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Effective length factors for solid round diagonal bracing members in lattice towers.

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EFFECTIVE LENGTH FACTORS FOR SOLID ROUND DIAGONAL BRACING MEMBERS IN LATTICE TOWERS

by

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ABSTRACT

Twenty-six all-welded lattice tower specimens were simply supported in the horizontal position and tested under a concentrated load at midspan. Of the twenty-six specimens, eight had solid round single-braced diagonals and the remaining eighteen had solid round cross-braced diagonals. Three different types of arrangements were used for the cross-braced specimens:

Type I: One diagonal is straight in-plane and the other is pre-bent out-of-plane. The two diagonals are welded at their intersection (six specimens).

Type II: One diagonal is straight, in-plane, and continuous. The other diagonal is straight, in-plane, and cut and welded to the first diagonal at intersection (eight specimens).

Type III: Both diagonals are pre-bent out-of-plane and welded together at intersection with welds in the plane of the face of the specimen (four specimens).

Specimens with three different leg sizes (38, 44, and 51 mm solid rounds) and two different sizes of diagonals (19 and 22 mm) were used in this investigation. Three single-braced specimens and twelve cross-braced specimens (four of each type) were instrumented with strain gauges and load-strain data were obtained till failure. The axial forces in diagonal members were computed for twelve specimens from the measured strain values assuming an elastic perfectly-plastic stress-strain curve for steel. Load-midspan deflection data were recorded for twenty-four specimens.

After testing the specimens, three tensile coupons were cut from the diagonals of each test specimen and yield stresses were determined. Axial forces in the diagonal members were computed using the measured values of the yield stresses and the effective length factors for the compression diagonals were determined. The experimentally determined buckling loads are compared with the buckling loads computed from CSA S37 "Antennas, Towers, and Antenna-

Supporting Structures" and ENV 1993-3-1:1997 "Eurocode 3: Design of steel structures - Part 3-1: Towers, masts and chimneys - Towers and masts". It was found that CSA S37 is conservative for all specimens. On the other hand, ENV 1993-3-1:1997 gives results on the unsafe side for Types I and III cross-braced specimens, using an effective length of 0.35 times the length of the diagonal.

Based on the test results, it is concluded that, of the three different types of arrangements of cross-bracing, Type II (cut and welded at intersection) is more efficient than the other two types. An effective length factor of 0.7 for single-braced diagonals, 0.5 for Type I cross-braced diagonals, 0.4 for Type II cross-braced diagonals, and 0.7 for Type III cross-braced diagonals is recommended when buckling loads are calculated according to CSA S37.

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To My Family

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NOTATION

A	=	cross-sectional area
B	=	width of a slice in the cross-section [Fig. D.1]
C	=	force in compression member
C_{cr}	=	buckling load for compression member
C_e	=	Euler Load
C_r	=	factored compressive resistance of compression member
C_T	=	tangent modulus load
dy	=	thickness of a slice in the cross-section [Appendix D]
D	=	diameter of the cross-section [Fig. D.1]
E	=	modulus of elasticity
E_{eff}	=	effective modulus of elasticity
E_r	=	reduced modulus of elasticity
E_T	=	tangent modulus of elasticity
F_y	=	yield stress of the material
I	=	moment of inertia
I_c	=	moment of inertia of the compression diagonal [Eq. 2.7]
I_t	=	moment of inertia of the tension diagonal [Eq. 2.7]
K	=	effective length factor for compression member
KL/r	=	effective slenderness ratio for compression member
L	=	length of compression member
L_d	=	total length of diagonal centre to centre of legs
	=	$L_{d1}+L_{d2}$ for cross-bracing [Eq. 2.12, Fig. 2.1]

L_{d1}	=	long portion of diagonal from centre of leg to centre of intersection with other diagonal in cross-bracing [Fig. 2.1]
L_{d2}	=	short portion of diagonal from centre of leg to centre of intersection with other diagonal in cross-bracing [Fig. 2.1]
m	=	number of slices to which the cross-section is divided
	=	200 [Appendix D]
n	=	1.34
r	=	radius of gyration
T	=	force in tension diagonal
u	=	$\frac{L}{2}\sqrt{\frac{T}{EI}}$ [Eq. 2.4]
X	=	depth of the neutral axis [Appendix D]
Y_1	=	distance of a slice from centroidal axis [Fig. D.1a]
Y_2	=	distance of a slice from top fibre. [Fig. D.1b]
α	=	stiffness furnished by tension diagonal for compression diagonal in cross-bracing [Eq. 2.4, 2.5, 2.11]
α_{lim}	=	limiting stiffness, above which $C_{cr} = 4C_e$ [Eq. 2.10]
γ	=	partial factor for resistance of member to buckling
	=	1.10 [Eq. 2.14]
$\varepsilon_1, \varepsilon_2$	=	strains in the top and bottom fibres in the cross-section [Appendix D]
λ	=	nondimensional slenderness parameter [Eq. 2.12, 2.13]

λ_y = yield slenderness parameter = $\pi\sqrt{\frac{E}{F_y}}$ [Eq. 214]

Λ_e = $\frac{(K)(Basic\ Slenderness\ Ratio)}{\lambda_y}$ [Eq. 2.14]

ξ = $0.5\,[1 + 0.49\,(\Lambda_e - 0.2) + \Lambda_e^2]$ [Eq. 2.14]

σ = stress [Appendix D]

ϕ = resistance factor for compression

χ = $\frac{1}{\xi + [\xi^2 - \Lambda_e^2]^{0.5}}$ [Eq. 2.14]

CHAPTER ONE

INTRODUCTION

1.1 GENERAL

The needs of telecommunications industry have resulted in an increase in the construction of antenna towers. Antenna towers are either self-supporting or guyed; the latter provide a more economical solution for taller towers. A guyed tower consists of a mast usually of a constant triangular cross section (some square cross section masts are built in Canada but are more popular in Europe) supported at several points by guy cables, as shown in Fig. 1.1.

The mast typically has three (triangular section) or four (square section) upright members (legs) connected by horizontal and diagonal components (webs). Solid rounds, tubes, as well as angles, are used for these members. The following are some of the web systems used in towers:

(a) Web systems with horizontals:
- Single diagonals
- Diagonals with midspan horizontals
- Tension-Compression diagonals (cross-braced diagonals)

(b) Web systems without horizontals.

These are shown in Fig. 1.2.

The present study is carried out on web systems with horizontals. Both single diagonals and cross-braced diagonals are included in this investigation. All the members are solid rounds connected to each other by welding. The effective length factors of the diagonal bracing members is the main subject of this study. The effective length factor, which is influenced by the end conditions and the lateral restraint at intermediate points (for cross-bracing), is one of the factors which determine the compressive strength of any member.

Cross-braced diagonals may be fabricated in different ways as shown in Fig 1.3. Three of the common fabrication methods are:

Type I: One diagonal is straight in-plane and the other is pre-bent out-of-plane with the two diagonals welded at their intersection.

Type II: One diagonal is straight, in-plane, and continuous. The other diagonal is straight, in-plane, and cut and welded to the first diagonal at intersection.

Type III: Both diagonals are pre-bent out-of-plane and welded together at intersection with welds in the plane of the face of the specimen.

1.2 NEED FOR INVESTIGATION

Most of the experimental investigation carried out thus far is on angle bracings and to the best of the author's knowledge, no experimental results are available on solid round bars used as diagonals in lattice towers. Therefore, there is a need to experimentally study the behaviour of lattice towers with solid round diagonals.

CSA S37-94 "Antennas, Towers and Antenna-Supporting Structures" [CSA 1994] does not specifically give the effective length factors for solid round diagonals. It gives the effective length factors for compression members and mentions that these factors are primarily applicable for angles, and it notes that for other member shapes including solid rounds, the general philosophy is the same as that of angles.

The effective slenderness ratio for single-bracing is 0.7 L_d/r in ENV 1993-3-1:1997 "Eurocode 3: Design of steel structures - Part 3-1: Towers, masts and chimneys - Towers and masts" [ENV 1997] and is L_d/r according to CSA S37 (assuming the same values given for angles). Similarly, for cross-braced diagonals, the effective slenderness ratios, according to Eurocode3 and the Canadian Standard S37, are 0.35 L_d/r and 0.75 L_d/r, respectively. In view of the above discrepancies in the effective slenderness ratios in the two standards, there is a need for experimental investigation of the effective length factors of solid round diagonals in lattice towers.

In view of all the above considerations, it can be seen that there is an urgent need for the present investigation.

1.3 OBJECTIVES OF PRESENT RESEARCH

The objectives of this study are the following:

- To study the behaviour of lattice towers with solid round single- and cross-braced diagonals.
- To compare the performance of Type III cross-bracing with that of Types I and II.
- To compare the experimental failure loads of such members with those calculated using CSA S37-94 "Antennas, Towers, and Antenna–Supporting Structures" and European Prestandard ENV 1993-3-1:1997 "Eurocode 3: Design of steel structures - Part 3-1: Towers, masts and chimneys - Towers and masts" [ENV 1997].
- To determine effective length factors for solid steel round compression members in single- and cross-braced diagonals.

The study was carried out on segments of actual towers, with all the connections welded, fabricated by two companies, viz., Trylon Manufacturing Company Ltd., Elmira, Ontario and LeBlanc & Royle Telcom Inc., Oakville, Ontario.

CHAPTER TWO

LITERATURE REVIEW

2.1 GENERAL

The use of circular columns dates back many centuries. The materials used varied from stone, wood, concrete, and metals. Steel has been widely used in many structural elements. Round steel bars have been used in constructing trusses, frames, and towers. In lattice towers, solid rounds are used for legs, horizontal members, and bracing diagonals. Single- and cross-braced diagonals are frequently used in lattice towers.

An extensive amount of literature is available, theoretical and experimental, on the design of cross-bracing, but most of the work carried out was on angles and some was conducted on flat bars. To the best of the author's knowledge, no literature is available on cross-bracing made of round bars, although these are used quite extensively in the mast of guyed towers.

Steel section capacities are dependent upon the mode of buckling. For axisymmetric solid circular cross sections, the dominant mode of buckling is flexural buckling.

2.2 FLEXURAL BUCKLING – THEORY

Stability of columns has been one of the most widely known aspects of structural engineering. Attempts at finding a solution to column problem date back many centuries. One of the most important contributions to the problem was made by Euler [1759] who established a formula for the buckling of columns which now has a wide application in analyzing the elastic stability of many engineering structures. Euler's formula is given below;

$$C_e = \frac{\pi^2 EI}{(KL)^2} \tag{2.1}$$

where, E is the modulus of elasticity, I is the moment of inertia, K is the effective length factor, and L is the length of the column. Euler load, C_e, is the critical load at which a slender elastic column can be held in a bent configuration under axial load alone. Lamarle [Timoshenko 1953] was the first to introduce a definite limit up to which Euler's formula should be used, and concluded that the formula gives satisfactory results only so long as the stresses do not exceed the elastic limit of the material.

More studies were carried out on columns in the early years of the nineteenth century. Lagrange [Todhunter 1960] found out that it is possible to have an infinite number of buckling curves. During that period, it was observed that the Euler column formula, although theoretically sound, gave unconservative column capacities for the materials and member shapes available at that time. It was not until 1820 that the material to which

Euler's formula is most applicable became available for commercial use. These materials were initially wrought iron and then around 1850, structural steel. More recently in the 1900's, structural aluminum alloys have been added to the family of construction metals.

Due to lack of knowledge as to relationship between stress, strain, curvature, and bending moment beyond the elastic range, progress beyond Euler's early statements concerning inelastic behavior remained dormant for many years. In 1889, Engesser [Timoshenko 1953] proposed that Euler's formula should be extended to include the inelastic range by introducing a variable quantity E_T which is called the tangent modulus, instead of the constant modulus E. Thus for a pinned-end column,

$$C_T = \frac{\pi^2 E_T A}{\left(\frac{KL}{r}\right)^2} \tag{2.2}$$

where, E_T is the slope of the tangent to stress-strain curve corresponding to the stress at failure, A is the area of the cross section, KL/r is the effective slenderness ratio of the member, and C_T is the critical tangent modulus load. Independently of Engesser, Considère in 1889 conducted a series of 32 column tests and suggested that if buckling occurred above the proportional limit, the elastic modulus, E, should be replaced in Euler's formula by an E_{eff}. He stated that the effective modulus should be somewhere between E and E_T. Jasinsky brought Considère's work to the attention of Engesser, who revised his theory by introducing two different moduli for the two parts, convex and concave sides of the buckled shape, of the cross section.

In 1910 Kármán derived explicit expressions for the reduced modulus for both the rectangular and the idealized H-section columns. The formula for critical reduced modulus stress in a pinned-end column is the same as Eq. 2.2 except that E_T is replaced by E_r, where

$$E_r = f(E_T, E) \tag{2.3}$$

Experimental results obtained by several researchers, Templin, Strum, Hartman, and Holt [Templin et al. 1938] in testing circular rods of aluminum alloy were in agreement with the tangent modulus theory. Shanley [1947] explained that for columns beyond the elastic range, out of the two theories, i.e, the tangent modulus and reduced modulus theories, the latter is an upper bound while the former is a lower bound and has been proven to be better suited for engineering design.

The need for information on the strength of solid round compression members arose from the increased use of these bars in communication towers. For this reason, an extensive program of experimental and analytical work was initiated in 1954 at Lehigh University, Bethleham, Pennsylvania. Beedle, Galambos, and Tall [Beedle et al. 1961] studied the effect of heat-treatment and cold bending on the residual stresses and thus the column strength. Effects of initial out-of-straightness were also illustrated. It was stated that for solid round bars the residual stress distribution is triaxial, i.e, there are longitudinal, tangential and radial residual stresses. Different final heat treatment methods like quenching, air cooling, and stress relieving were considered in the study. It was found that of the three types of heat treatment, quenching leads to high residual stresses while the other two methods reduce the stresses considerably. It was also shown that columns with initial out-of-straightness have lower strength than straight columns. Fujita and Driscoll [1962] presented results of the aforementioned experimental investigation on the strength of axially and eccentrically loaded solid round columns of 2-3/4 in. (70 mm) diameter. Nine axially loaded column tests and two eccentrically loaded column tests were reported. Comparison with a theory based on the "tangent modulus" concept for axially loaded columns, and with an inelastic-strength theory for the eccentrically loaded columns, showed that the strength of solid round columns may be predicted adequately. Galambos [1965] presented the research on the strength of solid rounds carried out between 1954 and 1965 at Lehigh University. Recommendations for the design of axially loaded steel columns were presented based on the research program. It was stated that both residual stresses and initial crookedness have a significant influence on the strength of round columns in the inelastic region. Galambos' paper was discussed by Williamson and Johnston [1965] and several other researchers.

2.3 FLEXURAL BUCKLING - EXPERIMENTAL INVESTIGATION

Experimental investigations on columns date back to the first half of the eighteenth century. A practical investigation of the phenomenon of lateral buckling was first undertaken by Musschenbrock [Timoshenko 1953]. As a result of his research, he stated that the buckling load is inversely proportional to the square of the length of the strut. During the closing years of the eighteenth century, a series of investigations with wooden struts was made.

Hodgkinson in 1840 [Timoshenko 1953] tested specimens of cast iron. Cylindrical, solid and hollow specimens with rounded and flat ends were tested. For slender, solid struts, good accord was found with Euler's formula. At the end of the nineteenth century more experiments on buckling of columns were conducted by Bauschinger, Tetmajer, and Considère [Timoshenko 1953].

Several researchers studied the column buckling criteria in the first half of this century and found that the results showed column failure at tangent modulus loads. Templin and others [Templin et al. 1938] also discovered that practical tests on columns yielded capacities that are closer to tangent modulus theory than to the seemingly more refined reduced modulus theory.

As discussed earlier, the primary research on the strength of solid rounds was carried out between 1954 and 1965 at Lehigh University. The tests were performed primarily on stress relieved constructional alloy steel bars. Twenty-seven bars, some with 2-3/4 in. (70 mm) diameter and others with 7-1/2 in. (190 mm) diameter were tested to failure as axially loaded columns. In the main phase of the research program, the effect of residual stresses and initial crookedness on the strength of the axially loaded columns was investigated. It appears that no major research work in this area was undertaken after this time.

2.4 BRACINGS - THEORY AND EXPERIMENTAL INVESTIGATION

Bracings are widely used in many structures. Bracings in wooden bridge trusses and roof trusses, were used by the Romans. The first metal trusses in England were built in 1845 [Timoshenko 1953].

The first experiments on lattice girders treated as cantilevers were made in 1857 by H. Lohse [Todhunter 1960]. Single, double, triple, and fourfold types of bracings were used. The bars were riveted to each other. The loads at which the bracing buckled were noted. It is noteworthy that in several cases the bracing bars bent elastically into an approximate S-form, a result which the researchers at the time did not take into account in their theoretical analysis. From these experiments, a great increase of strength due to multiple bracing and to the riveting together of the bracing bars, was noticed.

Wöhler in 1855 [Todhunter 1960] deduced the stresses in the bracing bars of a girder from purely statical consideration. De Clercq in 1857 and Winkler in 1859 theoretically analyzed lattice girders and the stresses in the bracing bars [Todhunter 1960].

For cross-bracings or tension-compression diagonals, Jasinsky was the first to investigate the stability of the compressed diagonals and to evaluate the strengthening afforded by the diagonals in tension in lattice trusses [Timoshenko 1953].

Wood [1975], Chairman of the Committee No. 22 of Working Group 08, undertook a series of tests to establish the performance of crossed diagonals. The tests were conducted on angles used as cross-bracings attached with 1, 2 and 3 bolts to the legs. One hundred and five of these tests were carried out with strain gauges attached to the compressed diagonal members, while 48 tests were carried out without strain gauge readings. It was concluded that eccentricity and rigidity of the connections have special influence on relatively low values of slenderness ratio. The influence of the moment resulting from the eccentricity decreases with increasing slenderness ratio.

DeWolf and Pelliccione [1979] reported that the design practice for cross-bracing members adopted at that time, which entirely neglected the contribution of the compression member and relied solely on the tension member, was conservative and resulted in overdesign. Eight sets of cross-bracing, using flat bars with rectangular cross section, were tested to failure. A square frame was used with connections, at each corner of the frame, designed to allow all members to rotate in the plane of the frame and for the two diagonals to rotate out of the plane. Strain gauges were placed in pairs on opposite sides of the members on the faces parallel to the plane of the frame. From the tests in that investigation it was observed that using the design practice, which neglects the contribution of compression members, the predicted frame load ranged between 40% to 78% of the failure load. The critical load of the compression member about its in-plane axis is related to the force in the tension member that braces it at the centre, and when the two members are made of the same material, the tension member is equivalent to an unyielding support. Thus the compression member buckles into a full sine wave, S-shape, at a load equal to four times that without any centre bracing. The stiffness, α, furnished by the tension member acting on compression member in the out-of- plane direction was given as follows ;

$$\alpha = \frac{48EI}{L^3}\left[\frac{u^3}{3(u - \tanh u)}\right] \tag{2.4}$$

where, L represents the total length of the diagonal, and

$$u = \frac{L}{2}\sqrt{\frac{T}{EI}} \ ,$$

in which T is the force in tension member.

It was also stated that, following buckling of the compression member, its load decreases and the load in the tension member then increases with an overall increase in frame load. Predicted frame loads, based on the critical load in the compression member determined by using the tension member as a brace, were within 10% of the test load for compression members with low slenderness ratios and on the conservative side for those with higher ratios.

A theoretical investigation was made by Vickers [1982] into the behaviour and design of cross-bracing. His discussion emphasized the use of cruciform (star shaped) double angle struts for bracing members. The extent of lateral support provided to the compression diagonal by the tension diagonal at their point of intersection was analyzed. From his study, it was concluded that the design concept of shared load between tension and compression members, with the compression member designed using an effective length factor equal to half the total length of the diagonals, is more realistic than " tension only" bracing design.

El-Tayem and Goel [1986] studied experimentally and theoretically full-scale cross-bracing specimens. Five single angles and one double angle cross-bracing specimens, made of ASTM A36 steel, were included in the study. Quasi-static cyclic loading was used in the tests and strain gauges were attached to measure the loads. It was noticed that the interconnection provided an elastic restraint against both lateral and rotational deformations of the compression diagonal at the point of intersection. It was concluded that for cross-bracing systems made from single equal-leg angles, an effective length of 0.85 times the half diagonal length is reasonable.

Picard and Beaulieu [1987] performed a theoretical study aimed at the determination of the transverse stiffness offered by the tension diagonal in cross-bracing systems and at the evaluation of this stiffness on the out-of-plane buckling resistance of the compression diagonal. When the diagonals are continuous and attached at the intersection, it was concluded that the effective length of the compression diagonal is 0.5 times the total diagonal length. A simpler form of equation was given by the writers for the stiffness, α, provided by the tension diagonal, assuming the two diagonals to be equal in length and to have the same cross-sectional area:

$$\alpha = \frac{48EI}{L^3} + 4.36\frac{T}{L} \tag{2.5}$$

where, L is the total length of the diagonal, and T is the force in tension diagonal. They also suggested that the effective length factor, K, for calculating the buckling load of the compression diagonal to be as follows:

$$K = \sqrt{0.523 - \frac{0.428}{C/T}} \quad \geq 0.5 \tag{2.6}$$

where C and T are the forces, just before buckling, in the compression and the tension diagonals, respectively.

Picard and Beaulieu [1988] performed two series of tests to demonstrate the validity of their theoretical study. Seven transverse stiffness tests and fifteen buckling tests were performed on flat bars and the results verified the validity of the equations presented by them.

The theoretical analysis carried out in 1987 by the same authors was generalized in 1989 [Picard and Beaulieu, 1989a and 1989b], which gave the following effective length factor for cross-bracings:

$$K = \sqrt{\frac{1 - 0.818/(C/T)}{1 + 0.911(I_t/I_c)}} \tag{2.7}$$

where, C/T is the ratio of the force in compression member just before buckling to the force in tension diagonal, and I_t/I_c is the ratio of moment of inertia of the tension diagonal to the moment of inertia of the compression diagonal. This theoretical study was also verified by fifteen buckling tests carried out in 1988 [Picard and Beaulieu 1988].

Kemp and Behncke [1998] described a series of tests on cross-bracing systems with slenderness ratios in the range of 102 to 160. Other variables included the inclination of the main legs and bracing, the number of bolts in each end connection, and the size of the main leg relative to the bracing. The measured behaviour was compared with the results of a flexibility-based analysis and the formulas from the American and European Transmission Tower Design manuals. The results confirmed the complexity of the behavior of cross-bracing in latticed towers. Strain measurements showed that yielding of the extreme fibre of the strut in the central region of the largest subspan is the primary cause of failure. The effect of the end eccentricity was partially alleviated by the restraint provided by the main legs to the ends of the compression diagonal. Consequently the ultimate strength in the tests was increased by up to 17% by changing the number of bolts at the end connection from one to two. A smaller but nevertheless significant 10% benefit was obtained by increasing the size of the main leg relative to the bracing.

2.5 CROSS-BRACING AS A CONTINUOUS BEAM ON ELASTIC SUPPORT

Connections in trusses and frames are treated in many different ways, but the traditional assumption of considering these connections to be perfectly hinged joints in an idealized frame made the design of such frames or trusses simpler.

In cross-braced diagonals, the tension diagonal acts as an elastic spring at the point of intersection with the compression diagonal. Thus the compression diagonal could be assumed as a continuous bar simply supported at the ends and having an intermediate elastic support. Timoshenko and Gere [1961] discussed such a problem. A case where the intermediate elastic support is at the middle and the axial force does not change within the two halves of the member was explained. It was shown that if the stiffness of the elastic support, α, approaches infinity, a case of a bar on three hinged supports, the deflected shape will be a full sine wave, and the critical load, C_{cr}, for the compression member will be:

$$C_{cr} = \frac{4\pi^2 EI}{L^2} \tag{2.8}$$

and when α approaches zero, assuming the intermediate support to be absolutely flexible, the shape of the deflection curve of the buckled bar will be as half sine wave, and the critical load, C_{cr}, will be:

$$C_{cr} = C_e = \frac{\pi^2 EI}{L^2} \tag{2.9}$$

The limiting value of the stiffness of the elastic support, at which the full sine wave shape of the buckled bar occurs, was given as below:

$$\alpha_{\lim} = \frac{16\pi^2 EI}{L^3} \tag{2.10}$$

For values of α smaller than α_{lim}, the flexibility of the intermediate support should be considered, and it is shown that the relation between the elastic critical load C_{cr} and the stiffness of the elastic support α deviates little from a straight line. The resulting value of C_{cr} is given as:

$$C_{cr} = C_e + \frac{3\,\alpha\,L}{16} \quad \leq 4C_e \tag{2.11}$$

where C_e is as given by Eq. 2.9.

