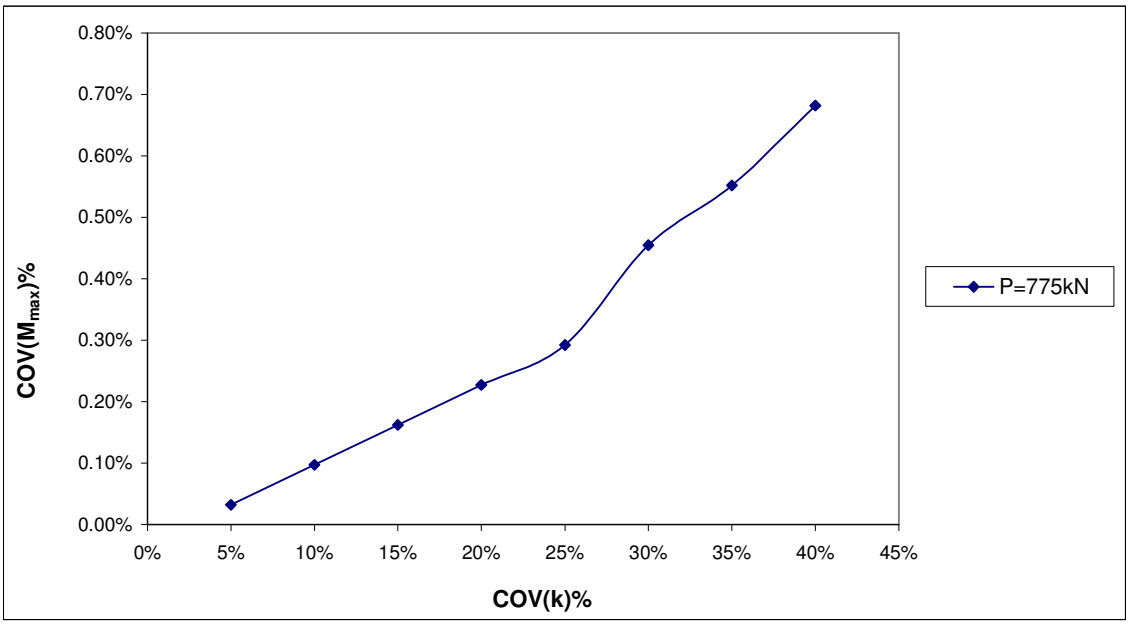


Fig. E.93 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.119 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 1000kN.

P=1000kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.50E-03	0.02%
10%	2.66E+06	2.25E-02	0.07%
15%	5.98E+06	6.25E-02	0.12%
20%	1.06E+07	1.23E-01	0.17%
25%	1.66E+07	1.60E-01	0.19%
30%	2.39E+07	2.03E-01	0.21%
35%	3.25E+07	3.02E-01	0.26%
40%	4.25E+07	4.23E-01	0.31%

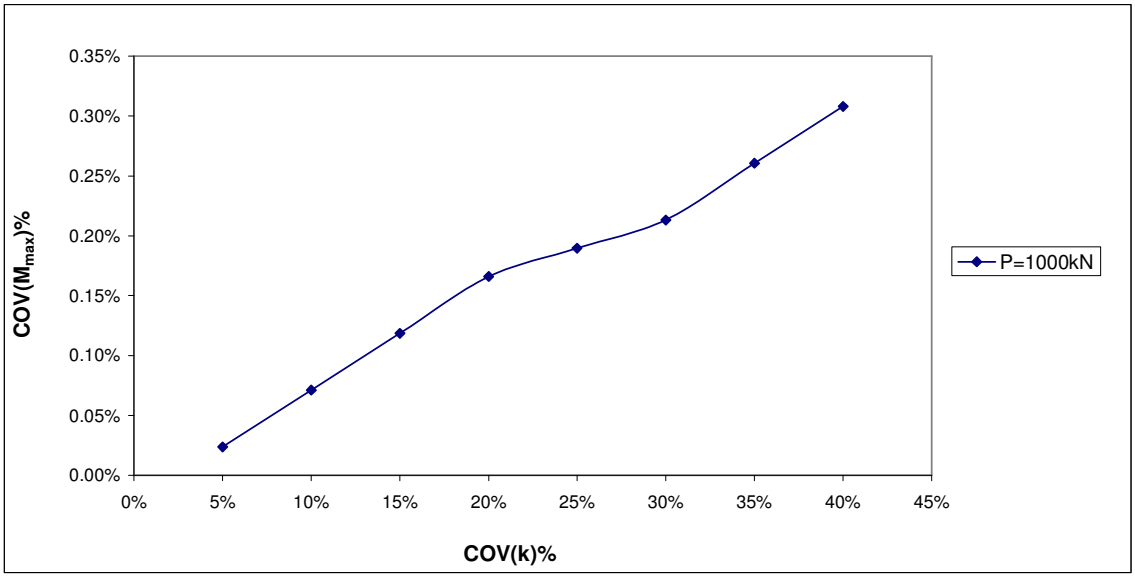


Fig. E.94 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.120 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 1300kN.

P=1300kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	2.50E-03	0.02%
10%	2.66E+06	2.50E-03	0.02%
15%	5.98E+06	2.50E-03	0.02%
20%	1.06E+07	1.00E-02	0.03%
25%	1.66E+07	4.00E-02	0.06%
30%	2.39E+07	9.00E-02	0.10%
35%	3.25E+07	2.50E-01	0.16%
40%	4.25E+07	3.02E-01	0.17%

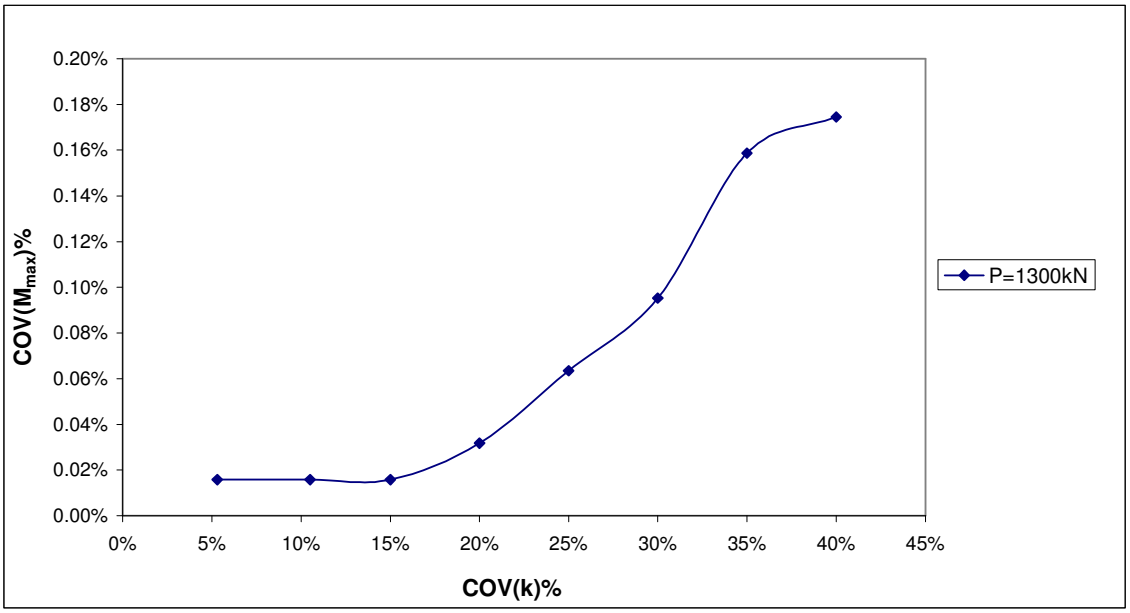


Fig. E.95 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

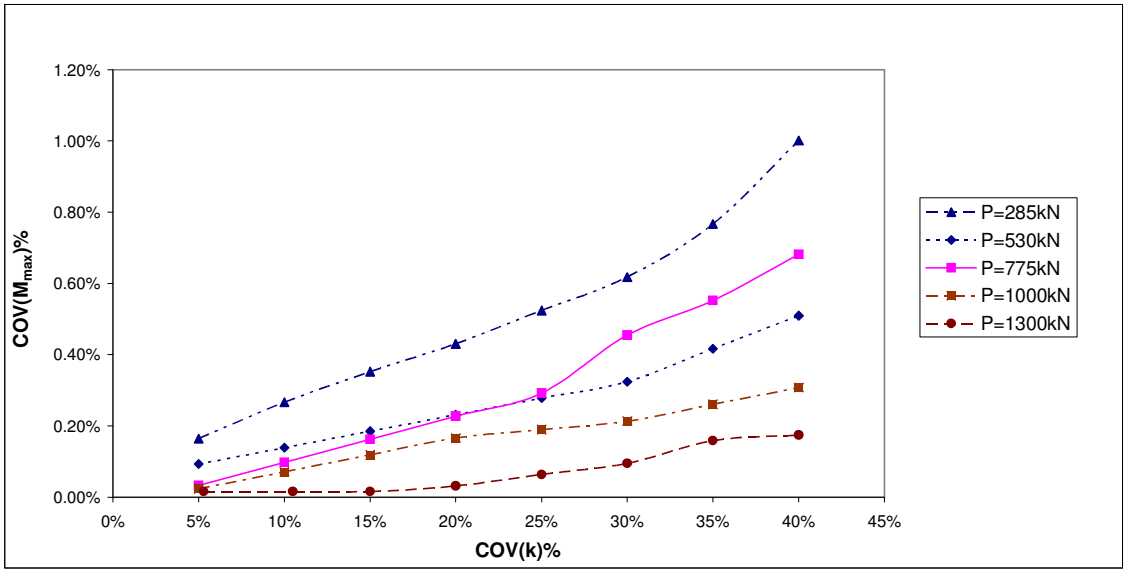


Fig. E.96 Variability of COV (M_{max}) vs. COV (k) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table E.121 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (B) and load 285kN.

P=285kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	6.84E+01				
5%	0.406			4.12E-04	7.23E-01	6.39E+01	0.33%
		0.3857	7.01E+01				
		0.4466	6.75E+01				
10%	0.406			1.65E-03	2.51E+00	6.39E+01	0.76%
		0.3654	7.07E+01				
		0.4669	6.66E+01				
15%	0.406			3.71E-03	5.29E+00	6.39E+01	1.17%
		0.3451	7.12E+01				
		0.4872	6.58E+01				
20%	0.406			6.59E-03	8.88E+00	6.39E+01	1.60%
		0.3248	7.18E+01				
		0.5075	6.49E+01				
25%	0.406			1.03E-02	1.40E+01	6.39E+01	1.97%
		0.3045	7.23E+01				
		0.5278	6.41E+01				
30%	0.406			1.48E-02	1.80E+01	6.39E+01	2.30%
		0.2842	7.26E+01				
		0.5472	6.38E+01				
35%	0.406			2.02E-02	1.94E+01	6.39E+01	2.60%
		0.2648	7.26E+01				
		0.5684	6.36E+01				
40%	0.406			2.64E-02	2.06E+01	6.39E+01	2.86%
		0.2436	7.27E+01				

Table E.122 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (B) and load 530kN.

P=530kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	1.13E+02				
5%	0.406			4.12E-04	4.90E-01	1.08E+02	0.40%
		0.3857	1.15E+02				
		0.4466	1.12E+02				
10%	0.406			1.65E-03	1.82E+00	1.08E+02	0.82%
		0.3654	1.15E+02				
		0.4669	1.11E+02				
15%	0.406			3.71E-03	3.80E+00	1.08E+02	1.33%
		0.3451	1.15E+02				
		0.4872	1.11E+02				
20%	0.406			6.59E-03	6.00E+00	1.08E+02	1.77%
		0.3248	1.16E+02				
		0.5075	1.10E+02				
25%	0.406			1.03E-02	9.92E+00	1.08E+02	2.13%
		0.3045	1.16E+02				
		0.5278	1.09E+02				
30%	0.406			1.48E-02	1.33E+01	1.08E+02	2.49%
		0.2842	1.16E+02				
		0.5472	1.08E+02				
35%	0.406			2.02E-02	1.66E+01	1.08E+02	2.84%
		0.2648	1.16E+02				
		0.5684	1.07E+02				
40%	0.406			2.64E-02	1.98E+01	1.08E+02	3.04%
		0.2436	1.16E+02				

Table E.123 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (B) and load 775kN.

P=775kN							
COV(B) (%)	B° (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	1.60E+02				
5%	0.406			4.12E-04	4.23E-01	1.54E+02	0.42%
		0.3857	1.61E+02				
		0.4466	1.59E+02				
10%	0.406			1.65E-03	1.32E+00	1.54E+02	0.93%
		0.3654	1.61E+02				
		0.4669	1.58E+02				
15%	0.406	0.0609		3.71E-03	1.97E-01	1.54E+02	1.47%
			1.61E+02				
		0.4872	1.57E+02				
20%	0.406			6.59E-03	4.41E+00	1.54E+02	1.93%
		0.3248	1.61E+02				
		0.5075	1.56E+02				
25%	0.406			1.03E-02	7.02E+00	1.54E+02	2.36%
		0.3045	1.61E+02				
		0.5278	1.55E+02				
30%	0.406			1.48E-02	1.16E+01	1.54E+02	2.69%
		0.2842	1.62E+02				
		0.5472	1.54E+02				
35%	0.406			2.02E-02	1.66E+01	1.54E+02	3.00%
		0.2648	1.62E+02				
		0.5684	1.53E+02				
40%	0.406			2.64E-02	2.07E+01	1.54E+02	3.27%
		0.2436	1.62E+02				

Table E.124 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (B) and load 1000kN.

P=1000kN							
COV(B) (%)	B° (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	2.10E+02				
5%	0.406			4.12E-04	5.62E-01	2.11E+02	0.65%
		0.3857	2.11E+02				
		0.4466	2.09E+02				
10%	0.406			1.65E-03	1.96E+00	2.11E+02	1.25%
		0.3654	2.12E+02				
		0.4669	2.08E+02				
15%	0.406			3.71E-03	4.00E+00	2.11E+02	1.81%
		0.3451	2.12E+02				
		0.4872	2.07E+02				
20%	0.406			6.59E-03	8.41E+00	2.11E+02	2.51%
		0.3248	2.13E+02				
		0.5075	2.06E+02				
25%	0.406			1.03E-02	1.52E+01	2.11E+02	2.92%
		0.3045	2.14E+02				
		0.5278	2.05E+02				
30%	0.406			1.48E-02	2.40E+01	2.11E+02	3.38%
		0.2842	2.15E+02				
		0.5472	2.04E+02				
35%	0.406			2.02E-02	3.35E+01	2.11E+02	3.77%
		0.2648	2.15E+02				
		0.5684	2.03E+02				
40%	0.406			2.64E-02	4.56E+01	2.11E+02	4.12%
		0.2436	2.16E+02				

Table E.125 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (B) and load 1300kN.

P=1300kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	2.63E+02				
5%	0.406			4.12E-04	1.56E+00	3.15E+02	1.33%
		0.3857	2.66E+02				
		0.4466	2.62E+02				
10%	0.406			1.65E-03	5.52E+00	3.15E+02	2.48%
		0.3654	2.67E+02				
		0.4669	2.61E+02				
15%	0.406			3.71E-03	1.37E+01	3.15E+02	3.60%
		0.3451	2.68E+02				
		0.4872	2.60E+02				
20%	0.406			6.59E-03	2.65E+01	3.15E+02	4.66%
		0.3248	2.70E+02				
		0.5075	2.59E+02				
25%	0.406			1.03E-02	4.10E+01	3.15E+02	5.72%
		0.3045	2.71E+02				
		0.5278	2.57E+02				
30%	0.406			1.48E-02	6.01E+01	3.15E+02	6.47%
		0.2842	2.73E+02				
		0.5472	2.56E+02				
35%	0.406			2.02E-02	8.29E+01	3.15E+02	6.90%
		0.2648	2.74E+02				
		0.5684	2.55E+02				
40%	0.406			2.64E-02	1.12E+02	3.15E+02	7.10%
		0.2436	2.76E+02				

Table E.126 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 285kN.

P=285kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	7.23E-01	0.33%
10%	1.65E-03	2.51E+00	0.76%
15%	3.71E-03	5.29E+00	1.17%
20%	6.59E-03	8.88E+00	1.60%
25%	1.03E-02	1.40E+01	1.97%
30%	1.48E-02	1.80E+01	2.30%
35%	2.02E-02	1.94E+01	2.60%
40%	2.64E-02	2.06E+01	2.86%

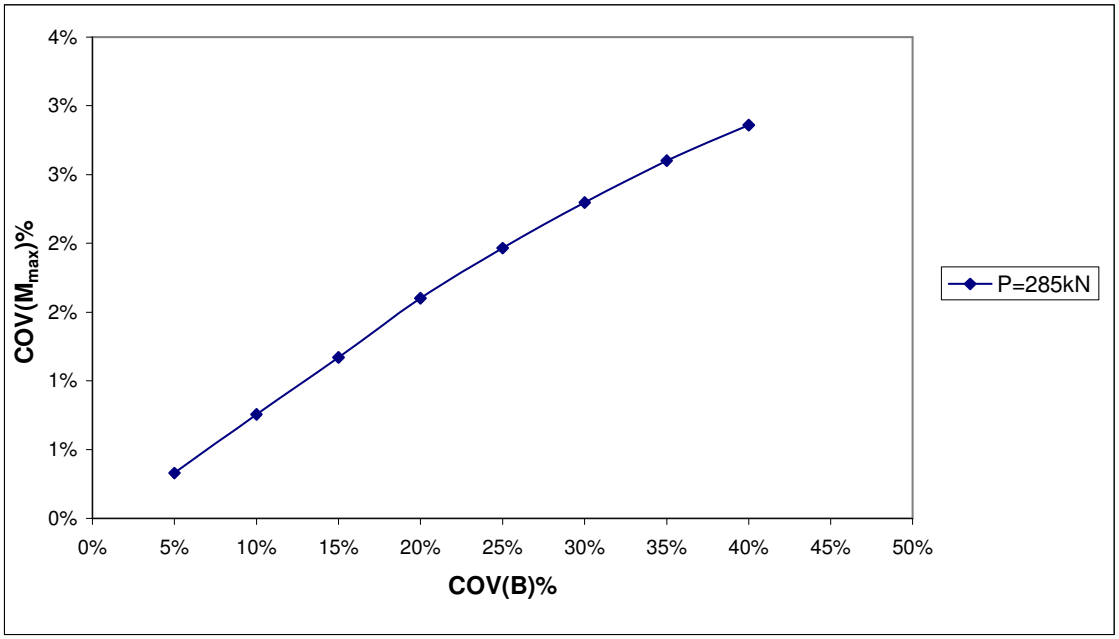


Fig. E.97 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.127 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 530kN.

P=530kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	4.90E-01	0.40%
10%	1.65E-03	1.82E+00	0.82%
15%	3.71E-03	3.80E+00	1.33%
20%	6.59E-03	6.00E+00	1.77%
25%	1.03E-02	9.92E+00	2.13%
30%	1.48E-02	1.33E+01	2.49%
35%	2.02E-02	1.66E+01	2.84%
40%	2.64E-02	1.98E+01	3.04%

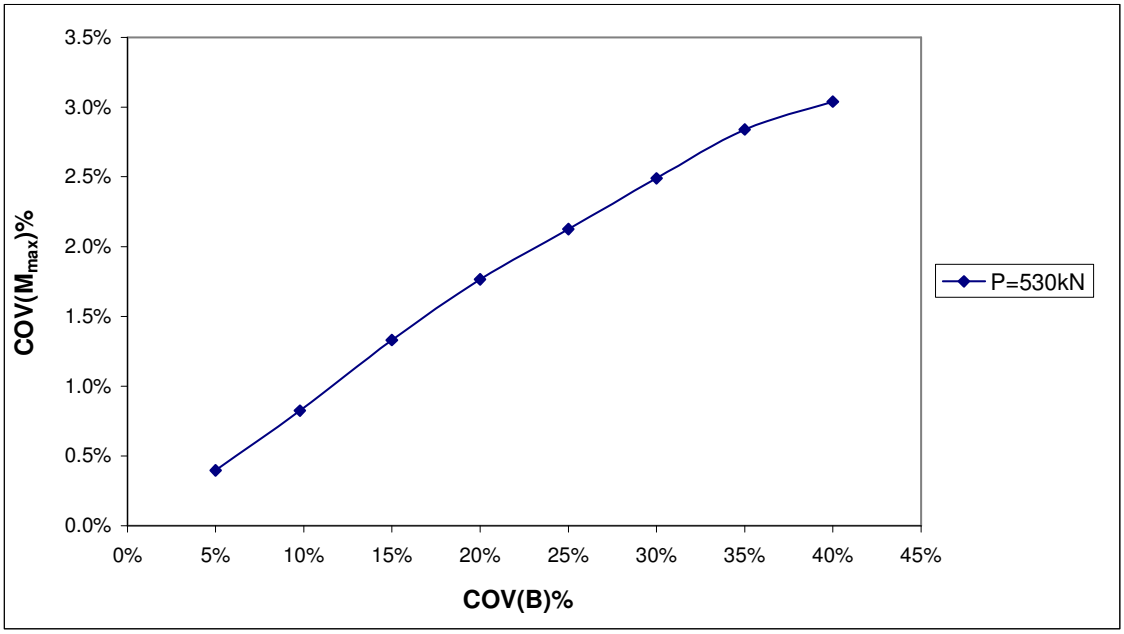


Fig. E.98 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.128 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 775kN.

P=775kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	4.23E-01	0.42%
10%	1.65E-03	1.32E+00	0.93%
15%	3.71E-03	2.89E+00	1.47%
20%	6.59E-03	4.41E+00	1.93%
25%	1.03E-02	7.02E+00	2.36%
30%	1.48E-02	1.16E+01	2.69%
35%	2.02E-02	1.66E+01	3.00%
40%	2.64E-02	2.07E+01	3.27%

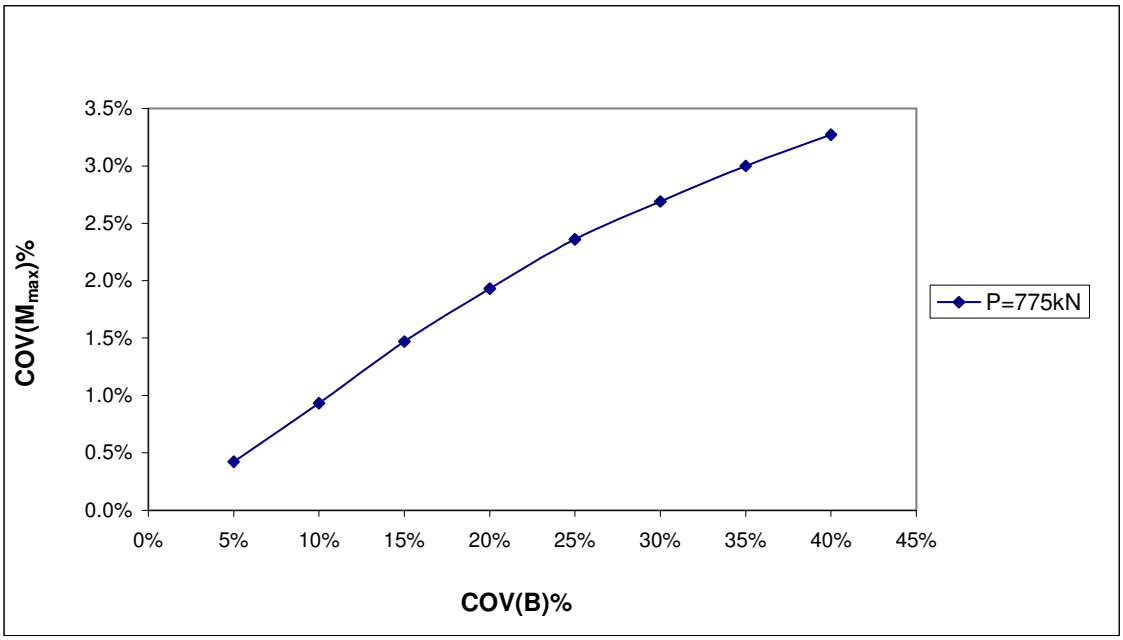


Fig. E.99 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.129 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 1000kN.

P=1000kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	5.62E-01	0.65%
10%	1.65E-03	1.96E+00	1.25%
15%	3.71E-03	4.00E+00	1.81%
20%	6.59E-03	8.41E+00	2.51%
25%	1.03E-02	1.52E+01	2.92%
30%	1.48E-02	2.40E+01	3.38%
35%	2.02E-02	3.35E+01	3.77%
40%	2.64E-02	4.56E+01	4.12%

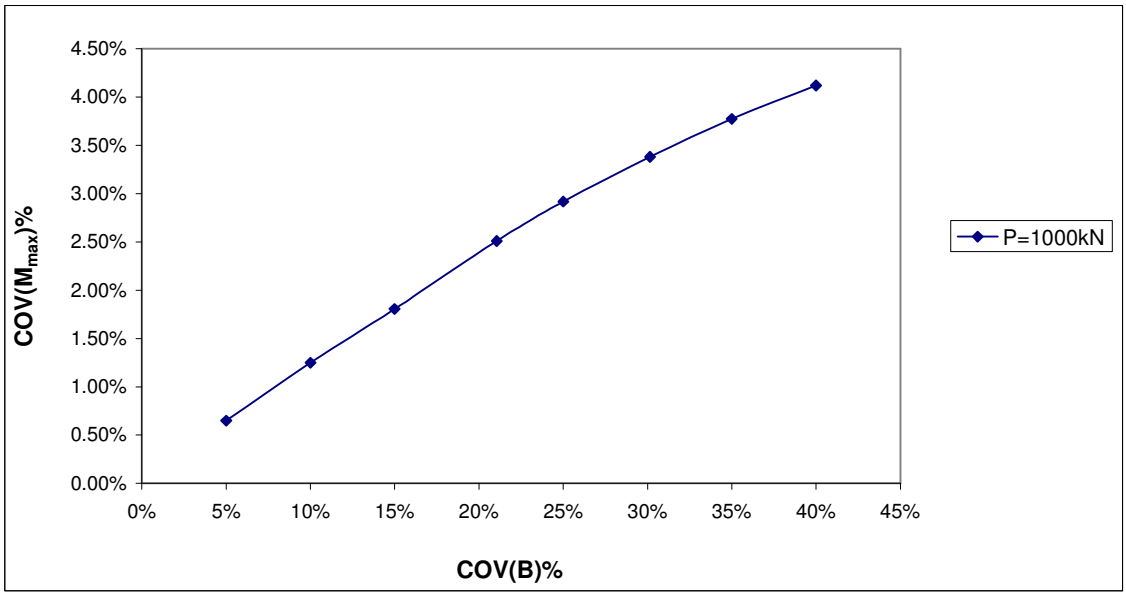


Fig. E.100 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.130 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 1300kN.

P=1300kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	1.56E+00	1.33%
10%	1.65E-03	5.52E+00	2.48%
15%	3.71E-03	1.37E+01	3.60%
20%	6.59E-03	2.65E+01	4.66%
25%	1.03E-02	4.10E+01	5.72%
30%	1.48E-02	6.01E+01	6.47%
35%	2.02E-02	8.29E+01	6.90%
40%	2.64E-02	1.12E+02	7.10%

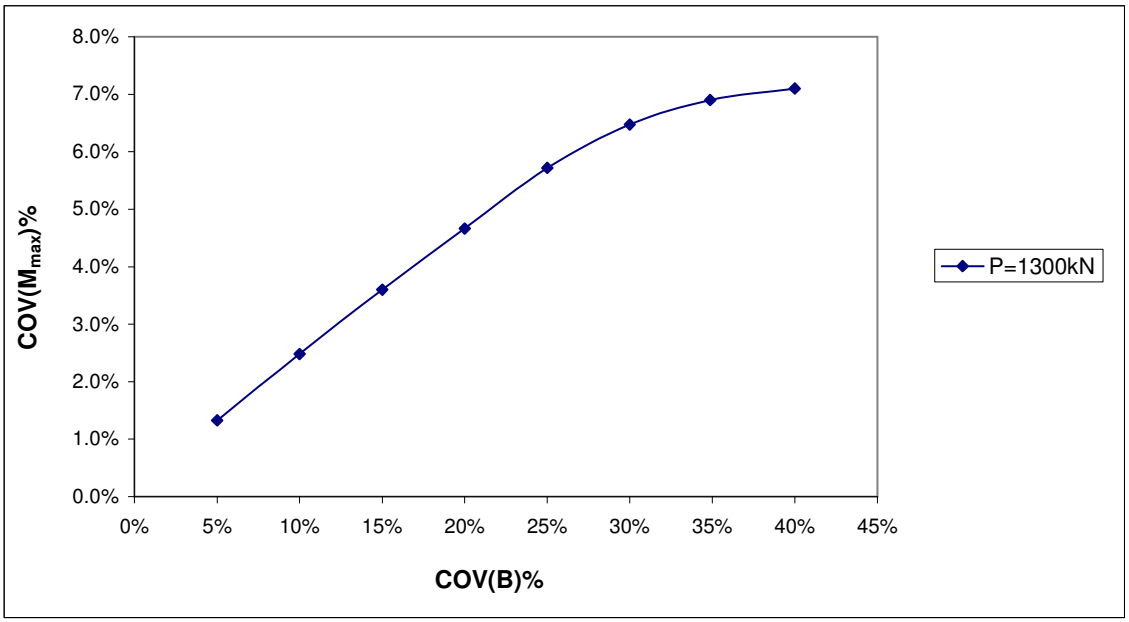


Fig. E.101 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

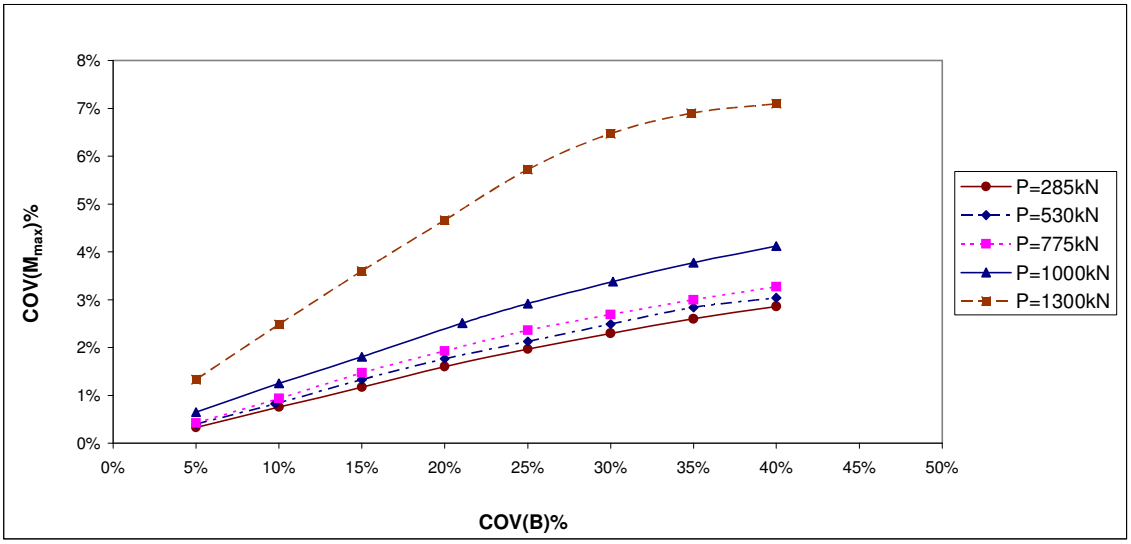


Fig. E.102 Variability of COV (M_{max}) vs. COV (B) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table E.131 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (EI) and load 285kN.

P=285kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	6.96E+01				
5%	61000			9.30E+06	8.70E-02	6.39E+01	0.32%
		57950	6.90E+01				
		67100	6.99E+01				
10%	61000			3.72E+07	4.10E-01	6.39E+01	0.43%
		54900	6.87E+01				
		70150	7.02E+01				
15%	61000			8.37E+07	9.41E-01	6.39E+01	0.65%
		51850	6.83E+01				
		73200	7.05E+01				
20%	61000			1.49E+08	1.69E+00	6.39E+01	0.83%
		48800	6.79E+01				
		76250	7.07E+01				
25%	61000			2.33E+08	2.71E+00	6.39E+01	0.97%
		45750	6.74E+01				
		79300	7.10E+01				
30%	61000			3.35E+08	4.00E+00	6.39E+01	1.11%
		42700	6.70E+01				
		82350	7.12E+01				
35%	61000			4.56E+08	5.64E+00	6.39E+01	1.30%
		39650	6.65E+01				
		85400	7.14E+01				
40%	61000			5.95E+08	7.67E+00	6.39E+01	1.49%
		36600	6.59E+01				

Table E.132 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (EI) and load 530kN.

P=530kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	1.15E+02				
5%	61000			9.30E+06	4.90E-01	1.08E+02	0.38%
		57950	1.13E+02				
		67100	1.15E+02				
10%	61000			3.72E+07	9.02E-01	1.08E+02	0.85%
		54900	1.13E+02				
		70150	1.15E+02				
15%	61000			8.37E+07	2.10E+00	1.08E+02	1.28%
		51850	1.12E+02				
		73200	1.16E+02				
20%	61000			1.49E+08	3.80E+00	1.08E+02	1.73%
		48800	1.12E+02				
		76250	1.16E+02				
25%	61000			2.33E+08	6.00E+00	1.08E+02	2.16%
		45750	1.11E+02				
		79300	1.16E+02				
30%	61000			3.35E+08	9.30E+00	1.08E+02	2.54%
		42700	1.10E+02				
		82350	1.17E+02				
35%	61000			4.56E+08	1.37E+01	1.08E+02	2.94%
		39650	1.10E+02				
		85400	1.17E+02				
40%	61000			5.95E+08	1.89E+01	1.08E+02	3.34%
		36600	1.09E+02				

Table E.133 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (EI) and load 775kN.

P=775kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	1.61E+02				
5%	61000			9.30E+06	8.10E-01	1.54E+02	0.42%
		57950	1.59E+02				
		67100	1.62E+02				
10%	61000			3.72E+07	3.42E+00	1.54E+02	0.88%
		54900	1.58E+02				
		70150	1.63E+02				
15%	61000			8.37E+07	7.56E+00	1.54E+02	1.34%
		51850	1.57E+02				
		73200	1.64E+02				
20%	61000			1.49E+08	1.23E+01	1.54E+02	1.81%
		48800	1.57E+02				
		76250	1.65E+02				
25%	61000			2.33E+08	1.85E+01	1.54E+02	2.27%
		45750	1.56E+02				
		79300	1.65E+02				
30%	61000			3.35E+08	2.50E+01	1.54E+02	2.82%
		42700	1.55E+02				
		82350	1.66E+02				
35%	61000			4.56E+08	3.31E+01	1.54E+02	3.43%
		39650	1.54E+02				
		85400	1.67E+02				
40%	61000			5.95E+08	4.10E+01	1.54E+02	4.03%
		36600	1.54E+02				

Table E.134 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (EI) and load 1000kN.

P=1000kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	2.11E+02				
5%	61000			9.30E+06	6.40E-01	2.11E+02	0.46%
		57950	2.10E+02				
		67100	2.12E+02				
10%	61000			3.72E+07	3.24E+00	2.11E+02	1.00%
		54900	2.09E+02				
		70150	2.13E+02				
15%	61000			8.37E+07	7.29E+00	2.11E+02	1.52%
		51850	2.08E+02				
		73200	2.14E+02				
20%	61000			1.49E+08	1.33E+01	2.11E+02	2.03%
		48800	2.07E+02				
		76250	2.15E+02				
25%	61000			2.33E+08	2.07E+01	2.11E+02	2.57%
		45750	2.06E+02				
		79300	2.16E+02				
30%	61000			3.35E+08	2.86E+01	2.11E+02	3.13%
		42700	2.05E+02				
		82350	2.16E+02				
35%	61000			4.56E+08	3.84E+01	2.11E+02	3.72%
		39650	2.04E+02				
		85400	2.17E+02				
40%	61000			5.95E+08	4.97E+01	2.11E+02	4.33%
		36600	2.03E+02				

Table E.135 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (EI) and load 1300kN.

P=1300kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	2.66E+02				
5%	61000			9.30E+06	1.00E+00	3.15E+02	0.58%
		57950	2.64E+02				
		67100	2.66E+02				
10%	61000			3.72E+07	1.82E+00	3.15E+02	1.20%
		54900	2.63E+02				
		70150	2.66E+02				
15%	61000			8.37E+07	4.20E+00	3.15E+02	1.79%
		51850	2.62E+02				
		73200	2.67E+02				
20%	61000			1.49E+08	6.76E+00	3.15E+02	2.27%
		48800	2.62E+02				
		76250	2.67E+02				
25%	61000			2.33E+08	9.30E+00	3.15E+02	2.79%
		45750	2.61E+02				
		79300	2.68E+02				
30%	61000			3.35E+08	1.23E+01	3.15E+02	3.50%
		42700	2.61E+02				
		82350	2.69E+02				
35%	61000			4.56E+08	1.68E+01	3.15E+02	3.92%
		39650	2.60E+02				
		85400	2.69E+02				
40%	61000			5.95E+08	2.21E+01	3.15E+02	4.52%
		36600	2.60E+02				

Table E.136 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 285kN.

P=285kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	8.70E-02	0.32%
10%	3.72E+07	4.10E-01	0.43%
15%	8.37E+07	9.41E-01	0.65%
20%	1.49E+08	1.69E+00	0.83%
25%	2.33E+08	2.71E+00	0.97%
30%	3.35E+08	4.00E+00	1.11%
35%	4.56E+08	5.64E+00	1.30%
40%	5.95E+08	7.67E+00	1.49%

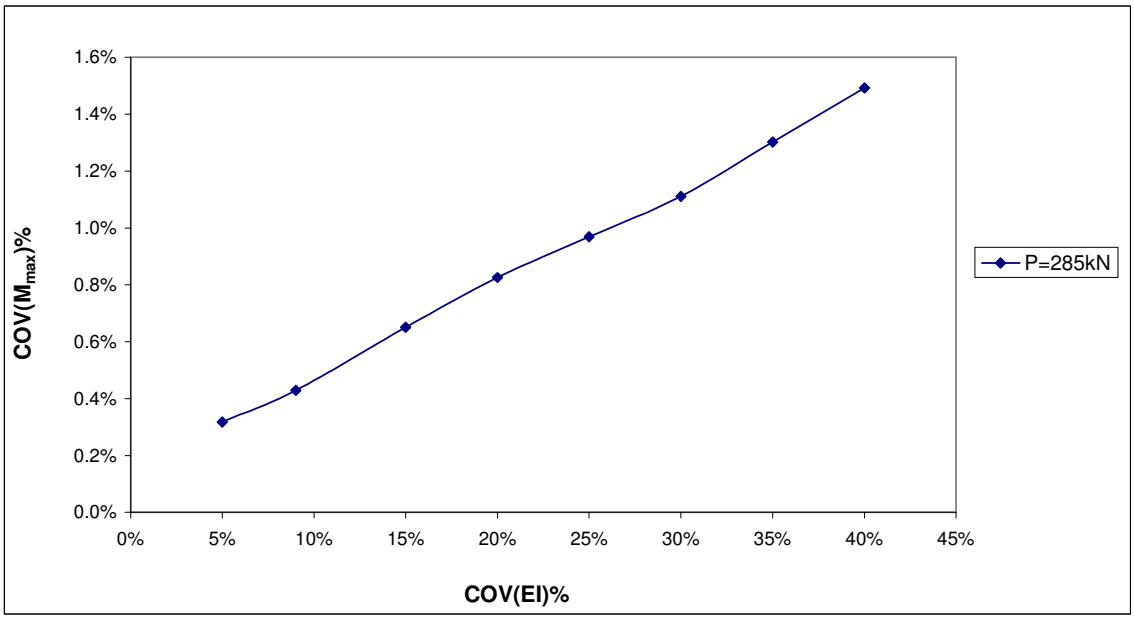


Fig. E.103 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.137 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 530kN.

P=530kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	4.90E-01	0.38%
10%	3.72E+07	9.02E-01	0.85%
15%	8.37E+07	2.10E+00	1.28%
20%	1.49E+08	3.80E+00	1.73%
25%	2.33E+08	6.00E+00	2.16%
30%	3.35E+08	9.30E+00	2.54%
35%	4.56E+08	1.37E+01	2.94%
40%	5.95E+08	1.89E+01	3.34%

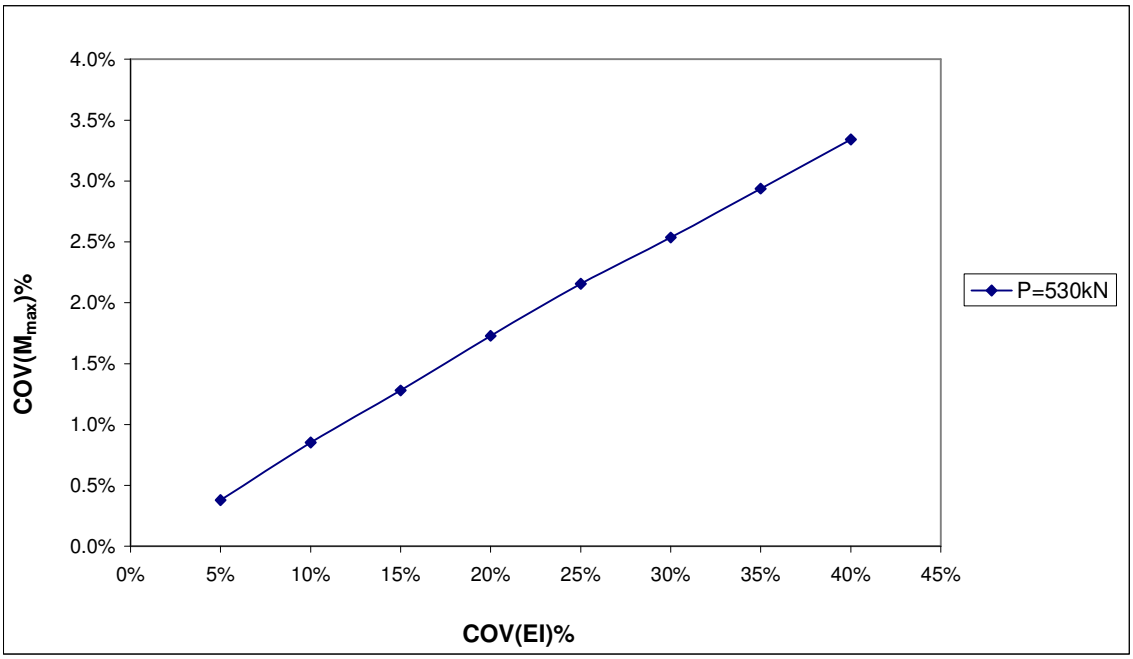


Fig. E.104 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.138 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 775kN.

P=775kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	8.10E-01	0.42%
10%	3.72E+07	3.42E+00	0.88%
15%	8.37E+07	7.56E+00	1.34%
20%	1.49E+08	1.23E+01	1.81%
25%	2.33E+08	1.85E+01	2.27%
30%	3.35E+08	2.50E+01	2.82%
35%	4.56E+08	3.31E+01	3.43%
40%	5.95E+08	4.10E+01	4.03%

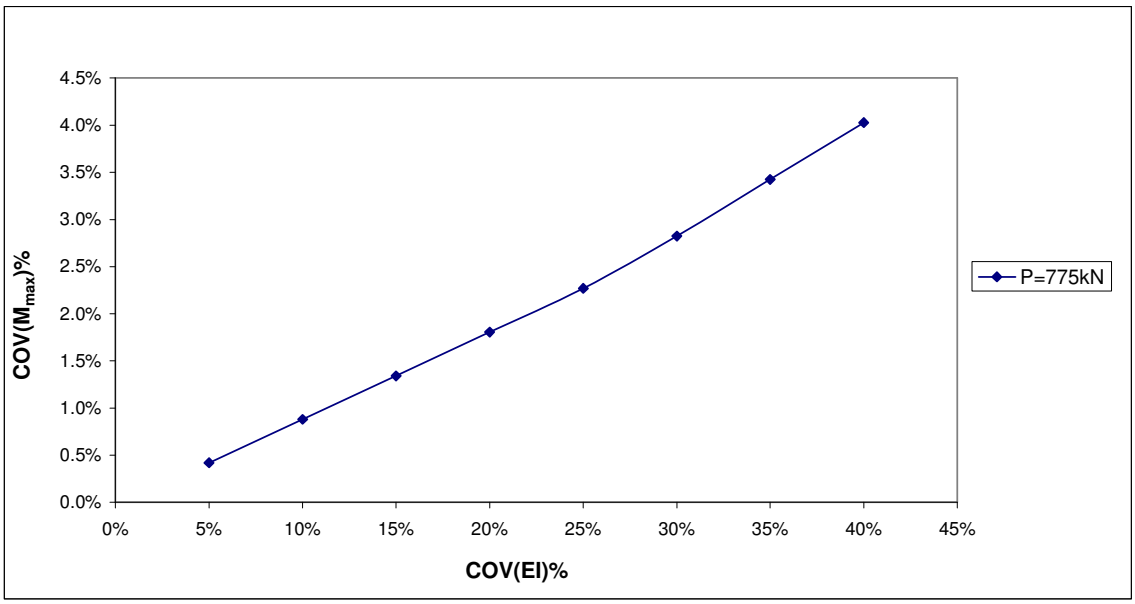


Fig. E.105 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.139 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 1000kN.

P=1000kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	6.40E-01	0.46%
10%	3.72E+07	3.24E+00	1.00%
15%	8.37E+07	7.29E+00	1.52%
20%	1.49E+08	1.33E+01	2.03%
25%	2.33E+08	2.07E+01	2.57%
30%	3.35E+08	2.86E+01	3.13%
35%	4.56E+08	3.84E+01	3.72%
40%	5.95E+08	4.97E+01	4.33%

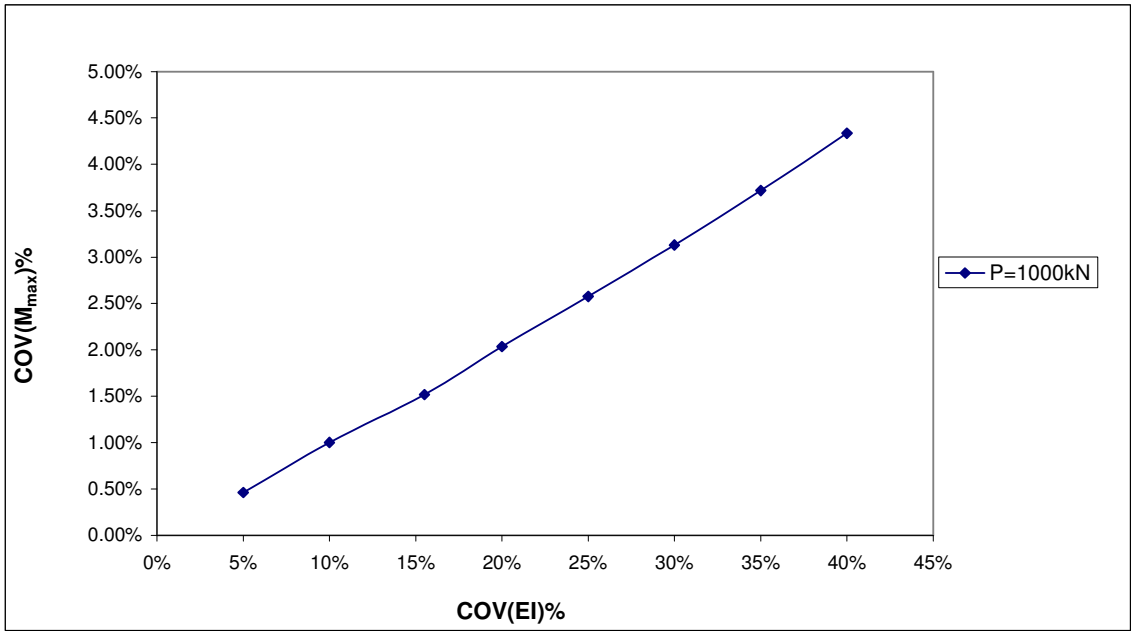


Fig. E.106 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.140 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 1300kN.

P=1300kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.00E+00	0.58%
10%	3.72E+07	1.82E+00	1.20%
15%	8.37E+07	4.20E+00	1.79%
20%	1.49E+08	6.76E+00	2.27%
25%	2.33E+08	9.30E+00	2.79%
30%	3.35E+08	1.23E+01	3.50%
35%	4.56E+08	1.68E+01	3.92%
40%	5.95E+08	2.21E+01	4.52%

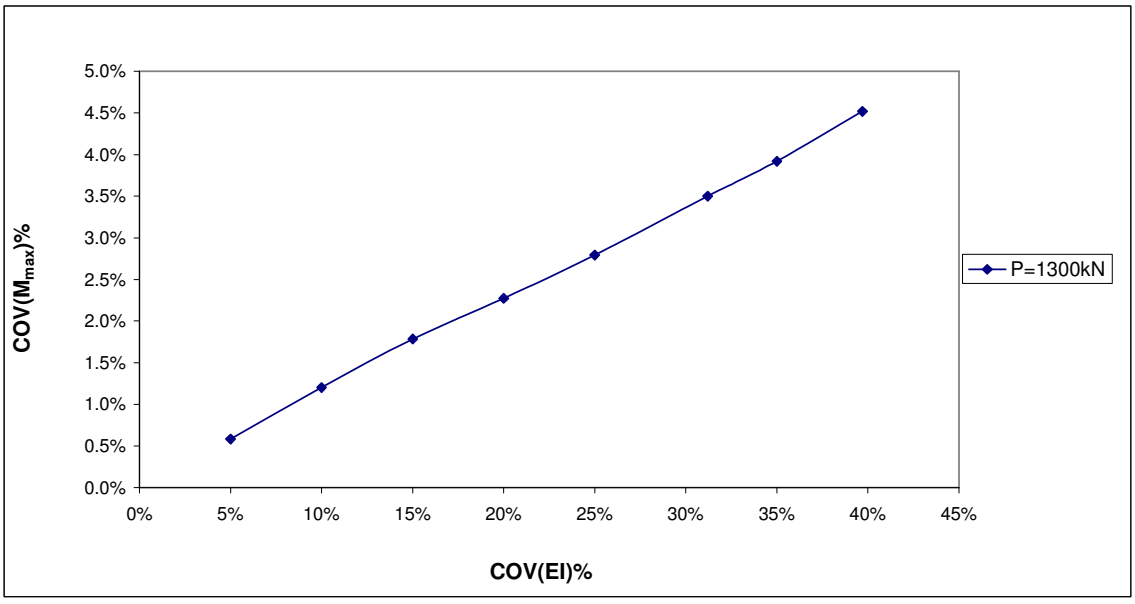


Fig. E.107 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

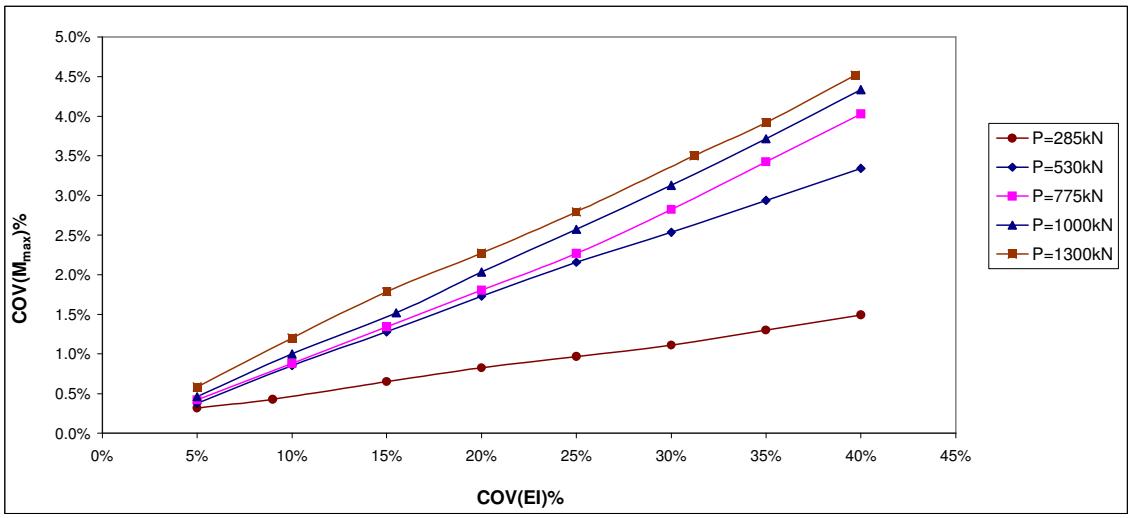


Fig. E.108 Variability of COV (M_{max}) vs. COV (EI) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table E.141 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (P) and load 285kN.

P=285kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		299.25	7.38E+01				
5%	285			2.03E+02	1.98E+01	6.39E+01	5.30%
		270.75	6.49E+01				
		313.5	7.82E+01				
10%	285			8.12E+02	7.77E+01	6.39E+01	10.71%
		256.5	6.06E+01				
		327.75	8.26E+01				
15%	285			1.83E+03	1.74E+02	6.39E+01	16.02%
		242.25	5.63E+01				
		342	8.71E+01				
20%	285			3.25E+03	3.07E+02	6.39E+01	21.37%
		228	5.20E+01				
		356.25	9.15E+01				
25%	285			5.08E+03	4.79E+02	6.39E+01	26.65%
		213.75	4.78E+01				
		370.5	9.60E+01				
30%	285			7.31E+03	6.83E+02	6.39E+01	32.02%
		199.5	4.37E+01				
		384.75	1.00E+02				
35%	285			9.95E+03	9.18E+02	6.39E+01	37.32%
		185.25	3.98E+01				
		399	1.05E+02				
40%	285			1.30E+04	1.19E+03	6.39E+01	42.83%
		171	3.60E+01				

Table E.142 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (P) and load 530kN.

P=530kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		556.5	1.21E+02				
5%	530			7.02E+02	4.56E+01	1.08E+02	6.16%
		503.5	1.07E+02				
		583	1.28E+02				
10%	530			2.81E+03	1.84E+02	1.08E+02	12.25%
		477	1.00E+02				
		609.5	1.34E+02				
15%	530			6.32E+03	4.09E+02	1.08E+02	18.48%
		450.5	9.38E+01				
		636	1.41E+02				
20%	530			1.12E+04	7.30E+02	1.08E+02	24.72%
		424	8.71E+01				
		662.5	1.48E+02				
25%	530			1.76E+04	1.15E+03	1.08E+02	30.83%
		397.5	8.04E+01				
		689	1.56E+02				
30%	530			2.53E+04	1.67E+03	1.08E+02	37.09%
		371	7.38E+01				
		715.5	1.63E+02				
35%	530			3.44E+04	2.28E+03	1.08E+02	43.27%
		344.5	6.71E+01				
		742	1.70E+02				
40%	530			4.49E+04	3.00E+03	1.08E+02	49.50%
		318	6.06E+01				

Table E.143 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (P) and load 775kN.

P=775kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		813.75	1.70E+02				
5%	775			1.50E+03	9.41E+01	1.54E+02	6.30%
		736.25	1.51E+02				
		852.5	1.80E+02				
10%	775			6.01E+03	3.78E+02	1.54E+02	12.63%
		697.5	1.41E+02				
		891.25	1.90E+02				
15%	775			1.35E+04	8.41E+02	1.54E+02	18.83%
		658.75	1.32E+02				
		930	2.00E+02				
20%	775			2.40E+04	1.49E+03	1.54E+02	25.10%
		620	1.23E+02				
		968.75	2.11E+02				
25%	775			3.75E+04	2.34E+03	1.54E+02	31.43%
		581.25	1.14E+02				
		1007.5	2.21E+02				
30%	775			5.41E+04	3.37E+03	1.54E+02	37.69%
		542.5	1.05E+02				
		1046.25	2.31E+02				
35%	775			7.36E+04	4.58E+03	1.54E+02	43.94%
		503.75	9.60E+01				
		1085	2.42E+02				
40%	775			9.61E+04	6.02E+03	1.54E+02	50.40%
		465	8.71E+01				

Table E.144 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (P) and load 1000kN.

P=1000kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		1050	2.24E+02				
5%	1000			2.50E+03	1.69E+02	2.11E+02	6.80%
		950	1.98E+02				
		1100	2.37E+02				
10%	1000			1.00E+04	6.68E+02	2.11E+02	12.90%
		900	1.85E+02				
		1150	2.51E+02				
15%	1000			2.25E+04	1.52E+03	2.11E+02	19.00%
		850	1.73E+02				
		1200	2.65E+02				
20%	1000			4.00E+04	2.72E+03	2.11E+02	25.50%
		800	1.60E+02				
		1250	2.78E+02				
25%	1000			6.25E+04	4.23E+03	2.11E+02	32.10%
		750	1.48E+02				
		1300	2.93E+02				
30%	1000			9.00E+04	6.12E+03	2.11E+02	38.00%
		700	1.36E+02				
		1350	3.08E+02				
35%	1000			1.23E+05	8.34E+03	2.11E+02	44.70%
		650	1.25E+02				
		1400	3.23E+02				
40%	1000			1.60E+05	1.09E+04	2.11E+02	50.69%
		600	1.14E+02				

Table E.145 Probabilistic modeling of laterally loaded free head long (10T) pile group with spacing (5D) with varying (P) and load 1300kN.

P=1300kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		1365	2.81E+02				
5%	1300			4.23E+03	2.79E+02	3.15E+02	6.96%
		1235	2.48E+02				
		1430	2.99E+02				
10%	1300			1.69E+04	1.14E+03	3.15E+02	13.79%
		1170	2.31E+02				
		1495	3.17E+02				
15%	1300			3.80E+04	2.55E+03	3.15E+02	20.63%
		1105	2.16E+02				
		1560	3.35E+02				
20%	1300			6.76E+04	4.53E+03	3.15E+02	27.44%
		1040	2.00E+02				
		1625	3.53E+02				
25%	1300			1.06E+05	7.05E+03	3.15E+02	34.23%
		975	1.85E+02				
		1690	3.72E+02				
30%	1300			1.52E+05	1.02E+04	3.15E+02	40.90%
		910	1.70E+02				
		1755	3.91E+02				
35%	1300			2.07E+05	1.38E+04	3.15E+02	47.43%
		845	1.56E+02				
		1820	4.11E+02				
40%	1300			2.70E+05	1.82E+04	3.15E+02	53.95%
		780	1.41E+02				

Table E.146 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 285kN.

P=285kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.03E+02	1.98E+01	5.30%
10%	8.12E+02	7.77E+01	10.71%
15%	1.83E+03	1.74E+02	16.02%
20%	3.25E+03	3.07E+02	21.37%
25%	5.08E+03	4.79E+02	26.65%
30%	7.31E+03	6.83E+02	32.02%
35%	9.95E+03	9.18E+02	37.32%
40%	1.30E+04	1.19E+03	42.83%

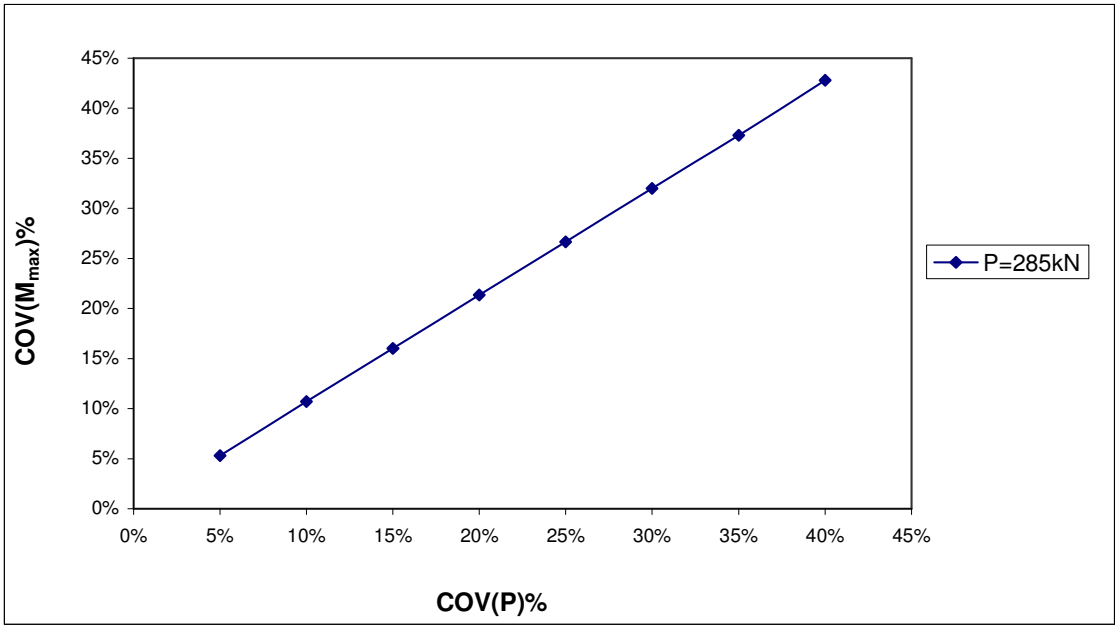


Fig. E.109 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force 285kN.

Table E.147 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 530kN.

P=530kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	7.02E+02	4.56E+01	6.16%
10%	2.81E+03	1.84E+02	12.25%
15%	6.32E+03	4.09E+02	18.48%
20%	1.12E+04	7.30E+02	24.72%
25%	1.76E+04	1.15E+03	30.83%
30%	2.53E+04	1.67E+03	37.09%
35%	3.44E+04	2.28E+03	43.27%
40%	4.49E+04	3.00E+03	49.50%

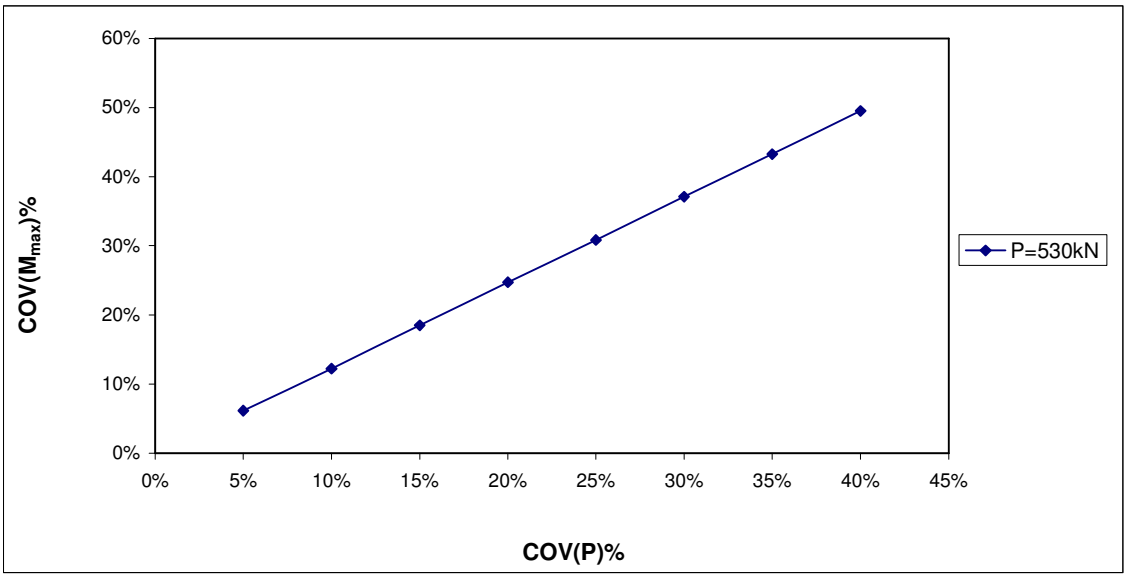


Fig. E.110 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force 530kN.

Table E.148 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 775kN.

P=775kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	1.50E+03	9.41E+01	6.30%
10%	6.01E+03	3.78E+02	12.63%
15%	1.35E+04	8.41E+02	18.83%
20%	2.40E+04	1.49E+03	25.10%
25%	3.75E+04	2.34E+03	31.43%
30%	5.41E+04	3.37E+03	37.69%
35%	7.36E+04	4.58E+03	43.94%
40%	9.61E+04	6.02E+03	50.40%

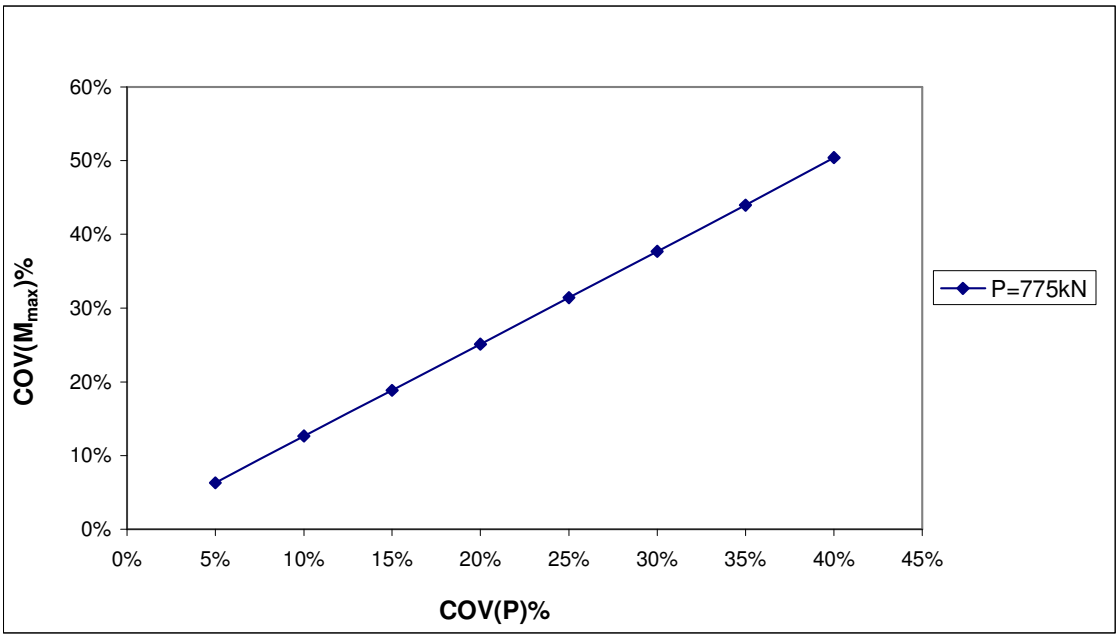


Fig. E.111 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force 775kN.

Table E.149 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 1000kN.

P=1000kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.50E+03	1.69E+02	6.80%
10%	1.00E+04	6.68E+02	12.90%
15%	2.25E+04	1.52E+03	19.00%
20%	4.00E+04	2.72E+03	25.50%
25%	6.25E+04	4.23E+03	32.10%
30%	9.00E+04	6.12E+03	38.00%
35%	1.23E+05	8.34E+03	44.70%
40%	1.60E+05	1.09E+04	50.69%

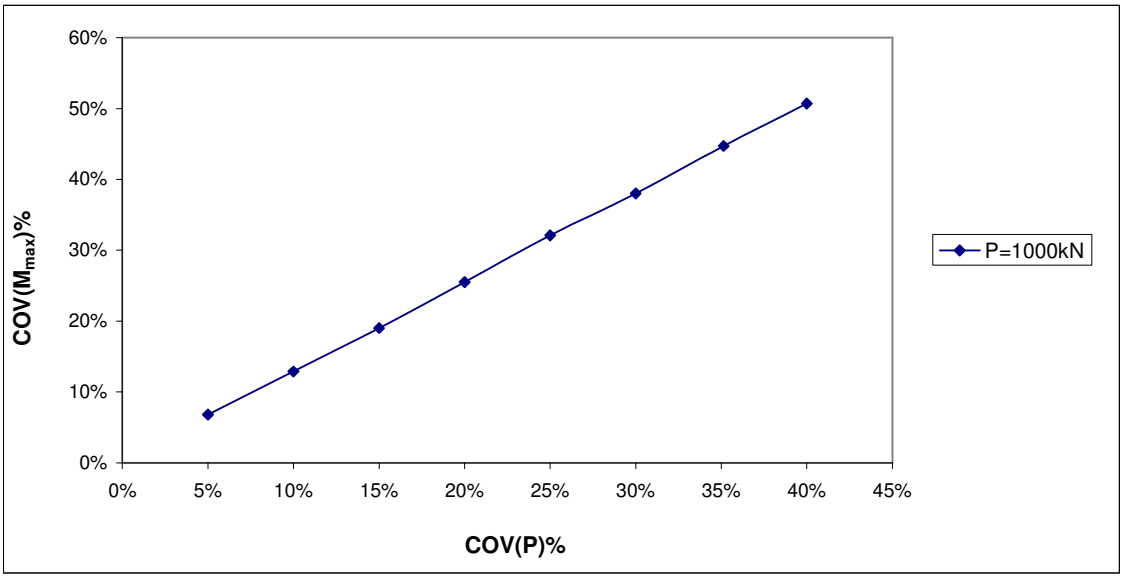


Fig. E.112 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table E.150 Value of COV (M_{max}) for free head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 1300kN.

P=1300kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.23E+03	2.79E+02	6.96%
10%	1.69E+04	1.14E+03	13.79%
15%	3.80E+04	2.55E+03	20.63%
20%	6.76E+04	4.53E+03	27.44%
25%	1.06E+05	7.05E+03	34.23%
30%	1.52E+05	1.02E+04	40.90%
35%	2.07E+05	1.38E+04	47.43%
40%	2.70E+05	1.82E+04	53.95%

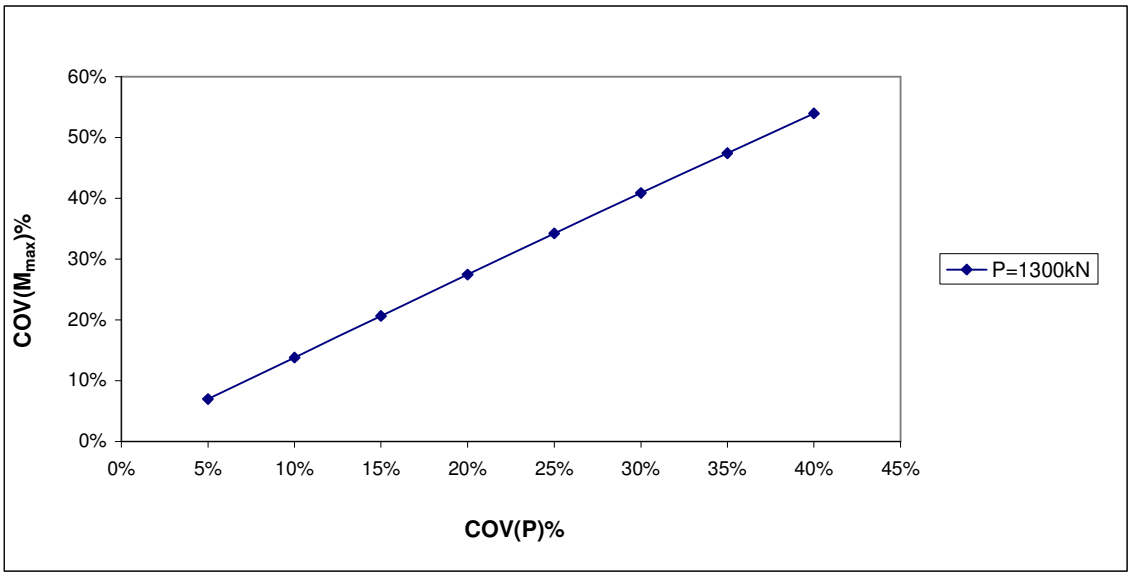


Fig. E.113 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force 1300kN.

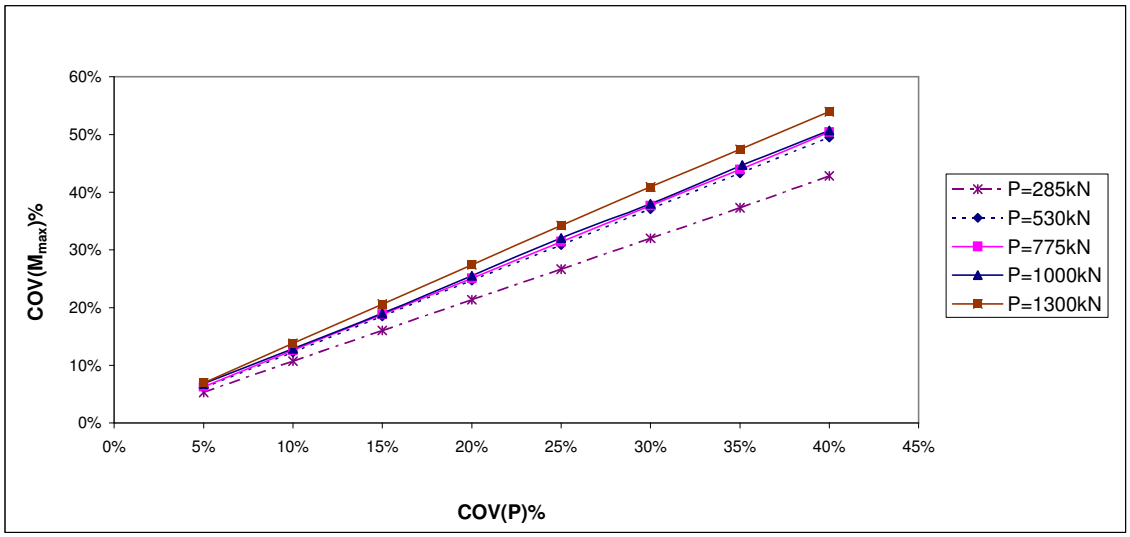


Fig. E.114 Variability of COV (M_{max}) vs. COV (P) for free head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

E.5 Reliability Index (β) of bending moment vs. COV (Variables)

Table E.151 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'Φ ' subjected to lateral load 285kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
8.47E+00	10696.73	5%	103.4659	6.0464
3.26E+01	10696.73	10%	103.5825	6.0396
6.70E+01	10696.73	15%	103.7484	6.0300
1.24E+02	10696.73	20%	104.0221	6.0141
1.98E+02	10696.73	25%	104.3777	5.9936
2.82E+02	10696.73	30%	104.7798	5.9706
3.58E+02	10696.73	35%	105.1413	5.9501
4.56E+02	10696.73	40%	105.6087	5.9238

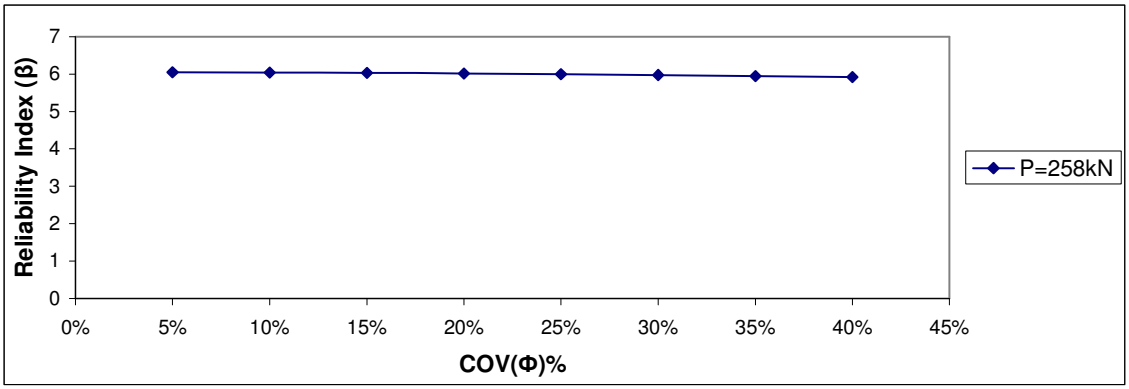


Fig.E.115 Reliability Index (β) of M_{max} vs. COV(Φ) for free head long pile group (10T) subjected to lateral force 285kN.