It has to be mentioned that the assumption of hinged joints does not represent correctly all the types of connections in trusses or frames as the rotational restraint of the joints does exist in cases where the joints are welded or even bolted.

2.6 ANTENNAS, TOWERS, AND ANTENNA SUPPORTING STRUCTURES - CSA S37-94 [CSA 1994]

CSA S37-94 is the Canadian Standard for communication towers. The maximum slenderness ratio for bracing members is limited to 200 as stated in Clause 6.1.5.2 of CSA S37.

For the computation of compressive strength of solid rounds as single bracing in towers, Clause 6.2.2.1 of the Standard states:

> "The unbraced length, L_d, of compression members other than leg members, shall be the distance along the axis of the member to which it is attached. For simple web bracing systems, with web member connected directly or by gussets to the leg member, the slenderness ratio is L_d / r, where, L_d is the length of the diagonal, and r is the radius of gyration."

As for cross bracing, Clause 6.2.2.2 of the Standard states:

> "For tension-compression web systems the diagonals shall be connected where they intersect and the lengths of the compression member shall be the distances from the intersection of the two diagonal members to the centre of the leg members at the ends of the compression member."

The effective slenderness ratio of the compression member is KL_d/r where $KL_d = L_{d1} + 0.5L_{d2}$ ($L_{d1} \geq L_{d2}$, as shown in Fig. 2.1), and r = radius of gyration.

After determining the slenderness ratio of the member, the nondimensional slenderness parameter, λ, is calculated as:

$$\lambda = \frac{KL_d}{r}\sqrt{\frac{F_y}{E\pi^2}} \tag{2.12}$$

This nondimensional slenderness parameter is used in computing factored compressive resistance C_r of the member:

$$C_r = \phi A F_y (1 + \lambda^{2n})^{-\frac{1}{n}} \tag{2.13}$$

where,

ϕ = resistance factor for compression = 0.90

A = cross-sectional area of the member in mm^2

F_y = yield stress in MPa

λ = nondimensional slenderness parameter, and

n = 1.34

2.7 EUROCODE 3: DESIGN OF STEEL STRUCTURES - PART 3.1: TOWERS, MASTS AND CHIMNEYS - TOWERS AND MASTS [ENV 1997]

ENV 1993-3-1:1997 is the European Prestandard for the design of towers and masts. The slenderness ratio of primary bracing members in the Prestandard is limited to 180. The limitation is because high slenderness ratios may lead to the posibility of individual members vibrating and that makes them vulnerable to damage due to bending from local loads.

For single-bracing, Clause 5.6.3.2 of ENV 1993-3-1:1997 states:

> "A single lattice may be used where the loads are light and the lengths relatively short, as for instance near the top of towers or in light guyed masts. The basic slenderness ratio should be taken as: L_d/r for tubes. "

For cross-braced lattice towers, Clause 5.6.3.3 of the Prestandard states:

> "Provided the load is equally split into tension and compression and provided also that both members are continuous, the centre of the cross may be considered as a point of restraint both transverse to and in the plane of the bracing and the critical system length becomes half the total length of the diagonal on the minor axis. The basic slenderness should be taken as: $0.5L_d/r$ for tubes."

In the same clause it is also mentioned that in case that the load is not equally split into tension and compression and provided both members are continuous, the compression members should be checked in the same way for the largest compressive force. In addition, it should be checked that the sum of the buckling resistances of both members in compression is at least equal to the algebraic sum of the axial forces in the two members. For the calculation of buckling resistance, the system length should be taken as L_d and the radius of gyration as that about the rectangular axis parallel to the plane of the bracing.

To be able to calculate the appropriate effective slenderness ratio of the member, the buckling length factor K shall be determined, which depends on the structural configuration and for diagonal bracing members Clause 5.7 of the Prestandard states: "K is dependent on both the bracing pattern and the connections of the bracing to the legs" and it is also mentioned that in absence of accurate information K can be taken as 0.7 for the case of tubes welded to the legs. In this investigation, the basic system length is multiplied by the effective length factor of 0.7 to give an effective length of 0.35 L_d for cross-braced diagonals, which is much less than 0.75 L_d used in CSA S37-94. The compression resistance is calculated from the following:

$$C_r = \chi A F_y / \gamma \tag{2.14}$$

Where,

$$\chi = \frac{1}{\xi + [\xi^2 - \Lambda_e^2]^{0.5}} \quad \text{but } \chi \leq 1$$

$$\Lambda_e = \frac{(K)(Basic\ Slenderness\ Ratio)}{\lambda_y}$$

$$\xi = 0.5\,[1 + 0.49\,(\Lambda_e - 0.2) + \Lambda_e^2]$$

$$\lambda_y = \pi \sqrt{\frac{E}{F_y}}$$

γ = partial factor for resistance of member to buckling = 1.10

0CHAPTER THREE

EXPERIMENTAL INVESTIGATION

3.1 GENERAL

Tests were carried out on six specimens supplied by Trylon Manufacturing Co. Ltd., Elmira, Ontario and twenty specimens supplied by LeBlanc & Royle Telcom Inc., Oakville, Ontario. The specimens were segments of actual towers fabricated by these two companies. Three different leg sizes (38, 44, and 51 mm) and two different sizes of diagonals (19 and 22 mm) were included in this investigation. Sixteen of the specimens had web systems with horizontal members and cross-braced diagonals with three different fabrication methods, while eight specimens had horizontal members and single-braced diagonals. Two specimens with Type I cross-braced diagonals had no horizontals at midspan. For fifteen specimens, strain gauges were attached to the bracing members. All the specimens were loaded to failure. Tensile tests were conducted on coupons taken from the diagonals for all specimens.

3.2 DETAILS OF SPECIMENS

All specimens were of triangular section with legs, horizontal, and diagonal members connected together by welding. The details of the specimens are given in Table 3.1.

3.2.1 Single-Braced Specimens

Eight specimens (LR3, LR4, LR7 to LR12) with horizontal members and single-braced diagonals were tested. Two different leg sizes (38 and 51 mm) were used. All the connections were of welded type. The bracing members are identified as follows:

C1, C2 for compression diagonals, T1, T2 for tension diagonals, and HF, HR for the horizontals at midspan in the front and rear, respectively. The details of this type of specimens are shown in Fig. 3.1 to 3.3.

3.2.2 Cross-Braced Specimens - Type I

Six specimens (TR1 to TR6) with cross-braced diagonals (one diagonal in-plane and the other out-of-plane pre-bent and welded at the intersection) were tested. Of the six specimens, two of the specimens did not have horizontal bracing at all locations.

Specimens of this type consisted of three solid round bars, 44 mm diameter, for the legs. Angles 76×76×9.5 mm as well as 22mm diameter solid round bars were used as horizontal members welded to the legs, and the bracing diagonals were solid round bars 19 mm in diameter. Specimens TR5 and TR6 had no horizontal members at midspan of the specimen. All the members were welded together using a submerged metal arc welding. The nomenclature for the bracing members is as follows:

Each bracing member is identified with two letters, a number, followed by a letter. The first letter (C or T) refers to compression or tension diagonal. Second letter (S or B) refers to straight or bent configuration. The numbers 1, 2, 3, and 4 refer to location of diagonals where 1 refers to East front diagonal, 2 to West front diagonal, 3 to East rear diagonal, and 4 to West rear diagonal. The last letter T or B refers to the top half or bottom half of the diagonal. These types of specimens, with all the dimensions, are shown in Fig. 3.4 to 3.6.

3.2.3 Cross-Braced Specimens - Type II

In this type, both the cross-braced diagonals were in-plane, with one of them continuous (full) and the other cut and welded to the continuous member. Eight specimens of this type (LR1, LR2, LR5, LR6, LR14 to LR16, and LR19) with two different leg sizes (38 and 51 mm) were tested. The horizontal members were all of solid round bars, 19 mm diameter, and the bracing diagonals were also of solid round bars of 22 mm diameter. The nomenclature for the bracing members is as follows:

Each bracing member is identified with two letters, a number, followed by a letter. The first letter (C or T) refers to compression or tension diagonal. Second letter (C or F) refers to cut or full configuration. The numbers 1, 2, 3, and 4 refer to location of diagonals where 1 refers to East front diagonal, 2 to West front diagonal, 3 to East rear diagonal, and 4 to West rear diagonal. The last letter T or B refers to the top half or bottom half of the diagonal. The specimens and their dimensions are shown in Fig. 3.7 to 3.9.

3.2.4 Cross-Braced Specimens - Type III

In this type of fabrication, both cross-braced diagonals are pre-bent out-of-plane (one outside and the other inside) and welded in-plane at their intersection and currently is not used in canada. Some fabricators feel that this type of bracing is more efficient than Type I because of the lower initial curvature in the diagonals compared to those of Type I. The nomenclature for the bracing members is as follows:

Each bracing member is identified with two letters, a number, followed by a letter. The first letter (C or T) refers to compression or tension diagonal. Second letter (I or O) refers to inside or outside configuration. The numbers 1 to 4 refer to location of diagonals (same as for Type I and Type II cross-bracing). The last letter T or B refers to the top half or bottom half of the diagonal. The details of this type of specimens (LR13, LR17, LR18, and LR20) are shown in Fig. 3.10 to 3.13.

3.3 TEST SETUP

The specimens were tested in a horizontal position, simply supported at the ends and loaded with a central concentrated load on the top chord (leg), as shown in Fig. 3.14 and 3.15.

3.3.1 Support Assembly

The support assembly consisted of several steel sections built-up as shown in Fig 3.14. All these steel sections were assembled together to furnish enough height to be able to test the specimens using the testing frame available in the Structural Laboratory at the University of Windsor. The specimens were simply supported on solid round steel bars, 100 mm diameter and 914 mm long.

3.3.2 Load Application

The load was applied through a hydraulic jack attached to the testing frame through a 433x278x50 mm plate. The load cell was screwed to the bottom of hydraulic jack. The load to the specimen was applied through a steel block, 100×75×100 mm, machined and grooved as shown in Fig. 3.15 which seated properly on the top chord of the specimen. The load was applied using a mechanical pump connected to the hydraulic jack. The load cell through a strain indicator measured the applied load.

A 448 kN (100 kip) load cell was used for testing the first six specimens, TR1 to TR6, and a 896 kN (200 kip) load cell was used for the remaining twenty specimens, LR1 to LR20, as these specimens contained larger diameter bracings and preliminary calculations showed that a load higher than 448 kN might be needed to fail the specimens. Both load cells were calibrated using a

Universal Testing Machine and a strain indicator. Calibration curves are shown in Fig. 3.16a and 3.16b.

3.4 TESTING PROCEDURE

3.4.1 Strain Gauging

Electric resistance strain gauges, type N11-FA-5-120-11, with a gauge length of 5mm, 120.3 Ω, and a gauge factor of 2.14, were used to measure strains of the outer fibres of the bracing members under consideration.

A properly cleaned polished surface was prepared for each strain gauge prior to fixing the strain gauge to the member. To ensure that the strain gauges are on opposite sides, 180^0 apart, a magic tape, with proper marking on it, was attached to the member. Fig. 3.17 shows a close-up of test setup with all the wiring used to connect the strain gauges to the strain indicators.

Strain gauges were attached to specimens TR1 to TR4 and LR10 to LR20. A minimum of 8 to a maximum of 32 strain gauges were used for the specimens. The numbers and locations of the strain gauges used in each specimen are shown in Tables A.1 to A.15 and Fig. 3.18 to 3.31.

Initially, only eight strain gauges located at the quarter points of the compression diagonals of the two middle panels in specimen TR1 were used as shown in Fig. 3.18. Based on the observations of the buckled shape, the location of strain gauges for specimen TR2 was changed from quarter points to one-third points as shown in Fig. 3.19. For specimen TR3, in order to study the force distribution in tension diagonals, four additional strain gauges, one on each tension diagonal member, were attached at quarter points (a total of 12 gauges) as shown in Fig. 3.20. In order to get more information from strain gauges, ten additional gauges (a total of 22) as shown in Fig. 3.21 were used for specimen TR4.

After obtaining the necessary financial assistance from the industry, eleven of the specimens were fully strain-gauged. Specimens LR10, LR11, and LR12 were single-braced specimens and 16, 16, and 12 strain gauges respectively were attached to the bracing to get complete information about the force distribution in diagonals. The location of strain gauges are shown in Fig. 3.22 to 3.24. Cross-braced Specimens LR13 to LR20 had 32 strain gauges each as shown in Fig. 3.25 to 3.31.

3.4.2 Testing of Specimens

The specimens were mounted on the supports and centered. The diagonal bracing members in compression at the end panels were stiffened by bolting 89×64×6.4 mm angles, 855 mm long, supplied by the manufacturing company, to ensure the failure of the compression bracing diagonals at the intermediate panels. A dial indicator was mounted on top of the load cell to measure the deflection of the top chord of the specimen at the point of application of load. It is to be pointed out that the load-deflection data was obtained for the sake of completeness and is not used in this investigation.

Load was applied in larger increments at the beginning of the test and was followed by smaller increments as the bracing diagonals started to buckle, until the maximum load was reached. For each increment of load the dial gauge reading and strain gauge readings were recorded. Load-deflection data for twenty-four specimens are shown in Tables B.1 to B.24 in Appendix B.

For specimens LR1 to LR3, the buckling of the horizontal members preceded the buckling of the compression bracing diagonals. As the members of interest were the bracing diagonals and not the horizontal members, it was realized that a modification is required for the remaining specimens in order to be able to get the required information. This problem was solved by the stiffening of the horizontal members which ensured that the diagonals failed prior to the failure of the horizontal members. Initially the horizontal members at the ends were stiffened by bolting angles. This type of stiffening was found to be unsatisfactory and it was decided to stiffen the horizontal members at the middle and at the ends by welding angles to them, instead of bolting. One leg of the angle was welded along the length of the member and the ends of the angle were welded to the chords. Another angle was welded at the centre, connecting the two angles welded to each of the two horizontal members on the two opposite faces of the specimen. In the stiffening process, it was ensured that the diagonal bracing members were not affected by the welding of the angles to the horizontal members. A specimen with stiffened horizontal members is shown in Fig. 3.14. Details of the stiffening of the horizontal members are given in Table 3.1. Fig. 3.33 to 3.58 show test specimens after failure.

3.4.3 Tensile Coupons

Because the bracing members in the interior panels buckled during the test, tensile coupons were taken from the bracings in the end panels. Three coupons were taken from three different diagonals (one from each).

A hand saw was used for cutting the coupons for specimens TR1 to TR6. Since this procedure took unduly long time, a plasma cutter and a masonry saw were used for cutting coupons from the remaining specimens. Coupons cut using this latter method were cut to longer lengths than required and the ends were cut again using a band saw to remove the heat-affected material. The tensile test specimens were prepared according to ASTM A370-88a.

Either two or three tensile coupons for each specimen were tested. A total of 73 coupons were tested. Prior to testing, an indentation was marked on the tensile test specimen to measure the elongation after failure. A 300 kN capacity Universal Testing Machine was used for testing the specimens and the load vs. elongation curve for the tensile coupons was plotted using Tinius Olsen electronic extensometer. A definite yield point was noted for the specimens, from which the yield stresses of the specimens were calculated. Coupons were loaded up to failure, the maximum load obtained was recorded and the elongation over 50 mm gauge length was measured. A setup of testing of tensile coupon is shown in Fig. 3.32 and the test results are given in Tables 3.2a and 3.2b.

CHAPTER FOUR

ANALYSIS AND DISCUSSION OF RESULTS

4.1 GENERAL

The behaviour of test specimens is described in detail in this chapter. Axial forces in the diagonals are computed from the measured strain readings at various load levels. These are compared with loads computed using the commercially available computer packages ANSYS and S-Frame.

The buckling loads determined experimentally are compared with the values calculated according to Canadian Standard S37-94 and European Prestandard ENV 1993-3-1: 1997. It is shown that the Canadian Standard is conservative and the European Prestandard is unsafe for cross-bracing Types I and III. In view of the conservative nature of CSA S37-94, it is proposed to use reduced effective length factors when using it.

4.2 BEHAVIOUR OF TEST SPECIMENS

The load-deflection data and the behaviour for 24 of the 26 test specimens are presented in Tables B.1 to B.24. The behaviour of specimens with different arrangements of bracing are now discussed in detail.

4.2.1 Single-Braced Specimens

For specimens with single-bracing, the failure mode was symmetric. Buckling of compression diagonals was visually very clear at time of buckling. Initial buckling of diagonal was either in-plane or out-of-plane. At the time of collapse of the specimen, most of the diagonals failed in a combined in-plane and out-of-plane mode. The buckling load for the second compression diagonal is less than the buckling load of the first compression diagonal. This is because of the reduction in the end restraint for the second diagonal after the buckling of the first diagonal.

4.2.2 Type I Cross-Braced Specimens

Behaviour of specimens TR1 to TR4 is quite similar and the total load applied at midspan of each specimen at failure is approximately the same. All of the buckled members failed out-of-plane in S-shape. After computing the axial loads from the strain data for specimen TR4, it was observed that the straight compression diagonal was carrying greater portion of the load than the pre-bent diagonal and therefore this member (straight) buckled first. Axial force at buckling in the pre-bent diagonal is about 20% less than the buckling force for the straight diagonal. After the failure of the first compression diagonal, load was redistributed to the other diagonals through the horizontal bracing members. Further increase in the applied load at midspan was being resisted by the tension diagonals.

As for specimens TR5 and TR6 where no horizontal bracing member existed at midspan, the collapse of the test specimen was sudden and simultaneous with the buckling of the diagonals. The total load carried by these specimens was only one-third that of specimens TR1 to TR4.

It should be pointed out that in tower industry there can be tower sections fabricated without horizontal bracing members and with only diagonal bracing. The failure in such cases will not be sudden (as experienced in the laboratory) as the loads from the wind are uniformly distributed over the entire length and are not concentrated at a point as it is in the experimental setup.

4.2.3 Type II Cross-Braced Specimens

Of the three types of cross-bracing, this type is the most efficient with regard to the compressive axial load carrying capacity. All compression diagonals (whether continuous or cut) failed out-of-plane. There is no difference in the load carrying capacity of the continuous and the cut diagonals.

4.2.4 Type III Cross-Braced specimens

This type of cross-bracing had both diagonals pre-bent out-of-plane with the weld at their intersection in the plane of the face of the tower. Because of the initial curvature of those members, it was difficult to visually determine the load at which first buckling occurred. In all cases this arrangement is found to be less efficient than Type I cross-bracing. All the compression diagonals failed out-of-plane.

4.2.5 Effect of Leg Size

As expected, for single-bracing, the buckling loads were greater for specimens with larger leg members because of the increased restraint afforded by them. Contrary to the observations made for single-bracing, the leg size did not have significant effect on the buckling load of compression diagonals for cross-bracing. This is probably because the slenderness ratios of these members are much less than that of the single bracing and hence end restraint did not have as much a role to play as for slender members.

4.3 DETERMINATION OF AXIAL FORCES IN DIAGONALS

4.3.1 Determination of Axial Forces from Strain Data

The cross-section of each diagonal was divided into 200 equal strips. A linear variation of strain across the cross-section was assumed. A linear elastic-perfectly plastic stress-strain model was used and the resultant axial force in the member was computed. The results of the computations are given in Appendix C, and the formulas used are presented in Appendix D. The accuracy of the computations was verified by carrying an equilibrium check for twelve specimens (TR4, LR10 to LR20) for which sufficient information about force distribution is available and are shown in Tables C.1 to C.12 of Appendix C. A summary of buckling loads of compression diagonals is given in Table 4.1.

4.3.2 Commercially Available Computer Packages

S-Frame (which uses matrix stiffness method of analysis) and ANSYS (which uses a finite element analysis) were used to determine the force distribution in the elastic range. As expected, both packages gave identical results with equally distributed forces in compression and tension diagonals. For single-braced specimens the axial force in compression diagonals is 0.352 of the applied load at midspan. For cross-braced specimens Type II and III, the axial forces in the compression and tension diagonals are each equal to 0.174 of the applied load. The computed forces are compared with actual force distribution in Tables C.2 to C.4 and C.7 to C.11, and it can be seen that the usual assumption of equal distribution of forces in compression and tension diagonal is not true at any load level.

4.4 FAILURE LOADS ACCORDING TO CSA S37-94 AND ENV 1993-3-1:1997

Tables 4.2 and 4.3 present the buckling loads of compression diagonals according to CSA S37-94 and ENV 1993-3-1:1997 using resistance factor of 1.0 and the actual yield stresses. In table 4.4, these are compared with the experimentally determined minimum axial forces in the compression diagonals. From these tables it is obvious that the Canadian Standard S37-94 is conservative for all specimens and the European code gives results which are safe for single-bracing and Type II cross-bracing only, but unsafe for Types I and III cross-bracing (based on an effective length of $0.35L_d$).

In Table 4.5 the effective length factors are determined from the experimental buckling loads. The average effective length factor for single-bracing is found to be 0.525 and the factors are 0.429, 0.365, and 0.580 for Types I, II, and III, respectively. In view of this, it is proposed that an effective length of $0.7L_d$ be used for single bracing, $0.5L_d$ for Type I cross-bracing, $0.4L_d$ for Type II cross-bracing, and $0.7L_d$ for Type III cross-bracing when buckling loads are calculated according to CSA S37. The buckling loads, recalculated using the proposed reduced effective length factors, are shown in Table 4.6a.

It can be seen that the proposed effective length factors result in greater buckling loads for compression diagonals though still less than the experimentally determined loads. It should be noted that these computations are based on actual yield stresses though in actual practice the Standard allows the use of nominal yield stress of 300 MPa only. This further decreases the calculated buckling loads as shown in Table 4.6b, resulting in greater margin of safety. A further increase in margin of safety is available through the use of resistance factor ϕ of 0.9 in the calculation of buckling load C_r.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL

Twenty-six specimens, actual tower segments produced by two companies, were simply supported and tested under a concentrated load at midspan. Specimens with single-braced diagonals as well as cross-braced diagonals (with three different fabrication methods) were included in this investigation. All the specimens were made of welded members and all the bracing diagonal members were of solid rounds.

5.2 CONCLUSIONS

Based on experimental investigation, for the conditions reported herein, the following conclusions can be drawn:

1(a) The distribution of forces in compression and tension diagonals are not equal at any load level. Sometimes the compression diagonal force is greater than the force in the tension diagonal and in other cases the opposite is true. No definite conclusions about the distribution between compression and tension diagonals can be drawn.

(b) The initiation of failure of a diagonal in compression did not result in the failure of the tower segment. There was a redistribution of forces and the collapse load of the specimen was much more than the load at initiation of buckling of the compression diagonal.

(c) When the horizontal members at midspan failed, there was a sudden failure of the entire tower specimen.

(d) For Type I arrangement of cross-bracing, the buckling load of the pre-bent compression diagonal is less than that of the straight in-plane diagonal.

(e) For Type II cross-bracing, the buckling load of the compression diagonal is the same for both the continuous diagonal and the cut-and-welded diagonal.

(f) The leg size had no effect on the buckling load of compression diagonals in cross-braced specimens; however for single-braced diagonals the buckling load increased with increase in the leg size.

(g) For all types of cross-bracing, the compression diagonals buckled out-of-plane. For single-braced diagonals, a few diagonals buckled in-plane, a few buckled out-of-plane, while most diagonals failed in a combination of in- and out-of-plane buckling.

2. Of the three different types of cross-braced specimens, the buckling load for the compression diagonals for Type II arrangement with both diagonals in-plane, one continuous and the other cut-and-welded at intersection, is greater than that of the other two types.

3(a) CSA S37-94 " Antennas, Towers, and Antenna-Supporting Structures" gives buckling loads which are much lower than the experimentally obtained values for single-bracing and all types of cross-bracing.

(b) For single-bracing, ENV 1993-3-1: 1997 "Eurocode 3: Design of steel structures – Part 3-1: Towers, masts and chimneys – Towers and masts" gives buckling loads which are much less than the experimental loads.

(c) For Type II cross-bracing, ENV 1993-3-1:1997 "Eurocode 3: Design of steel structures – Part 3-1: Towers, masts and chimneys – Towers and masts" gives buckling loads which are closer to experimental failure loads.

(d) For Type I and Type III cross-bracing, ENV 1993-3-1: 1997 " Eurocode 3: Design of steel structures - Part 3-1: Towers, masts and chimneys - Towers and masts" gives buckling loads which are greater than the experimental loads (based on effective length of $0.35L_d$).

4. Effective lengths of $0.7L_d$ for single-bracing, $0.5L_d$ for Type I cross-bracing, $0.4L_d$ for Type II cross-bracing, and $0.7L_d$ for Type III cross-bracing (instead of $1.0L_d$ for single-bracing and $0.75L_d$ for all types of cross-bracing which are currently specified) result in buckling loads which are closer to and slightly less than the experimentally determined values and are therefore recommended for use in CSA S37-94.

5.3 RECOMMENDATIONS FOR FURTHER RESEARCH

- To know the distribution of forces in the members, tests should be carried out on tower segments with loads applied at each panel point (instead of a single concentrated load at midspan of top chord as in the current investigation) to simulate the actual distributed wind load.
- Additional testing may be carried out for the case of cross-bracing with secondary bracing (redundants).
- Since only one specimen with Type I cross-bracing had strain gauges, it is recommended to carry out tests on two or three additional specimens to verify the validity of the recommendation of buckling length of $0.5L_d$.

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TABLES

Table 3.1 Details of Test Specimens

Serial No.	Specimen ID	Fabricator	Type of Coating	Span (mm)	Face Width c/c of Legs (mm)	Type of Bracing	Leg Size (mm)	Diagonal Size (mm)	Stiffening of Horizontal Members at Midspan	Stiffening of the End Horizontal	Strain Gauging	Max. Load at Midspan (kN)
1	TR1	Trylon	Galvanized	2965	763	Type I X-Bracing	44	19	None	None	Yes	347
2	TR2	Trylon	Galvanized	2965	763	Type I X-Bracing	44	19	None	None	Yes	343
3	TR3	Trylon	Galvanized	2965	763	Type I X-Bracing	44	19	None	None	Yes	350
4	TR4	Trylon	Galvanized	2965	763	Type I X-Bracing	44	19	None	None	Yes	350
5	TR5	Trylon	Galvanized	2965	763	Type I X-Bracing	44	19	None	None	No	117
6	TR6	Trylon	Galvanized	2965	763	Type I X-Bracing	44	19	None	None	No	120
7	LR1	LeBlanc	Galvanized	2400	851	Type II X-Bracing	51	22	None	None	No	399
8	LR2	LeBlanc	Galvanized	2400	838	Type II X-Bracing	38	22	None	Bolted angle	No	313
9	LR3	LeBlanc	Galvanized	2400	851	Single-Bracing	51	22	None	Bolted angle	No	153
10	LR4	LeBlanc	Galvanized	2400	851	Single-Bracing	51	22	Two bolted angles	Bolted angle	No	153
11	LR5	LeBlanc	Galvanized	2400	851	Type II X-Bracing	51	22	Welded angle	Two bolted angles	No	446
12	LR6	LeBlanc	Galvanized	2356	838	Type II X-Bracing	38	22	Welded angle	Welded angle	No	513
13	LR7	LeBlanc	Painted	2400	851	Single-Bracing	51	22	Welded angle	Welded angle	No	246
14	LR8	LeBlanc	Galvanized	2400	838	Single-Bracing	38	22	Welded angle	Welded angle	No	184
15	LR9	LeBlanc	Galvanized	2356	838	Single-Bracing	38	22	Welded angle	Welded angle	No	184
16	LR10	LeBlanc	Galvanized	2400	838	Single-Bracing	38	22	Welded angle	Welded angle	No	184
17	LR11	LeBlanc	Painted	2400	851	Single-Bracing	51	22	Welded angle	Welded angle	Yes	184
18	LR12	LeBlanc	Galvanized	2400	838	Single-Bracing	38	22	Welded angle	Welded angle	Yes	281
19	LR13	LeBlanc	None	2356	838	Type III X-Bracing	38	22	Welded angle	Welded angle	Yes	176
20	LR14	LeBlanc	Galvanized	2356	851	Type II X-Bracing	51	22	Welded angle	Welded angle	Yes	425
21	LR15	LeBlanc	Galvanized	2400	851	Type II X-Bracing	51	22	Welded angle	Welded angle	Yes	485
22	LR16	LeBlanc	Galvanized	2400	838	Type II X-Bracing	38	22	Welded angle	Welded angle	Yes	516
23	LR17	LeBlanc	None	2400	851	Type III X-Bracing	51	22	Welded angle	Welded angle	Yes	519
24	LR18	LeBlanc	None	2400	838	Type III X-Bracing	38	22	Welded angle	Welded angle	Yes	529
25	LR19	LeBlanc	Galvanized	2400	838	Type II X-Bracing	38	22	Welded angle	Welded angle	Yes	435
26	LR20	LeBlanc	None	2356	851	Type III X-Bracing	51	22	Welded angle	Welded angle	Yes	482

Table 3.2a Tensile Coupon Test Results for Specimens TR1 to TR6

Specimen ID	Coupon No.	Avg. Dia. of Three measurements (mm)	Area (mm^2)	Yield Load (kN)	Yield Stress (MPa)	Maximum Load (kN)	Tensile Strength (MPa)	Elongation %	Avg. Yield Stress (MPa)
TR1	1	12.7	126	37.6	298	57.0	451	41	298
	2	12.7	127	37.7	298	57.1	451	40	
	3	12.7	126	37.7	298	57.1	451	-	
TR2	4	12.7	127	41.6	328	63.6	502	38	329
	5	12.7	127	41.8	329	63.9	503	37	
TR3	7	12.7	126	41.7	331	63.2	502	36	336
	8	12.7	127	43.3	341	64.7	510	36	
TR4	10	12.7	127	42.3	332	63.4	498	38	328
	11	12.7	127	41.1	324	62.9	497	37	
	12	12.5	124	40.3	326	62.3	504	35	
TR5	13	12.7	127	38.0	300	56.9	450	38	301
	14	12.5	123	36.7	298	56.3	458	38	
	15	12.7	127	38.9	306	58.2	458	39	
TR6	16	12.6	124	37.1	300	56.1	453	38	300
	17	12.7	127	37.9	299	57.6	455	39	
	18	12.6	125	37.8	302	56.7	453	38	

Table 3.2b Tensile Coupon Test Results for Specimens LR1 to LR20

Specimen ID	Coupon No.	Avg. Dia. of Three Measurements (mm)	Area (mm^2)	Yield Load (kN)	Yield Stress (MPa)	Maximum Load (kN)	Tensile Strength (MPa)	Elongation %	Avg. Yield Stress (MPa)
LR1	6	12.7	126	38.6	306	60.6	481	37	312
	7	12.5	122	39.2	320	59.9	489	39	
	8	12.5	123	38.3	310	59.5	482	36	
LR2	9	12.7	126	40.8	323	60.8	482	39	325
	10	12.6	125	40.4	324	60.2	483	38	
	11	12.6	125	40.7	326	60.6	486	38	
LR3	12	12.6	124	38.3	308	59.7	481	35	310
	13	12.7	126	39.2	311	60.6	481	38	
	14	12.7	127	39.4	310	61.6	484	37	
LR4	15	12.6	124	40.0	322	60.3	485	37	317
	16	12.7	127	39.4	311	60.9	481	37	
LR5	18	12.6	125	48.4	387	72.3	578	33	341
	19	12.7	127	40.4	319	61.5	485	38	
	20	12.8	129	41.2	319	62.9	486	37	
LR6	21	12.7	128	40.0	313	61.2	480	38	335
	22	12.7	126	40.2	319	60.4	479	37	
	23	12.6	124	46.1	372	69.3	559	34	
LR7	24	12.7	126	46.0	366	68.7	546	36	369
	25	12.7	126	47.0	372	69.3	549	35	
	26	12.7	126	46.4	369	69.2	550	34	
LR8	27	12.7	127	40.5	319	61.6	485	37	315
	28	12.7	126	39.0	309	60.5	479	37	
	29	12.7	126	40.2	318	61.0	483	38	
LR9	30	12.7	126	41.2	327	63.0	500	34	326
	31	12.7	126	41.1	326	63.2	502	35	
	32	12.7	126	41.0	325	63.3	501	35	
LR10	33	12.6	124	41.4	333	62.8	506	36	330
	34	12.7	127	41.8	330	63.7	503	36	
	35	12.7	126	41.3	327	63.7	504	36	

Table 3.2b Continued

Specimen ID	Coupon No.	Avg. Dia. of Three Measurements (mm)	Area (mm^2)	Yield Load (kN)	Yield Stress (MPa)	Maximum Load (kN)	Tensile Strength (MPa)	Elongation %	Avg. Yield Stress (MPa)
LR11	36	12.7	127	47.4	374	69.6	549	34	369
	37	12.7	127	46.6	367	69.8	549	34	
	38	12.6	125	45.8	365	68.2	544	34	
LR12	39	12.7	126	40.0	318	61.1	486	38	311
	40	12.7	126	39.4	312	60.6	479	38	
	41	12.6	126	38.0	303	59.8	476	35	
LR13	42	12.7	126	45.7	362	69.9	553	34	339
	43	12.7	126	41.6	330	63.7	505	37	
	44	12.7	126	40.9	325	62.6	497	37	
LR14	45	12.7	127	39.7	314	60.8	480	38	313
	46	12.7	126	39.5	312	61.1	483	38	
	47	12.7	127	39.7	314	60.8	480	38	
LR15	48	12.7	126	38.4	305	60.0	476	39	311
	49	12.7	127	39.5	311	61.2	482	37	
	50	12.7	127	40.3	318	61.4	484	37	
LR16	52	12.7	126	45.0	357	68.7	545	36	363
	53	12.7	126	46.6	369	70.5	558	38	
LR17	54	12.6	125	41.1	328	62.8	501	37	329
	55	12.7	127	41.9	330	63.6	500	37	
	56	12.7	126	41.7	330	63.0	498	37	
LR18	58	12.7	126	40.8	324	63.0	500	37	329
	59	12.7	127	42.4	333	64.0	503	37	
LR19	60 ·	12.7	127	40.2	318	61.0	482	40	321
	61	12.7	126	40.3	320	60.3	478	37	
	62	12.7	127	41.1	325	61.1	483	38	
LR20	63	12.7	126	41.0	325	62.8	498	38	329
	64	12.7	126	41.6	330	62.8	498	37	
	65	12.7	127	42.1	332	63.6	501	36	

Table 4.1 Summary of Experimental Buckling Loads of Compression Diagonals Determined from Strain Data

Specimen ID	Type of Bracing	Compression Diagonal Members	Figure Reference	Sequence of Buckling	Buckling Load of Member (kN)
TR4	Type I x-braced	CS2	Fig. 3.4	first	55.4
		CB4		second	43.5
LR10	Single-braced	C1	Fig. 3.3	first	69.9
		C2		second	59.6
LR11	Single-braced	C1	Fig. 3.2	first	87.0
		C2		second	68.1
LR12	Single-braced	C1	Fig. 3.1	second	60.1
		C2		first	52.0
LR13	Type III x-braced	CO1	Fig. 3.10	second	55.8
		CO2		first	70.8
		CI3		third	59.4
		CI4		third	64.1
LR14	Type II x-braced	CF1	Fig. 3.9	second	92.9
		CF2		first	100
		CC3		third	108
		CC4		fourth	95.1
LR15	Type II x-braced	CC1	Fig. 3.7	second	82.8
		CC2		fourth	99.4
		CF3		first	96.9
		CF4		third	90.0
LR16	Type II x-braced	CC1	Fig. 3.8	second	88.1
		CC2		first	94.8
		CF3		third	108
		CF4		fourth	95.9
LR17	Type III x-braced	CI1	Fig. 3.11	third	57.0
		CO2		first	64.7
		CI3		second	47.8
		CI4		fourth	59.9
LR18	Type III x-braced	CI1	Fig. 3.12	fourth	56.7
		CI2		second	47.7
		CO3		first	62.3
		CO4		third	68.0
LR19	Type II x-braced	CC1	Fig. 3.7	third	85.7
		CC2		first	84.1
		CF3		fourth	95.0
		CF4		second	79.2
LR20	Type III x-braced	CI1	Fig. 3.13	third	56.0
		CO2		first	60.9
		CO3		second	63.4
		CI4		fourth	58.9

Table 4.2 Buckling Loads of Compression Diagonals according to CSA S37 (ϕ =1.0)

Specimen ID	Actual F_y (MPa)	Total Length L_d (mm)	Radius of Gyration r (mm)	K	$\lambda=(KL_d/r)^*(F_y/E\pi^2)^{0.5}$	Area A (mm^2)	$C_r=\phi AF_y(1+\lambda^{2n})^{-1/n}$ (kN)
TR4	328	1070	4.76	0.75	2.17	285	18.1
LR10	330	1020	5.56	1.00	2.37	388	21.2
LR11	369	1030	5.56	1.00	2.53	388	21.0
LR12	311	1020	5.56	1.00	2.30	388	21.1
LR13	339	1020	5.56	0.75	1.80	388	35.1
LR14	313	1030	5.56	0.75	1.75	388	34.1
LR15	311	1030	5.56	0.75	1.74	388	34.1
LR16	363	1020	5.56	0.75	1.87	388	35.5
LR17	329	1030	5.56	0.75	1.79	388	34.4
LR18	329	1020	5.56	0.75	1.78	388	35.0
LR19	321	1020	5.56	0.75	1.76	388	34.8
LR20	329	1030	5.56	0.75	1.79	388	34.4

Table 4.3 Buckling Loads of Compression Diagonals according to ENV 1993-3-1 (γ =1.0)

Specimen ID	Actual F_y (MPa)	Total Length L_d (mm)	Radius of Gyration r (mm)	Basic Slenderness Ratio	K^* Basic Slenderness Ratio	$\lambda_y=\pi(E/F_y)^{0.5}$	Λ_e [Eq. 2.14]	ξ [Eq. 2.14]	χ [Eq. 2.14]	Area A (mm^2)	$C_r=\chi A F_y/\gamma$ (kN)
TR4	328	1070	4.76	112.34	78.64	77.58	1.01	1.21	0.532	285	49.7
LR10	330	1020	5.56	183.54	128.48	77.34	1.66	2.24	0.268	388	34.3
LR11	369	1030	5.56	185.34	129.73	73.14	1.77	2.46	0.240	388	34.4
LR12	311	1020	5.56	183.54	128.48	79.67	1.61	2.15	0.281	388	33.9
LR13	339	1020	5.56	91.77	64.24	76.31	0.84	1.01	0.636	388	83.6
LR14	313	1030	5.56	92.67	64.87	79.41	0.82	0.98	0.652	388	79.1
LR15	311	1030	5.56	92.67	64.87	79.67	0.81	0.98	0.653	388	78.8
LR16	363	1020	5.56	91.77	64.24	73.74	0.87	1.04	0.618	388	87.0
LR17	329	1030	5.56	92.67	64.87	77.46	0.84	1.01	0.639	388	81.5
LR18	329	1020	5.56	91.77	64.24	77.46	0.83	1.00	0.644	388	82.2
LR19	321	1020	5.56	91.77	64.24	78.42	0.82	0.99	0.650	388	81.0
LR20	329	1030	5.56	92.67	64.87	77.46	0.84	1.01	0.639	388	81.5

Table 4.4 Comparison of Critical Buckling Loads according to CSA S37 and ENV 1993-3-1 with the Loads Calculated from Strain Data

Specimen ID	Type of Bracing	Compressive Resistance using Actual F_y (kN)		Minimum Buckling Load from Strain Data (kN)
		CSA	ENV	
TR4	Type I X-Braced	18.1	49.7	43.5
LR10	Single-Braced	21.2	34.3	59.6
LR11	Single-Braced	21.0	34.4	68.1
LR12	Single-Braced	21.1	33.9	52.0
LR13	Type III X-Braced	35.1	83.6	55.8
LR14	Type II X-Braced	34.1	79.1	92.9
LR15	Type II X-Braced	34.1	78.8	82.8
LR16	Type II X-Braced	35.5	87.0	88.1
LR17	Type III X-Braced	34.4	81.5	47.8
LR18	Type III X-Braced	35.0	82.2	47.7
LR19	Type II X-Braced	34.8	81.0	79.2
LR20	Type III X-Braced	34.4	81.5	56.0

Table 4.5 Effective Length Factors calculated from Experimental Buckling Loads using Actual Yield Stress

Specimen ID	Type of Bracing	Actual F_y (MPa)	C_r Min. Value of Experimental Buckling Loads (kN)	λ Corresponding to C_r	KL_d (mm)	L_d (c/c Length of the Diagonal) (mm)	K
TR4	Type I X-Braced	328	43.5	1.24	459	1070	0.429
LR10	Single-Braced	330	59.6	1.24	534	1020	0.523
LR11	Single-Braced	369	68.1	1.22	496	1030	0.482
LR12	Single-Braced	311	52.0	1.32	583	1020	0.571
LR13	Type III X-Braced	339	55.8	1.33	565	1020	0.554
LR14	Type II X-Braced	313	92.9	0.73	323	1030	0.313
LR15	Type II X-Braced	311	82.8	0.85	378	1030	0.367
LR16	Type II X-Braced	363	88.1	0.95	390	1020	0.382
LR17	Type III X-Braced	329	47.8	1.45	626	1030	0.608
LR18	Type III X-Braced	329	47.7	1.46	627	1020	0.615
LR19	Type II X-Braced	321	79.2	0.93	407	1020	0.399
LR20	Type III X-Braced	329	56.0	1.30	559	1030	0.543

* Average 'K' values

For single-bracing = 0.525

For Type I cross-bracing = 0.429

For Type II cross-bracing = 0.365

For Type III cross-bracing = 0.580

Table 4.6a Calculation of Buckling Loads according to CSA S37 using the Proposed Effective Length Factors (Actual Yield Stress and ϕ=1.0)

Specimen ID	Actual F_y (MPa)	Total Length L_d (mm)	Radius of Gyration r (mm)	Proposed K	$\lambda=(KL_d/r)*(F_y/E\pi^2)^{0.5}$	Area A (mm^2)	$C_r=\phi AF_y(1+\lambda^{2n})^{-1/n}$ (kN)
TR4	328	1070	4.76	0.5	1.45	285	35.2
LR10	330	1020	5.56	0.7	1.66	388	39.1
LR11	369	1030	5.56	0.7	1.77	388	39.3
LR12	311	1020	5.56	0.7	1.61	388	38.6
LR13	339	1020	5.56	0.7	1.68	388	39.3
LR14	313	1030	5.56	0.4	0.93	388	77.3
LR15	311	1030	5.56	0.4	0.93	388	77.0
LR16	363	1020	5.56	0.4	1.00	388	84.3
LR17	329	1030	5.56	0.7	1.67	388	38.5
LR18	329	1020	5.56	0.7	1.66	388	39.1
LR19	321	1020	5.56	0.4	0.94	388	79.1
LR20	329	1030	5.56	0.7	1.67	388	38.5

Table 4.6b Calculation of Buckling Loads according to CSA S37 using the Proposed Effective Length Factors (Nominal Yield Stress and ϕ=0.9)

Specimen ID	Nominal F_y (MPa)	Total Length L_d (mm)	Radius of Gyration r (mm)	Proposed K	$\lambda=(KL_d/r)*(F_y/E\pi^2)^{0.5}$	Area A (mm^2)	$C_r=\phi AF_y(1+\lambda^{2n})^{-1/n}$ (kN)
TR4	300	1070	4.76	0.5	1.38	285	30.9
LR10	300	1020	5.56	0.7	1.58	388	34.5
LR11	300	1030	5.56	0.7	1.60	388	34.0
LR12	300	1020	5.56	0.7	1.58	388	34.5
LR13	300	1020	5.56	0.7	1.58	388	34.5
LR14	300	1030	5.56	0.4	0.91	388	68.0
LR15	300	1030	5.56	0.4	0.91	388	68.0
LR16	300	1020	5.56	0.4	0.91	388	68.5
LR17	300	1030	5.56	0.7	1.60	388	34.0
LR18	300	1020	5.56	0.7	1.58	388	34.5
LR19	300	1020	5.56	0.4	0.91	388	68.5
LR20	300	1030	5.56	0.7	1.60	388	34.0

FIGURES

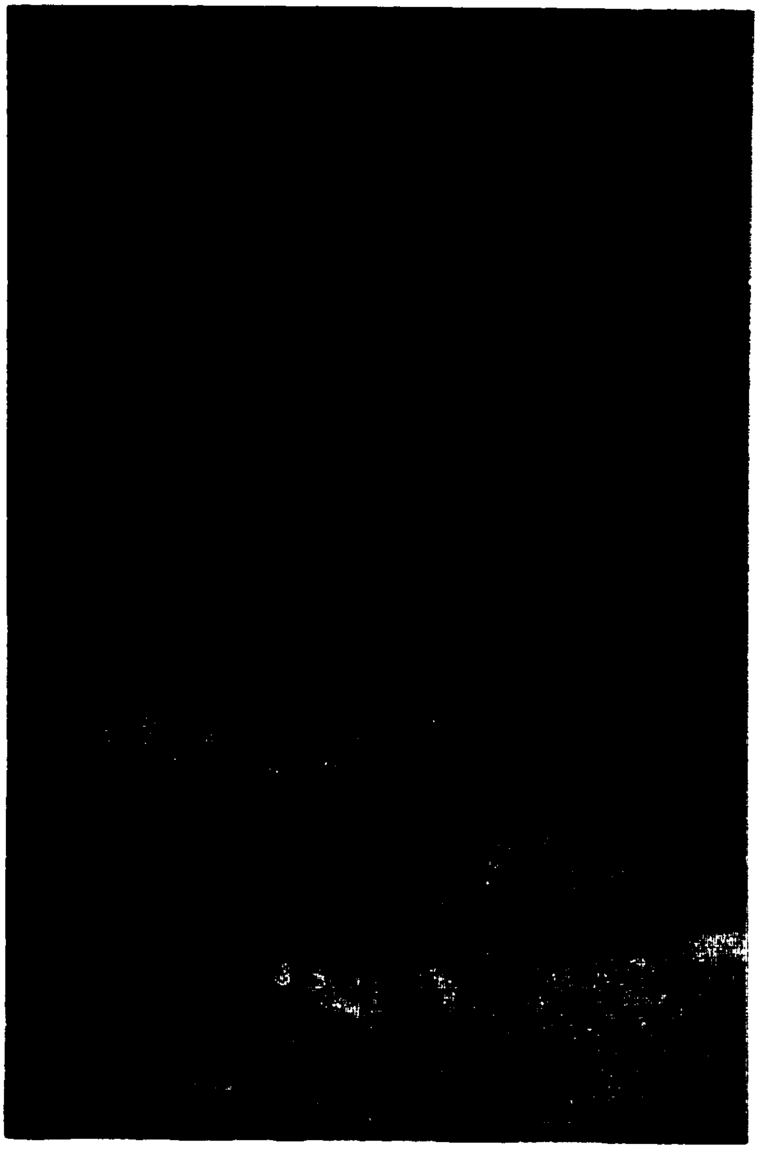


Fig. 1.1 300m-high Guyed Television Mast at Barrie, Ontario

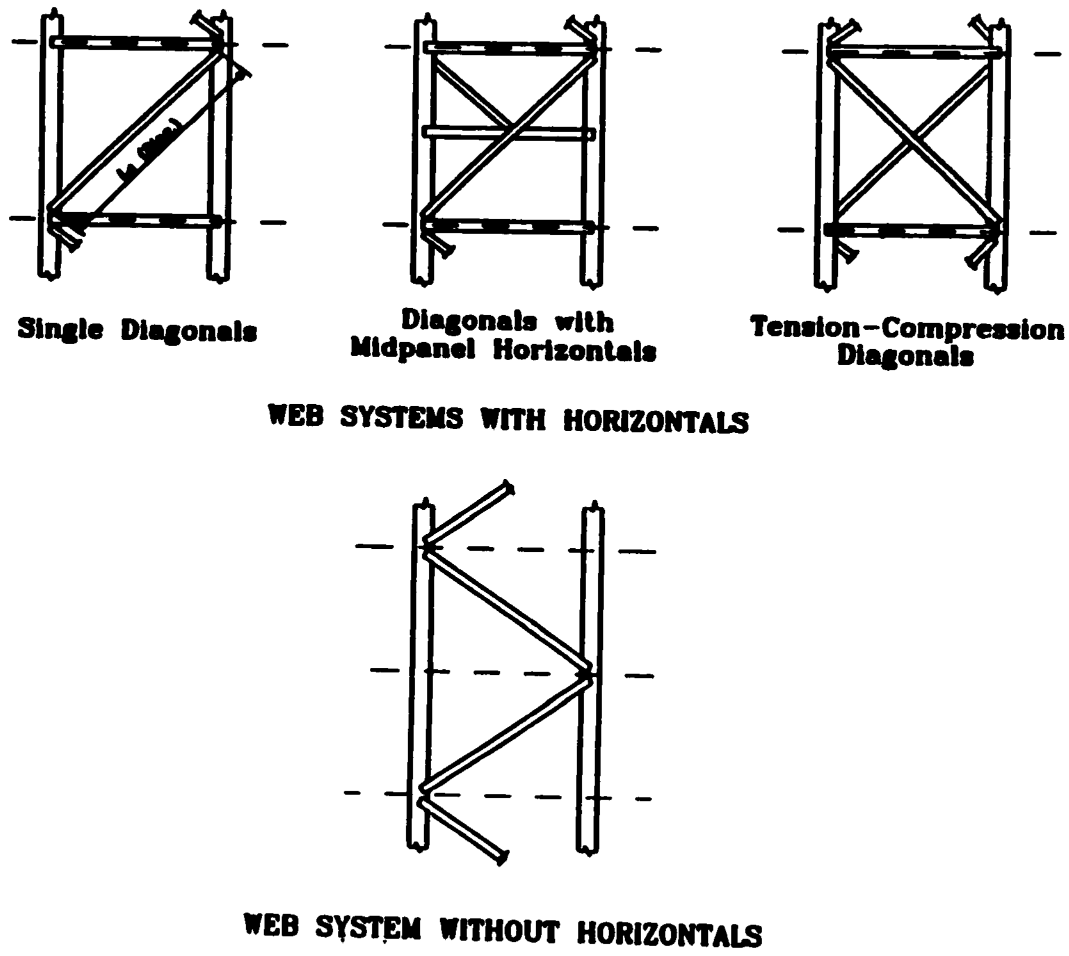


Fig. 1.2 Web Systems in Lattice Communication Towers
(Source: CSA S37-94, pp. 25-26)