Table E.152 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 530kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.33E+01	10696.73	5%	103.4894	5.6189
6.40E+01	10696.73	10%	103.7339	5.6057
1.53E+02	10696.73	15%	104.1597	5.5828
2.81E+02	10696.73	20%	104.7750	5.5500
4.14E+02	10696.73	25%	105.4090	5.5166
6.10E+02	10696.73	30%	106.3324	5.4687
8.69E+02	10696.73	35%	107.5430	5.4071
1.18E+03	10696.73	40%	108.9722	5.3362

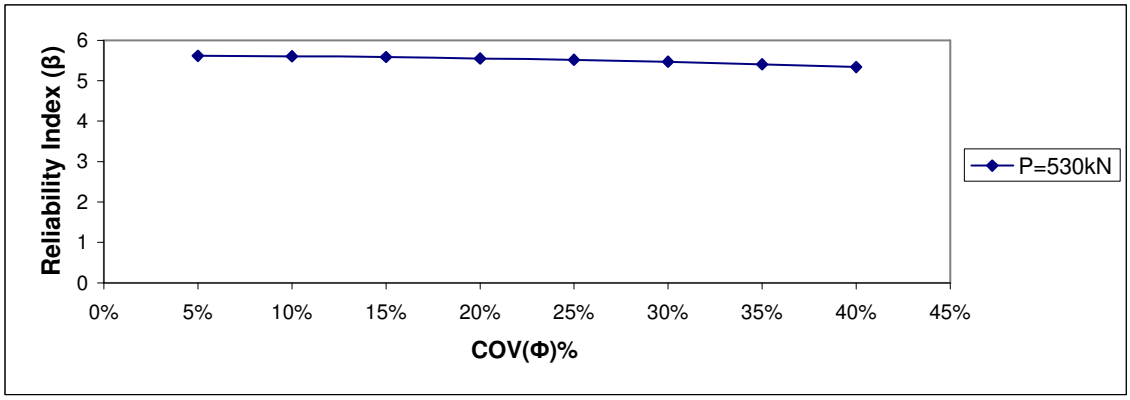


Fig.E.116 Reliability Index (β) of M_{max} vs. COV(Φ) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.153 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 775kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.31E+01	10696.73	5%	103.5847	5.1697
1.19E+02	10696.73	10%	103.9978	5.1491
2.61E+02	10696.73	15%	104.6783	5.1157
4.67E+02	10696.73	20%	105.6565	5.0683
8.12E+02	10696.73	25%	107.2799	4.9916
1.23E+03	10696.73	30%	109.2027	4.9037
1.71E+03	10696.73	35%	111.3847	4.8077
2.37E+03	10696.73	40%	114.3172	4.6843

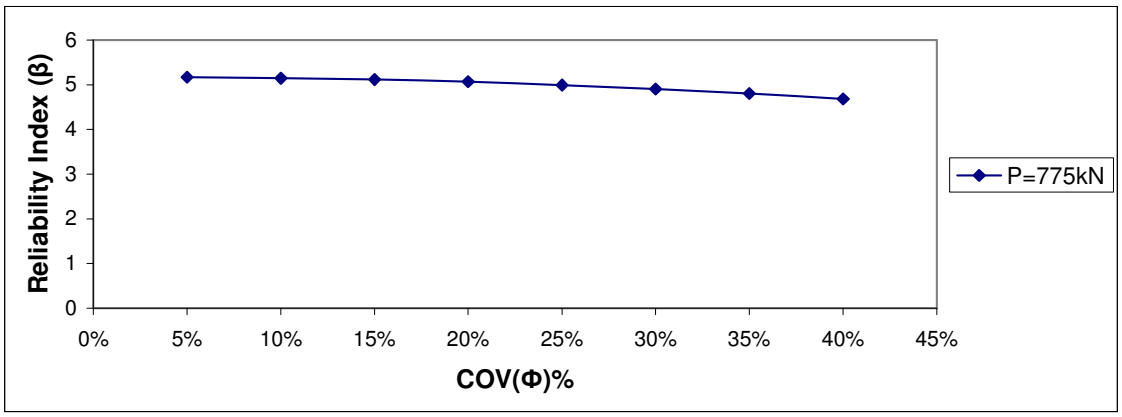


Fig.E.117 Reliability Index (β) of M_{max} vs. COV(Φ) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.154 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
5.93E+01	10696.73	5%	103.7112	4.6138
2.28E+02	10696.73	10%	104.5215	4.5780
4.77E+02	10696.73	15%	105.7079	4.5266
9.24E+02	10696.73	20%	107.8002	4.4388
1.53E+03	10696.73	25%	110.5692	4.3276
2.32E+03	10696.73	30%	114.0840	4.1943
3.36E+03	10696.73	35%	118.5780	4.0353
4.64E+03	10696.73	40%	123.8319	3.8641

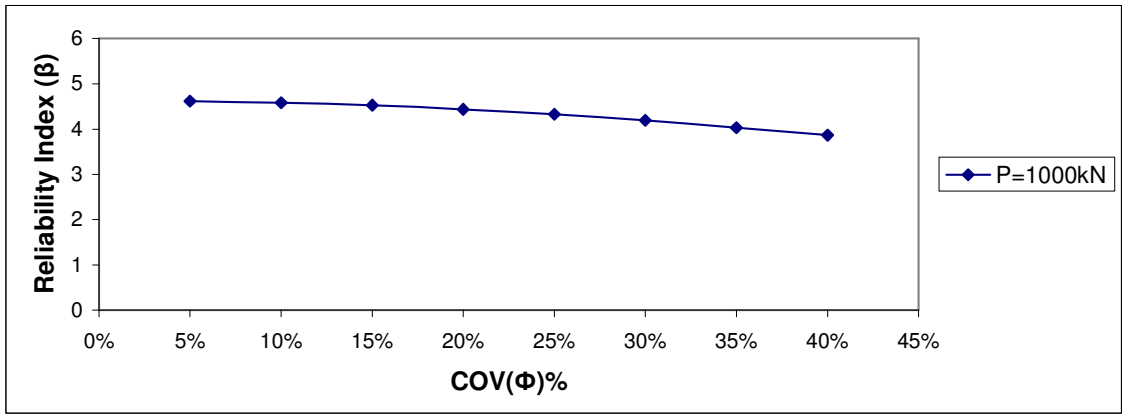


Fig.E.118 Reliability Index (β) of M_{max} vs. COV(Φ) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.155 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 1300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
9.90E+01	10696.73	5%	103.9025	3.6043
4.04E+02	10696.73	10%	105.3601	3.5545
9.61E+02	10696.73	15%	107.9710	3.4685
1.72E+03	10696.73	20%	111.4405	3.3605
2.70E+03	10696.73	25%	115.7391	3.2357
4.15E+03	10696.73	30%	121.8363	3.0738
6.03E+03	10696.73	35%	129.3300	2.8957
8.16E+03	10696.73	40%	137.3312	2.7270

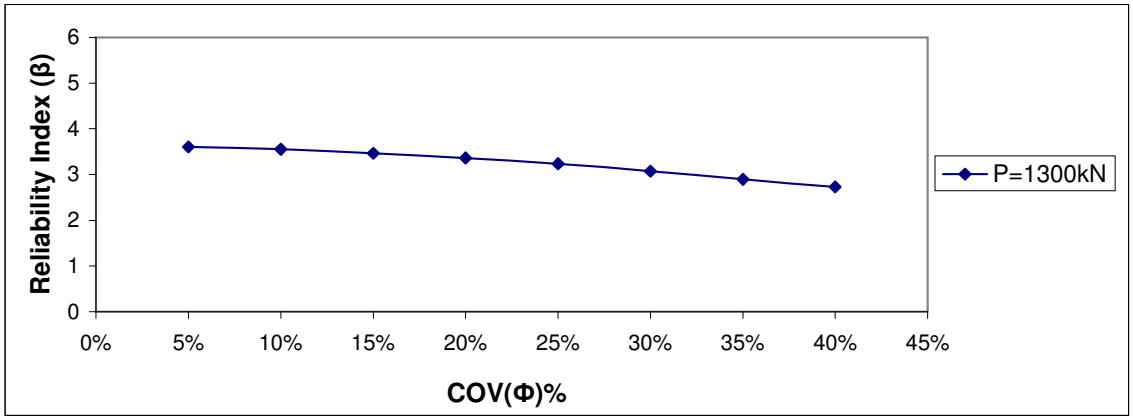


Fig.E.119 Reliability Index (β) of M_{max} vs. COV(Φ) for free head long pile group (10T) subjected to lateral force 1300kN.

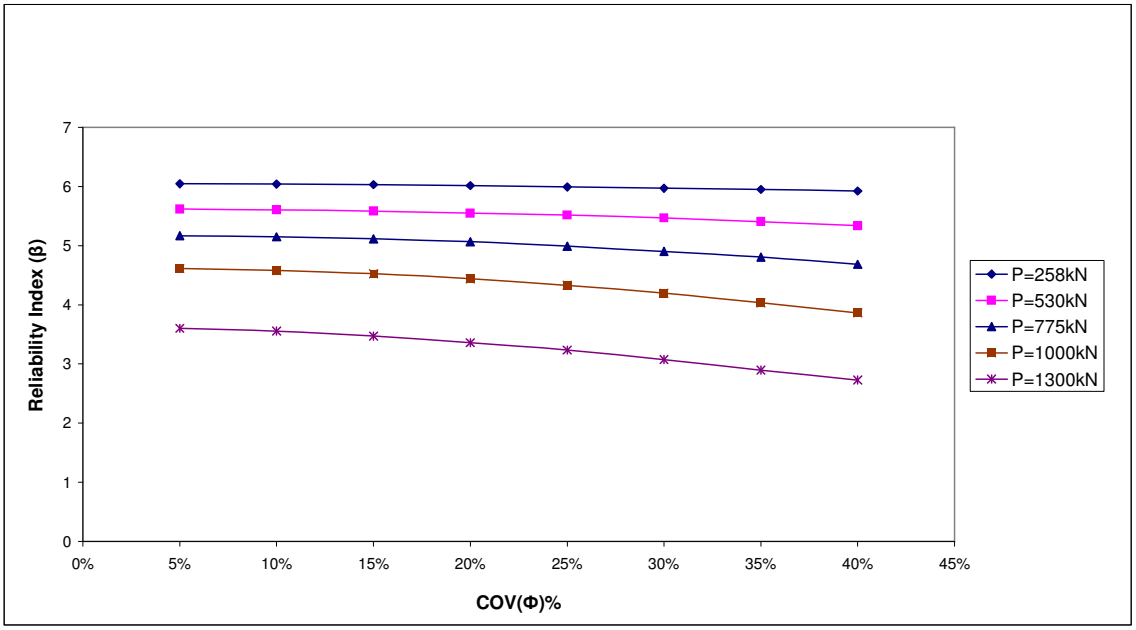


Fig.E.120 Reliability Index (β) of M_{max} vs. COV(Φ) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table E.156 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 285kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.76E+00	10696.73	5%	103.4335	6.0483
6.66E+00	10696.73	10%	103.4572	6.0469
1.47E+01	10696.73	15%	103.4961	6.0447
2.61E+01	10696.73	20%	103.5509	6.0415
4.05E+01	10696.73	25%	103.6207	6.0374
5.72E+01	10696.73	30%	103.7013	6.0327
8.09E+01	10696.73	35%	103.8154	6.0261
1.10E+02	10696.73	40%	103.9551	6.0180

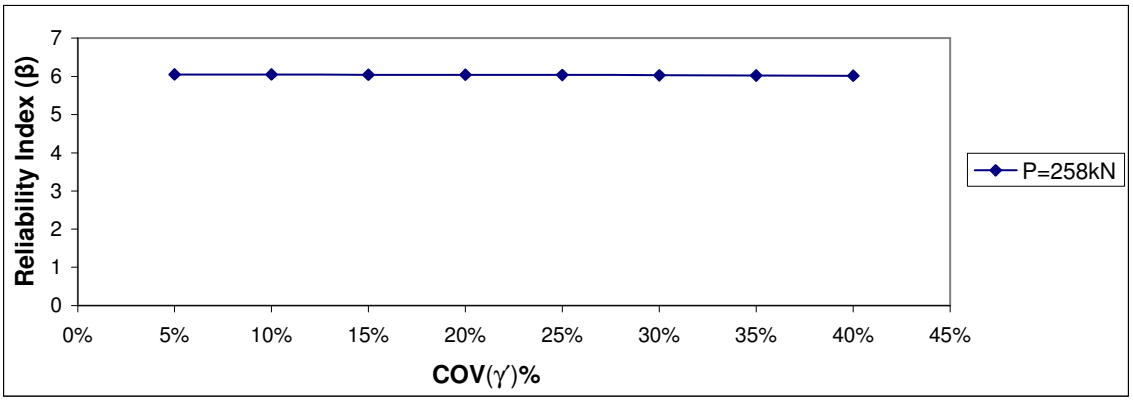


Fig.E.121 Reliability Index (β) of M_{max} vs. COV(γ) for free head long pile group (10T) subjected to lateral force 258kN.

Table E.157 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 530kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
2.40E+00	10696.73	5%	103.4366	5.6218
9.92E+00	10696.73	10%	103.4730	5.6198
2.55E+01	10696.73	15%	103.5482	5.6157
4.83E+01	10696.73	20%	103.6583	5.6098
8.19E+01	10696.73	25%	103.8202	5.6010
1.20E+02	10696.73	30%	104.0030	5.5912
1.69E+02	10696.73	35%	104.2388	5.5785
2.28E+02	10696.73	40%	104.5215	5.5634

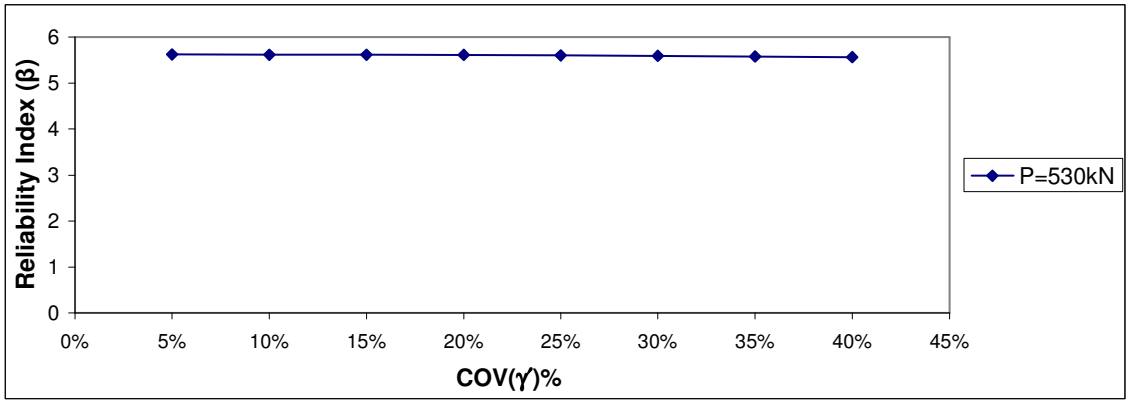


Fig.E.122 Reliability Index (β) of M_{max} vs. COV(γ) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.158 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 775kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
7.02E+00	10696.73	5%	103.4589	5.1760
2.70E+01	10696.73	10%	103.5556	5.1711
5.55E+01	10696.73	15%	103.6930	5.1643
9.60E+01	10696.73	20%	103.8883	5.1546
1.49E+02	10696.73	25%	104.1421	5.1420
2.16E+02	10696.73	30%	104.4644	5.1261
2.92E+02	10696.73	35%	104.8291	5.1083
3.90E+02	10696.73	40%	105.2938	5.0858

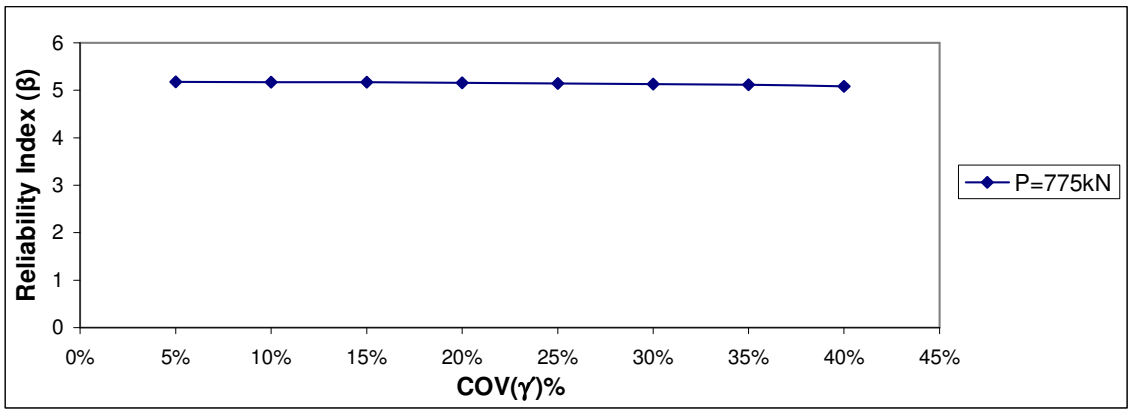


Fig.E.123 Reliability Index (β) of M_{max} vs. COV(γ) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.159 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.12E+01	10696.73	5%	103.4792	4.6241
4.42E+01	10696.73	10%	103.6386	4.6170
1.01E+02	10696.73	15%	103.9121	4.6049
1.85E+02	10696.73	20%	104.3153	4.5871
2.79E+02	10696.73	25%	104.7646	4.5674
3.92E+02	10696.73	30%	105.3032	4.5440
5.78E+02	10696.73	35%	106.1844	4.5063
8.12E+02	10696.73	40%	107.2799	4.4603

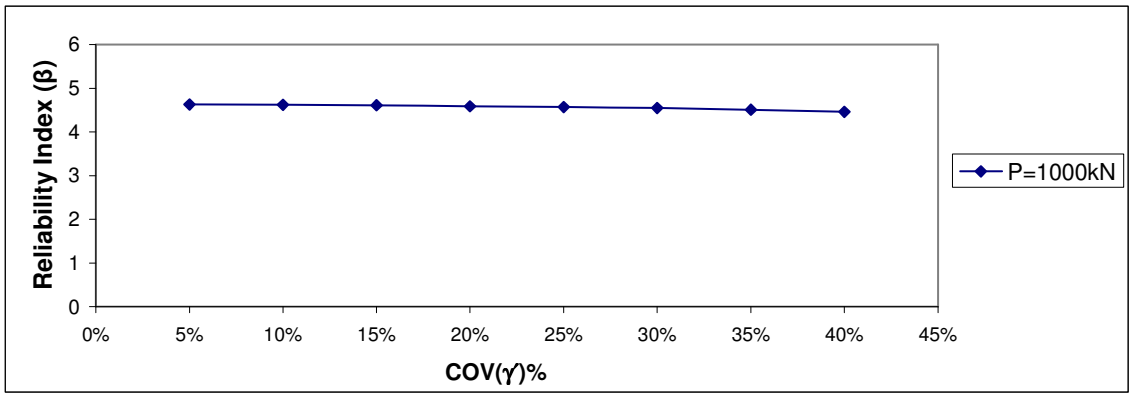


Fig.E.124 Reliability Index (β) of M_{max} vs. COV(γ) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.160 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 1300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.68E+01	10696.73	5%	103.5062	3.6181
6.97E+01	10696.73	10%	103.7615	3.6092
1.70E+02	10696.73	15%	104.2451	3.5925
3.03E+02	10696.73	20%	104.8785	3.5708
5.00E+02	10696.73	25%	105.8123	3.5393
7.70E+02	10696.73	30%	107.0831	3.4973
1.12E+03	10696.73	35%	108.7151	3.4448
1.50E+03	10696.73	40%	110.4459	3.3908

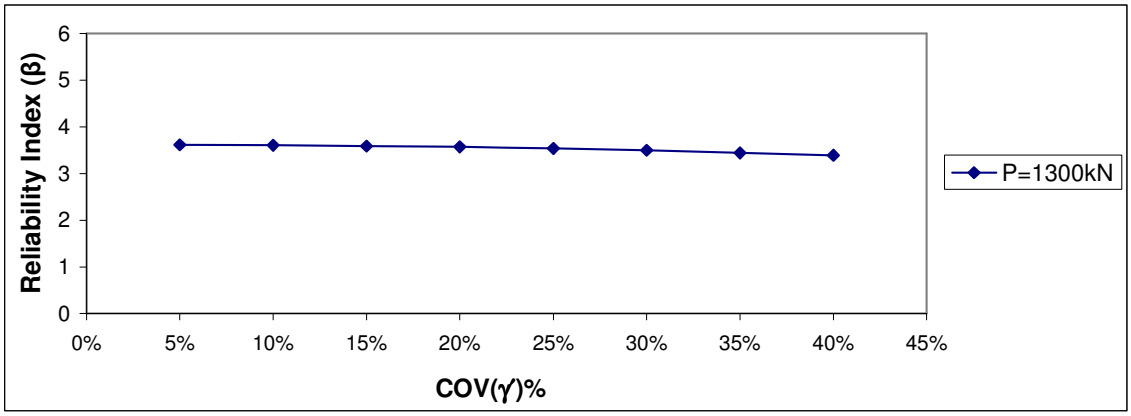


Fig.E.125 Reliability Index (β) of M_{max} vs. COV(γ) for free head long pile group (10T) subjected to lateral force 1300kN.

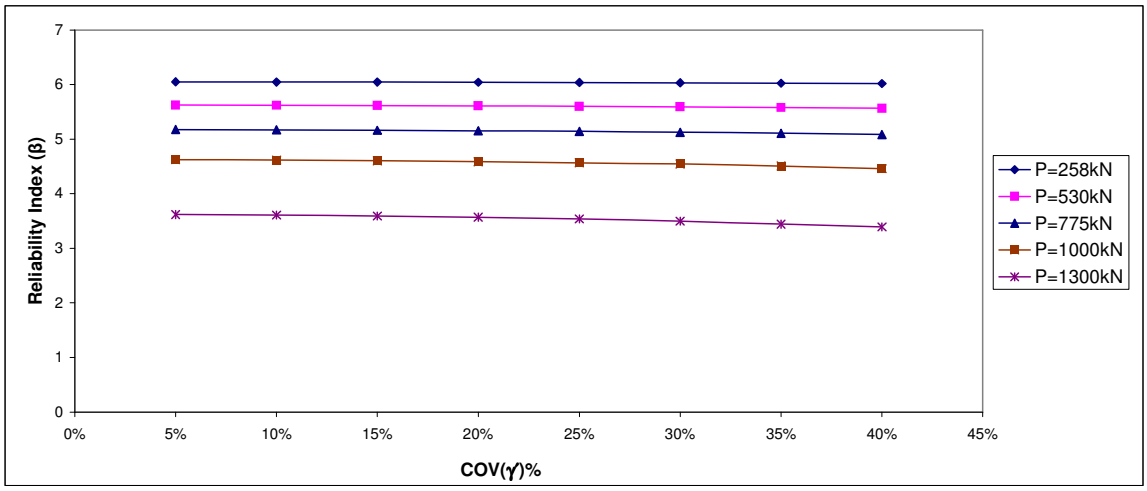


Fig.E.126 Reliability Index (β) of M_{max} vs. COV(γ) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table E.161 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 285kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.10E-02	10696.73	5%	103.4251	6.0488
2.89E-02	10696.73	10%	103.4251	6.0488
5.06E-02	10696.73	15%	103.4252	6.0488
7.56E-02	10696.73	20%	103.4254	6.0488
1.12E-01	10696.73	25%	103.4255	6.0488
1.56E-01	10696.73	30%	103.4258	6.0488
2.40E-01	10696.73	35%	103.4262	6.0488
4.10E-01	10696.73	40%	103.4270	6.0487

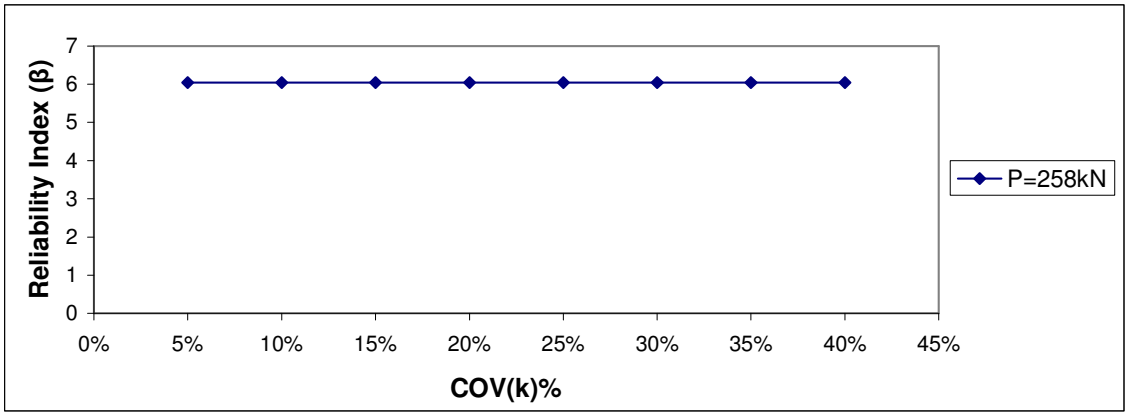


Fig.E.127 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force 258kN.

Table E.162 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 530kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E-02	10696.73	5%	103.4250	5.6224
2.25E-02	10696.73	10%	103.4251	5.6224
4.00E-02	10696.73	15%	103.4252	5.6224
6.25E-02	10696.73	20%	103.4253	5.6224
9.00E-02	10696.73	25%	103.4254	5.6224
1.23E-01	10696.73	30%	103.4256	5.6224
2.03E-01	10696.73	35%	103.4260	5.6224
3.03E-01	10696.73	40%	103.4265	5.6224

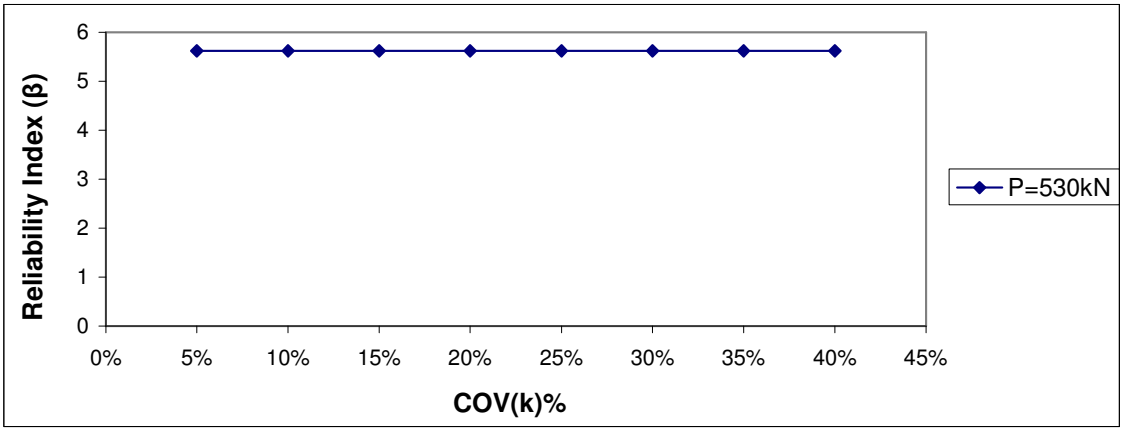


Fig.E.128 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.163 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 775kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-03	10696.73	5%	103.4250	5.1777
2.25E-02	10696.73	10%	103.4251	5.1777
6.25E-02	10696.73	15%	103.4253	5.1776
1.22E-01	10696.73	20%	103.4256	5.1776
2.03E-01	10696.73	25%	103.4260	5.1776
4.90E-01	10696.73	30%	103.4274	5.1775
7.23E-01	10696.73	35%	103.4285	5.1775
1.10E+00	10696.73	40%	103.4303	5.1774

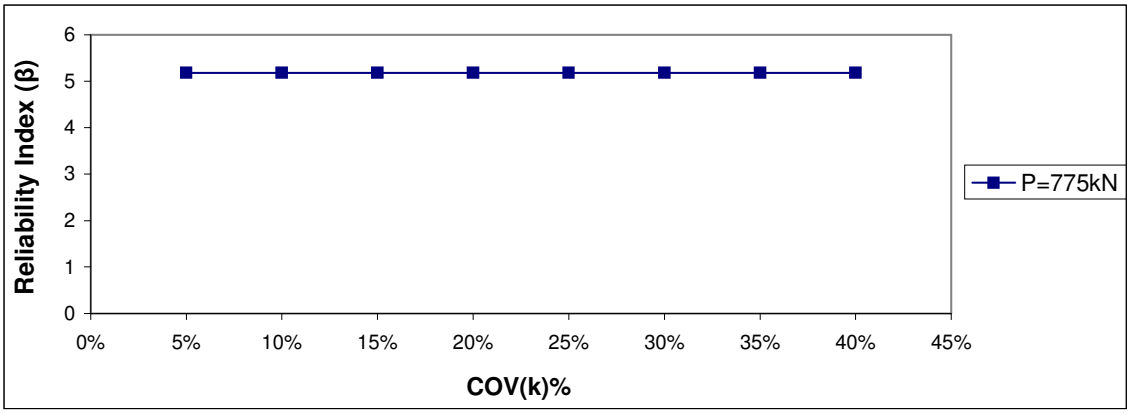


Fig.E.129 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.164 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-03	10696.73	5%	103.4250	4.6265
2.25E-02	10696.73	10%	103.4251	4.6265
6.25E-02	10696.73	15%	103.4253	4.6265
1.23E-01	10696.73	20%	103.4256	4.6265
1.60E-01	10696.73	25%	103.4258	4.6265
2.03E-01	10696.73	30%	103.4260	4.6265
3.02E-01	10696.73	35%	103.4265	4.6265
4.23E-01	10696.73	40%	103.4270	4.6264

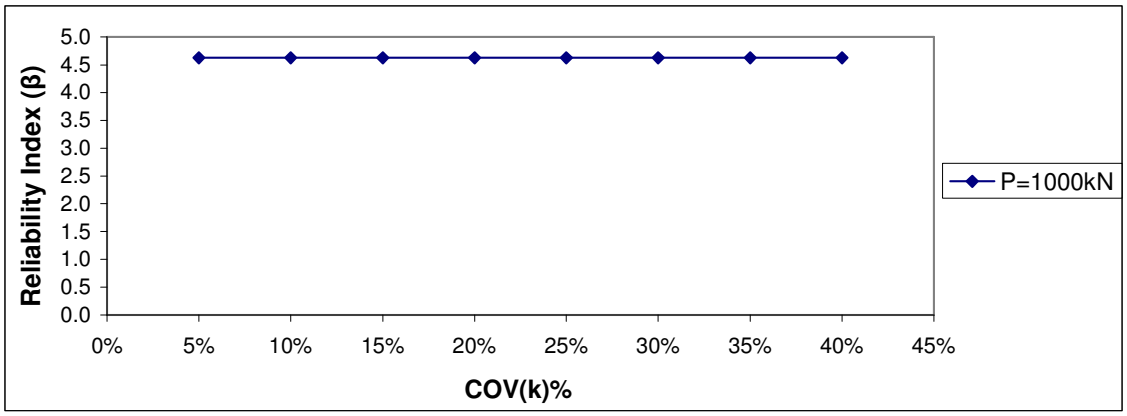


Fig.E.130 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.165 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 1300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.50E-03	10696.73	5%	103.4250	3.6210
2.50E-03	10696.73	10%	103.4250	3.6210
2.50E-03	10696.73	15%	103.4250	3.6210
1.00E-02	10696.73	20%	103.4250	3.6210
4.00E-02	10696.73	25%	103.4252	3.6210
9.00E-02	10696.73	30%	103.4254	3.6210
2.50E-01	10696.73	35%	103.4262	3.6209
3.02E-01	10696.73	40%	103.4265	3.6209

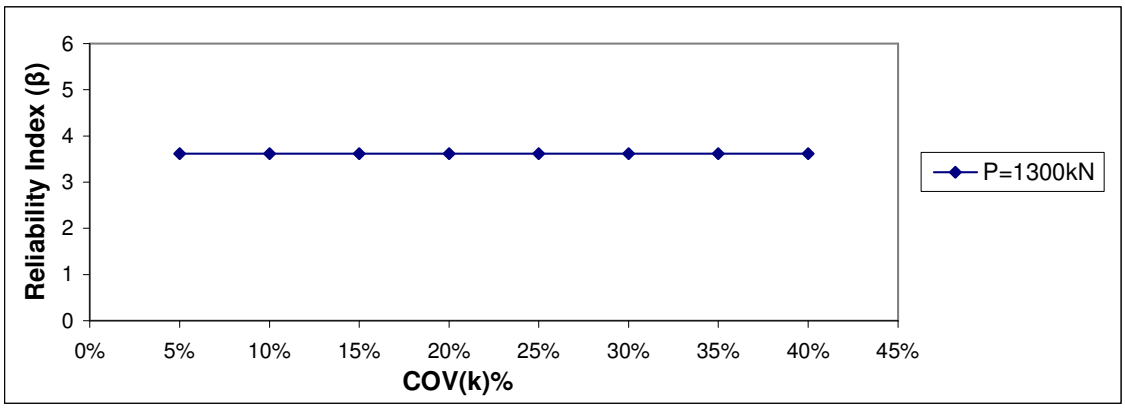


Fig.E.131 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force 1300kN.

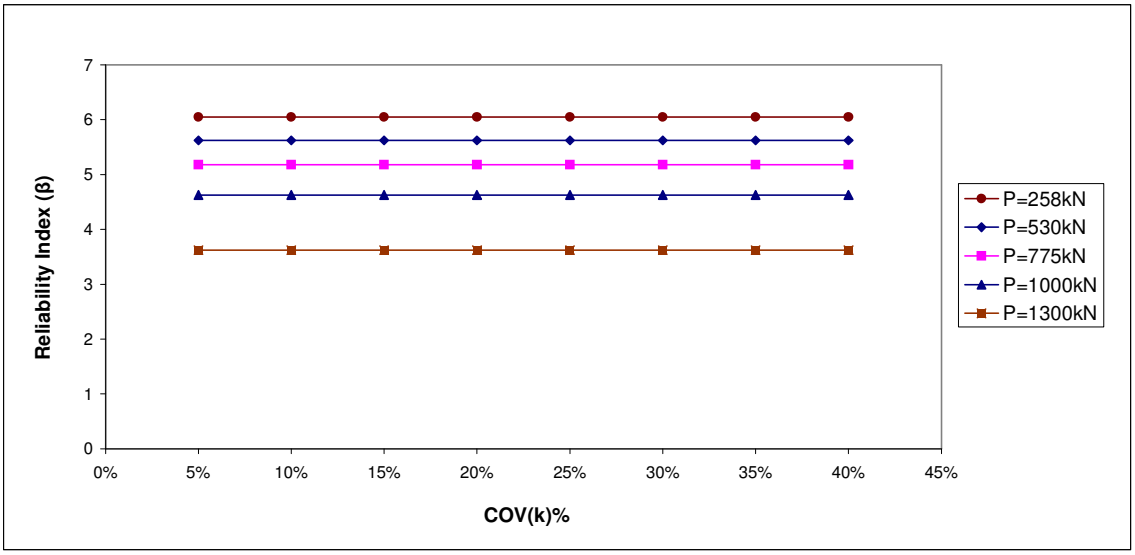


Fig.E.132 Reliability Index (β) of M_{max} vs. COV (k) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table E.166 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 285kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
7.23E-01	1.07E+04	5%	103.4285	6.0486
2.51E+00	1.07E+04	10%	103.4371	6.0481
5.29E+00	1.07E+04	15%	103.4506	6.0473
8.88E+00	1.07E+04	20%	103.4679	6.0463
1.40E+01	1.07E+04	25%	103.4926	6.0449
1.80E+01	1.07E+04	30%	103.5121	6.0437
1.94E+01	1.07E+04	35%	103.5189	6.0433
2.06E+01	1.07E+04	40%	103.5244	6.0430

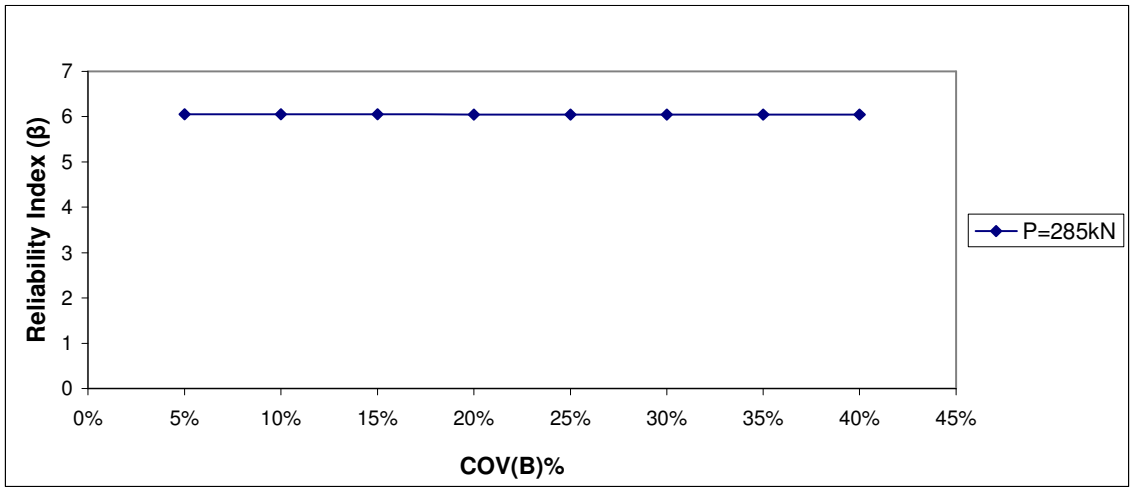


Fig.E.133 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force 258kN.

Table E.167 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 530kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.90E-01	10696.73	5%	103.4274	5.6223
1.82E+00	10696.73	10%	103.4338	5.6220
3.80E+00	10696.73	15%	103.4434	5.6214
6.00E+00	10696.73	20%	103.4540	5.6209
9.92E+00	10696.73	25%	103.4730	5.6198
1.33E+01	10696.73	30%	103.4894	5.6189
1.66E+01	10696.73	35%	103.5053	5.6181
1.98E+01	10696.73	40%	103.5207	5.6172

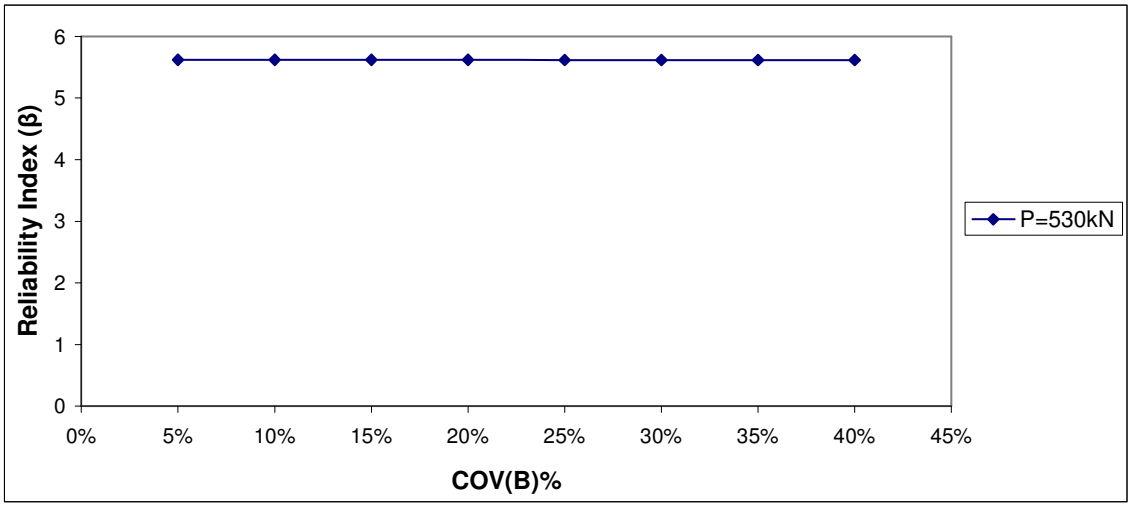


Fig.E.134 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.168 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 775kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.23E-01	10696.73	5%	103.4270	5.1776
1.32E+00	10696.73	10%	103.4314	5.1773
2.89E+00	10696.73	15%	103.4390	5.1770
4.41E+00	10696.73	20%	103.4463	5.1766
7.02E+00	10696.73	25%	103.4589	5.1760
1.16E+01	10696.73	30%	103.4809	5.1749
1.66E+01	10696.73	35%	103.5053	5.1736
2.07E+01	10696.73	40%	103.5250	5.1727

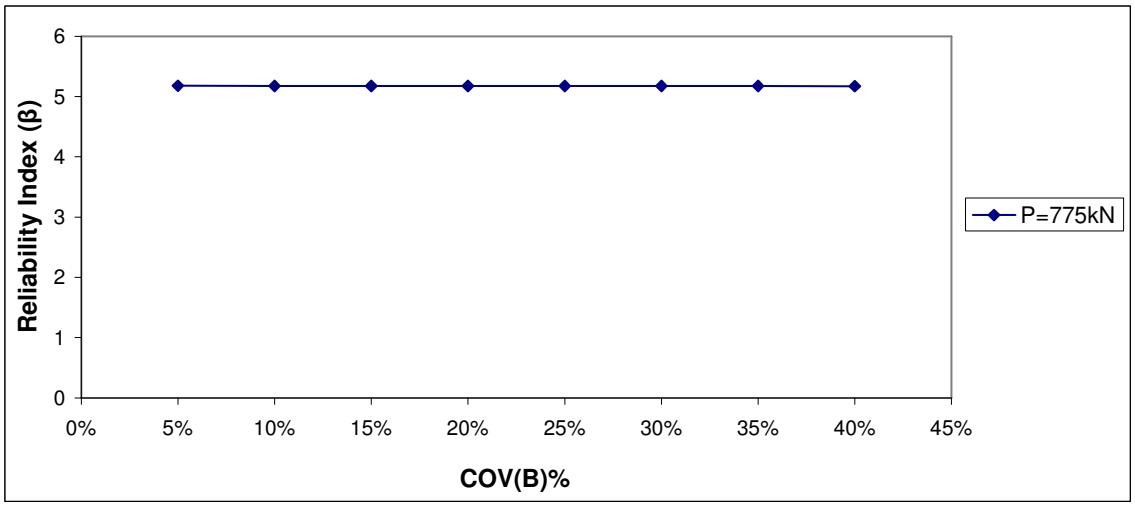


Fig.E.135 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.169 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
5.62E-01	10696.73	5%	103.4277	4.6264
1.96E+00	10696.73	10%	103.4345	4.6261
4.00E+00	10696.73	15%	103.4443	4.6257
8.41E+00	10696.73	20%	103.4656	4.6247
1.52E+01	10696.73	25%	103.4985	4.6233
2.40E+01	10696.73	30%	103.5410	4.6214
3.35E+01	10696.73	35%	103.5868	4.6193
4.56E+01	10696.73	40%	103.6450	4.6167

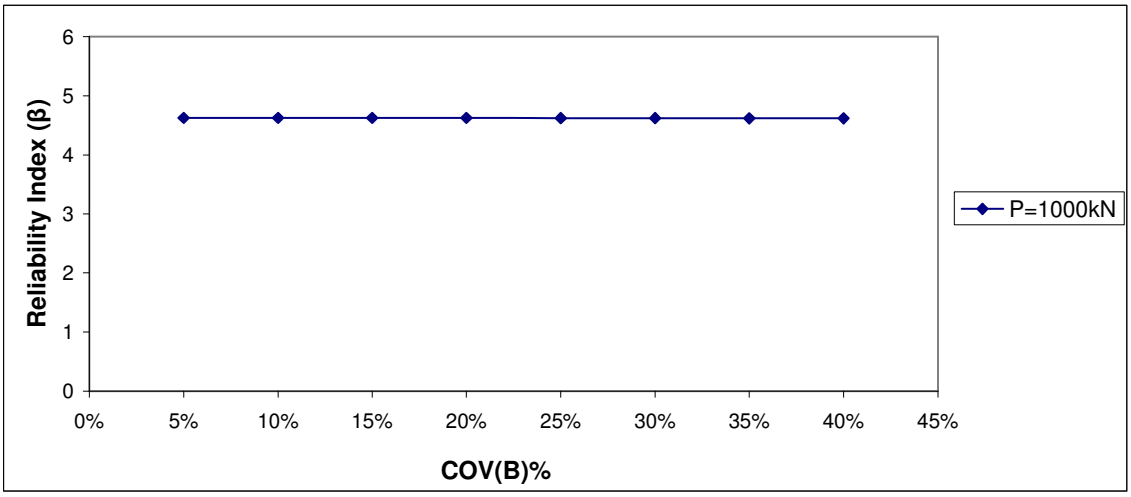


Fig.E.136 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.170 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 1300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.56E+00	10696.73	5%	103.4326	3.6207
5.52E+00	10696.73	10%	103.4517	3.6200
1.37E+01	10696.73	15%	103.4912	3.6187
2.65E+01	10696.73	20%	103.5531	3.6165
4.10E+01	10696.73	25%	103.6228	3.6141
6.01E+01	10696.73	30%	103.7150	3.6109
8.29E+01	10696.73	35%	103.8252	3.6070
1.12E+02	10696.73	40%	103.9668	3.6021

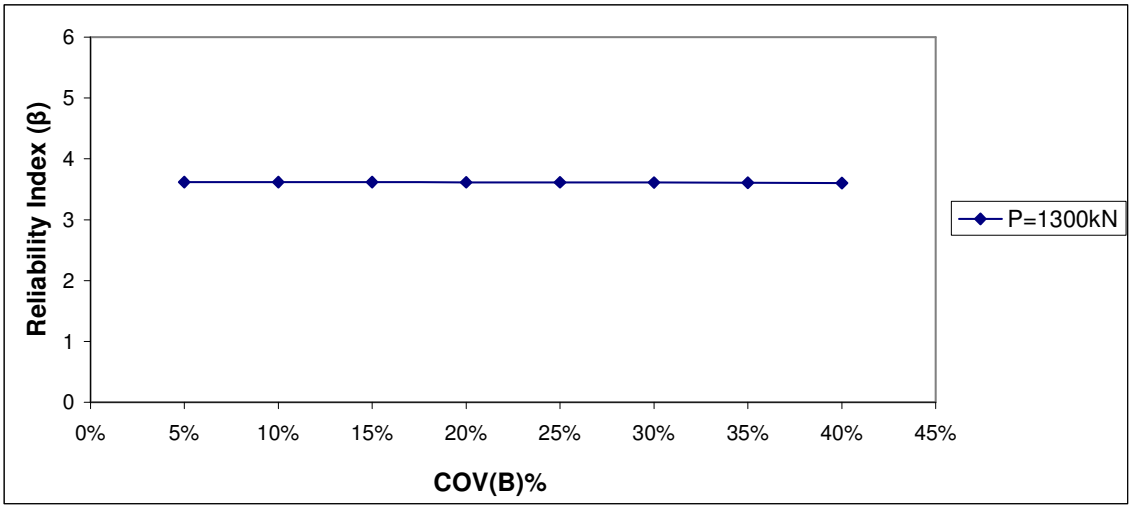


Fig.E.137 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force 1300kN.

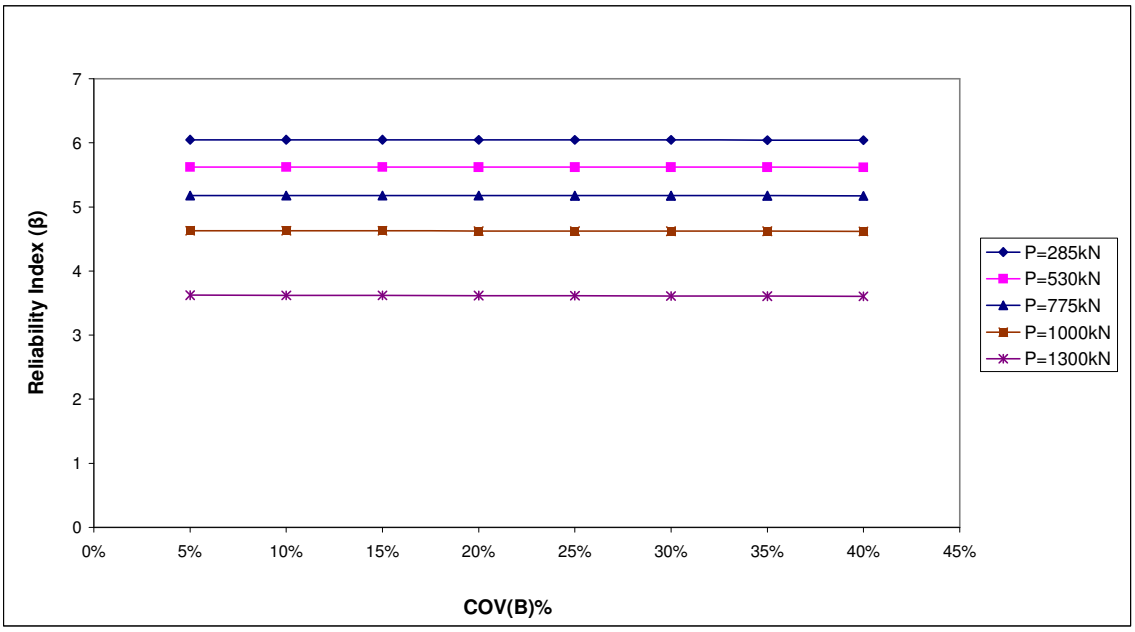


Fig.E.138 Reliability Index (β) of M_{max} vs. COV (B) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table E.171 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 285kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
8.70E-02	10696.73	5%	103.4254	6.0488
4.10E-01	10696.73	10%	103.4270	6.0487
9.41E-01	10696.73	15%	103.4295	6.0486
1.69E+00	10696.73	20%	103.4332	6.0483
2.71E+00	10696.73	25%	103.4381	6.0481
4.00E+00	10696.73	30%	103.4443	6.0477
5.64E+00	10696.73	35%	103.4523	6.0472
7.67E+00	10696.73	40%	103.4621	6.0467

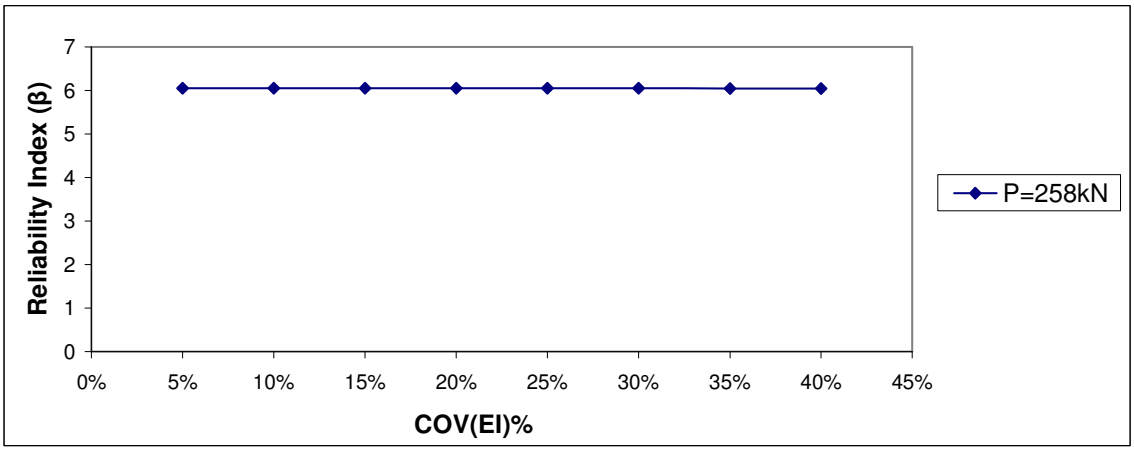


Fig.E.139 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 285kN.

Table E.172 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 530kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.90E-01	10696.73	5%	103.4274	5.6223
9.02E-01	10696.73	10%	103.4294	5.6222
2.10E+00	10696.73	15%	103.4352	5.6219
3.80E+00	10696.73	20%	103.4434	5.6214
6.00E+00	10696.73	25%	103.4540	5.6209
9.30E+00	10696.73	30%	103.4700	5.6200
1.37E+01	10696.73	35%	103.4912	5.6188
1.89E+01	10696.73	40%	103.5164	5.6175

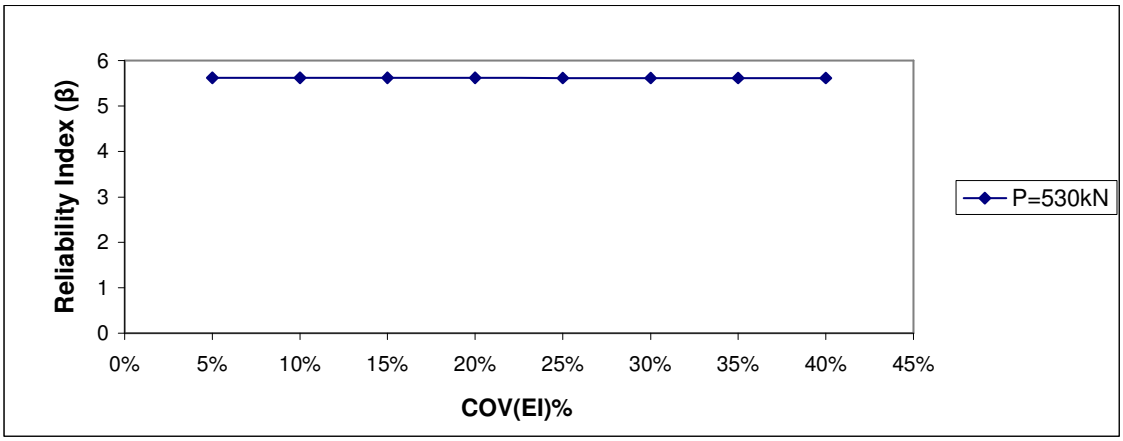


Fig.E.140 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.173 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 775kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
8.10E-01	10696.73	5%	103.4289	5.1775
3.42E+00	10696.73	10%	103.4415	5.1768
7.56E+00	10696.73	15%	103.4616	5.1758
1.23E+01	10696.73	20%	103.4842	5.1747
1.85E+01	10696.73	25%	103.5143	5.1732
2.50E+01	10696.73	30%	103.5458	5.1716
3.31E+01	10696.73	35%	103.5847	5.1697
4.10E+01	10696.73	40%	103.6228	5.1678

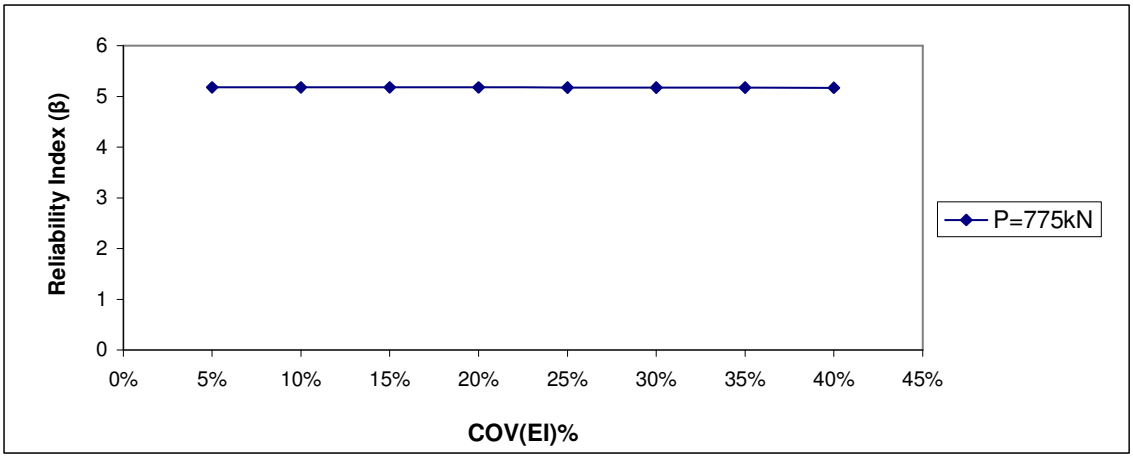


Fig.E.141 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.174 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
6.40E-01	10696.73	5%	103.4281	4.6264
3.24E+00	10696.73	10%	103.4407	4.6258
7.29E+00	10696.73	15%	103.4602	4.6250
1.33E+01	10696.73	20%	103.4894	4.6237
2.07E+01	10696.73	25%	103.5250	4.6221
2.86E+01	10696.73	30%	103.5633	4.6204
3.84E+01	10696.73	35%	103.6107	4.6183
4.97E+01	10696.73	40%	103.6650	4.6158

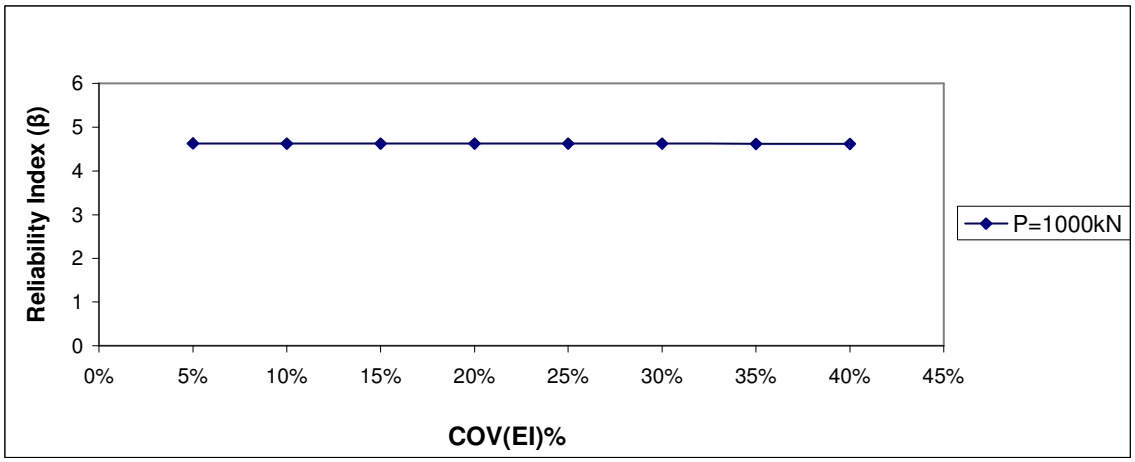


Fig.E.142 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.175 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 1300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E+00	10696.73	5%	103.4298	3.6208
1.82E+00	10696.73	10%	103.4338	3.6207
4.20E+00	10696.73	15%	103.4453	3.6203
6.76E+00	10696.73	20%	103.4577	3.6198
9.30E+00	10696.73	25%	103.4700	3.6194
1.23E+01	10696.73	30%	103.4842	3.6189
1.68E+01	10696.73	35%	103.5062	3.6181
2.21E+01	10696.73	40%	103.5317	3.6172

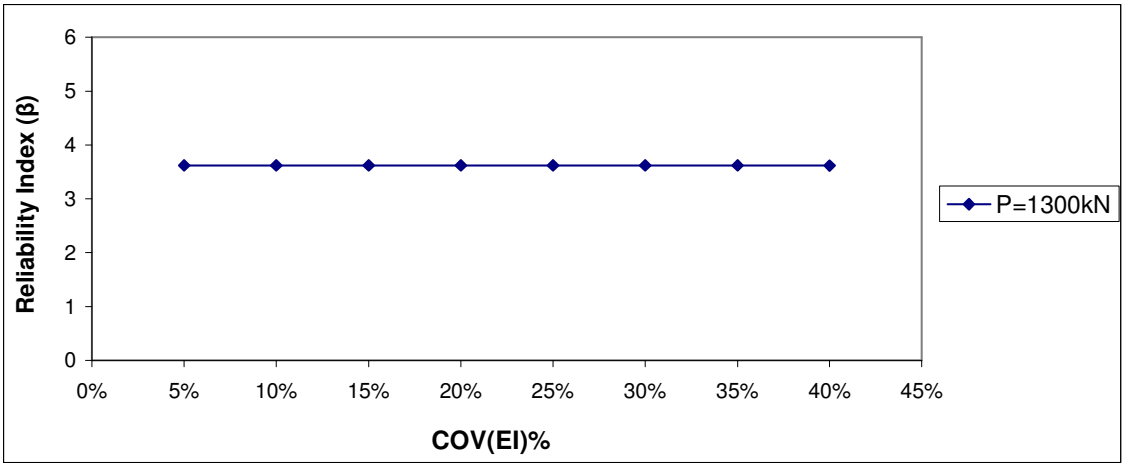


Fig.E.143 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 1300kN.

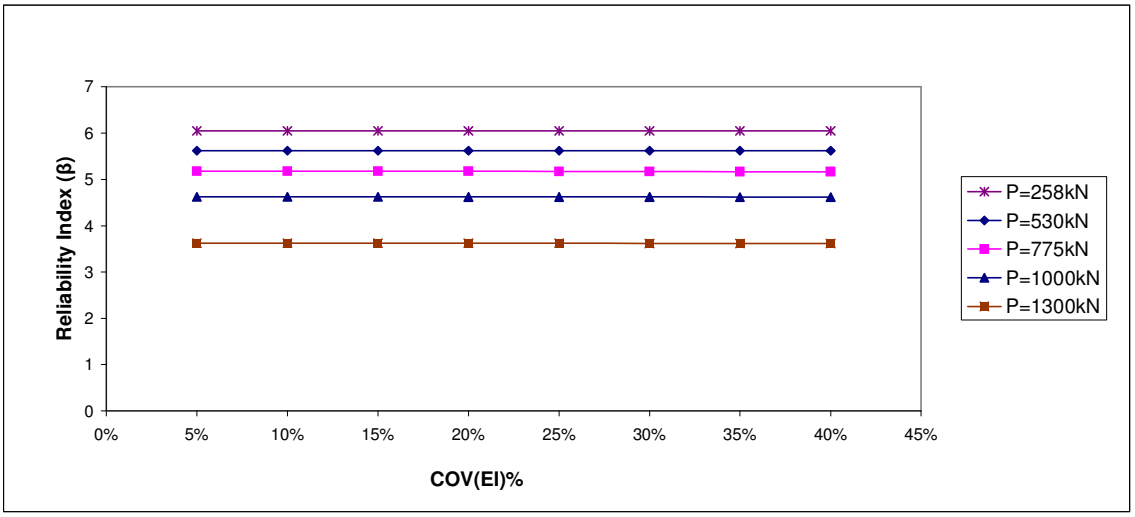


Fig.E.144 Reliability Index (β) of M_{max} vs. COV (EI) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table E.176 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 285kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.98E+01	10696.73	5%	103.5207	6.0432
7.77E+01	10696.73	10%	103.8000	6.0270
1.74E+02	10696.73	15%	104.2614	6.0003
3.07E+02	10696.73	20%	104.9009	5.9637
4.79E+02	10696.73	25%	105.7130	5.9179
6.83E+02	10696.73	30%	106.6760	5.8645
9.18E+02	10696.73	35%	107.7735	5.8048
1.19E+03	10696.73	40%	109.0195	5.7384

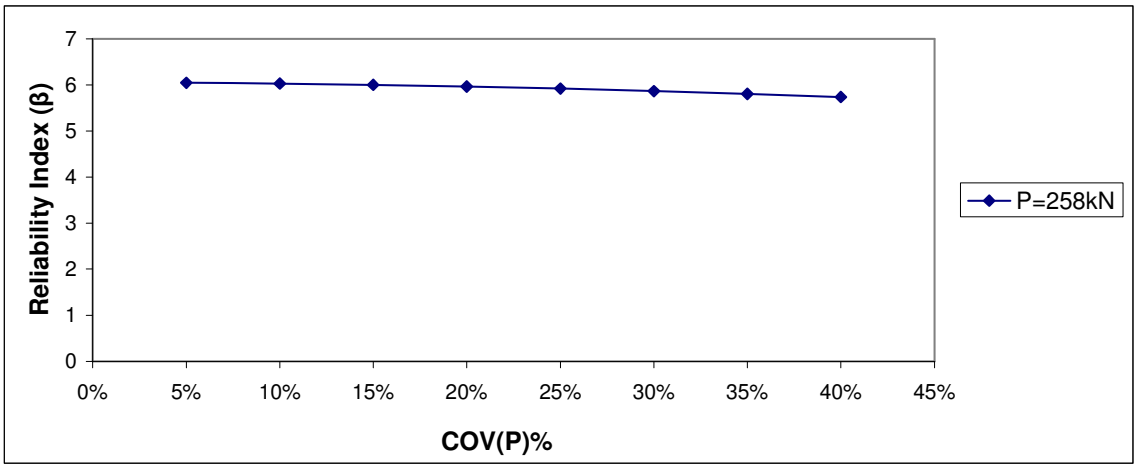


Fig.E.145 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force 258kN.

Table E.177 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 530kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.56E+01	10696.73	5%	103.6450	5.6105
1.84E+02	10696.73	10%	104.3088	5.5748
4.09E+02	10696.73	15%	105.3840	5.5179
7.30E+02	10696.73	20%	106.8950	5.4399
1.15E+03	10696.73	25%	108.8500	5.3422
1.67E+03	10696.73	30%	111.1927	5.2297
2.28E+03	10696.73	35%	113.9283	5.1041
3.00E+03	10696.73	40%	117.0226	4.9691

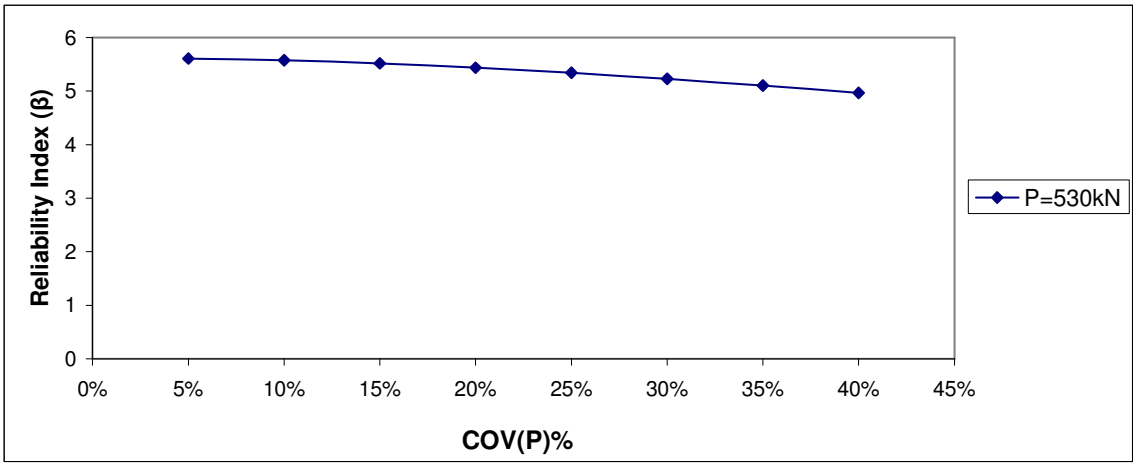


Fig.E.146 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force 530kN.

Table E.178 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 775kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
9.41E+01	10696.73	5%	103.8789	5.1550
3.78E+02	10696.73	10%	105.2380	5.0885
8.41E+02	10696.73	15%	107.4138	4.9854
1.49E+03	10696.73	20%	110.4108	4.8501
2.34E+03	10696.73	25%	114.1897	4.6896
3.37E+03	10696.73	30%	118.6024	4.5151
4.58E+03	10696.73	35%	123.5905	4.3329
6.02E+03	10696.73	40%	129.3090	4.1412

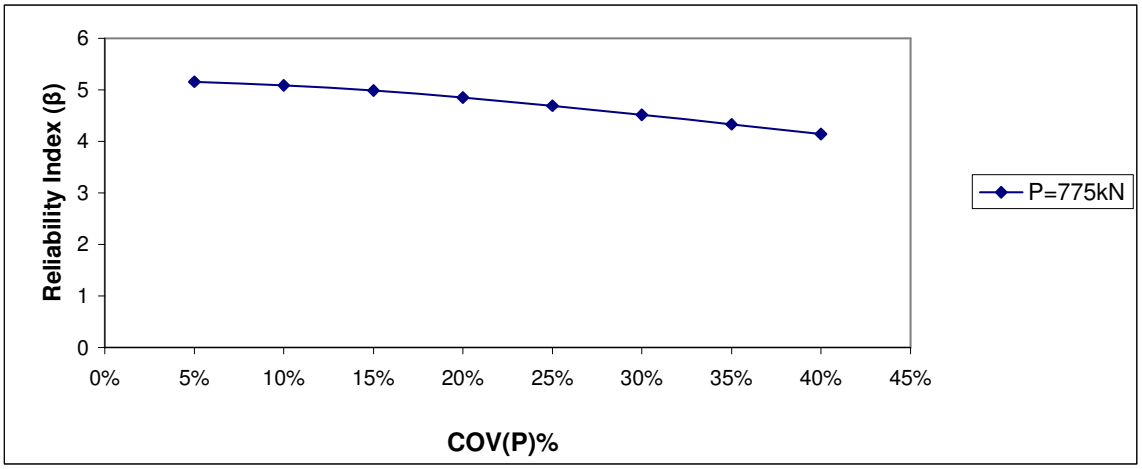


Fig.E.147 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force 775kN.

Table E.179 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.69E+02	10696.73	5%	104.2388	4.5904
6.68E+02	10696.73	10%	106.6065	4.4885
1.52E+03	10696.73	15%	110.5338	4.3290
2.72E+03	10696.73	20%	115.8290	4.1311
4.23E+03	10696.73	25%	122.1811	3.9163
6.12E+03	10696.73	30%	129.6911	3.6895
8.34E+03	10696.73	35%	137.9580	3.4684
1.09E+04	10696.73	40%	146.9916	3.2553

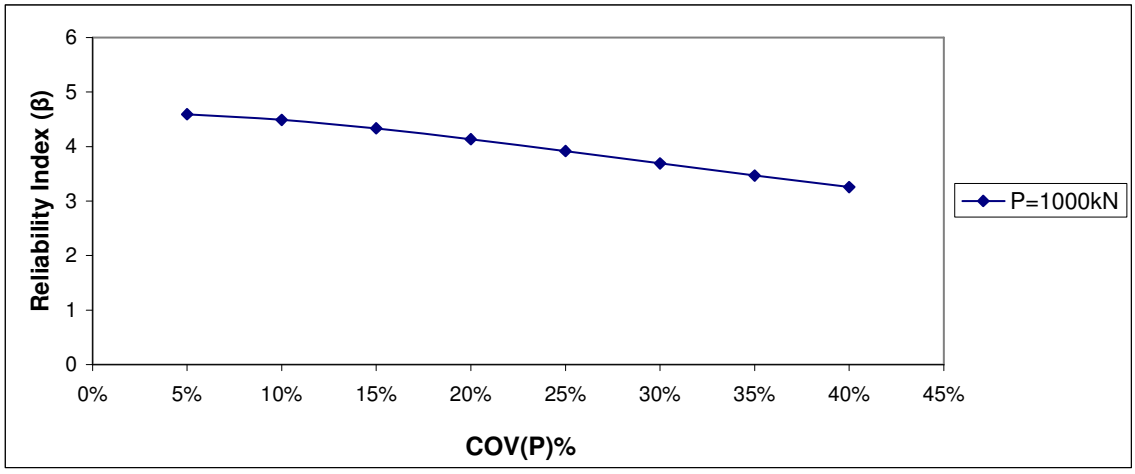


Fig.E.148 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force 1000kN.

Table E.180 Reliability Index (β) connected to M_{max} for free head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 1300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.79E+02	10696.73	5%	104.7646	3.5747
1.14E+03	10696.73	10%	108.7924	3.4423
2.55E+03	10696.73	15%	115.0736	3.2544
4.53E+03	10696.73	20%	123.3938	3.0350
7.05E+03	10696.73	25%	133.2079	2.8114
1.02E+04	10696.73	30%	144.4557	2.5925
1.38E+04	10696.73	35%	156.5718	2.3919
1.82E+04	10696.73	40%	169.9845	2.2031

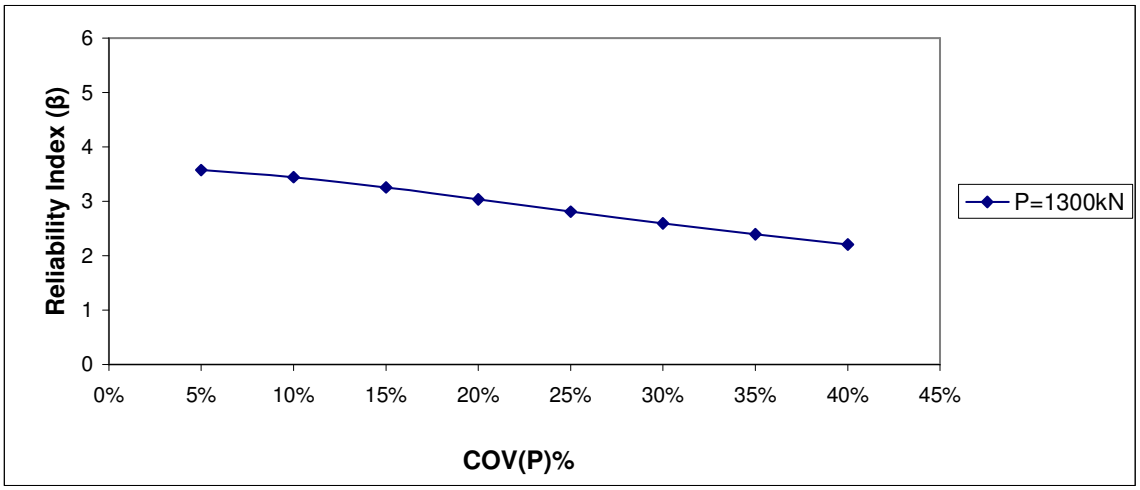


Fig.E.149 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force 1300kN.

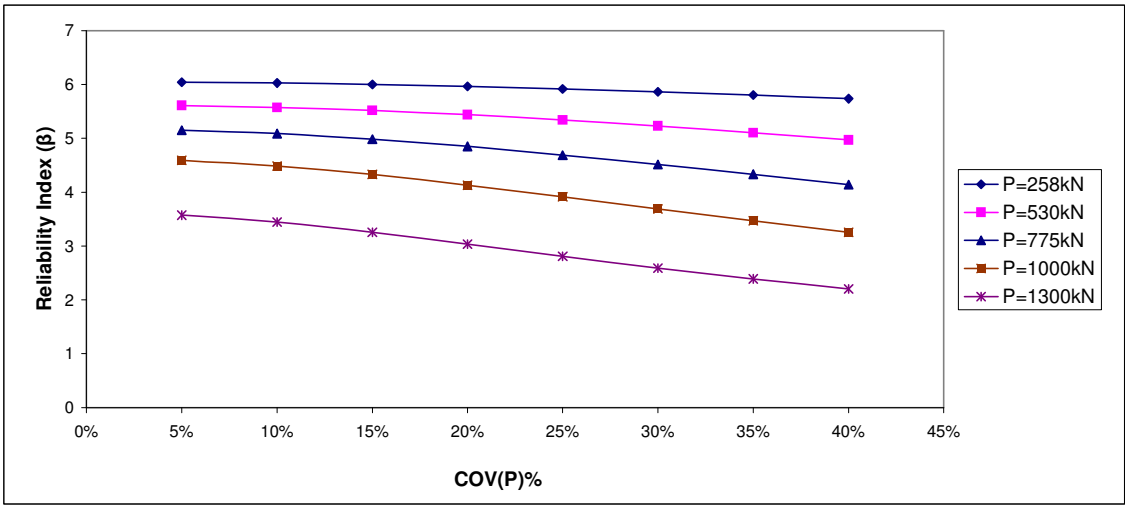


Fig.E.150 Reliability Index (β) of M_{max} vs. COV (P) for free head long pile group (10T) subjected to lateral force of discrete variability.

E.6 Probability of failure, $p_f(M_{max})$ of bending moment vs. COV (Variables).

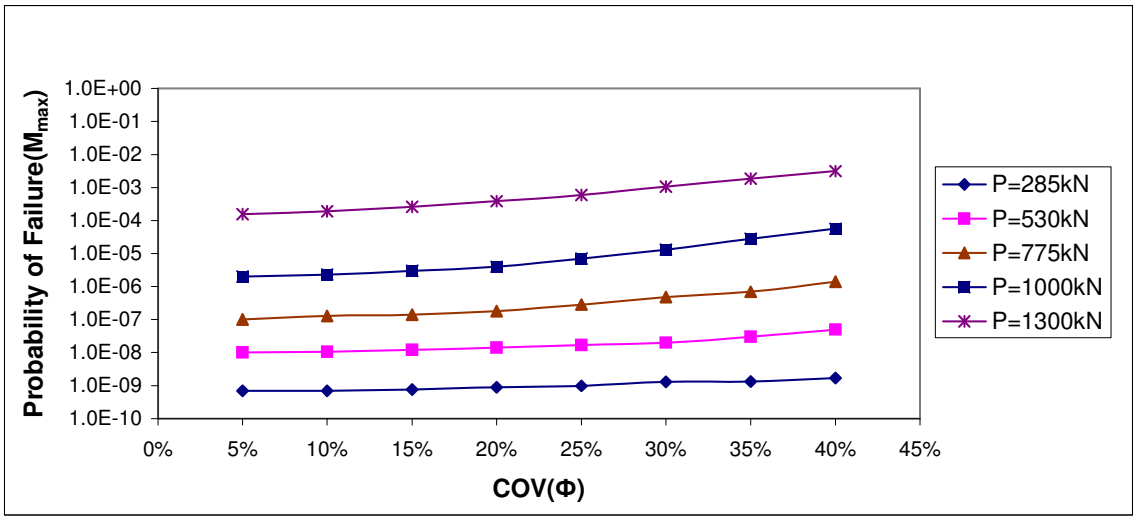


Fig. E.151 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (Φ) for free head long pile group of length 10T.

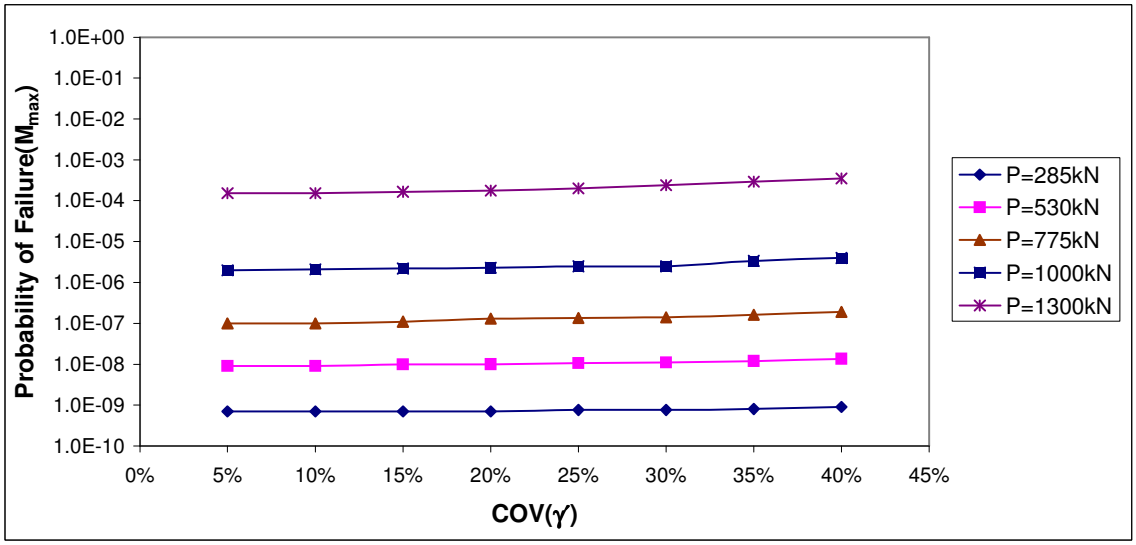


Fig. E.152 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (γ) for free head long pile group of length 10T.

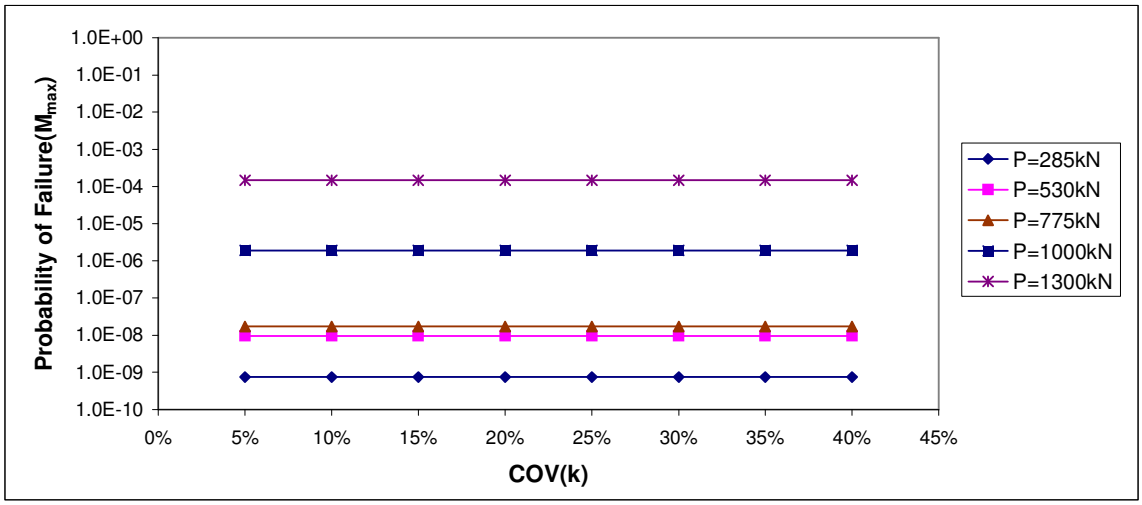


Fig. E.153 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (k) for free head long pile group of length 10T.

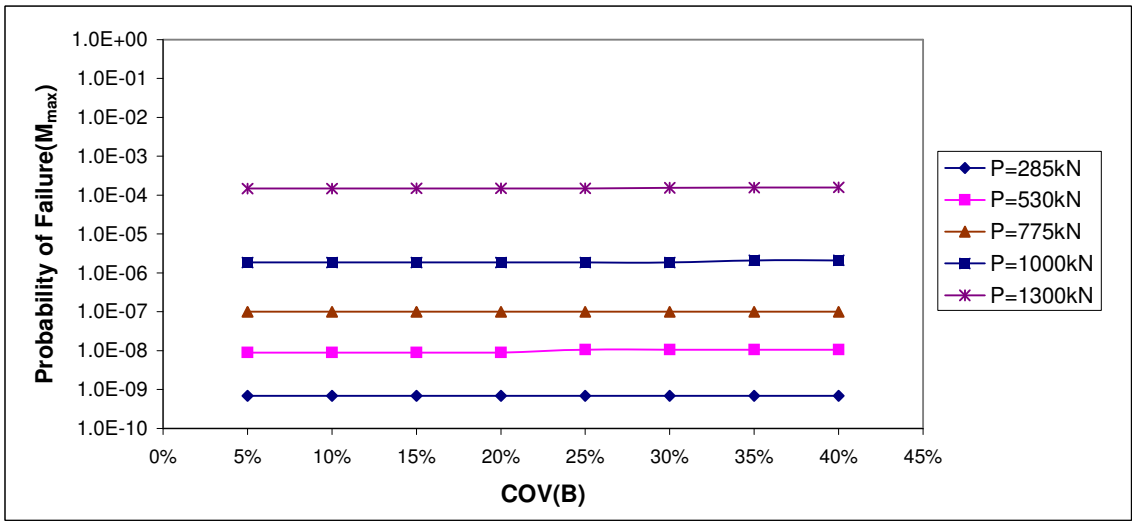


Fig. E.154 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (B) for free head long pile group of length 10T.

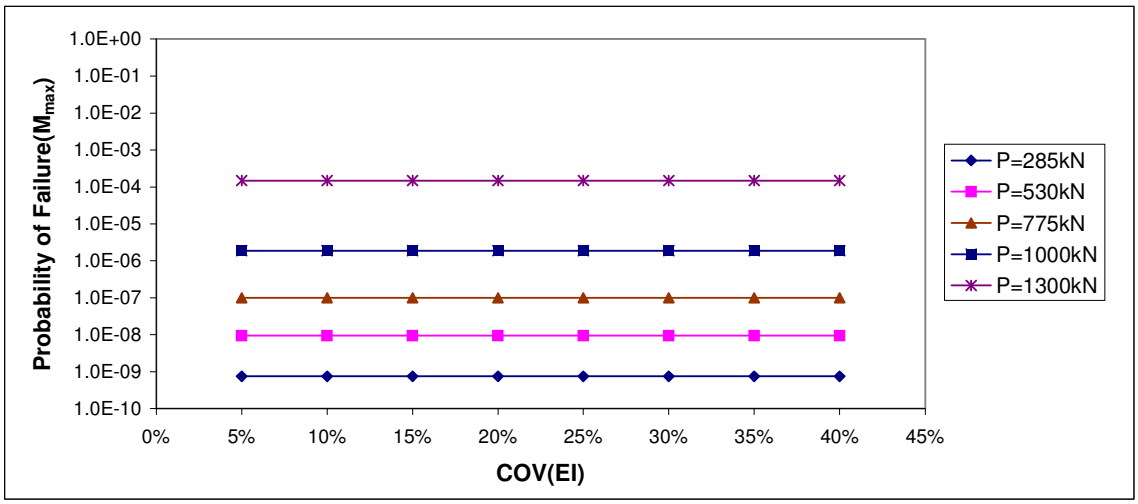


Fig. E.155 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (EI) for free head long pile group of length 10T .

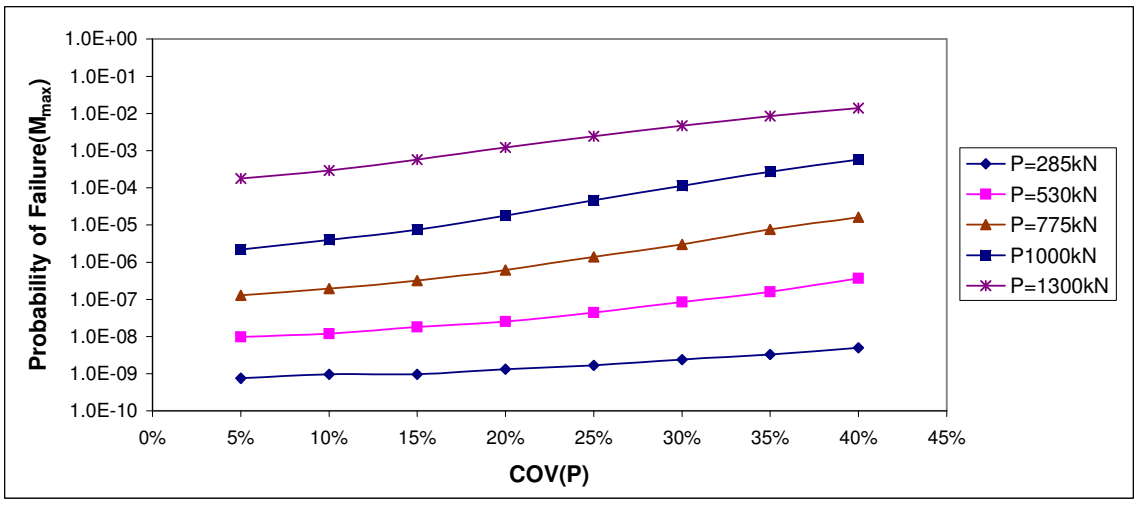


Fig. E.156 Probability of failure of bending moment $p_f(M_{max})$ vs. COV (P) for free head long pile group of length 10T.

APPENDIX F

LATERALLY LOADED FIXED HEAD LONG (10T) PILE GROUP WITH (5D) SPACING

F-1 Deflection of fixed head long pile group (Y_{Top}) and COV (Y_{Top}) vs. COV (Variables)

Table F.1 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (Φ) and load 1000kN.

P=1000kN

COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	7.72E-03				
5%	30			2.25E+00	5.01E-07	6.22E-03	6.32%
		28.5	9.14E-03				
		33	7.13E-03				
10%	30			9.00E+00	1.99E-06	6.22E-03	12.61%
		27	9.95E-03				
		34.5	6.58E-03				
15%	30			2.03E+01	4.56E-06	6.22E-03	19.07%
		25.5	1.09E-02				
		36	6.10E-03				
20%	30			3.60E+01	8.31E-06	6.22E-03	25.73%
		24	1.19E-02				
		37.5	5.67E-03				
25%	30			5.63E+01	1.34E-05	6.22E-03	32.67%
		22.5	1.30E-02				
		39	5.27E-03				
30%	30			8.10E+01	2.03E-05	6.22E-03	40.27%
		21	1.43E-02				
		40.5	4.95E-03				
35%	30			1.10E+02	2.93E-05	6.22E-03	48.35%
		19.5	1.58E-02				
		42	4.65E-03				
40%	30			1.44E+02	4.17E-05	6.22E-03	57.65%
		18	1.76E-02				

Table F.2 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (Φ) and load 1550kN.

P=1550kN

COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	1.24E-02				
5%	30			2.25E+00	1.23E-06	7.40E-03	6.73%
		28.5	1.46E-02				
		33	1.15E-02				
10%	30			9.00E+00	4.88E-06	7.40E-03	13.39%
		27	1.59E-02				
		34.5	1.06E-02				
15%	30			2.03E+01	1.13E-05	7.40E-03	20.33%
		25.5	1.73E-02				
		36	9.77E-03				
20%	30			3.60E+01	2.06E-05	7.40E-03	27.52%
		24	1.89E-02				
		37.5	9.07E-03				
25%	30			5.63E+01	3.38E-05	7.40E-03	35.22%
		22.5	2.07E-02				
		39	8.41E-03				
30%	30			8.10E+01	5.24E-05	7.40E-03	43.85%
		21	2.29E-02				
		40.5	7.85E-03				
35%	30			1.10E+02	7.83E-05	7.40E-03	53.63%
		19.5	2.56E-02				
		42	7.35E-03				
40%	30			1.44E+02	1.16E-04	7.40E-03	65.34%
		18	2.89E-02				

Table F.3 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (Φ) and load 2100kN.

P=2100kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	1.75E-02				
5%	30			2.25E+00	2.50E-06	1.65E-02	6.61%
		28.5	2.07E-02				
		33	1.62E-02				
10%	30			9.00E+00	1.01E-05	1.65E-02	13.31%
		27	2.25E-02				
		34.5	1.49E-02				
15%	30			2.03E+01	2.37E-05	1.65E-02	20.32%
		25.5	2.47E-02				
		36	1.38E-02				
20%	30			3.60E+01	4.47E-05	1.65E-02	28.01%
		24	2.72E-02				
		37.5	1.28E-02				
25%	30			5.63E+01	7.52E-05	1.65E-02	36.77%
		22.5	3.02E-02				
		39	1.19E-02				
30%	30			8.10E+01	1.20E-04	1.65E-02	47.19%
		21	3.38E-02				
		40.5	1.10E-02				
35%	30			1.10E+02	1.86E-04	1.65E-02	58.00%
		19.5	3.83E-02				
		42	1.03E-02				
40%	30			1.44E+02	2.87E-04	1.65E-02	71.30%
		18	4.42E-02				

Table F.4 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (Φ) and load 2650kN.

P=2650kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	2.32E-02				
5%	30			2.25E+00	5.09E-06	2.98E-02	9.58%
		28.5	2.77E-02				
		33	2.13E-02				
10%	30			9.00E+00	2.09E-05	2.98E-02	19.24%
		27	3.05E-02				
		34.5	1.96E-02				
15%	30			2.03E+01	4.91E-05	2.98E-02	29.48%
		25.5	3.36E-02				
		36	1.82E-02				
20%	30			3.60E+01	9.24E-05	2.98E-02	40.52%
		24	3.74E-02				
		37.5	1.68E-02				
25%	30			5.63E+01	1.58E-04	2.98E-02	52.55%
		22.5	4.19E-02				
		39	1.56E-02				
30%	30			8.10E+01	2.56E-04	2.98E-02	66.33%
		21	4.76E-02				
		40.5	1.45E-02				
35%	30			1.10E+02	4.05E-04	2.98E-02	82.67%
		19.5	5.48E-02				
		42	1.35E-02				
40%	30			1.44E+02	6.47E-04	2.98E-02	102.64%
		18	6.44E-02				

Table F.5 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (Φ) and load 3300kN.

P=3300kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	Y_{TOP} (m)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		31.5	2.98E-02				
5%	30			2.25E+00	9.95E-06	4.77E-02	7.57%
		28.5	3.61E-02				
		33	2.72E-02				
10%	30			9.00E+00	4.03E-05	4.77E-02	15.35%
		27	3.99E-02				
		34.5	2.49E-02				
15%	30			2.03E+01	9.40E-05	4.77E-02	23.51%
		25.5	4.43E-02				
		36	2.29E-02				
20%	30			3.60E+01	1.78E-04	4.77E-02	32.27%
		24	4.96E-02				
		37.5	2.11E-02				
25%	30			5.63E+01	3.08E-04	4.77E-02	42.11%
		22.5	5.62E-02				
		39	1.96E-02				
30%	30			8.10E+01	5.07E-04	4.77E-02	53.64%
		21	6.46E-02				
		40.5	1.81E-02				
35%	30			1.10E+02	8.26E-04	4.77E-02	67.55%
		19.5	7.56E-02				
		42	1.69E-02				
40%	30			1.44E+02	1.35E-03	4.77E-02	85.35%
		18	9.03E-02				

Table F.6 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV(Φ) and lateral load 1000kN.

P=1000kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	5.01E-07	6.32%
10%	9.00E+00	1.99E-06	12.61%
15%	2.03E+01	4.56E-06	19.07%
20%	3.60E+01	8.31E-06	25.73%
25%	5.63E+01	1.34E-05	32.67%
30%	8.10E+01	2.03E-05	40.27%
35%	1.10E+02	2.93E-05	48.35%
40%	1.44E+02	4.17E-05	57.65%

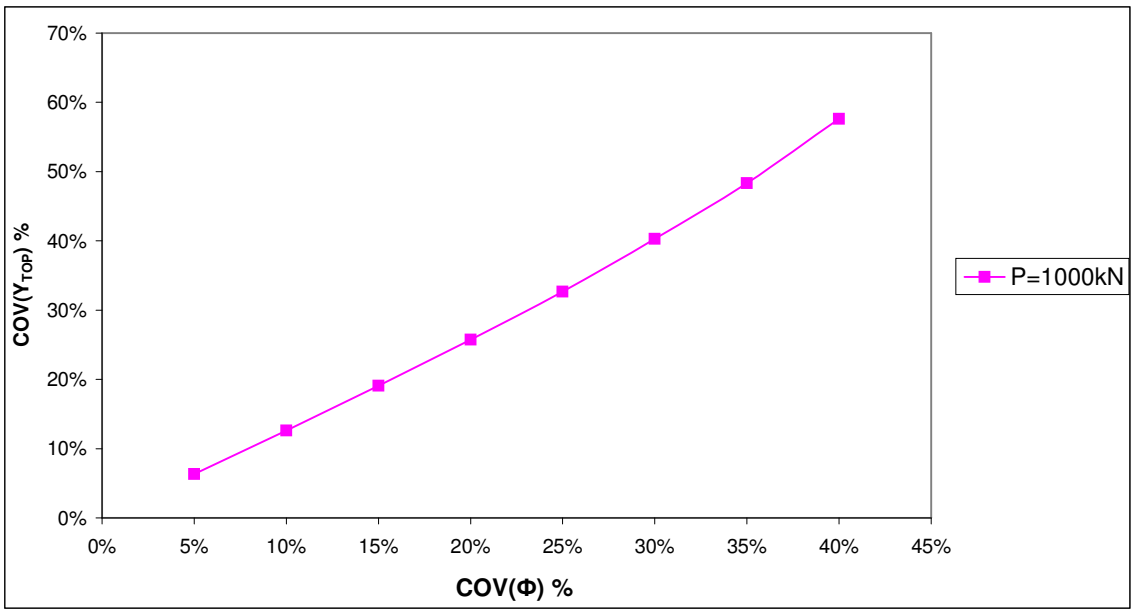


Fig. F.1 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.7 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 1550kN.

P=1550kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	1.23E-06	6.73%
10%	9.00E+00	4.88E-06	13.39%
15%	2.03E+01	1.13E-05	20.33%
20%	3.60E+01	2.06E-05	27.52%
25%	5.63E+01	3.38E-05	35.22%
30%	8.10E+01	5.24E-05	43.85%
35%	1.10E+02	7.83E-05	53.63%
40%	1.44E+02	1.16E-04	65.34%

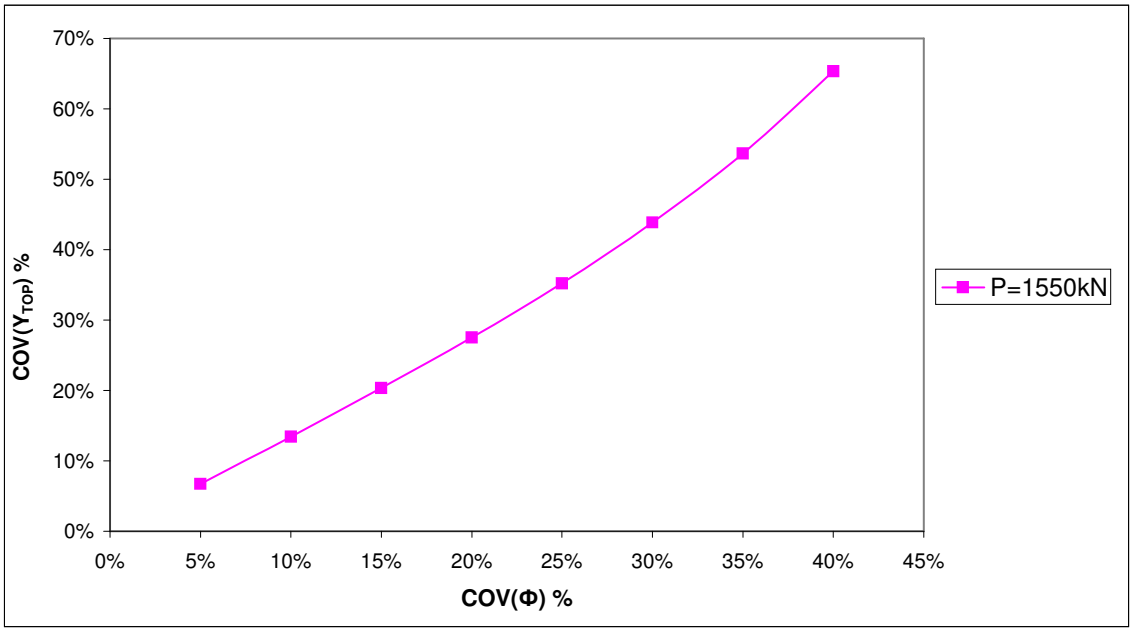


Fig. F.2 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.8 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 2100kN.

P=2100kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	2.50E-06	6.61%
10%	9.00E+00	1.01E-05	13.31%
15%	2.03E+01	2.37E-05	20.32%
20%	3.60E+01	4.47E-05	28.01%
25%	5.63E+01	7.52E-05	36.77%
30%	8.10E+01	1.20E-04	47.19%
35%	1.10E+02	1.86E-04	58.00%
40%	1.44E+02	2.87E-04	71.30%

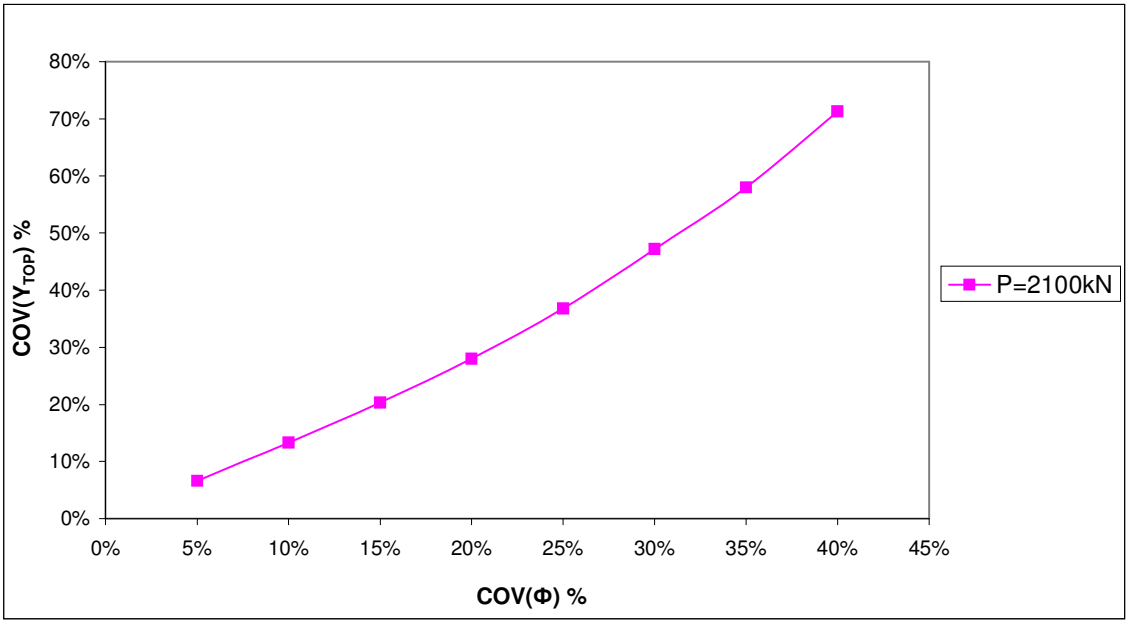


Fig. F.3 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.9 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 2650kN.

P=2650kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	5.09E-06	6.96%
10%	9.00E+00	2.09E-05	13.99%
15%	2.03E+01	4.91E-05	21.43%
20%	3.60E+01	9.24E-05	29.45%
25%	5.63E+01	1.58E-04	38.19%
30%	8.10E+01	2.56E-04	48.22%
35%	1.10E+02	4.05E-04	60.09%
40%	1.44E+02	6.47E-04	74.60%

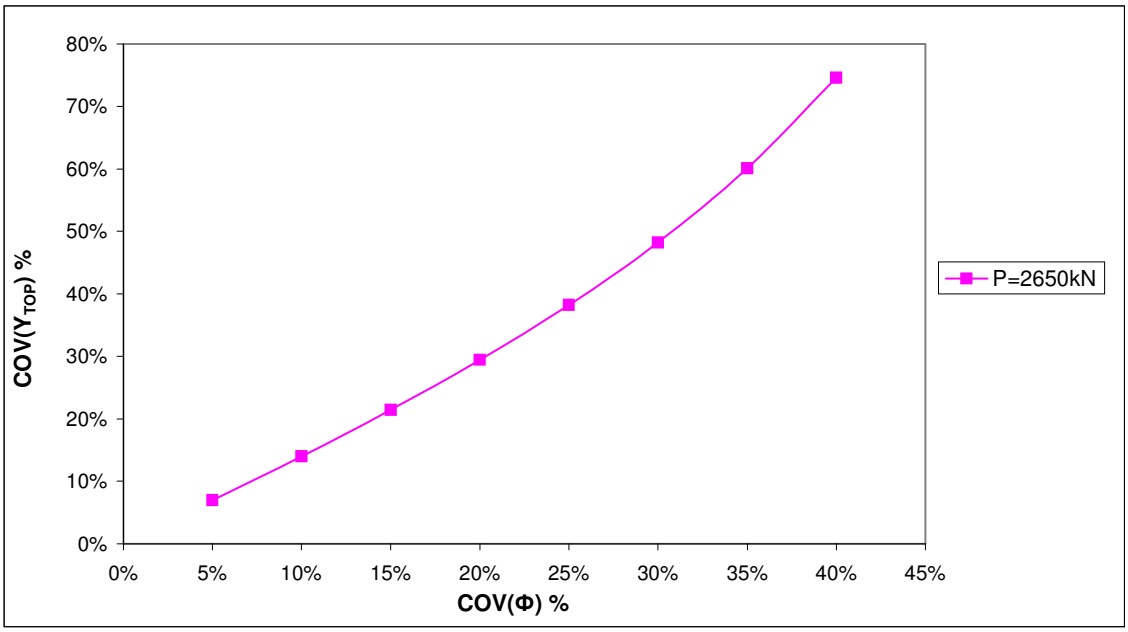


Fig. F.4 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.10 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 3300kN.

P=3300kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.25E+00	3.16E-05	7.57%
10%	9.00E+00	1.31E-04	15.35%
15%	2.03E+01	3.22E-04	23.51%
20%	3.60E+01	6.51E-04	32.27%
25%	5.63E+01	1.22E-03	42.11%
30%	8.10E+01	2.24E-03	53.64%
35%	1.10E+02	4.04E-03	67.55%
40%	1.44E+02	7.37E-03	85.35%

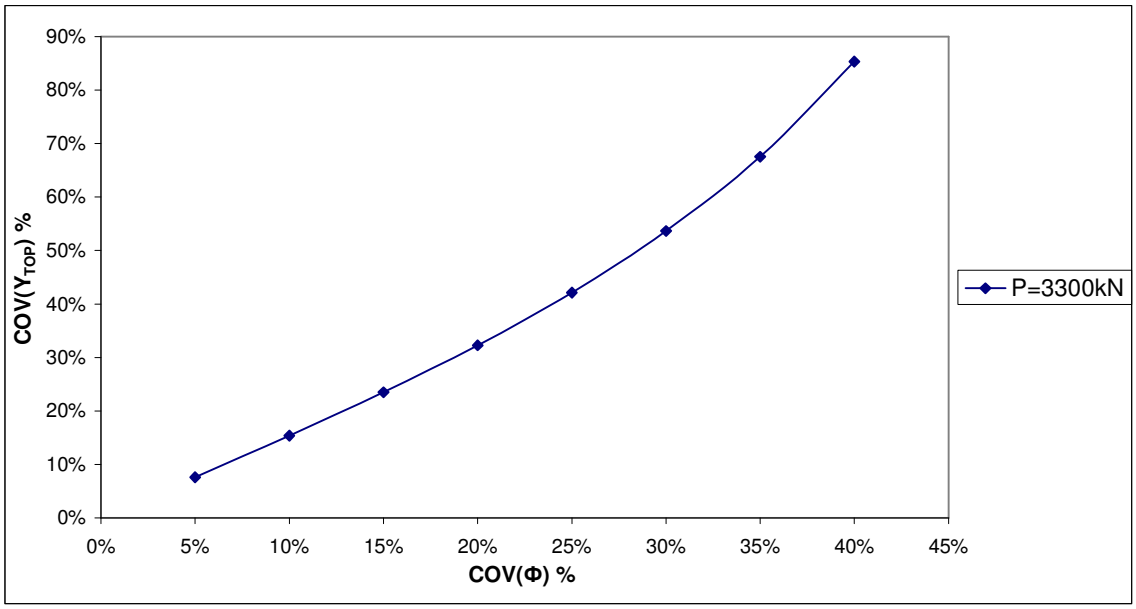


Fig. F.5 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

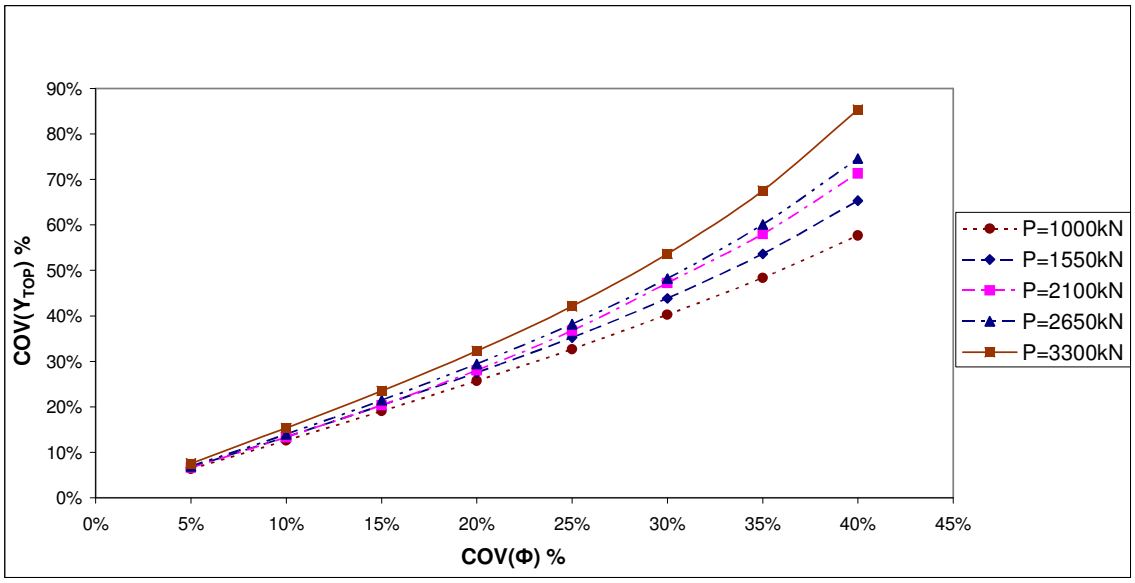


Fig. F.6 Variability of COV (Y_{TOP}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table F.11 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (γ') and load 1000kN.

P=1000kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^{o} (m)	COV(Y_{TOP}) (%)
		11.025	8.12E-03				
5%	10.5			2.76E-01	8.29E-08	6.22E-03	2.57%
		9.975	8.69E-03				
		11.55	7.86E-03				
10%	10.5			1.10E+00	3.49E-07	6.22E-03	5.27%
		9.45	9.04E-03				
		12.075	7.61E-03				
15%	10.5			2.48E+00	8.06E-07	6.22E-03	8.02%
		8.925	9.40E-03				
		12.6	7.39E-03				
20%	10.5			4.41E+00	1.45E-06	6.22E-03	10.76%
		8.4	9.80E-03				
		13.125	7.20E-03				
25%	10.5			6.89E+00	2.35E-06	6.22E-03	13.68%
		7.875	1.03E-02				
		13.65	7.01E-03				
30%	10.5			9.92E+00	3.54E-06	6.22E-03	16.80%
		7.35	1.08E-02				
		14.175	6.82E-03				
35%	10.5			1.35E+01	5.08E-06	6.22E-03	20.12%
		6.825	1.13E-02				
		14.7	6.65E-03				
40%	10.5			1.76E+01	7.10E-06	6.22E-03	23.80%
		6.3	1.20E-02				

Table F.12 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (γ') and load 1550kN.

P=1550kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	Y_{TOP}^{o} (m)	COV(Y_{TOP}) (%)
		11.025	1.30E-02				
5%	10.5			2.76E-01	2.03E-07	7.40E-03	2.73%
		9.975	1.39E-02				
		11.55	1.26E-02				
10%	10.5			1.10E+00	8.46E-07	7.40E-03	5.58%
		9.45	1.45E-02				
		12.075	1.22E-02				
15%	10.5			2.48E+00	1.95E-06	7.40E-03	8.45%
		8.925	1.50E-02				
		12.6	1.19E-02				
20%	10.5			4.41E+00	3.50E-06	7.40E-03	11.33%
		8.4	1.56E-02				
		13.125	1.16E-02				
25%	10.5			6.89E+00	5.69E-06	7.40E-03	14.45%
		7.875	1.63E-02				
		13.65	1.13E-02				
30%	10.5			9.92E+00	8.53E-06	7.40E-03	17.70%
		7.35	1.71E-02				
		14.175	1.10E-02				
35%	10.5			1.35E+01	1.23E-05	7.40E-03	21.21%
		6.825	1.80E-02				
		14.7	1.07E-02				
40%	10.5			1.76E+01	1.72E-05	7.40E-03	25.12%
		6.3	1.90E-02				

Table F.13 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (γ') and load 2100kN.

P=2100kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^{o}$ (m)	COV(Y_{TOP}) (%)
		11.025	1.84E-02				
5%	10.5			2.76E-01	4.16E-07	1.65E-02	2.65%
		9.975	1.97E-02				
		11.55	1.78E-02				
10%	10.5			1.10E+00	1.70E-06	1.65E-02	5.41%
		9.45	2.04E-02				
		12.075	1.73E-02				
15%	10.5			2.48E+00	3.94E-06	1.65E-02	8.20%
		8.925	2.12E-02				
		12.6	1.68E-02				
20%	10.5			4.41E+00	7.18E-06	1.65E-02	11.12%
		8.4	2.22E-02				
		13.125	1.63E-02				
25%	10.5			6.89E+00	1.17E-05	1.65E-02	14.25%
		7.875	2.32E-02				
		13.65	1.59E-02				
30%	10.5			9.92E+00	1.79E-05	1.65E-02	17.49%
		7.35	2.44E-02				
		14.175	1.55E-02				
35%	10.5			1.35E+01	2.59E-05	1.65E-02	21.26%
		6.825	2.57E-02				
		14.7	1.52E-02				
40%	10.5			1.76E+01	3.69E-05	1.65E-02	25.26%
		6.3	2.73E-02				

Table F.14 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (γ') and load 2650kN.

P=2650kN							
COV(γ') (%)	γ'^{o} (kN/m^3)	γ'(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ') (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^{o}$ (m)	COV(Y_{TOP}) (%)
		11.025	2.44E-02				
5%	10.5			2.76E-01	8.65E-07	2.98E-02	3.91%
		9.975	2.63E-02				
		11.55	2.36E-02				
10%	10.5			1.10E+00	3.46E-06	2.98E-02	7.91%
		9.45	2.73E-02				
		12.075	2.29E-02				
15%	10.5			2.48E+00	7.98E-06	2.98E-02	12.03%
		8.925	2.85E-02				
		12.6	2.22E-02				
20%	10.5			4.41E+00	1.47E-05	2.98E-02	16.24%
		8.4	2.99E-02				
		13.125	2.16E-02				
25%	10.5			6.89E+00	2.41E-05	2.98E-02	20.73%
		7.875	3.14E-02				
		13.65	2.10E-02				
30%	10.5			9.92E+00	3.68E-05	2.98E-02	25.67%
		7.35	3.31E-02				
		14.175	2.05E-02				
35%	10.5			1.35E+01	5.34E-05	2.98E-02	30.85%
		6.825	3.51E-02				
		14.7	2.00E-02				
40%	10.5			1.76E+01	7.60E-05	2.98E-02	36.82%
		6.3	3.74E-02				

Table F.15 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (γ) and load 3300kN.

P=3300kN							
COV(γ) (%)	γ^o (kN/m^3)	γ(current) (kN/m^3)	Y_{TOP} (m)	VAR(γ) (kN/m^3)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		11.025	3.15E-02				
5%	10.5			2.76E-01	1.60E-06	4.77E-02	3.12%
		9.975	3.40E-02				
		11.55	3.04E-02				
10%	10.5			1.10E+00	6.66E-06	4.77E-02	6.24%
		9.45	3.56E-02				
		12.075	2.94E-02				
15%	10.5			2.48E+00	1.53E-05	4.77E-02	9.48%
		8.925	3.72E-02				
		12.6	2.84E-02				
20%	10.5			4.41E+00	2.81E-05	4.77E-02	12.89%
		8.4	3.90E-02				
		13.125	2.76E-02				
25%	10.5			6.89E+00	4.62E-05	4.77E-02	16.46%
		7.875	4.12E-02				
		13.65	2.68E-02				
30%	10.5			9.92E+00	6.96E-05	4.77E-02	20.37%
		7.35	4.35E-02				
		14.175	2.61E-02				
35%	10.5			1.35E+01	1.03E-04	4.77E-02	24.51%
		6.825	4.63E-02				
		14.7	2.54E-02				
40%	10.5			1.76E+01	1.45E-04	4.77E-02	29.26%
		6.3	4.95E-02				

Table F.16 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 1000kN.

P=1000kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	8.29E-08	2.57%
10%	1.10E+00	3.49E-07	5.27%
15%	2.48E+00	8.06E-07	8.02%
20%	4.41E+00	1.45E-06	10.76%
25%	6.89E+00	2.35E-06	13.68%
30%	9.92E+00	3.54E-06	16.80%
35%	1.35E+01	5.08E-06	20.12%
40%	1.76E+01	7.10E-06	23.80%

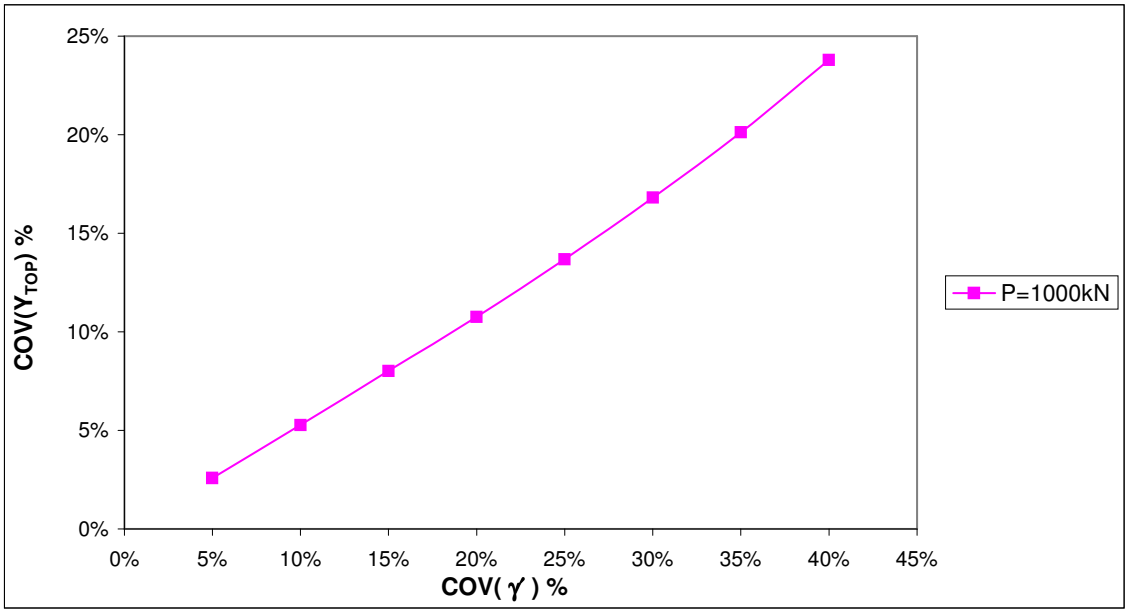


Fig. F.7 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.17 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 1550kN.

P=1550kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	2.03E-07	2.73%
10%	1.10E+00	8.46E-07	5.58%
15%	2.48E+00	1.95E-06	8.45%
20%	4.41E+00	3.50E-06	11.33%
25%	6.89E+00	5.69E-06	14.45%
30%	9.92E+00	8.53E-06	17.70%
35%	1.35E+01	1.23E-05	21.21%
40%	1.76E+01	1.72E-05	25.12%

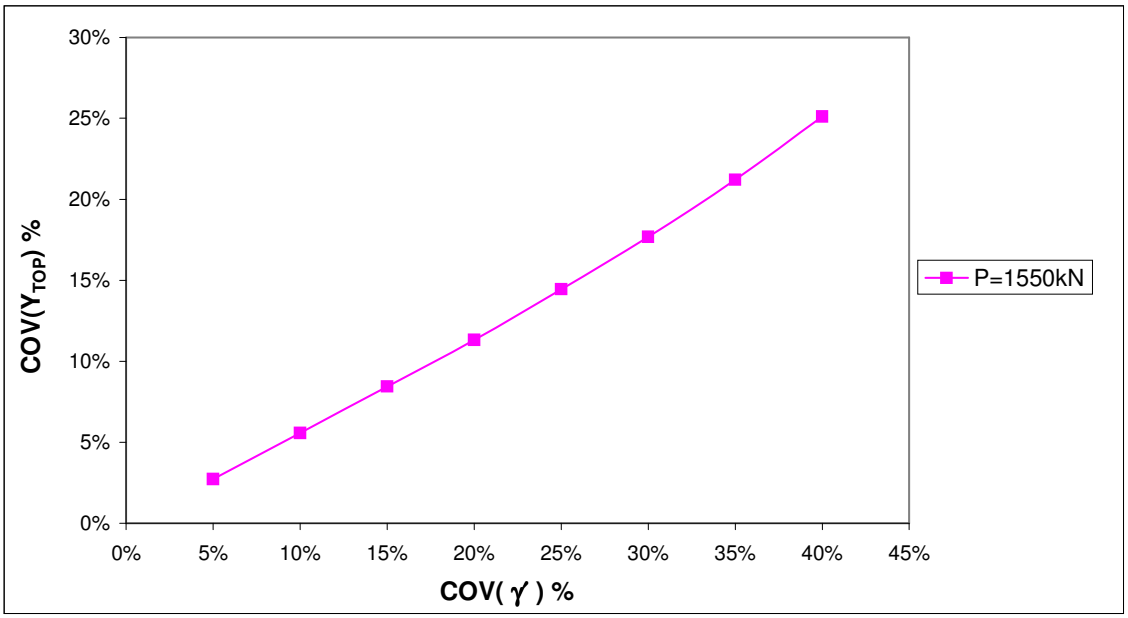


Fig. F.8 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.18 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 2100kN.

P=2100kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	4.16E-07	2.65%
10%	1.10E+00	1.70E-06	5.41%
15%	2.48E+00	3.94E-06	8.20%
20%	4.41E+00	7.18E-06	11.12%
25%	6.89E+00	1.17E-05	14.25%
30%	9.92E+00	1.79E-05	17.49%
35%	1.35E+01	2.59E-05	21.26%
40%	1.76E+01	3.69E-05	25.26%

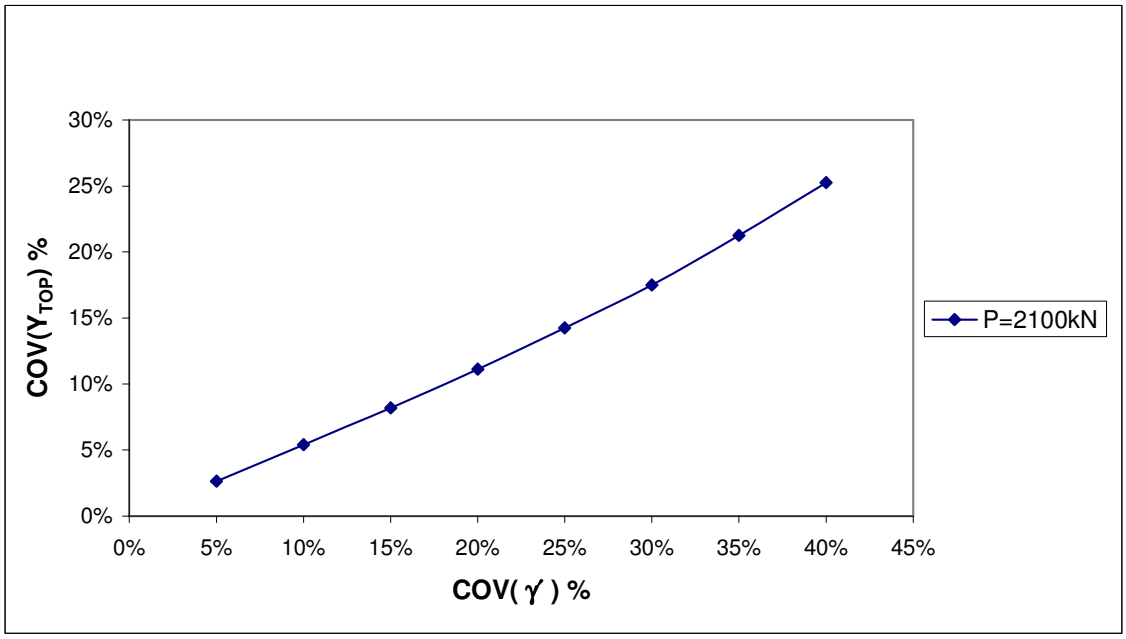


Fig. F.9 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.19 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 2650kN.

P=2650kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	8.65E-07	2.84%
10%	1.10E+00	3.46E-06	5.75%
15%	2.48E+00	7.98E-06	8.74%
20%	4.41E+00	1.47E-05	11.81%
25%	6.89E+00	2.41E-05	15.07%
30%	9.92E+00	3.68E-05	18.66%
35%	1.35E+01	5.34E-05	22.42%
40%	1.76E+01	7.60E-05	26.76%

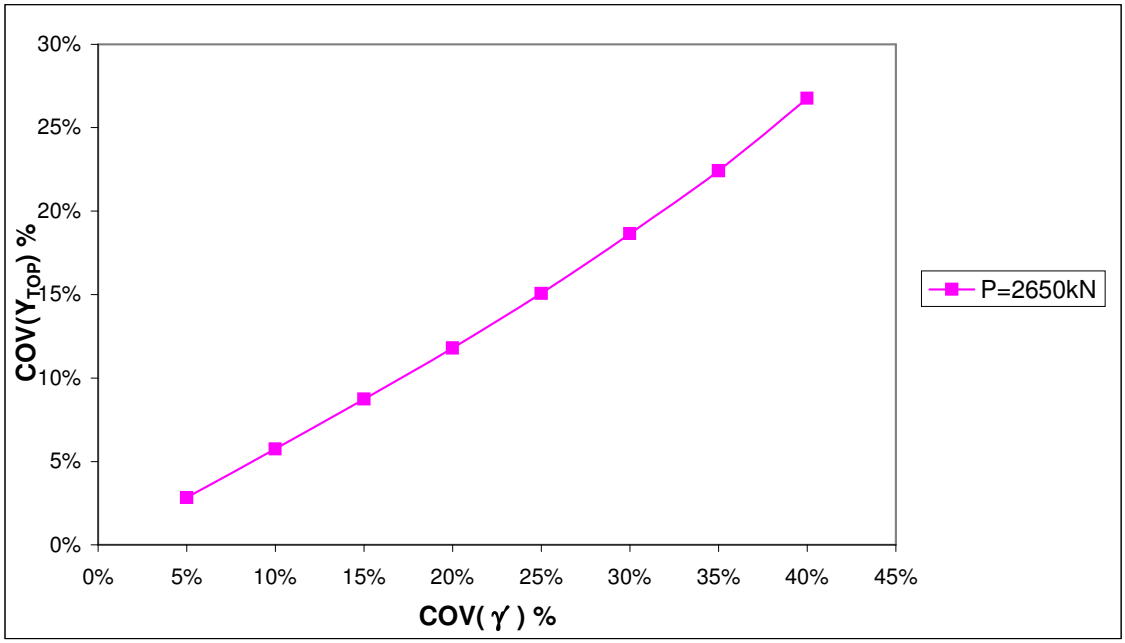


Fig. F.10 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.20 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 3300kN.

P=3300kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.76E-01	1.60E-06	3.12%
10%	1.10E+00	6.66E-06	6.24%
15%	2.48E+00	1.53E-05	9.48%
20%	4.41E+00	2.81E-05	12.89%
25%	6.89E+00	4.62E-05	16.46%
30%	9.92E+00	6.96E-05	20.37%
35%	1.35E+01	1.03E-04	24.51%
40%	1.76E+01	1.45E-04	29.26%

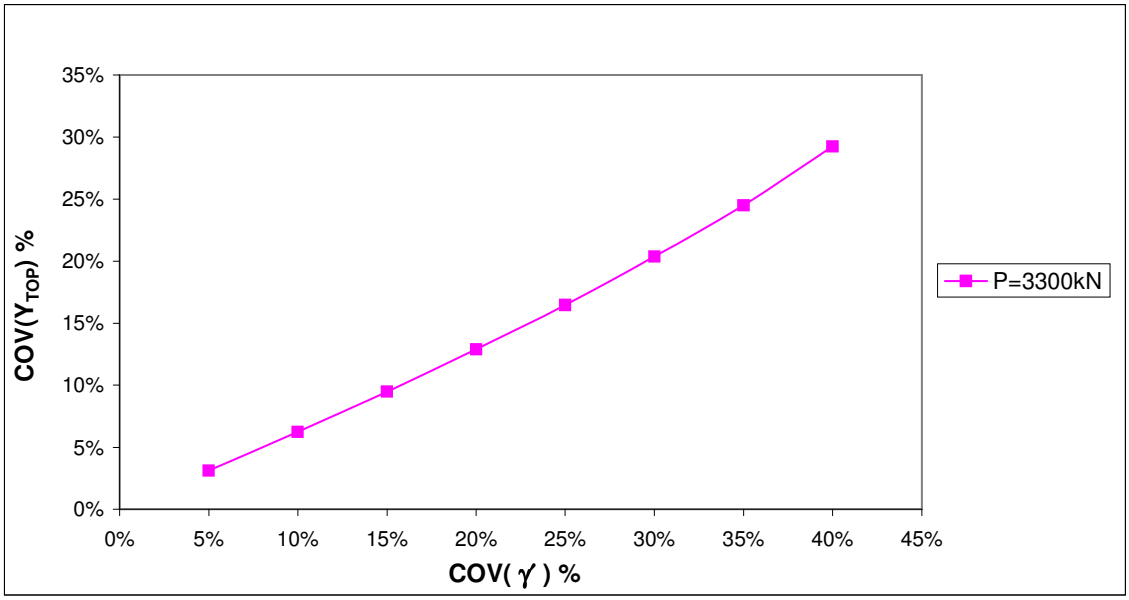


Fig. F.11 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

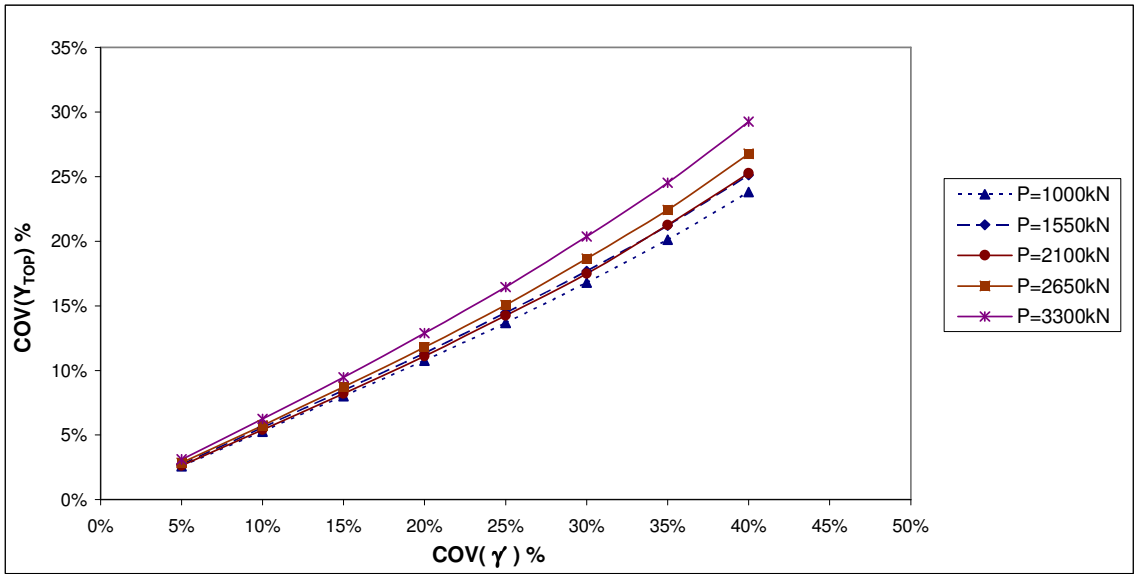


Fig. F.12 Variability of COV (Y_{TOP}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table F.21 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (k) and load 1000kN.

P=1000kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	8.36E-03				
5%	16300			6.64E+05	7.29E-10	6.22E-03	0.24%
		15485	8.42E-03				
		17930	8.35E-03				
10%	16300			2.66E+06	2.55E-09	6.22E-03	0.45%
		14670	8.45E-03				
		18745	8.34E-03				
15%	16300			5.98E+06	5.18E-09	6.22E-03	0.64%
		13855	8.48E-03				
		19560	8.33E-03				
20%	16300			1.06E+07	8.74E-09	6.22E-03	0.83%
		13040	8.51E-03				
		20375	8.31E-03				
25%	16300			1.66E+07	1.36E-08	6.22E-03	1.04%
		12225	8.55E-03				
		21190	8.30E-03				
30%	16300			2.39E+07	2.33E-08	6.22E-03	1.36%
		11410	8.61E-03				
		22005	8.29E-03				
35%	16300			3.25E+07	3.80E-08	6.22E-03	1.74%
		10595	8.68E-03				
		22820	8.28E-03				
40%	16300			4.25E+07	5.81E-08	6.22E-03	2.15%
		9780	8.77E-03				

Table F.22 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (k) and load 1550kN.

P=1550kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	1.34E-02				
5%	16300			6.64E+05	9.00E-10	7.40E-03	0.18%
		15485	1.35E-02				
		17930	1.34E-02				
10%	16300			2.66E+06	3.02E-09	7.40E-03	0.33%
		14670	1.35E-02				
		18745	1.34E-02				
15%	16300			5.98E+06	6.40E-09	7.40E-03	0.48%
		13855	1.36E-02				
		19560	1.34E-02				
20%	16300			1.06E+07	1.00E-08	7.40E-03	0.61%
		13040	1.36E-02				
		20375	1.34E-02				
25%	16300			1.66E+07	1.56E-08	7.40E-03	0.76%
		12225	1.36E-02				
		21190	1.34E-02				
30%	16300			2.39E+07	2.56E-08	7.40E-03	0.97%
		11410	1.37E-02				
		22005	1.34E-02				
35%	16300			3.25E+07	4.41E-08	7.40E-03	1.27%
		10595	1.38E-02				
		22820	1.33E-02				
40%	16300			4.25E+07	6.76E-08	7.40E-03	1.58%
		9780	1.39E-02				

Table F.23 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (k) and load 2100kN.

P=2100kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	1.90E-02				
5%	16300			6.64E+05	6.25E-10	1.65E-02	0.11%
		15485	1.90E-02				
		17930	1.90E-02				
10%	16300			2.66E+06	2.50E-09	1.65E-02	0.22%
		14670	1.91E-02				
		18745	1.89E-02				
15%	16300			5.98E+06	6.40E-09	1.65E-02	0.35%
		13855	1.91E-02				
		19560	1.89E-02				
20%	16300			1.06E+07	1.10E-08	1.65E-02	0.46%
		13040	1.91E-02				
		20375	1.89E-02				
25%	16300			1.66E+07	1.96E-08	1.65E-02	0.62%
		12225	1.92E-02				
		21190	1.89E-02				
30%	16300			2.39E+07	3.24E-08	1.65E-02	0.79%
		11410	1.92E-02				
		22005	1.89E-02				
35%	16300			3.25E+07	5.06E-08	1.65E-02	0.99%
		10595	1.93E-02				
		22820	1.89E-02				
40%	16300			4.25E+07	7.29E-08	1.65E-02	1.19%
		9780	1.94E-02				

Table F.24 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (k) and load 2650kN.

P=2650kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	2.53E-02				
5%	16300			6.64E+05	4.00E-10	2.98E-02	0.07%
		15485	2.53E-02				
		17930	2.53E-02				
10%	16300			2.66E+06	2.50E-09	2.98E-02	0.17%
		14670	2.54E-02				
		18745	2.52E-02				
15%	16300			5.98E+06	7.23E-09	2.98E-02	0.29%
		13855	2.54E-02				
		19560	2.52E-02				
20%	16300			1.06E+07	1.56E-08	2.98E-02	0.42%
		13040	2.55E-02				
		20375	2.52E-02				
25%	16300			1.66E+07	2.56E-08	2.98E-02	0.54%
		12225	2.55E-02				
		21190	2.52E-02				
30%	16300			2.39E+07	4.00E-08	2.98E-02	0.67%
		11410	2.56E-02				
		22005	2.52E-02				
35%	16300			3.25E+07	6.00E-08	2.98E-02	0.82%
		10595	2.57E-02				
		22820	2.52E-02				
40%	16300			4.25E+07	9.92E-08	2.98E-02	1.06%
		9780	2.58E-02				

Table F.25 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (k) and load 3300kN.

P=3300kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	Y_{TOP} (m)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		17115	3.26E-02				
5%	16300			6.64E+05	1.23E-09	4.77E-02	0.07%
		15485	3.27E-02				
		17930	3.26E-02				
10%	16300			2.66E+06	6.40E-09	4.77E-02	0.17%
		14670	3.28E-02				
		18745	3.26E-02				
15%	16300			5.98E+06	1.32E-08	4.77E-02	0.24%
		13855	3.28E-02				
		19560	3.26E-02				
20%	16300			1.06E+07	2.10E-08	4.77E-02	0.30%
		13040	3.29E-02				
		20375	3.25E-02				
25%	16300			1.66E+07	3.24E-08	4.77E-02	0.38%
		12225	3.29E-02				
		21190	3.25E-02				
30%	16300			2.39E+07	5.52E-08	4.77E-02	0.49%
		11410	3.30E-02				
		22005	3.25E-02				
35%	16300			3.25E+07	9.30E-08	4.77E-02	0.64%
		10595	3.31E-02				
		22820	3.25E-02				
40%	16300			4.25E+07	1.44E-07	4.77E-02	0.80%
		9780	3.33E-02				

Table F.26 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 1000kN.

P=1000kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	7.29E-10	0.24%
10%	2.66E+06	2.55E-09	0.45%
15%	5.98E+06	5.18E-09	0.64%
20%	1.06E+07	8.74E-09	0.83%
25%	1.66E+07	1.36E-08	1.04%
30%	2.39E+07	2.33E-08	1.36%
35%	3.25E+07	3.80E-08	1.74%
40%	4.25E+07	5.81E-08	2.15%

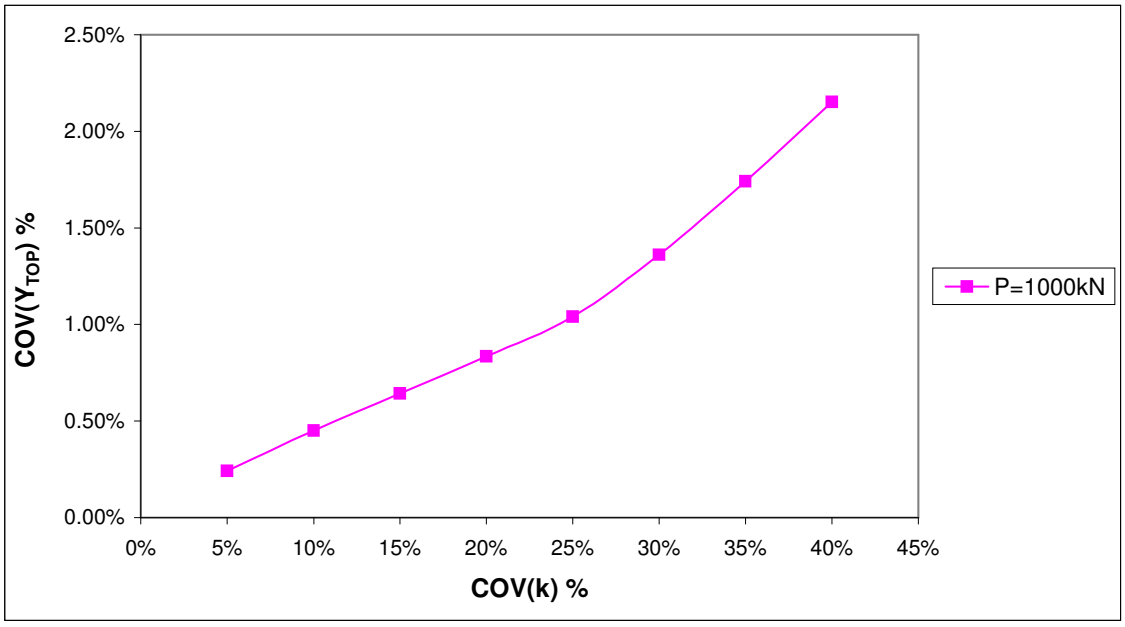


Fig. F.13 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.27 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 1550kN.

P=1550kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	9.00E-10	0.18%
10%	2.66E+06	3.02E-09	0.33%
15%	5.98E+06	6.40E-09	0.48%
20%	1.06E+07	1.00E-08	0.61%
25%	1.66E+07	1.56E-08	0.76%
30%	2.39E+07	2.56E-08	0.97%
35%	3.25E+07	4.41E-08	1.27%
40%	4.25E+07	6.76E-08	1.58%

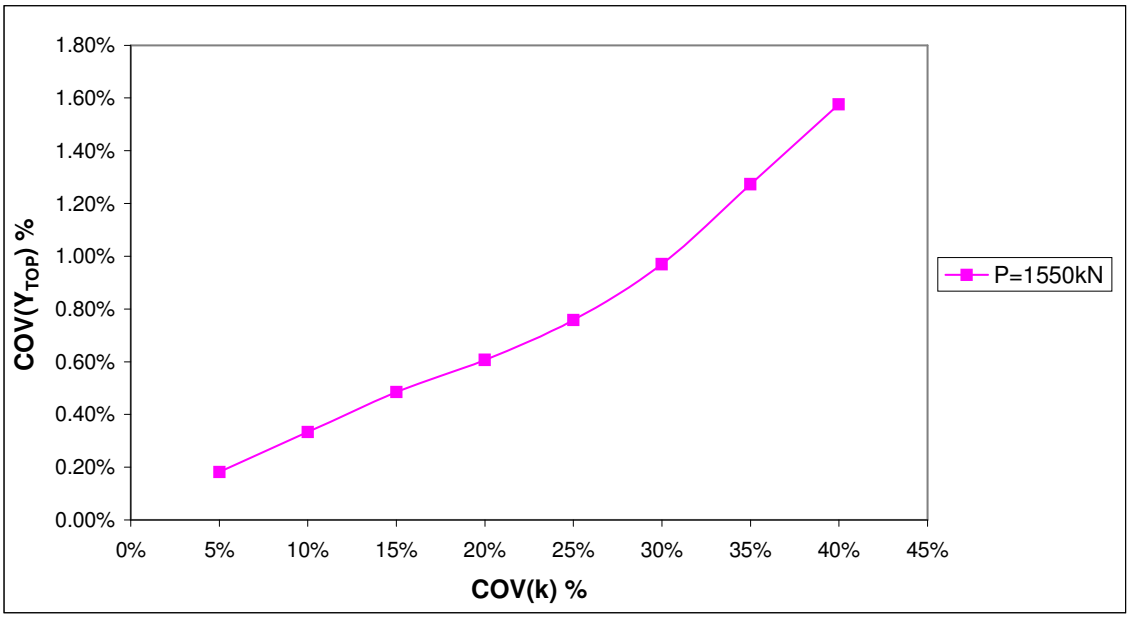


Fig. F.14 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.28 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 2100kN.

P=2100kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	6.25E-10	0.11%
10%	2.66E+06	2.50E-09	0.22%
15%	5.98E+06	6.40E-09	0.35%
20%	1.06E+07	1.10E-08	0.46%
25%	1.66E+07	1.96E-08	0.62%
30%	2.39E+07	3.24E-08	0.79%
35%	3.25E+07	5.06E-08	0.99%
40%	4.25E+07	7.29E-08	1.19%

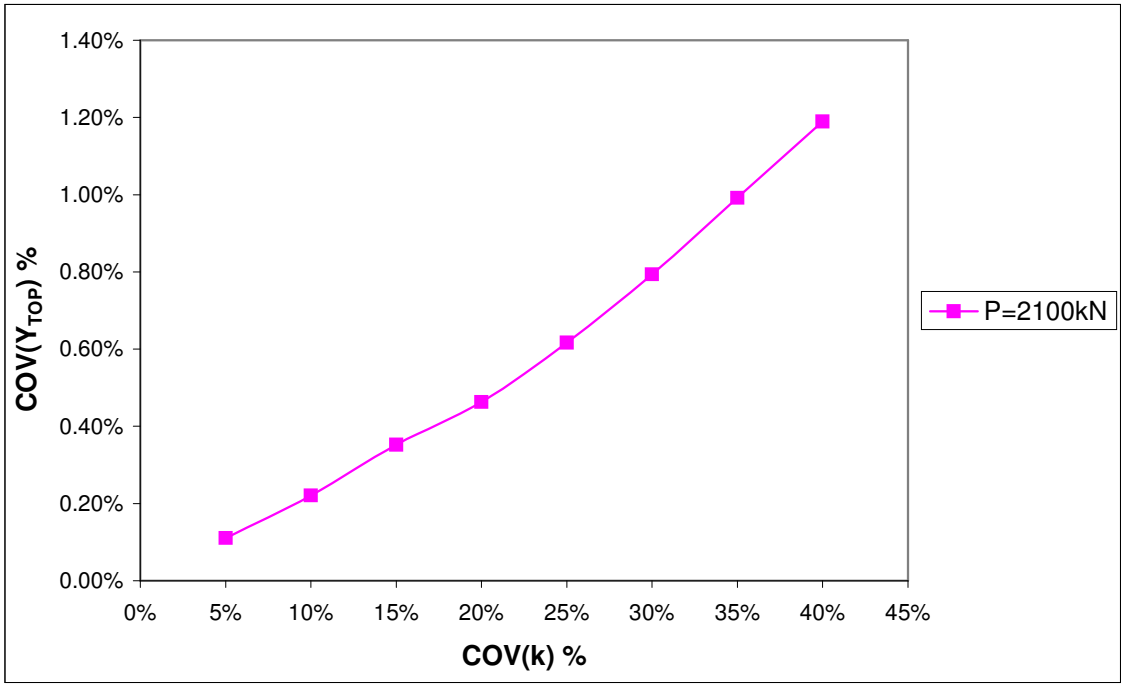


Fig. F.15 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.29 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 2650kN.

P=2650kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	4.00E-10	0.07%
10%	2.66E+06	2.50E-09	0.17%
15%	5.98E+06	7.23E-09	0.29%
20%	1.06E+07	1.56E-08	0.42%
25%	1.66E+07	2.56E-08	0.54%
30%	2.39E+07	4.00E-08	0.67%
35%	3.25E+07	6.00E-08	0.82%
40%	4.25E+07	9.92E-08	1.06%

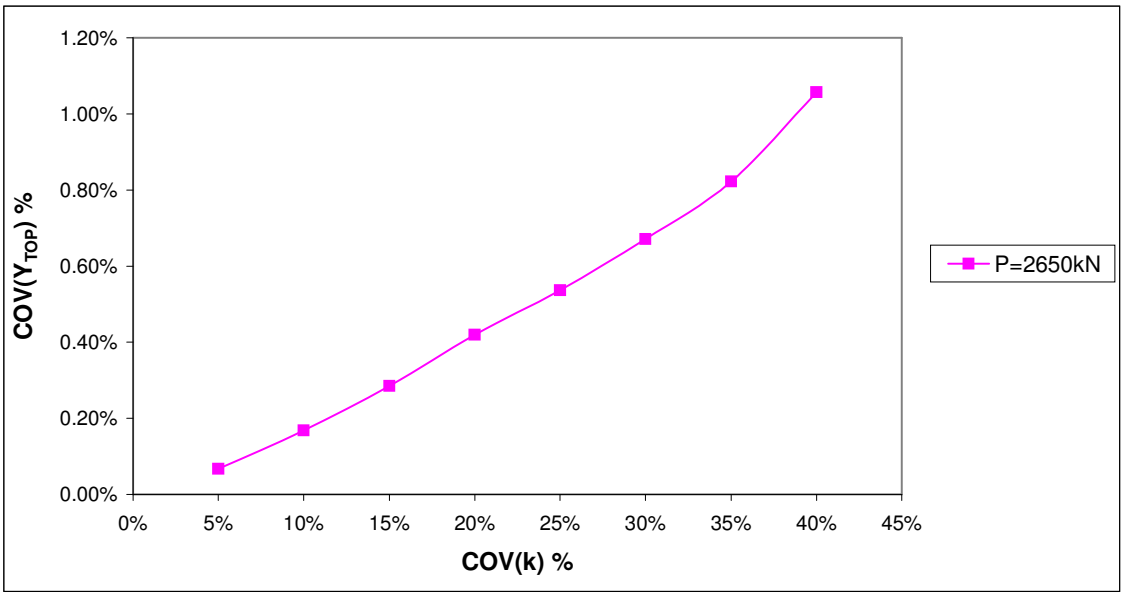


Fig. F.16 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.30 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 3300kN.

P=3300kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.64E+05	1.23E-09	0.07%
10%	2.66E+06	6.40E-09	0.17%
15%	5.98E+06	1.32E-08	0.24%
20%	1.06E+07	2.10E-08	0.30%
25%	1.66E+07	3.24E-08	0.38%
30%	2.39E+07	5.52E-08	0.49%
35%	3.25E+07	9.30E-08	0.64%
40%	4.25E+07	1.44E-07	0.80%

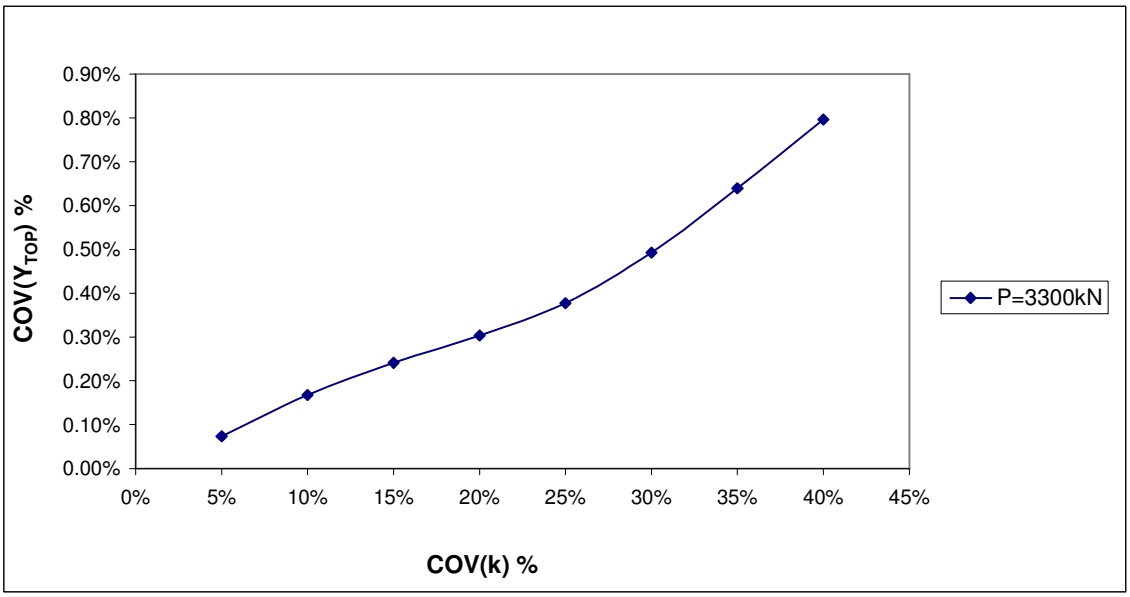


Fig. F.17 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

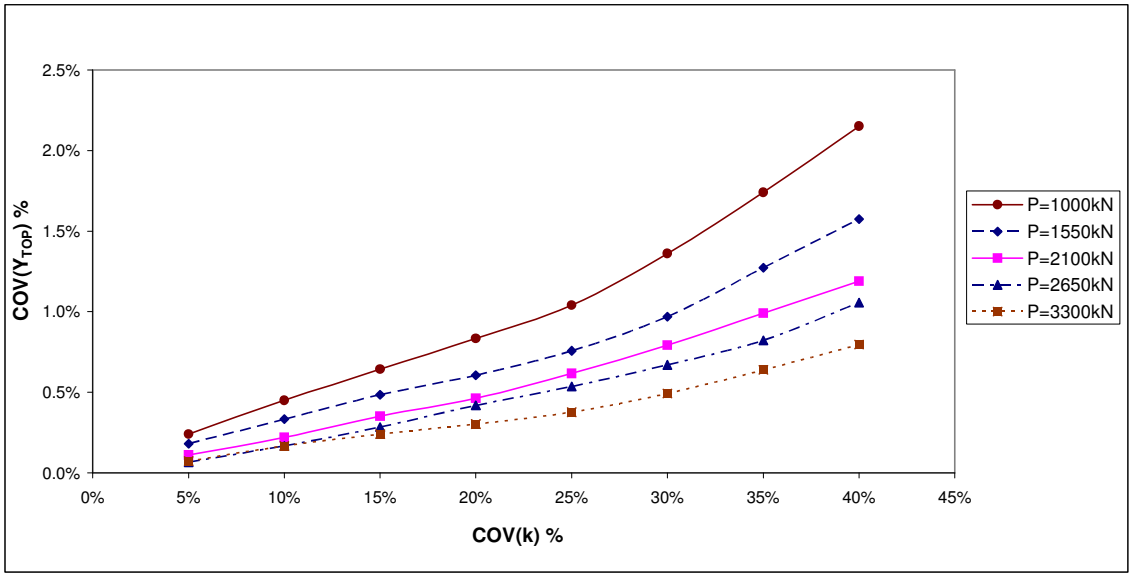


Fig. F.18 Variability of COV (Y_{TOP}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table F.31 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (B) and load 1000kN.

P=1000kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.4263	8.34E-03				
5%	0.406			4.12E-04	1.64E-08	6.22E-03	0.13%
		0.3857	8.60E-03				
		0.4466	8.26E-03				
10%	0.406			1.65E-03	2.82E-08	6.22E-03	0.27%
		0.3654	8.60E-03				
		0.4669	8.12E-03				
15%	0.406			3.71E-03	5.66E-08	6.22E-03	0.55%
		0.3451	8.60E-03				
		0.4872	8.05E-03				
20%	0.406			6.59E-03	8.97E-08	6.22E-03	0.60%
		0.3248	8.65E-03				
		0.5075	7.97E-03				
25%	0.406			1.03E-02	1.34E-07	6.22E-03	0.90%
		0.3045	8.70E-03				
		0.5278	7.84E-03				
30%	0.406			1.48E-02	2.16E-07	6.22E-03	1.90%
		0.2842	8.77E-03				
		0.5472	7.71E-03				
35%	0.406			2.02E-02	3.36E-07	6.22E-03	3.00%
		0.2648	8.86E-03				
		0.5684	7.59E-03				
40%	0.406			2.64E-02	4.75E-07	6.22E-03	5.00%
		0.2436	8.97E-03				

Table F.32 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (B) and load 1550kN.

P=1550kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.4263	1.35E-02				
5%	0.406			4.12E-04	1.00E-08	7.40E-03	0.61%
		0.3857	1.37E-02				
		0.4466	1.34E-02				
10%	0.406			1.65E-03	2.25E-08	7.40E-03	0.64%
		0.3654	1.37E-02				
		0.4669	1.33E-02				
15%	0.406			3.71E-03	1.82E-08	7.40E-03	0.82%
		0.3451	1.36E-02				
		0.4872	1.32E-02				
20%	0.406			6.59E-03	4.20E-08	7.40E-03	1.24%
		0.3248	1.36E-02				
		0.5075	1.31E-02				
25%	0.406			1.03E-02	6.76E-08	7.40E-03	1.58%
		0.3045	1.37E-02				
		0.5278	1.30E-02				
30%	0.406			1.48E-02	1.41E-07	7.40E-03	2.60%
		0.2842	1.38E-02				
		0.5472	1.29E-02				
35%	0.406			2.02E-02	2.79E-07	7.40E-03	3.80%
		0.2648	1.39E-02				
		0.5684	1.28E-02				
40%	0.406			2.64E-02	5.70E-07	7.40E-03	6.10%
		0.2436	1.43E-02				

Table F.33 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (B) and load 2100kN.

P=2100kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.4263	1.92E-02				
5%	0.406			4.12E-04	2.50E-09	1.65E-02	0.73%
		0.3857	1.91E-02				
		0.4466	1.91E-02				
10%	0.406			1.65E-03	2.02E-09	1.65E-02	0.89%
		0.3654	1.92E-02				
		0.4669	1.90E-02				
15%	0.406			3.71E-03	8.10E-09	1.65E-02	1.23%
		0.3451	1.92E-02				
		0.4872	1.89E-02				
20%	0.406			6.59E-03	4.41E-08	1.65E-02	1.81%
		0.3248	1.93E-02				
		0.5075	1.88E-02				
25%	0.406			1.03E-02	1.12E-07	1.65E-02	2.76%
		0.3045	1.95E-02				
		0.5278	1.88E-02				
30%	0.406			1.48E-02	3.14E-07	1.65E-02	4.07%
		0.2842	1.99E-02				
		0.5472	1.87E-02				
35%	0.406			2.02E-02	8.67E-07	1.65E-02	5.52%
		0.2648	2.05E-02				
		0.5684	1.86E-02				
40%	0.406			2.64E-02	2.87E-06	1.65E-02	7.57%
		0.2436	2.20E-02				

Table F.34 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (B) and load 2650kN.

P=2650kN							
COV(B) (%)	B° (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		0.4263	2.54E-02				
5%	0.406			4.12E-04	6.25E-08	2.98E-02	0.84%
		0.3857	2.49E-02				
		0.4466	2.53E-02				
10%	0.406			1.65E-03	9.61E-08	2.98E-02	1.04%
		0.3654	2.59E-02				
		0.4669	2.52E-02				
15%	0.406			3.71E-03	1.12E-07	2.98E-02	1.12%
		0.3451	2.59E-02				
		0.4872	2.51E-02				
20%	0.406			6.59E-03	3.60E-07	2.98E-02	2.01%
		0.3248	2.63E-02				
		0.5075	2.50E-02				
25%	0.406			1.03E-02	8.19E-07	2.98E-02	3.04%
		0.3045	2.68E-02				
		0.5278	2.50E-02				
30%	0.406			1.48E-02	2.36E-06	2.98E-02	5.15%
		0.2842	2.80E-02				
		0.5472	2.49E-02				
35%	0.406			2.02E-02	8.78E-06	2.98E-02	9.95%
		0.2648	3.08E-02				
		0.5684	2.48E-02				
40%	0.406			2.64E-02	3.49E-05	2.98E-02	19.82%
		0.2436	3.66E-02				

Table F.35 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (B) and load 3300kN.

P=3300kN							
COV(B) (%)	B^o (m)	B(current) (m)	Y_{TOP} (m)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		0.4263	3.23E-02				
5%	0.406			4.12E-04	2.25E-08	4.77E-02	1.50%
		0.3857	3.20E-02				
		0.4466	3.22E-02				
10%	0.406			1.65E-03	8.01E-07	4.77E-02	1.88%
		0.3654	3.40E-02				
		0.4669	3.21E-02				
15%	0.406			3.71E-03	8.93E-07	4.77E-02	1.98%
		0.3451	3.40E-02				
		0.4872	3.20E-02				
20%	0.406			6.59E-03	2.09E-06	4.77E-02	3.10%
		0.3248	3.49E-02				
		0.5075	3.19E-02				
25%	0.406			1.03E-02	6.08E-06	4.77E-02	5.17%
		0.3045	3.69E-02				
		0.5278	3.18E-02				
30%	0.406			1.48E-02	2.23E-05	4.77E-02	9.91%
		0.2842	4.13E-02				
		0.5472	3.18E-02				
35%	0.406			2.02E-02	7.65E-05	4.77E-02	18.33%
		0.2648	4.91E-02				
		0.5684	3.17E-02				
40%	0.406			2.64E-02	1.96E-04	4.77E-02	29.37%
		0.2436	5.97E-02				

Table F.36 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 1000kN.