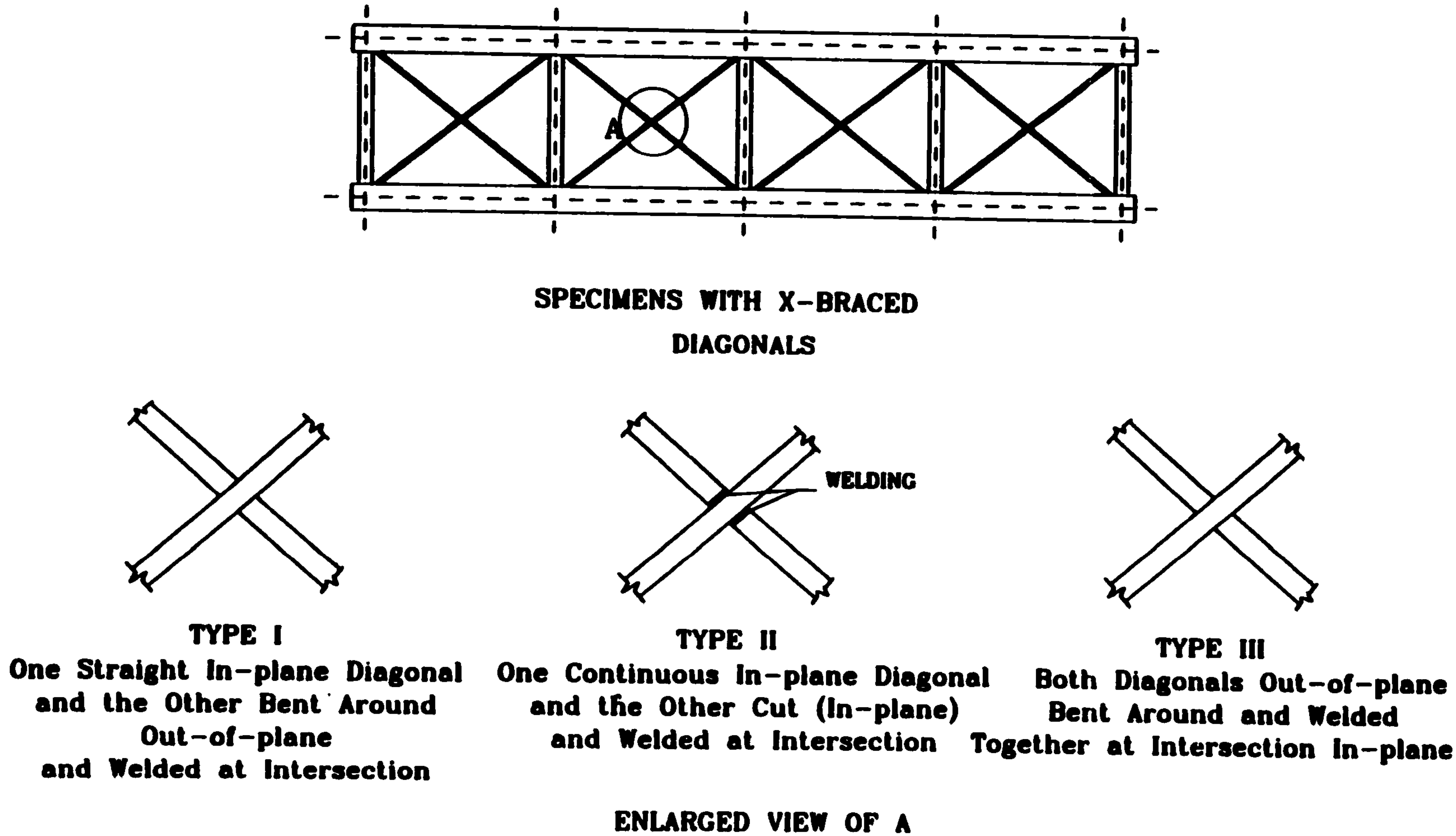


Fig. 1.3 Different Methods of Fabrication for Cross-Bracing

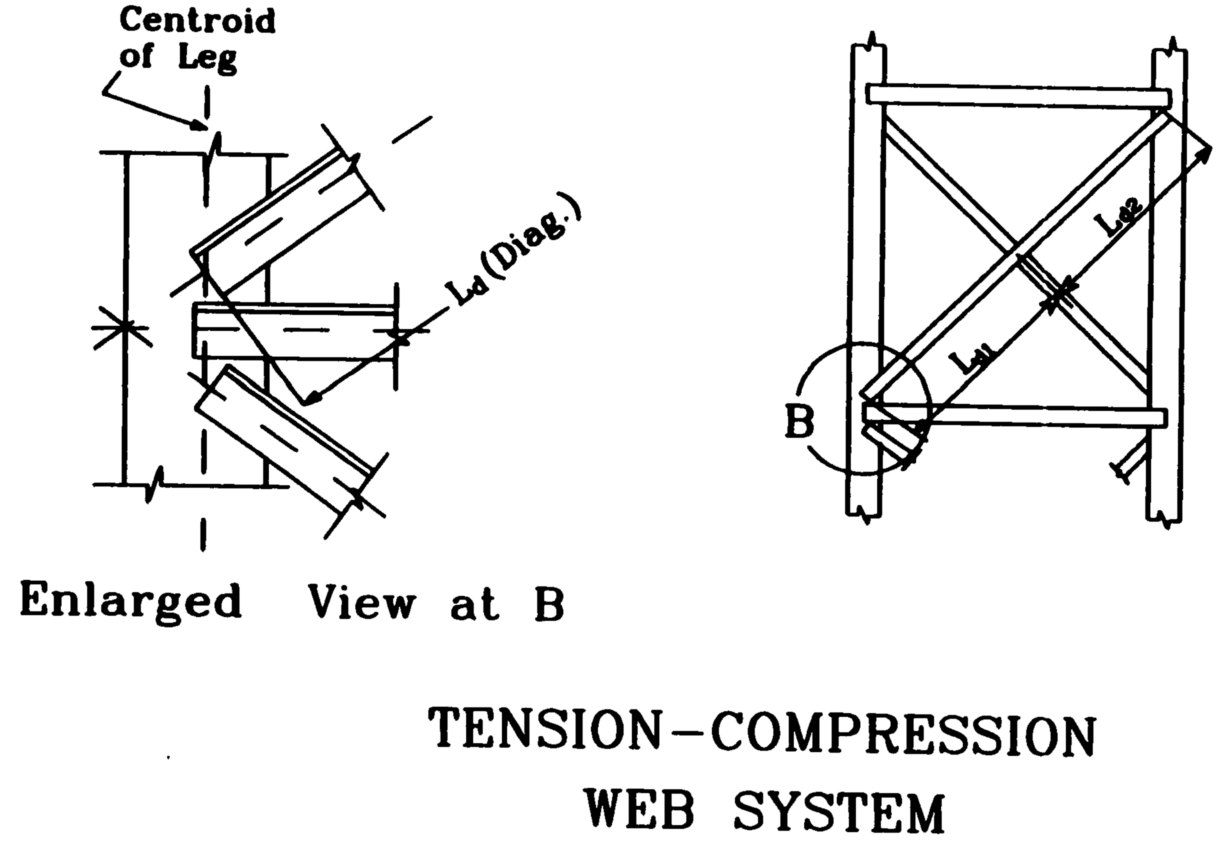
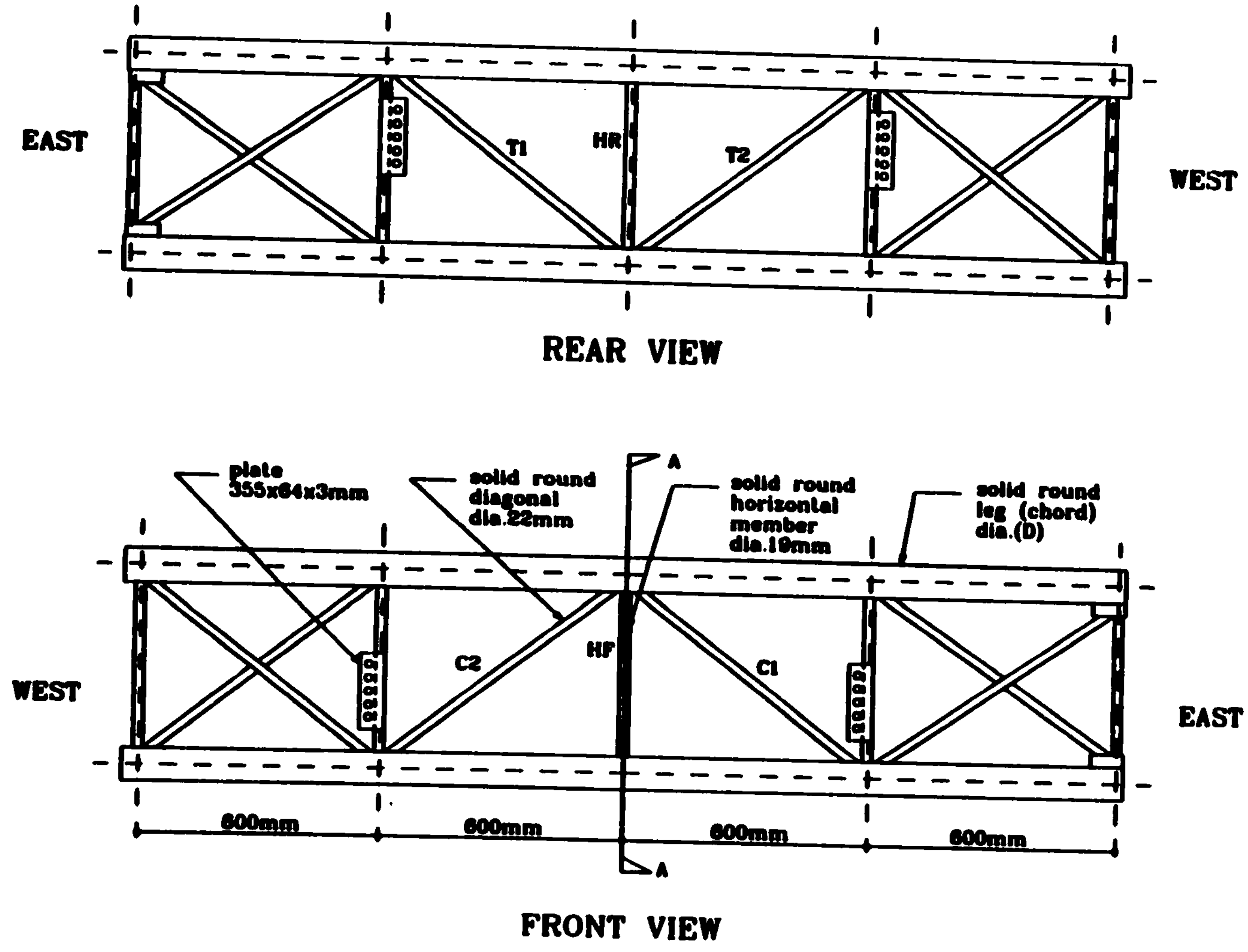


Fig. 2.1 System Lengths for Cross-Braced Specimens (Source: CSA S37-94, p.27)



SPECIMEN I.D.	(D)
LR3&LR4	51 mm
LR8&LR12	38 mm

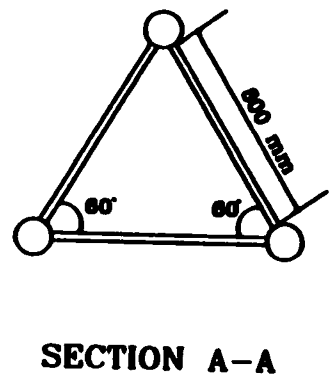


Fig. 3.1 Dimensions of Specimens LR3, LR4, LR8, and LR12

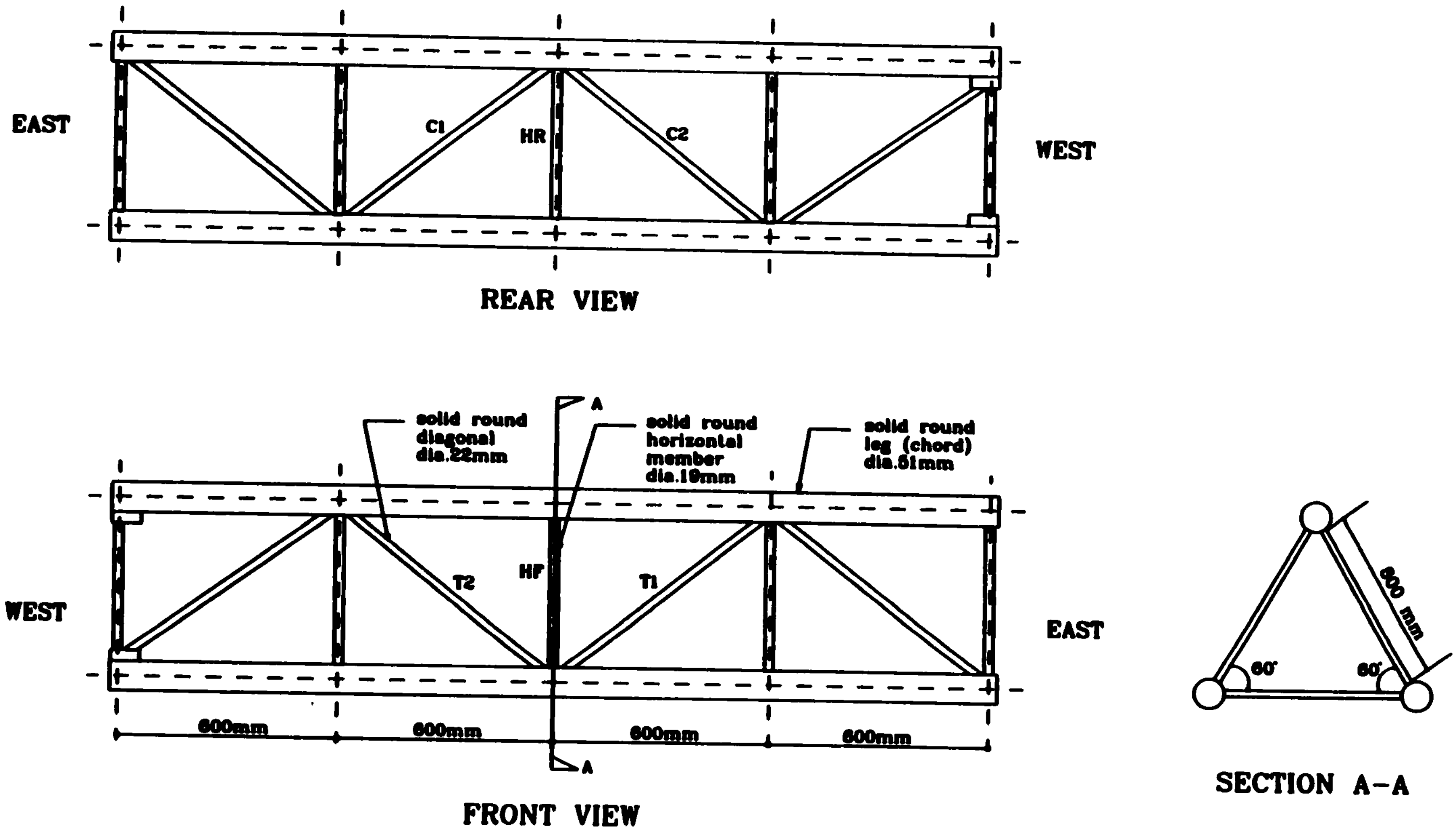
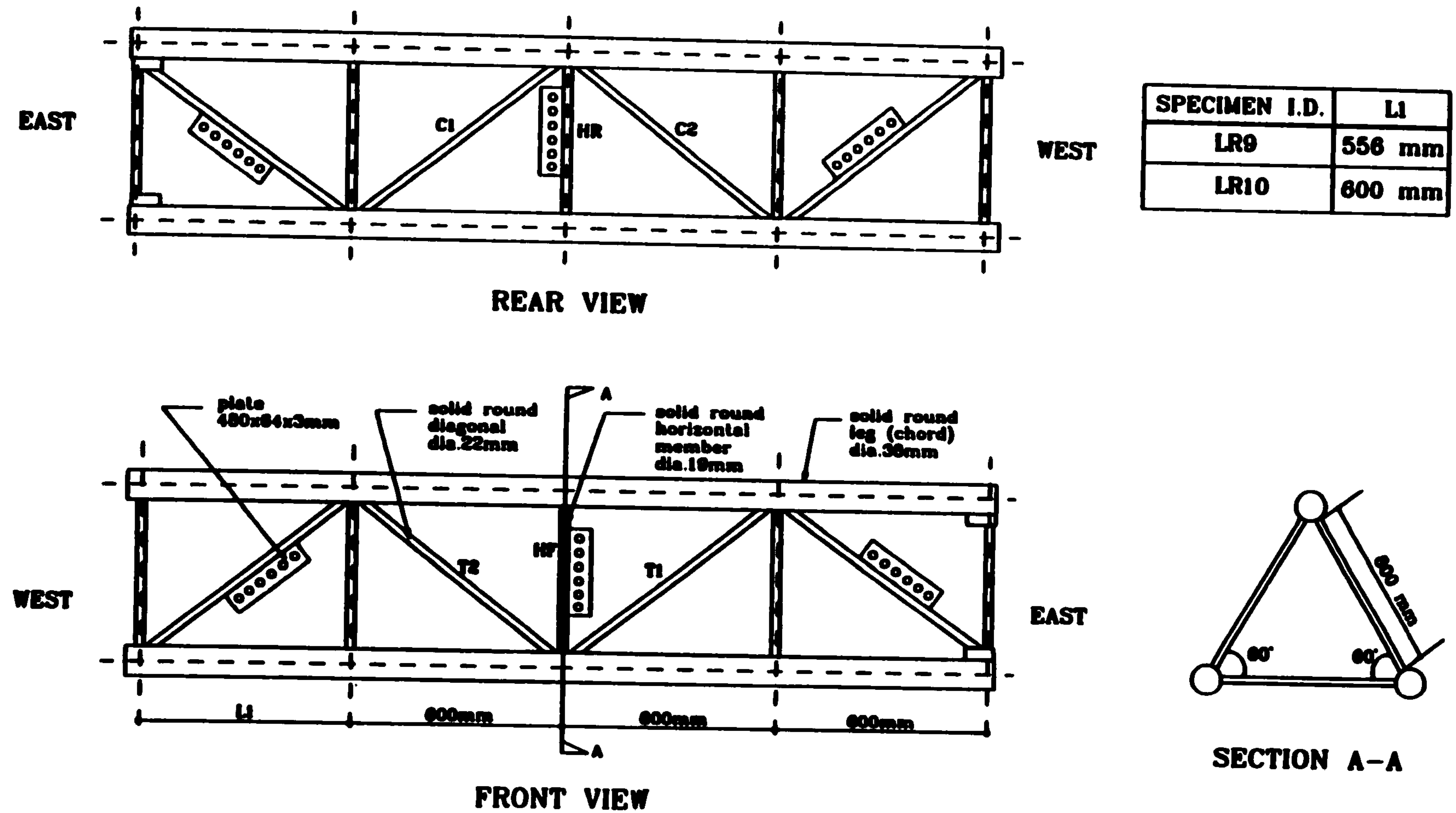