P=1000kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.64E-08	0.13%
10%	1.65E-03	2.82E-08	0.20%
15%	3.71E-03	5.66E-08	0.40%
20%	6.59E-03	8.97E-08	0.60%
25%	1.03E-02	1.34E-07	0.90%
30%	1.48E-02	2.16E-07	1.90%
35%	2.02E-02	3.36E-07	3.00%
40%	2.64E-02	4.75E-07	5.00%

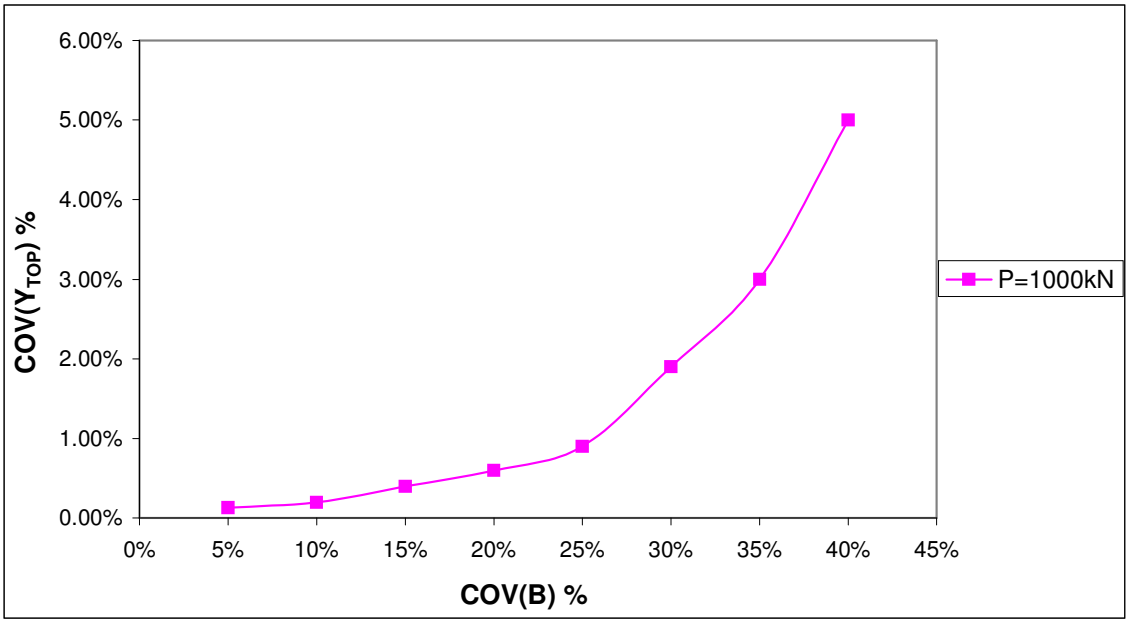


Fig. F.19 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.37 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 1550kN.

P=1550kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	1.00E-08	0.61%
10%	1.65E-03	2.25E-08	0.64%
15%	3.71E-03	1.82E-08	0.82%
20%	6.59E-03	4.20E-08	1.24%
25%	1.03E-02	6.76E-08	1.58%
30%	1.48E-02	1.41E-07	2.60%
35%	2.02E-02	2.79E-07	3.80%
40%	2.64E-02	5.70E-07	6.10%

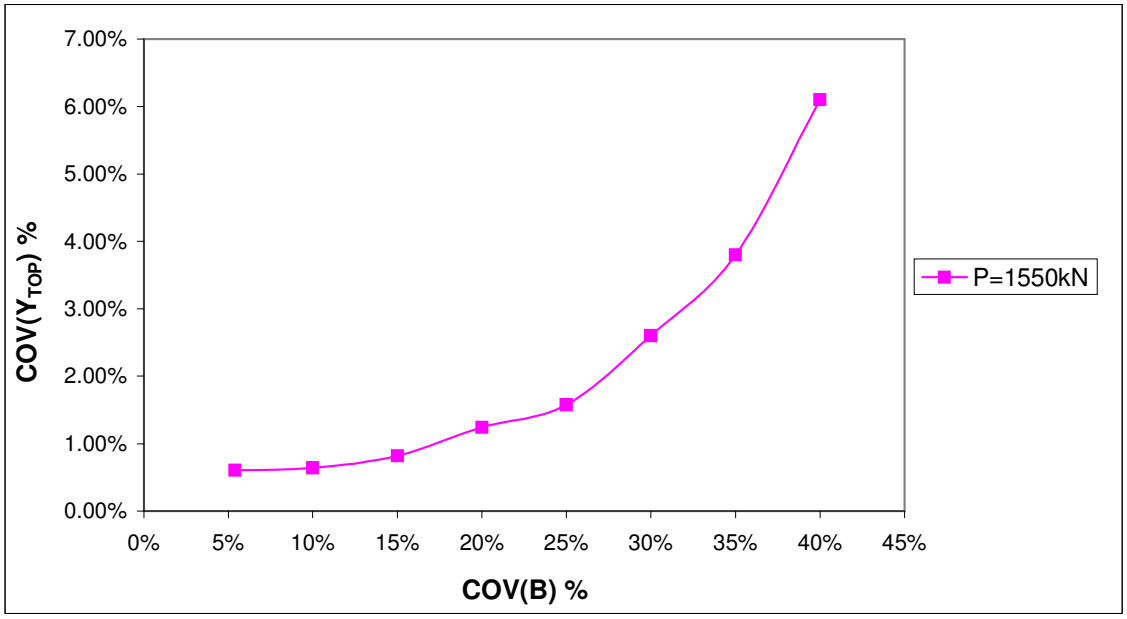


Fig. F.20 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.38 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 2100kN.

P=2100kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	2.50E-09	0.73%
10%	1.65E-03	2.02E-09	0.89%
15%	3.71E-03	8.10E-09	1.23%
20%	6.59E-03	4.41E-08	1.81%
25%	1.03E-02	1.12E-07	2.76%
30%	1.48E-02	3.14E-07	4.07%
35%	2.02E-02	8.67E-07	5.52%
40%	2.64E-02	2.87E-06	7.57%
40%	2.64E-02	2.87E-06	7.57%

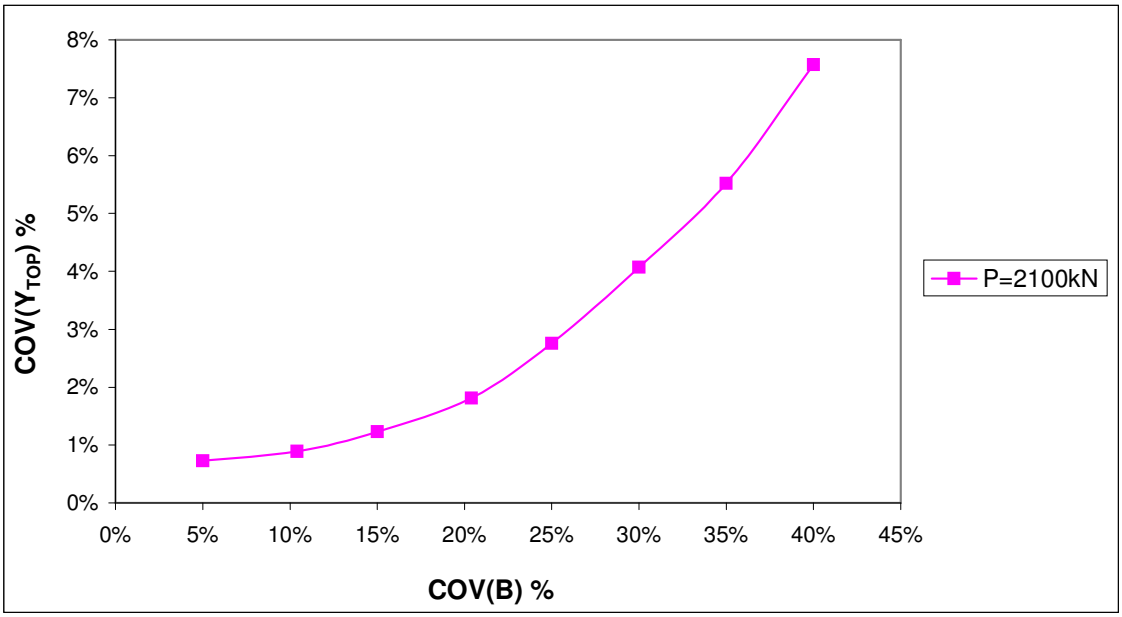


Fig. F.21 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.39 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 2650kN.

P=2650kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	6.25E-08	0.84%
10%	1.65E-03	9.61E-08	1.04%
15%	3.71E-03	1.12E-07	1.12%
20%	6.59E-03	3.60E-07	2.01%
25%	1.03E-02	8.19E-07	3.04%
30%	1.48E-02	2.36E-06	5.15%
35%	2.02E-02	8.78E-06	9.95%
40%	2.64E-02	3.49E-05	19.82%

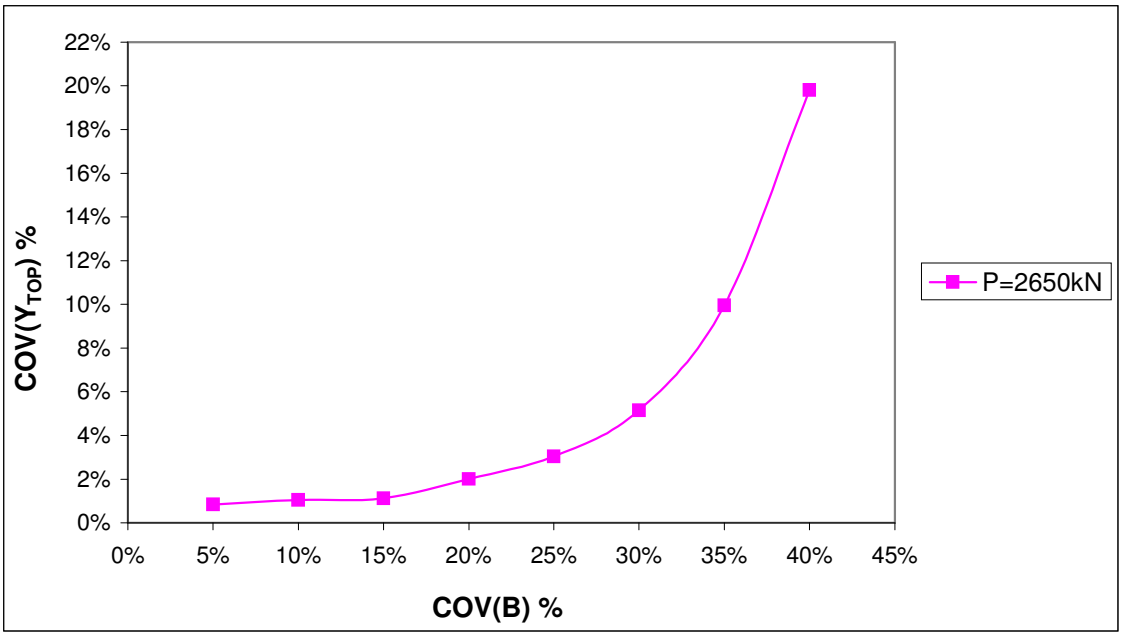


Fig. F.22 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.40 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 3300kN.

P=3300kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	4.12E-04	2.25E-08	1.50%
10%	1.65E-03	8.01E-07	1.88%
15%	3.71E-03	8.93E-07	1.98%
20%	6.59E-03	2.09E-06	3.10%
25%	1.03E-02	6.08E-06	5.17%
30%	1.48E-02	2.23E-05	9.91%
35%	2.02E-02	7.65E-05	18.33%
40%	2.64E-02	1.96E-04	29.37%

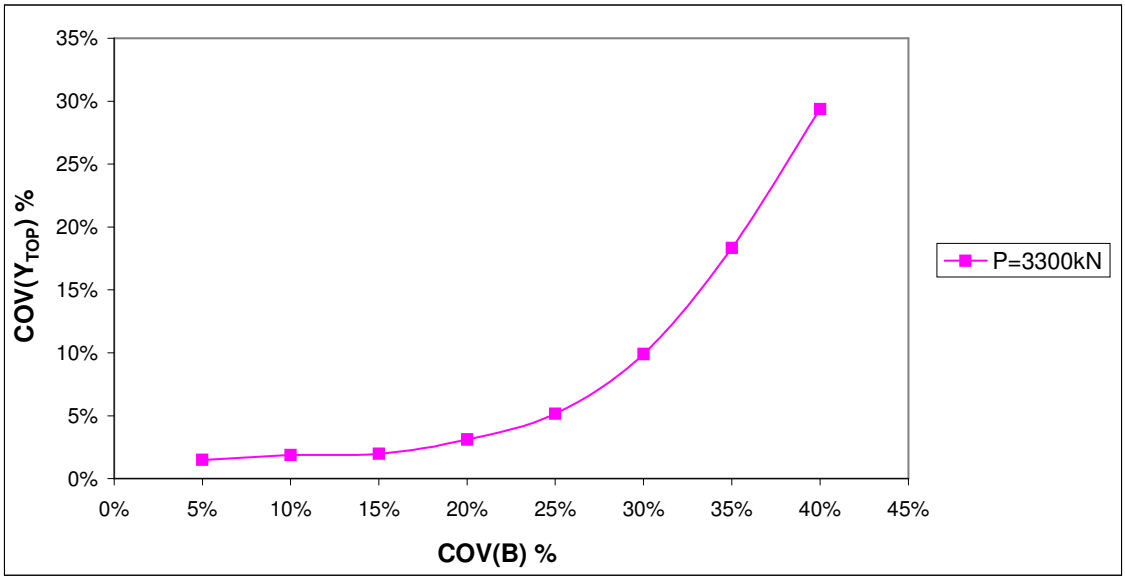


Fig. F.23 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

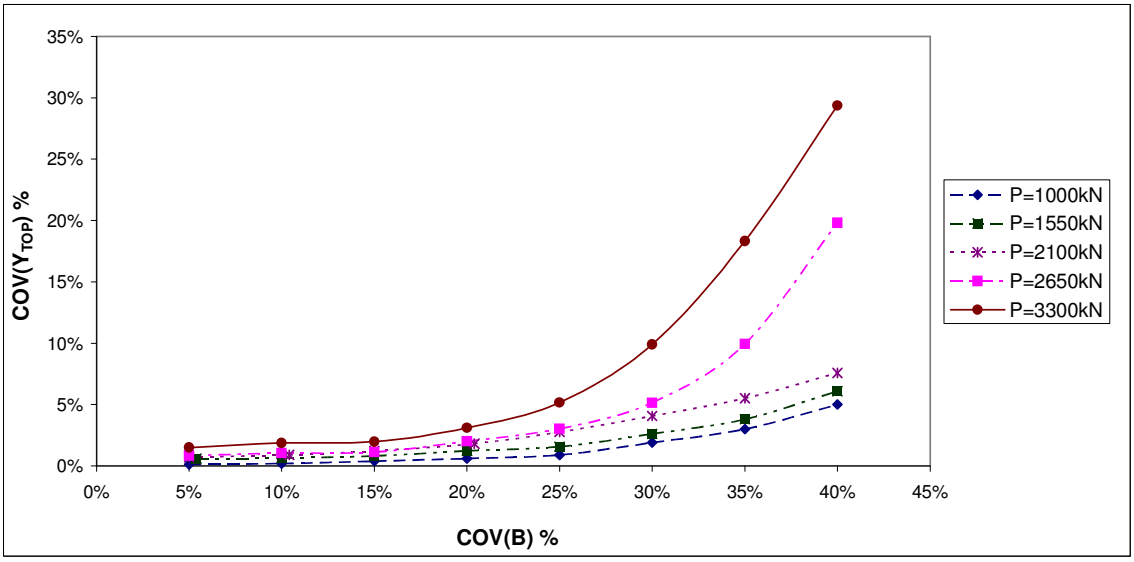


Fig. F.24 Variability of COV (Y_{TOP}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table F.41 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (EI) and load 1000kN.

P=1000kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) ($kN-m^2$)	Y_{TOP} (m)	VAR(EI) $(kN-m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	7.84E-03				
5%	61000			9.30E+06	5.95E-08	6.22E-03	2.18%
		57950	8.33E-03				
		67100	7.63E-03				
10%	61000			3.72E+07	2.42E-07	6.22E-03	4.39%
		54900	8.61E-03				
		70150	7.43E-03				
15%	61000			8.37E+07	5.54E-07	6.22E-03	6.64%
		51850	8.91E-03				
		73200	7.24E-03				
20%	61000			1.49E+08	1.01E-06	6.22E-03	8.98%
		48800	9.25E-03				
		76250	7.07E-03				
25%	61000			2.33E+08	1.64E-06	6.22E-03	11.42%
		45750	9.63E-03				
		79300	6.91E-03				
30%	61000			3.35E+08	2.46E-06	6.22E-03	13.99%
		42700	1.00E-02				
		82350	6.75E-03				
35%	61000			4.56E+08	3.55E-06	6.22E-03	16.81%
		39650	1.05E-02				
		85400	6.61E-03				
40%	61000			5.95E+08	4.92E-06	6.22E-03	19.81%
		36600	1.11E-02				

Table F.42 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (EI) and load 1550kN.

P=1550kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) ($kN-m^2$)	Y_{TOP} (m)	VAR(EI) $(kN-m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	1.26E-02				
5%	61000			9.30E+06	1.52E-07	7.40E-03	2.24%
		57950	1.34E-02				
		67100	1.22E-02				
10%	61000			3.72E+07	6.16E-07	7.40E-03	4.56%
		54900	1.38E-02				
		70150	1.19E-02				
15%	61000			8.37E+07	1.40E-06	7.40E-03	6.97%
		51850	1.43E-02				
		73200	1.16E-02				
20%	61000			1.49E+08	2.58E-06	7.40E-03	9.49%
		48800	1.48E-02				
		76250	1.13E-02				
25%	61000			2.33E+08	4.16E-06	7.40E-03	12.15%
		45750	1.54E-02				
		79300	1.11E-02				
30%	61000			3.35E+08	6.25E-06	7.40E-03	14.98%
		42700	1.61E-02				
		82350	1.08E-02				
35%	61000			4.56E+08	8.94E-06	7.40E-03	18.03%
		39650	1.68E-02				
		85400	1.06E-02				
40%	61000			5.95E+08	1.25E-05	7.40E-03	21.45%
		36600	1.77E-02				

Table F.43 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (EI) and load 2100kN.

P=2100kN							
COV(EI) (%)	EI° ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	1.78E-02				
5%	61000			9.30E+06	3.08E-07	1.65E-02	5.27%
		57950	1.89E-02				
		67100	1.73E-02				
10%	61000			3.72E+07	1.25E-06	1.65E-02	10.61%
		54900	1.95E-02				
		70150	1.68E-02				
15%	61000			8.37E+07	2.86E-06	1.65E-02	16.01%
		51850	2.02E-02				
		73200	1.64E-02				
20%	61000			1.49E+08	5.27E-06	1.65E-02	21.69%
		48800	2.10E-02				
		76250	1.60E-02				
25%	61000			2.33E+08	8.61E-06	1.65E-02	27.57%
		45750	2.19E-02				
		79300	1.56E-02				
30%	61000			3.35E+08	1.30E-05	1.65E-02	33.78%
		42700	2.29E-02				
		82350	1.53E-02				
35%	61000			4.56E+08	1.88E-05	1.65E-02	40.41%
		39650	2.40E-02				
		85400	1.50E-02				
40%	61000			5.95E+08	2.66E-05	1.65E-02	10.76%
		36600	2.53E-02				

Table F.44 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (EI) and load 2650kN.

P=2650kN							
COV(EI) (%)	EI° ($kN\text{-}m^2$)	EI(current) ($kN\text{-}m^2$)	Y_{TOP} (m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		64050	2.35E-02				
5%	61000			9.30E+06	6.40E-07	2.98E-02	3.36%
		57950	2.51E-02				
		67100	2.28E-02				
10%	61000			3.72E+07	2.56E-06	2.98E-02	6.79%
		54900	2.60E-02				
		70150	2.22E-02				
15%	61000			8.37E+07	5.81E-06	2.98E-02	10.24%
		51850	2.70E-02				
		73200	2.16E-02				
20%	61000			1.49E+08	1.06E-05	2.98E-02	13.91%
		48800	2.81E-02				
		76250	2.11E-02				
25%	61000			2.33E+08	1.74E-05	2.98E-02	17.79%
		45750	2.94E-02				
		79300	2.06E-02				
30%	61000			3.35E+08	2.66E-05	2.98E-02	21.88%
		42700	3.09E-02				
		82350	2.01E-02				
35%	61000			4.56E+08	3.89E-05	2.98E-02	26.30%
		39650	3.26E-02				
		85400	1.97E-02				
40%	61000			5.95E+08	5.49E-05	2.98E-02	31.24%
		36600	3.45E-02				

Table F.45 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (EI) and load 3300kN.

P=3300kN							
COV(EI) (%)	EI^{o} (kN-m^2)	EI(current) (kN-m^2)	Y_{TOP} (m)	VAR(EI) (kN-m^2)^2	VAR (Y_{TOP}) (m)^2	$Y_{TOP}{}^{o}$ (m)	COV(Y_{TOP}) (%)
		64050	3.03E-02				
5%	61000			9.30E+06	1.14E-06	4.77E-02	2.68%
		57950	3.24E-02				
		67100	2.93E-02				
10%	61000			3.72E+07	4.73E-06	4.77E-02	5.37%
		54900	3.37E-02				
		70150	2.85E-02				
15%	61000			8.37E+07	1.11E-05	4.77E-02	8.09%
		51850	3.51E-02				
		73200	2.77E-02				
20%	61000			1.49E+08	2.05E-05	4.77E-02	10.91%
		48800	3.67E-02				
		76250	2.69E-02				
25%	61000			2.33E+08	3.36E-05	4.77E-02	13.99%
		45750	3.85E-02				
		79300	2.62E-02				
30%	61000			3.35E+08	5.11E-05	4.77E-02	17.32%
		42700	4.05E-02				
		82350	2.56E-02				
35%	61000			4.56E+08	7.40E-05	4.77E-02	20.92%
		39650	4.28E-02				
		85400	2.50E-02				
40%	61000			5.95E+08	1.05E-04	4.77E-02	24.87%
		36600	4.55E-02				

Table F.46 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 1000kN.

P=1000kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	5.95E-08	2.18%
10%	3.72E+07	2.42E-07	4.39%
15%	8.37E+07	5.54E-07	6.64%
20%	1.49E+08	1.01E-06	8.98%
25%	2.33E+08	1.64E-06	11.42%
30%	3.35E+08	2.46E-06	13.99%
35%	4.56E+08	3.55E-06	16.81%
40%	5.95E+08	4.92E-06	19.81%

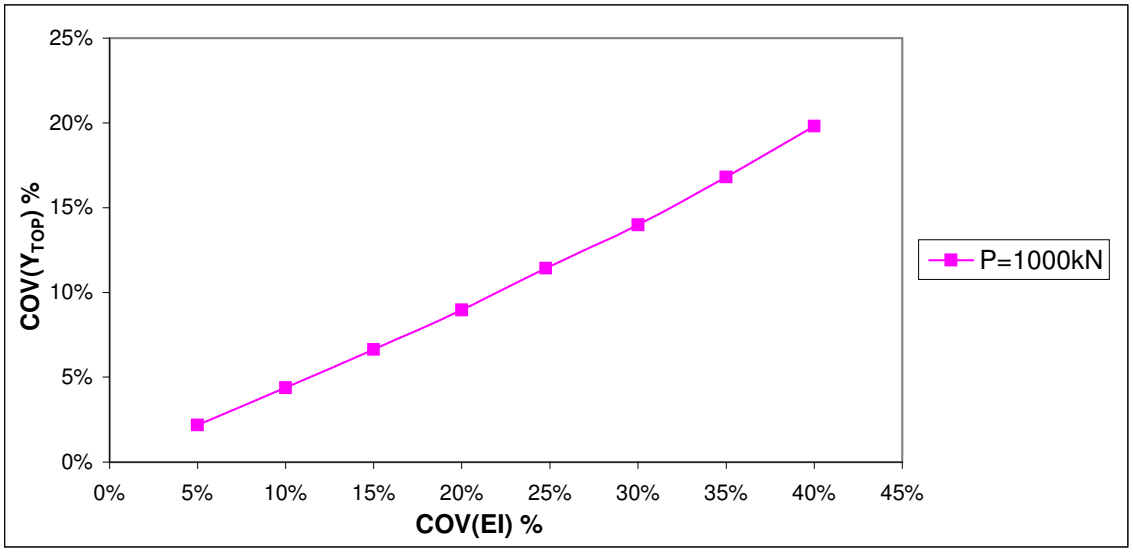


Fig. F.25 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.47 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 1550kN.

P=1550kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	1.52E-07	2.24%
10%	3.72E+07	6.16E-07	4.56%
15%	8.37E+07	1.40E-06	6.97%
20%	1.49E+08	2.58E-06	9.49%
25%	2.33E+08	4.16E-06	12.15%
30%	3.35E+08	6.25E-06	14.98%
35%	4.56E+08	8.94E-06	18.03%
40%	5.95E+08	1.25E-05	21.45%

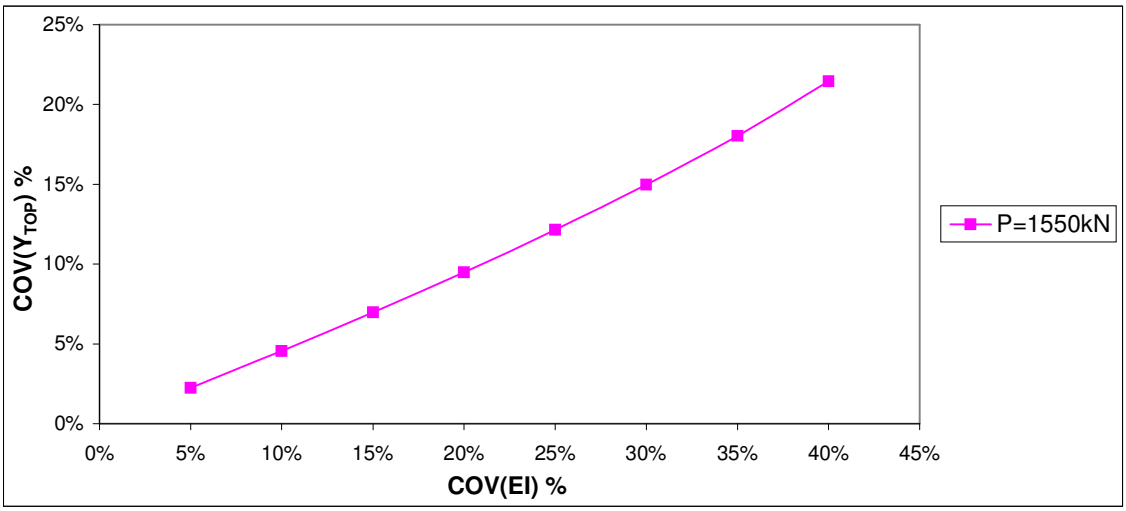


Fig. F.26 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.48 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 2100kN.

P=2100kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	3.08E-07	2.36%
10%	3.72E+07	1.25E-06	4.76%
15%	8.37E+07	2.86E-06	7.18%
20%	1.49E+08	5.27E-06	9.73%
25%	2.33E+08	8.61E-06	12.36%
30%	3.35E+08	1.30E-05	15.15%
35%	4.56E+08	1.88E-05	18.12%
40%	5.95E+08	2.66E-05	21.76%

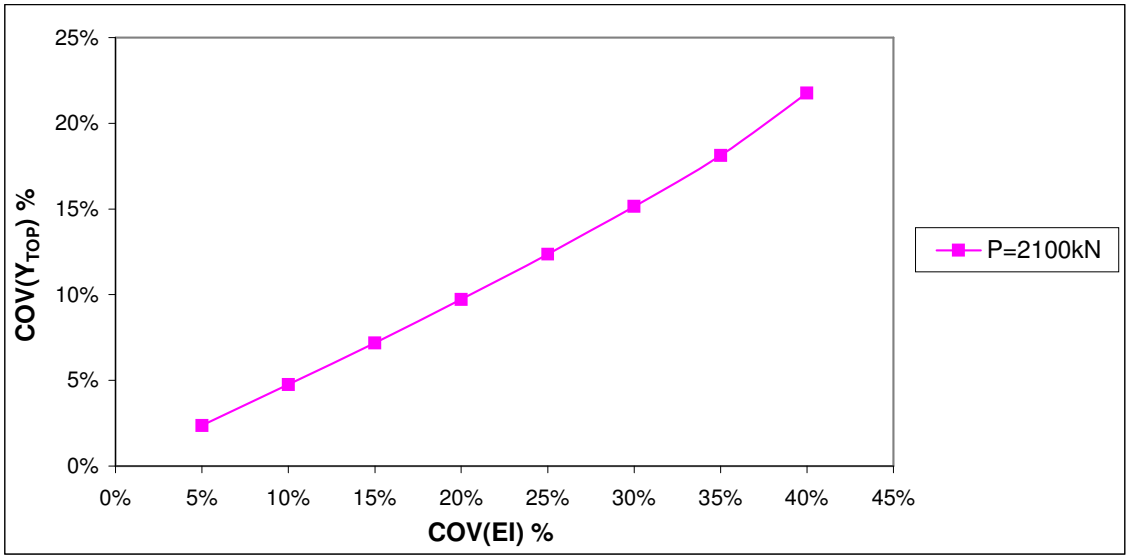


Fig. F.27 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.49 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 2650kN.

P=2650kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	6.40E-07	2.44%
10%	3.72E+07	2.56E-06	4.93%
15%	8.37E+07	5.81E-06	7.44%
20%	1.49E+08	1.06E-05	10.11%
25%	2.33E+08	1.74E-05	12.93%
30%	3.35E+08	2.66E-05	15.90%
35%	4.56E+08	3.89E-05	19.12%
40%	5.95E+08	5.49E-05	22.71%

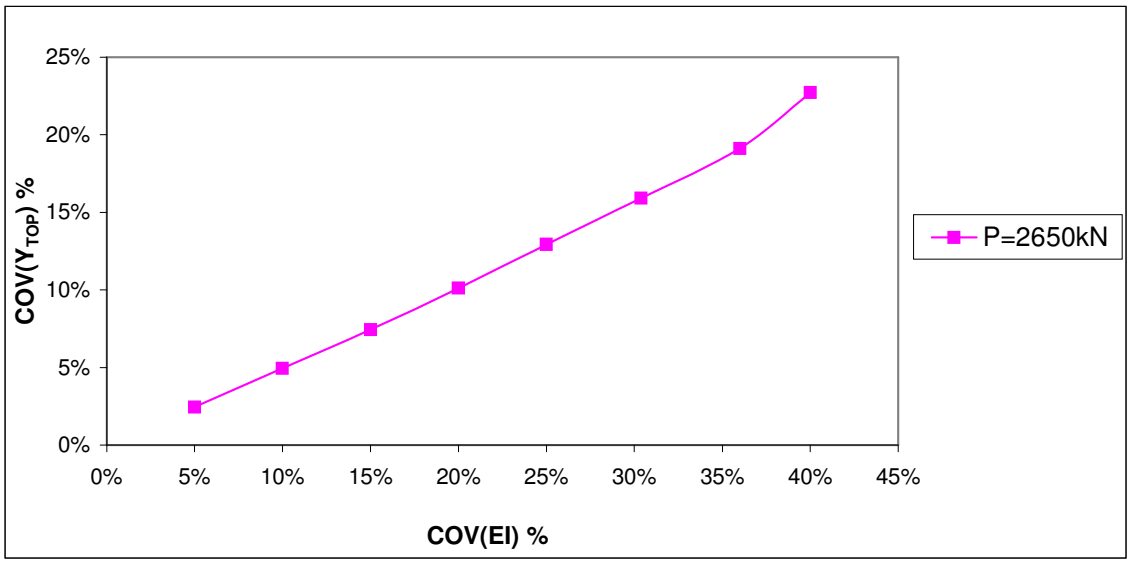


Fig. F.28 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.50 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 3300kN.

P=3300kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	9.30E+06	1.14E-06	2.68%
10%	3.72E+07	4.73E-06	5.37%
15%	8.37E+07	1.11E-05	8.09%
20%	1.49E+08	2.05E-05	10.91%
25%	2.33E+08	3.36E-05	13.99%
30%	3.35E+08	5.11E-05	17.32%
35%	4.56E+08	7.40E-05	20.92%
40%	5.95E+08	1.05E-04	24.87%

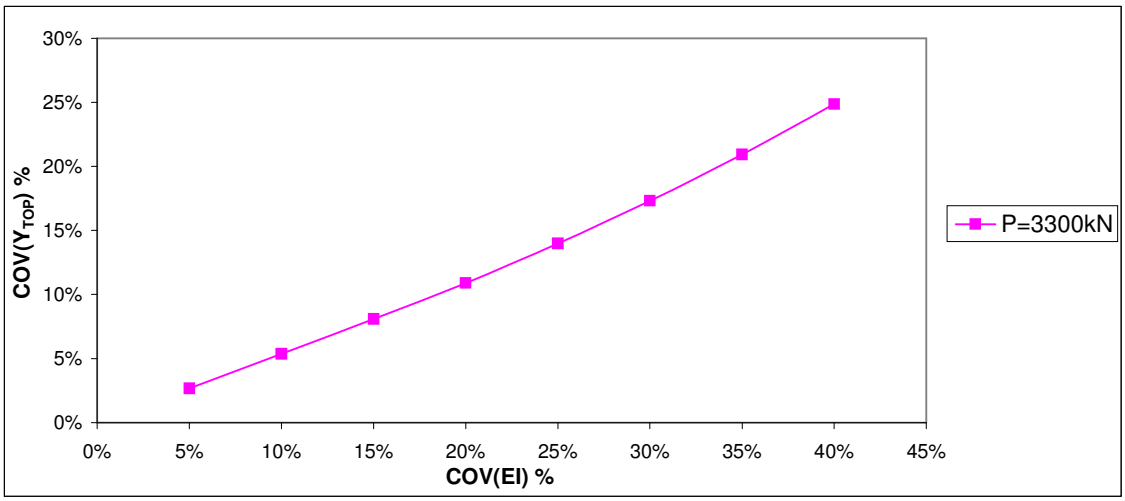


Fig. F.29 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

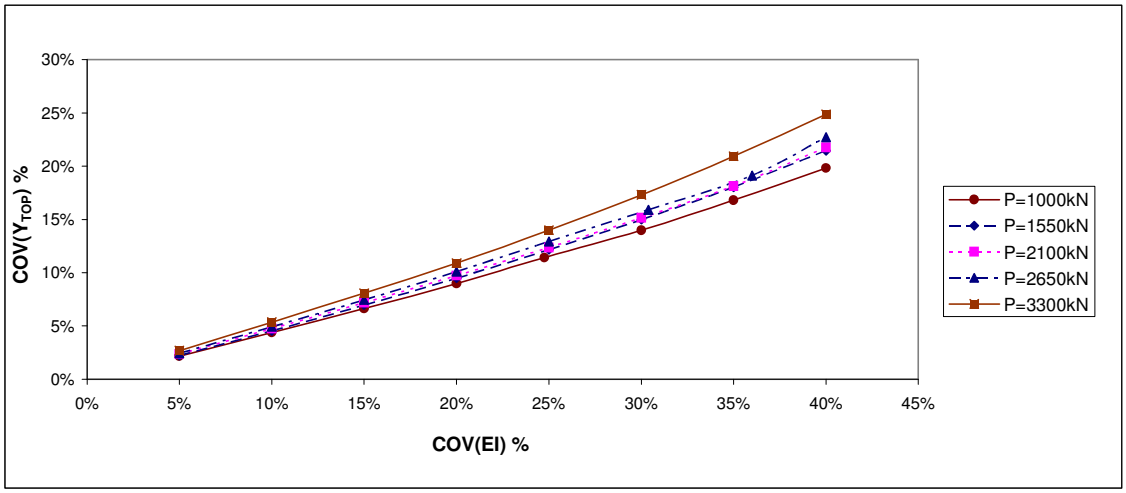


Fig. F.30 Variability of COV (Y_{TOP}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability

Table F.51 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (P) and load 1000kN.

P=1000kN							
COV(P) (%)	P° (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		1050	8.65E-03				
5%	1000			2.50E+03	3.22E-07	6.22E-03	5.07%
		950	7.51E-03				
		1100	9.24E-03				
10%	1000			1.00E+04	1.30E-06	6.22E-03	10.19%
		900	6.96E-03				
		1150	9.84E-03				
15%	1000			2.25E+04	2.95E-06	6.22E-03	15.33%
		850	6.41E-03				
		1200	1.05E-02				
20%	1000			4.00E+04	5.23E-06	6.22E-03	20.43%
		800	5.87E-03				
		1250	1.11E-02				
25%	1000			6.25E+04	8.17E-06	6.22E-03	25.53%
		750	5.35E-03				
		1300	1.17E-02				
30%	1000			9.00E+04	1.17E-05	6.22E-03	30.51%
		700	4.86E-03				
		1350	1.23E-02				
35%	1000			1.23E+05	1.58E-05	6.22E-03	35.50%
		650	4.37E-03				
		1400	1.30E-02				
40%	1000			1.60E+05	2.05E-05	6.22E-03	40.45%
		600	3.89E-03				

Table F.52 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (P) and load 1550kN.

P=1550kN							
COV(P) (%)	P° (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		1627.5	1.38E-02				
5%	1550			6.01E+03	7.83E-07	7.40E-03	5.13%
		1472.5	1.21E-02				
		1705	1.48E-02				
10%	1550			2.40E+04	3.17E-06	7.40E-03	10.34%
		1395	1.12E-02				
		1782.5	1.57E-02				
15%	1550			5.41E+04	7.18E-06	7.40E-03	15.46%
		1317.5	1.03E-02				
		1860	1.66E-02				
20%	1550			9.61E+04	2.89E-05	7.40E-03	20.77%
		1240	5.87E-03				
		1937.5	1.76E-02				
25%	1550			1.50E+05	1.99E-05	7.40E-03	26.03%
		1162.5	8.65E-03				
		2015	1.86E-02				
30%	1550			2.16E+05	2.87E-05	7.40E-03	31.24%
		1085	7.85E-03				
		2092.5	1.96E-02				
35%	1550			2.94E+05	3.90E-05	7.40E-03	36.72%
		1007.5	7.07E-03				
		2170	2.06E-02				
40%	1550			3.84E+05	5.08E-05	7.40E-03	42.29%
		930	6.30E-03				

Table F.53 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (P) and load 2100kN.

P=2100kN							
COV(P) (%)	P° (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		2205	1.96E-02				
5%	2100			1.10E+04	1.59E-06	1.65E-02	11.96%
		1995	1.70E-02				
		2310	2.09E-02				
10%	2100			4.41E+04	6.35E-06	1.65E-02	24.05%
		1890	1.58E-02				
		2415	2.22E-02				
15%	2100			9.92E+04	1.44E-05	1.65E-02	36.22%
		1785	1.46E-02				
		2520	2.36E-02				
20%	2100			1.76E+05	2.58E-05	1.65E-02	21.60%
		1680	1.35E-02				
		2625	2.51E-02				
25%	2100			2.76E+05	4.08E-05	1.65E-02	60.36%
		1575	1.23E-02				
		2730	2.66E-02				
30%	2100			3.97E+05	5.94E-05	1.65E-02	72.37%
		1470	1.12E-02				
		2835	2.82E-02				
35%	2100			5.40E+05	8.19E-05	1.65E-02	84.34%
		1365	1.01E-02				
		2940	2.98E-02				
40%	2100			7.06E+05	1.08E-04	1.65E-02	96.34%
		1260	9.00E-03				

Table F.54 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (P) and load 2650kN.

P=2650kN							
COV(P) (%)	P° (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	Y_{TOP}° (m)	COV(Y_{TOP}) (%)
		2782.5	2.61E-02				
5%	2650			1.76E+04	3.20E-06	2.98E-02	7.64%
		2517.5	2.25E-02				
		2915	2.80E-02				
10%	2650			7.02E+04	1.27E-05	2.98E-02	15.27%
		2385	2.09E-02				
		3047.5	3.00E-02				
15%	2650			1.58E+05	2.88E-05	2.98E-02	22.97%
		2252.5	1.93E-02				
		3180	3.20E-02				
20%	2650			2.81E+05	5.12E-05	2.98E-02	30.76%
		2120	1.77E-02				
		3312.5	3.42E-02				
25%	2650			4.39E+05	8.09E-05	2.98E-02	38.73%
		1987.5	1.62E-02				
		3445	3.65E-02				
30%	2650			6.32E+05	1.18E-04	2.98E-02	46.70%
		1855	1.48E-02				
		3577.5	3.88E-02				
35%	2650			8.60E+05	1.62E-04	2.98E-02	54.85%
		1722.5	1.33E-02				
		3710	4.13E-02				
40%	2650			1.12E+06	2.15E-04	2.98E-02	63.12%
		1590	1.19E-02				

Table F.55 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (P) and load 3300kN.

P=3300kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	Y_{TOP} (m)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	$Y_{TOP}{}^o$ (m)	COV(Y_{TOP}) (%)
		3465	3.38E-02				
5%	3300			2.72E+04	5.98E-06	4.77E-02	6.01%
		3135	2.89E-02				
		3630	3.65E-02				
10%	3300			1.09E+05	2.43E-05	4.77E-02	11.98%
		2970	2.66E-02				
		3795	3.92E-02				
15%	3300			2.45E+05	5.44E-05	4.77E-02	18.02%
		2805	2.44E-02				
		3960	4.22E-02				
20%	3300			4.36E+05	9.81E-05	4.77E-02	24.01%
		2640	2.24E-02				
		4125	4.52E-02				
25%	3300			6.81E+05	1.54E-04	4.77E-02	30.18%
		2475	2.04E-02				
		4290	4.84E-02				
30%	3300			9.80E+05	2.22E-04	4.77E-02	36.43%
		2310	1.86E-02				
		4455	5.18E-02				
35%	3300			1.33E+06	3.07E-04	4.77E-02	42.67%
		2145	1.68E-02				
		4620	5.54E-02				
40%	3300			1.74E+06	4.07E-04	4.77E-02	49.18%
		1980	1.50E-02				

Table F.56 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 1000kN.

P=1000kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.50E+03	3.22E-07	5.07%
10%	1.00E+04	1.30E-06	10.19%
15%	2.25E+04	2.95E-06	15.33%
20%	4.00E+04	5.23E-06	20.43%
25%	6.25E+04	8.17E-06	25.53%
30%	9.00E+04	1.17E-05	30.51%
35%	1.23E+05	1.58E-05	35.50%
40%	1.60E+05	2.05E-05	40.45%

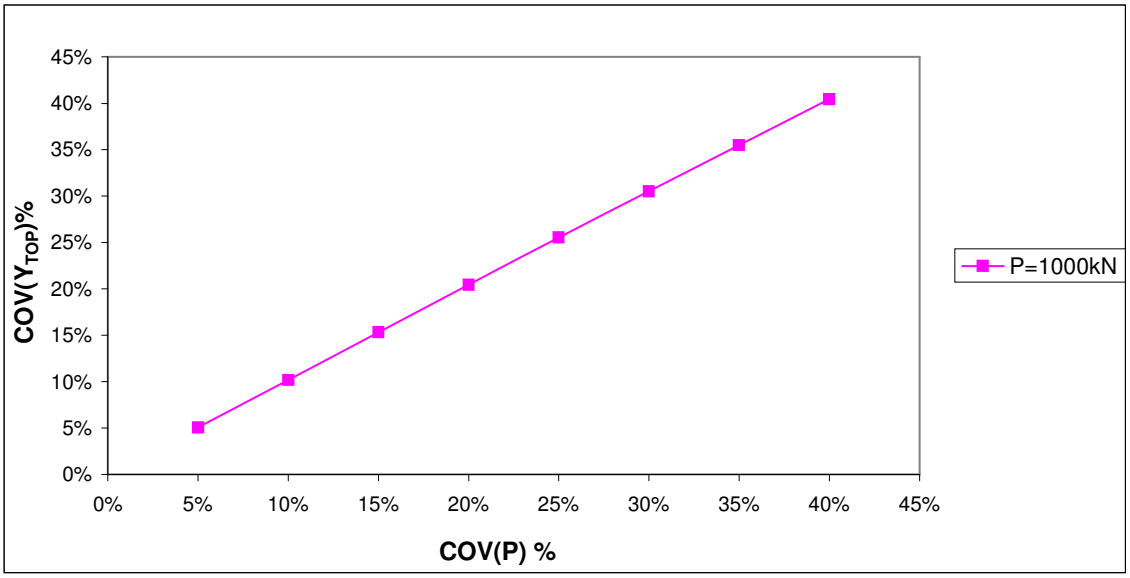


Fig. F.31 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.57 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 1550kN.

P=1550kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	6.01E+03	7.83E-07	5.13%
10%	2.40E+04	3.17E-06	10.34%
15%	5.41E+04	7.18E-06	15.46%
20%	9.61E+04	2.89E-05	20.77%
25%	1.50E+05	1.99E-05	26.03%
30%	2.16E+05	2.87E-05	31.24%
35%	2.94E+05	3.90E-05	36.72%
40%	3.84E+05	5.08E-05	42.29%

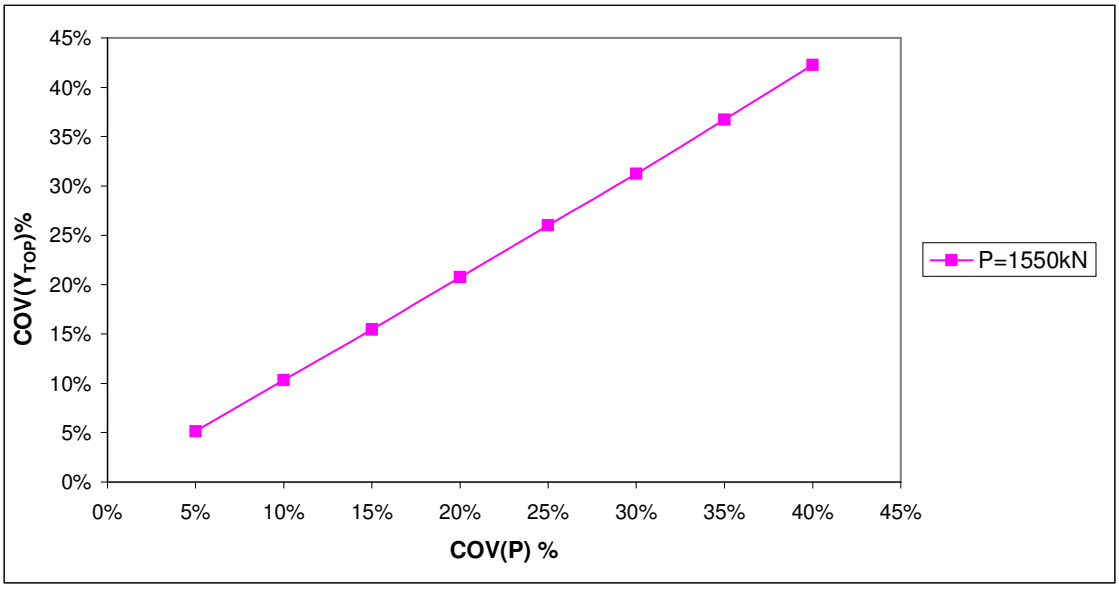


Fig. F.32 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.58 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 2100kN.

P=2100kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	1.10E+04	1.59E-06	5.36%
10%	4.41E+04	6.35E-06	10.79%
15%	9.92E+04	1.44E-05	16.24%
20%	1.76E+05	2.58E-05	21.60%
25%	2.76E+05	4.08E-05	27.07%
30%	3.97E+05	5.94E-05	32.46%
35%	5.40E+05	8.19E-05	37.83%
40%	7.06E+05	1.08E-04	43.21%

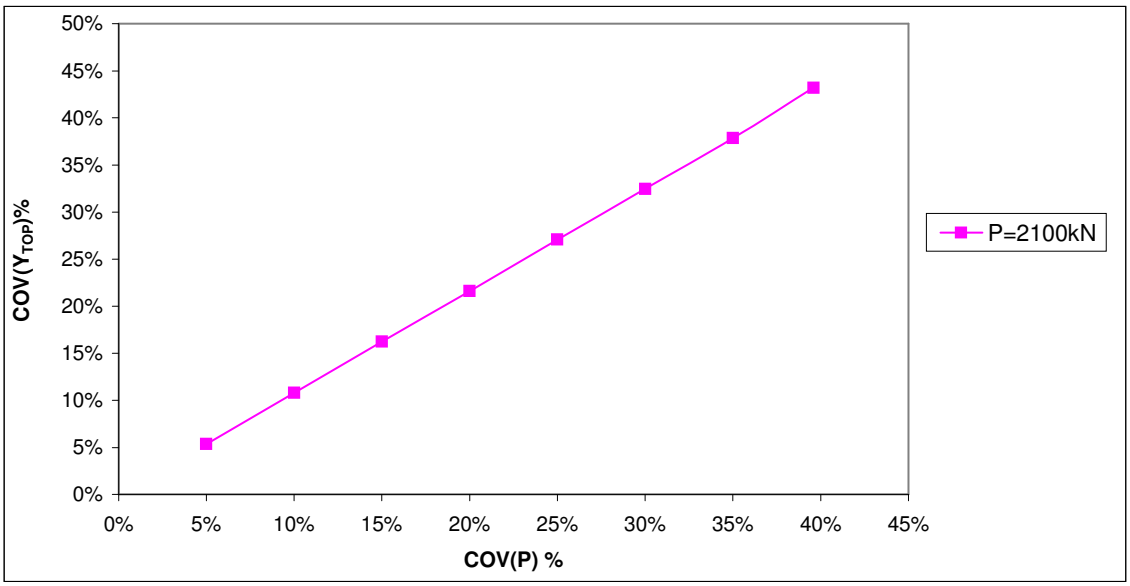


Fig. F.33 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.59 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 2650kN.

P=2650kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	1.76E+04	3.20E-06	5.55%
10%	7.02E+04	1.27E-05	11.10%
15%	1.58E+05	2.88E-05	16.70%
20%	2.81E+05	5.12E-05	22.36%
25%	4.39E+05	8.09E-05	28.15%
30%	6.32E+05	1.18E-04	33.94%
35%	8.60E+05	1.62E-04	39.87%
40%	1.12E+06	2.15E-04	45.88%

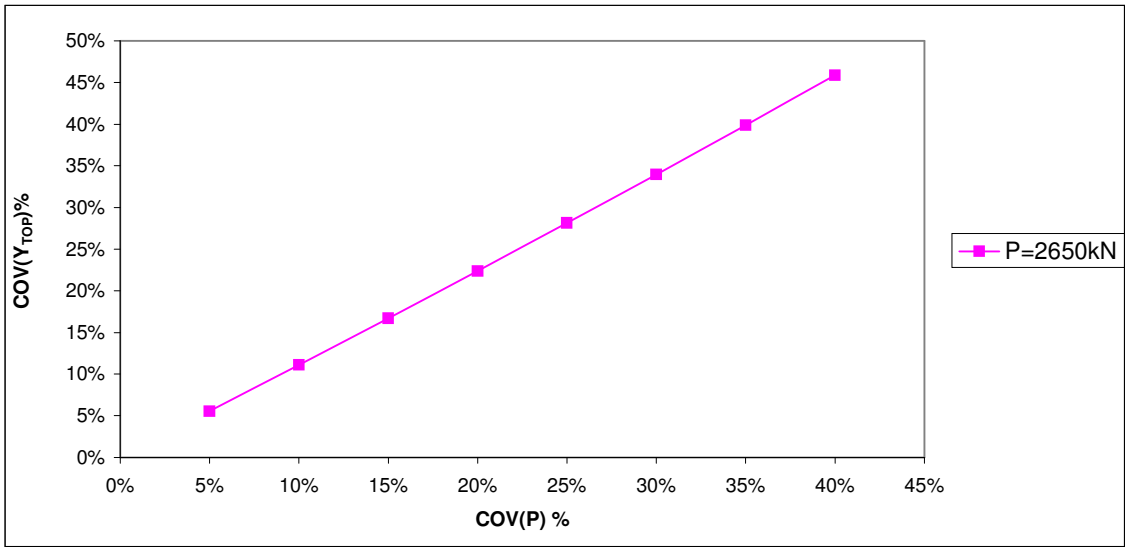


Fig. F.34 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.60 Value of COV (Y_{TOP}) for fixed head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 3300kN.

P=3300kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (Y_{TOP}) $(m)^2$	COV(Y_{TOP}) (%)
5%	2.72E+04	5.98E-06	6.01%
10%	1.09E+05	2.43E-05	11.98%
15%	2.45E+05	5.44E-05	18.02%
20%	4.36E+05	9.81E-05	24.01%
25%	6.81E+05	1.54E-04	30.18%
30%	9.80E+05	2.22E-04	36.43%
35%	1.33E+06	3.07E-04	42.67%
40%	1.74E+06	4.07E-04	49.18%

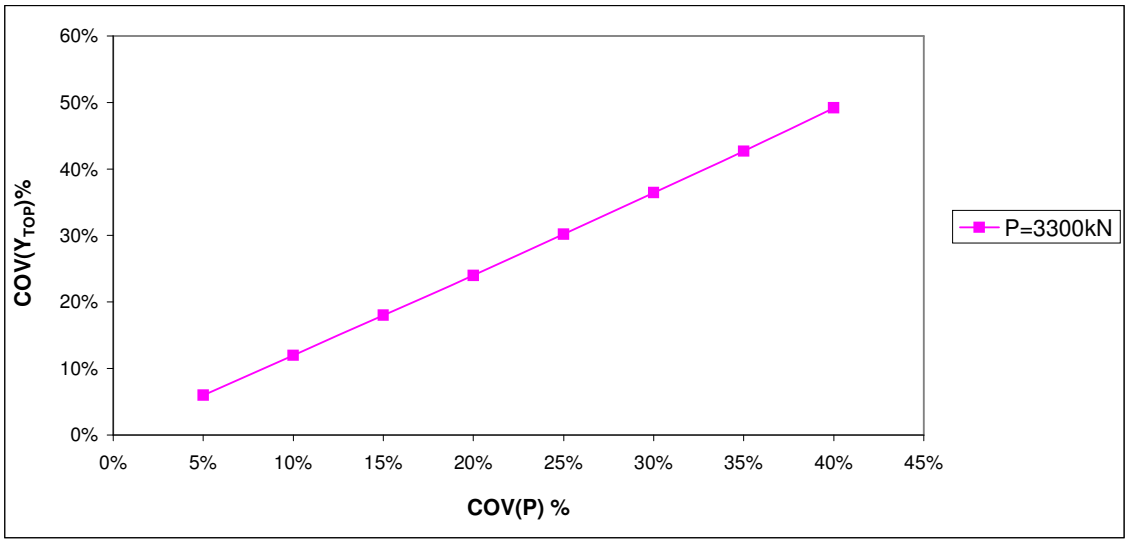


Fig. F.35 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

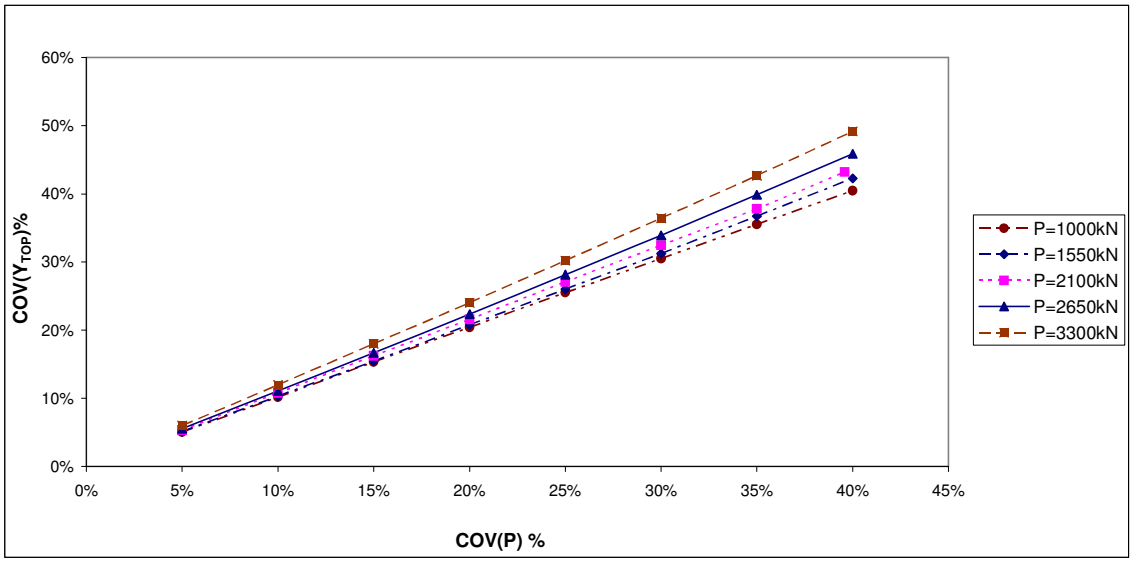


Fig. F.36 Variability of COV (Y_{TOP}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability

F-2 Reliability Index (β) of top deflection vs. COV (Variables).

Table F.61 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.01E-07	0.000225	5%	0.0150	5.9134
1.99E-06	0.000225	10%	0.0151	5.8939
4.56E-06	0.000225	15%	0.0152	5.8609
8.31E-06	0.000225	20%	0.0153	5.8137
1.34E-05	0.000225	25%	0.0154	5.7514
2.03E-05	0.000225	30%	0.0157	5.6693
2.93E-05	0.000225	35%	0.0159	5.5682
4.17E-05	0.000225	40%	0.0163	5.4377

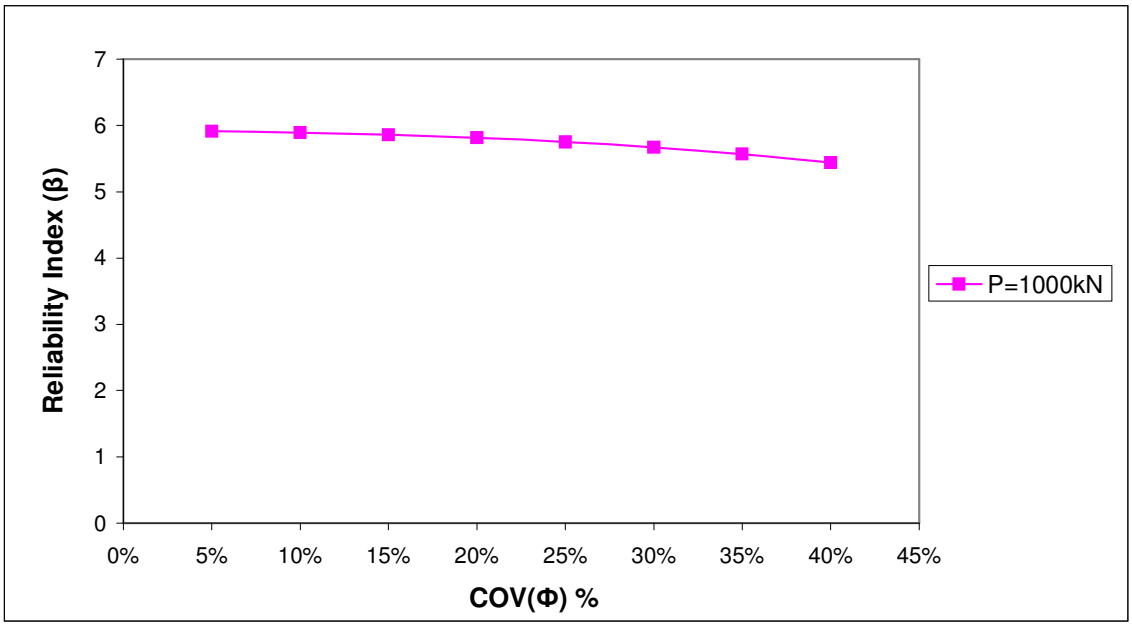


Fig. F.37 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 1000kN.

Table F.62 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 1550kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.23E-06	0.000225	5%	0.0150	5.5515
4.88E-06	0.000225	10%	0.0152	5.5072
1.13E-05	0.000225	15%	0.0154	5.4324
2.06E-05	0.000225	20%	0.0157	5.3279
3.38E-05	0.000225	25%	0.0161	5.1908
5.24E-05	0.000225	30%	0.0167	5.0138
7.83E-05	0.000225	35%	0.0174	4.7945
1.16E-04	0.000225	40%	0.0185	4.5202

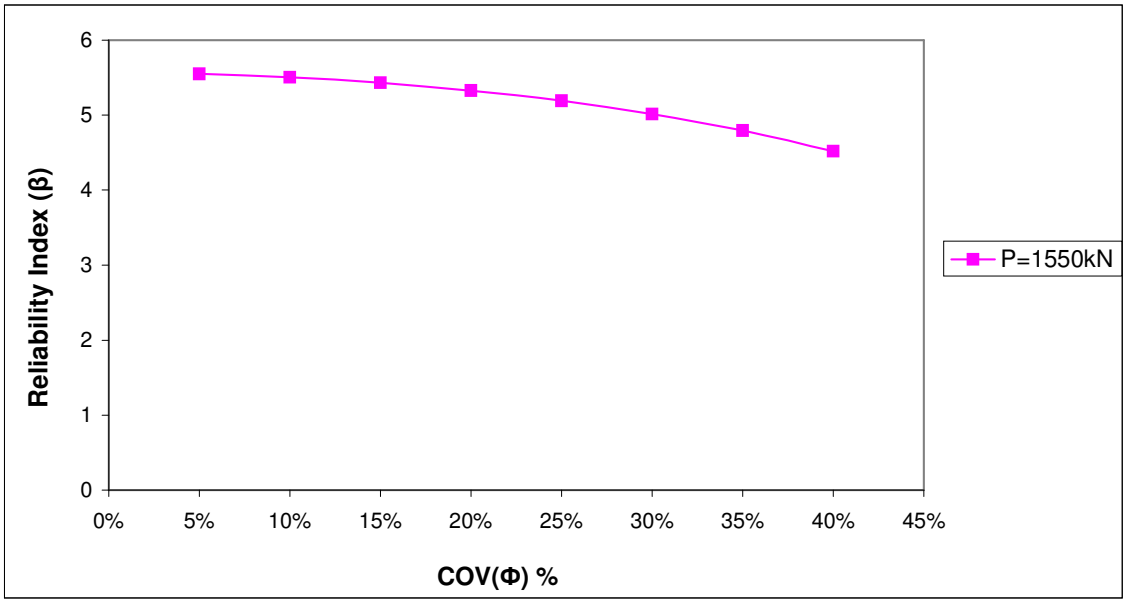


Fig. F.38 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 1550kN.

Table F.63 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 2100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.50E-06	0.000225	5%	0.0151	5.1250
1.01E-05	0.000225	10%	0.0153	5.0416
2.37E-05	0.000225	15%	0.0158	4.9020
4.47E-05	0.000225	20%	0.0164	4.7070
7.52E-05	0.000225	25%	0.0173	4.4617
1.20E-04	0.000225	30%	0.0186	4.1629
1.86E-04	0.000225	35%	0.0203	3.8127
2.87E-04	0.000225	40%	0.0226	3.4169

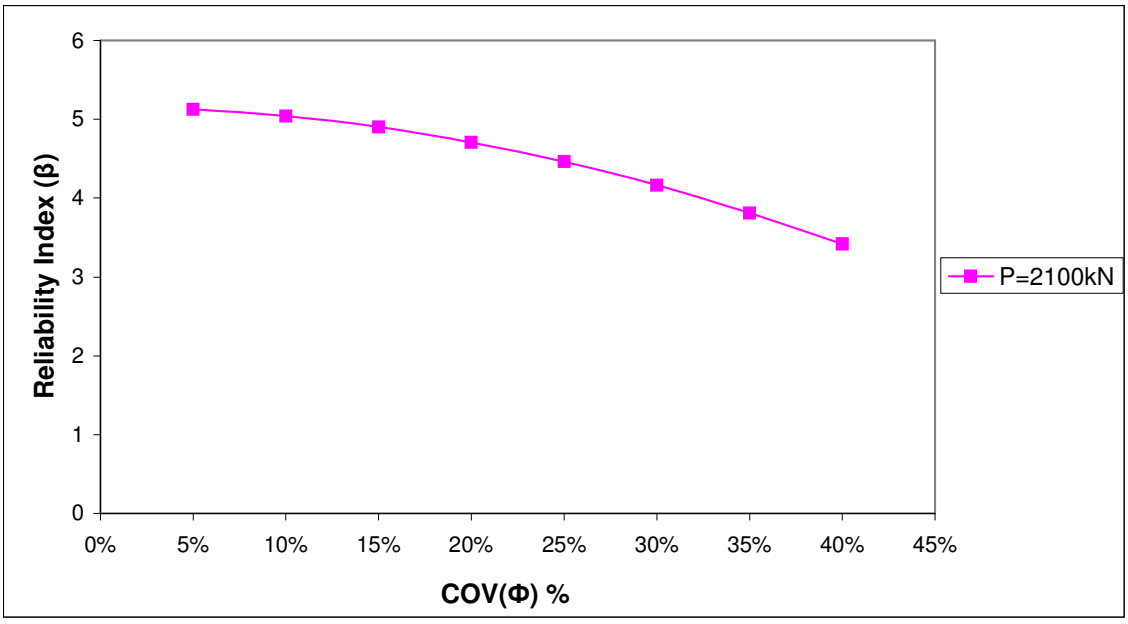


Fig. F.39 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 2100kN.

Table F.64 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 2650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.09E-06	0.000225	5%	0.0152	4.6280
2.09E-05	0.000225	10%	0.0157	4.4764
4.91E-05	0.000225	15%	0.0166	4.2404
9.24E-05	0.000225	20%	0.0178	3.9400
1.58E-04	0.000225	25%	0.0196	3.5894
2.56E-04	0.000225	30%	0.0219	3.2024
4.05E-04	0.000225	35%	0.0251	2.7964
6.47E-04	0.000225	40%	0.0295	2.3774

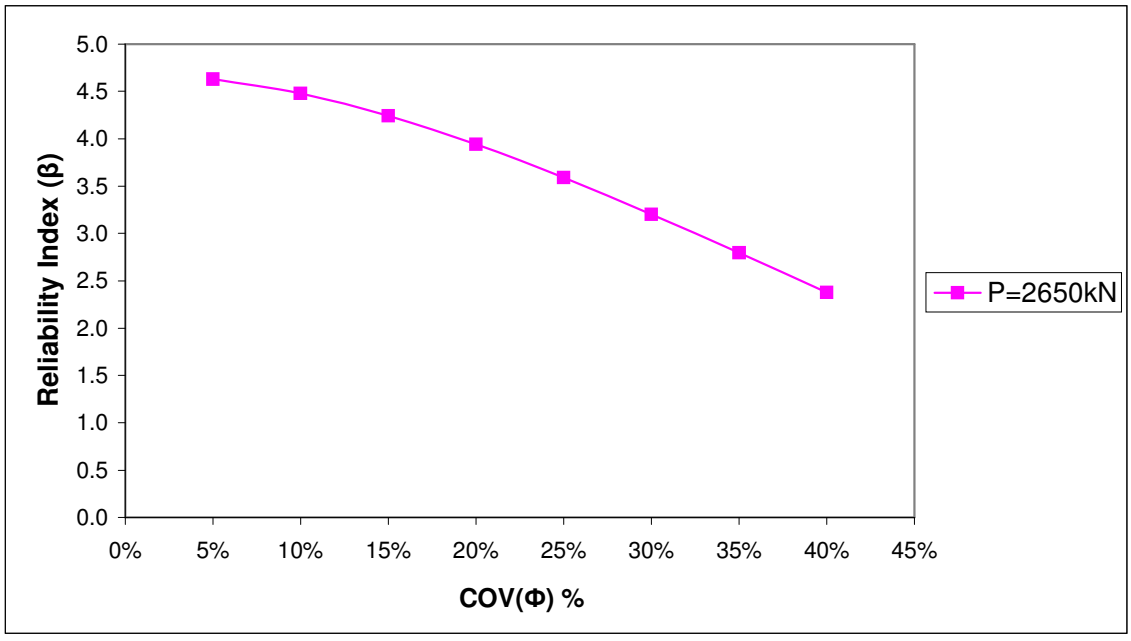


Fig. F.40 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 2650kN.

Table F.65 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 3300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(Φ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.16E-05	0.000225	5%	0.0160	3.2650
1.31E-04	0.000225	10%	0.0189	2.7702
3.22E-04	0.000225	15%	0.0234	2.2365
6.51E-04	0.000225	20%	0.0296	1.7676
1.22E-03	0.000225	25%	0.0380	1.3746
2.24E-03	0.000225	30%	0.0496	1.0535
4.04E-03	0.000225	35%	0.0653	0.8007
7.37E-03	0.000225	40%	0.0871	0.6002

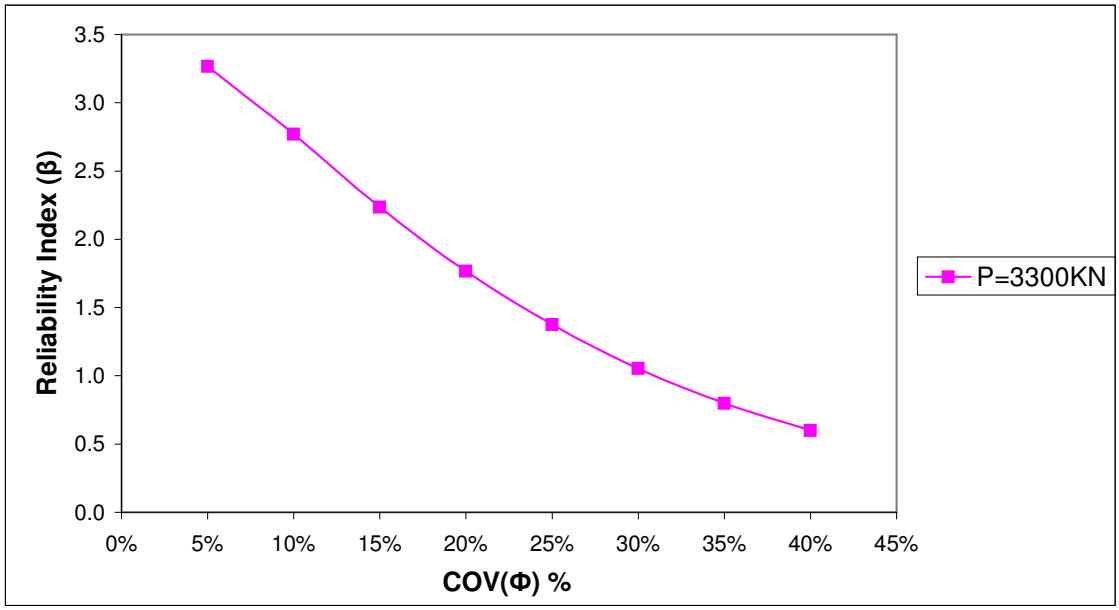


Fig. F.41 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force 3300kN.

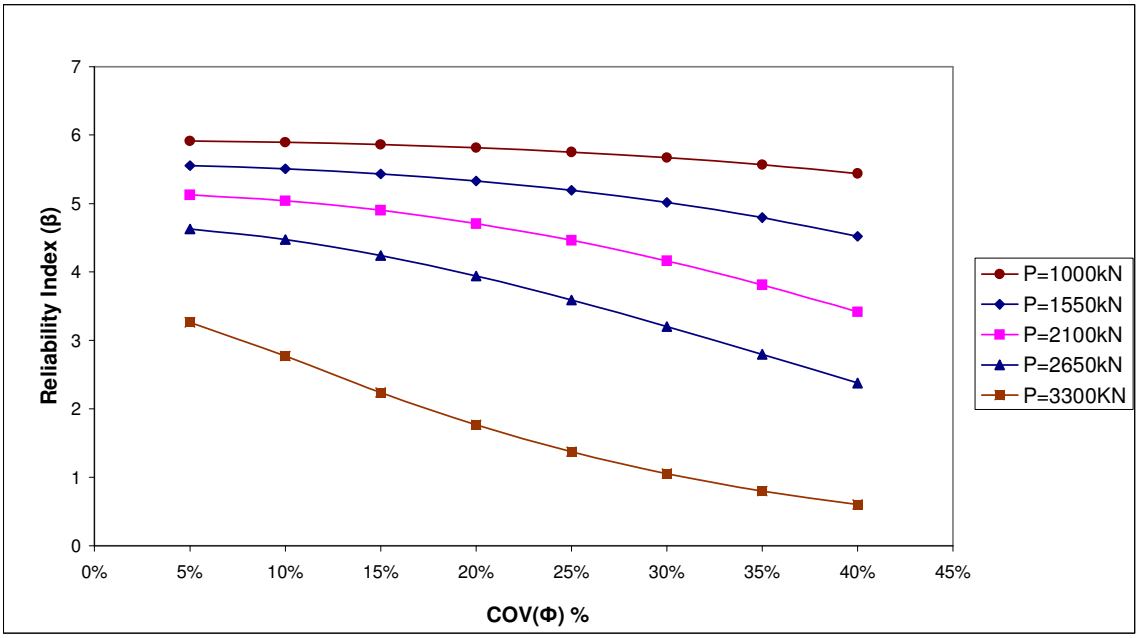


Fig. F.42 Reliability Index (β) of Y_{TOP} vs. COV (Φ) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table F.66 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
8.29E-08	0.000225	5%	0.0150	5.9189
3.49E-07	0.000225	10%	0.0150	5.9154
8.06E-07	0.000225	15%	0.0150	5.9094
1.45E-06	0.000225	20%	0.0150	5.9010
2.35E-06	0.000225	25%	0.0151	5.8893
3.54E-06	0.000225	30%	0.0151	5.8739
5.08E-06	0.000225	35%	0.0152	5.8543
7.10E-06	0.000225	40%	0.0152	5.8287

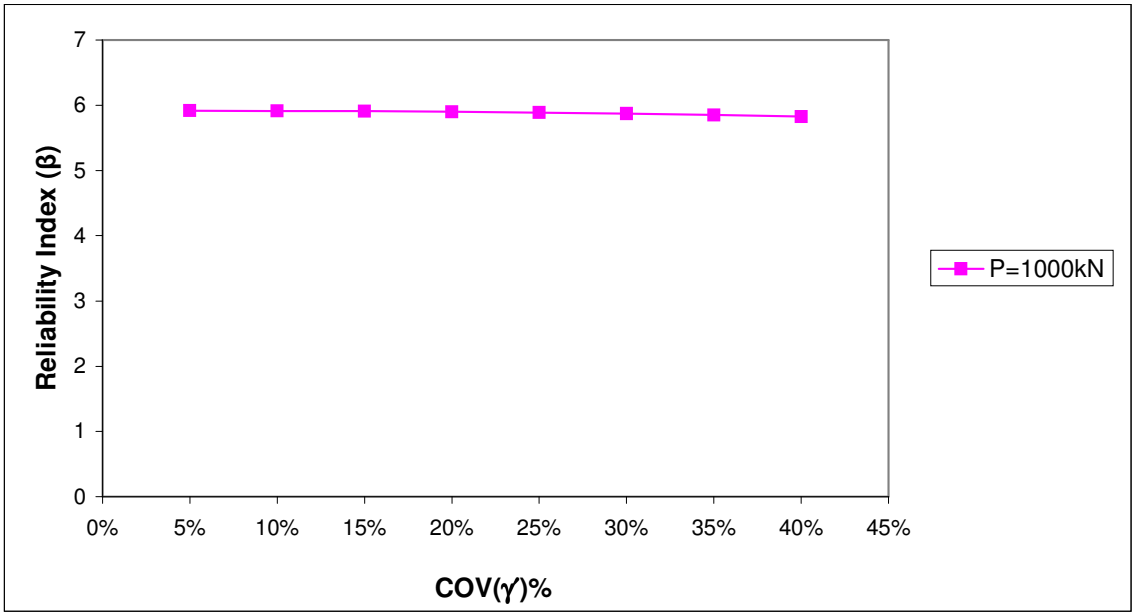


Fig. F.43 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 1000kN.

Table F.67 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 1550kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.03E-07	0.000225	5%	0.0150	5.5642
8.46E-07	0.000225	10%	0.0150	5.5562
1.95E-06	0.000225	15%	0.0151	5.5427
3.50E-06	0.000225	20%	0.0151	5.5239
5.69E-06	0.000225	25%	0.0152	5.4976
8.53E-06	0.000225	30%	0.0153	5.4641
1.23E-05	0.000225	35%	0.0154	5.4210
1.72E-05	0.000225	40%	0.0156	5.3656

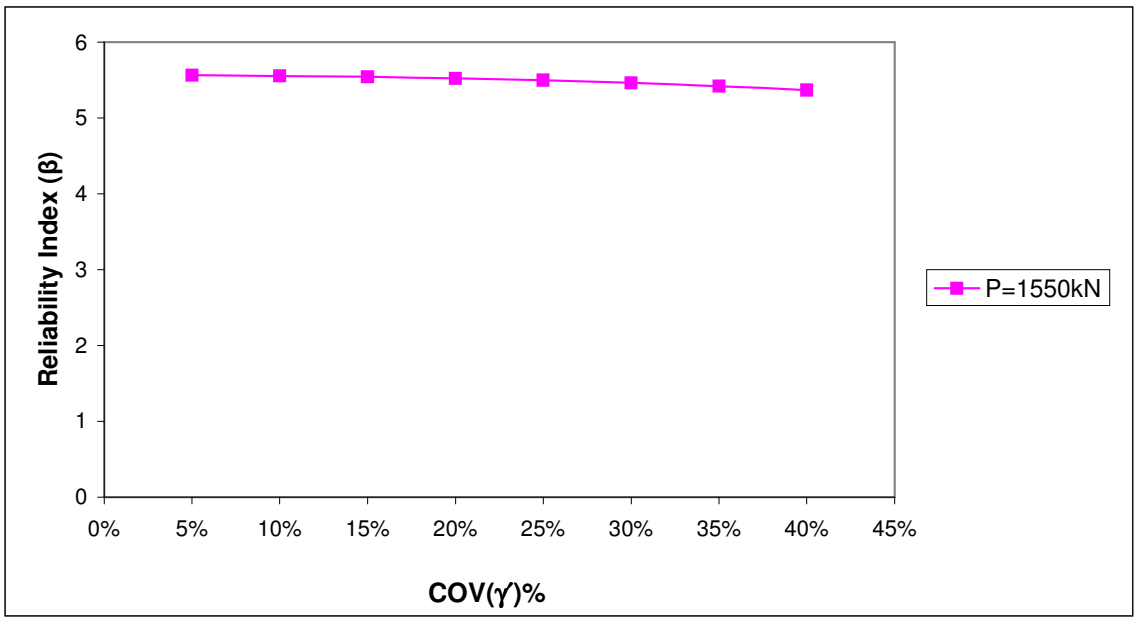


Fig. F.44 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 1550kN.

Table F.68 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 2100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.16E-07	0.000225	5%	0.0150	5.1486
1.70E-06	0.000225	10%	0.0151	5.1339
3.94E-06	0.000225	15%	0.0151	5.1088
7.18E-06	0.000225	20%	0.0152	5.0730
1.17E-05	0.000225	25%	0.0154	5.0244
1.79E-05	0.000225	30%	0.0156	4.9595
2.59E-05	0.000225	35%	0.0158	4.8800
3.69E-05	0.000225	40%	0.0162	4.7765

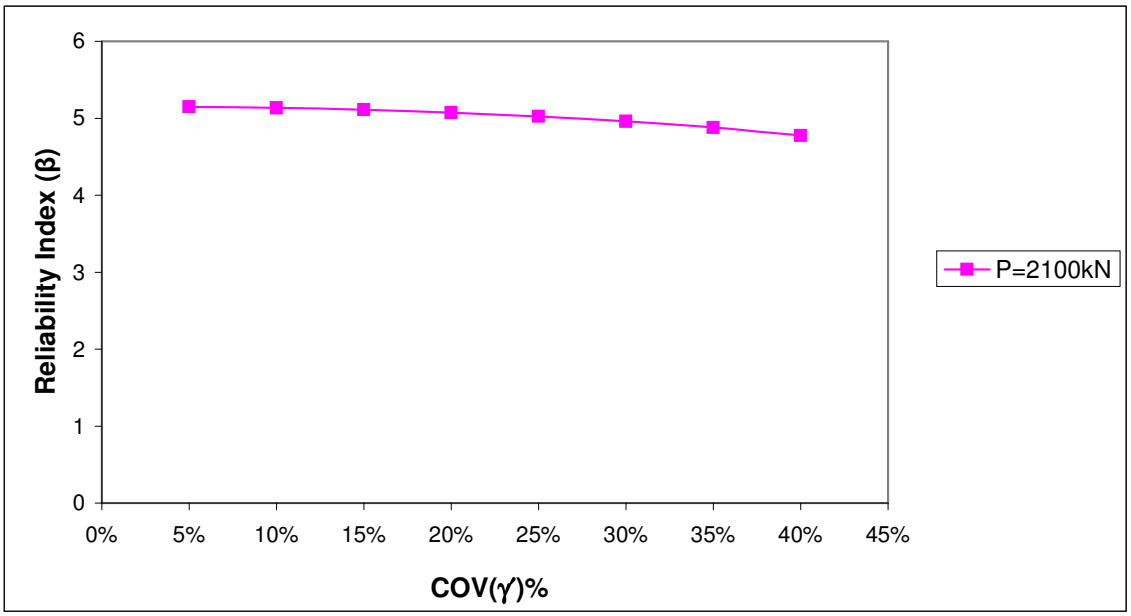


Fig. F.45 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 2100kN.

Table F.69 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 2650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
8.65E-07	0.000225	5%	0.0150	4.6710
3.46E-06	0.000225	10%	0.0151	4.6444
7.98E-06	0.000225	15%	0.0153	4.5991
1.47E-05	0.000225	20%	0.0155	4.5338
2.41E-05	0.000225	25%	0.0158	4.4482
3.68E-05	0.000225	30%	0.0162	4.3383
5.34E-05	0.000225	35%	0.0167	4.2076
7.60E-05	0.000225	40%	0.0174	4.0460

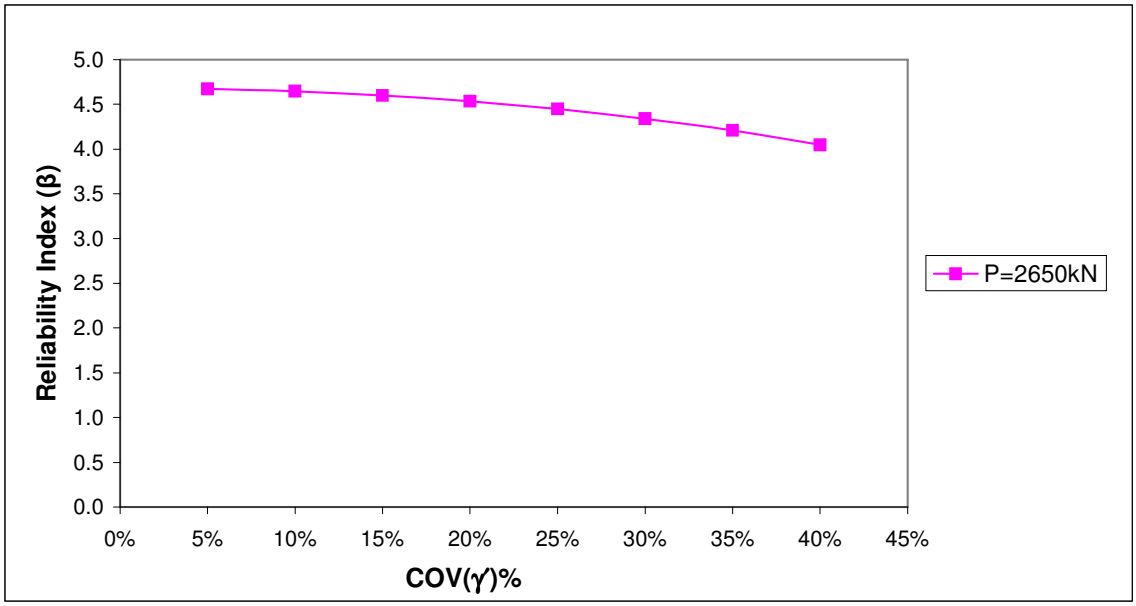


Fig. F.46 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 2650kN.

Table F.70 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 3300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(γ) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.60E-06	0.000225	5%	0.0151	3.4743
6.66E-06	0.000225	10%	0.0152	3.4362
1.53E-05	0.000225	15%	0.0155	3.3739
2.81E-05	0.000225	20%	0.0159	3.2871
4.62E-05	0.000225	25%	0.0165	3.1760
6.96E-05	0.000225	30%	0.0172	3.0469
1.03E-04	0.000225	35%	0.0181	2.8886
1.45E-04	0.000225	40%	0.0192	2.7182

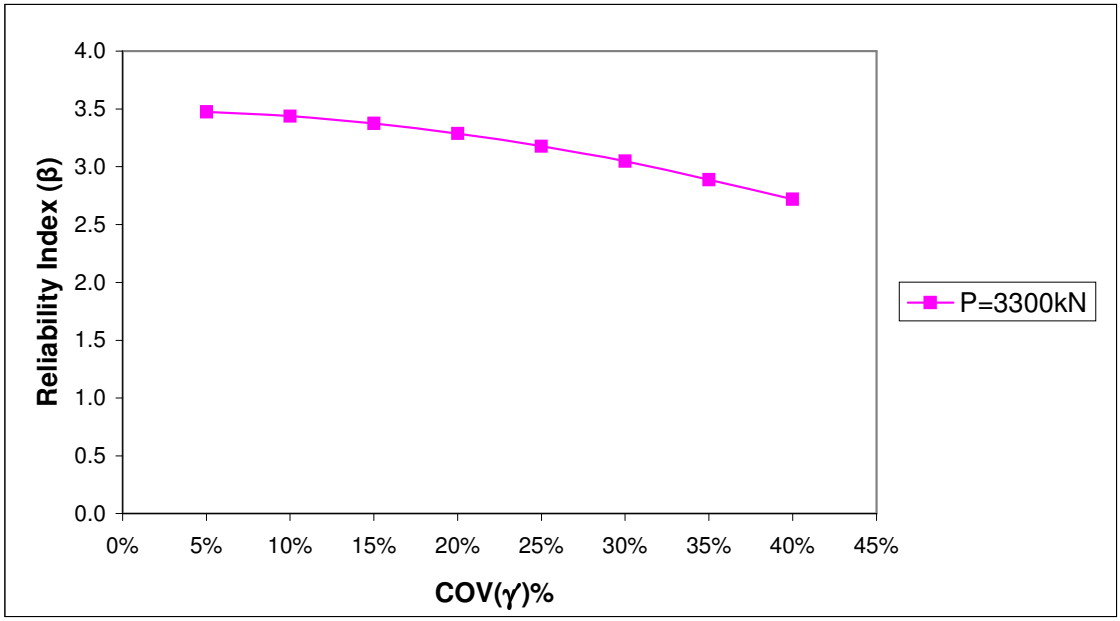


Fig. F.47 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force 3300kN.

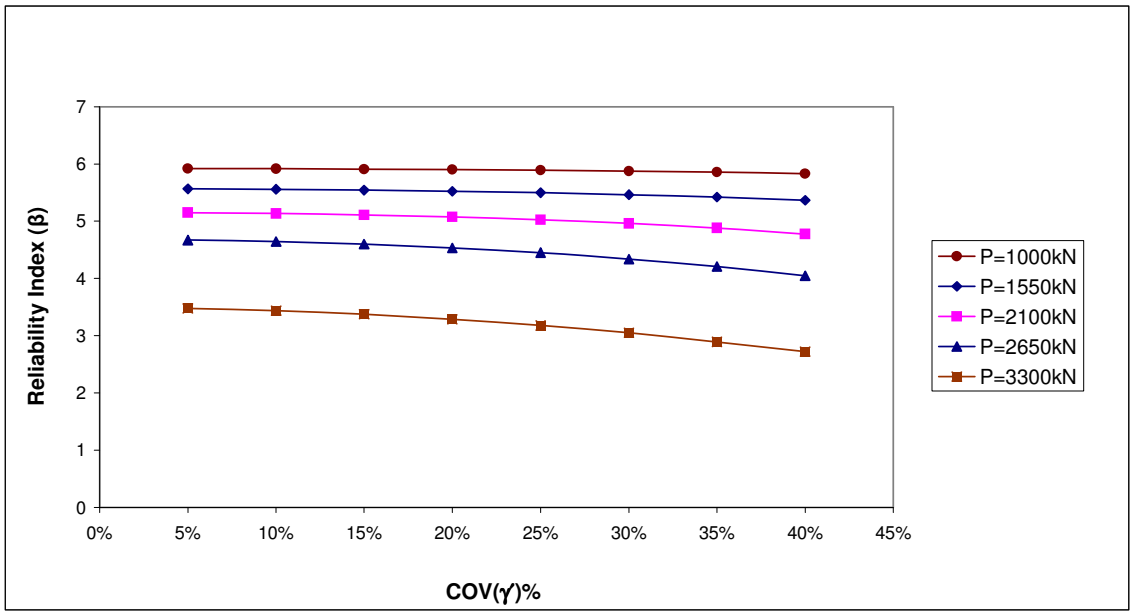


Fig. F.48 Reliability Index (β) of Y_{TOP} vs. COV (γ) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table F.71 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
7.29E-10	0.000225	5%	0.0150	5.9200
2.55E-09	0.000225	10%	0.0150	5.9200
5.18E-09	0.000225	15%	0.0150	5.9199
8.74E-09	0.000225	20%	0.0150	5.9199
1.36E-08	0.000225	25%	0.0150	5.9198
2.33E-08	0.000225	30%	0.0150	5.9197
3.80E-08	0.000225	35%	0.0150	5.9195
5.81E-08	0.000225	40%	0.0150	5.9192

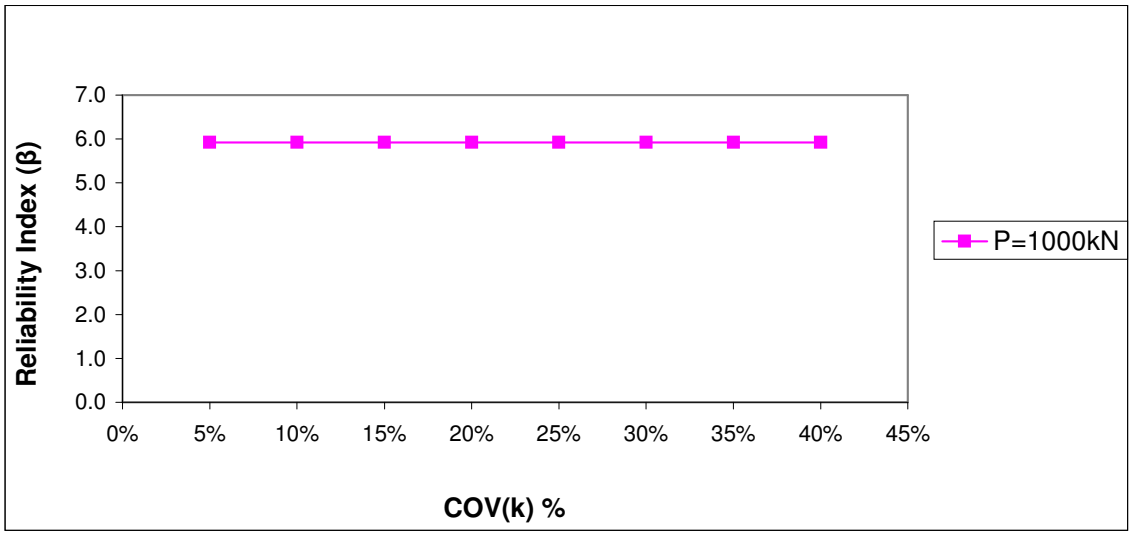


Fig. F.49 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 1000kN.

Table F.72 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 1550kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
9.00E-10	0.000225	5%	0.0150	5.5667
3.02E-09	0.000225	10%	0.0150	5.5666
6.40E-09	0.000225	15%	0.0150	5.5666
1.00E-08	0.000225	20%	0.0150	5.5665
1.56E-08	0.000225	25%	0.0150	5.5665
2.56E-08	0.000225	30%	0.0150	5.5664
4.41E-08	0.000225	35%	0.0150	5.5661
6.76E-08	0.000225	40%	0.0150	5.5658

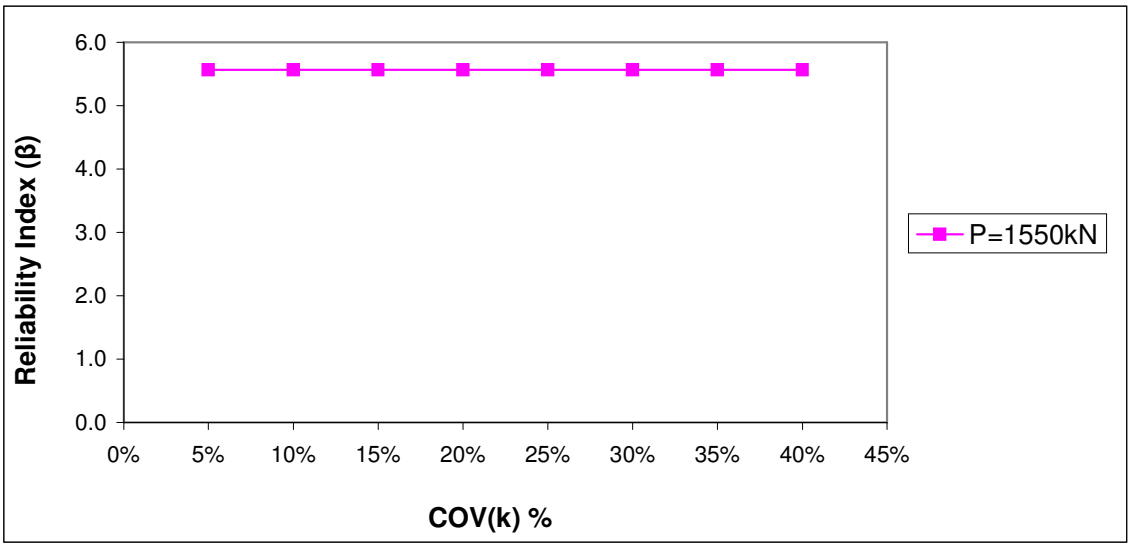


Fig. F.50 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 1550kN.

Table F.73 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 2100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.25E-10	0.000225	5%	0.0150	5.1533
2.50E-09	0.000225	10%	0.0150	5.1533
6.40E-09	0.000225	15%	0.0150	5.1533
1.10E-08	0.000225	20%	0.0150	5.1532
1.96E-08	0.000225	25%	0.0150	5.1531
3.24E-08	0.000225	30%	0.0150	5.1530
5.06E-08	0.000225	35%	0.0150	5.1528
7.29E-08	0.000225	40%	0.0150	5.1525

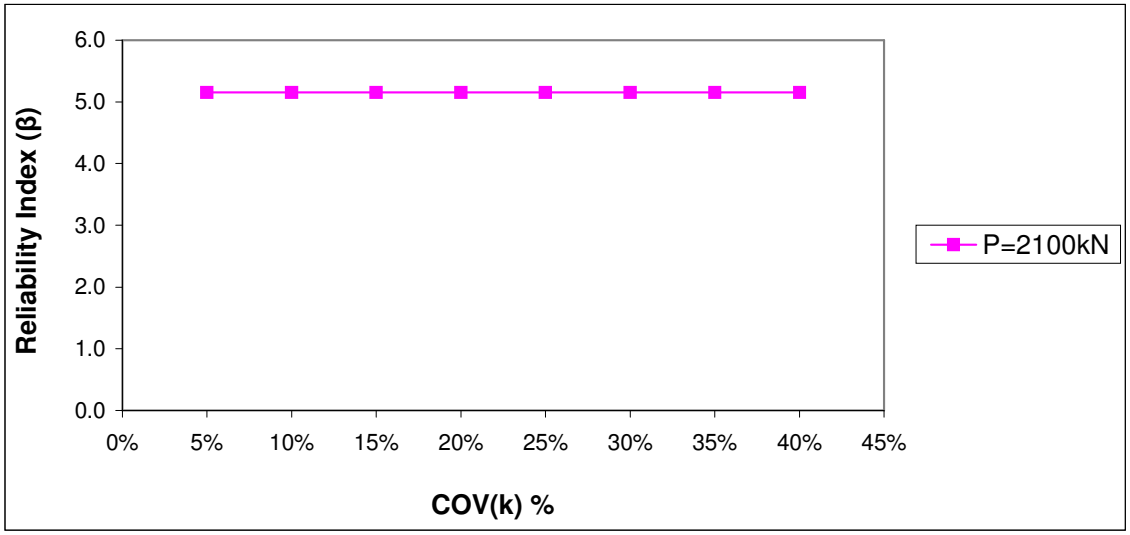


Fig. F.51 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 2100kN.

Table F.74 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 2650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
4.00E-10	0.000225	5%	0.0150	4.6800
2.50E-09	0.000225	10%	0.0150	4.6800
7.23E-09	0.000225	15%	0.0150	4.6799
1.56E-08	0.000225	20%	0.0150	4.6798
2.56E-08	0.000225	25%	0.0150	4.6797
4.00E-08	0.000225	30%	0.0150	4.6796
6.00E-08	0.000225	35%	0.0150	4.6794
9.92E-08	0.000225	40%	0.0150	4.6790

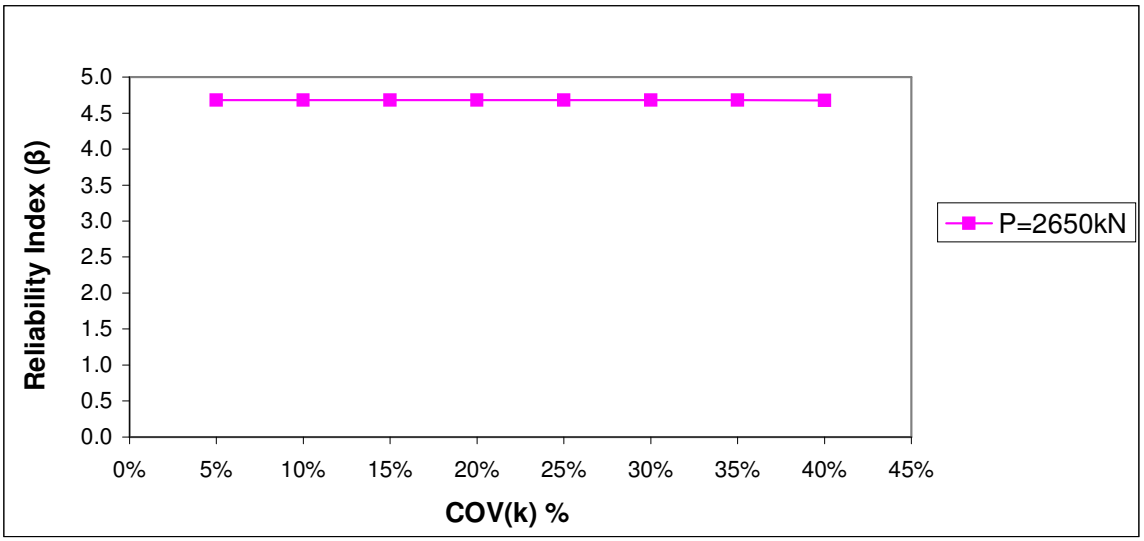


Fig. F.52 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 2650kN.

Table F.75 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 3300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(k) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.23E-09	0.000225	5%	0.0150	3.4867
6.40E-09	0.000225	10%	0.0150	3.4866
1.32E-08	0.000225	15%	0.0150	3.4866
2.10E-08	0.000225	20%	0.0150	3.4865
3.24E-08	0.000225	25%	0.0150	3.4864
5.52E-08	0.000225	30%	0.0150	3.4862
9.30E-08	0.000225	35%	0.0150	3.4859
1.44E-07	0.000225	40%	0.0150	3.4855

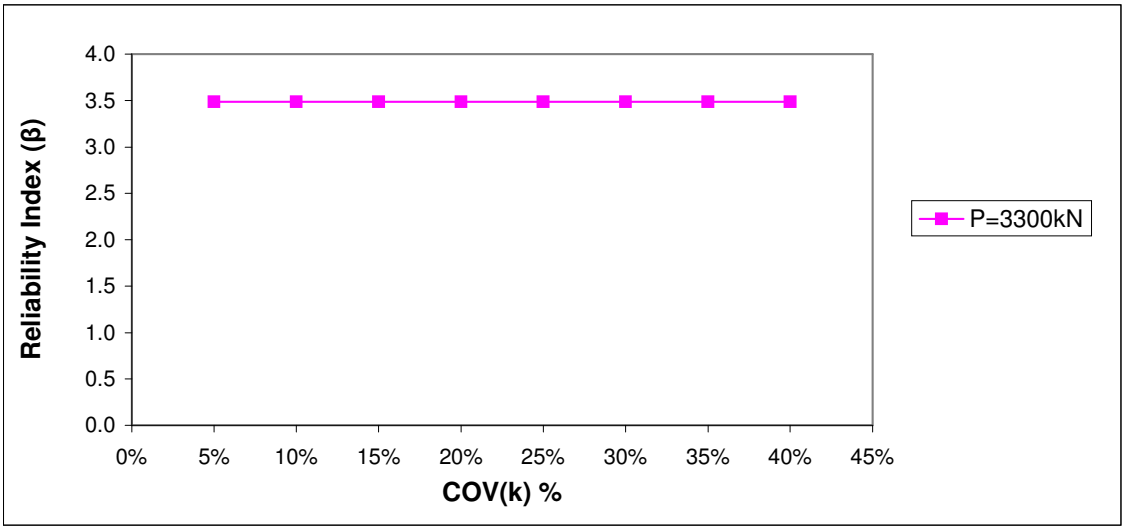


Fig. F.53 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force 3300kN.

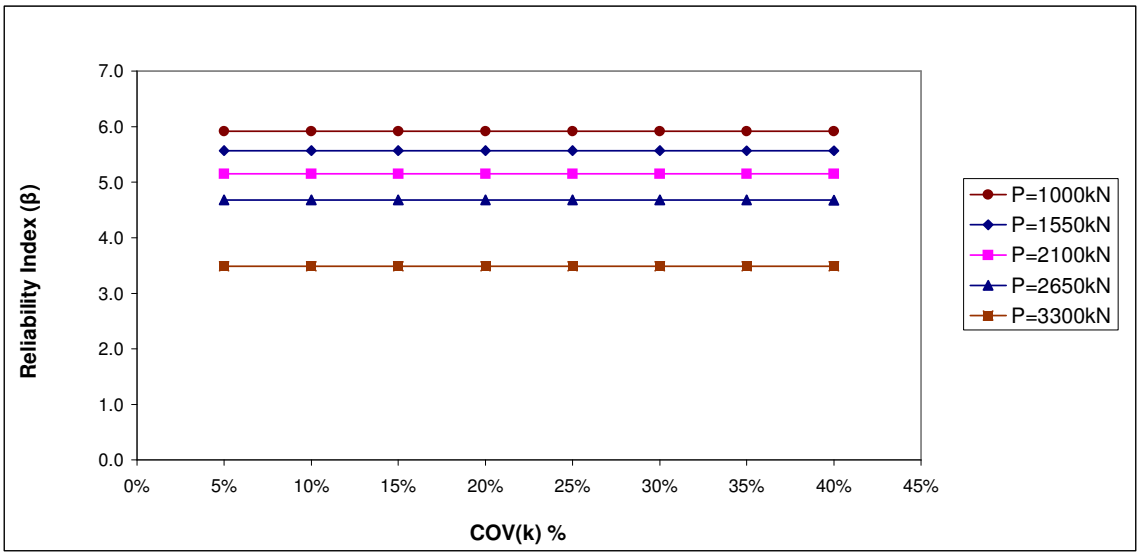


Fig. F.54 Reliability Index (β) of Y_{TOP} vs. COV (k) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table F.76 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.64E-08	0.000225	5%	0.0150	5.9198
2.82E-08	0.000225	10%	0.0150	5.9196
5.66E-08	0.000225	15%	0.0150	5.9193
8.97E-08	0.000225	20%	0.0150	5.9188
1.34E-07	0.000225	25%	0.0150	5.9182
2.16E-07	0.000225	30%	0.0150	5.9172
3.36E-07	0.000225	35%	0.0150	5.9156
4.75E-07	0.000225	40%	0.0150	5.9138

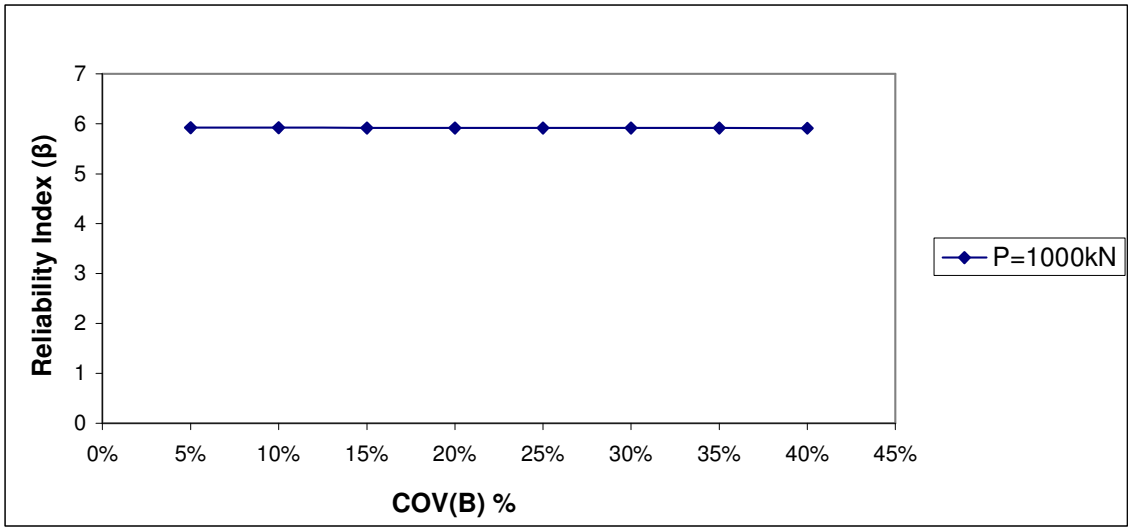


Fig. F.55 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 1000kN.

Table F.77 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 1550kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.00E-08	0.000225	5%	0.0150	5.5665
2.25E-08	0.000225	10%	0.0150	5.5664
1.82E-08	0.000225	15%	0.0150	5.5664
4.20E-08	0.000225	20%	0.0150	5.5661
6.76E-08	0.000225	25%	0.0150	5.5658
1.41E-07	0.000225	30%	0.0150	5.5649
2.79E-07	0.000225	35%	0.0150	5.5632
5.70E-07	0.000225	40%	0.0150	5.5596

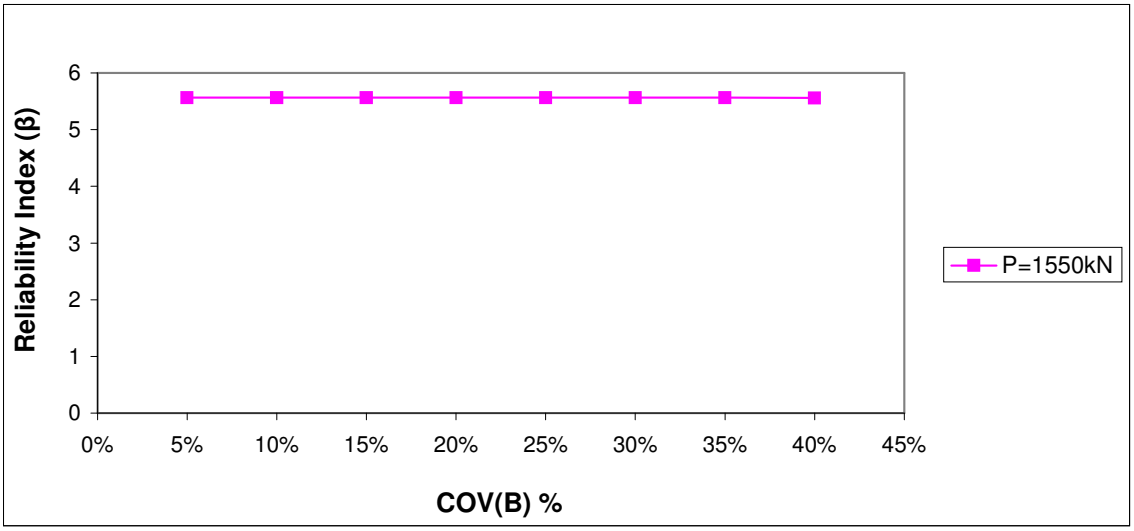


Fig. F.56 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 1550kN.

Table F.78 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 2100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.50E-09	0.000225	5%	0.0150	5.1533
2.02E-09	0.000225	10%	0.0150	5.1533
8.10E-09	0.000225	15%	0.0150	5.1532
4.41E-08	0.000225	20%	0.0150	5.1528
1.12E-07	0.000225	25%	0.0150	5.1520
3.14E-07	0.000225	30%	0.0150	5.1497
8.67E-07	0.000225	35%	0.0150	5.1434
2.87E-06	0.000225	40%	0.0151	5.1207

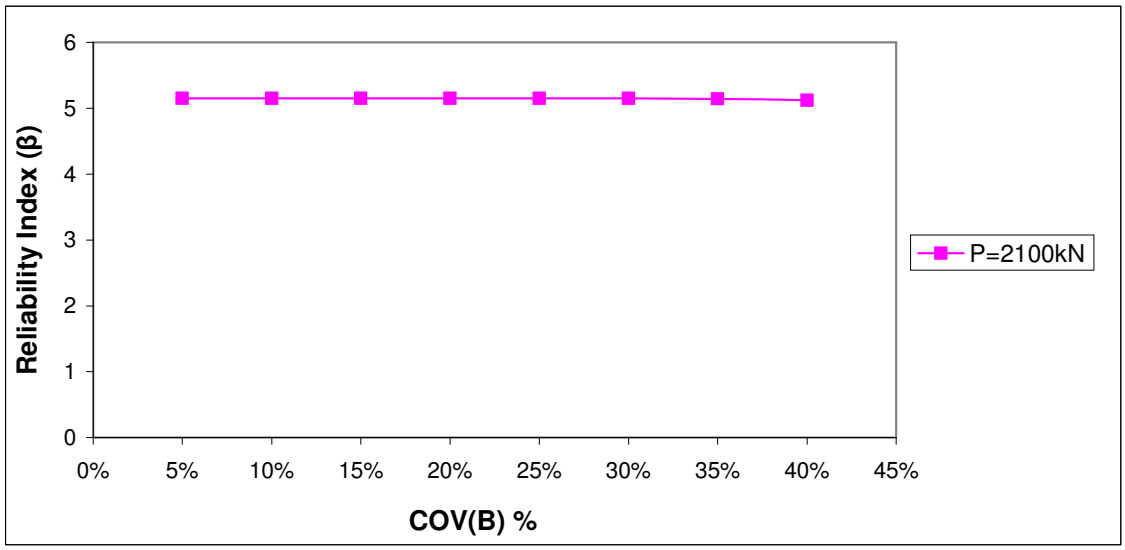


Fig. F.57 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 2100kN.

Table F.79 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 2650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.25E-08	0.000225	5%	0.0150	4.6794
9.61E-08	0.000225	10%	0.0150	4.6790
1.12E-07	0.000225	15%	0.0150	4.6788
3.60E-07	0.000225	20%	0.0150	4.6763
8.19E-07	0.000225	25%	0.0150	4.6715
2.36E-06	0.000225	30%	0.0151	4.6557
8.78E-06	0.000225	35%	0.0153	4.5912
3.49E-05	0.000225	40%	0.0161	4.3547

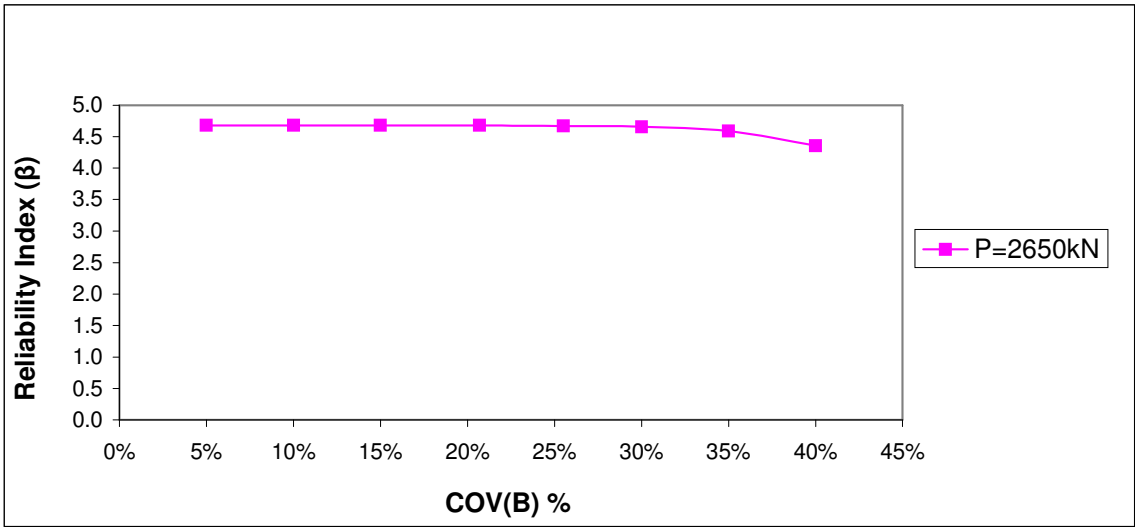


Fig. F.58 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 2650kN.

Table F.80 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 3300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(B) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
2.25E-08	0.000225	5%	0.0150	3.4865
8.01E-07	0.000225	10%	0.0150	3.4805
8.93E-07	0.000225	15%	0.0150	3.4798
2.09E-06	0.000225	20%	0.0151	3.4706
6.08E-06	0.000225	25%	0.0152	3.4405
2.23E-05	0.000225	30%	0.0157	3.3256
7.65E-05	0.000225	35%	0.0174	3.1500
1.96E-04	0.000225	40%	0.0205	2.9300

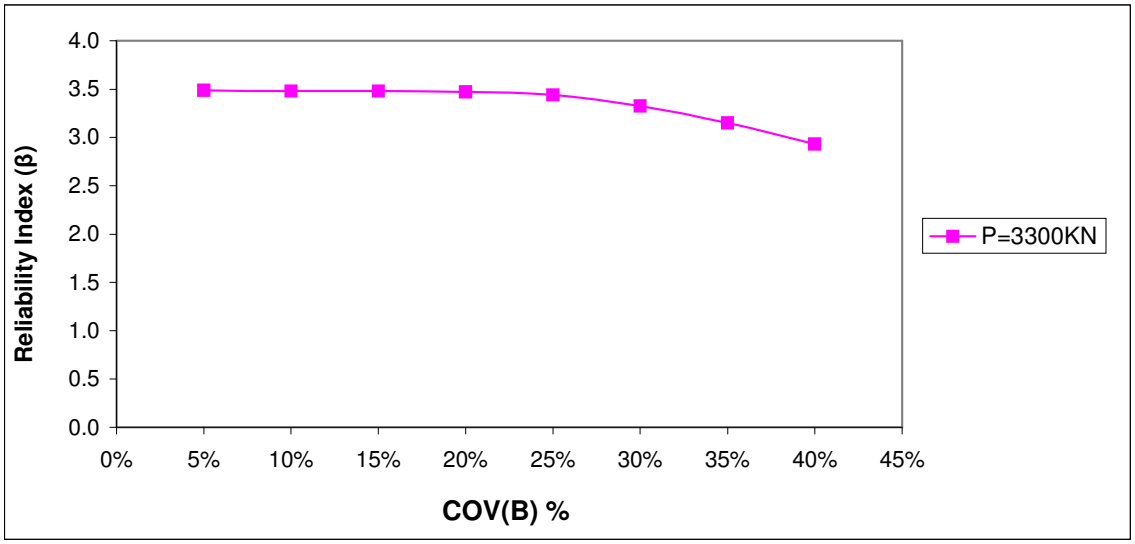


Fig. F.59 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force 3300kN.

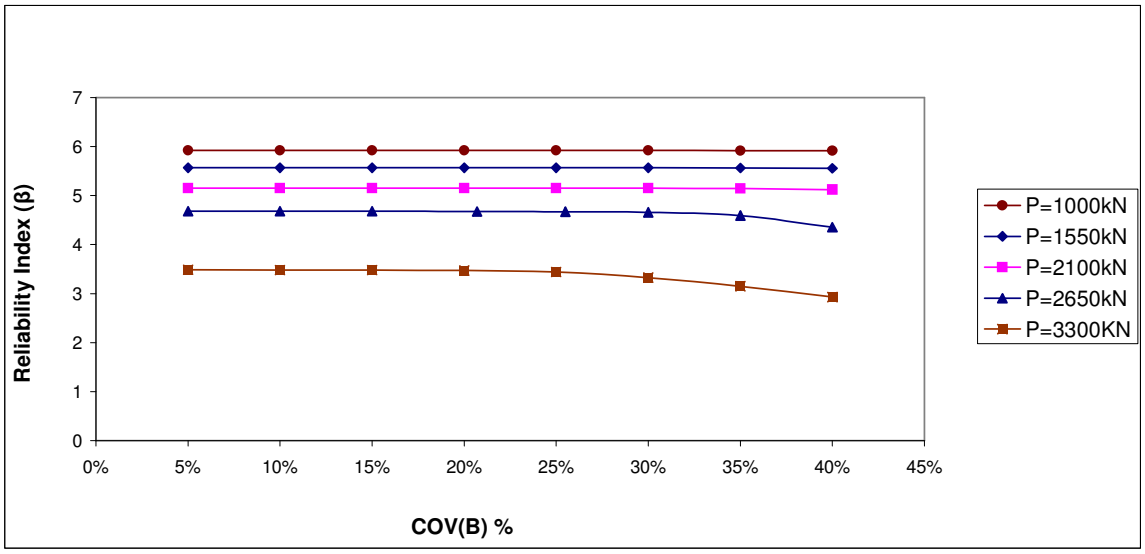


Fig. F.60 Reliability Index (β) of Y_{TOP} vs. COV (B) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table F.81 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.95E-08	0.000225	5%	0.0150	5.9192
2.42E-07	0.000225	10%	0.0150	5.9168
5.54E-07	0.000225	15%	0.0150	5.9127
1.01E-06	0.000225	20%	0.0150	5.9067
1.64E-06	0.000225	25%	0.0151	5.8986
2.46E-06	0.000225	30%	0.0151	5.8880
3.55E-06	0.000225	35%	0.0151	5.8739
4.92E-06	0.000225	40%	0.0152	5.8563

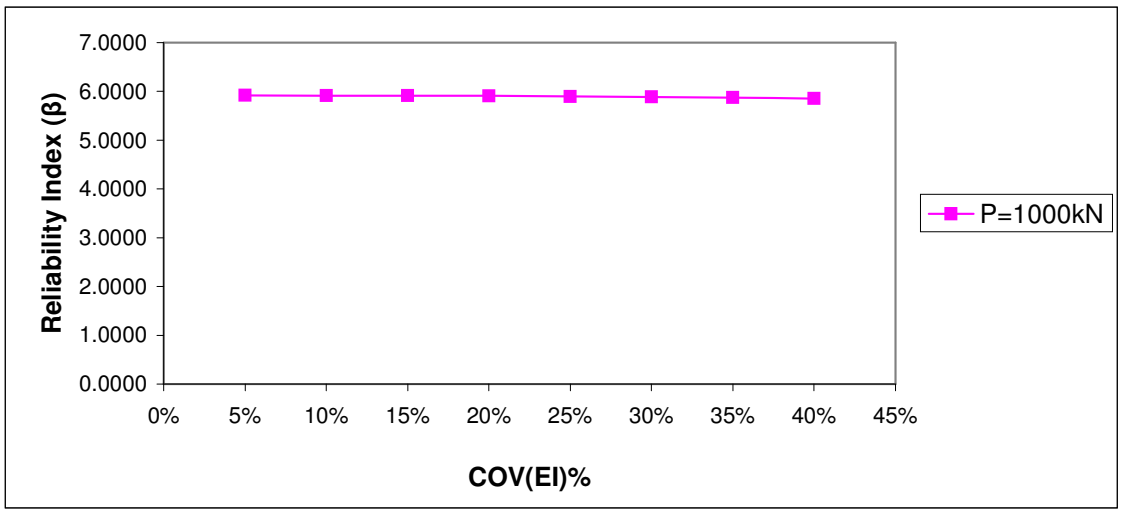


Fig. F.61 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 1000kN.

Table F.82 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 1550kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.52E-07	0.000225	5%	0.0150	5.5648
6.16E-07	0.000225	10%	0.0150	5.5591
1.40E-06	0.000225	15%	0.0150	5.5494
2.58E-06	0.000225	20%	0.0151	5.5351
4.16E-06	0.000225	25%	0.0151	5.5159
6.25E-06	0.000225	30%	0.0152	5.4909
8.94E-06	0.000225	35%	0.0153	5.4593
1.25E-05	0.000225	40%	0.0154	5.4182

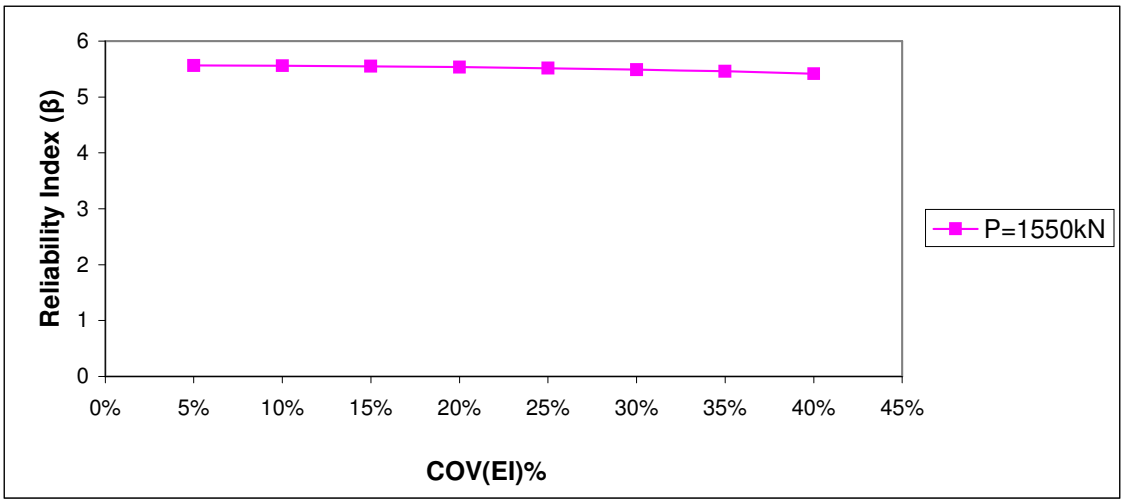


Fig. F.62 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 1550kN.

Table F.83 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 2100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.08E-07	0.000225	5%	0.0150	5.1498
1.25E-06	0.000225	10%	0.0150	5.1390
2.86E-06	0.000225	15%	0.0151	5.1209
5.27E-06	0.000225	20%	0.0152	5.0941
8.61E-06	0.000225	25%	0.0153	5.0574
1.30E-05	0.000225	30%	0.0154	5.0103
1.88E-05	0.000225	35%	0.0156	4.9503
2.66E-05	0.000225	40%	0.0159	4.8736

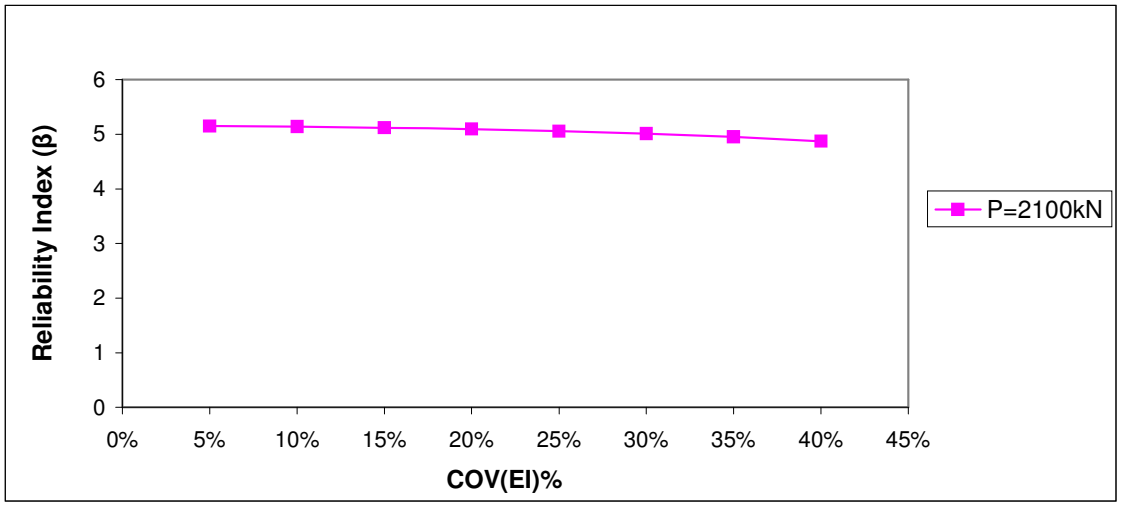


Fig. F.63 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 2100kN.

Table F.84 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 2650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
6.40E-07	0.000225	5%	0.0150	4.6734
2.56E-06	0.000225	10%	0.0151	4.6536
5.81E-06	0.000225	15%	0.0152	4.6207
1.06E-05	0.000225	20%	0.0153	4.5739
1.74E-05	0.000225	25%	0.0156	4.5090
2.66E-05	0.000225	30%	0.0159	4.4255
3.89E-05	0.000225	35%	0.0162	4.3215
5.49E-05	0.000225	40%	0.0167	4.1959

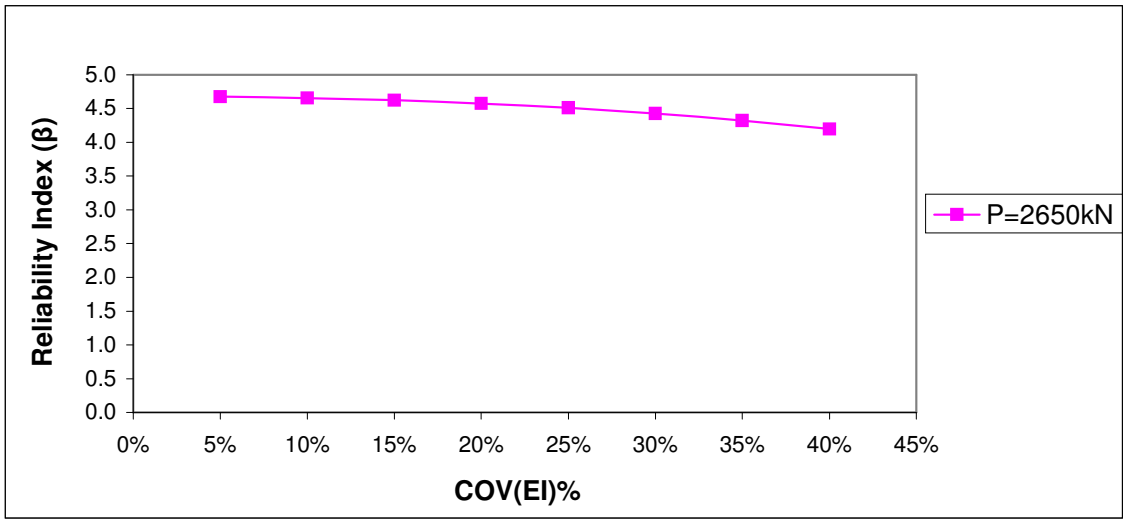


Fig. F.64 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 2650kN.

Table F.85 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 3300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(EI) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.14E-06	0.000225	5%	0.0150	3.4778
4.73E-06	0.000225	10%	0.0152	3.4506
1.11E-05	0.000225	15%	0.0154	3.4040
2.05E-05	0.000225	20%	0.0157	3.3381
3.36E-05	0.000225	25%	0.0161	3.2524
5.11E-05	0.000225	30%	0.0166	3.1478
7.40E-05	0.000225	35%	0.0173	3.0248
1.05E-04	0.000225	40%	0.0182	2.8805

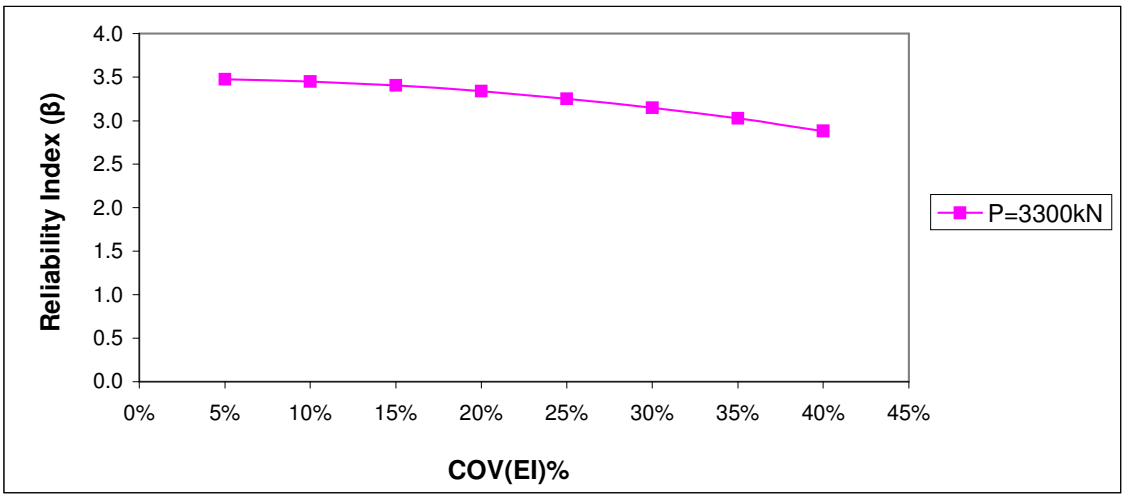


Fig. F.65 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force 3300kN.

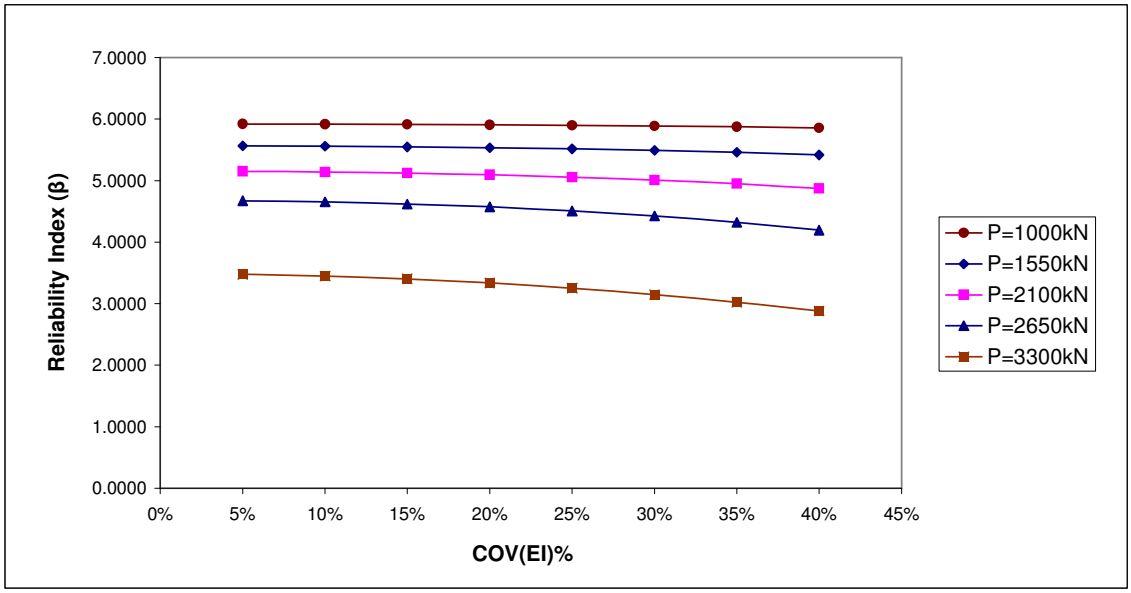


Fig. F.66 Reliability Index (β) of Y_{TOP} vs. COV (EI) for free head long pile group (10T) subjected to lateral force of discrete variability.

Table F.86 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 1000kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.22E-07	0.000225	5%	0.0150	5.9158
1.30E-06	0.000225	10%	0.0150	5.9029
2.95E-06	0.000225	15%	0.0151	5.8816
5.23E-06	0.000225	20%	0.0152	5.8523
8.17E-06	0.000225	25%	0.0153	5.8153
1.17E-05	0.000225	30%	0.0154	5.7721
1.58E-05	0.000225	35%	0.0155	5.7223
2.05E-05	0.000225	40%	0.0157	5.6672

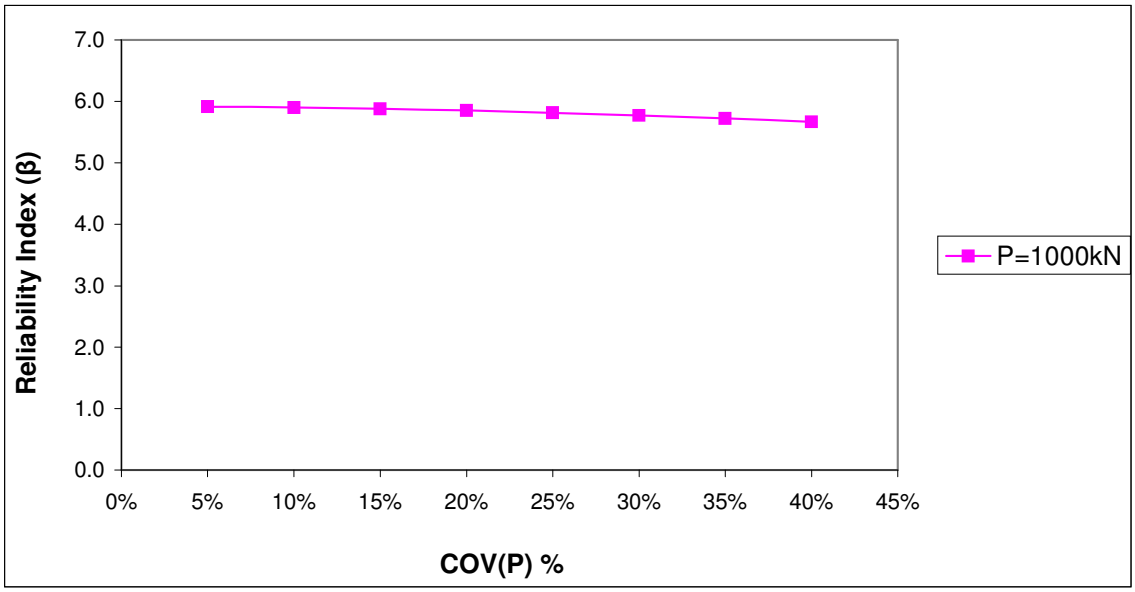


Fig. F.67 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 1000kN.

Table F.87 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 1550kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
7.83E-07	0.000225	5%	0.0150	5.5570
3.17E-06	0.000225	10%	0.0151	5.5279
7.18E-06	0.000225	15%	0.0152	5.4799
2.89E-05	0.000225	20%	0.0159	5.4031
1.99E-05	0.000225	25%	0.0157	5.3352
2.87E-05	0.000225	30%	0.0159	5.2425
3.90E-05	0.000225	35%	0.0162	5.1395
5.08E-05	0.000225	40%	0.0166	5.0277

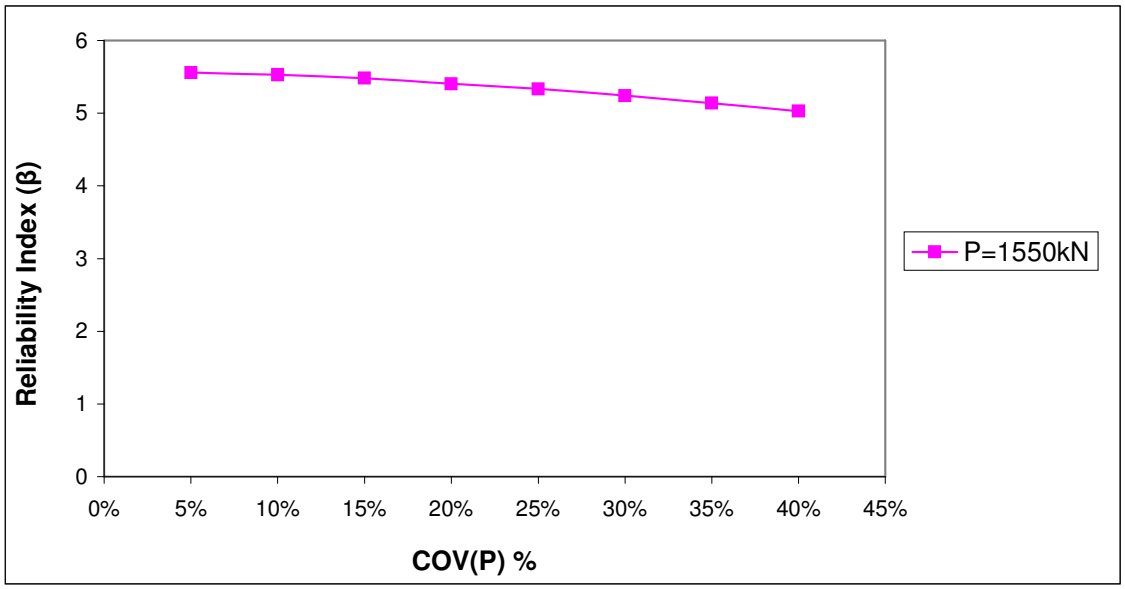


Fig. F.68 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 1550kN.

Table F.88 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 2100kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
1.59E-06	0.000225	5%	0.0151	5.1352
6.35E-06	0.000225	10%	0.0152	5.0821
1.44E-05	0.000225	15%	0.0155	4.9963
2.58E-05	0.000225	20%	0.0158	4.8815
4.08E-05	0.000225	25%	0.0163	4.7411
5.94E-05	0.000225	30%	0.0169	4.5840
8.19E-05	0.000225	35%	0.0175	4.4124
1.08E-04	0.000225	40%	0.0183	4.2331

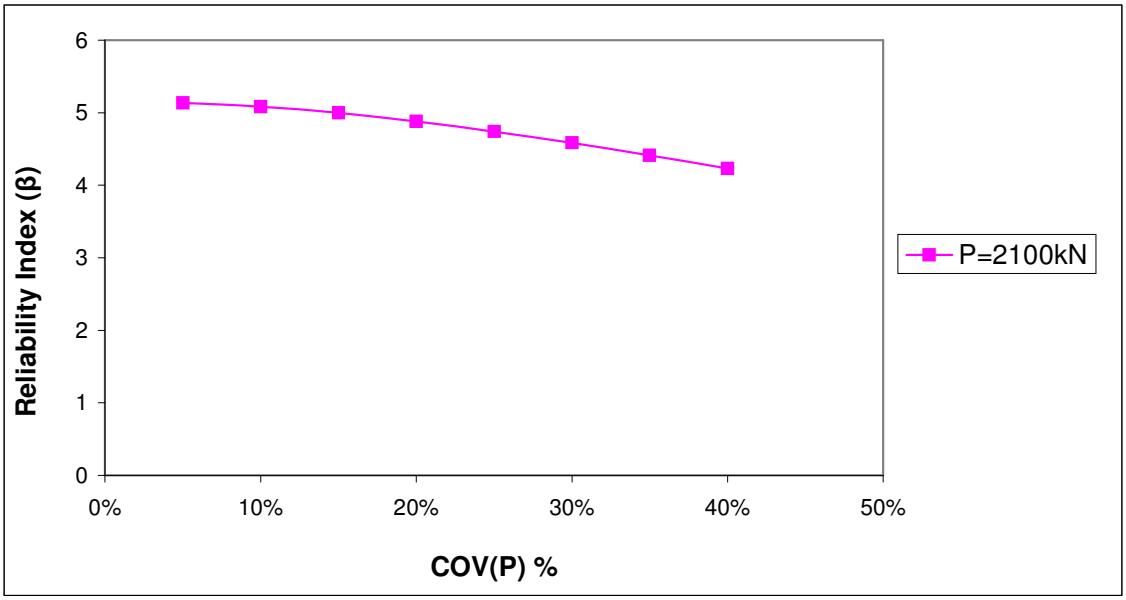


Fig. F.69 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 2100kN.

Table F.89 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 2650kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
3.20E-06	0.000225	5%	0.0151	4.6470
1.27E-05	0.000225	10%	0.0154	4.5528
2.88E-05	0.000225	15%	0.0159	4.4062
5.12E-05	0.000225	20%	0.0166	4.2241
8.09E-05	0.000225	25%	0.0175	4.0137
1.18E-04	0.000225	30%	0.0185	3.7914
1.62E-04	0.000225	35%	0.0197	3.5700
2.15E-04	0.000225	40%	0.0210	3.3475

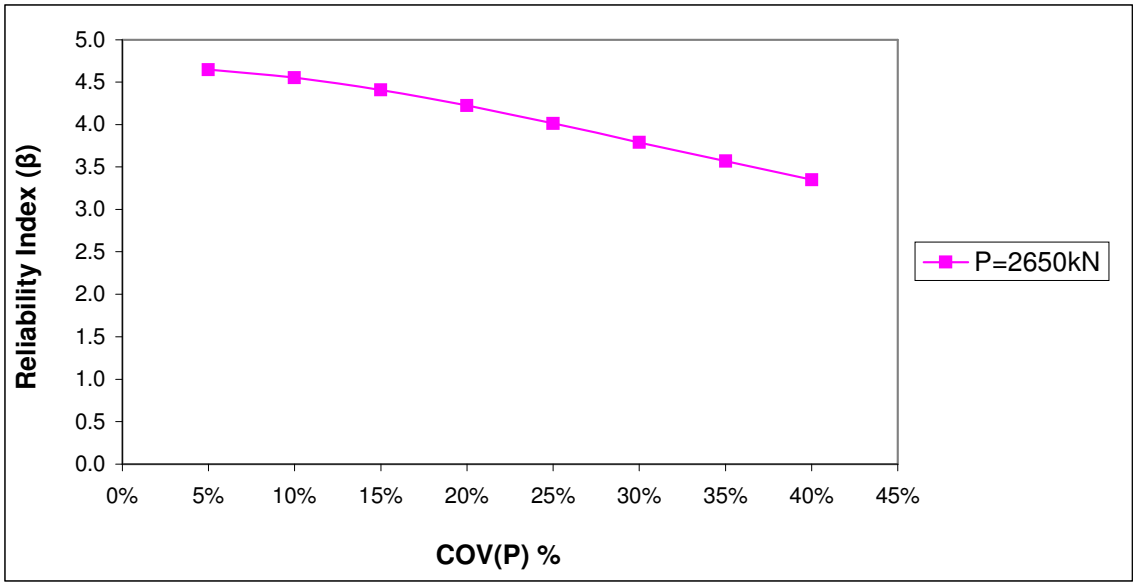


Fig. F.70 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 2650kN.

Table F.90 Reliability Index (β) connected to Y_{TOP} for fixed head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 3300kN.

VAR (Y_{TOP}) $(m)^2$	$\sigma(Y_{TOP}^{max2})$ (m)	COV(P) (%)	$\sigma(Y_{TOP}^{M})$ (m)	Reliability Index (β)
5.98E-06	0.000225	5%	0.0152	3.4413
2.43E-05	0.000225	10%	0.0158	3.3124
5.44E-05	0.000225	15%	0.0167	3.1289
9.81E-05	0.000225	20%	0.0180	2.9096
1.54E-04	0.000225	25%	0.0195	2.6860
2.22E-04	0.000225	30%	0.0211	2.4737
3.07E-04	0.000225	35%	0.0231	2.2680
4.07E-04	0.000225	40%	0.0251	2.0807

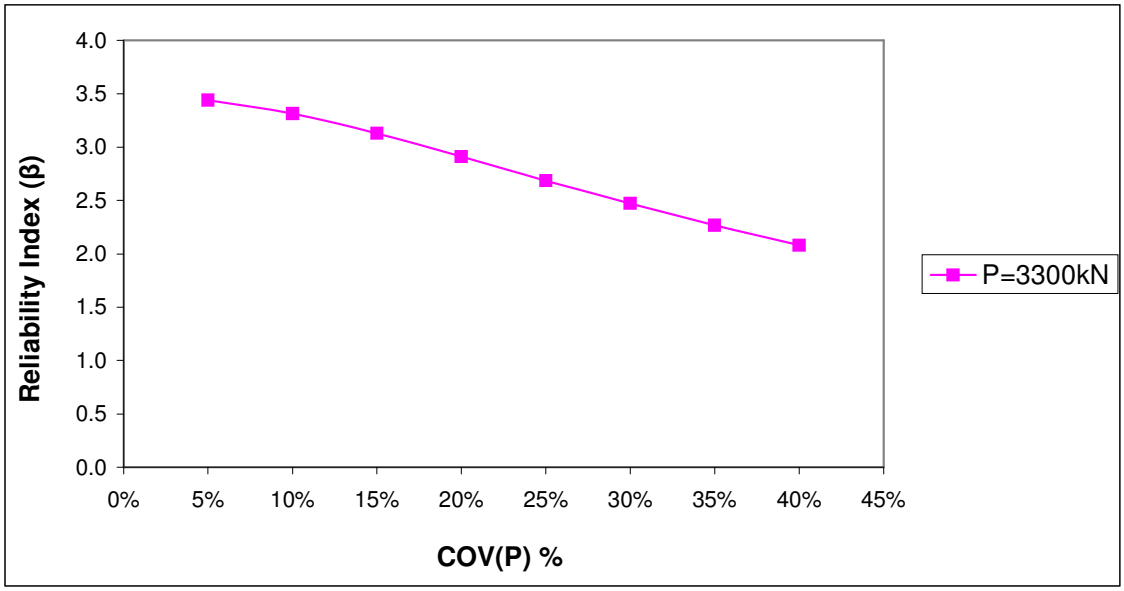


Fig. F.71 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force 3300kN.

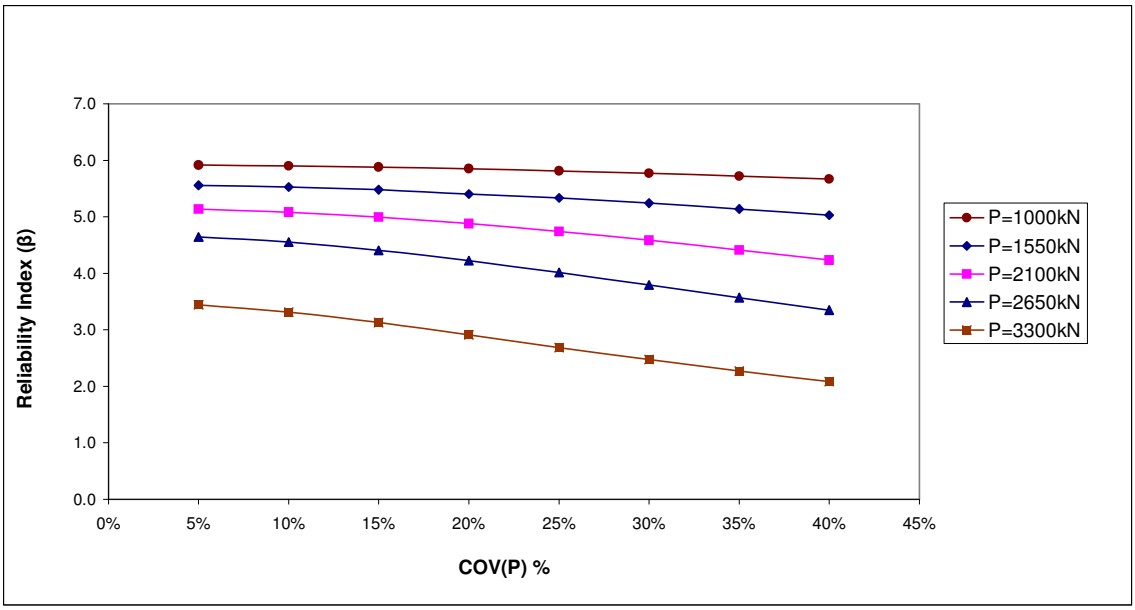


Fig. F.72 Reliability Index (β) of Y_{TOP} vs. COV (P) for free head long pile group (10T) subjected to lateral force of discrete variability.

F.3 Probability of failure, p_f (Y_{Top}) of top deflection vs. COV(Variables).

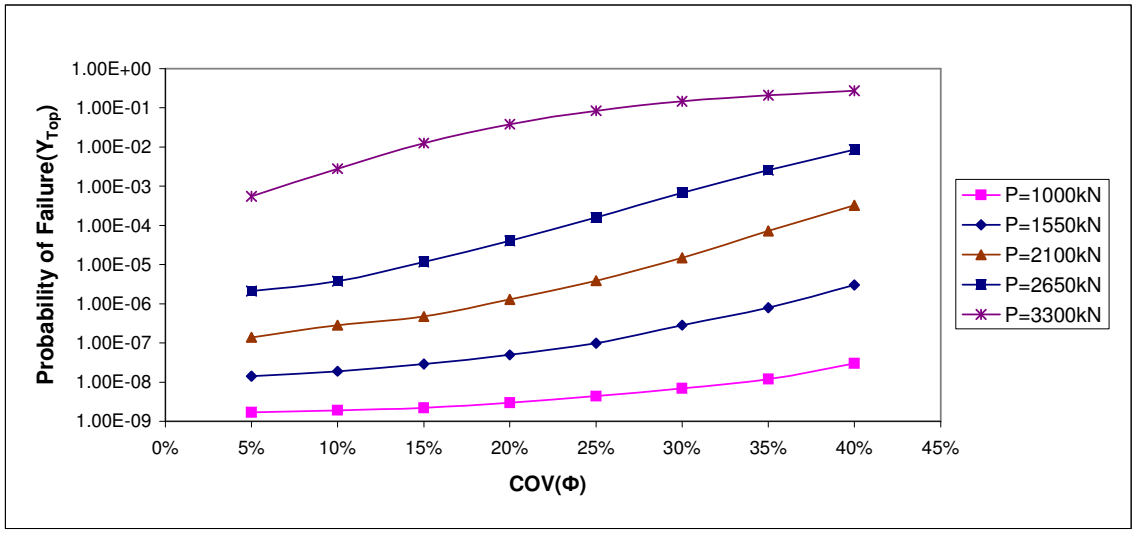


Fig. F.73 Probability of failure of top deflection p_f (Y_{Top})vs. COV (Φ) for fixed head long pile group of length 10T.

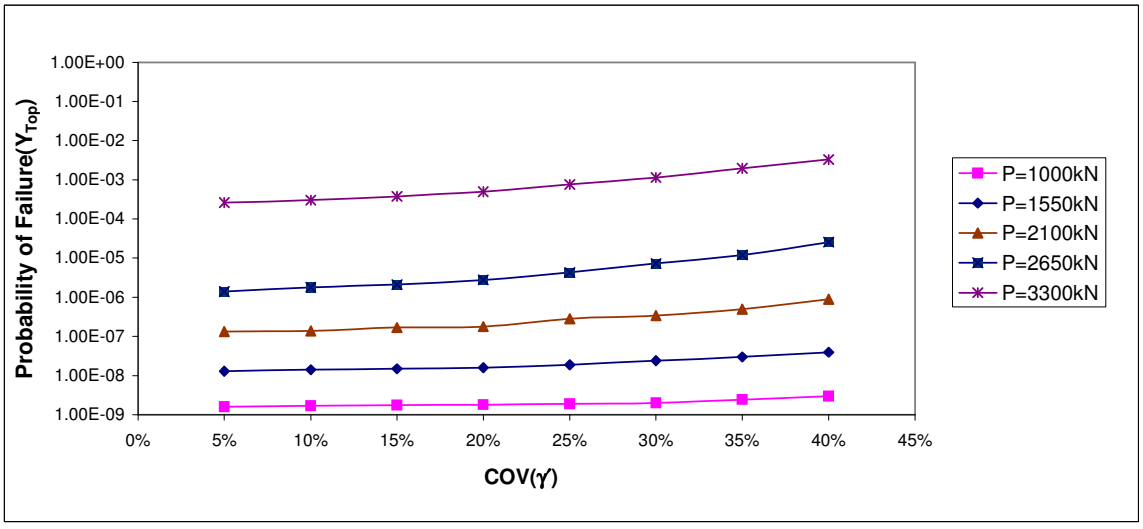


Fig. F.74 Probability of failure of top deflection p_f (Y_{Top})vs. COV (γ) for fixed head long pile group of length 10T.

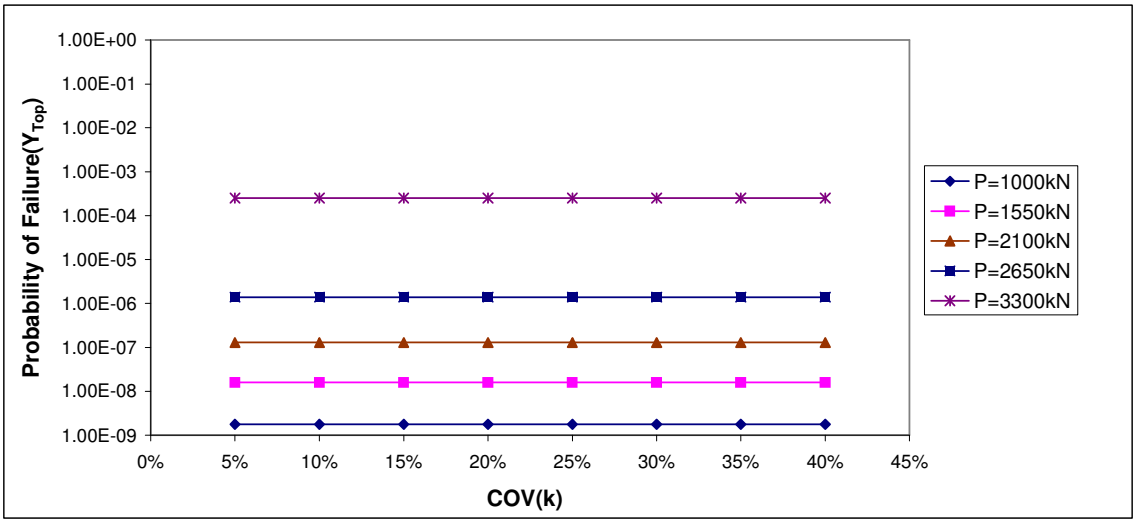


Fig. F.75 Probability of failure of top deflection p_f (Y_{Top})vs. COV (k) for fixed head long pile group of length 10T.

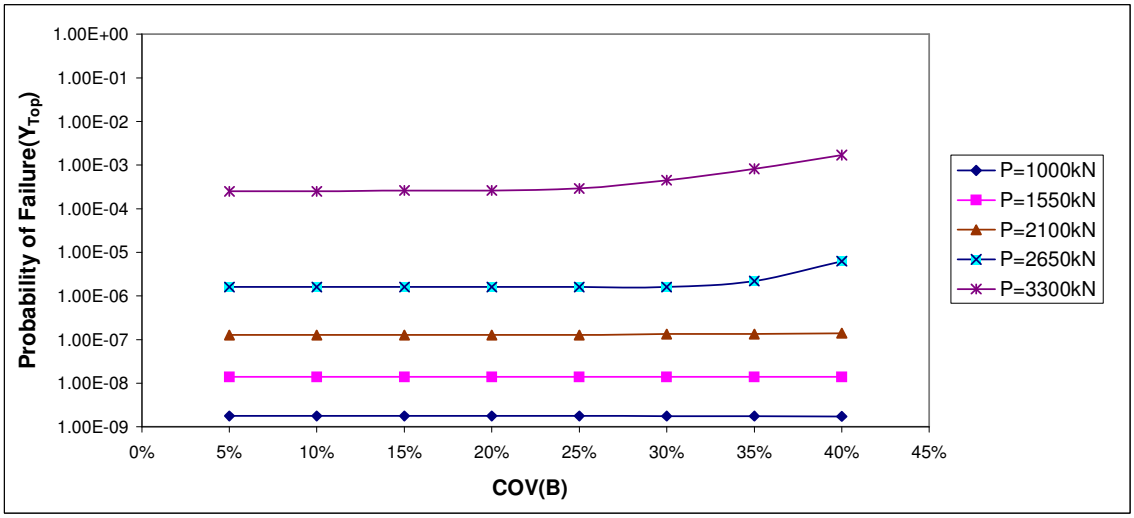


Fig. F.76 Probability of failure of top deflection p_f (Y_{Top})vs. COV (B) for fixed head long pile group of length 10T.