Fig. 3.2 Dimensions of Specimens LR7 and LR11



SPECIMEN I.D.	L1
LR9	556 mm
LR10	600 mm

Fig. 3.3 Dimensions of Specimens LR9 and LR10

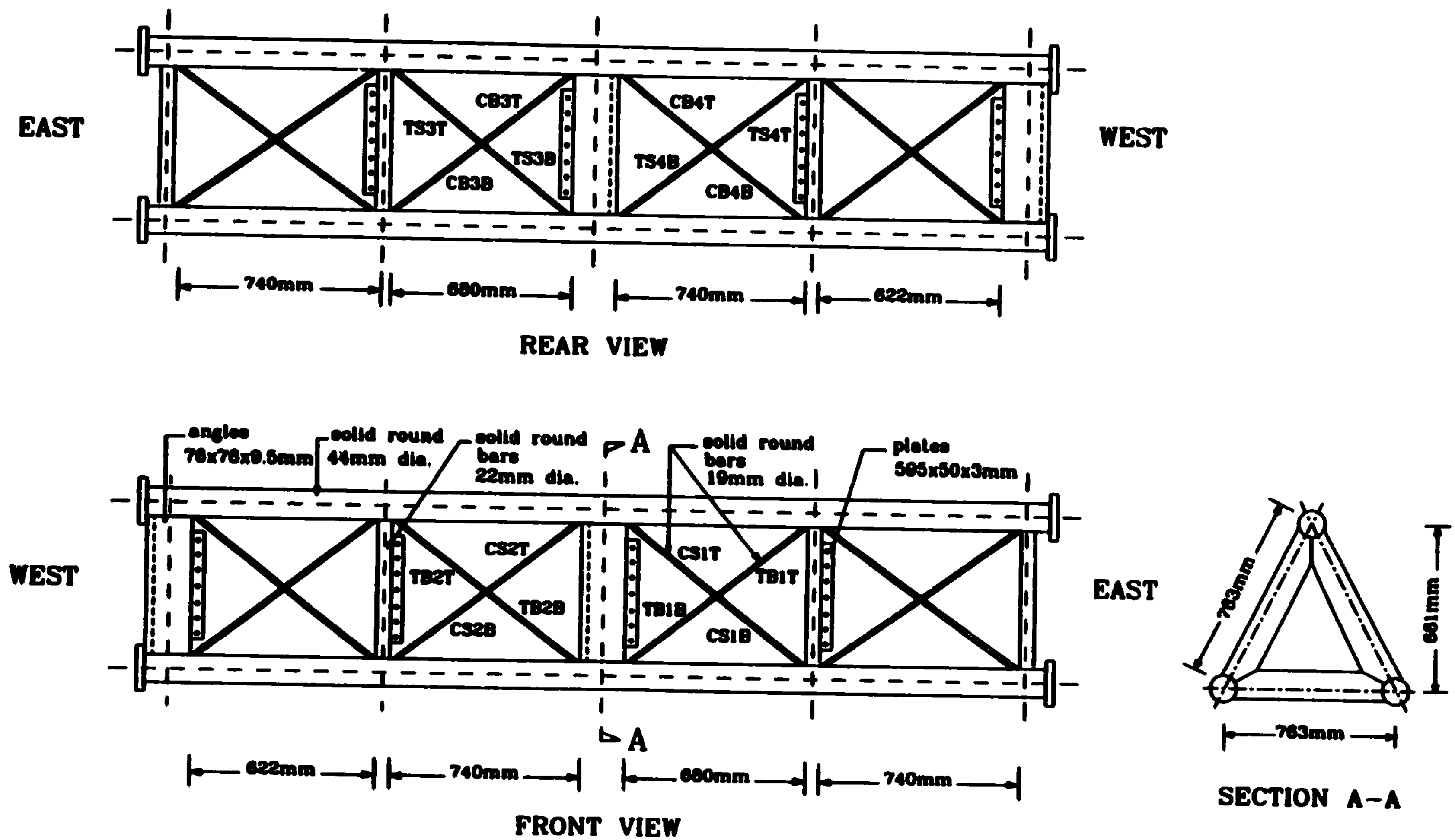


Fig. 3.4 Dimensions of Specimens TR1 to TR4

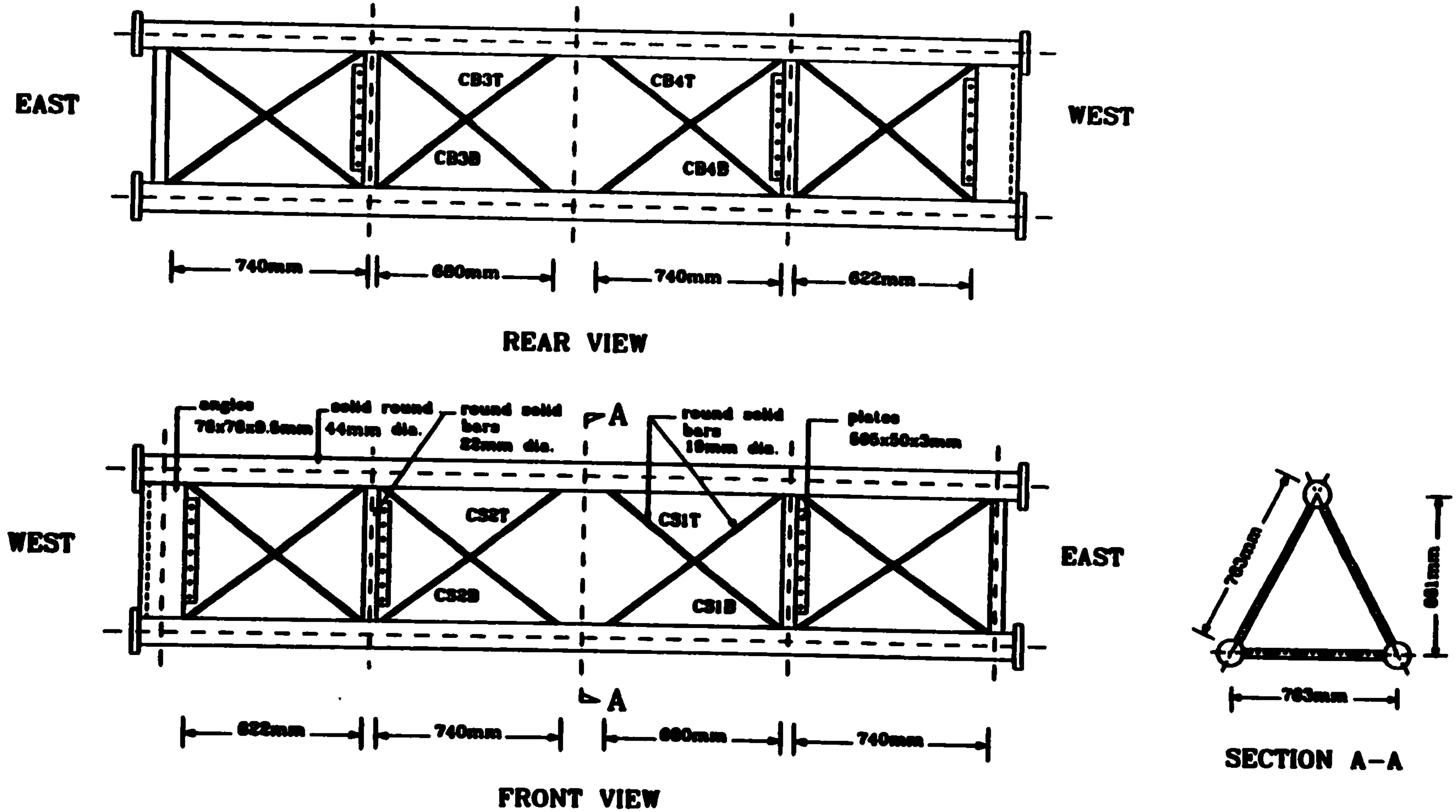


Fig. 3.5 Dimensions of Specimen TR5

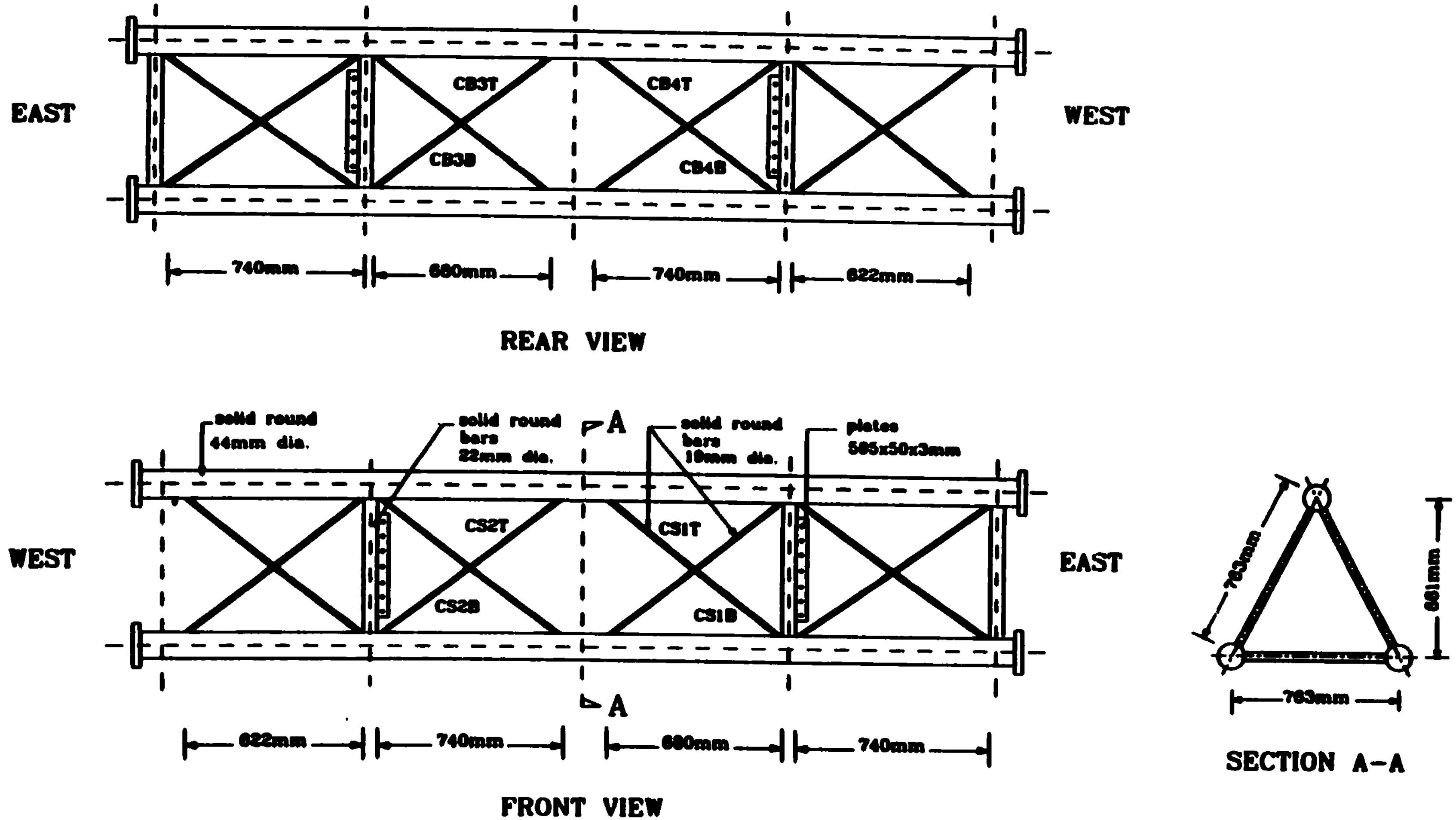
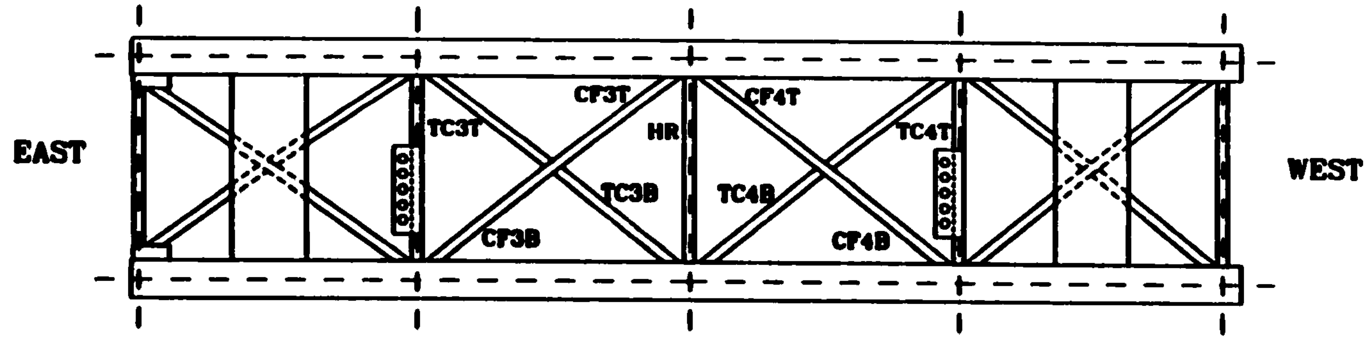
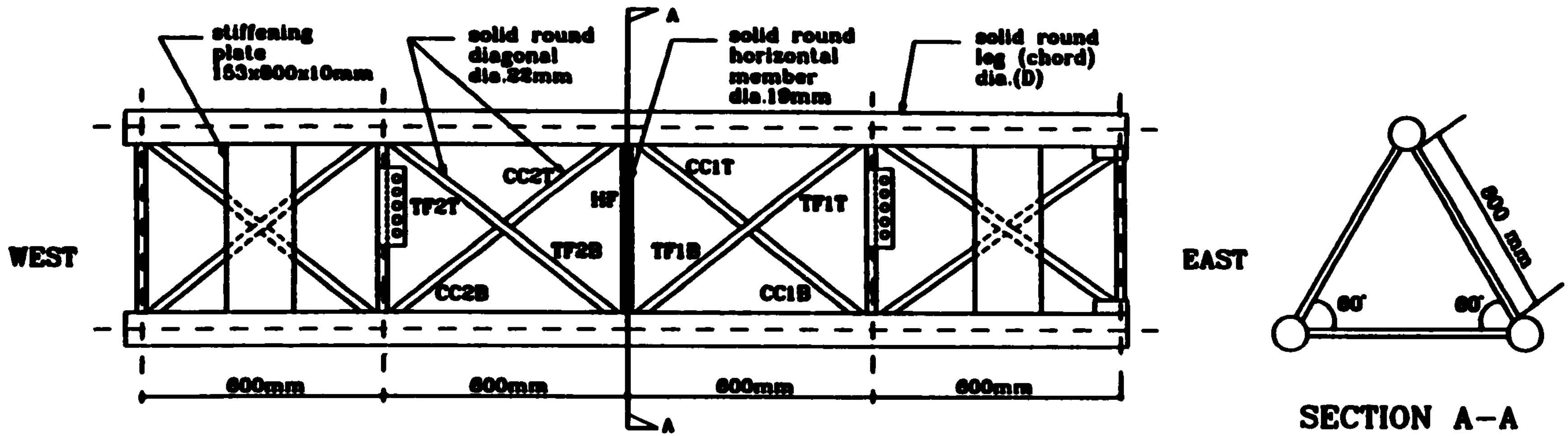