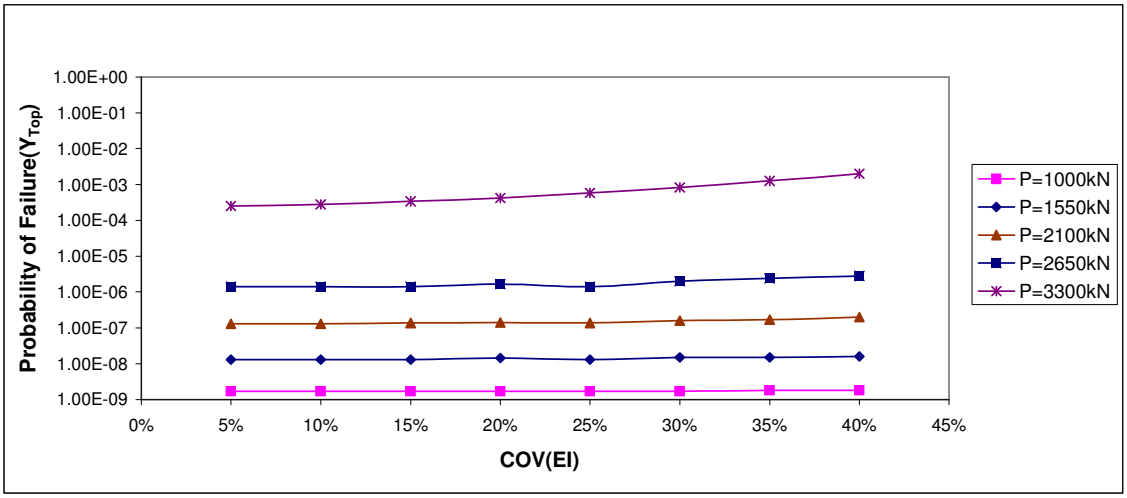


Fig. F.77 Probability of failure of top deflection p_f (Y_{Top})vs. COV (EI) for fixed head long pile group of length 10T.

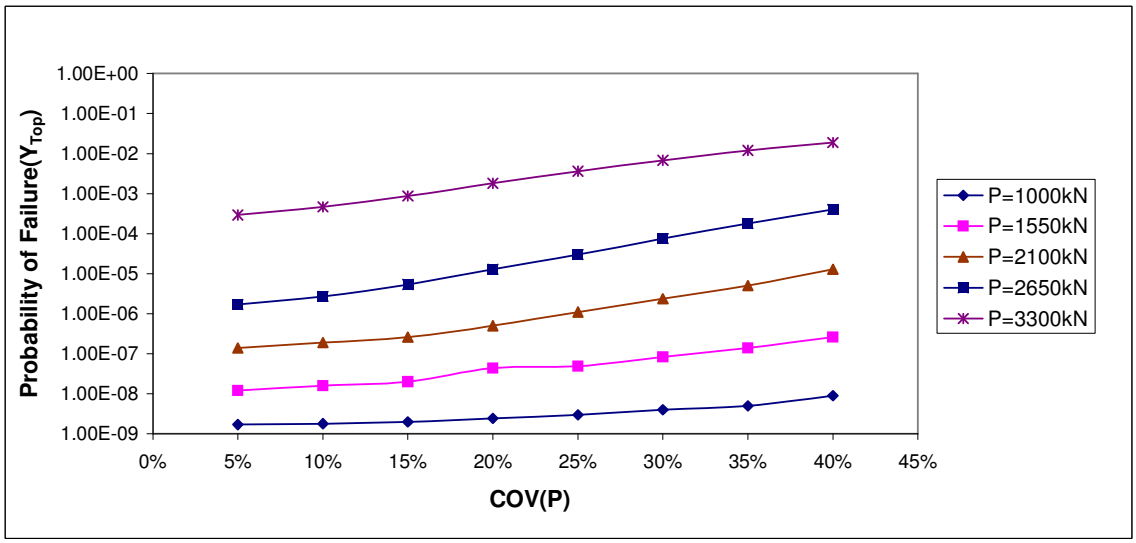


Fig. F.78 Probability of failure of top deflection p_f (Y_{Top})vs. COV (P) for fixed head long pile group of length 10T.

F.4 Moment of fixed head long pile group and coefficient of (M_{max}) vs. COV (Variables).

Table F.91 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (Φ) and load 1000kN.

P=1000kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-1.75E+02				
5%	30			2.25E+00	3.36E+01	1.81E+02	2.42%
		28.5	-1.87E+02				
		33	-1.70E+02				
10%	30			9.00E+00	1.35E+02	1.81E+02	4.80%
		27	-1.93E+02				
		34.5	-1.65E+02				
15%	30			2.03E+01	3.03E+02	1.81E+02	7.33%
		25.5	-1.99E+02				
		36	-1.60E+02				
20%	30			3.60E+01	5.36E+02	1.81E+02	9.95%
		24	-2.06E+02				
		37.5	-1.55E+02				
25%	30			5.63E+01	8.38E+02	1.81E+02	12.66%
		22.5	-2.13E+02				
		39	-1.50E+02				
30%	30			8.10E+01	1.22E+03	1.81E+02	15.59%
		21	-2.20E+02				
		40.5	-1.45E+02				
35%	30			1.10E+02	1.66E+03	1.81E+02	18.80%
		19.5	-2.27E+02				
		42	-1.41E+02				
40%	30			1.44E+02	2.21E+03	1.81E+02	22.29%
		18	-2.35E+02				

Table F.92 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (Φ) and load 1550kN.

P=1550kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-2.59E+02				
5%	30			2.25E+00	6.48E+01	3.12E+02	2.58%
		28.5	-2.75E+02				
		33	-2.52E+02				
10%	30			9.00E+00	2.59E+02	3.12E+02	5.17%
		27	-2.84E+02				
		34.5	-2.44E+02				
15%	30			2.03E+01	5.88E+02	3.12E+02	7.78%
		25.5	-2.92E+02				
		36	-2.37E+02				
20%	30			3.60E+01	1.06E+03	3.12E+02	10.45%
		24	-3.02E+02				
		37.5	-2.29E+02				
25%	30			5.63E+01	1.70E+03	3.12E+02	13.23%
		22.5	-3.12E+02				
		39	-2.22E+02				
30%	30			8.10E+01	2.54E+03	3.12E+02	16.16%
		21	-3.23E+02				
		40.5	-2.16E+02				
35%	30			1.10E+02	3.59E+03	3.12E+02	19.25%
		19.5	-3.36E+02				
		42	-2.09E+02				
40%	30			1.44E+02	4.97E+03	3.12E+02	22.63%
		18	-3.50E+02				

Table F.93 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (Φ) and load 2100kN.

P=2100kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-3.45E+02				
5%	30			2.25E+00	1.19E+02	4.51E+02	2.70%
		28.5	-3.67E+02				
		33	-3.35E+02				
10%	30			9.00E+00	4.69E+02	4.51E+02	5.42%
		27	-3.79E+02				
		34.5	-3.25E+02				
15%	30			2.03E+01	1.09E+03	4.51E+02	8.19%
		25.5	-3.92E+02				
		36	-3.16E+02				
20%	30			3.60E+01	2.01E+03	4.51E+02	11.06%
		24	-4.06E+02				
		37.5	-3.07E+02				
25%	30			5.63E+01	3.25E+03	4.51E+02	14.07%
		22.5	-4.21E+02				
		39	-2.98E+02				
30%	30			8.10E+01	4.94E+03	4.51E+02	17.28%
		21	-4.38E+02				
		40.5	-2.89E+02				
35%	30			1.10E+02	7.17E+03	4.51E+02	20.84%
		19.5	-4.58E+02				
		42	-2.81E+02				
40%	30			1.44E+02	1.01E+04	4.51E+02	24.85%
		18	-4.81E+02				

Table F.94 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (Φ) and load 2650kN.

P=2650kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-4.35E+02				
5%	30			2.25E+00	2.21E+02	5.51E+02	2.96%
		28.5	-4.65E+02				
		33	-4.22E+02				
10%	30			9.00E+00	8.91E+02	5.51E+02	5.93%
		27	-4.81E+02				
		34.5	-4.09E+02				
15%	30			2.03E+01	2.03E+03	5.51E+02	8.96%
		25.5	-4.99E+02				
		36	-3.97E+02				
20%	30			3.60E+01	3.71E+03	5.51E+02	12.03%
		24	-5.19E+02				
		37.5	-3.85E+02				
25%	30			5.63E+01	6.01E+03	5.51E+02	15.30%
		22.5	-5.40E+02				
		39	-3.74E+02				
30%	30			8.10E+01	9.06E+03	5.51E+02	18.85%
		21	-5.65E+02				
		40.5	-3.64E+02				
35%	30			1.10E+02	1.32E+04	5.51E+02	22.83%
		19.5	-5.93E+02				
		42	-3.53E+02				
40%	30			1.44E+02	1.87E+04	5.51E+02	27.20%
		18	-6.27E+02				

Table F.95 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (Φ) and load 3300kN.

P=3300kN							
COV(Φ) (%)	Φ° (degree)	Φ° (current)	M_{max} (kN-m)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		31.5	-5.32E+02				
5%	30			2.25E+00	3.78E+02	6.58E+02	3.20%
		28.5	-5.70E+02				
		33	-5.14E+02				
10%	30			9.00E+00	1.52E+03	6.58E+02	6.40%
		27	-5.92E+02				
		34.5	-4.97E+02				
15%	30			2.03E+01	3.47E+03	6.58E+02	9.60%
		25.5	-6.15E+02				
		36	-4.81E+02				
20%	30			3.60E+01	6.26E+03	6.58E+02	12.78%
		24	-6.40E+02				
		37.5	-4.67E+02				
25%	30			5.63E+01	1.01E+04	6.58E+02	15.98%
		22.5	-6.68E+02				
		39	-4.53E+02				
30%	30			8.10E+01	1.54E+04	6.58E+02	19.31%
		21	-7.01E+02				
		40.5	-4.39E+02				
35%	30			1.10E+02	2.25E+04	6.58E+02	23.24%
		19.5	-7.39E+02				
		42	-4.27E+02				
40%	30			1.44E+02	3.20E+04	6.58E+02	27.25%
		18	-7.84E+02				

Table F.96 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 1000kN.

P=1000kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	3.36E+01	2.42%
10%	9.00E+00	1.35E+02	4.80%
15%	2.03E+01	3.03E+02	7.33%
20%	3.60E+01	5.36E+02	9.95%
25%	5.63E+01	8.38E+02	12.66%
30%	8.10E+01	1.22E+03	15.59%
35%	1.10E+02	1.66E+03	18.80%
40%	1.44E+02	2.21E+03	22.29%

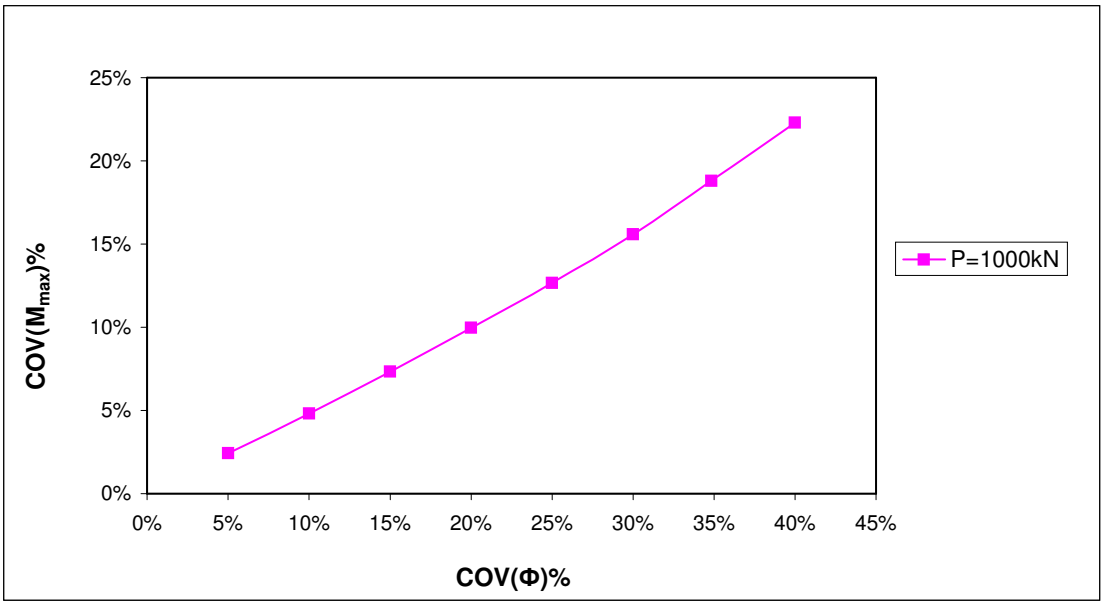


Fig. F.79 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.97 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 1550kN.

P=1550kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	6.48E+01	2.58%
10%	9.00E+00	2.59E+02	5.17%
15%	2.03E+01	5.88E+02	7.78%
20%	3.60E+01	1.06E+03	10.45%
25%	5.63E+01	1.70E+03	13.23%
30%	8.10E+01	2.54E+03	16.16%
35%	1.10E+02	3.59E+03	19.25%
40%	1.44E+02	4.97E+03	22.63%

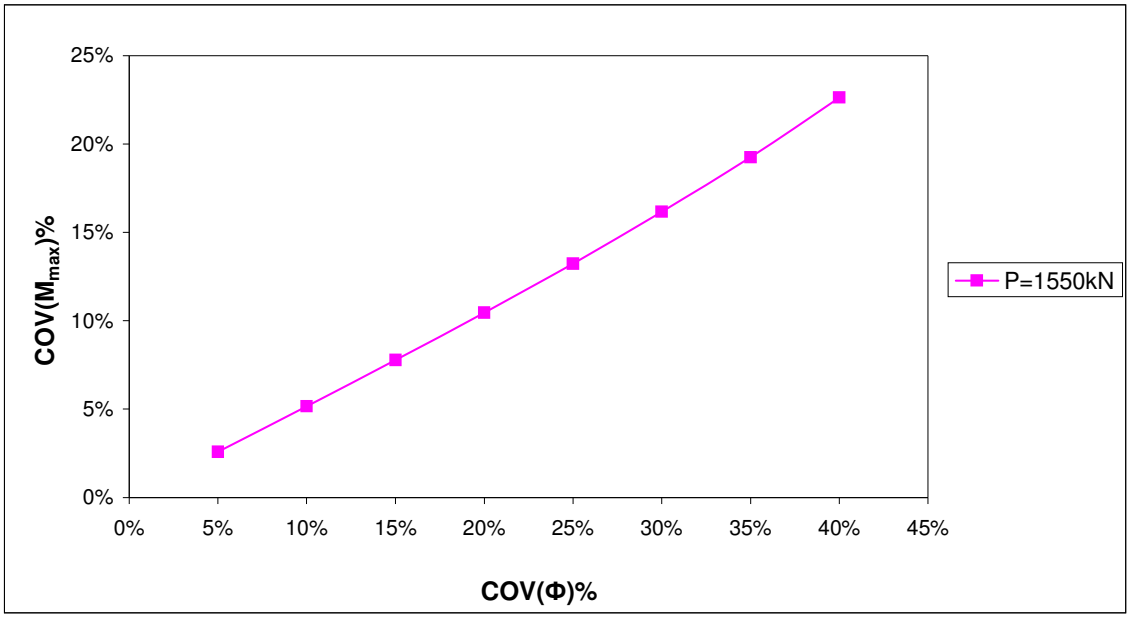


Fig. F.80 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.98 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 2100kN.

P=2100kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	1.19E+02	2.70%
10%	9.00E+00	4.69E+02	5.42%
15%	2.03E+01	1.09E+03	8.19%
20%	3.60E+01	2.01E+03	11.06%
25%	5.63E+01	3.25E+03	14.07%
30%	8.10E+01	4.94E+03	17.28%
35%	1.10E+02	7.17E+03	20.84%
40%	1.44E+02	1.01E+04	24.85%

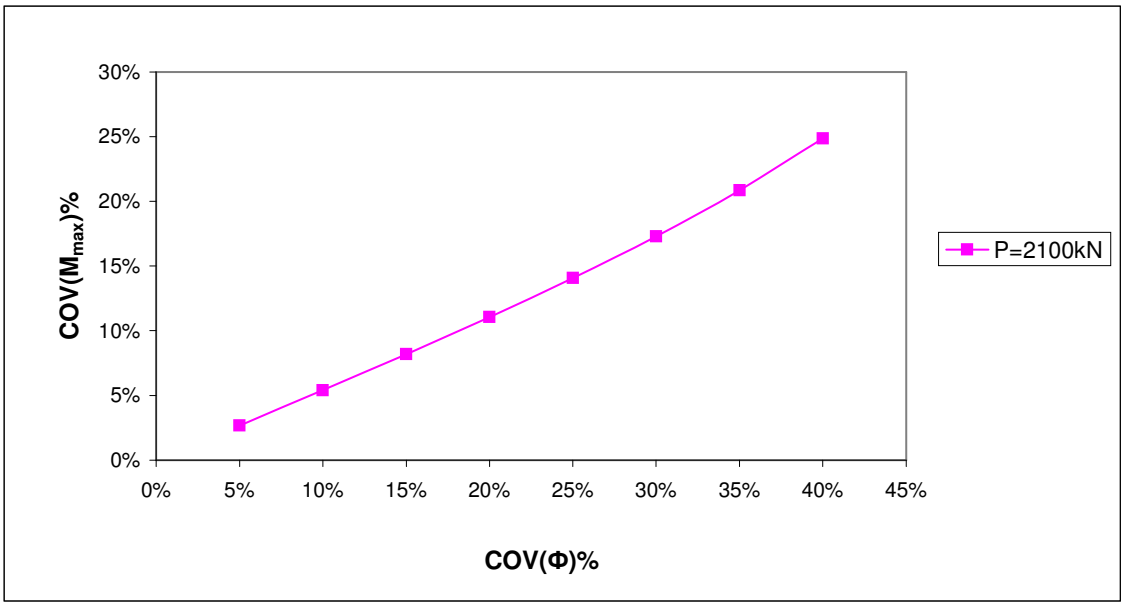


Fig. F.81 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.99 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 2650kN.

P=2650kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	2.21E+02	2.96%
10%	9.00E+00	8.91E+02	5.93%
15%	2.03E+01	2.03E+03	8.96%
20%	3.60E+01	3.71E+03	12.03%
25%	5.63E+01	6.01E+03	15.30%
30%	8.10E+01	9.06E+03	18.85%
35%	1.10E+02	1.32E+04	22.83%
40%	1.44E+02	1.87E+04	26.58%

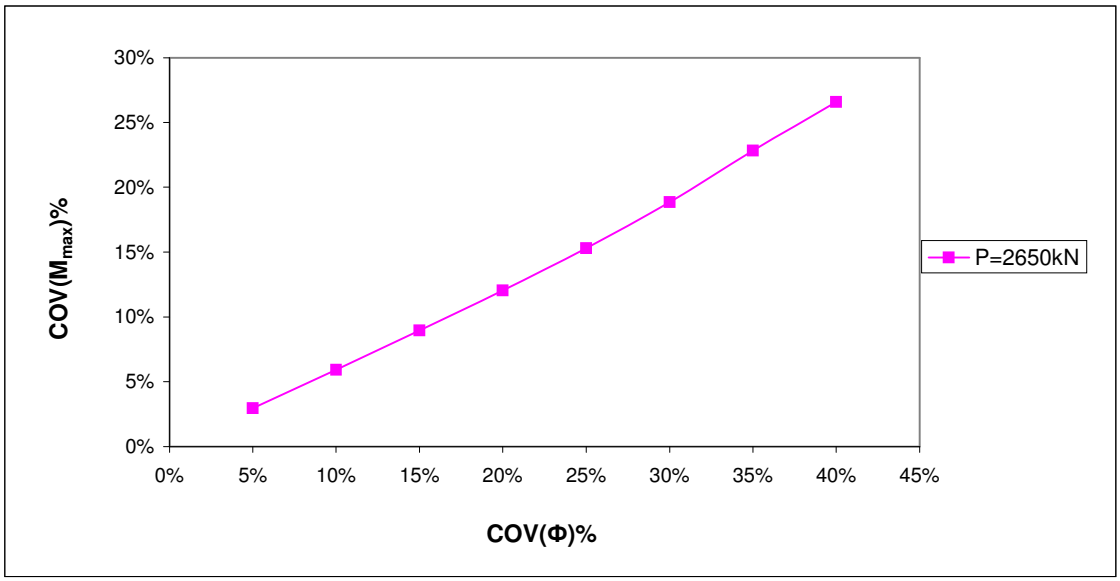


Fig. F.82 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.100 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (Φ) and lateral load 3300kN.

P=3300kN			
COV(Φ) (%)	VAR(Φ) (degree)	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.25E+00	3.80E+02	3.20%
10%	9.00E+00	1.56E+03	6.40%
15%	2.03E+01	3.61E+03	9.60%
20%	3.60E+01	6.50E+03	12.78%
25%	5.63E+01	1.04E+04	15.98%
30%	8.10E+01	1.57E+04	19.31%
35%	1.10E+02	2.26E+04	23.24%
40%	1.44E+02	3.15E+04	27.25%

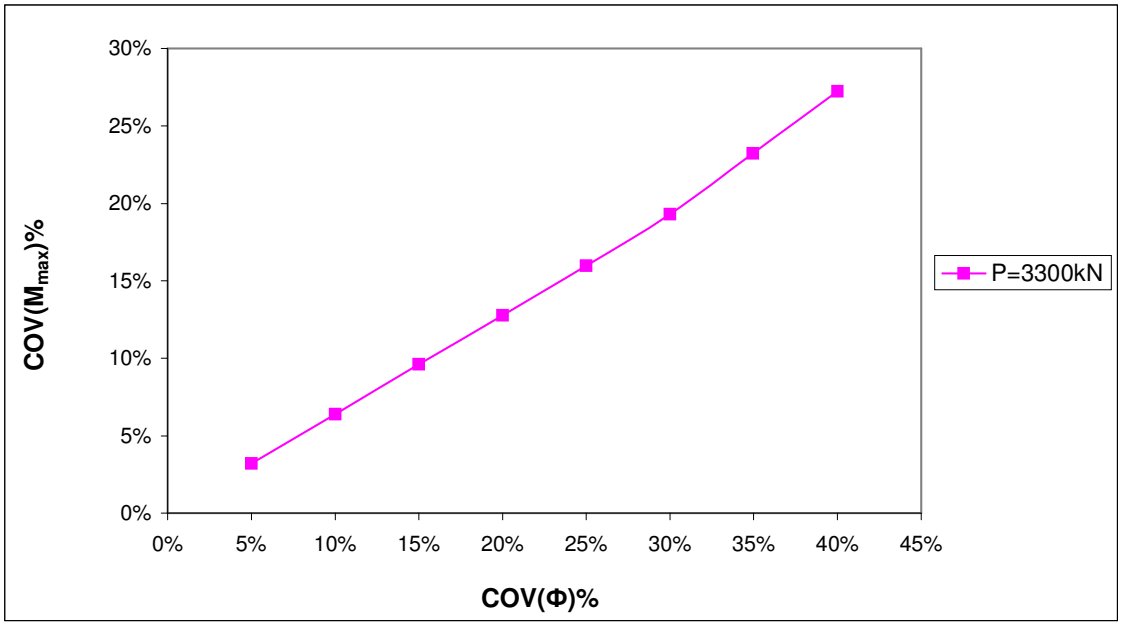


Fig. F.83 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

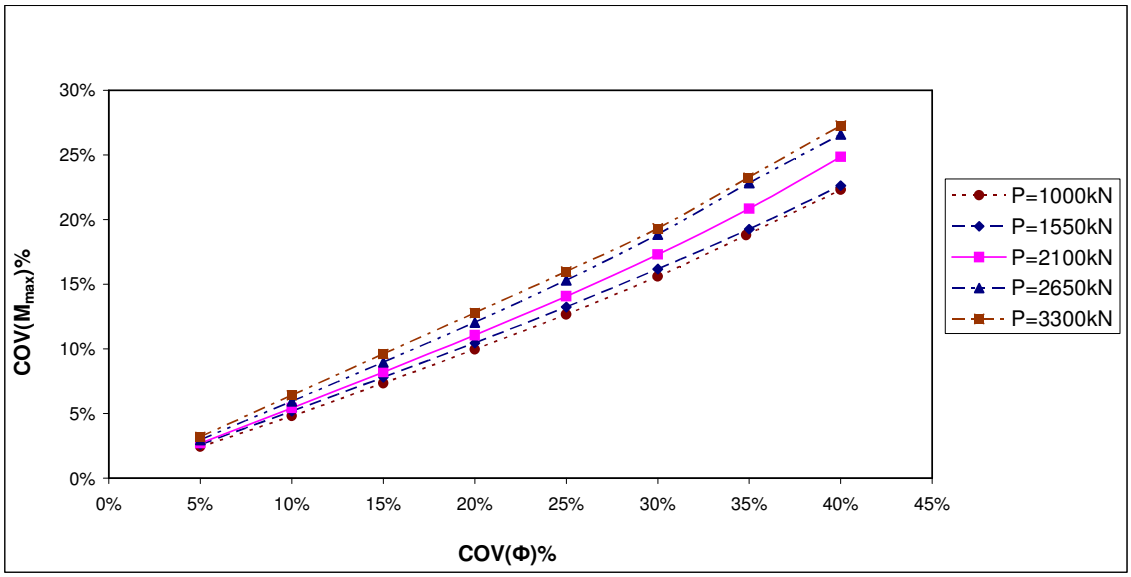


Fig. F.84 Variability of COV (M_{max}) vs. COV (Φ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table F.101 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (γ) and load 1000kN.

P=1000kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		11.025	-1.79E+02				
5%	10.5			2.76E-01	6.25E+00	1.81E+02	0.99%
		9.975	-1.84E+02				
		11.55	-1.77E+02				
10%	10.5			1.10E+00	2.40E+01	1.81E+02	2.01%
		9.45	-1.86E+02				
		12.075	-1.74E+02				
15%	10.5			2.48E+00	5.40E+01	1.81E+02	3.06%
		8.925	-1.89E+02				
		12.6	-1.72E+02				
20%	10.5			4.41E+00	1.00E+02	1.81E+02	4.11%
		8.4	-1.92E+02				
		13.125	-1.70E+02				
25%	10.5			6.89E+00	1.58E+02	1.81E+02	5.20%
		7.875	-1.96E+02				
		13.65	-1.69E+02				
30%	10.5			9.92E+00	2.31E+02	1.81E+02	6.37%
		7.35	-1.99E+02				
		14.175	-1.67E+02				
35%	10.5			1.35E+01	3.22E+02	1.81E+02	7.59%
		6.825	-2.03E+02				
		14.7	-1.65E+02				
40%	10.5			1.76E+01	4.37E+02	1.81E+02	8.91%
		6.3	-2.07E+02				

Table F.102 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (γ) and load 1550kN.

P=1550kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		11.025	-2.64E+02				
5%	10.5			2.76E-01	1.16E+01	3.12E+02	1.09%
		9.975	-2.71E+02				
		11.55	-2.61E+02				
10%	10.5			1.10E+00	4.56E+01	3.12E+02	2.17%
		9.45	-2.74E+02				
		12.075	-2.58E+02				
15%	10.5			2.48E+00	1.04E+02	3.12E+02	3.27%
		8.925	-2.78E+02				
		12.6	-2.55E+02				
20%	10.5			4.41E+00	1.89E+02	3.12E+02	4.41%
		8.4	-2.83E+02				
		13.125	-2.52E+02				
25%	10.5			6.89E+00	2.99E+02	3.12E+02	5.55%
		7.875	-2.87E+02				
		13.65	-2.50E+02				
30%	10.5			9.92E+00	4.41E+02	3.12E+02	6.74%
		7.35	-2.92E+02				
		14.175	-2.47E+02				
35%	10.5			1.35E+01	6.23E+02	3.12E+02	8.01%
		6.825	-2.97E+02				
		14.7	-2.45E+02				
40%	10.5			1.76E+01	8.50E+02	3.12E+02	9.36%
		6.3	-3.03E+02				

Table F.103 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (γ) and load 2100kN.

P=2100kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		11.025	-3.51E+02				
5%	10.5			2.76E-01	1.98E+01	4.51E+02	1.13%
		9.975	-3.60E+02				
		11.55	-3.47E+02				
10%	10.5			1.10E+00	8.19E+01	4.51E+02	2.26%
		9.45	-3.65E+02				
		12.075	-3.43E+02				
15%	10.5			2.48E+00	1.90E+02	4.51E+02	3.41%
		8.925	-3.71E+02				
		12.6	-3.40E+02				
20%	10.5			4.41E+00	3.42E+02	4.51E+02	4.58%
		8.4	-3.77E+02				
		13.125	-3.36E+02				
25%	10.5			6.89E+00	5.50E+02	4.51E+02	5.81%
		7.875	-3.83E+02				
		13.65	-3.33E+02				
30%	10.5			9.92E+00	8.24E+02	4.51E+02	7.11%
		7.35	-3.90E+02				
		14.175	-3.30E+02				
35%	10.5			1.35E+01	1.17E+03	4.51E+02	8.42%
		6.825	-3.98E+02				
		14.7	-3.27E+02				
40%	10.5			1.76E+01	1.61E+03	4.51E+02	9.89%
		6.3	-4.07E+02				

Table F.104 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (γ) and load 2650kN.

P=2650kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		11.025	-4.44E+02				
5%	10.5			2.76E-01	3.91E+01	5.51E+02	1.22%
		9.975	-4.56E+02				
		11.55	-4.38E+02				
10%	10.5			1.10E+00	1.55E+02	5.51E+02	2.44%
		9.45	-4.63E+02				
		12.075	-4.33E+02				
15%	10.5			2.48E+00	3.53E+02	5.51E+02	3.69%
		8.925	-4.71E+02				
		12.6	-4.28E+02				
20%	10.5			4.41E+00	6.35E+02	5.51E+02	5.00%
		8.4	-4.79E+02				
		13.125	-4.23E+02				
25%	10.5			6.89E+00	1.02E+03	5.51E+02	6.31%
		7.875	-4.87E+02				
		13.65	-4.19E+02				
30%	10.5			9.92E+00	1.53E+03	5.51E+02	7.63%
		7.35	-4.97E+02				
		14.175	-4.15E+02				
35%	10.5			1.35E+01	2.15E+03	5.51E+02	9.15%
		6.825	-5.08E+02				
		14.7	-4.11E+02				
40%	10.5			1.76E+01	2.96E+03	5.51E+02	10.67%
		6.3	-5.20E+02				

Table F.105 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (γ) and load 3300kN.

P=3300kN							
COV(γ) (%)	γo (kN/m^3)	γ(current) (kN/m^3)	M_{max} (kN-m)	VAR(γ) (kN/m^3)^2	VAR (M_{max}) (kN-m)^2	M_{max}^{o} (kN-m)	COV(M_{max}) (%)
		11.025	-5.43E+02				
5%	10.5			2.76E-01	6.40E+01	6.58E+02	1.38%
		9.975	-5.59E+02				
		11.55	-5.36E+02				
10%	10.5			1.10E+00	2.58E+02	6.58E+02	2.70%
		9.45	-5.68E+02				
		12.075	-5.28E+02				
15%	10.5			2.48E+00	5.88E+02	6.58E+02	4.06%
		8.925	-5.77E+02				
		12.6	-5.22E+02				
20%	10.5			4.41E+00	1.08E+03	6.58E+02	5.52%
		8.4	-5.88E+02				
		13.125	-5.16E+02				
25%	10.5			6.89E+00	1.72E+03	6.58E+02	6.93%
		7.875	-5.99E+02				
		13.65	-5.11E+02				
30%	10.5			9.92E+00	2.52E+03	6.58E+02	8.39%
		7.35	-6.11E+02				
		14.175	-5.05E+02				
35%	10.5			1.35E+01	3.62E+03	6.58E+02	9.91%
		6.825	-6.26E+02				
		14.7	-5.00E+02				
40%	10.5			1.76E+01	4.93E+03	6.58E+02	11.53%
		6.3	-6.41E+02				

Table F.106 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 1000kN.

P=1000kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	6.25E+00	0.99%
10%	1.10E+00	2.40E+01	2.01%
15%	2.48E+00	5.40E+01	3.06%
20%	4.41E+00	1.00E+02	4.11%
25%	6.89E+00	1.58E+02	5.20%
30%	9.92E+00	2.31E+02	6.37%
35%	1.35E+01	3.22E+02	7.59%
40%	1.76E+01	4.37E+02	8.91%

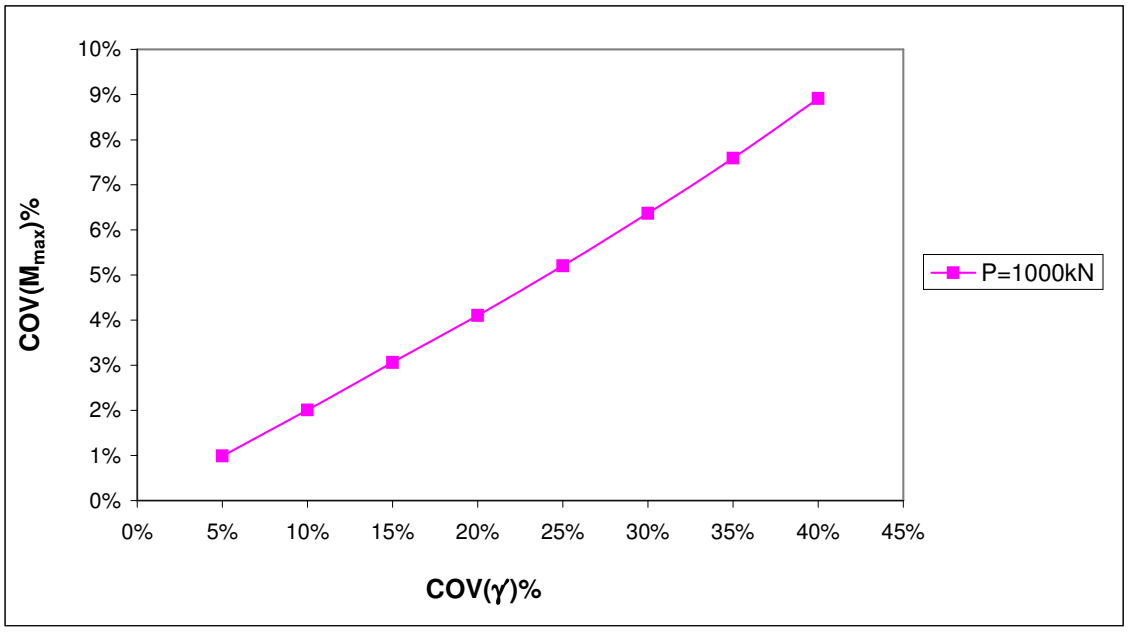


Fig. F.85 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.107 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 1550kN.

P=1550kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.76E-01	1.16E+01	1.09%
10%	1.10E+00	4.56E+01	2.17%
15%	2.48E+00	1.04E+02	3.27%
20%	4.41E+00	1.89E+02	4.41%
25%	6.89E+00	2.99E+02	5.55%
30%	9.92E+00	4.41E+02	6.74%
35%	1.35E+01	6.23E+02	8.01%
40%	1.76E+01	8.50E+02	9.36%

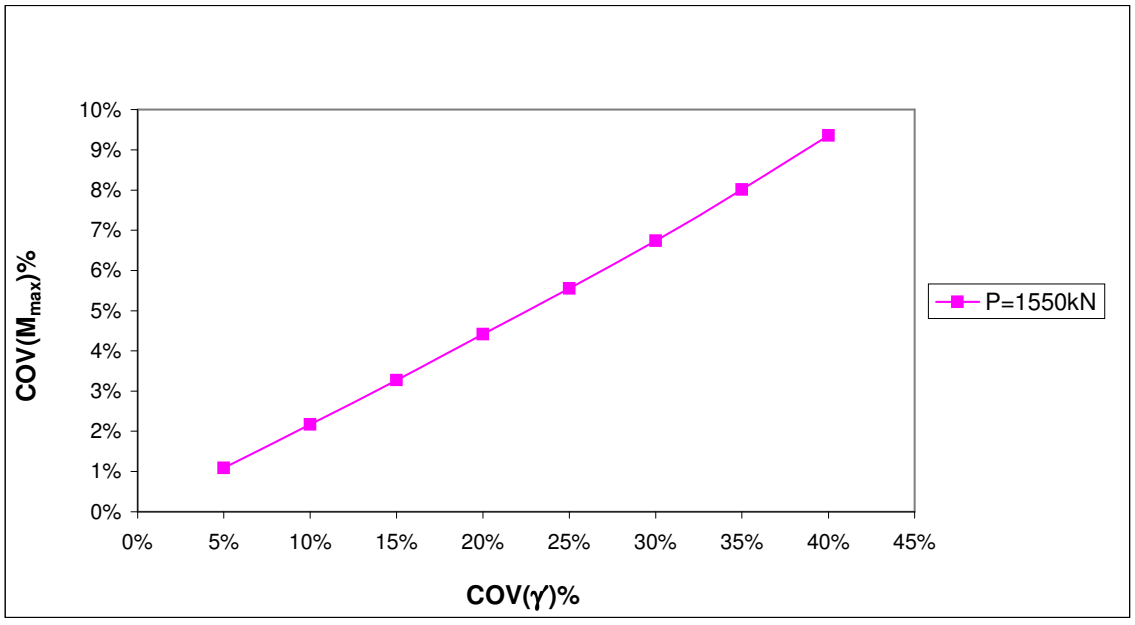


Fig. F.86 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.108 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 2100kN.

P=2100kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.98E+01	1.13%
10%	2.66E+06	8.19E+01	2.26%
15%	5.98E+06	1.90E+02	3.41%
20%	1.06E+07	3.42E+02	4.58%
25%	1.66E+07	5.50E+02	5.81%
30%	2.39E+07	8.24E+02	7.11%
35%	3.25E+07	1.17E+03	8.42%
40%	4.25E+07	1.61E+03	9.89%

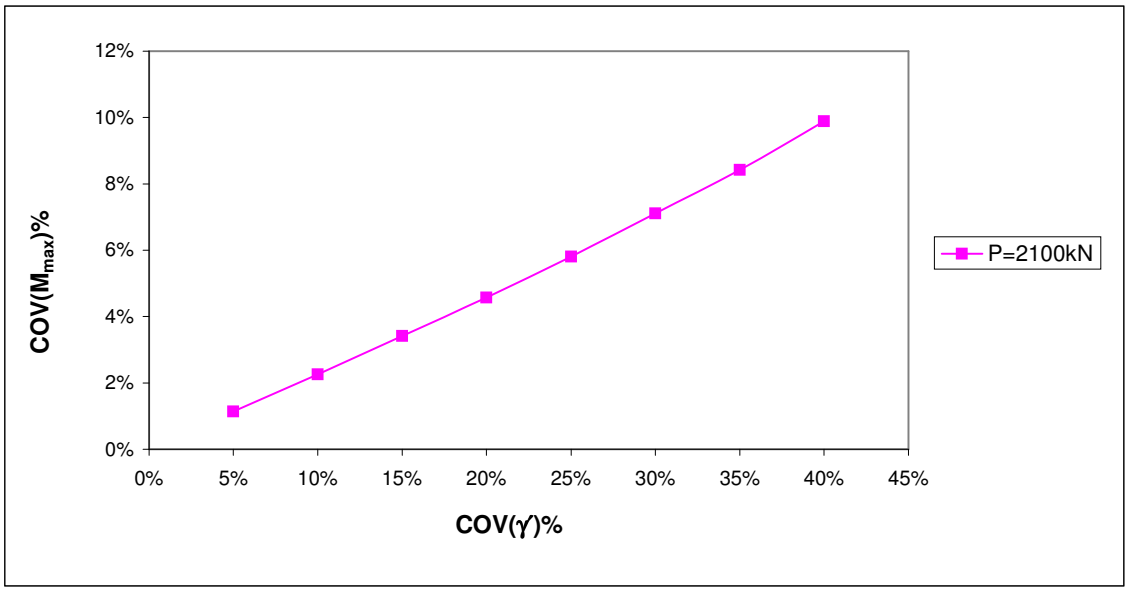


Fig. F.87 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.109 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (γ') and lateral load 2650kN.

P=2650kN			
COV(γ') (%)	VAR(γ') $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	3.91E+01	1.22%
10%	2.66E+06	1.55E+02	2.44%
15%	5.98E+06	3.53E+02	3.69%
20%	1.06E+07	6.35E+02	5.00%
25%	1.66E+07	1.02E+03	6.31%
30%	2.39E+07	1.53E+03	7.63%
35%	3.25E+07	2.15E+03	9.15%
40%	4.25E+07	2.96E+03	10.67%

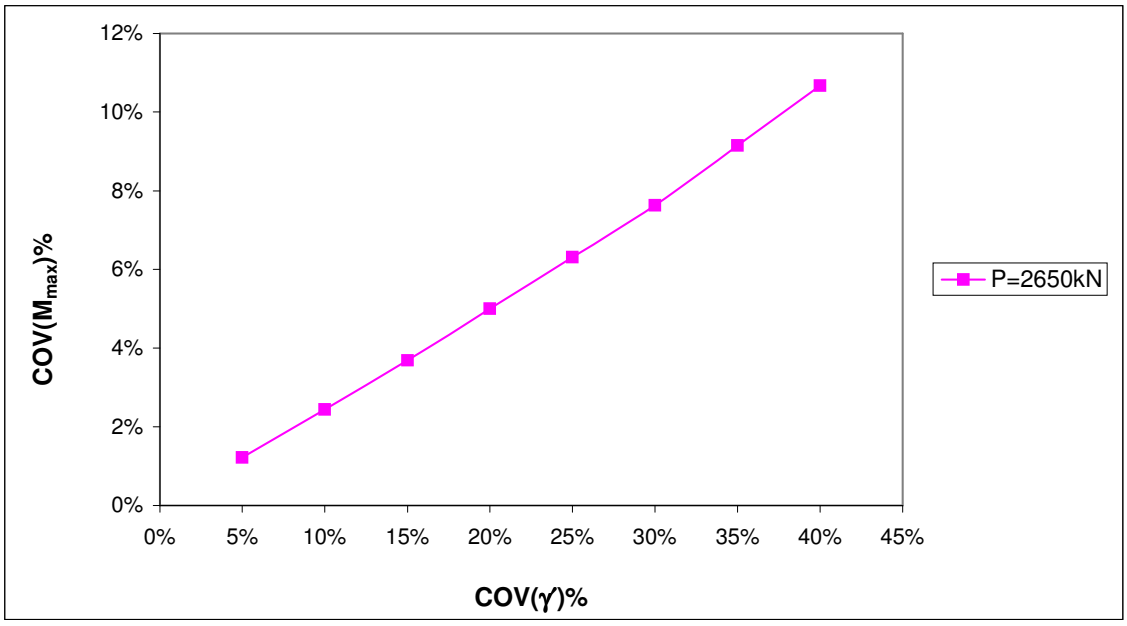


Fig. F.88 Variability of COV (M_{max}) vs. COV (γ') for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.110 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (γ) and lateral load 3300kN.

P=3300kN			
COV(γ) (%)	VAR(γ) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	6.40E+01	1.38%
10%	2.66E+06	2.58E+02	2.70%
15%	5.98E+06	5.88E+02	4.06%
20%	1.06E+07	1.08E+03	5.52%
25%	1.66E+07	1.72E+03	6.93%
30%	2.39E+07	2.52E+03	8.39%
35%	3.25E+07	3.62E+03	9.91%
40%	4.25E+07	4.93E+03	11.53%

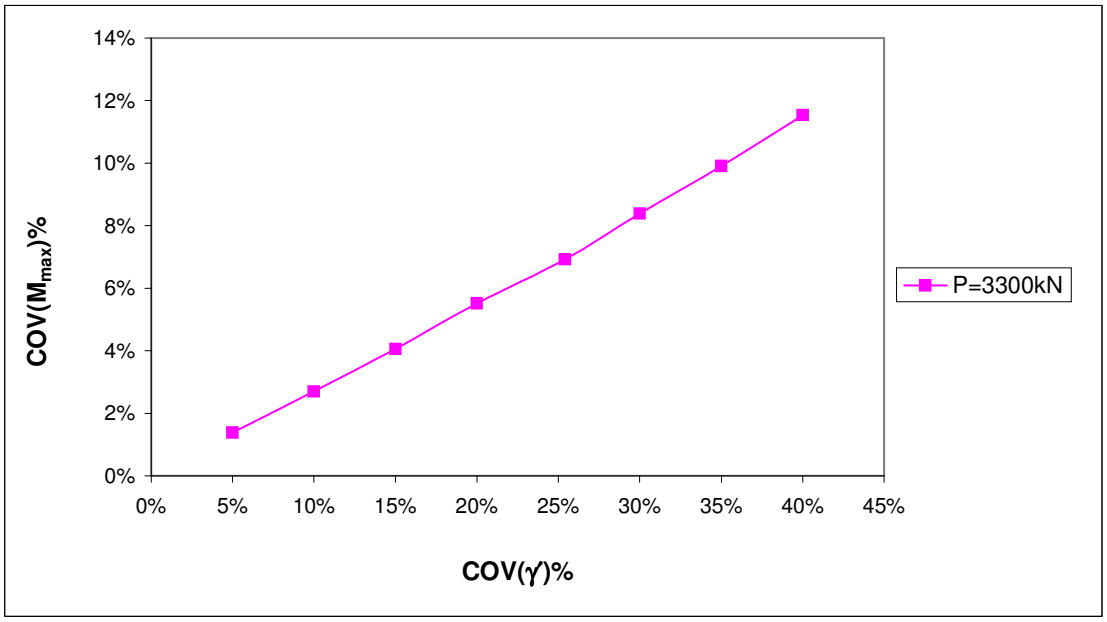


Fig. F.89 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

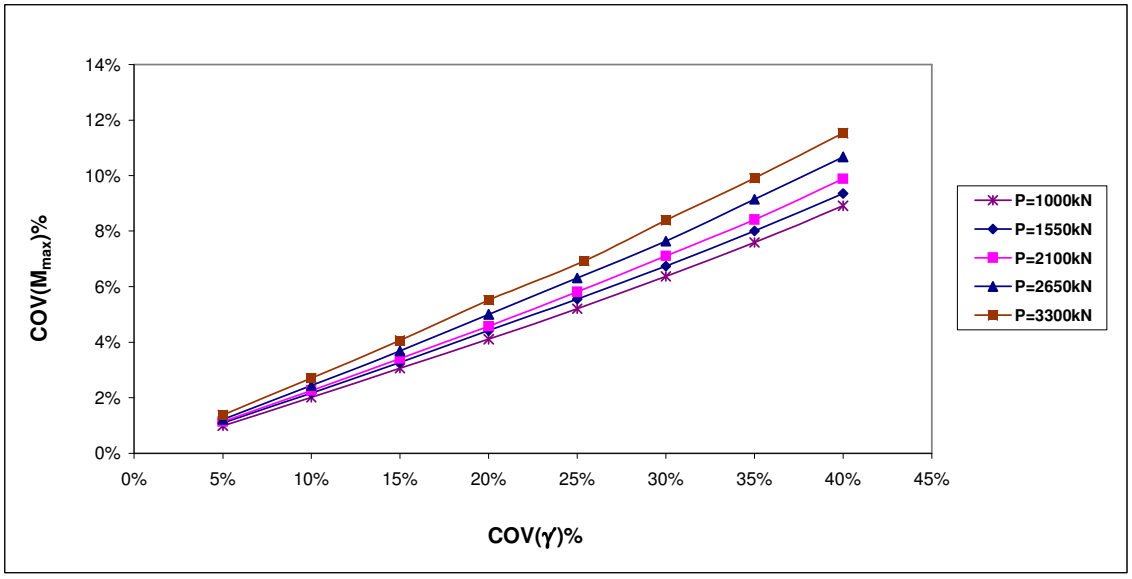


Fig. F.90 Variability of COV (M_{max}) vs. COV (γ) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table F.111 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (k) and load 1000kN.

P=1000kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	-1.81E+02				
5%	16300			6.64E+05	1.00E-02	1.81E+02	0.06%
		15485	-1.81E+02				
		17930	-1.81E+02				
10%	16300			2.66E+06	2.25E-02	1.81E+02	0.08%
		14670	-1.81E+02				
		18745	-1.81E+02				
15%	16300			5.98E+06	4.00E-02	1.81E+02	0.11%
		13855	-1.81E+02				
		19560	-1.81E+02				
20%	16300			1.06E+07	9.00E-02	1.81E+02	0.17%
		13040	-1.82E+02				
		20375	-1.81E+02				
25%	16300			1.66E+07	1.22E-01	1.81E+02	0.19%
		12225	-1.82E+02				
		21190	-1.81E+02				
30%	16300			2.39E+07	1.60E-01	1.81E+02	0.22%
		11410	-1.82E+02				
		22005	-1.81E+02				
35%	16300			3.25E+07	3.60E-01	1.81E+02	0.33%
		10595	-1.82E+02				
		22820	-1.81E+02				
40%	16300			4.25E+07	5.63E-01	1.81E+02	0.41%
		9780	-1.82E+02				

Table F.112 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (k) and load 1550kN.

P=1550kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	-2.67E+02				
5%	16300			6.64E+05	1.00E-02	3.12E+02	0.03%
		15485	-2.67E+02				
		17930	-2.67E+02				
10%	16300			2.66E+06	1.00E-02	3.12E+02	0.03%
		14670	-2.67E+02				
		18745	-2.67E+02				
15%	16300			5.98E+06	4.00E-02	3.12E+02	0.06%
		13855	-2.68E+02				
		19560	-2.67E+02				
20%	16300			1.06E+07	6.25E-02	3.12E+02	0.08%
		13040	-2.68E+02				
		20375	-2.67E+02				
25%	16300			1.66E+07	1.22E-01	3.12E+02	0.11%
		12225	-2.68E+02				
		21190	-2.67E+02				
30%	16300			2.39E+07	1.60E-01	3.12E+02	0.13%
		11410	-2.68E+02				
		22005	-2.67E+02				
35%	16300			3.25E+07	2.50E-01	3.12E+02	0.16%
		10595	-2.68E+02				
		22820	-2.67E+02				
40%	16300			4.25E+07	4.90E-01	3.12E+02	0.22%
		9780	-2.68E+02				

Table F.113 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (k) and load 2100kN.

P=2100kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	-3.56E+02				
5%	16300			6.64E+05	1.00E-02	4.51E+02	0.02%
		15485	-3.56E+02				
		17930	-3.56E+02				
10%	16300			2.66E+06	4.00E-02	4.51E+02	0.04%
		14670	-3.56E+02				
		18745	-3.56E+02				
15%	16300			5.98E+06	9.00E-02	4.51E+02	0.07%
		13855	-3.56E+02				
		19560	-3.56E+02				
20%	16300			1.06E+07	9.00E-02	4.51E+02	0.07%
		13040	-3.56E+02				
		20375	-3.56E+02				
25%	16300			1.66E+07	1.22E-01	4.51E+02	0.08%
		12225	-3.56E+02				
		21190	-3.56E+02				
30%	16300			2.39E+07	2.02E-01	4.51E+02	0.10%
		11410	-3.56E+02				
		22005	-3.55E+02				
35%	16300			3.25E+07	3.60E-01	4.51E+02	0.13%
		10595	-3.57E+02				
		22820	-3.55E+02				
40%	16300			4.25E+07	5.63E-01	4.51E+02	0.17%
		9780	-3.57E+02				

Table F.114 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (k) and load 2650kN.

P=2650kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	-4.50E+02				
5%	16300			6.64E+05	1.00E-02	5.51E+02	0.02%
		15485	-4.50E+02				
		17930	-4.50E+02				
10%	16300			2.66E+06	1.00E-02	5.51E+02	0.02%
		14670	-4.50E+02				
		18745	-4.50E+02				
15%	16300			5.98E+06	6.25E-02	5.51E+02	0.05%
		13855	-4.50E+02				
		19560	-4.49E+02				
20%	16300			1.06E+07	2.03E-01	5.51E+02	0.08%
		13040	-4.50E+02				
		20375	-4.49E+02				
25%	16300			1.66E+07	3.60E-01	5.51E+02	0.11%
		12225	-4.51E+02				
		21190	-4.49E+02				
30%	16300			2.39E+07	4.90E-01	5.51E+02	0.13%
		11410	-4.51E+02				
		22005	-4.49E+02				
35%	16300			3.25E+07	7.22E-01	5.51E+02	0.15%
		10595	-4.51E+02				
		22820	-4.49E+02				
40%	16300			4.25E+07	1.00E+00	5.51E+02	0.18%
		9780	-4.51E+02				

Table F.115 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (k) and load 3300kN.

P=3300kN							
COV(k) (%)	k^o (kN/m^3)	k(current) (kN/m^3)	M_{max} (kN-m)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		17115	-5.50E+02				
5%	16300			6.64E+05	4.00E-02	6.58E+02	0.03%
		15485	-5.50E+02				
		17930	-5.50E+02				
10%	16300			2.66E+06	1.22E-01	6.58E+02	0.05%
		14670	-5.50E+02				
		18745	-5.50E+02				
15%	16300			5.98E+06	2.50E-01	6.58E+02	0.08%
		13855	-5.51E+02				
		19560	-5.50E+02				
20%	16300			1.06E+07	3.60E-01	6.58E+02	0.09%
		13040	-5.51E+02				
		20375	-5.50E+02				
25%	16300			1.66E+07	5.63E-01	6.58E+02	0.11%
		12225	-5.51E+02				
		21190	-5.49E+02				
30%	16300			2.39E+07	8.10E-01	6.58E+02	0.14%
		11410	-5.51E+02				
		22005	-5.49E+02				
35%	16300			3.25E+07	1.32E+00	6.58E+02	0.17%
		10595	-5.52E+02				
		22820	-5.49E+02				
40%	16300			4.25E+07	2.25E+00	6.58E+02	0.23%
		9780	-5.52E+02				

Table F.116 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 1000kN.

P=1000kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.00E-02	0.06%
10%	2.66E+06	2.25E-02	0.08%
15%	5.98E+06	4.00E-02	0.11%
20%	1.06E+07	9.00E-02	0.17%
25%	1.66E+07	1.22E-01	0.19%
30%	2.39E+07	1.60E-01	0.22%
35%	3.25E+07	3.60E-01	0.33%
40%	4.25E+07	5.63E-01	0.41%

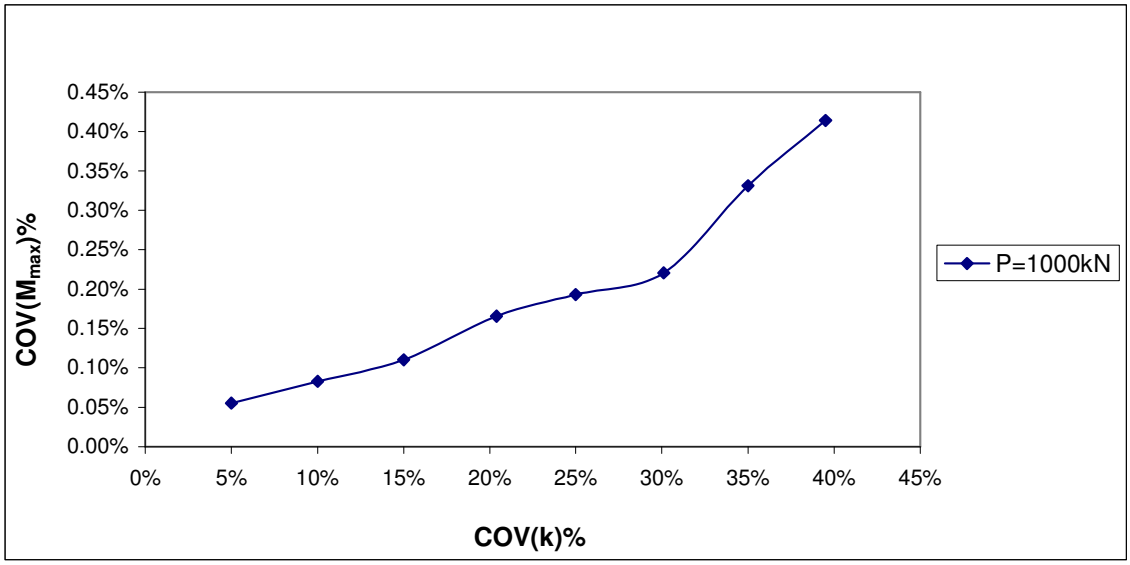


Fig. F.91 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.117 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 1550kN.

P=1550kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.00E-02	0.03%
10%	2.66E+06	1.00E-02	0.03%
15%	5.98E+06	4.00E-02	0.06%
20%	1.06E+07	6.25E-02	0.08%
25%	1.66E+07	1.22E-01	0.11%
30%	2.39E+07	1.60E-01	0.13%
35%	3.25E+07	2.50E-01	0.16%
40%	4.25E+07	4.90E-01	0.22%

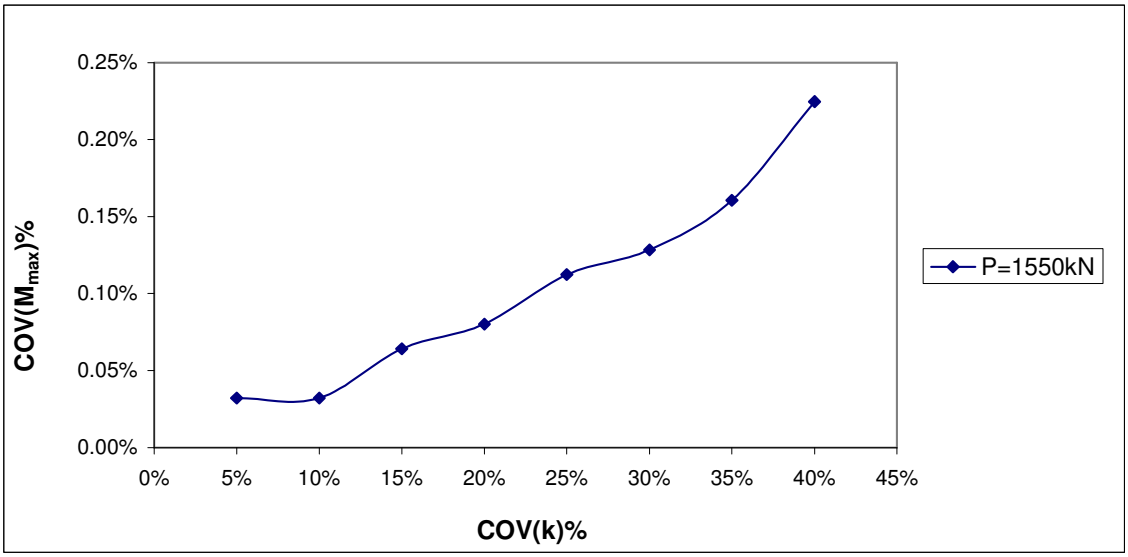


Fig. F.92 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.118 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 2100kN.

P=2100kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.00E-02	0.02%
10%	2.66E+06	4.00E-02	0.04%
15%	5.98E+06	9.00E-02	0.07%
20%	1.06E+07	9.00E-02	0.07%
25%	1.66E+07	1.22E-01	0.08%
30%	2.39E+07	2.02E-01	0.10%
35%	3.25E+07	3.60E-01	0.13%
40%	4.25E+07	5.63E-01	0.17%

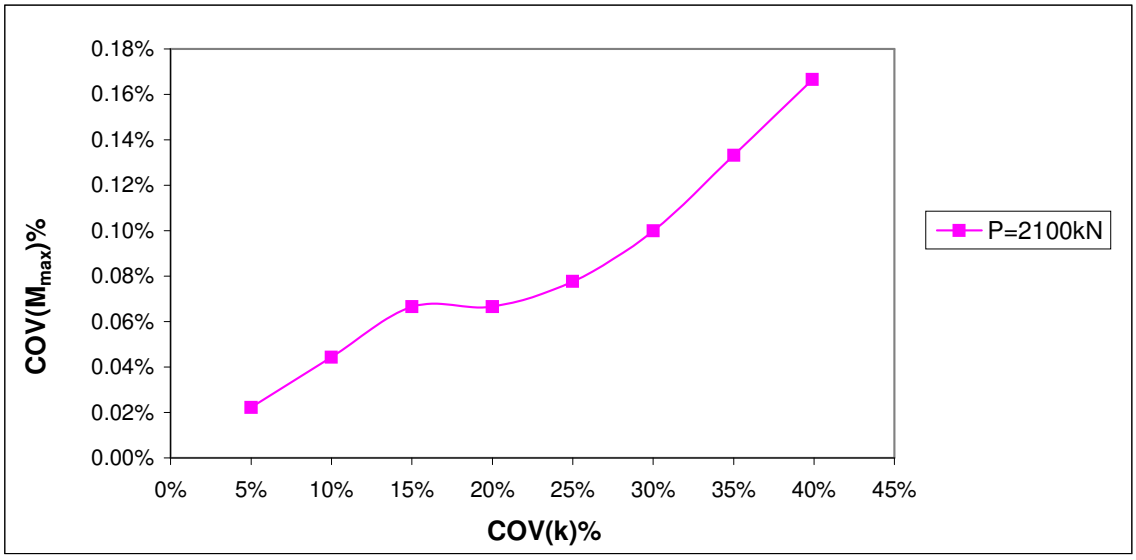


Fig. F.93 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.119 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 2650kN.

P=2650kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	1.00E-02	0.02%
10%	2.66E+06	1.00E-02	0.02%
15%	5.98E+06	6.25E-02	0.05%
20%	1.06E+07	2.03E-01	0.08%
25%	1.66E+07	3.60E-01	0.11%
30%	2.39E+07	4.90E-01	0.13%
35%	3.25E+07	7.22E-01	0.15%
40%	4.25E+07	1.00E+00	0.18%

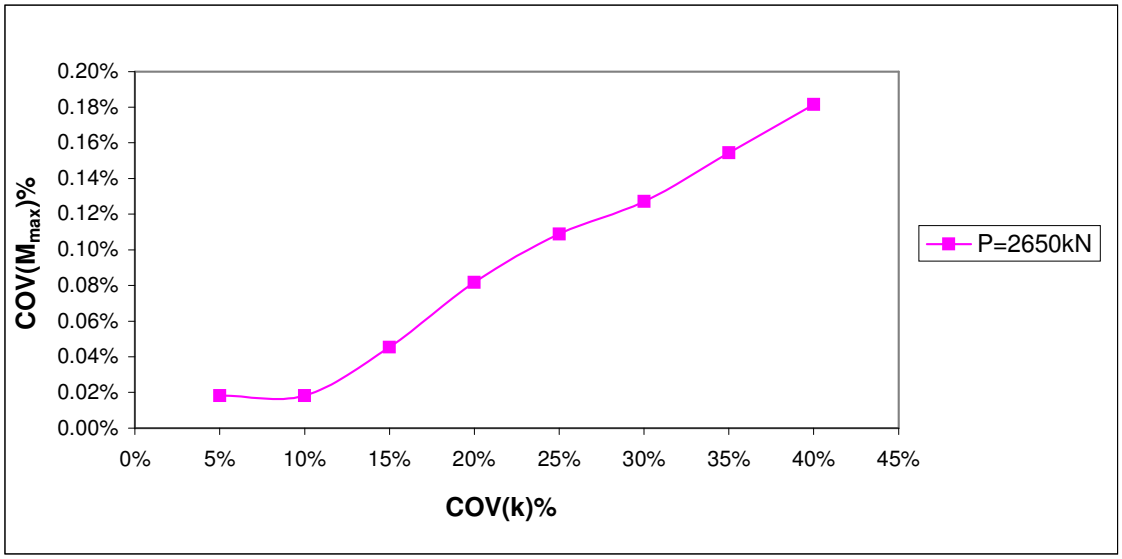


Fig. F.94 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.120 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (k) and lateral load 3300kN.

P=3300kN			
COV(k) (%)	VAR(k) $(kN/m^3)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.64E+05	4.00E-02	0.03%
10%	2.66E+06	1.22E-01	0.05%
15%	5.98E+06	2.50E-01	0.08%
20%	1.06E+07	3.60E-01	0.09%
25%	1.66E+07	5.63E-01	0.11%
30%	2.39E+07	8.10E-01	0.14%
35%	3.25E+07	1.32E+00	0.17%
40%	4.25E+07	2.25E+00	0.23%

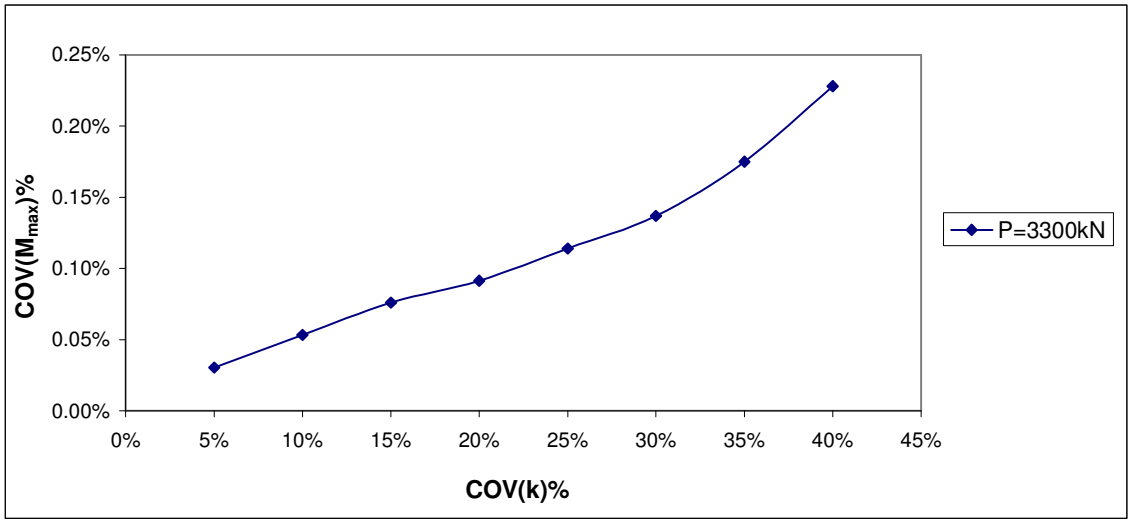


Fig. F.95 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

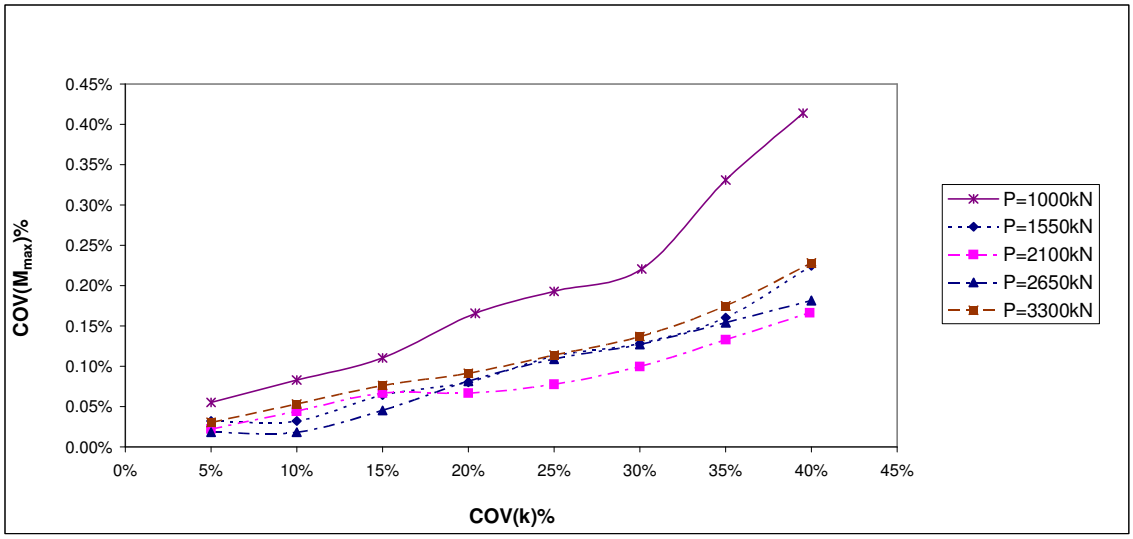


Fig. F.96 Variability of COV (M_{max}) vs. COV (k) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table F.121 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (B) and load 1000kN.

P=1000kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		0.4263	-1.79E+02				
5%	0.406			4.12E-04	4.22E-01	1.81E+02	0.10%
		0.3857	-1.80E+02				
		0.4466	-1.79E+02				
10%	0.406			1.65E-03	4.22E-01	1.81E+02	0.11%
		0.3654	-1.80E+02				
		0.4669	-1.79E+02				
15%	0.406			3.71E-03	4.22E-01	1.81E+02	0.14%
		0.3451	-1.80E+02				
		0.4872	-1.80E+02				
20%	0.406			6.59E-03	9.00E-02	1.81E+02	0.23%
		0.3248	-1.79E+02				
		0.5075	-1.80E+02				
25%	0.406			1.03E-02	4.90E-01	1.81E+02	0.39%
		0.3045	-1.78E+02				
		0.5278	-1.79E+02				
30%	0.406			1.48E-02	1.21E+00	1.81E+02	0.61%
		0.2842	-1.76E+02				
		0.5472	-1.78E+02				
35%	0.406			2.02E-02	2.93E+00	1.81E+02	0.94%
		0.2648	-1.74E+02				
		0.5684	-1.77E+02				
40%	0.406			2.64E-02	7.29E+00	1.81E+02	1.49%
		0.2436	-1.72E+02				

Table F.122 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (B) and load 1550kN.

P=1550kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		0.4263	-2.69E+02				
5%	0.406			4.12E-04	3.60E-01	3.12E+02	0.19%
		0.3857	-2.68E+02				
		0.4466	-2.68E+02				
10%	0.406			1.65E-03	1.84E+00	3.12E+02	0.39%
		0.3654	-2.65E+02				
		0.4669	-2.68E+02				
15%	0.406			3.71E-03	4.41E+00	3.12E+02	0.60%
		0.3451	-2.64E+02				
		0.4872	-2.68E+02				
20%	0.406			6.59E-03	9.30E+00	3.12E+02	0.87%
		0.3248	-2.62E+02				
		0.5075	-2.68E+02				
25%	0.406			1.03E-02	1.76E+01	3.12E+02	1.21%
		0.3045	-2.60E+02				
		0.5278	-2.67E+02				
30%	0.406			1.48E-02	2.81E+01	3.12E+02	1.58%
		0.2842	-2.57E+02				
		0.5472	-2.67E+02				
35%	0.406			2.02E-02	4.55E+01	3.12E+02	2.01%
		0.2648	-2.53E+02				
		0.5684	-2.66E+02				
40%	0.406			2.64E-02	7.31E+01	3.12E+02	2.74%
		0.2436	-2.49E+02				

Table F.123 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (B) and load 2100kN.

P=2100kN							
COV(B) (%)	B° (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	-3.58E+02				
5%	0.406			4.12E-04	2.25E+00	4.51E+02	0.33%
		0.3857	-3.55E+02				
		0.4466	-3.58E+02				
10%	0.406			1.65E-03	6.25E+00	4.51E+02	0.55%
		0.3654	-3.53E+02				
		0.4669	-3.58E+02				
15%	0.406			3.71E-03	1.23E+01	4.51E+02	0.78%
		0.3451	-3.51E+02				
		0.4872	-3.58E+02				
20%	0.406			6.59E-03	2.16E+01	4.51E+02	1.03%
		0.3248	-3.49E+02				
		0.5075	-3.59E+02				
25%	0.406			1.03E-02	3.78E+01	4.51E+02	1.43%
		0.3045	-3.47E+02				
		0.5278	-3.59E+02				
30%	0.406			1.48E-02	6.40E+01	4.51E+02	1.78%
		0.2842	-3.43E+02				
		0.5472	-3.59E+02				
35%	0.406			2.02E-02	1.14E+02	4.51E+02	2.37%
		0.2648	-3.37E+02				
		0.5684	-3.59E+02				
40%	0.406			2.64E-02	2.31E+02	4.51E+02	3.37%
		0.2436	-3.28E+02				

Table F.124 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (B) and load 2650kN.

P=2650kN							
COV(B) (%)	B° (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		0.4263	-4.52E+02				
5%	0.406			4.12E-04	3.80E+00	5.51E+02	0.46%
		0.3857	-4.49E+02				
		0.4466	-4.52E+02				
10%	0.406			1.65E-03	6.00E+00	5.51E+02	0.68%
		0.3654	-4.48E+02				
		0.4669	-4.52E+02				
15%	0.406			3.71E-03	1.19E+01	5.51E+02	0.87%
		0.3451	-4.46E+02				
		0.4872	-4.52E+02				
20%	0.406			6.59E-03	2.26E+01	5.51E+02	1.20%
		0.3248	-4.43E+02				
		0.5075	-4.53E+02				
25%	0.406			1.03E-02	4.90E+01	5.51E+02	1.48%
		0.3045	-4.39E+02				
		0.5278	-4.53E+02				
30%	0.406			1.48E-02	1.05E+02	5.51E+02	1.94%
		0.2842	-4.32E+02				
		0.5472	-4.53E+02				
35%	0.406			2.02E-02	3.16E+02	5.51E+02	3.22%
		0.2648	-4.17E+02				
		0.5684	-4.53E+02				
40%	0.406			2.64E-02	9.99E+02	5.51E+02	5.74%
		0.2436	-3.89E+02				

Table F.125 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (B) and load 3300kN.

P=3300kN							
COV(B) (%)	B^o (m)	B(current) (m)	M_{max} (kN-m)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		0.4263	-5.52E+02				
5%	0.406			4.12E-04	9.02E-01	6.58E+02	0.51%
		0.3857	-5.51E+02				
		0.4466	-5.51E+02				
10%	0.406			1.65E-03	2.10E+00	6.58E+02	0.75%
		0.3654	-5.49E+02				
		0.4669	-5.51E+02				
15%	0.406			3.71E-03	8.70E+00	6.58E+02	0.97%
		0.3451	-5.46E+02				
		0.4872	-5.51E+02				
20%	0.406			6.59E-03	2.76E+01	6.58E+02	1.26%
		0.3248	-5.41E+02				
		0.5075	-5.52E+02				
25%	0.406			1.03E-02	9.41E+01	6.58E+02	1.77%
		0.3045	-5.32E+02				
		0.5278	-5.52E+02				
30%	0.406			1.48E-02	4.08E+02	6.58E+02	3.07%
		0.2842	-5.12E+02				
		0.5472	-5.52E+02				
35%	0.406			2.02E-02	1.38E+03	6.58E+02	5.65%
		0.2648	-4.78E+02				
		0.5684	-5.52E+02				
40%	0.406			2.64E-02	3.28E+03	6.58E+02	8.70%
		0.2436	-4.37E+02				

Table F.126 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 1000kN.

P=1000kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	4.22E-01	0.10%
10%	1.65E-03	4.22E-01	0.11%
15%	3.71E-03	4.22E-01	0.14%
20%	6.59E-03	9.00E-02	0.23%
25%	1.03E-02	4.90E-01	0.39%
30%	1.48E-02	1.21E+00	0.61%
35%	2.02E-02	2.93E+00	0.94%
40%	2.64E-02	7.29E+00	1.49%

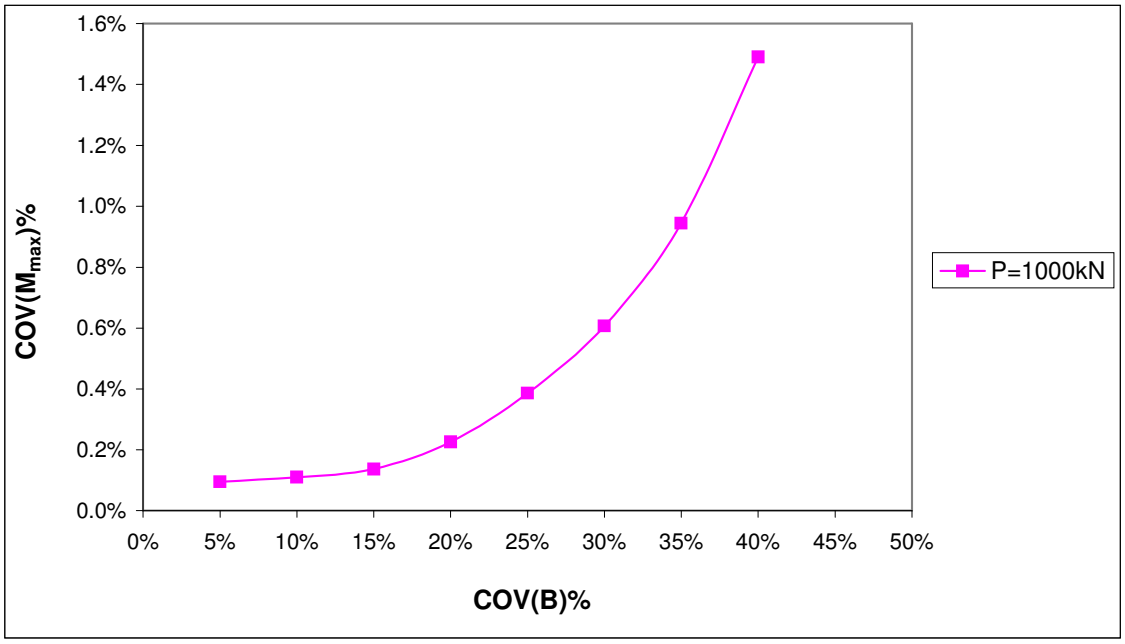


Fig. F.97 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.127 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 1550kN.

P=1550kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	3.60E-01	0.19%
10%	1.65E-03	1.84E+00	0.39%
15%	3.71E-03	4.41E+00	0.60%
20%	6.59E-03	9.30E+00	0.87%
25%	1.03E-02	1.76E+01	1.21%
30%	1.48E-02	2.81E+01	1.58%
35%	2.02E-02	4.55E+01	2.01%
40%	2.64E-02	7.31E+01	2.74%

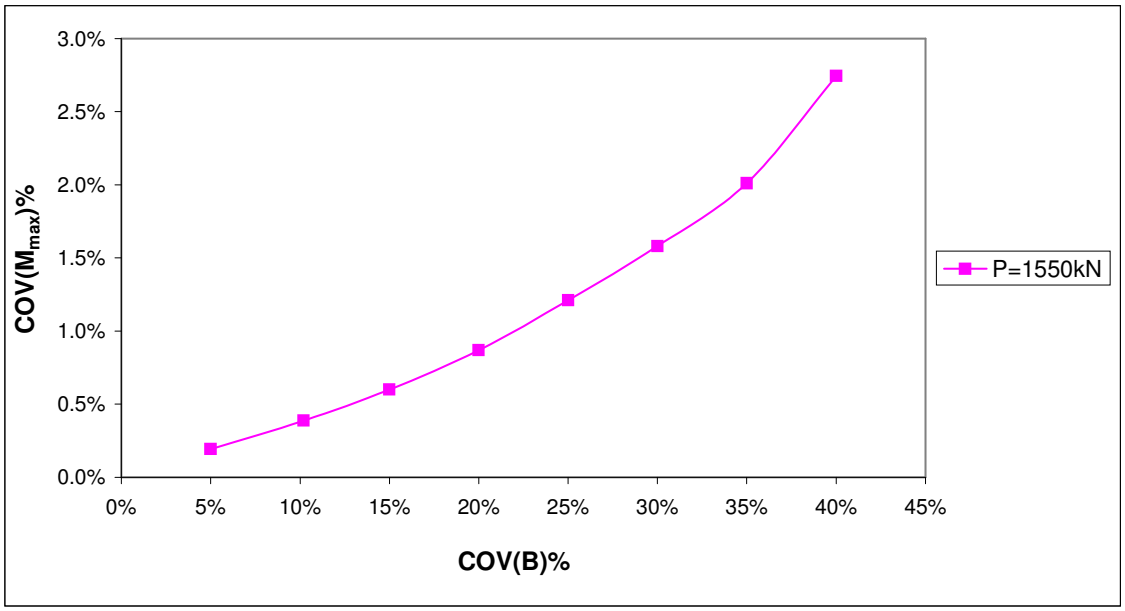


Fig. F.98 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.128 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 2100kN.