Fig. 3.6 Dimensions of Specimen TR6



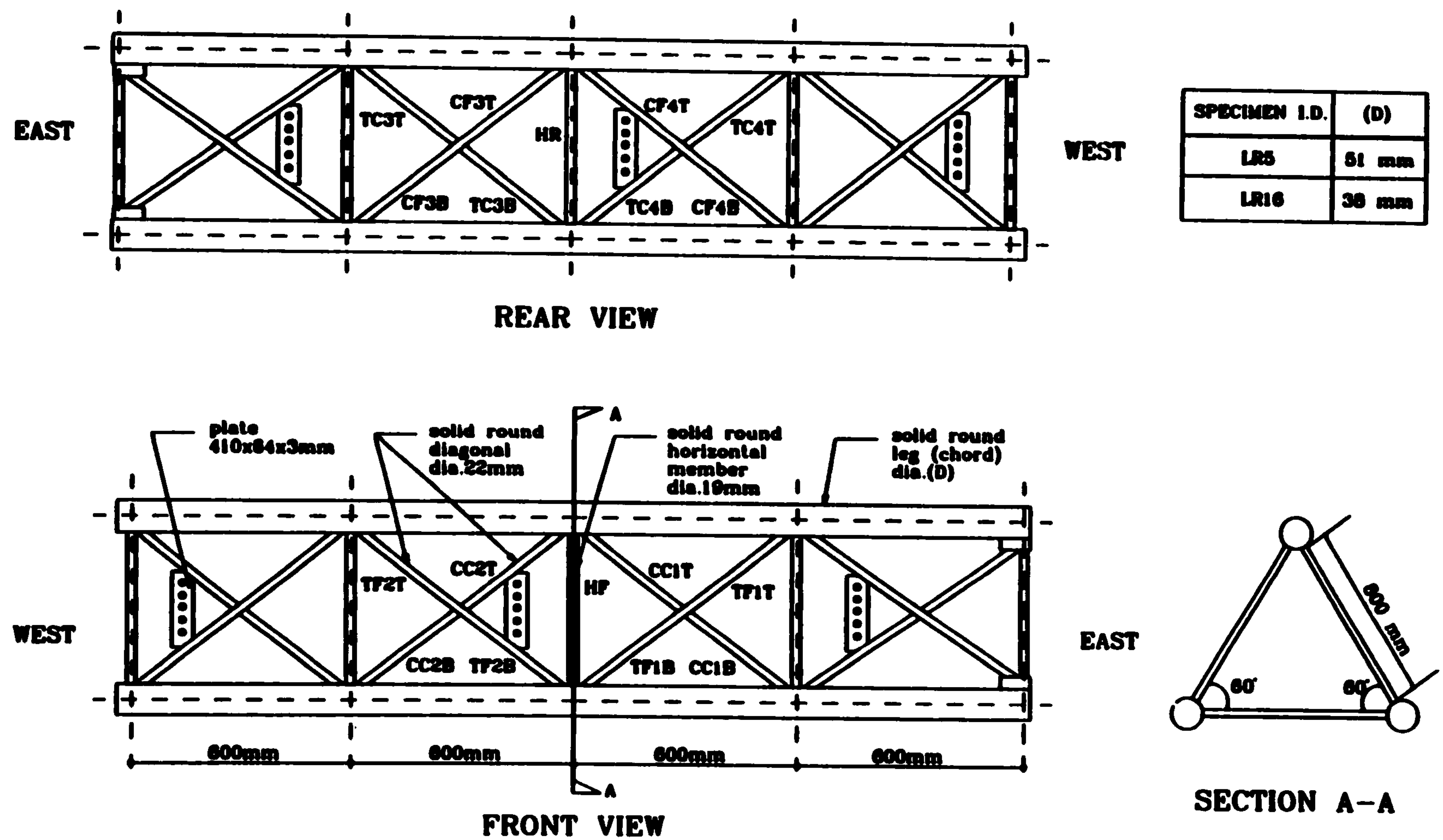
REAR VIEW

SPECIMEN I.D.	(D)
LR1&LR15	51 mm
LR2&LR19	38 mm



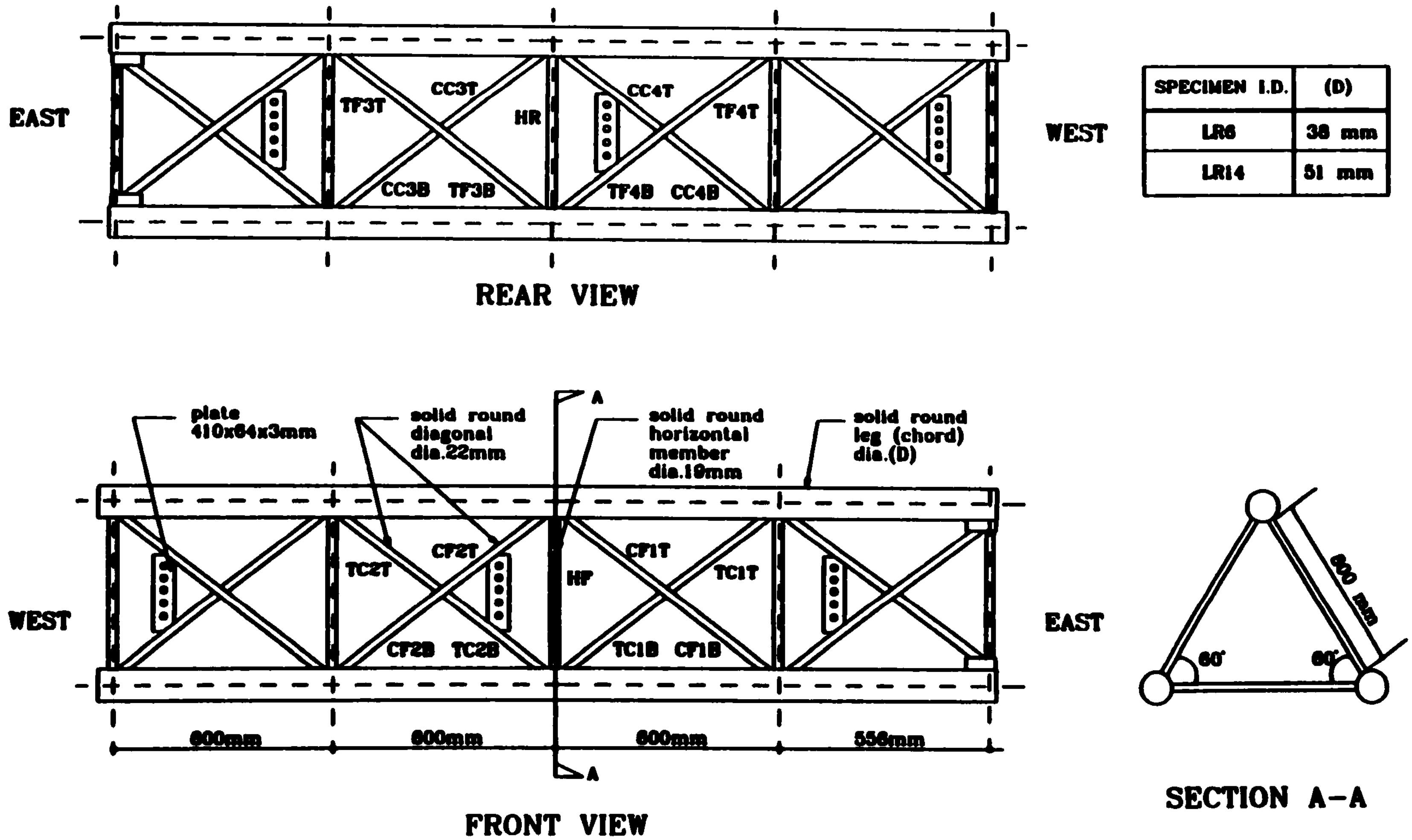
FRONT VIEW

Fig. 3.7 Dimensions of Specimens LR1, LR2, LR15, and LR19



SPECIMEN I.D.	(D)
LR5	51 mm
LR16	38 mm

Fig. 3.8 Dimensions of Specimens LR5 and LR16



SPECIMEN I.D.	(D)
LR6	38 mm
LR14	51 mm

Fig. 3.9 Dimensions of Specimens LR6 and LR14

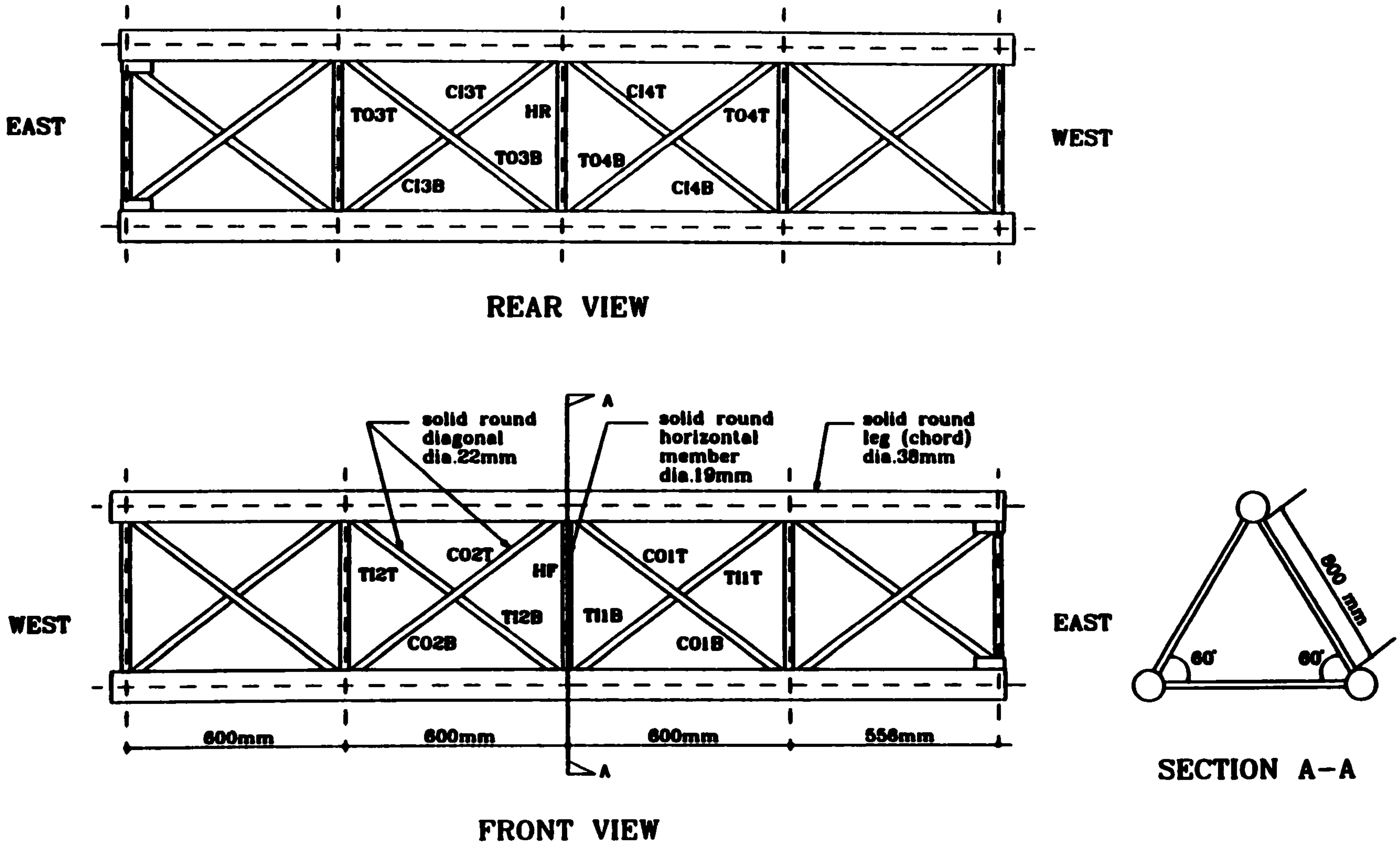


Fig. 3.10 Dimensions of Specimen LR13

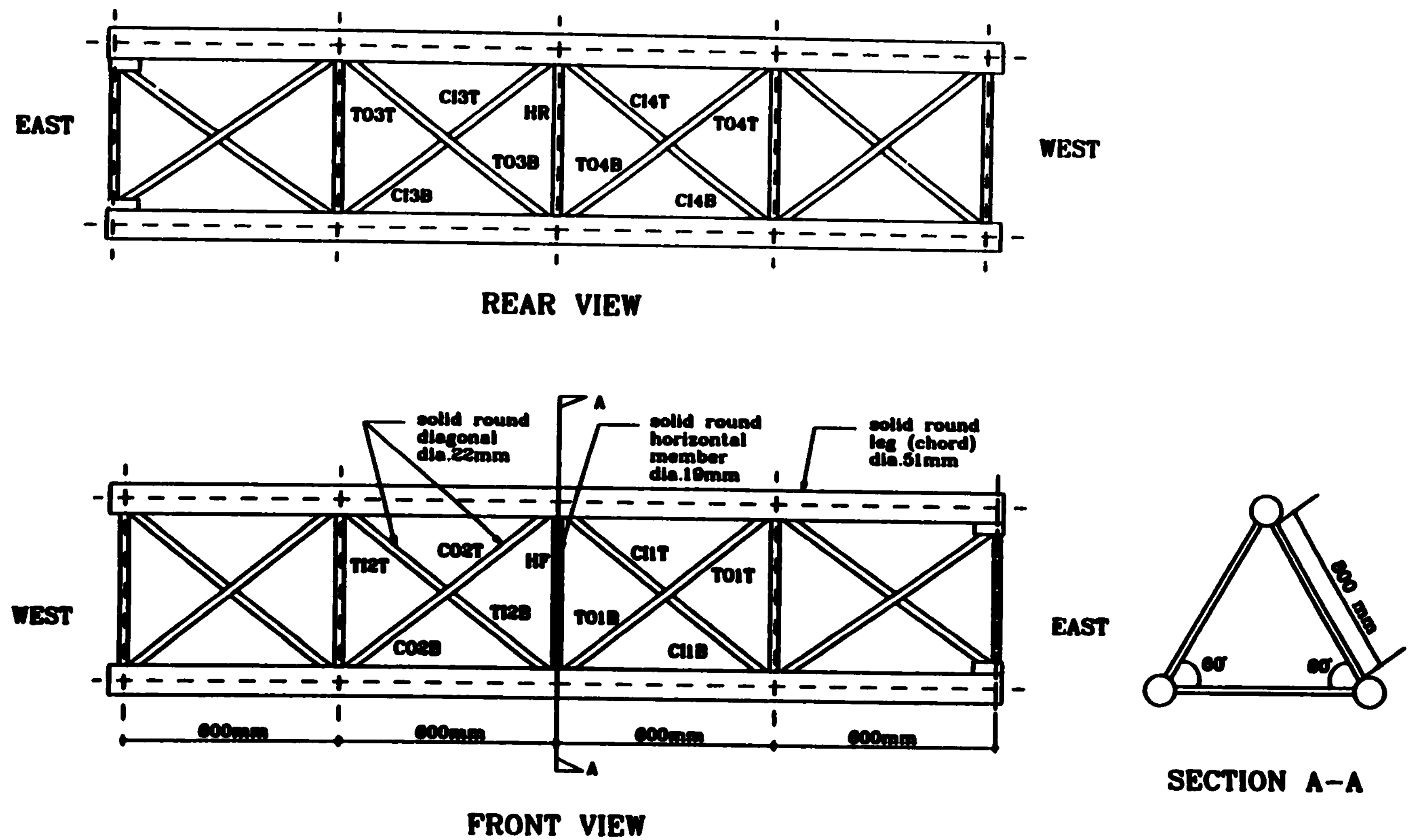


Fig. 3.11 Dimensions of Specimen LR17

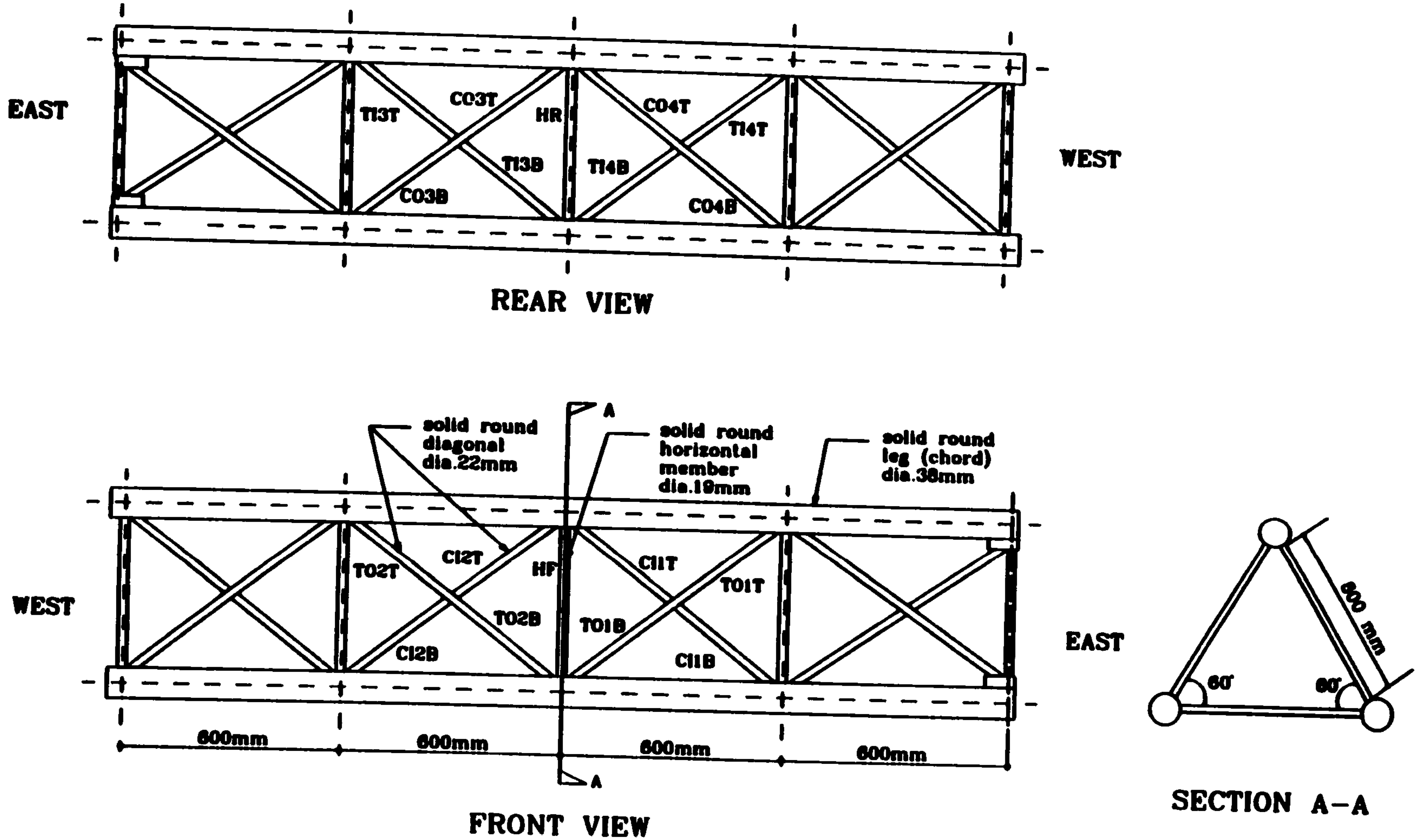


Fig. 3.12 Dimensions of Specimen LR18

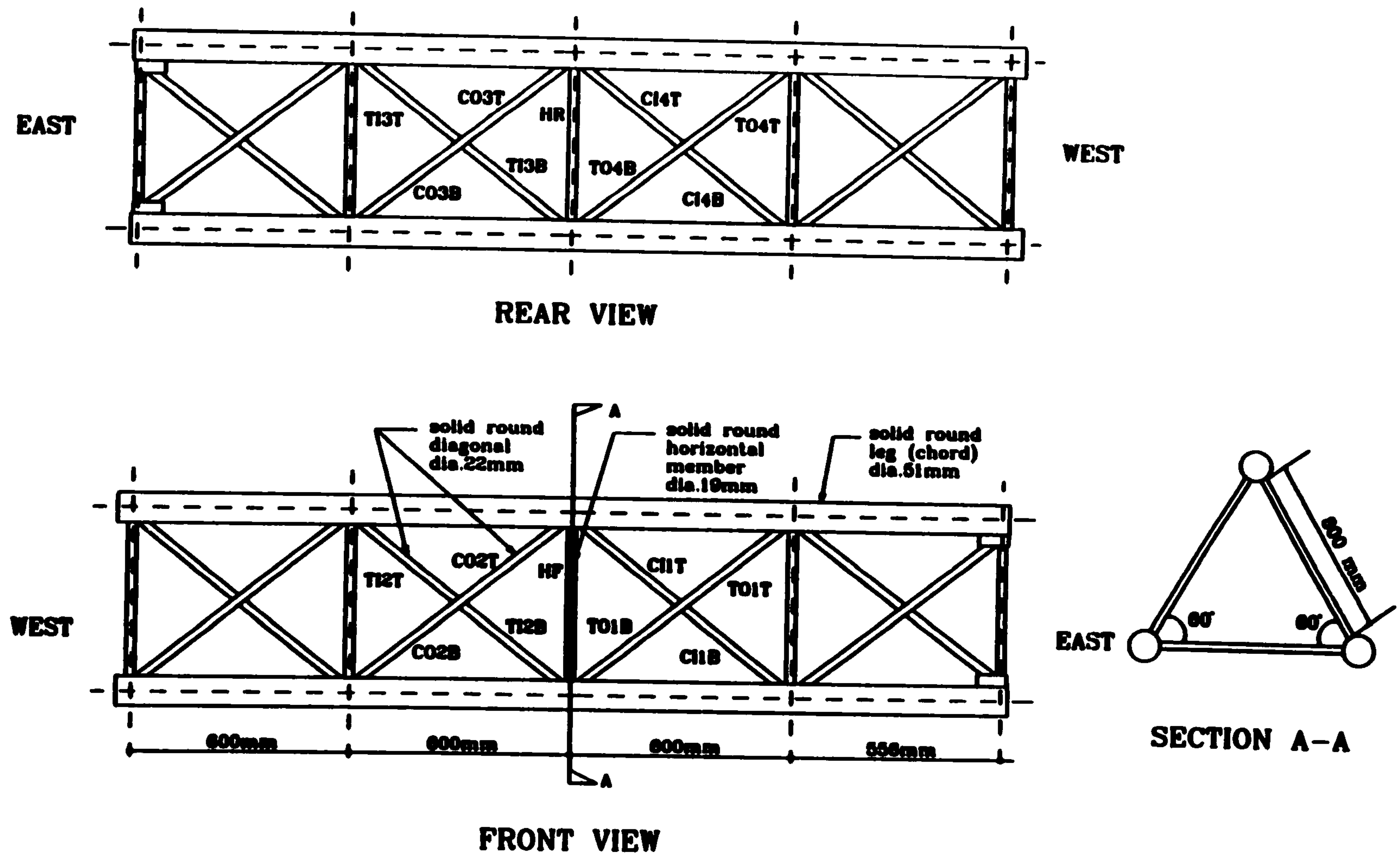


Fig. 3.13 Dimensions of Specimen LR20

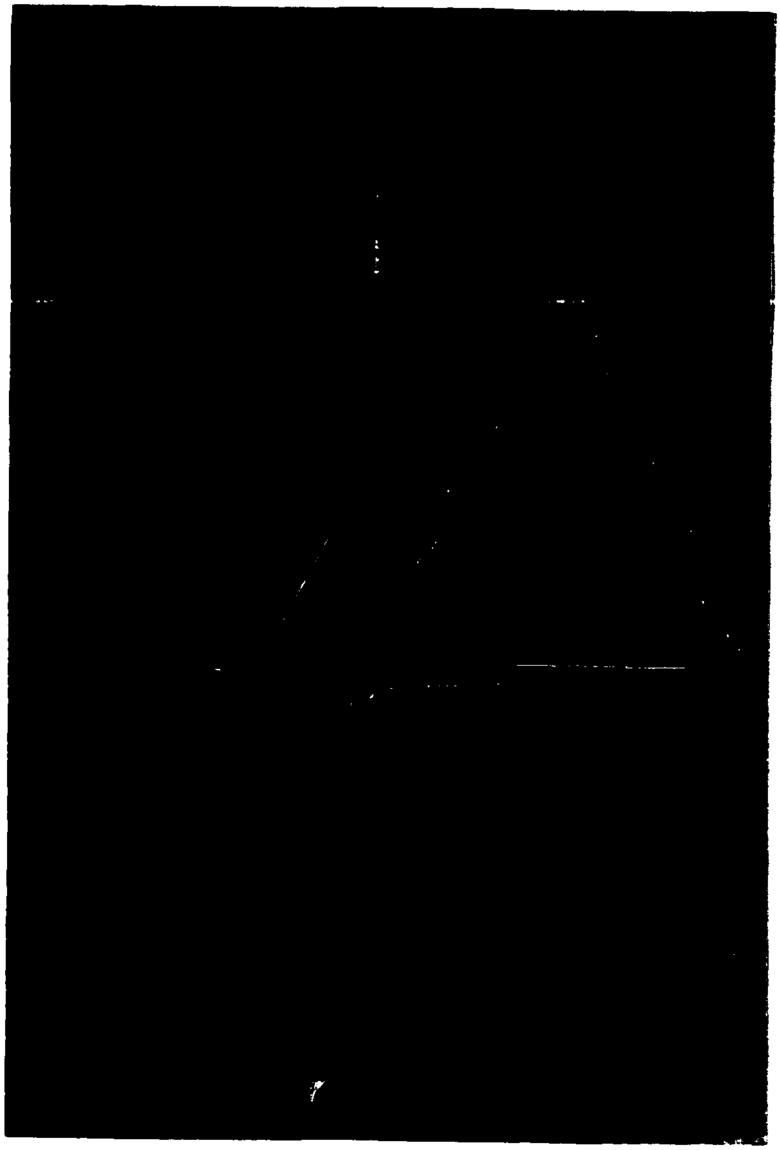


Fig. 3.14 Photograph of Experimental setup

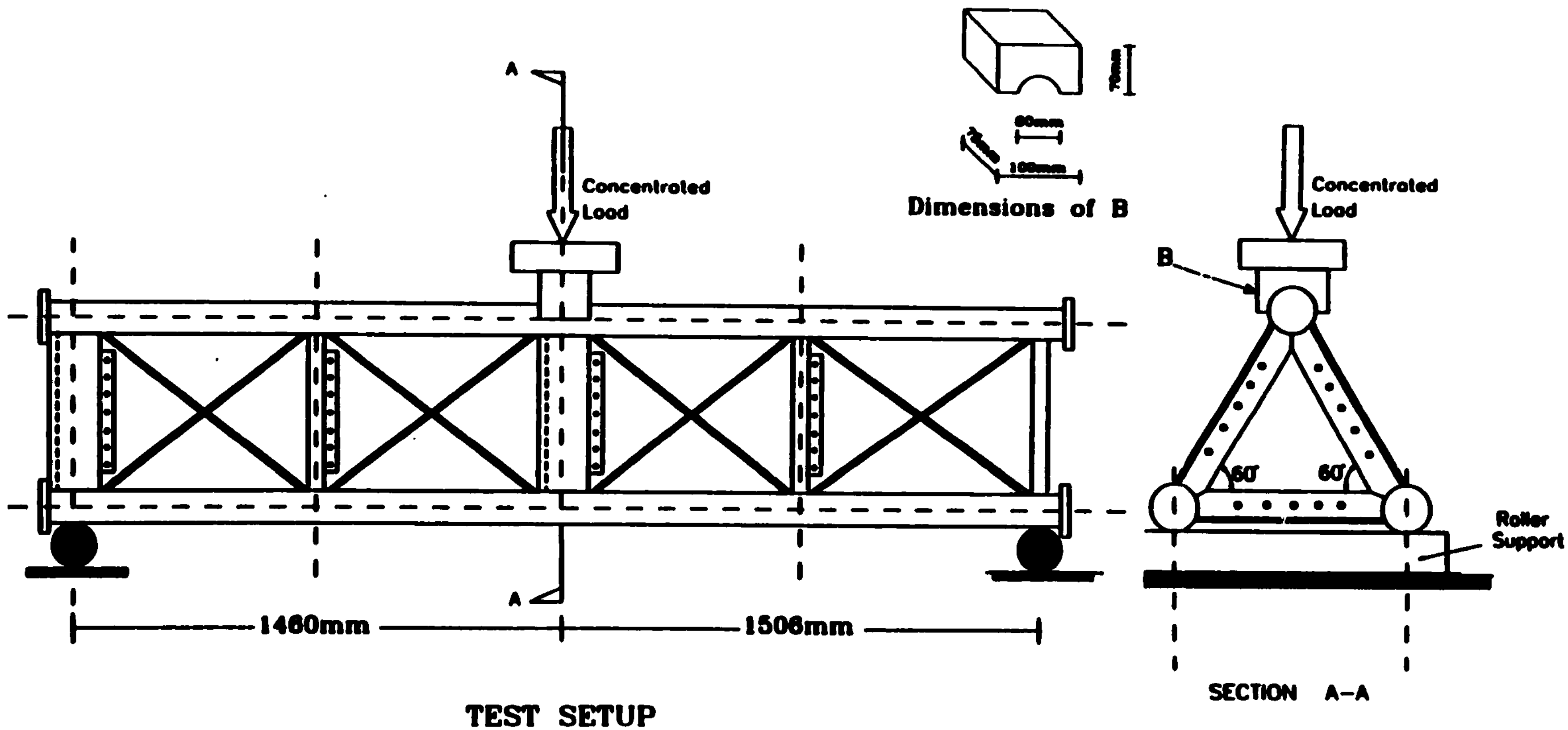


Fig. 3.15 Schematic of the Experimental Setup

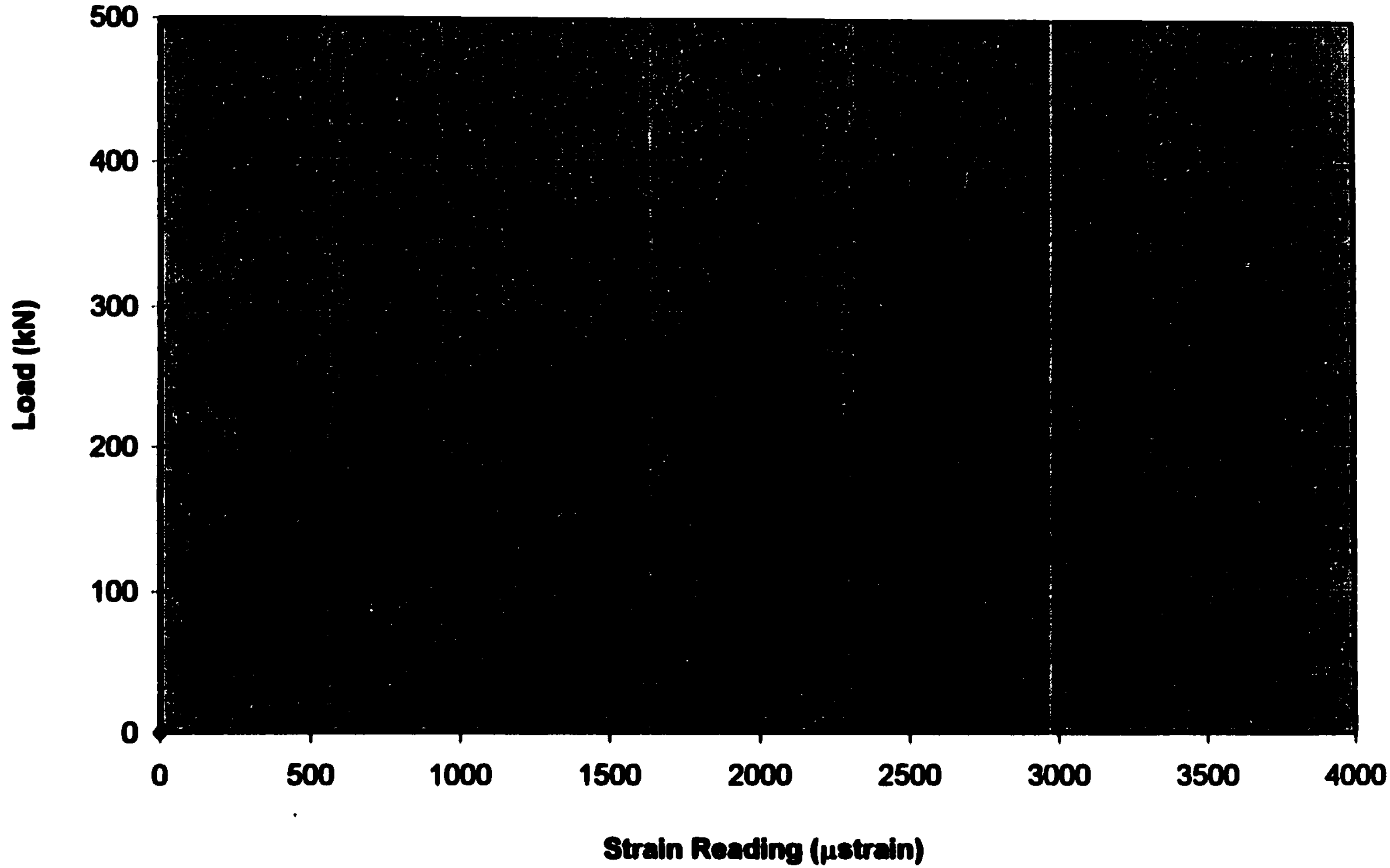


Fig 3.3a Calibration Curve for 448 kN (100 kip) Load Cell

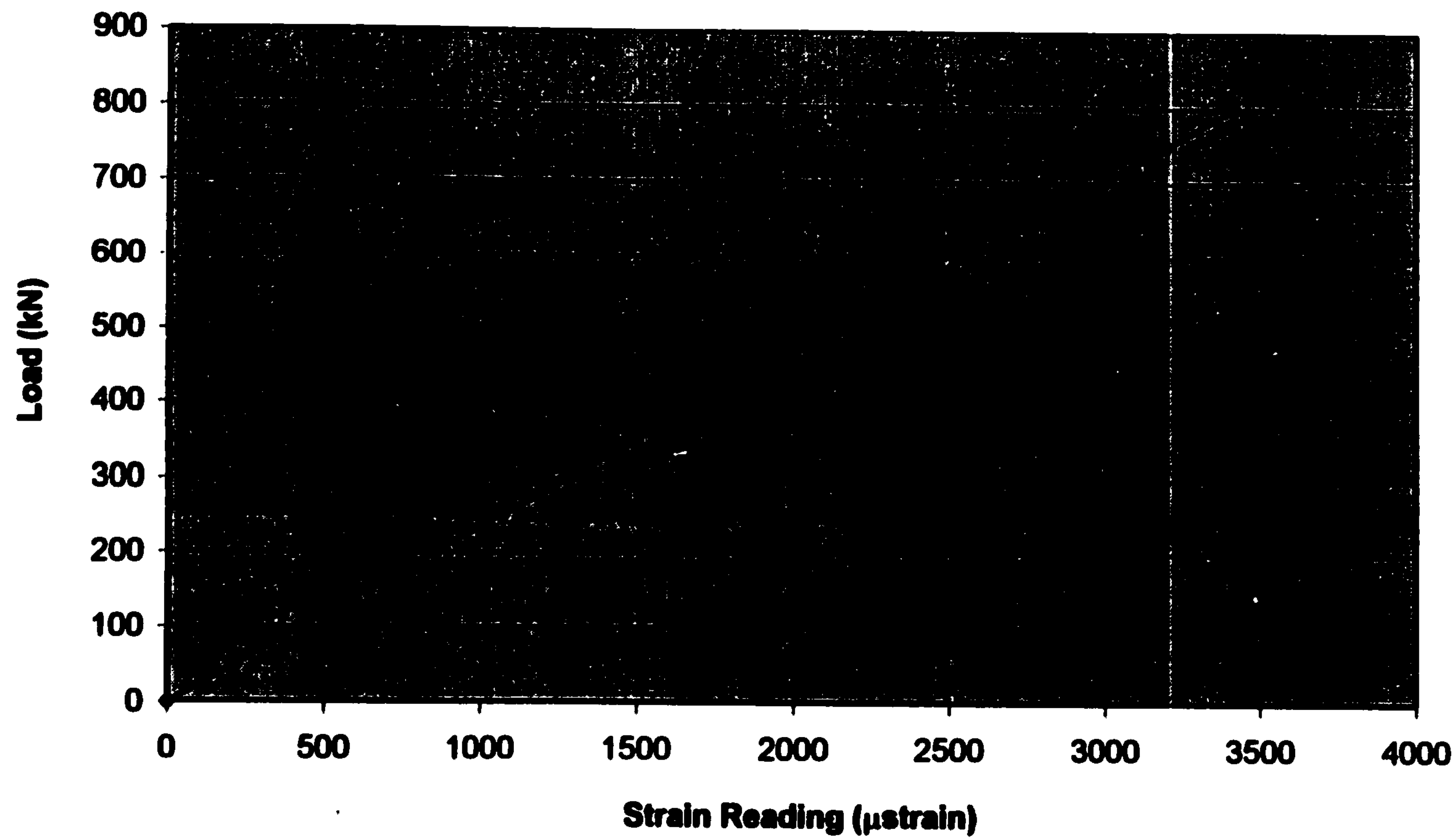


Fig. 3.3b Calibration Curve for 896 kN (200 kip) Load Cell