P=2100kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	2.25E+00	0.33%
10%	1.65E-03	6.25E+00	0.55%
15%	3.71E-03	1.23E+01	0.78%
20%	6.59E-03	2.16E+01	1.03%
25%	1.03E-02	3.78E+01	1.43%
30%	1.48E-02	6.40E+01	1.78%
35%	2.02E-02	1.14E+02	2.37%
40%	2.64E-02	2.31E+02	3.37%

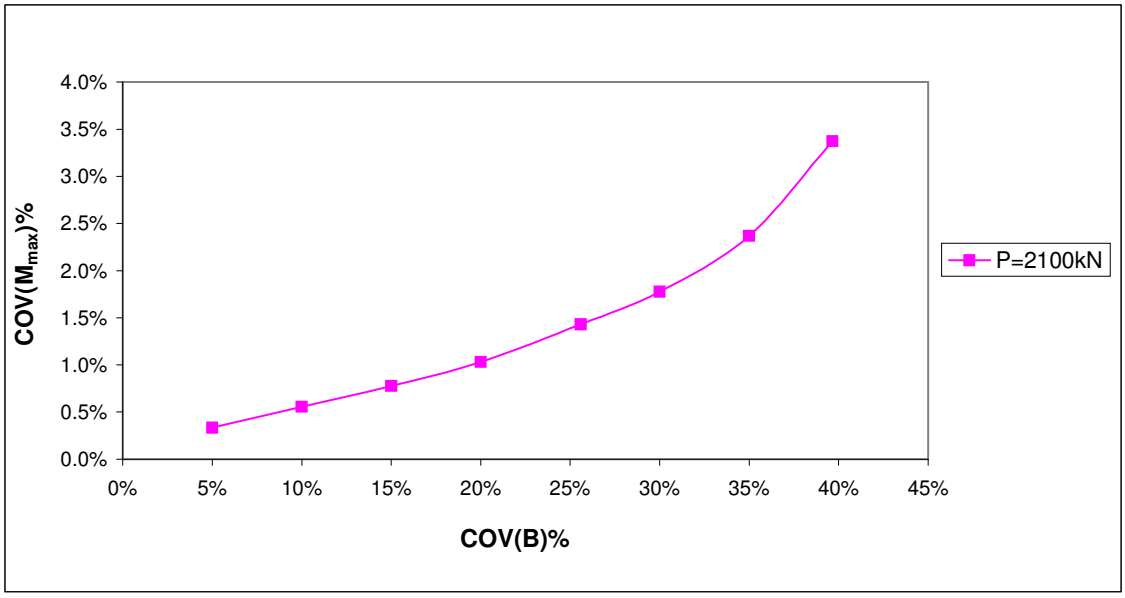


Fig. F.99 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.129 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 2650kN.

P=2650kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	3.80E+00	0.46%
10%	1.65E-03	6.00E+00	0.68%
15%	3.71E-03	1.19E+01	0.87%
20%	6.59E-03	2.26E+01	1.20%
25%	1.03E-02	4.90E+01	1.48%
30%	1.48E-02	1.05E+02	1.94%
35%	2.02E-02	3.16E+02	3.22%
40%	2.64E-02	9.99E+02	5.74%

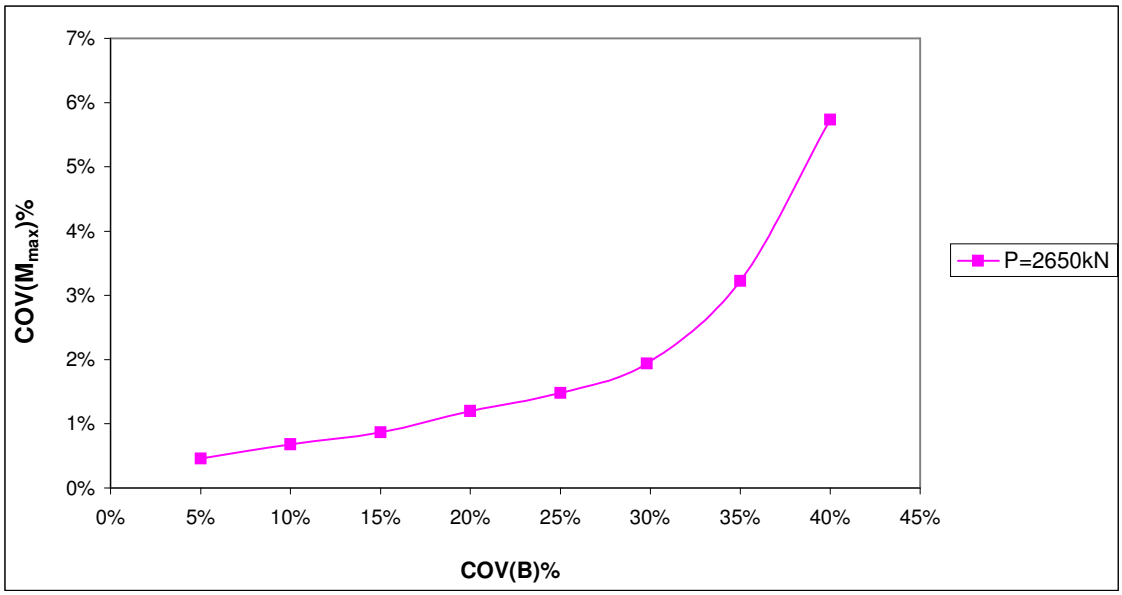


Fig. F.100 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.130 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (B) and lateral load 3300kN.

P=3300kN			
COV(B) (%)	VAR(B) $(m)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	4.12E-04	9.02E-01	0.51%
10%	1.65E-03	2.10E+00	0.75%
15%	3.71E-03	8.70E+00	0.97%
20%	6.59E-03	2.76E+01	1.26%
25%	1.03E-02	9.41E+01	1.77%
30%	1.48E-02	4.08E+02	3.07%
35%	2.02E-02	1.38E+03	5.65%
40%	2.64E-02	3.28E+03	8.70%

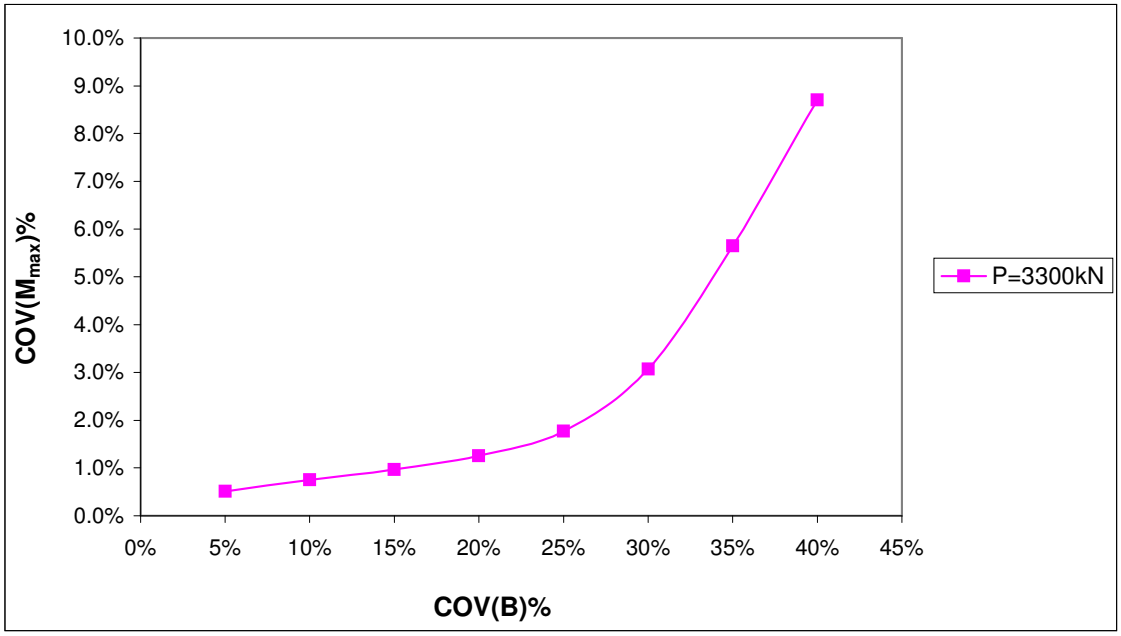


Fig. F.101 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

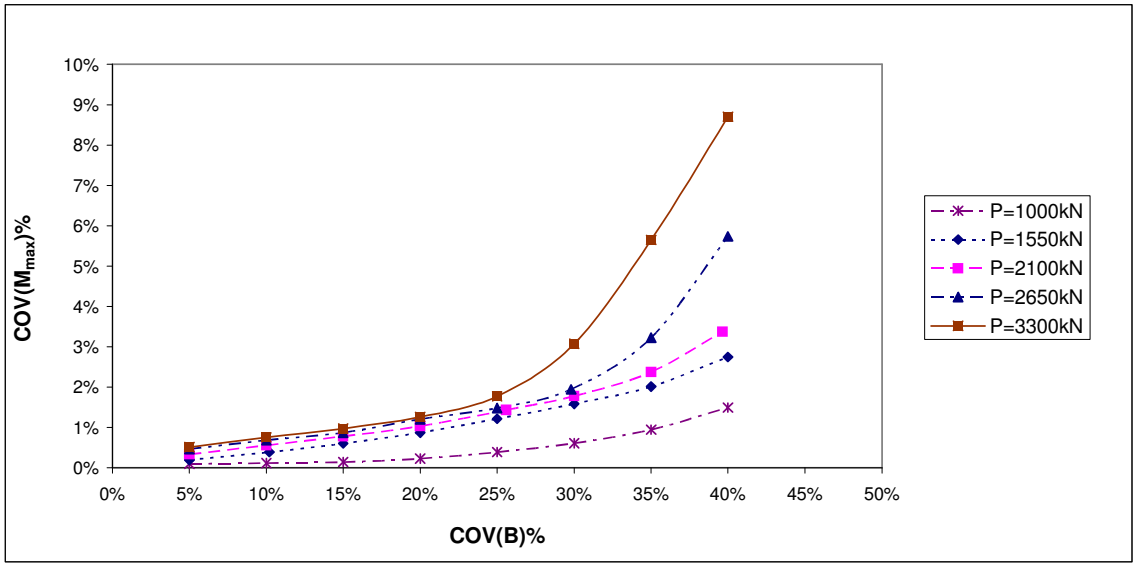


Fig. F.102 Variability of COV (M_{max}) vs. COV (B) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table F.131 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (EI) and load 1000kN.

P=1000kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN-m^2)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		64050	-1.83E+02				
5%	61000			9.30E+06	7.23E-01	1.81E+02	0.25%
		57950	-1.81E+02				
		67100	-1.84E+02				
10%	61000			3.72E+07	2.89E+00	1.81E+02	0.48%
		54900	-1.80E+02				
		70150	-1.84E+02				
15%	61000			8.37E+07	6.50E+00	1.81E+02	0.69%
		51850	-1.79E+02				
		73200	-1.85E+02				
20%	61000			1.49E+08	1.16E+01	1.81E+02	0.92%
		48800	-1.78E+02				
		76250	-1.86E+02				
25%	61000			2.33E+08	1.85E+01	1.81E+02	1.15%
		45750	-1.77E+02				
		79300	-1.87E+02				
30%	61000			3.35E+08	2.76E+01	1.81E+02	1.38%
		42700	-1.76E+02				
		82350	-1.87E+02				
35%	61000			4.56E+08	3.78E+01	1.81E+02	1.63%
		39650	-1.75E+02				
		85400	-1.88E+02				
40%	61000			5.95E+08	5.11E+01	1.81E+02	1.88%
		36600	-1.73E+02				

Table F.132 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (EI) and load 1550kN.

P=1550kN							
COV(EI) (%)	EI° ($kN-m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN-m^2)^2$	VAR (M_{max}) $(kN-m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		64050	-2.92E+02				
5%	61000			9.30E+06	1.32E+00	3.12E+02	0.29%
		57950	-2.89E+02				
		67100	-2.93E+02				
10%	61000			3.72E+07	5.76E+00	3.12E+02	0.59%
		54900	-2.88E+02				
		70150	-2.94E+02				
15%	61000			8.37E+07	1.26E+01	3.12E+02	0.92%
		51850	-2.87E+02				
		73200	-2.95E+02				
20%	61000			1.49E+08	2.26E+01	3.12E+02	1.23%
		48800	-2.85E+02				
		76250	-2.96E+02				
25%	61000			2.33E+08	3.60E+01	3.12E+02	1.52%
		45750	-2.84E+02				
		79300	-2.97E+02				
30%	61000			3.35E+08	5.18E+01	3.12E+02	1.82%
		42700	-2.82E+02				
		82350	-2.97E+02				
35%	61000			4.56E+08	7.06E+01	3.12E+02	2.12%
		39650	-2.81E+02				
		85400	-2.98E+02				
40%	61000			5.95E+08	9.31E+01	3.12E+02	2.43%
		36600	-2.79E+02				

Table F.133 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (EI) and load 2100kN.

P=2100kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	-3.59E+02				
5%	61000			9.30E+06	2.89E+00	4.51E+02	0.38%
		57950	-3.56E+02				
		67100	-3.61E+02				
10%	61000			3.72E+07	1.12E+01	4.51E+02	0.74%
		54900	-3.54E+02				
		70150	-3.63E+02				
15%	61000			8.37E+07	2.55E+01	4.51E+02	1.12%
		51850	-3.52E+02				
		73200	-3.64E+02				
20%	61000			1.49E+08	4.56E+01	4.51E+02	1.50%
		48800	-3.51E+02				
		76250	-3.66E+02				
25%	61000			2.33E+08	7.14E+01	4.51E+02	1.88%
		45750	-3.49E+02				
		79300	-3.67E+02				
30%	61000			3.35E+08	1.03E+02	4.51E+02	2.25%
		42700	-3.47E+02				
		82350	-3.68E+02				
35%	61000			4.56E+08	1.42E+02	4.51E+02	2.64%
		39650	-3.44E+02				
		85400	-3.70E+02				
40%	61000			5.95E+08	1.85E+02	4.51E+02	3.02%
		36600	-3.42E+02				

Table F.134 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (EI) and load 2650kN.

P=2650kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	-4.53E+02				
5%	61000			9.30E+06	2.56E+00	5.51E+02	0.37%
		57950	-4.50E+02				
		67100	-4.55E+02				
10%	61000			3.72E+07	1.06E+01	5.51E+02	0.77%
		54900	-4.48E+02				
		70150	-4.57E+02				
15%	61000			8.37E+07	2.55E+01	5.51E+02	1.14%
		51850	-4.46E+02				
		73200	-4.58E+02				
20%	61000			1.49E+08	4.62E+01	5.51E+02	1.52%
		48800	-4.45E+02				
		76250	-4.60E+02				
25%	61000			2.33E+08	6.97E+01	5.51E+02	1.93%
		45750	-4.43E+02				
		79300	-4.61E+02				
30%	61000			3.35E+08	1.00E+02	5.51E+02	2.31%
		42700	-4.41E+02				
		82350	-4.63E+02				
35%	61000			4.56E+08	1.36E+02	5.51E+02	2.70%
		39650	-4.39E+02				
		85400	-4.64E+02				
40%	61000			5.95E+08	1.80E+02	5.51E+02	3.10%
		36600	-4.37E+02				

Table F.135 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (EI) and load 3300kN.

P=3300kN							
COV(EI) (%)	EI^o ($kN\text{-}m^2$)	EI(current) (kN-m2)	M_{max} (kN-m)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}^o (kN-m)	COV(M_{max}) (%)
		64050	-5.53E+02				
5%	61000			9.30E+06	2.72E+00	6.58E+02	0.47%
		57950	-5.50E+02				
		67100	-5.55E+02				
10%	61000			3.72E+07	9.92E+00	6.58E+02	0.94%
		54900	-5.49E+02				
		70150	-5.56E+02				
15%	61000			8.37E+07	2.07E+01	6.58E+02	1.41%
		51850	-5.47E+02				
		73200	-5.58E+02				
20%	61000			1.49E+08	3.66E+01	6.58E+02	1.88%
		48800	-5.46E+02				
		76250	-5.59E+02				
25%	61000			2.33E+08	5.70E+01	6.58E+02	2.37%
		45750	-5.44E+02				
		79300	-5.60E+02				
30%	61000			3.35E+08	8.28E+01	6.58E+02	2.90%
		42700	-5.42E+02				
		82350	-5.62E+02				
35%	61000			4.56E+08	1.36E+02	6.58E+02	3.39%
		39650	-5.39E+02				
		85400	-5.63E+02				
40%	61000			5.95E+08	1.53E+02	6.58E+02	3.95%
		36600	-5.39E+02				

Table F.136 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 1000kN.

P=1000kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	7.23E-01	0.25%
10%	3.72E+07	2.89E+00	0.48%
15%	8.37E+07	6.50E+00	0.69%
20%	1.49E+08	1.16E+01	0.92%
25%	2.33E+08	1.85E+01	1.15%
30%	3.35E+08	2.76E+01	1.38%
35%	4.56E+08	3.78E+01	1.63%
40%	5.95E+08	5.11E+01	1.88%

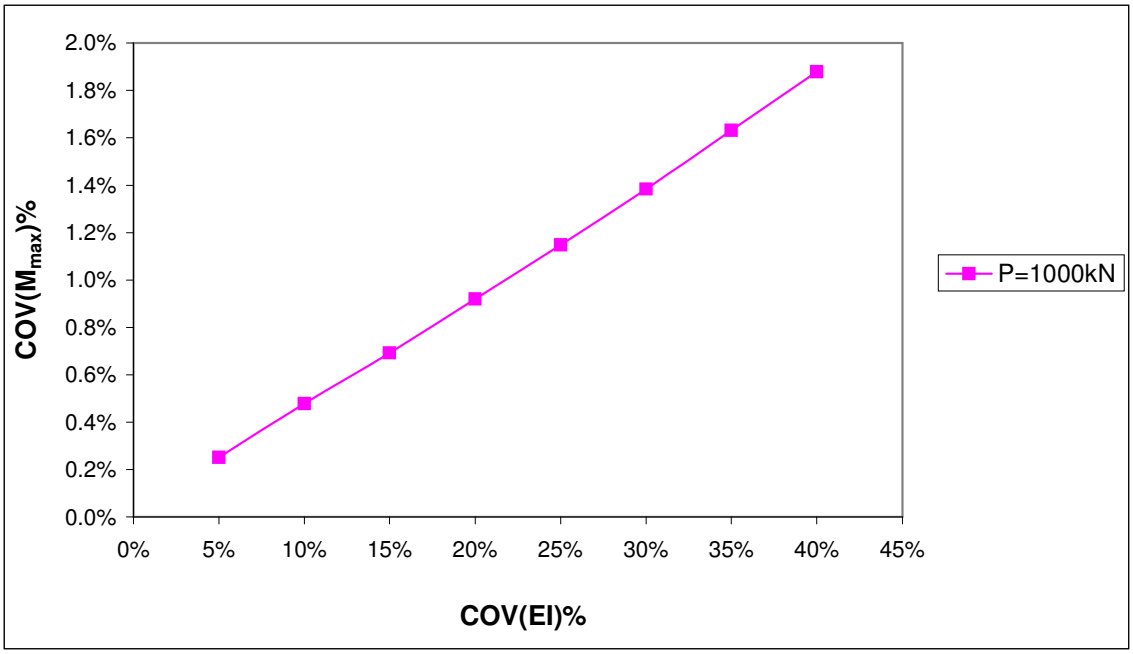


Fig. F.103 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.137 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 1550kN.

P=1550kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	1.32E+00	0.29%
10%	3.72E+07	5.76E+00	0.59%
15%	8.37E+07	1.26E+01	0.92%
20%	1.49E+08	2.26E+01	1.23%
25%	2.33E+08	3.60E+01	1.52%
30%	3.35E+08	5.18E+01	1.82%
35%	4.56E+08	7.06E+01	2.12%
40%	5.95E+08	9.31E+01	2.43%

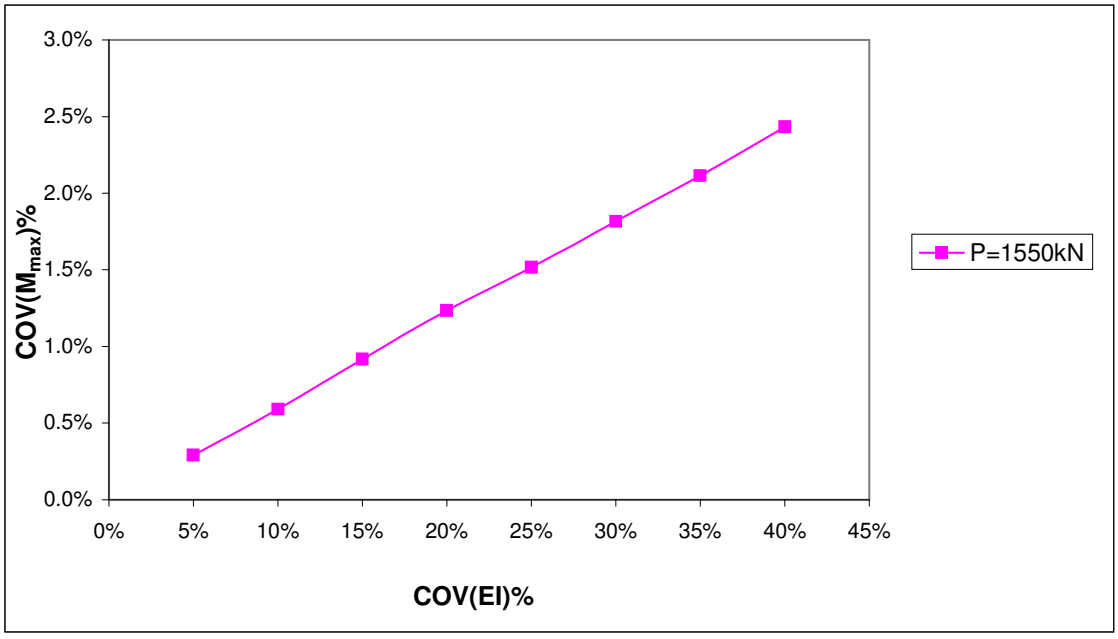


Fig. F.104 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.138 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 2100kN.

P=2100kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	2.89E+00	0.38%
10%	3.72E+07	1.12E+01	0.74%
15%	8.37E+07	2.55E+01	1.12%
20%	1.49E+08	4.56E+01	1.50%
25%	2.33E+08	7.14E+01	1.88%
30%	3.35E+08	1.03E+02	2.25%
35%	4.56E+08	1.42E+02	2.64%
40%	5.95E+08	1.85E+02	3.02%

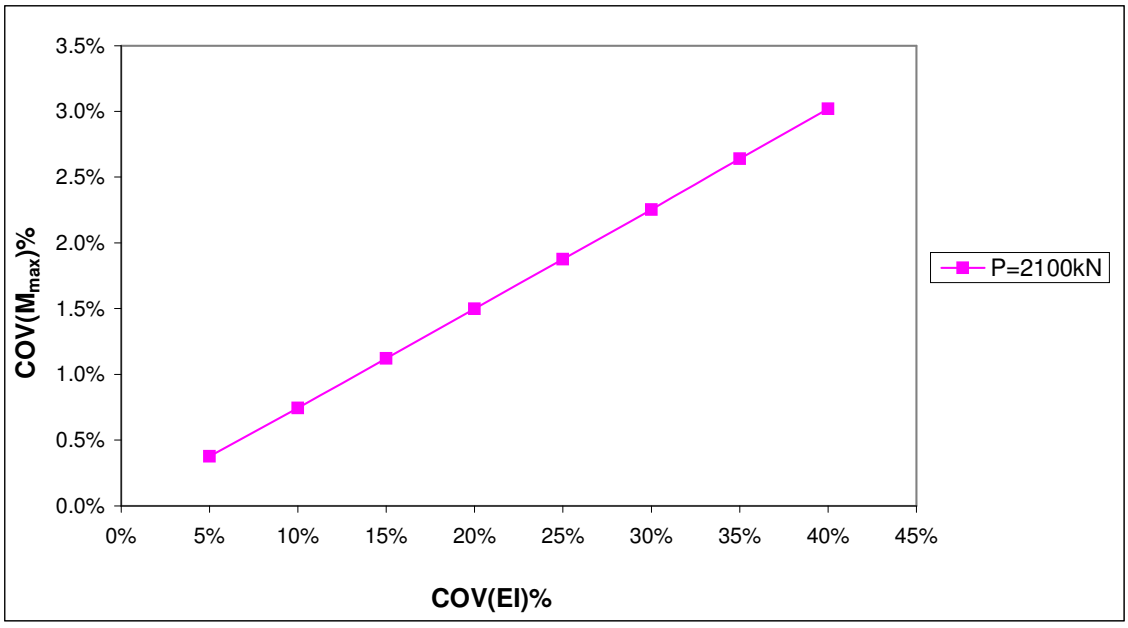


Fig. F.105 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.139 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 2650kN.

P=2650kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	2.56E+00	0.37%
10%	3.72E+07	1.06E+01	0.77%
15%	8.37E+07	2.55E+01	1.14%
20%	1.49E+08	4.62E+01	1.52%
25%	2.33E+08	6.97E+01	1.93%
30%	3.35E+08	1.00E+02	2.31%
35%	4.56E+08	1.36E+02	2.70%
40%	5.95E+08	1.80E+02	3.10%

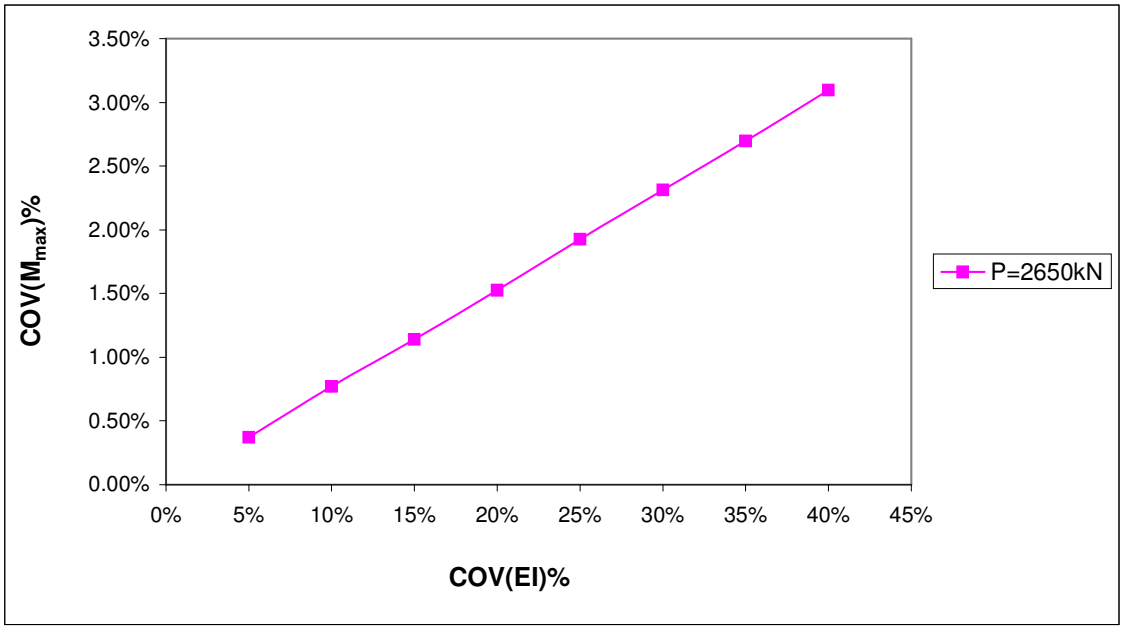


Fig. F.106 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.140 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (EI) and lateral load 3300kN.

P=3300kN			
COV(EI) (%)	VAR(EI) $(kN\text{-}m^2)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	9.30E+06	2.72E+00	0.47%
10%	3.72E+07	9.92E+00	0.94%
15%	8.37E+07	2.07E+01	1.41%
20%	1.49E+08	3.66E+01	1.88%
25%	2.33E+08	5.70E+01	2.37%
30%	3.35E+08	8.28E+01	2.90%
35%	4.56E+08	1.36E+02	3.39%
40%	5.95E+08	1.53E+02	3.95%

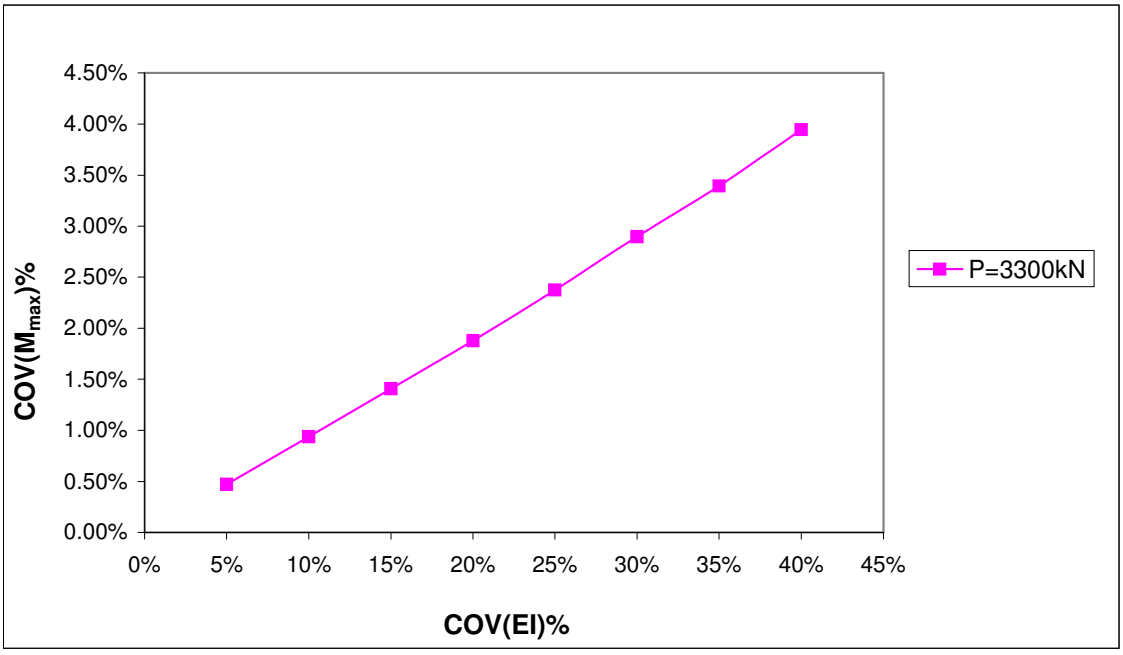


Fig. F.107 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

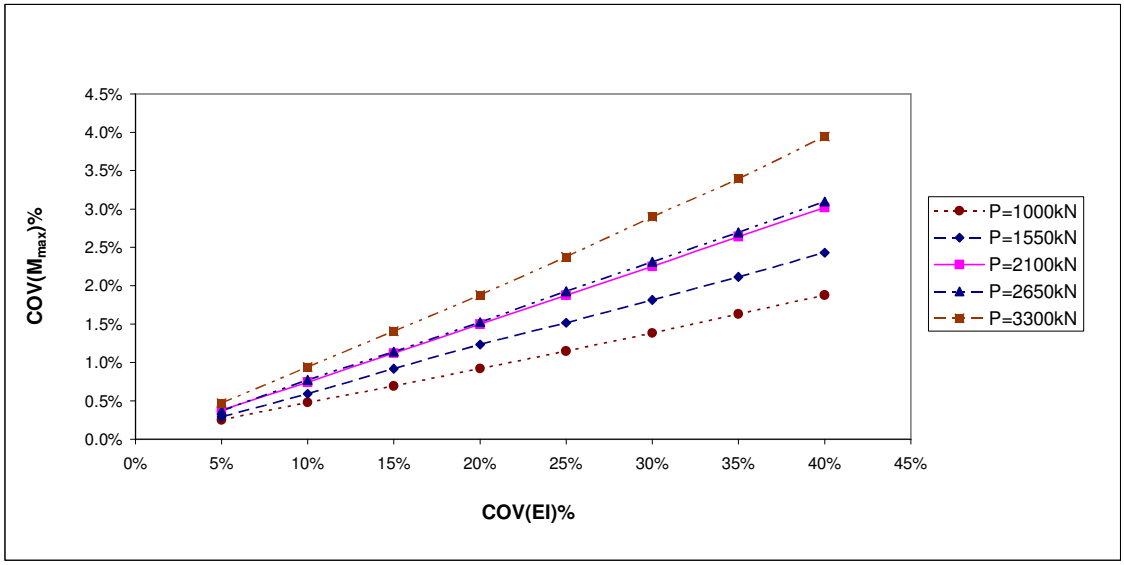


Fig. F.108 Variability of COV (M_{max}) vs. COV (EI) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

Table F.141 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (P) and load 1000kN.

P=1000kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		1050	-1.93E+02				
5%	1000			2.50E+03	1.12E+02	1.81E+02	4.54%
		950	-1.72E+02				
		1100	-2.04E+02				
10%	1000			1.00E+04	4.54E+02	1.81E+02	9.07%
		900	-1.61E+02				
		1150	-2.14E+02				
15%	1000			2.25E+04	1.02E+03	1.81E+02	13.63%
		850	-1.51E+02				
		1200	-2.25E+02				
20%	1000			4.00E+04	1.81E+03	1.81E+02	18.24%
		800	-1.40E+02				
		1250	-2.36E+02				
25%	1000			6.25E+04	2.82E+03	1.81E+02	22.87%
		750	-1.30E+02				
		1300	-2.47E+02				
30%	1000			9.00E+04	4.04E+03	1.81E+02	27.49%
		700	-1.20E+02				
		1350	-2.58E+02				
35%	1000			1.23E+05	5.49E+03	1.81E+02	32.17%
		650	-1.10E+02				
		1400	-2.69E+02				
40%	1000			1.60E+05	7.15E+03	1.81E+02	36.86%
		600	-9.97E+01				

Table F.142 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (P) and load 1550kN.

P=1550kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		1627.5	-2.84E+02				
5%	1550			6.01E+03	2.36E+02	3.12E+02	4.86%
		1472.5	-2.54E+02				
		1705	-3.00E+02				
10%	1550			2.40E+04	9.46E+02	3.12E+02	9.70%
		1395	-2.38E+02				
		1782.5	-3.15E+02				
15%	1550			5.41E+04	2.12E+03	3.12E+02	14.55%
		1317.5	-2.23E+02				
		1860	-3.31E+02				
20%	1550			9.61E+04	3.77E+03	3.12E+02	19.36%
		1240	-2.08E+02				
		1937.5	-3.46E+02				
25%	1550			1.50E+05	5.91E+03	3.12E+02	24.25%
		1162.5	-1.93E+02				
		2015	-3.62E+02				
30%	1550			2.16E+05	8.51E+03	3.12E+02	29.12%
		1085	-1.78E+02				
		2092.5	-3.78E+02				
35%	1550			2.94E+05	1.16E+04	3.12E+02	33.98%
		1007.5	-1.63E+02				
		2170	-3.94E+02				
40%	1550			3.84E+05	1.51E+04	3.12E+02	38.93%
		930	-1.48E+02				

Table F.143 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (P) and load 2100kN.

P=2100kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		2205	-3.78E+02				
5%	2100			1.10E+04	4.18E+02	4.51E+02	4.93%
		1995	-3.37E+02				
		2310	-3.99E+02				
10%	2100			4.41E+04	1.67E+03	4.51E+02	9.87%
		1890	-3.17E+02				
		2415	-4.20E+02				
15%	2100			9.92E+04	3.77E+03	4.51E+02	14.78%
		1785	-2.98E+02				
		2520	-4.42E+02				
20%	2100			1.76E+05	6.76E+03	4.51E+02	19.71%
		1680	-2.78E+02				
		2625	-4.64E+02				
25%	2100			2.76E+05	1.06E+04	4.51E+02	24.67%
		1575	-2.58E+02				
		2730	-4.86E+02				
30%	2100			3.97E+05	1.53E+04	4.51E+02	29.61%
		1470	-2.38E+02				
		2835	-5.09E+02				
35%	2100			5.40E+05	2.10E+04	4.51E+02	34.54%
		1365	-2.19E+02				
		2940	-5.32E+02				
40%	2100			7.06E+05	2.76E+04	4.51E+02	39.49%
		1260	-1.99E+02				

Table F.144 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (P) and load 2650kN.

P=2650kN							
COV(P) (%)	P° (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	M_{max}° (kN-m)	COV(M_{max}) (%)
		2782.5	-4.79E+02				
5%	2650			1.76E+04	7.16E+02	5.51E+02	5.09%
		2517.5	-4.25E+02				
		2915	-5.06E+02				
10%	2650			7.02E+04	2.86E+03	5.51E+02	10.23%
		2385	-3.99E+02				
		3047.5	-5.34E+02				
15%	2650			1.58E+05	6.42E+03	5.51E+02	15.28%
		2252.5	-3.74E+02				
		3180	-5.62E+02				
20%	2650			2.81E+05	1.14E+04	5.51E+02	20.40%
		2120	-3.49E+02				
		3312.5	-5.91E+02				
25%	2650			4.39E+05	1.78E+04	5.51E+02	25.46%
		1987.5	-3.24E+02				
		3445	-6.21E+02				
30%	2650			6.32E+05	2.57E+04	5.51E+02	30.45%
		1855	-3.00E+02				
		3577.5	-6.50E+02				
35%	2650			8.60E+05	3.50E+04	5.51E+02	35.51%
		1722.5	-2.75E+02				
		3710	-6.80E+02				
40%	2650			1.12E+06	4.60E+04	5.51E+02	40.52%
		1590	-2.51E+02				

Table F.145 Probabilistic modeling of laterally loaded fixed head long (10T) pile group with spacing (5D) with varying (P) and load 3300kN.

P=3300kN							
COV(P) (%)	P^o (kN)	P (current) (kN)	M_{max} (kN-m)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	$M_{max}{}^o$ (kN-m)	COV(M_{max}) (%)
		3465	-5.86E+02				
5%	3300			2.72E+04	1.12E+03	6.58E+02	5.85%
		3135	-5.19E+02				
		3630	-6.21E+02				
10%	3300			1.09E+05	4.53E+03	6.58E+02	11.75%
		2970	-4.86E+02				
		3795	-6.55E+02				
15%	3300			2.45E+05	1.01E+04	6.58E+02	17.63%
		2805	-4.54E+02				
		3960	-6.91E+02				
20%	3300			4.36E+05	1.80E+04	6.58E+02	23.45%
		2640	-4.23E+02				
		4125	-7.27E+02				
25%	3300			6.81E+05	2.80E+04	6.58E+02	29.30%
		2475	-3.92E+02				
		4290	-7.63E+02				
30%	3300			9.80E+05	4.01E+04	6.58E+02	35.10%
		2310	-3.62E+02				
		4455	-8.00E+02				
35%	3300			1.33E+06	5.45E+04	6.58E+02	40.89%
		2145	-3.33E+02				
		4620	-8.37E+02				
40%	3300			1.74E+06	7.10E+04	6.58E+02	46.66%
		1980	-3.04E+02				

Table F.146 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 1000kN.

P=1000kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.50E+03	4.54%	4.54%
10%	1.00E+04	9.07%	9.07%
15%	2.25E+04	13.63%	13.63%
20%	4.00E+04	18.24%	18.24%
25%	6.25E+04	22.87%	22.87%
30%	9.00E+04	27.49%	27.49%
35%	1.23E+05	32.17%	32.17%
40%	1.60E+05	36.86%	36.86%

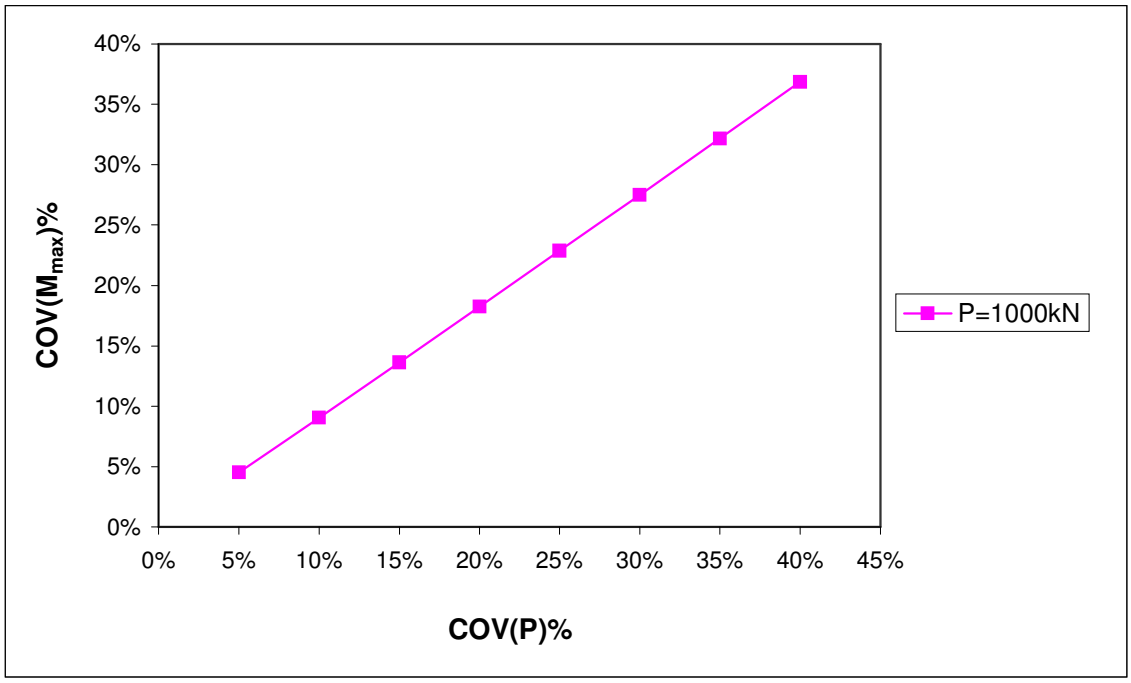


Fig. F.109 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1000kN.

Table F.147 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 1550kN.

P=1550kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	6.01E+03	2.36E+02	4.86%
10%	2.40E+04	9.46E+02	9.70%
15%	5.41E+04	2.12E+03	14.55%
20%	9.61E+04	3.77E+03	19.36%
25%	1.50E+05	5.91E+03	24.25%
30%	2.16E+05	8.51E+03	29.12%
35%	2.94E+05	1.16E+04	33.98%
40%	3.84E+05	1.51E+04	38.93%

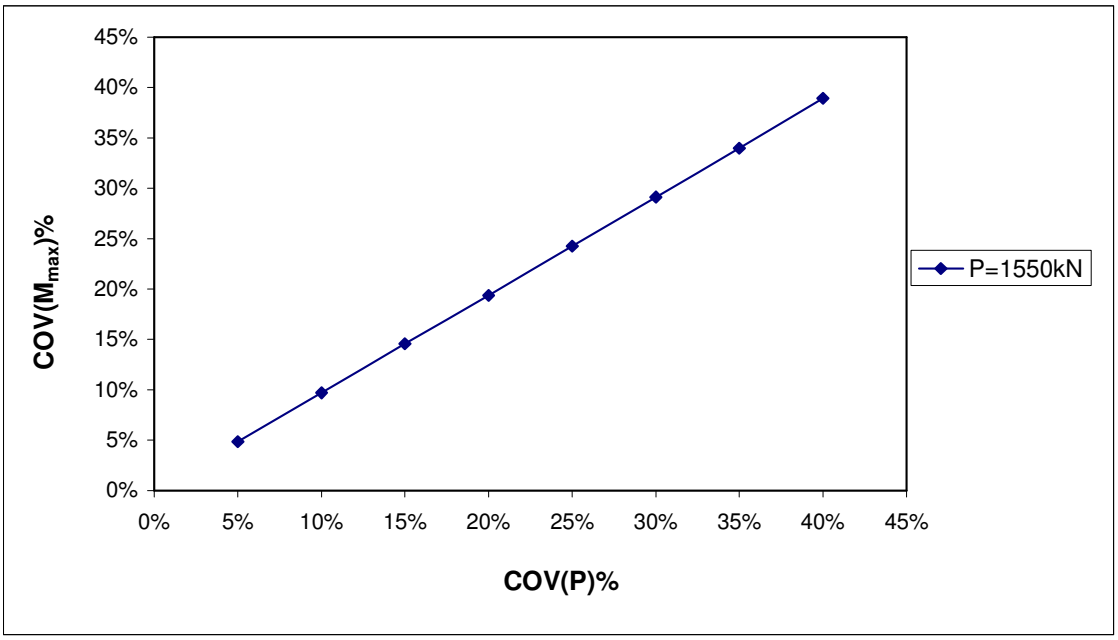


Fig. F.110 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 1550kN.

Table F.148 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 2100kN.

P=2100kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	1.10E+04	4.18E+02	4.93%
10%	4.41E+04	1.67E+03	9.87%
15%	9.92E+04	3.77E+03	14.78%
20%	1.76E+05	6.76E+03	19.71%
25%	2.76E+05	1.06E+04	24.67%
30%	3.97E+05	1.53E+04	29.61%
35%	5.40E+05	2.10E+04	34.54%
40%	7.06E+05	2.76E+04	39.49%

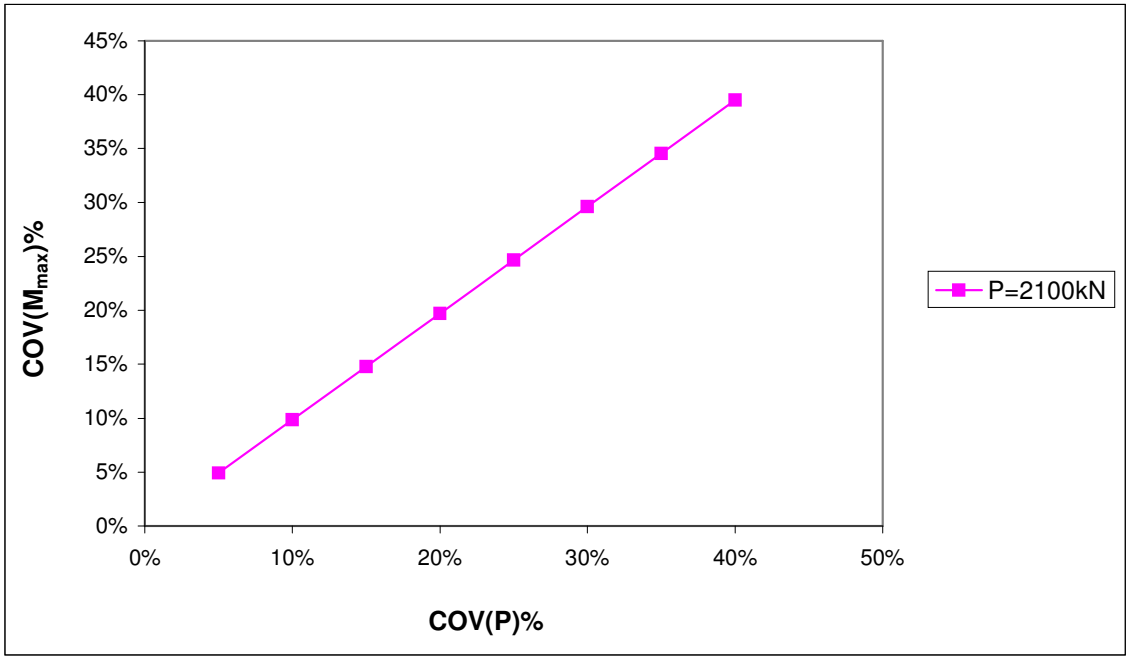


Fig. F.111 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2100kN.

Table F.149 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 2650kN.

P=2650kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	1.76E+04	7.16E+02	5.09%
10%	7.02E+04	2.86E+03	10.23%
15%	1.58E+05	6.42E+03	15.28%
20%	2.81E+05	1.14E+04	20.40%
25%	4.39E+05	1.78E+04	25.46%
30%	6.32E+05	2.57E+04	30.45%
35%	8.60E+05	3.50E+04	35.51%
40%	1.12E+06	4.60E+04	40.52%

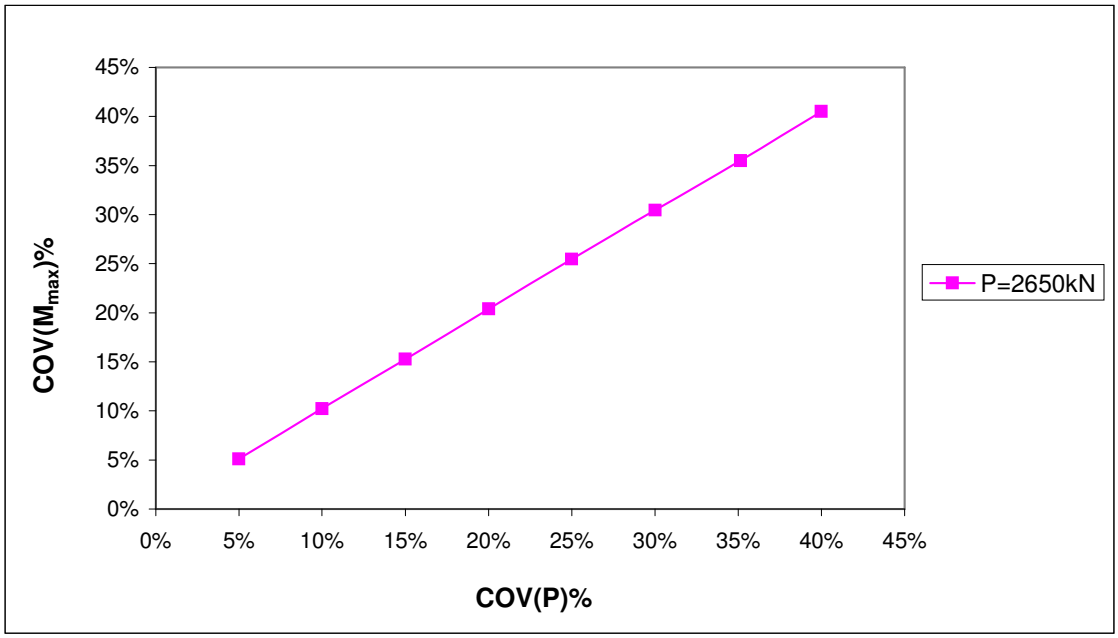


Fig. F.112 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 2650kN.

Table F.150 Value of COV (M_{max}) for fixed head long (10T) pile group with spacing (5D) with varying COV (P) and lateral load 3300kN.

P=3300kN			
COV(P) (%)	VAR(P) $(kN)^2$	VAR (M_{max}) $(kN\text{-}m)^2$	COV(M_{max}) (%)
5%	2.72E+04	1.12E+03	5.85%
10%	1.09E+05	4.53E+03	11.75%
15%	2.45E+05	1.01E+04	17.63%
20%	4.36E+05	1.80E+04	23.45%
25%	6.81E+05	2.80E+04	29.30%
30%	9.80E+05	4.01E+04	35.10%
35%	1.33E+06	5.45E+04	40.89%
40%	1.74E+06	7.10E+04	46.66%

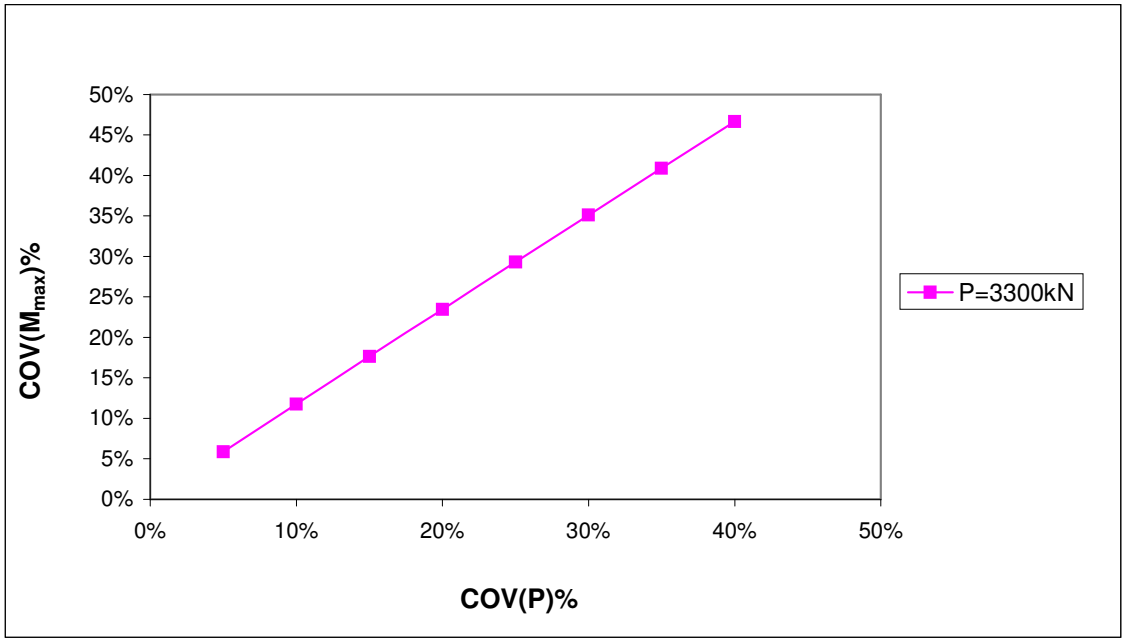


Fig. F.113 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force 3300kN.

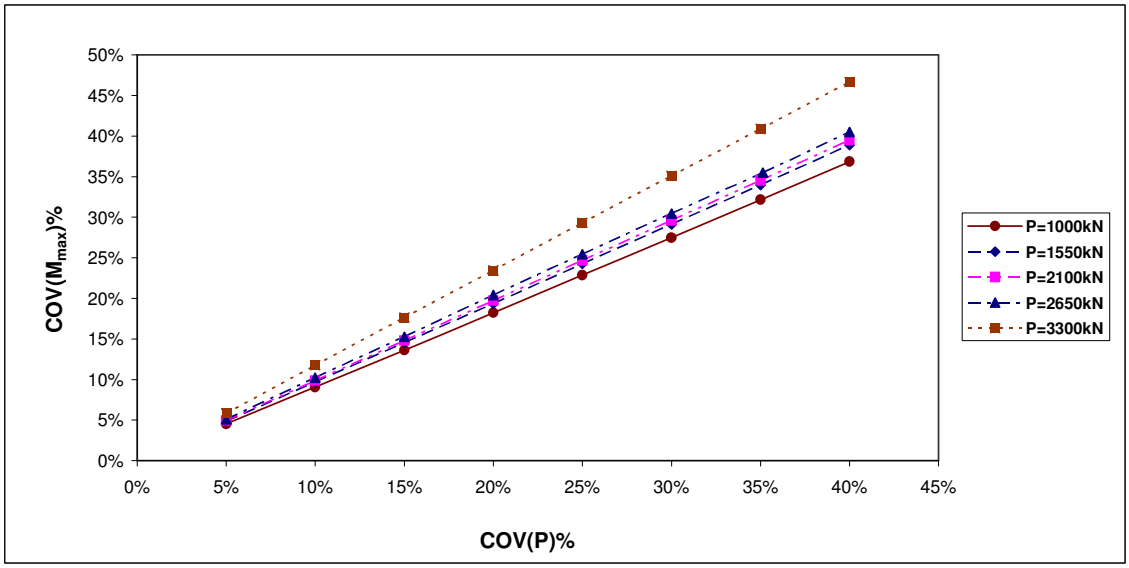


Fig. F.114 Variability of COV (M_{max}) vs. COV (P) for fixed head long (10T) pile group with spacing (5D) subjected to lateral force of discrete variability.

F.5 Reliability Index of bending moment vs. COV (Variables)

Table F.151 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.36E+01	10696.73	5%	103.5875	4.9070
1.35E+02	10696.73	10%	104.0735	4.8840
3.03E+02	10696.73	15%	104.8785	4.8466
5.36E+02	10696.73	20%	105.9842	4.7960
8.38E+02	10696.73	25%	107.4003	4.7328
1.22E+03	10696.73	30%	109.1707	4.6560
1.66E+03	10696.73	35%	111.1817	4.5718
2.21E+03	10696.73	40%	113.6241	4.4735

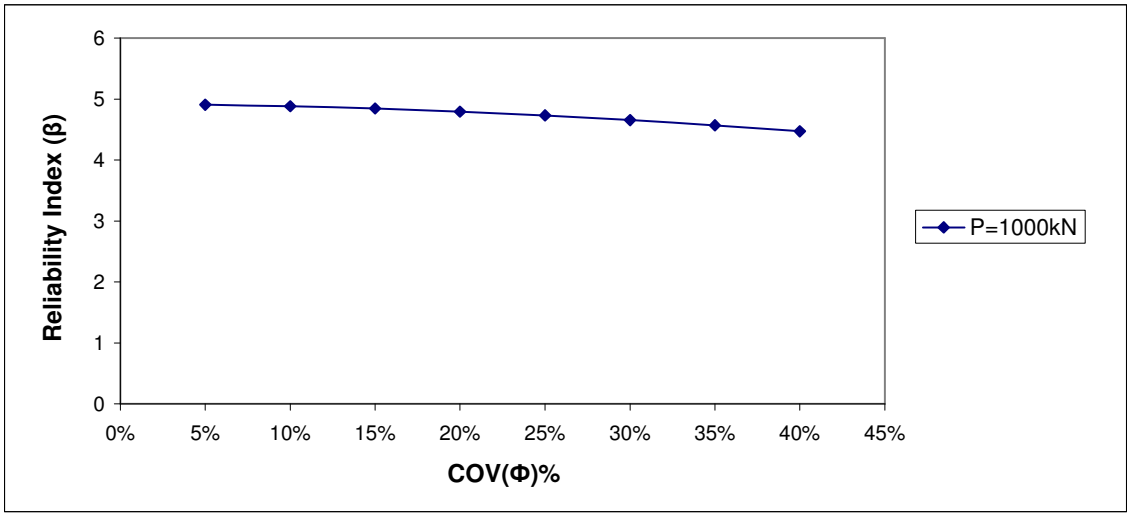


Fig. F.115 Reliability Index (β) of M_{max} vs. COV(Φ) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table F.152 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 1550kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
6.48E+01	10696.73	5%	103.7378	3.6438
2.59E+02	10696.73	10%	104.6706	3.6113
5.88E+02	10696.73	15%	106.2299	3.5583
1.06E+03	10696.73	20%	108.4262	3.4862
1.70E+03	10696.73	25%	111.3291	3.3953
2.54E+03	10696.73	30%	115.0298	3.2861
3.59E+03	10696.73	35%	119.5439	3.1620
4.97E+03	10696.73	40%	125.1678	3.0199

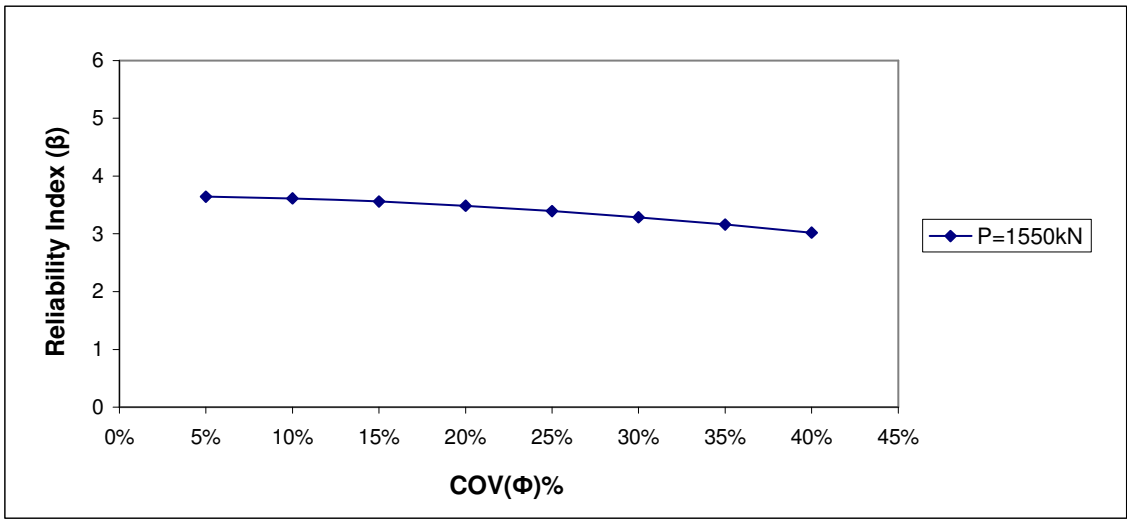


Fig. F.116 Reliability Index (β) of M_{max} vs. COV(Φ) for fixed head long pile group (10T) subjected to lateral force 1550kN.

Table F.153 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 2100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.19E+02	10696.73	5%	103.9978	2.2972
4.69E+02	10696.73	10%	105.6667	2.2609
1.09E+03	10696.73	15%	108.5773	2.2003
2.01E+03	10696.73	20%	112.7309	2.1192
3.25E+03	10696.73	25%	118.1162	2.0226
4.94E+03	10696.73	30%	125.0272	1.9108
7.17E+03	10696.73	35%	133.6818	1.7871
1.01E+04	10696.73	40%	144.1767	1.6570

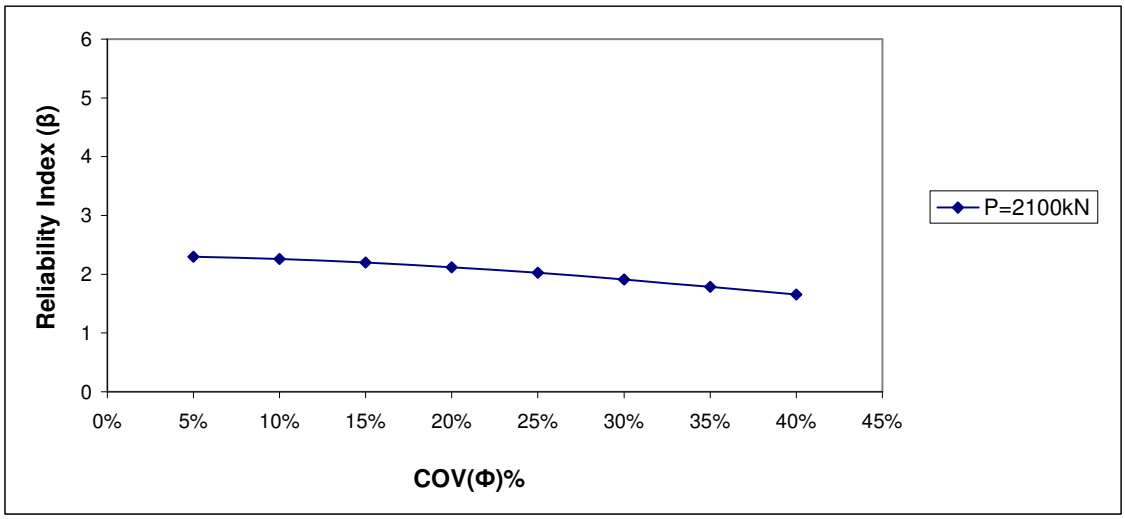


Fig. F.117 Reliability Index (β) of M_{max} vs. COV(Φ) for fixed head long pile group (10T) subjected to lateral force 2100kN.

Table F.154 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 2650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(Φ) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.21E+02	10696.73	5%	104.4857	1.3275
8.91E+02	10696.73	10%	107.6464	1.2885
2.03E+03	10696.73	15%	112.8306	1.2293
3.71E+03	10696.73	20%	120.0231	1.1556
6.01E+03	10696.73	25%	129.2400	1.0732
9.06E+03	10696.73	30%	140.5695	0.9867
1.32E+04	10696.73	35%	154.5179	0.8976
1.87E+04	10696.73	40%	171.5760	0.8084

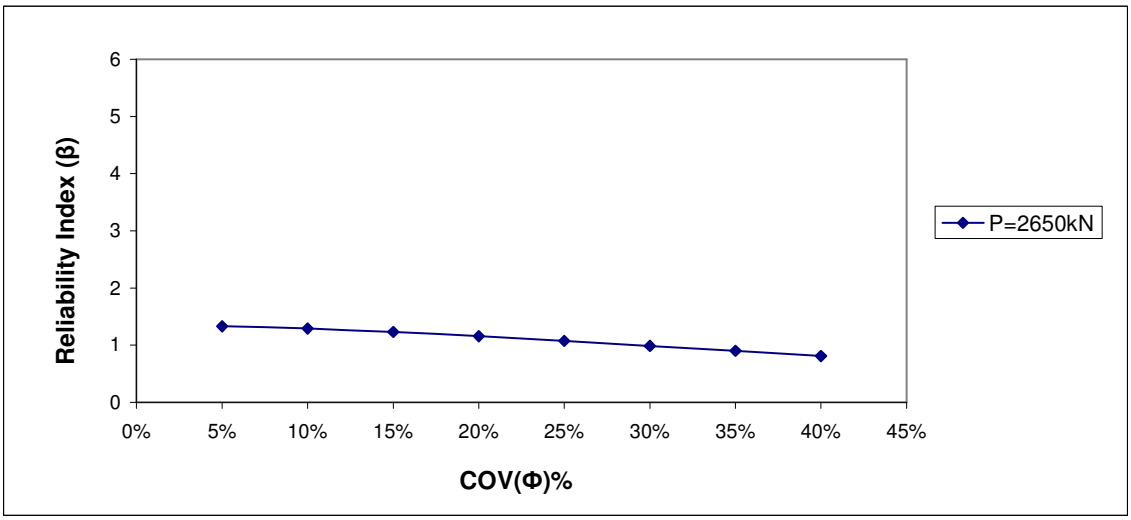


Fig. F.118 Reliability Index (β) of M_{max} vs. COV(Φ) for fixed head long pile group (10T) subjected to lateral force 2650kN.

Table F.155 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'Φ' subjected to lateral load 3300kN.

VAR (M_{max}) (kN-m)^2	VAR (M_{max}^{max}) (kN-m)^2	COV(Φ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
3.80E+02	10696.73	5%	105.2472	0.3021
1.56E+03	10696.73	10%	110.7291	0.2872
3.61E+03	10696.73	15%	119.5940	0.2659
6.50E+03	10696.73	20%	131.1224	0.2425
1.04E+04	10696.73	25%	145.3663	0.2188
1.57E+04	10696.73	30%	162.3939	0.1958
2.26E+04	10696.73	35%	182.4468	0.1743
3.15E+04	10696.73	40%	205.5200	0.1547

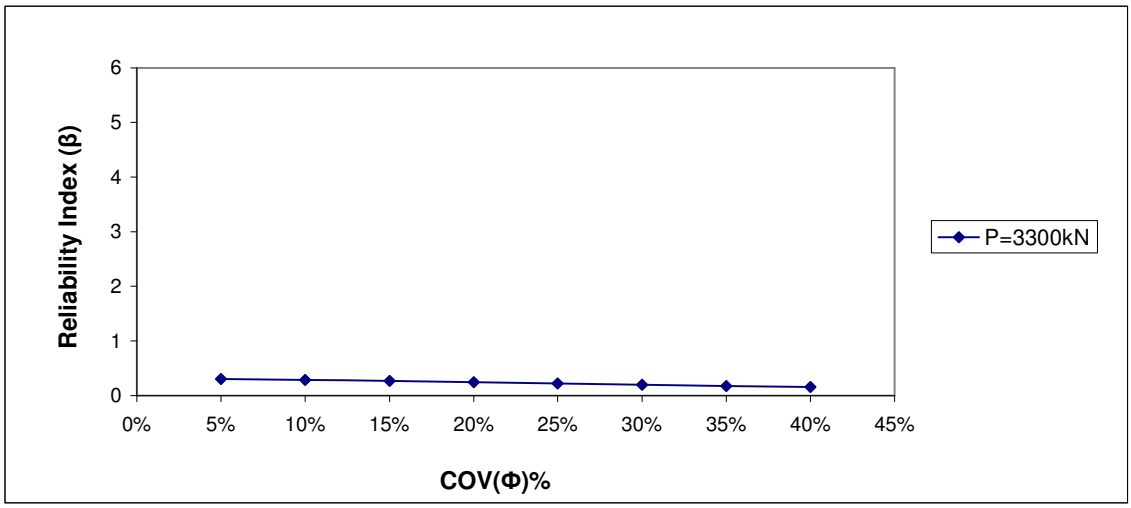


Fig. F.119 Reliability Index (β) of M_{max} vs. COV(Φ) for fixed head long pile group (10T) subjected to lateral force 3300kN.

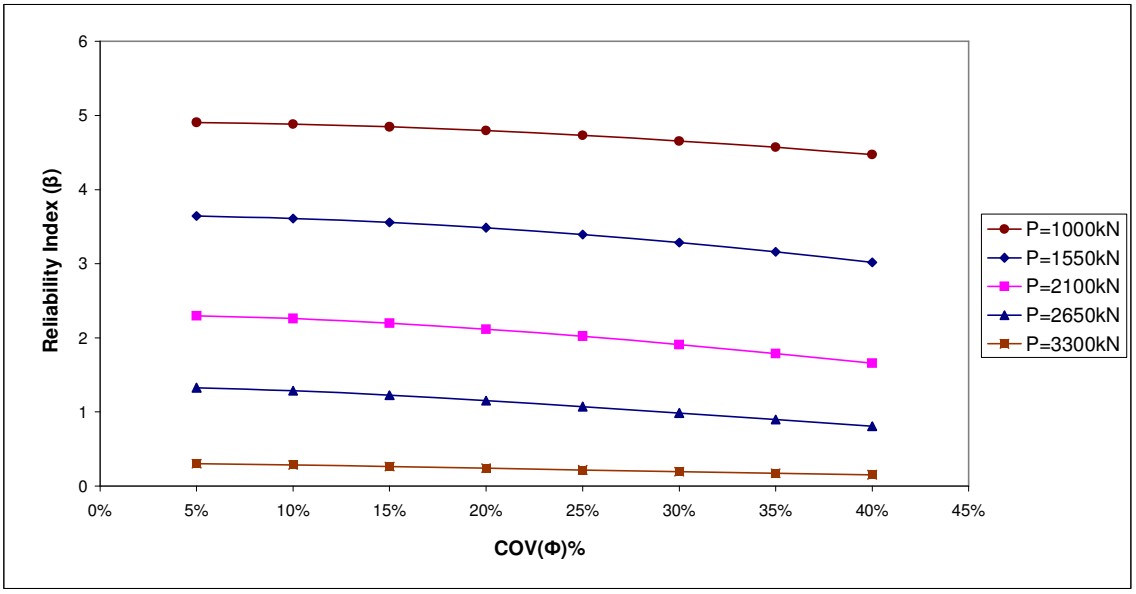


Fig. F.120 Reliability Index (β) of M_{max} vs. COV(Φ) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table F.156 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
6.25E+00	10696.73	5%	103.4552	4.9132
2.40E+01	10696.73	10%	103.5410	4.9092
5.40E+01	10696.73	15%	103.6858	4.9023
1.00E+02	10696.73	20%	103.9073	4.8919
1.58E+02	10696.73	25%	104.1837	4.8789
2.31E+02	10696.73	30%	104.5360	4.8624
3.22E+02	10696.73	35%	104.9711	4.8423
4.37E+02	10696.73	40%	105.5156	4.8173

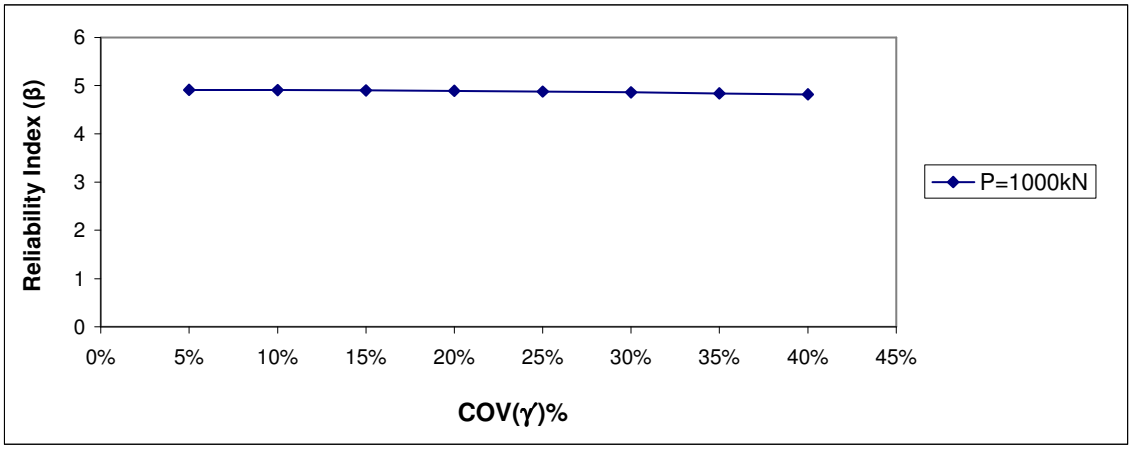


Fig. F.121 Reliability Index (β) of M_{max} vs. COV(γ) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table F.157 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 1550kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.16E+01	10696.73	5%	103.4809	3.6528
4.56E+01	10696.73	10%	103.6450	3.6471
1.04E+02	10696.73	15%	103.9268	3.6372
1.89E+02	10696.73	20%	104.3350	3.6229
2.99E+02	10696.73	25%	104.8619	3.6047
4.41E+02	10696.73	30%	105.5354	3.5817
6.23E+02	10696.73	35%	106.3919	3.5529
8.50E+02	10696.73	40%	107.4544	3.5178

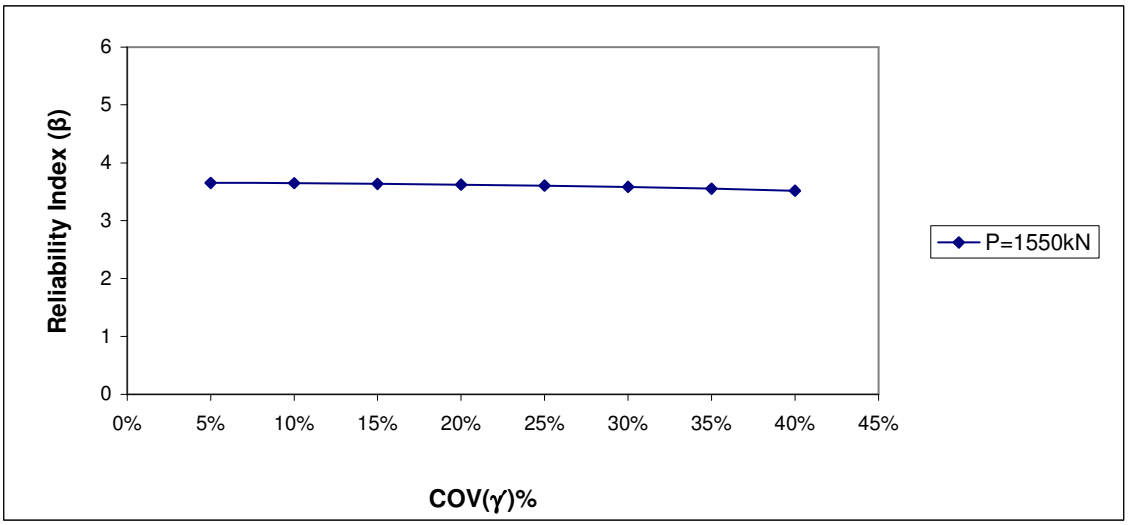


Fig. F.122 Reliability Index (β) of M_{max} vs. COV(γ) for fixed head long pile group (10T) subjected to lateral force 1550kN.

Table F.158 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 2100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
1.98E+01	10696.73	5%	103.5207	2.3078
8.19E+01	10696.73	10%	103.8202	2.3011
1.90E+02	10696.73	15%	104.3416	2.2896
3.42E+02	10696.73	20%	105.0666	2.2738
5.50E+02	10696.73	25%	106.0501	2.2527
8.24E+02	10696.73	30%	107.3332	2.2258
1.17E+03	10696.73	35%	108.9329	2.1931
1.61E+03	10696.73	40%	110.9448	2.1533

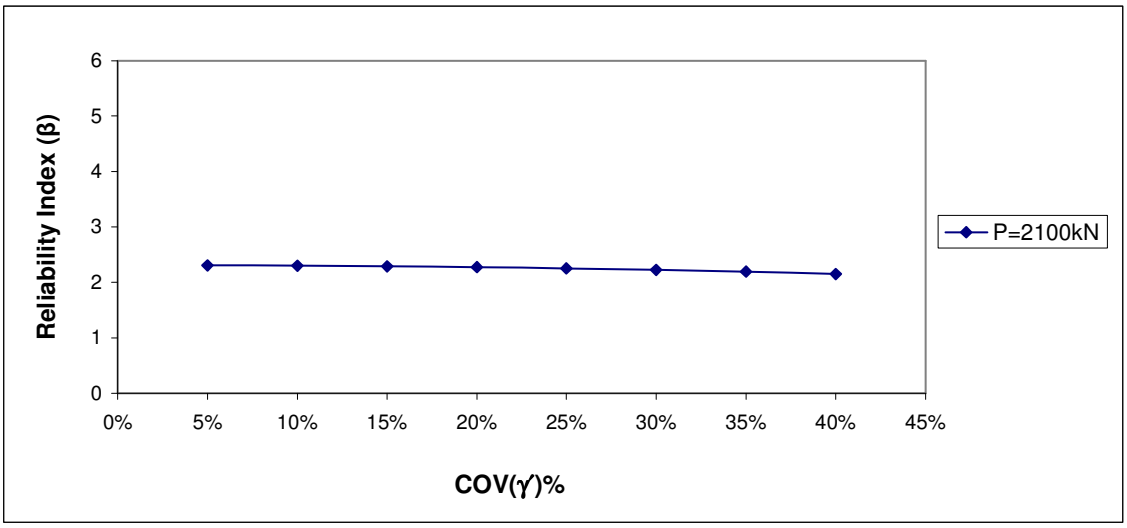


Fig. F.123 Reliability Index (β) of M_{max} vs. COV(γ) for fixed head long pile group (10T) subjected to lateral force 2100kN.