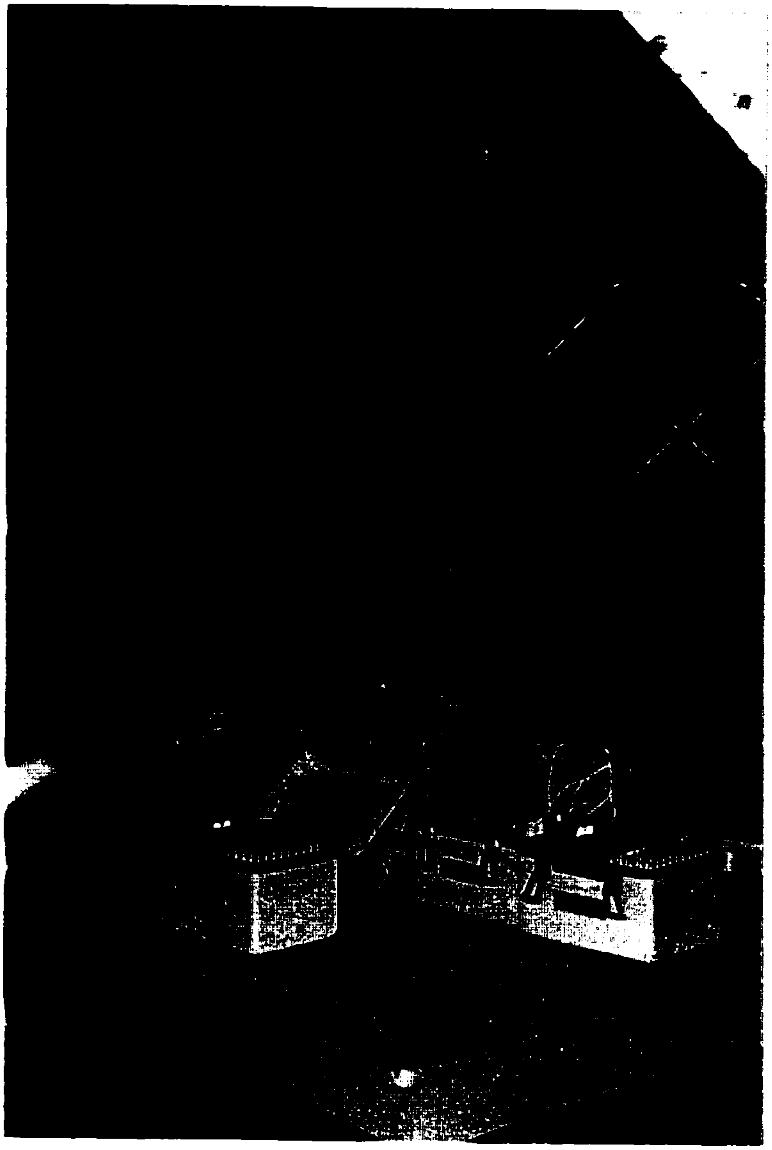
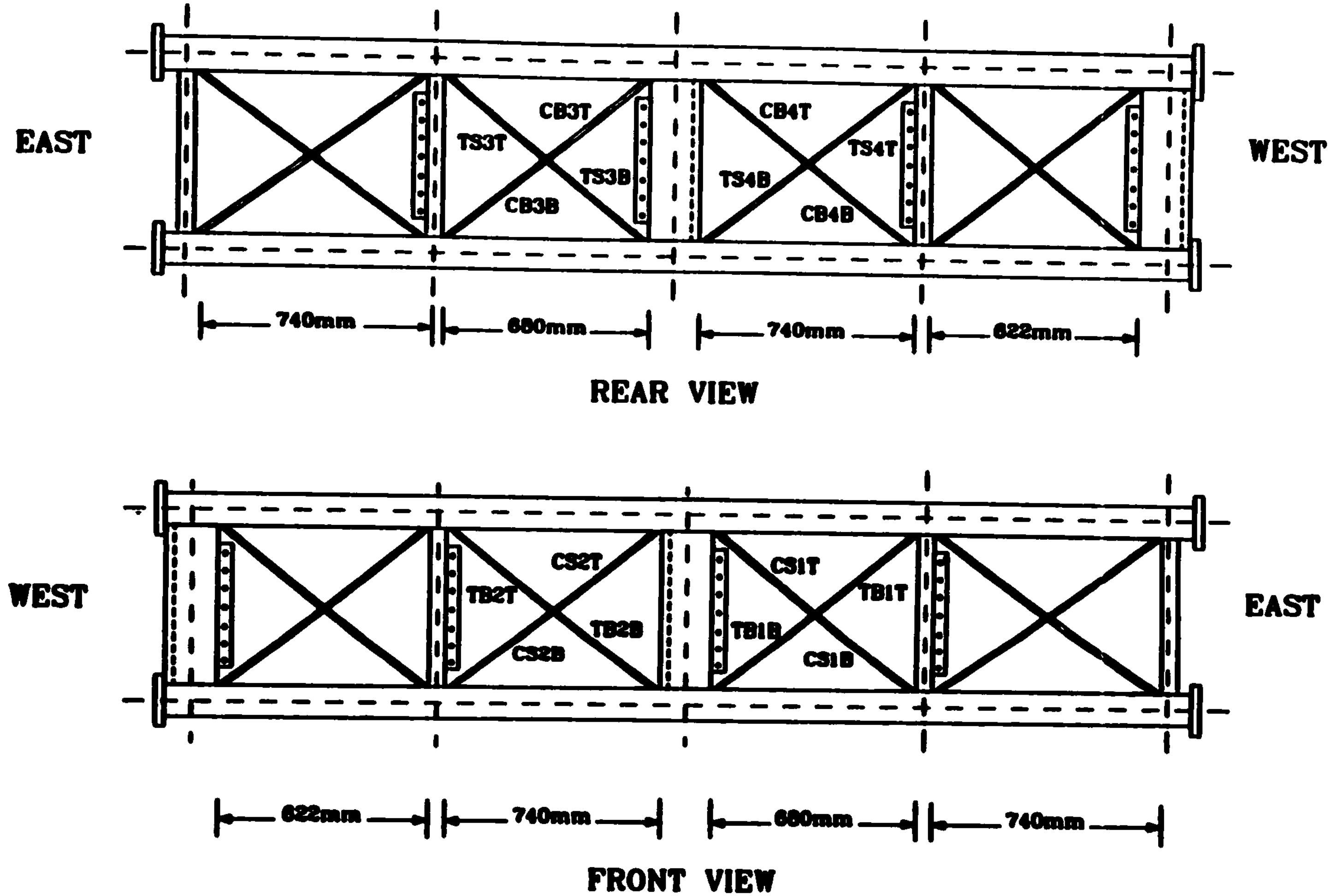
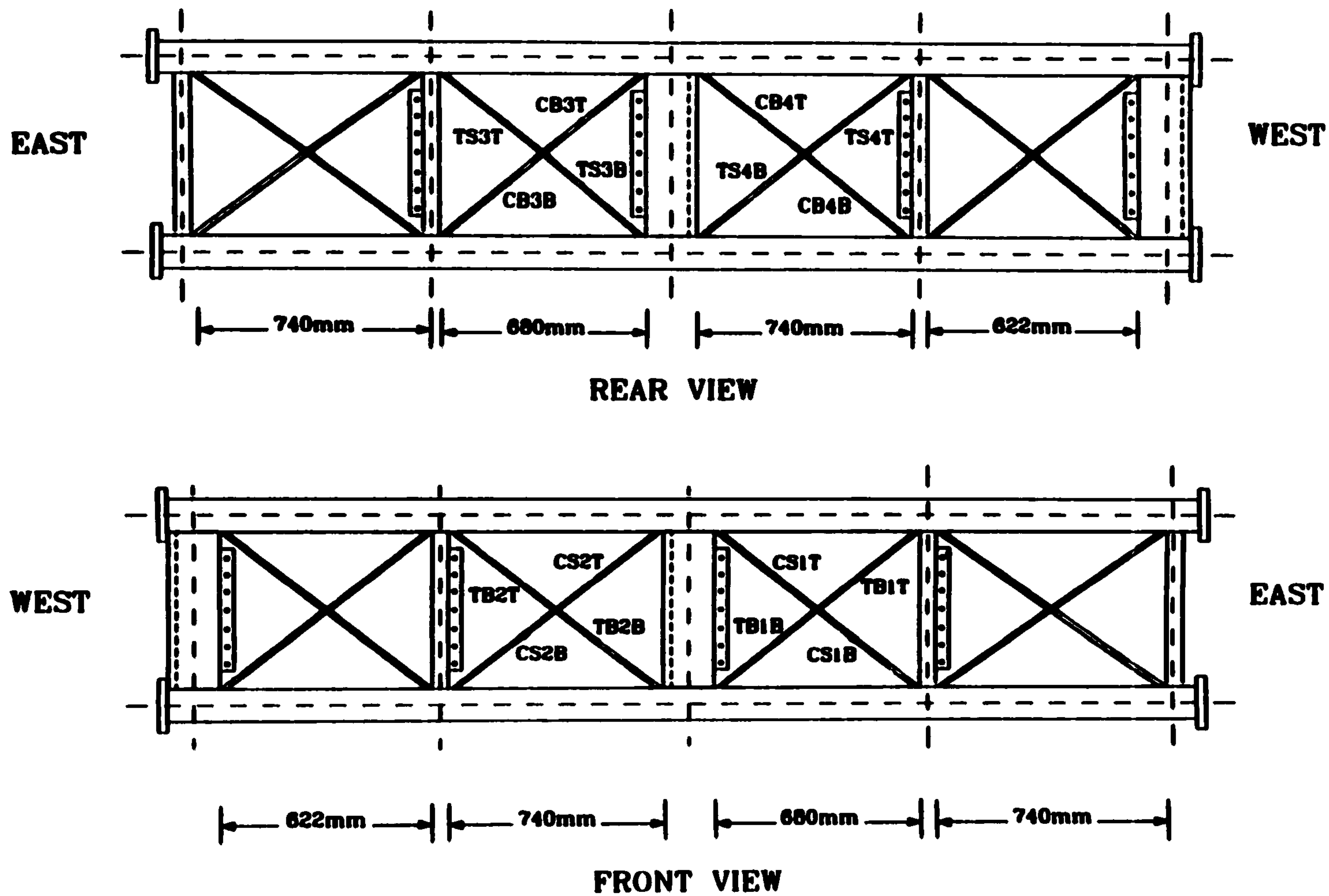


Fig. 3.17 Close-up of Test setup



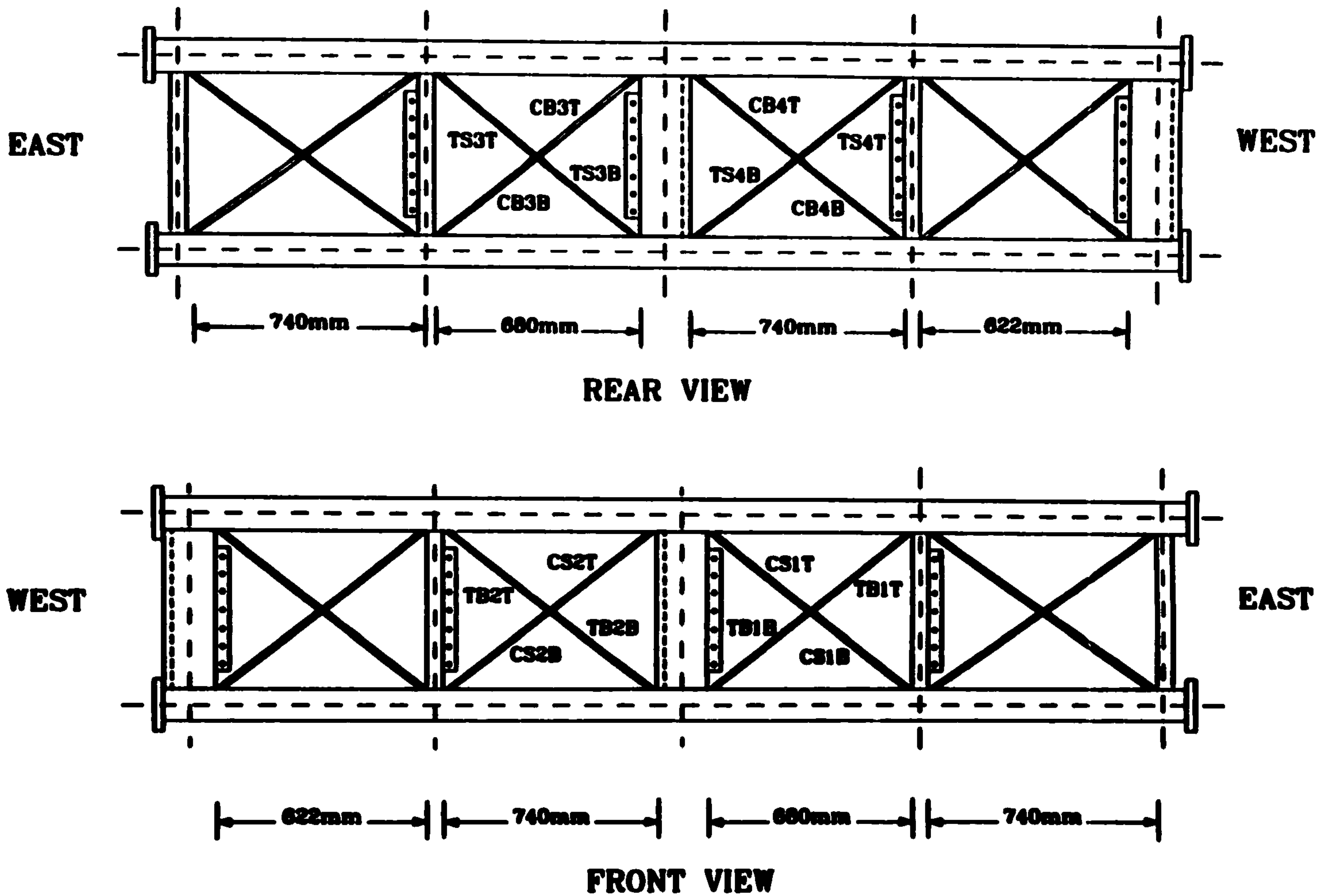
Note: Strain gauges are attached at quarter points on the outside face of the compression diagonals.

Fig. 3.18 Locations of Strain Gauges for Specimen TR1



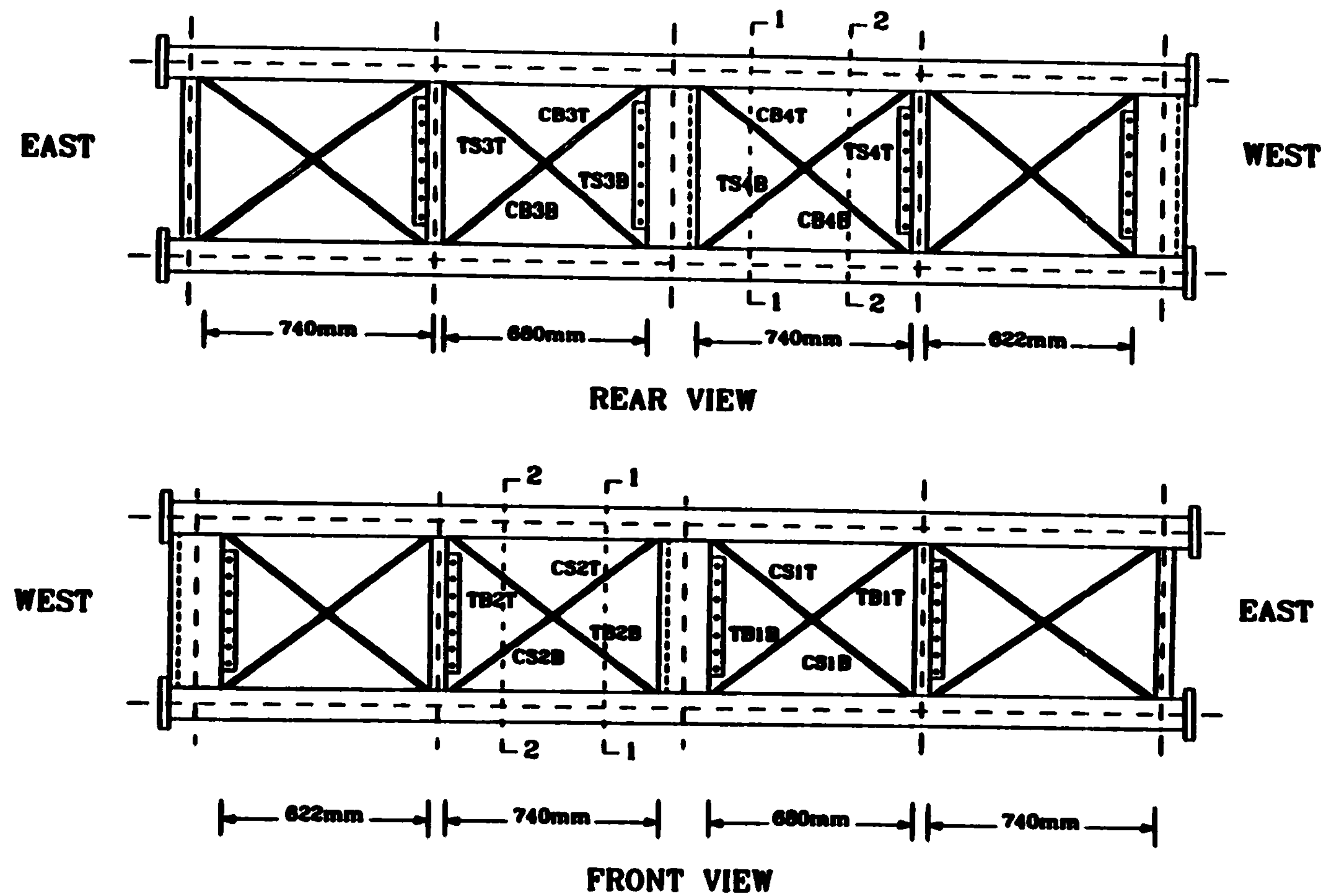
Note: Strain gauges are attached at one third points on the outside face of the compression diagonals.

Fig. 3.19 Locations of Strain Gauges for Specimen TR2



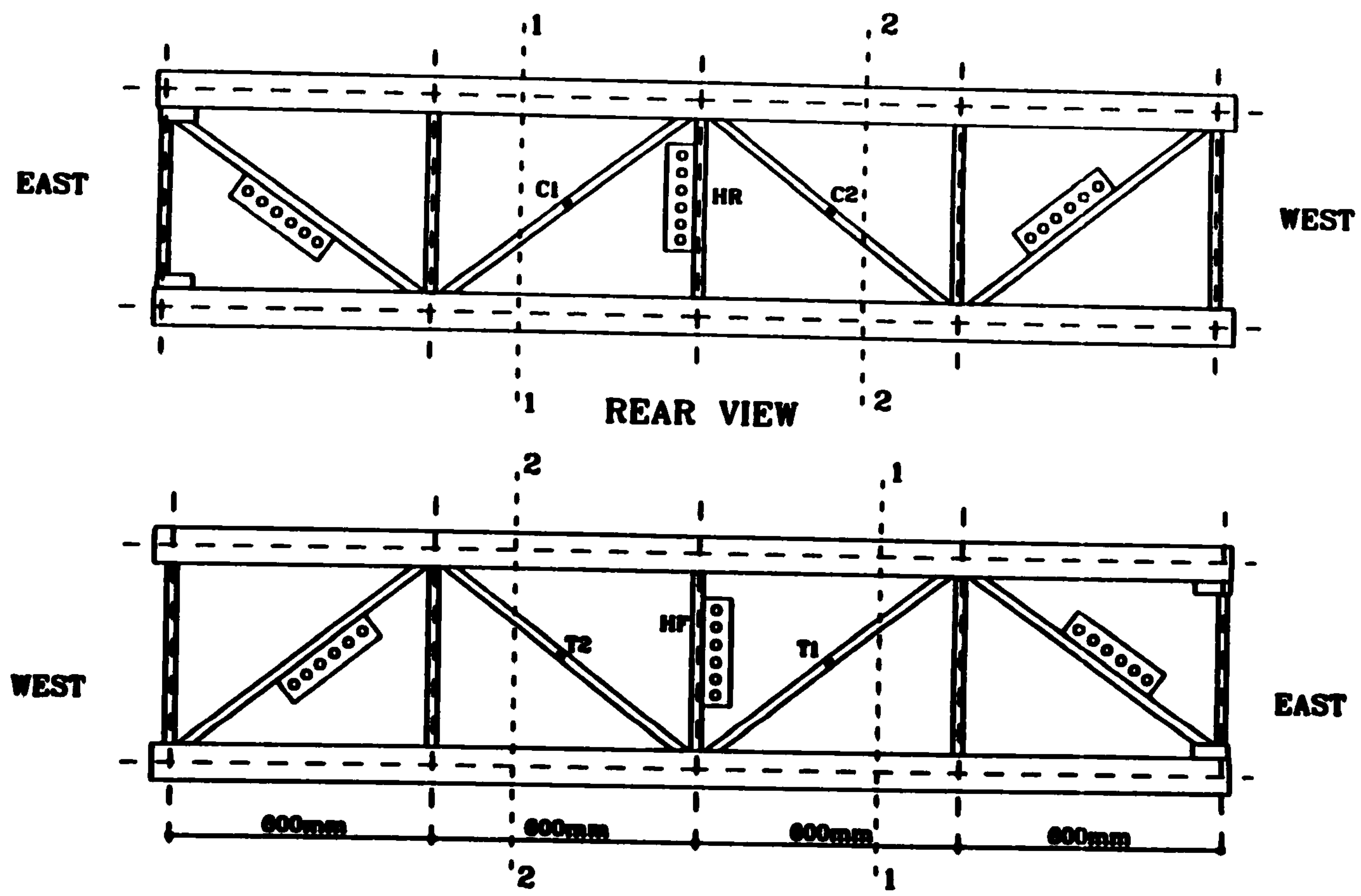
Note: Strain gauges on compression diagonals are attached at one third points, while those on tension diagonals are attached at quarter points. All strain gauges are on the outside face of the member.

Fig. 3.20 Locations of Strain Gauges for Specimen TR3



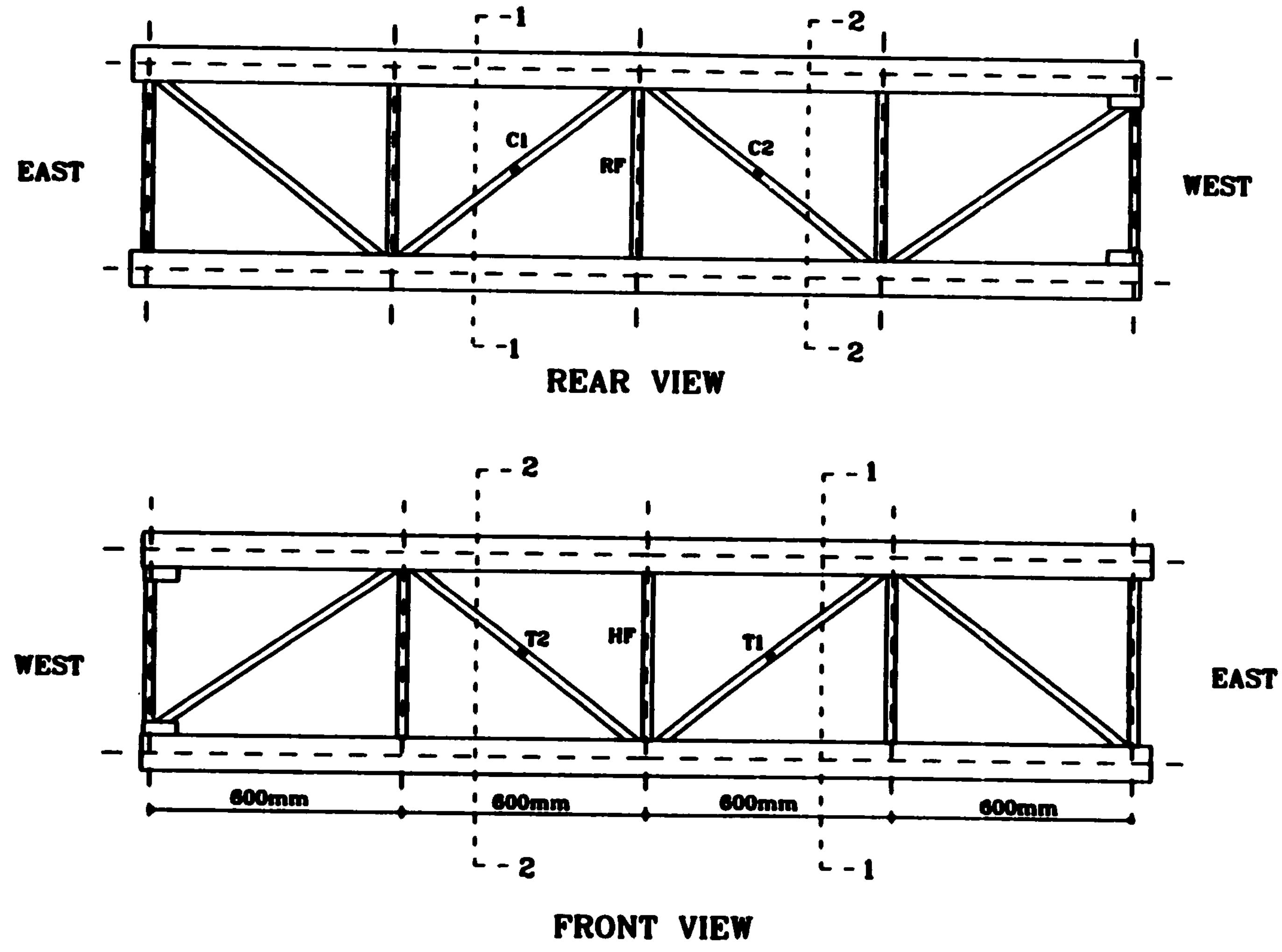
Note: Strain gauges are attached on diagonals CS2, TB2, CB4, and TS4 on the outside and inside faces of the members, while for the other diagonals, strain gauges are attached on the outside face only.