Table F.159 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 2650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
3.91E+01	10696.73	5%	103.6137	1.3386
1.55E+02	10696.73	10%	104.1717	1.3315
3.53E+02	10696.73	15%	105.1198	1.3194
6.35E+02	10696.73	20%	106.4508	1.3029
1.02E+03	10696.73	25%	108.2623	1.2811
1.53E+03	10696.73	30%	110.5869	1.2542
2.15E+03	10696.73	35%	113.3360	1.2238
2.96E+03	10696.73	40%	116.8826	1.1867

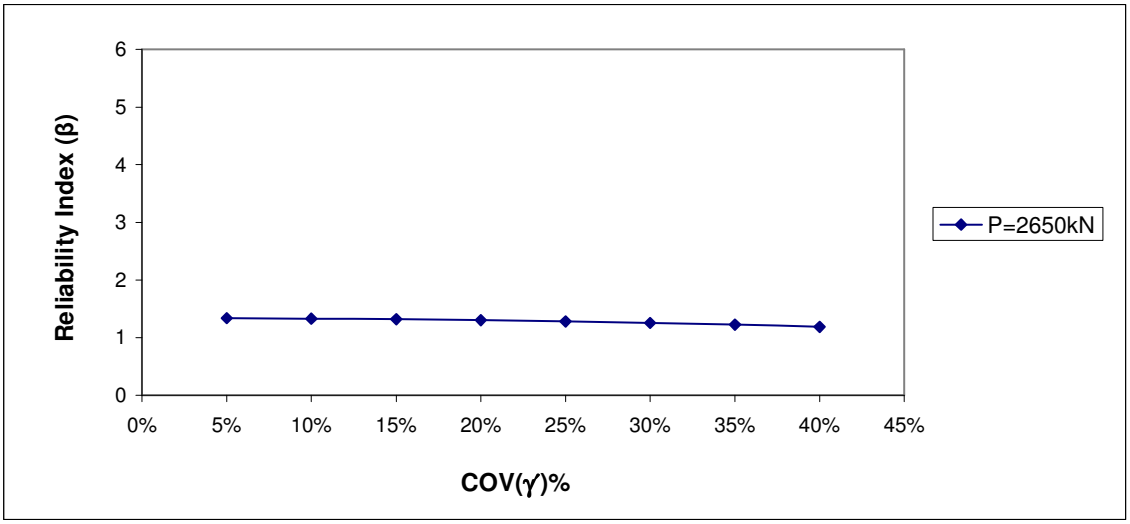


Fig. F.124 Reliability Index (β) of M_{max} vs. COV(γ) for fixed head long pile group (10T) subjected to lateral force 2650kN.

Table F.160 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'γ' subjected to lateral load 3300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(γ) (%)	σ(M_{max}^{M}) (kN-m)	Reliability Index (β)
6.40E+01	10696.73	5%	103.7339	0.3066
2.58E+02	10696.73	10%	104.6630	0.3038
5.88E+02	10696.73	15%	106.2299	0.2994
1.08E+03	10696.73	20%	108.5317	0.2930
1.72E+03	10696.73	25%	111.4405	0.2854
2.52E+03	10696.73	30%	114.9642	0.2766
3.62E+03	10696.73	35%	119.6443	0.2658
4.93E+03	10696.73	40%	124.9991	0.2544

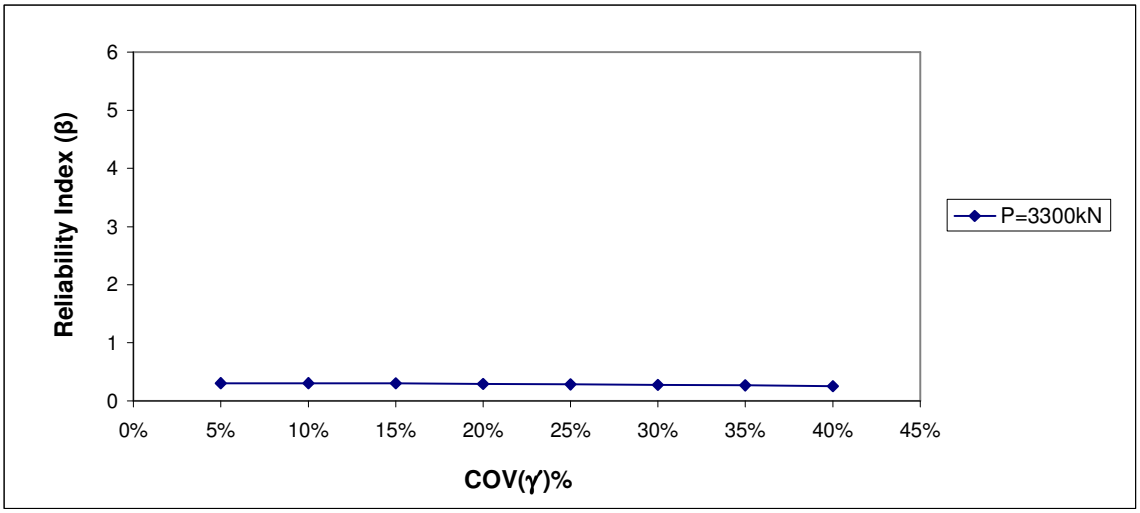


Fig. F.125 Reliability Index (β) of M_{max} vs. COV(γ) for fixed head long pile group (10T) subjected to lateral force 3100kN.

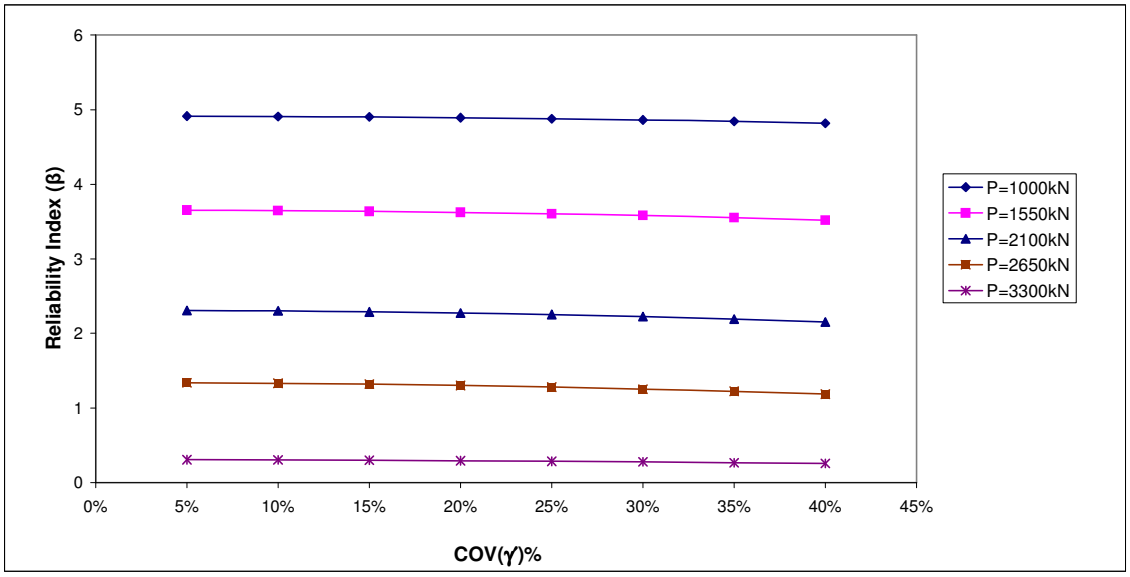


Fig. F.126 Reliability Index (β) of M_{max} vs. COV(γ) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table F.161 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E-02	10696.73	5%	103.4250	4.9147
2.25E-02	10696.73	10%	103.4251	4.9147
4.00E-02	10696.73	15%	103.4252	4.9147
9.00E-02	10696.73	20%	103.4254	4.9147
1.22E-01	10696.73	25%	103.4256	4.9146
1.60E-01	10696.73	30%	103.4258	4.9146
3.60E-01	10696.73	35%	103.4267	4.9146
5.63E-01	10696.73	40%	103.4277	4.9145

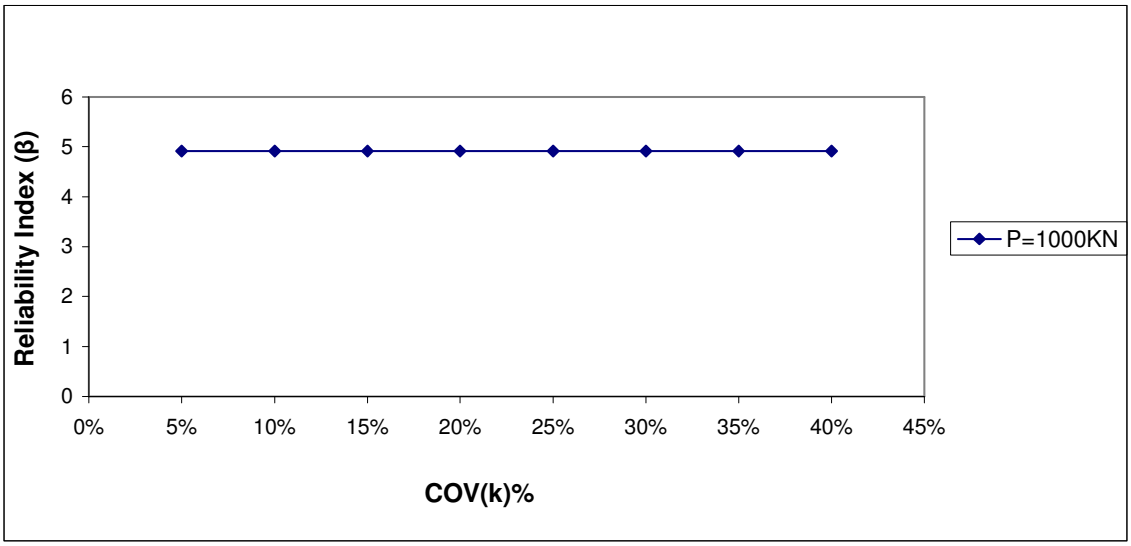


Fig. F.127 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table F.162 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 1550kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E-02	10696.73	5%	103.4250	3.6548
1.00E-02	10696.73	10%	103.4250	3.6548
4.00E-02	10696.73	15%	103.4252	3.6548
6.25E-02	10696.73	20%	103.4253	3.6548
1.22E-01	10696.73	25%	103.4256	3.6548
1.60E-01	10696.73	30%	103.4258	3.6548
2.50E-01	10696.73	35%	103.4262	3.6548
4.90E-01	10696.73	40%	103.4274	3.6547

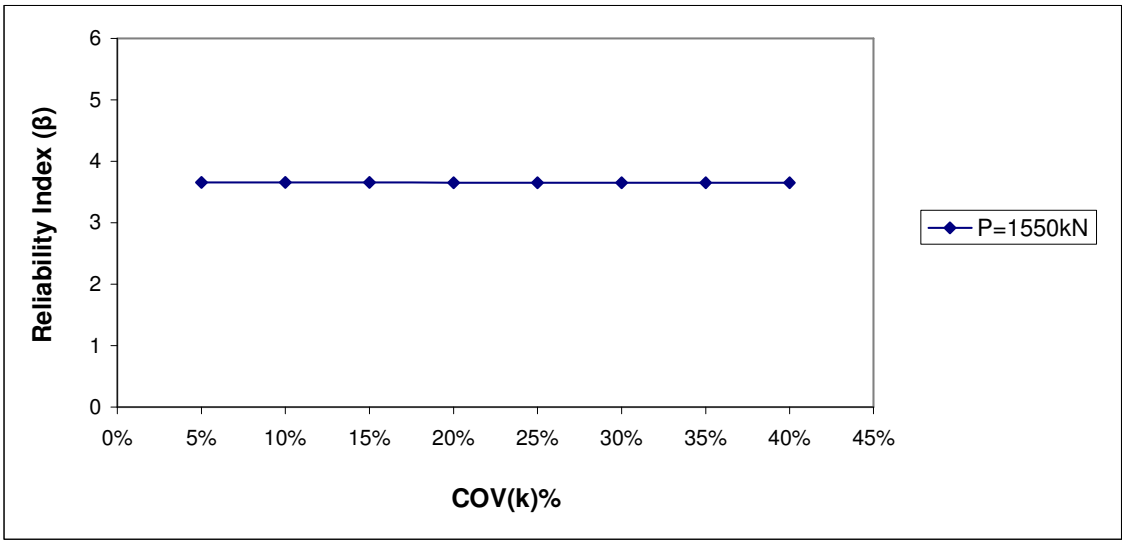


Fig. F.128 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 1550kN.

Table F.163 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 2100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E-02	10696.73	5%	103.4250	2.3099
4.00E-02	10696.73	10%	103.4252	2.3099
9.00E-02	10696.73	15%	103.4254	2.3099
9.00E-02	10696.73	20%	103.4254	2.3099
1.22E-01	10696.73	25%	103.4256	2.3099
2.02E-01	10696.73	30%	103.4260	2.3099
3.60E-01	10696.73	35%	103.4267	2.3098
5.63E-01	10696.73	40%	103.4277	2.3098

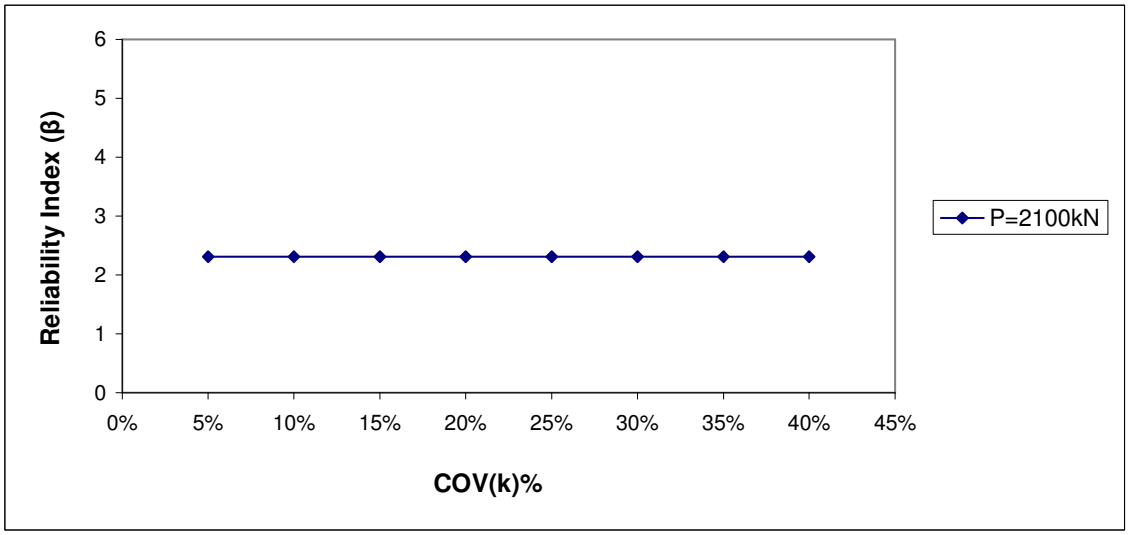


Fig. F.129 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 2100kN.

Table F.164 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 2650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.00E-02	10696.73	5%	103.4250	1.3411
1.00E-02	10696.73	10%	103.4250	1.3411
6.25E-02	10696.73	15%	103.4253	1.3411
2.03E-01	10696.73	20%	103.4260	1.3411
3.60E-01	10696.73	25%	103.4267	1.3410
4.90E-01	10696.73	30%	103.4274	1.3410
7.22E-01	10696.73	35%	103.4285	1.3410
1.00E+00	10696.73	40%	103.4298	1.3410

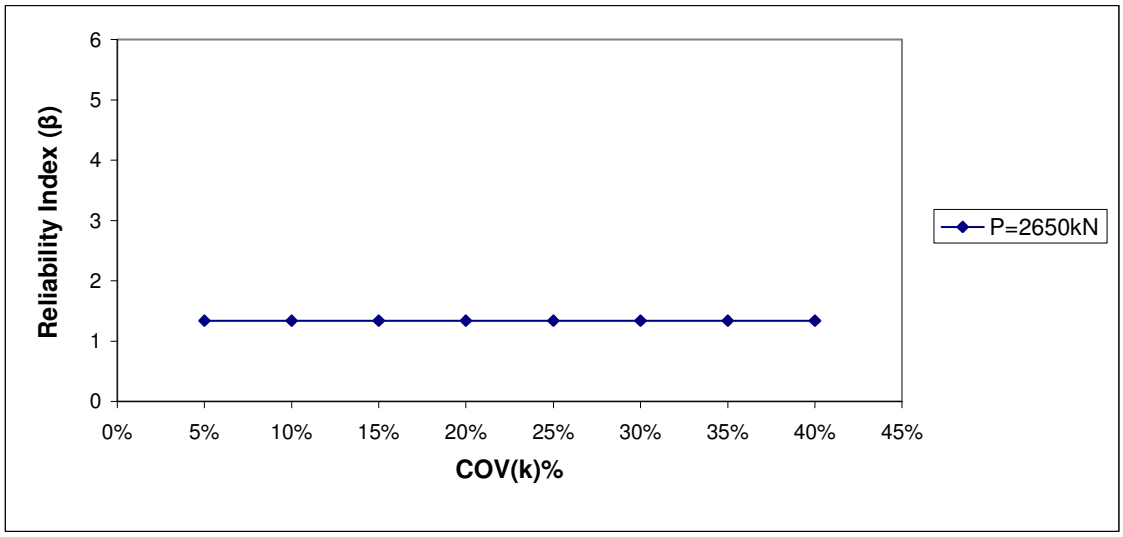


Fig. F.130 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 2650kN.

Table F.165 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'k' subjected to lateral load 3300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(k) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.00E-02	10696.73	5%	103.4252	0.3075
1.22E-01	10696.73	10%	103.4256	0.3075
2.50E-01	10696.73	15%	103.4262	0.3075
3.60E-01	10696.73	20%	103.4267	0.3075
5.63E-01	10696.73	25%	103.4277	0.3075
8.10E-01	10696.73	30%	103.4289	0.3075
1.32E+00	10696.73	35%	103.4314	0.3075
2.25E+00	10696.73	40%	103.4359	0.3074

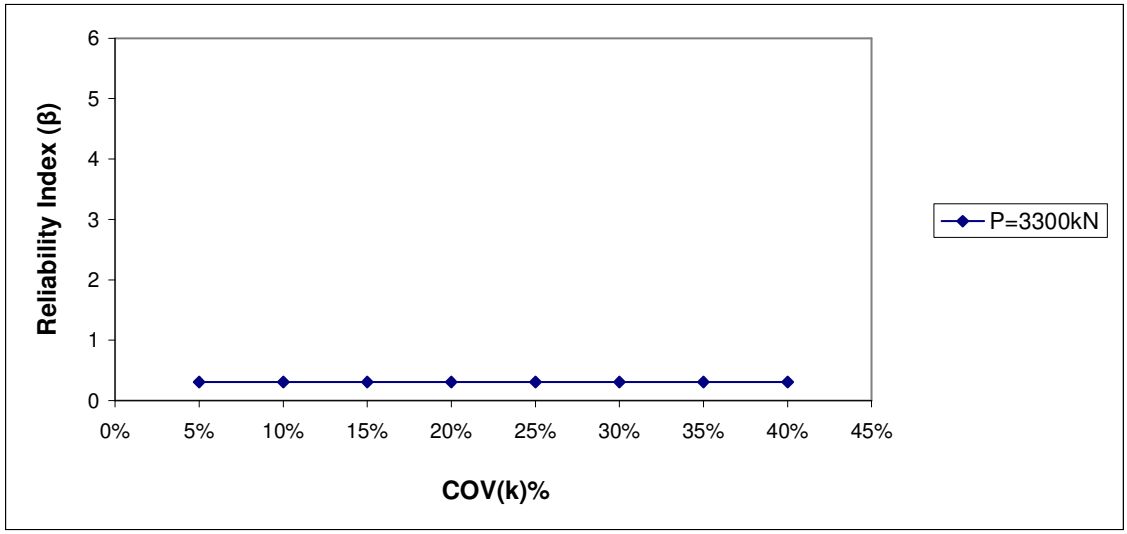


Fig. F.131 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force 3300kN.

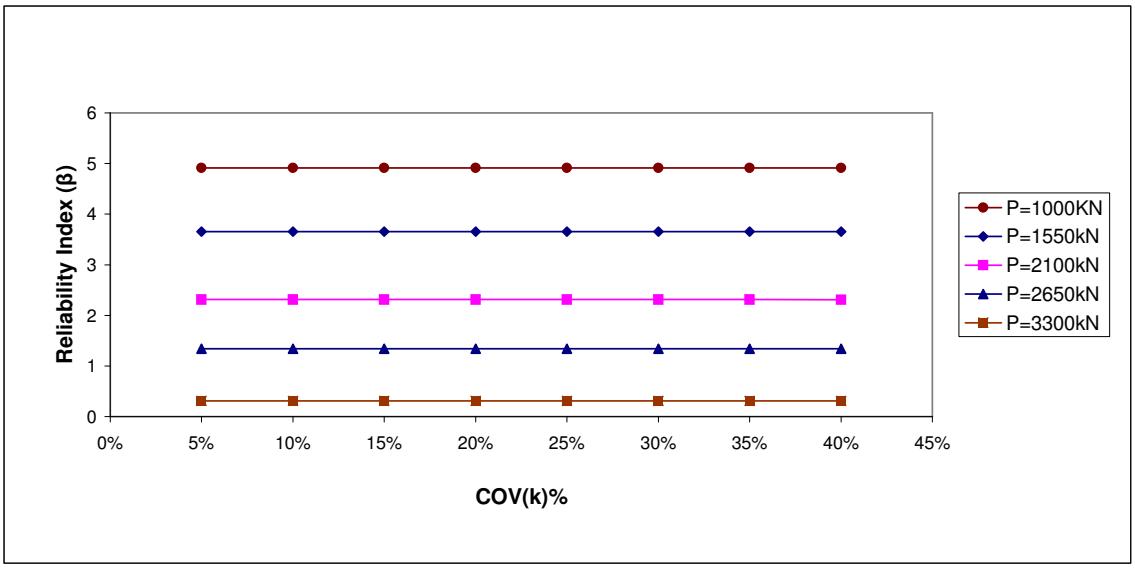


Fig. F.132 Reliability Index (β) of M_{max} vs. COV (k) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table F.166 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.22E-01	10696.73	5%	103.4270	4.9146
4.22E-01	10696.73	10%	103.4270	4.9146
4.22E-01	10696.73	15%	103.4270	4.9146
9.00E-02	10696.73	20%	103.4254	4.9147
4.90E-01	10696.73	25%	103.4274	4.9146
1.21E+00	10696.73	30%	103.4308	4.9144
2.93E+00	10696.73	35%	103.4391	4.9140
7.29E+00	10696.73	40%	103.4602	4.9130

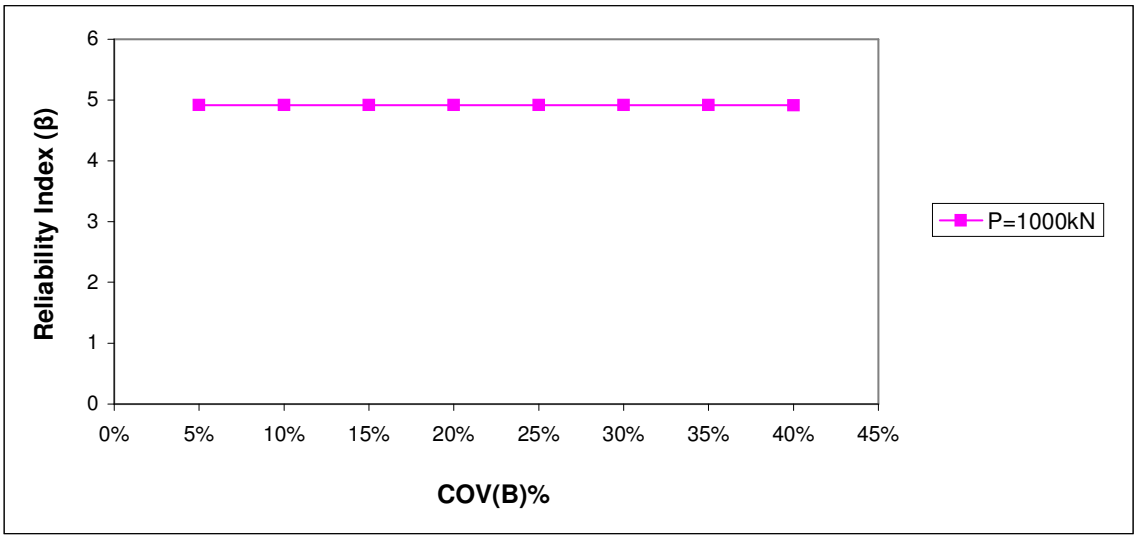


Fig. F.133 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table F.167 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 1550kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.60E-01	10696.73	5%	103.4267	3.6548
1.84E+00	10696.73	10%	103.4339	3.6545
4.41E+00	10696.73	15%	103.4463	3.6541
9.30E+00	10696.73	20%	103.4700	3.6532
1.76E+01	10696.73	25%	103.5102	3.6518
2.81E+01	10696.73	30%	103.5607	3.6500
4.55E+01	10696.73	35%	103.6446	3.6471
7.31E+01	10696.73	40%	103.7778	3.6424

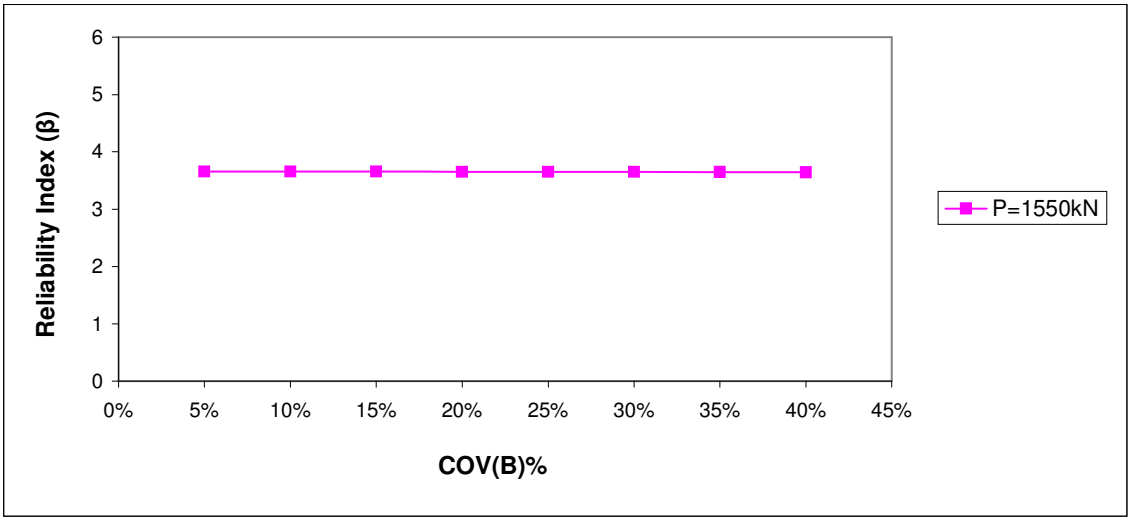


Fig. F.134 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 1550kN.

Table F.168 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 2100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.25E+00	10696.73	5%	103.4359	2.3096
6.25E+00	10696.73	10%	103.4552	2.3092
1.23E+01	10696.73	15%	103.4842	2.3086
2.16E+01	10696.73	20%	103.5295	2.3076
3.78E+01	10696.73	25%	103.6077	2.3058
6.40E+01	10696.73	30%	103.7339	2.3030
1.14E+02	10696.73	35%	103.9737	2.2977
2.31E+02	10696.73	40%	104.5360	2.2853

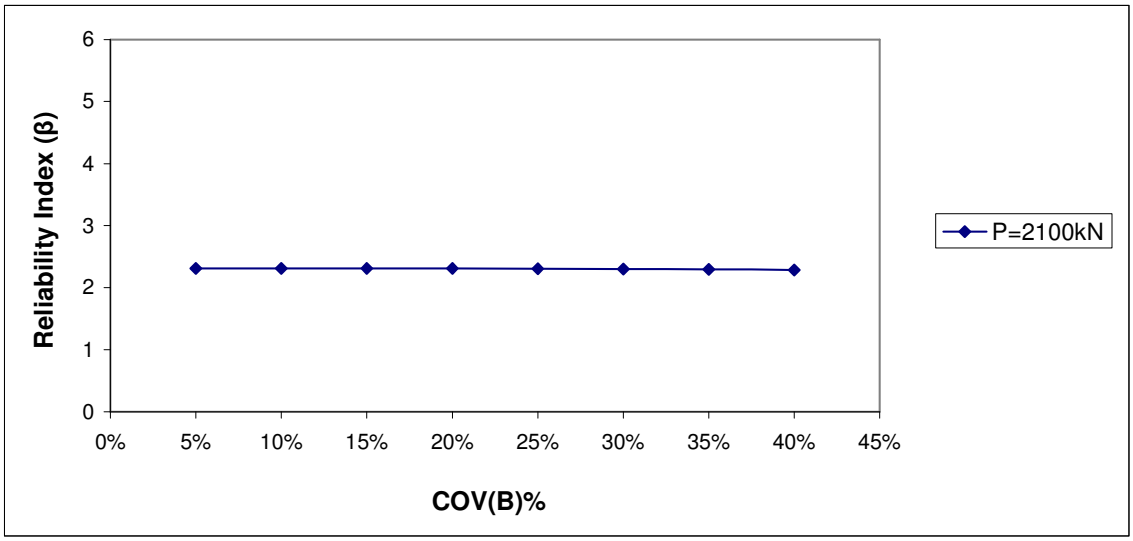


Fig. F.135 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 2100kN.

Table F.169 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 2650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
3.80E+00	10696.73	5%	103.4434	1.3408
6.00E+00	10696.73	10%	103.4540	1.3407
1.19E+01	10696.73	15%	103.4825	1.3403
2.26E+01	10696.73	20%	103.5340	1.3397
4.90E+01	10696.73	25%	103.6616	1.3380
1.05E+02	10696.73	30%	103.9317	1.3345
3.16E+02	10696.73	35%	104.9392	1.3217
9.99E+02	10696.73	40%	108.1448	1.2825

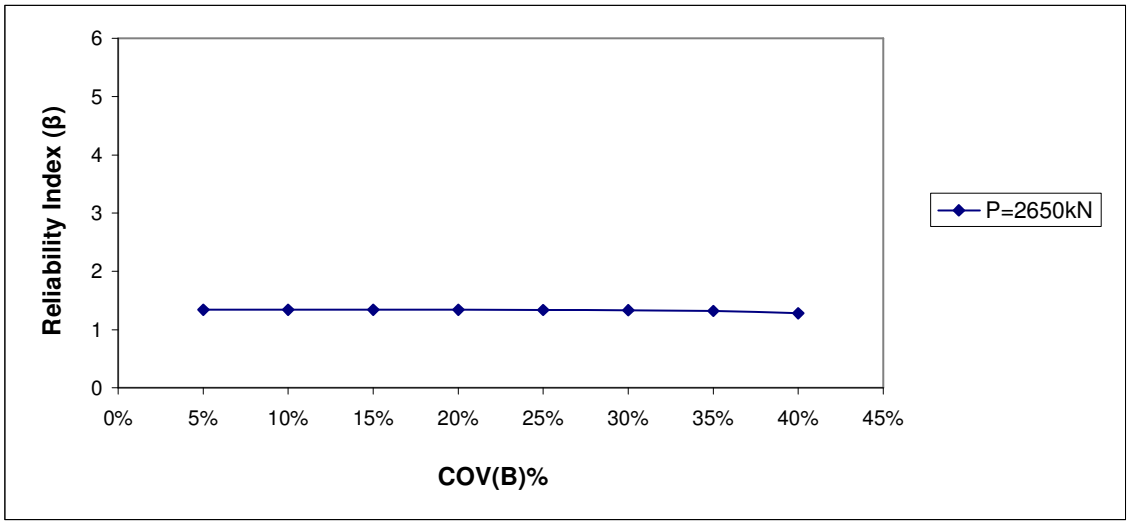


Fig. F.136 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 2650kN.

Table F.170 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'B' subjected to lateral load 3300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(B) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
9.02E-01	10696.73	5%	103.4294	0.3075
2.10E+00	10696.73	10%	103.4352	0.3074
8.70E+00	10696.73	15%	103.4671	0.3073
2.76E+01	10696.73	20%	103.5582	0.3071
9.41E+01	10696.73	25%	103.8789	0.3061
4.08E+02	10696.73	30%	105.3792	0.3018
1.38E+03	10696.73	35%	109.8897	0.2894
3.28E+03	10696.73	40%	118.2129	0.2690

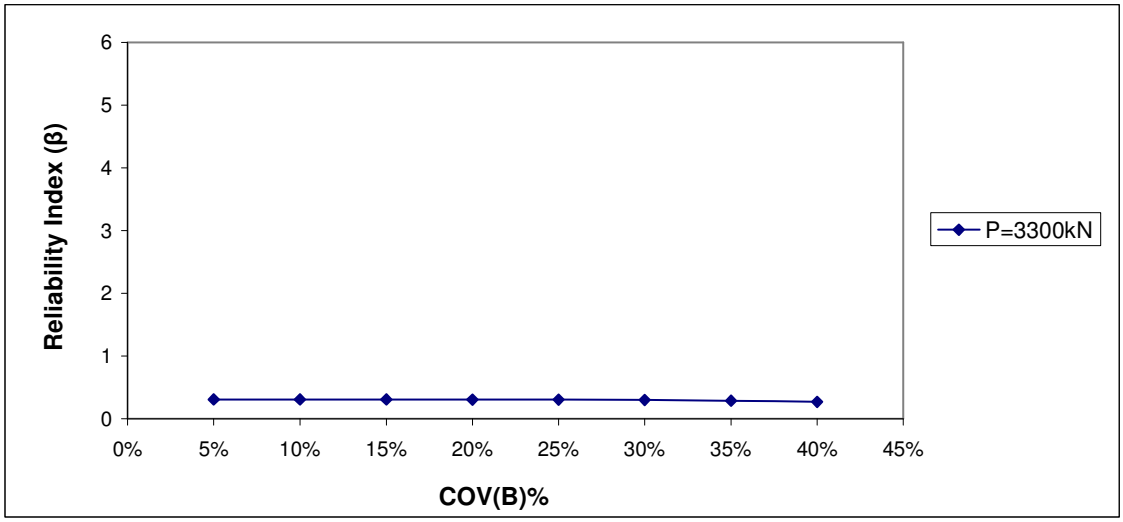


Fig. F.137 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force 3300kN.

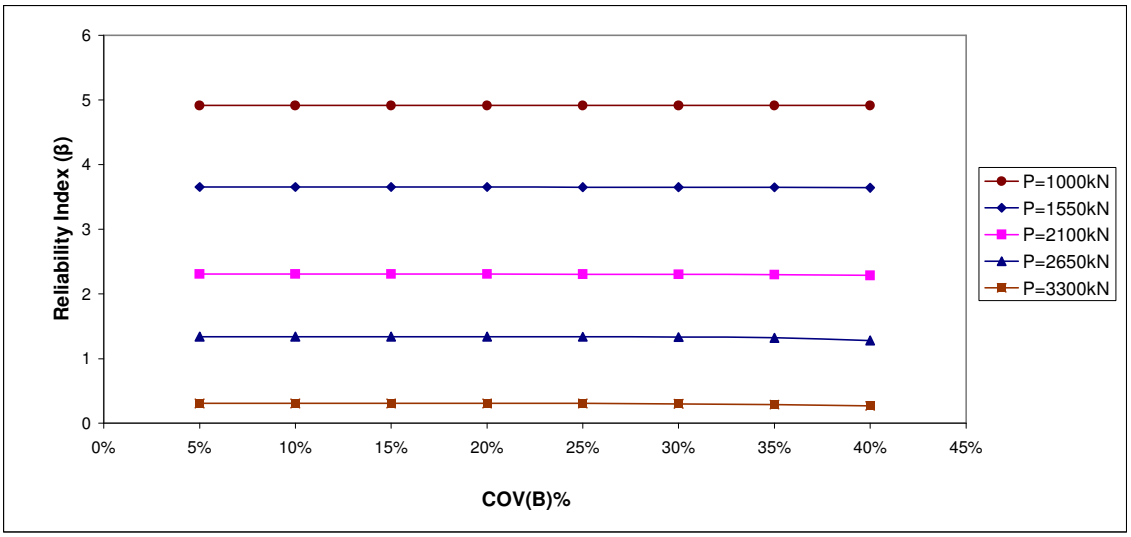


Fig. F.138 Reliability Index (β) of M_{max} vs. COV (B) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table F.171 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
7.23E-01	10696.73	5%	103.4285	4.9145
2.89E+00	10696.73	10%	103.4390	4.9140
6.50E+00	10696.73	15%	103.4564	4.9132
1.16E+01	10696.73	20%	103.4809	4.9120
1.85E+01	10696.73	25%	103.5143	4.9104
2.76E+01	10696.73	30%	103.5582	4.9084
3.78E+01	10696.73	35%	103.6077	4.9060
5.11E+01	10696.73	40%	103.6719	4.9030

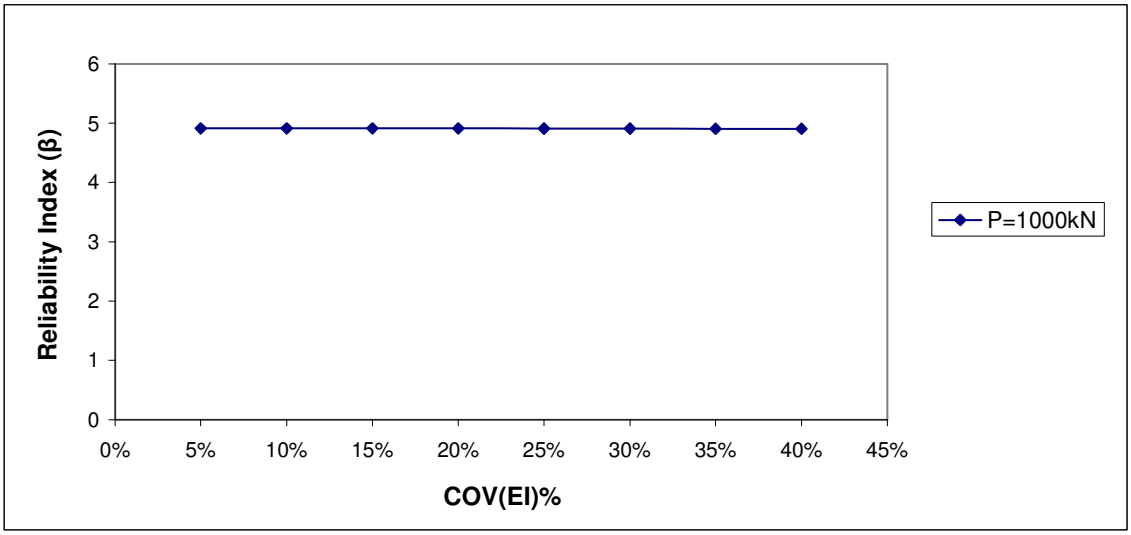


Fig. F.139 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table F.172 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 1550kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.32E+00	10696.73	5%	103.4314	3.6546
5.76E+00	10696.73	10%	103.4528	3.6538
1.26E+01	10696.73	15%	103.4859	3.6527
2.26E+01	10696.73	20%	103.5340	3.6510
3.60E+01	10696.73	25%	103.5989	3.6487
5.18E+01	10696.73	30%	103.6753	3.6460
7.06E+01	10696.73	35%	103.7656	3.6428
9.31E+01	10696.73	40%	103.8742	3.6390

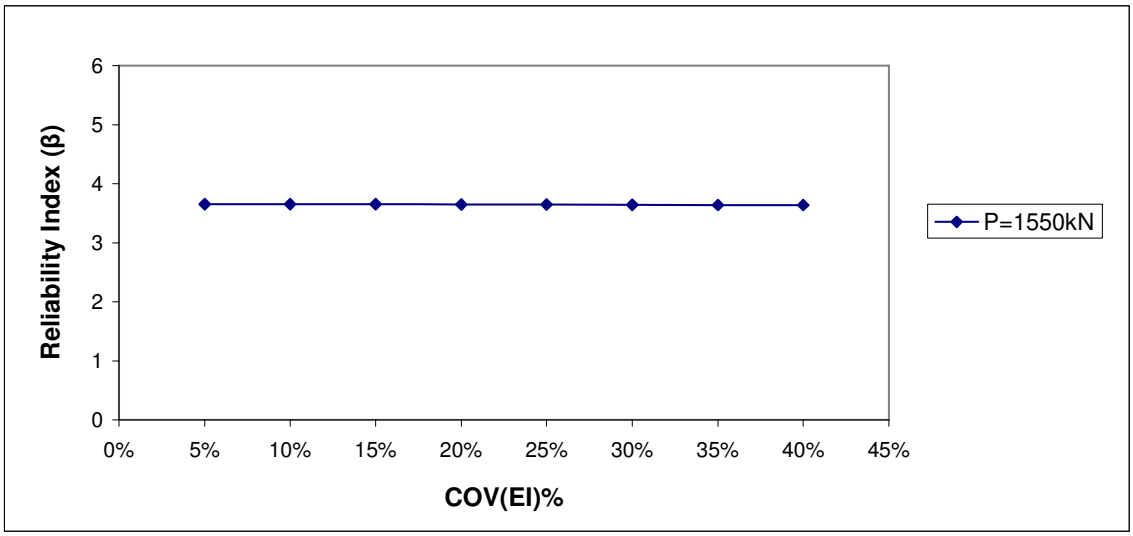


Fig. F.140 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 1550kN.

Table F.173 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 2100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.89E+00	10696.73	5%	103.4390	2.3096
1.12E+01	10696.73	10%	103.4792	2.3087
2.55E+01	10696.73	15%	103.5482	2.3071
4.56E+01	10696.73	20%	103.6450	2.3050
7.14E+01	10696.73	25%	103.7696	2.3022
1.03E+02	10696.73	30%	103.9219	2.2988
1.42E+02	10696.73	35%	104.1074	2.2947
1.85E+02	10696.73	40%	104.3153	2.2902

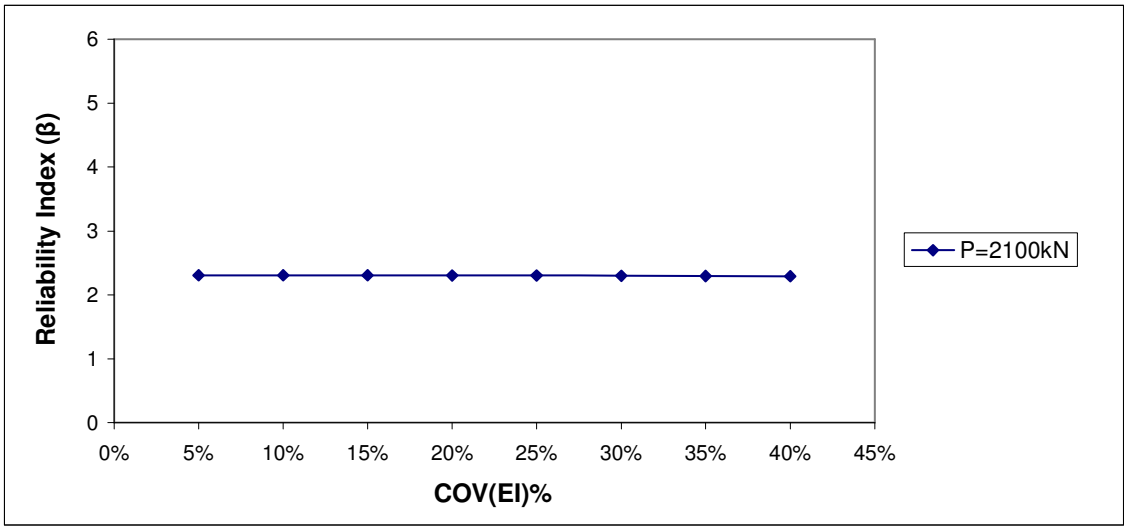


Fig. F.141 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 2100kN.

Table F.174 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 2650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.56E+00	10696.73	5%	103.4374	1.3409
1.06E+01	10696.73	10%	103.4761	1.3404
2.55E+01	10696.73	15%	103.5482	1.3395
4.62E+01	10696.73	20%	103.6483	1.3382
6.97E+01	10696.73	25%	103.7615	1.3367
1.00E+02	10696.73	30%	103.9073	1.3348
1.36E+02	10696.73	35%	104.0791	1.3326
1.80E+02	10696.73	40%	104.2895	1.3300

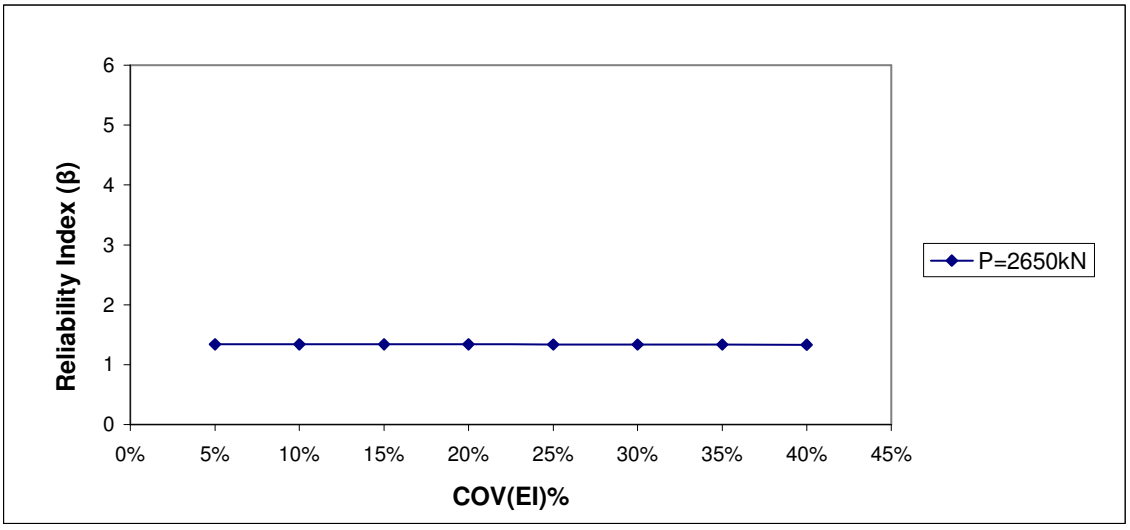


Fig. F.142 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 2650kN.

Table F.175 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'EI' subjected to lateral load 3300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(EI) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.72E+00	10696.73	5%	103.4382	0.3074
9.92E+00	10696.73	10%	103.4730	0.3073
2.07E+01	10696.73	15%	103.5250	0.3072
3.66E+01	10696.73	20%	103.6018	0.3069
5.70E+01	10696.73	25%	103.7002	0.3067
8.28E+01	10696.73	30%	103.8246	0.3063
1.36E+02	10696.73	35%	104.0791	0.3055
1.53E+02	10696.73	40%	104.1597	0.3053

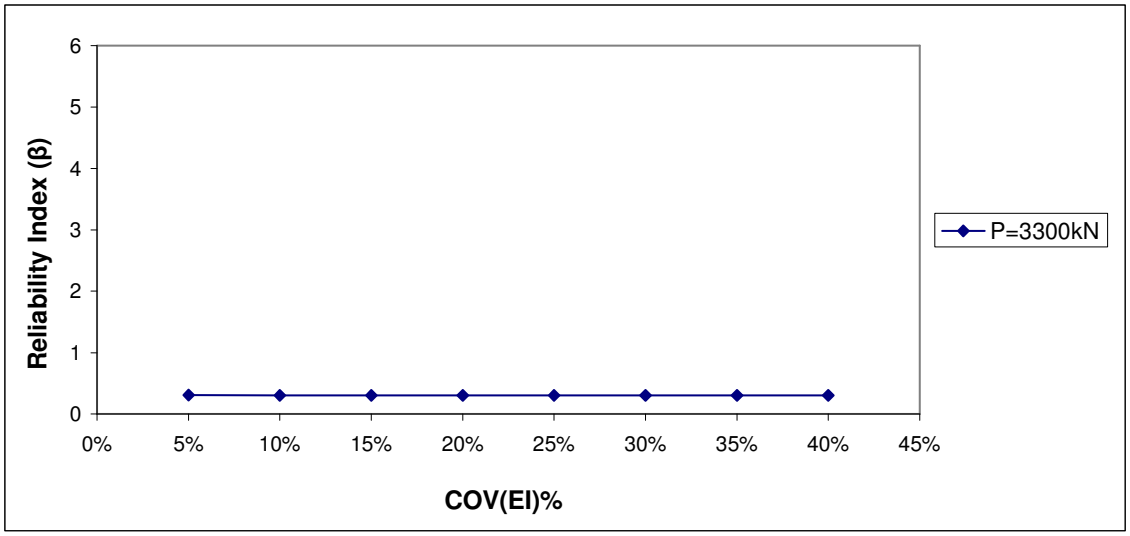


Fig. F.143 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force 3300kN.

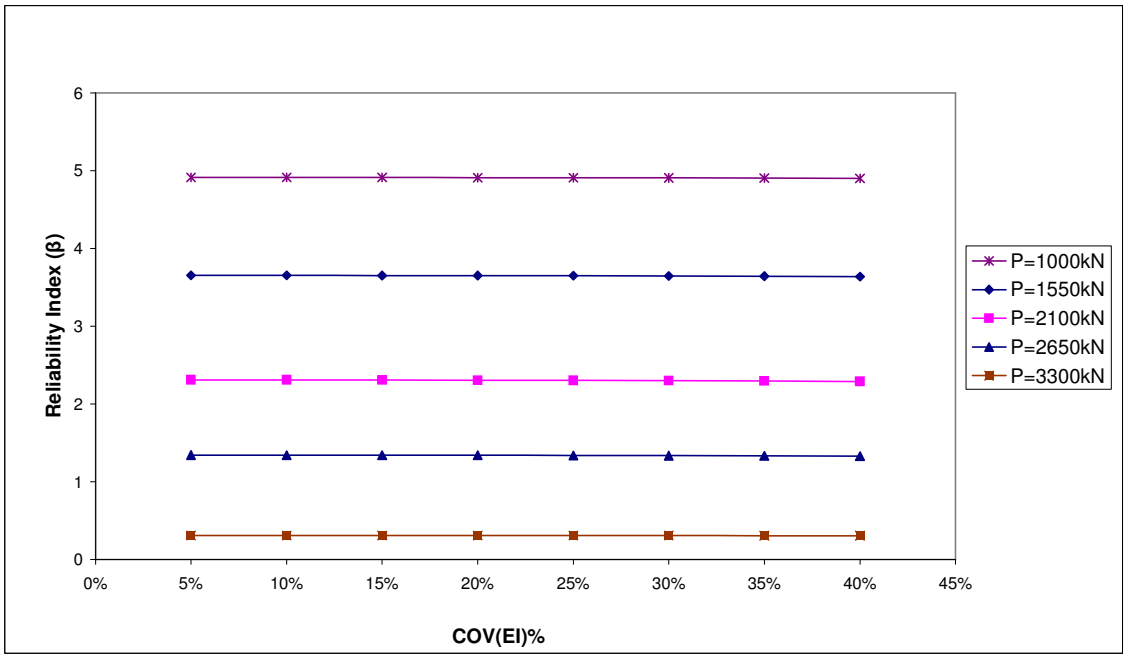


Fig. F.144 Reliability Index (β) of M_{max} vs. COV (EI) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

Table F.176 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 1000kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.12E+02	10696.73	5%	103.9668	4.8891
4.54E+02	10696.73	10%	105.5956	4.8136
1.02E+03	10696.73	15%	108.2476	4.6957
1.81E+03	10696.73	20%	111.8167	4.5458
2.82E+03	10696.73	25%	116.2598	4.3721
4.04E+03	10696.73	30%	121.4154	4.1865
5.49E+03	10696.73	35%	127.2303	3.9951
7.15E+03	10696.73	40%	133.5836	3.8051

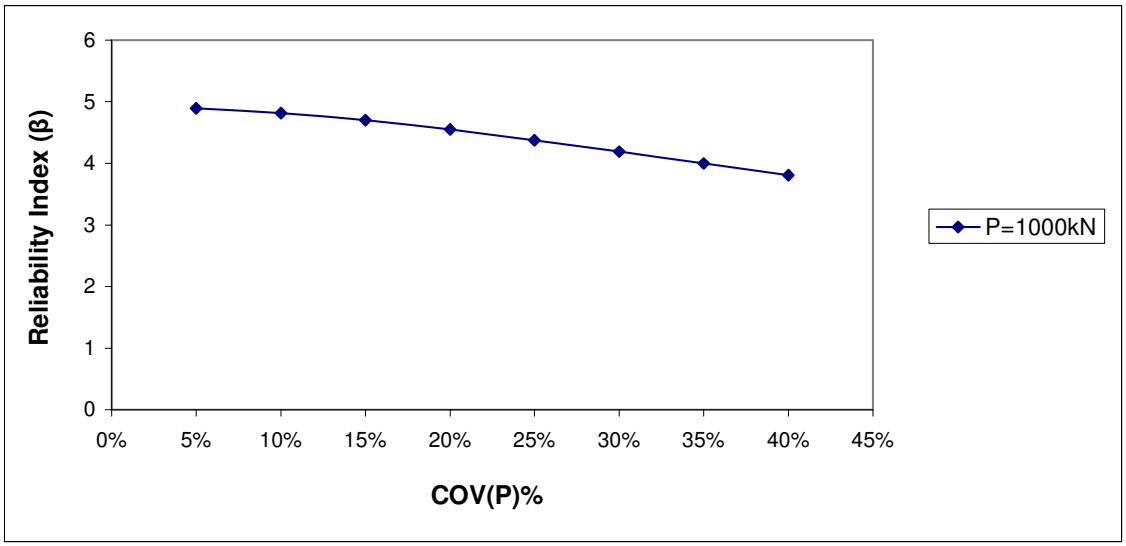


Fig. F.145 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 1000kN.

Table F.177 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 1550kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
2.36E+02	10696.73	5%	104.5579	3.6152
9.46E+02	10696.73	10%	107.8995	3.5033
2.12E+03	10696.73	15%	113.2137	3.3388
3.77E+03	10696.73	20%	120.2776	3.1427
5.91E+03	10696.73	25%	128.8513	2.9336
8.51E+03	10696.73	30%	138.5886	2.7275
1.16E+04	10696.73	35%	149.2464	2.5327
1.51E+04	10696.73	40%	160.7039	2.3522

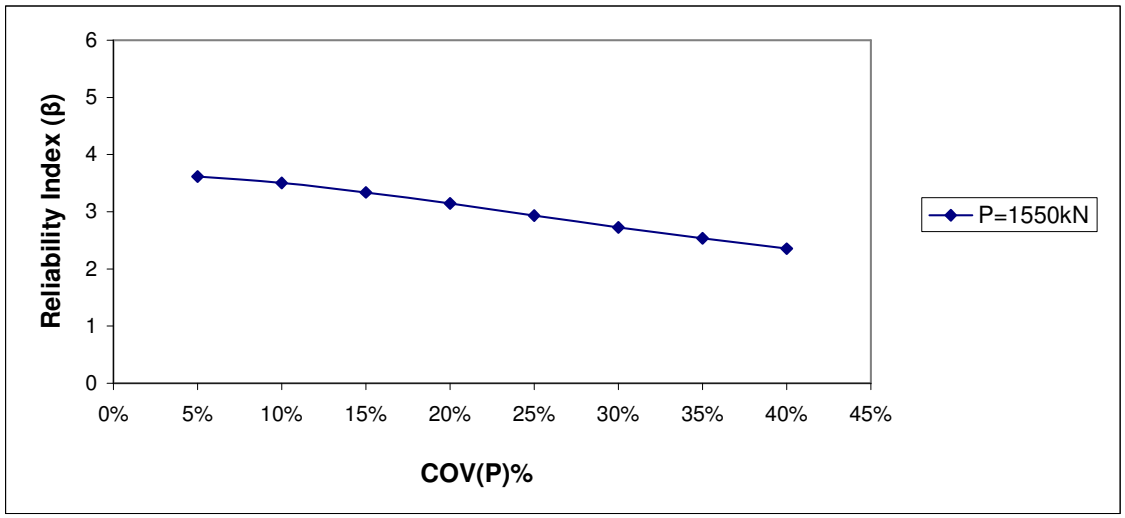


Fig. F.146 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 1550kN.

Table F.178 Reliability Index (β)connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 2100kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
4.18E+02	10696.73	5%	105.4274	2.2660
1.67E+03	10696.73	10%	111.2001	2.1484
3.77E+03	10696.73	15%	120.2776	1.9862
6.76E+03	10696.73	20%	132.1120	1.8083
1.06E+04	10696.73	25%	146.0001	1.6363
1.53E+04	10696.73	30%	161.3554	1.4806
2.10E+04	10696.73	35%	178.0652	1.3416
2.76E+04	10696.73	40%	195.6679	1.2209

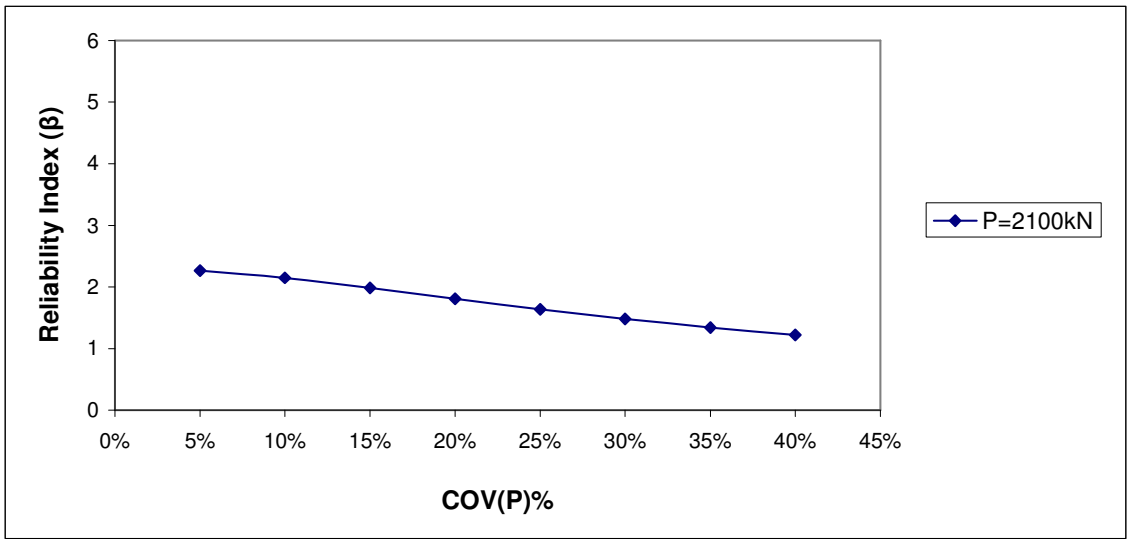


Fig. F.147 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 2100kN.

Table F.179 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 2650kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
7.16E+02	10696.73	5%	106.8283	1.2983
2.86E+03	10696.73	10%	116.4201	1.1914
6.42E+03	10696.73	15%	130.8463	1.0600
1.14E+04	10696.73	20%	148.5630	0.9336
1.78E+04	10696.73	25%	168.9152	0.8211
2.57E+04	10696.73	30%	190.8531	0.7267
3.50E+04	10696.73	35%	213.8267	0.6487
4.60E+04	10696.73	40%	238.0422	0.5827

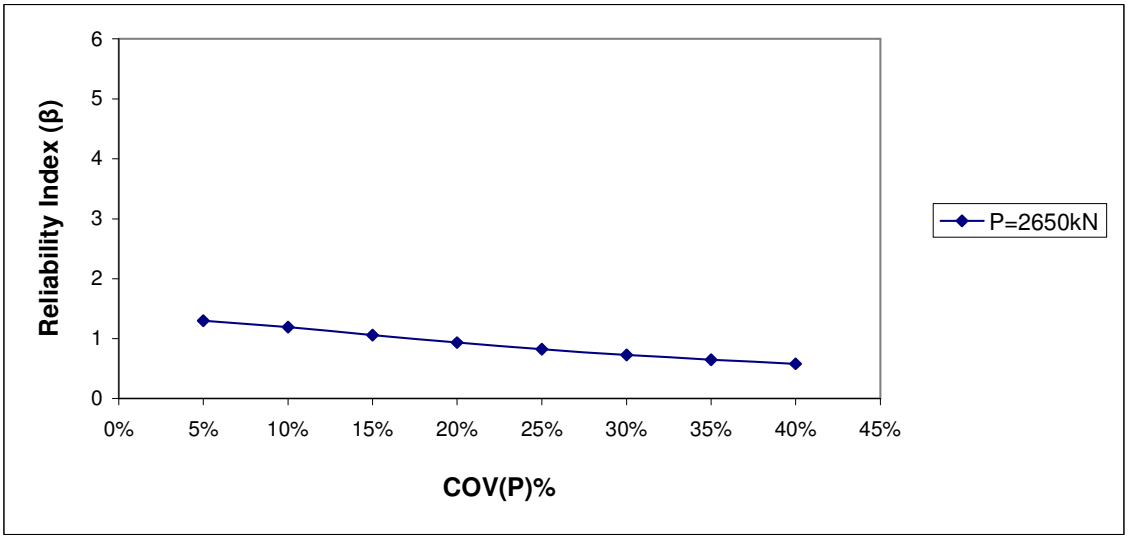


Fig. F.148 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 2650kN.

Table F.180 Reliability Index (β) connected to M_{max} for fixed head long (10T) group with spacing (5D) and with varying 'P' subjected to lateral load 3300kN.

VAR (M_{max}) $(kN\text{-}m)^2$	VAR (M_{max}^{max}) $(kN\text{-}m)^2$	COV(P) (%)	$\sigma(M_{max}^{M})$ (kN-m)	Reliability Index (β)
1.12E+03	10696.73	5%	108.7151	0.2925
4.53E+03	10696.73	10%	123.3938	0.2577
1.01E+04	10696.73	15%	144.2116	0.2205
1.80E+04	10696.73	20%	169.4295	0.1877
2.80E+04	10696.73	25%	196.8152	0.1616
4.01E+04	10696.73	30%	225.4259	0.1411
5.45E+04	10696.73	35%	255.4258	0.1245
7.10E+04	10696.73	40%	285.8653	0.1112

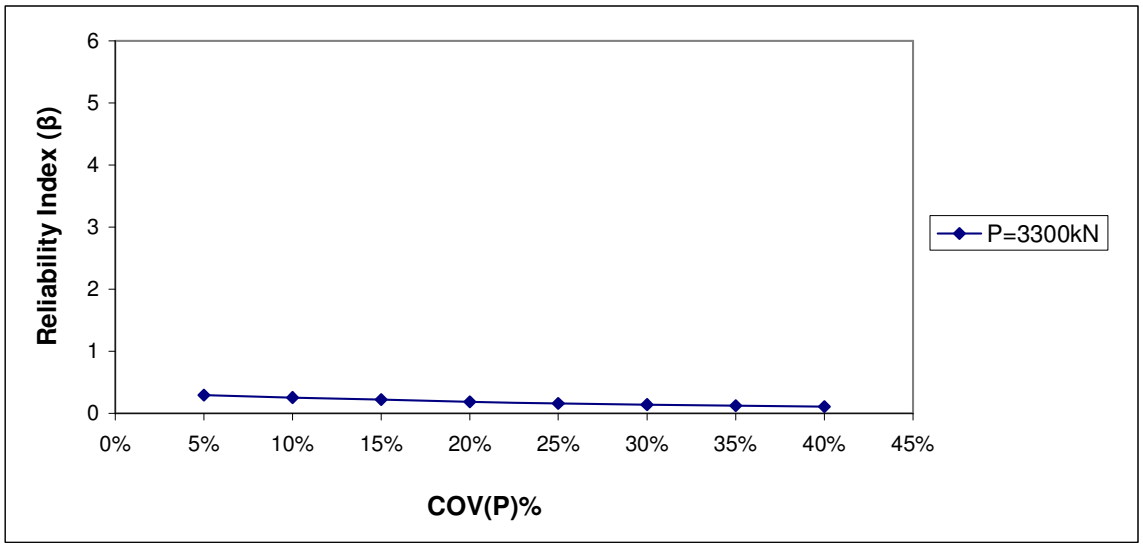


Fig. F.149 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force 3300kN.

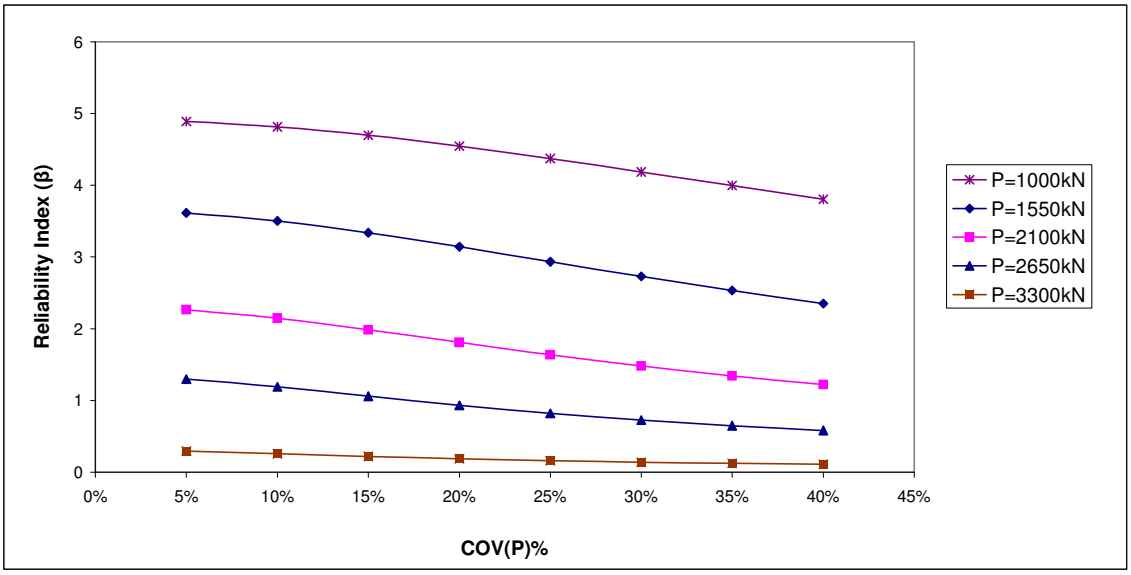


Fig. F.150 Reliability Index (β) of M_{max} vs. COV (P) for fixed head long pile group (10T) subjected to lateral force of discrete variability.

F.6 Probability of failure, p_f (M_{max})of bending moment vs. COV (Variables).

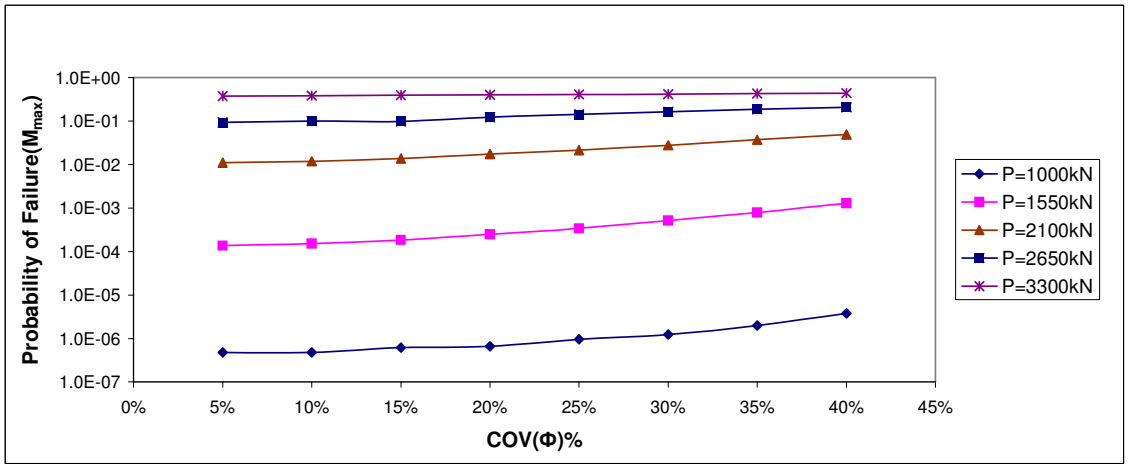


Fig. F.151 Probability of failure of bending moment p_f (M_{max}) vs. COV (Φ) for fixed head. long pile group of length 10T .

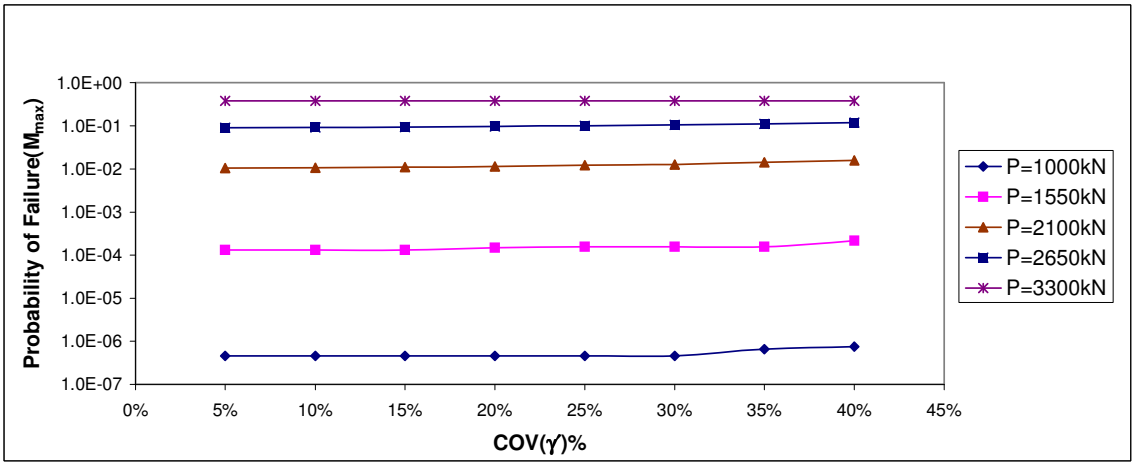


Fig. F.152 Probability of failure of bending moment p_f (M_{max}) vs. COV (γ) for fixed head long pile group of length 10T.

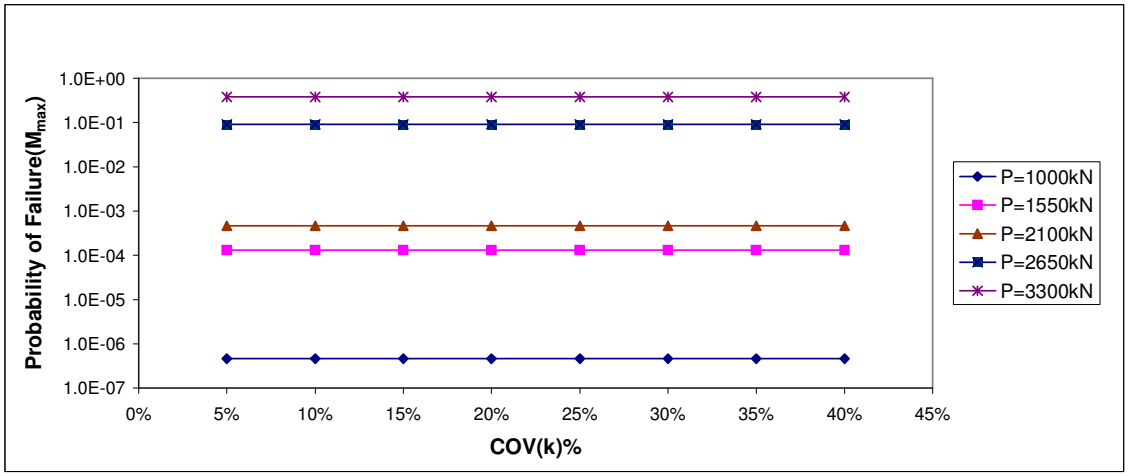


Fig. F.153 Probability of failure of bending moment p_f (M_{max}) vs. COV (k) for fixed head long pile group of length 10T.

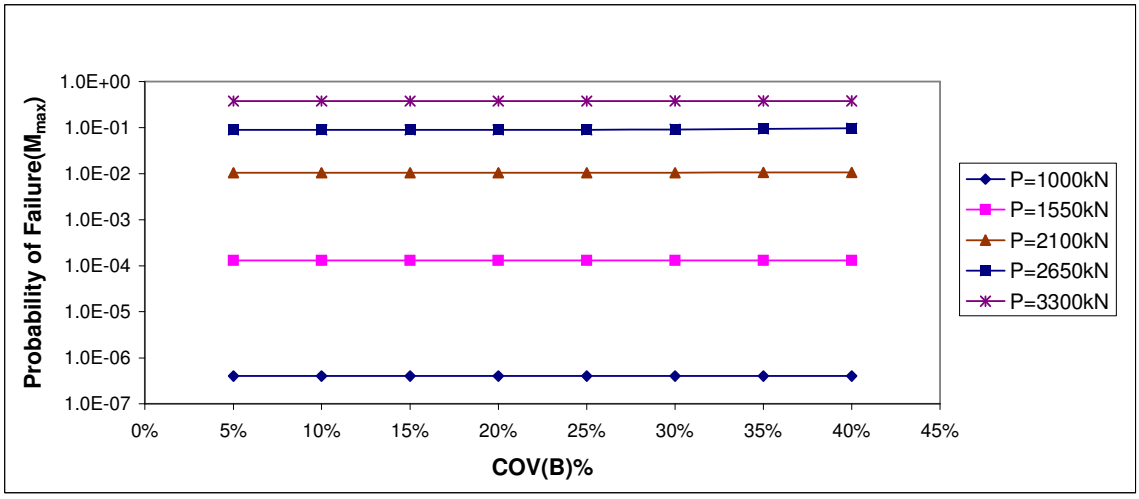


Fig. F.154 Probability of failure of bending moment p_f (M_{max}) vs. COV (B) for fixed head long pile group of length 10T.

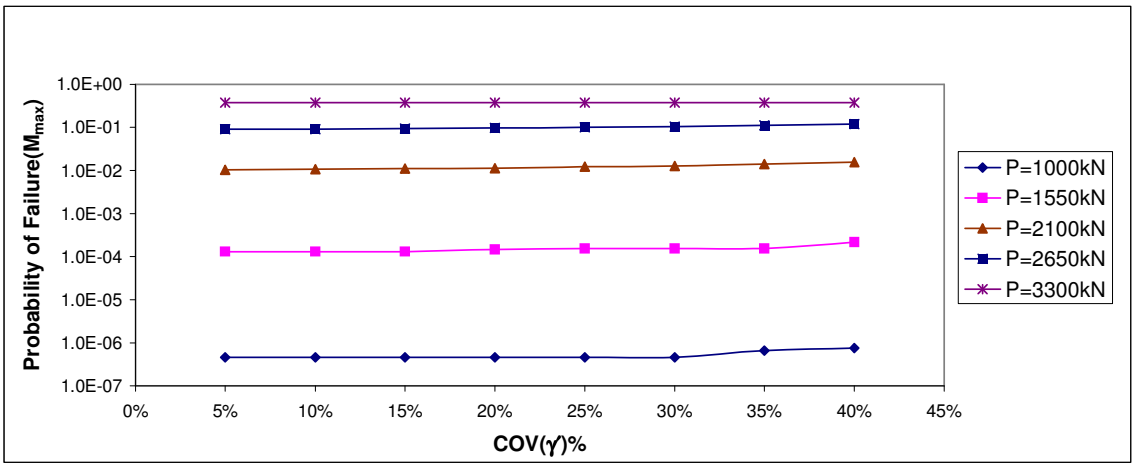


Fig. F.155 Probability of failure of bending moment p_f (M_{max}) vs. COV (EI) for fixed head long pile group of length 10T.

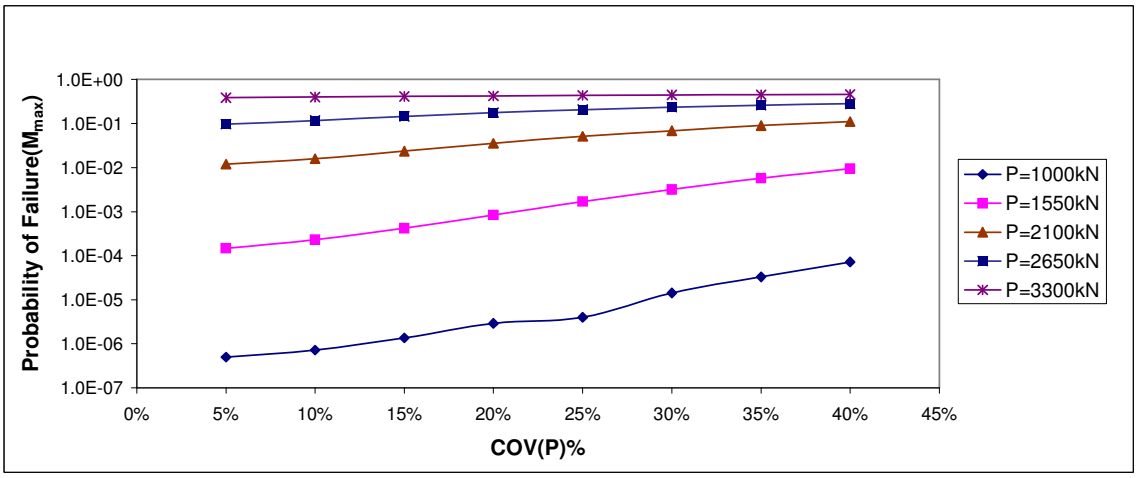


Fig. F.156 Probability of failure of bending moment p_f (M_{max}) vs. COV (P) for fixed head long pile group of length 10T.