Fig. 3.21 Locations of Strain Gauges and Sections for Equilibrium Check for Specimen TR4



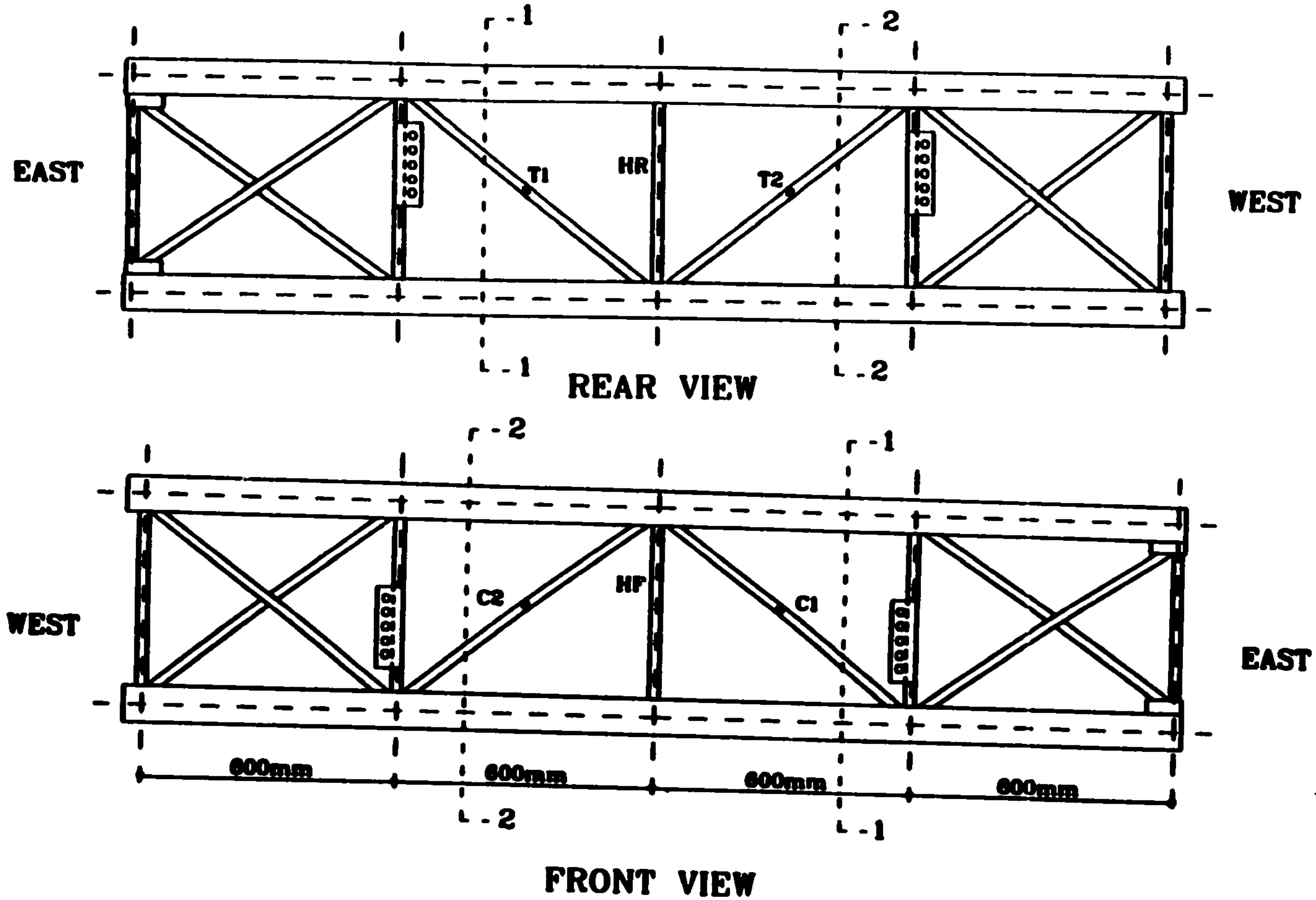
Note: At each location, four strain gauges were attached at 90° intervals around the periphery of the member

Fig. 3.22 Locations of Strain Gauges and Sections for Equilibrium Check for Specimen LR10



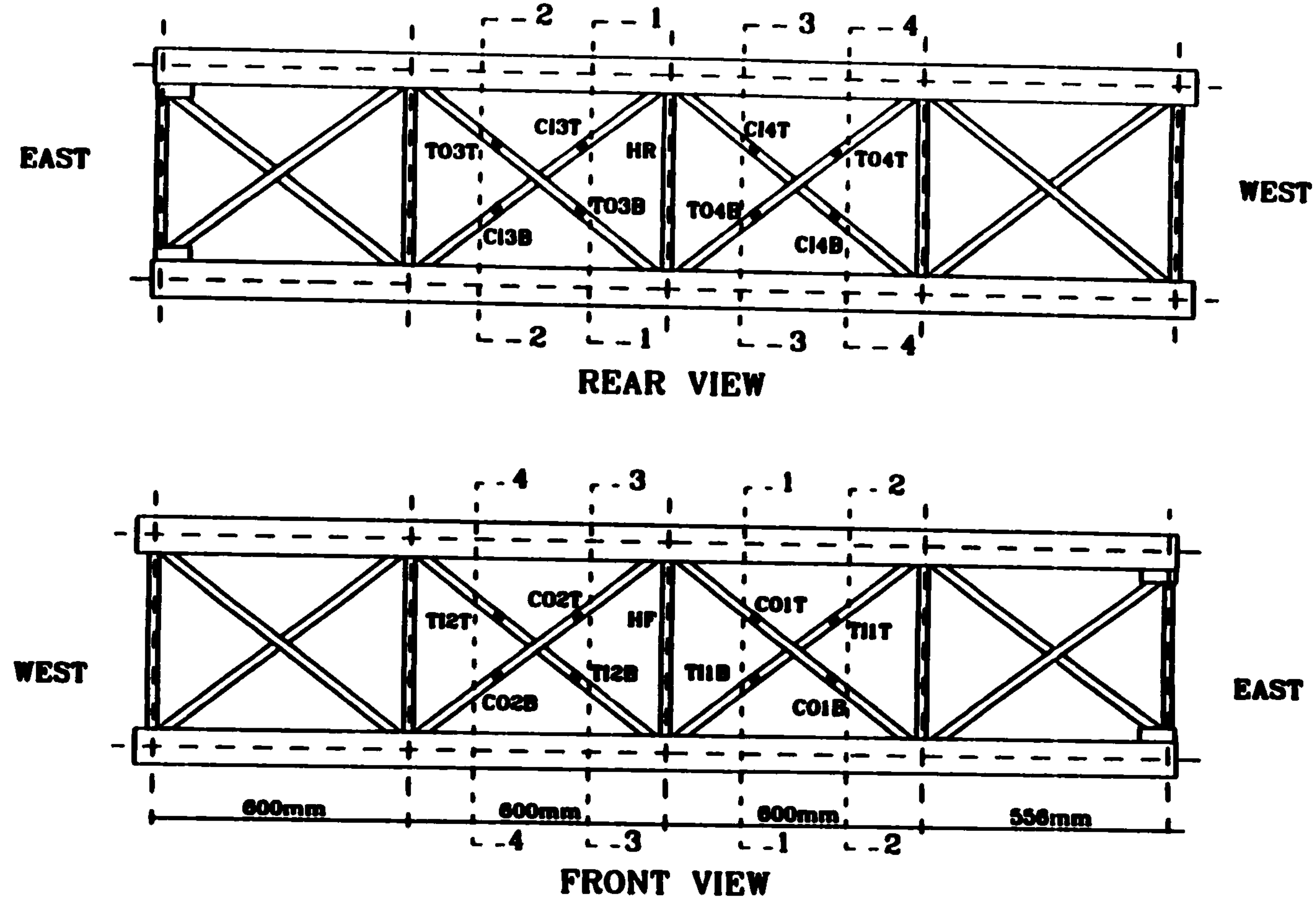
Note: At each loaction, four strain gauges were attached at 90° intervals around the periphery of the member

Fig. 3.23 Locations of Strain Gauges and Sections for Equilibrium Check for Specimen LR11



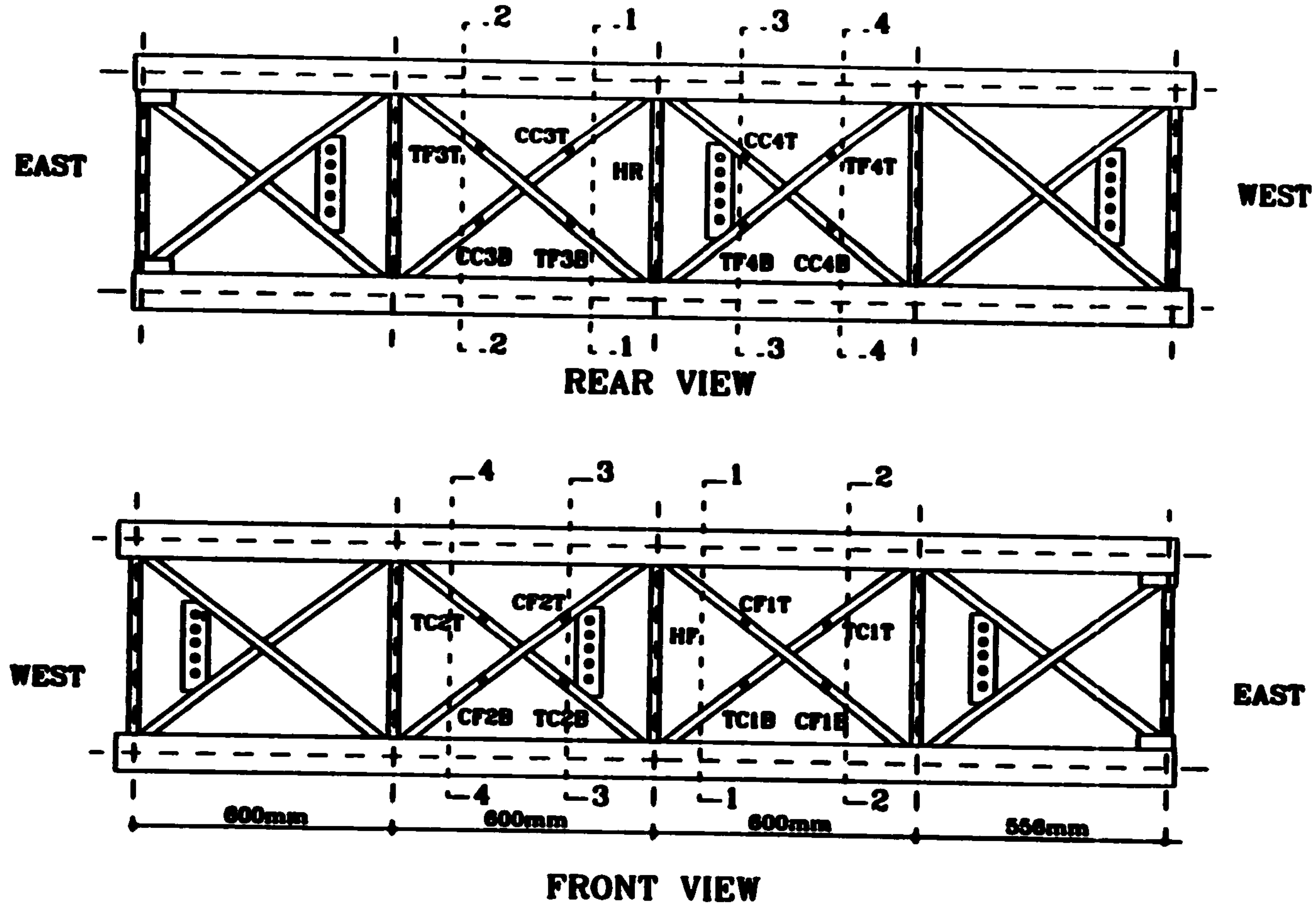
Note : Four strain gauges were attachedf or eaccompression diagonal at 90 intervals around the periphery of the member, while two strain gauges were attached for tension diagonals one on the outside face and the other on the inside face

Fig. 3.24 Locations of Strain Gauges and Sections for Equilibrium Check for Specimen LR12



Note: Strain gauges are attached on the outside and inside faces of the diagonals at each location

Fig. 3.25 Locations of Strain Gauges and Sections for Equilibrium Check for Specimen LR13



Note: Strain gauges are attached on the outside and inside faces of the diagonals at each location.

Fig. 3.26 Locations of Strain Gauges and Sections for Equilibrium Check for Specimen LR14

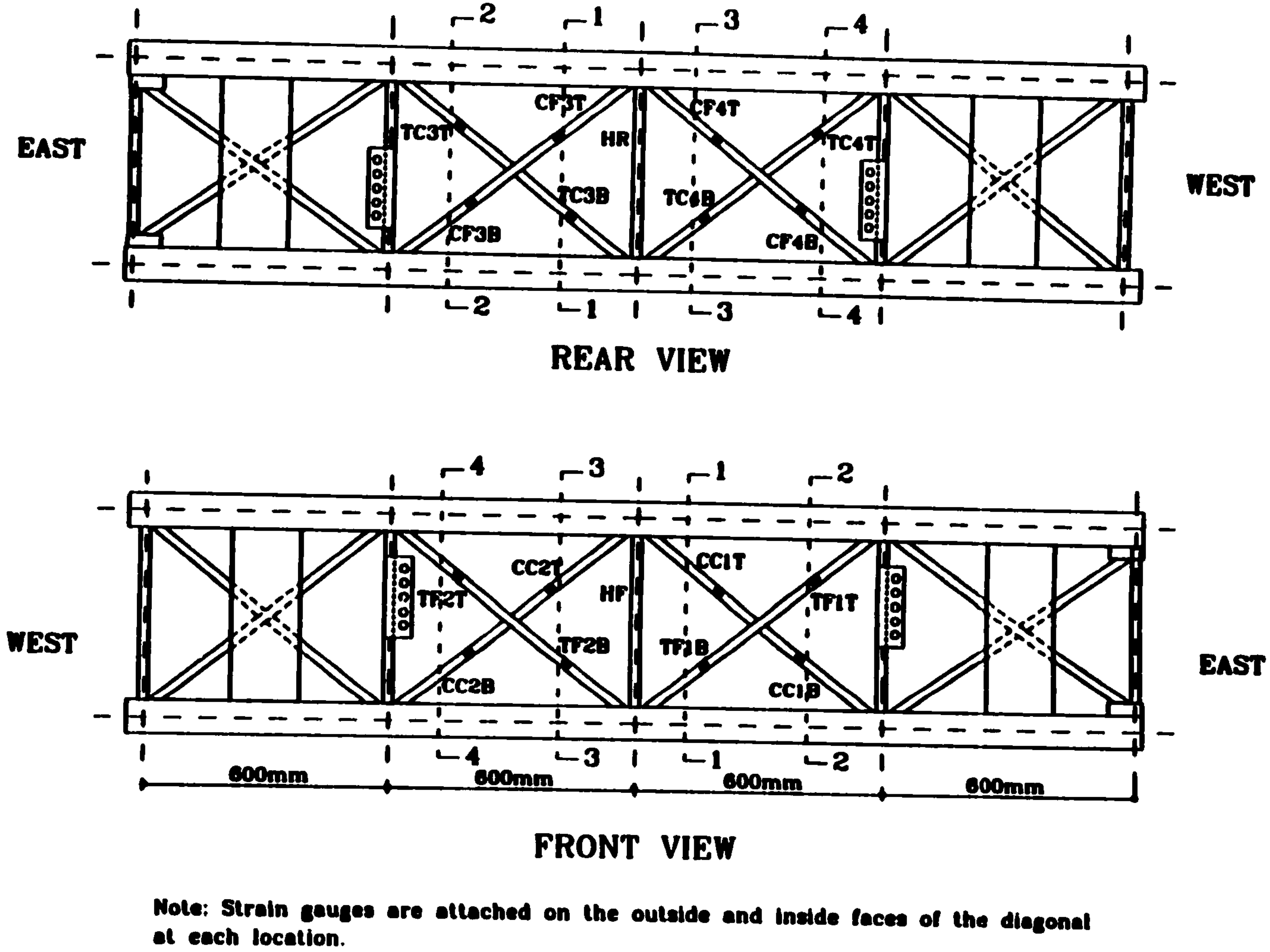
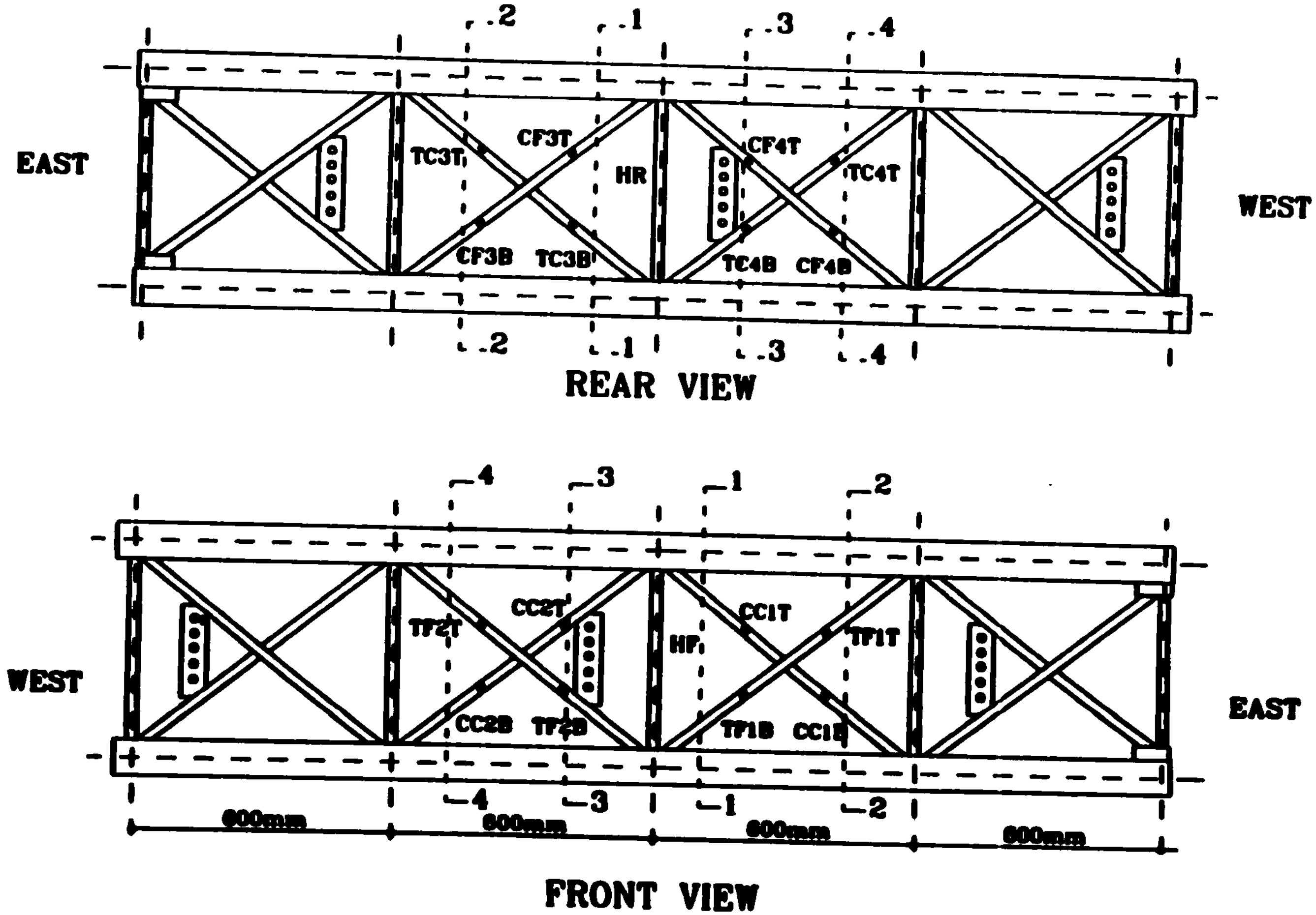
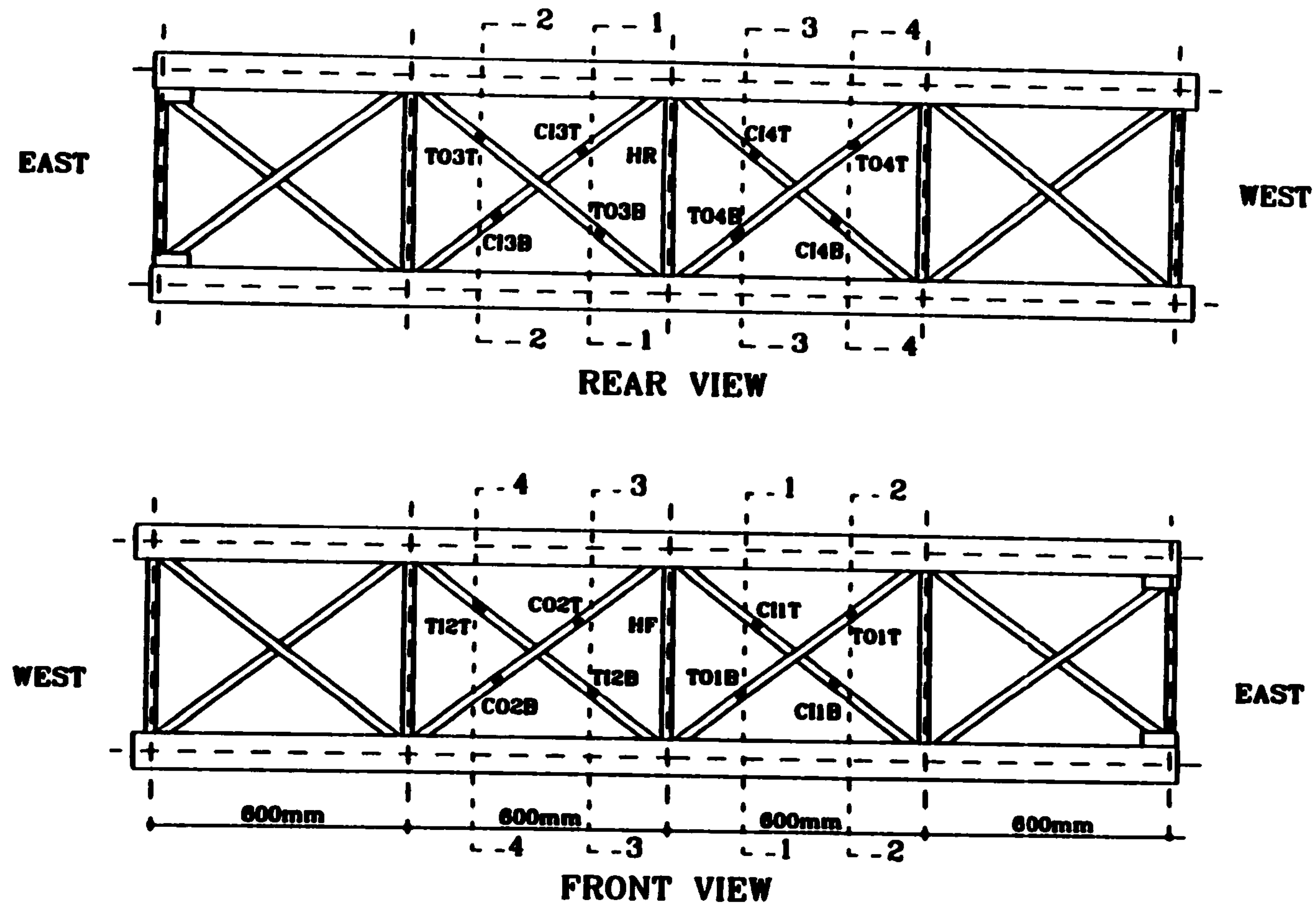


Fig. 3.27 Locations of Strain Gauges and Sections for Equilibrium Check for Specimens LR15 and LR19



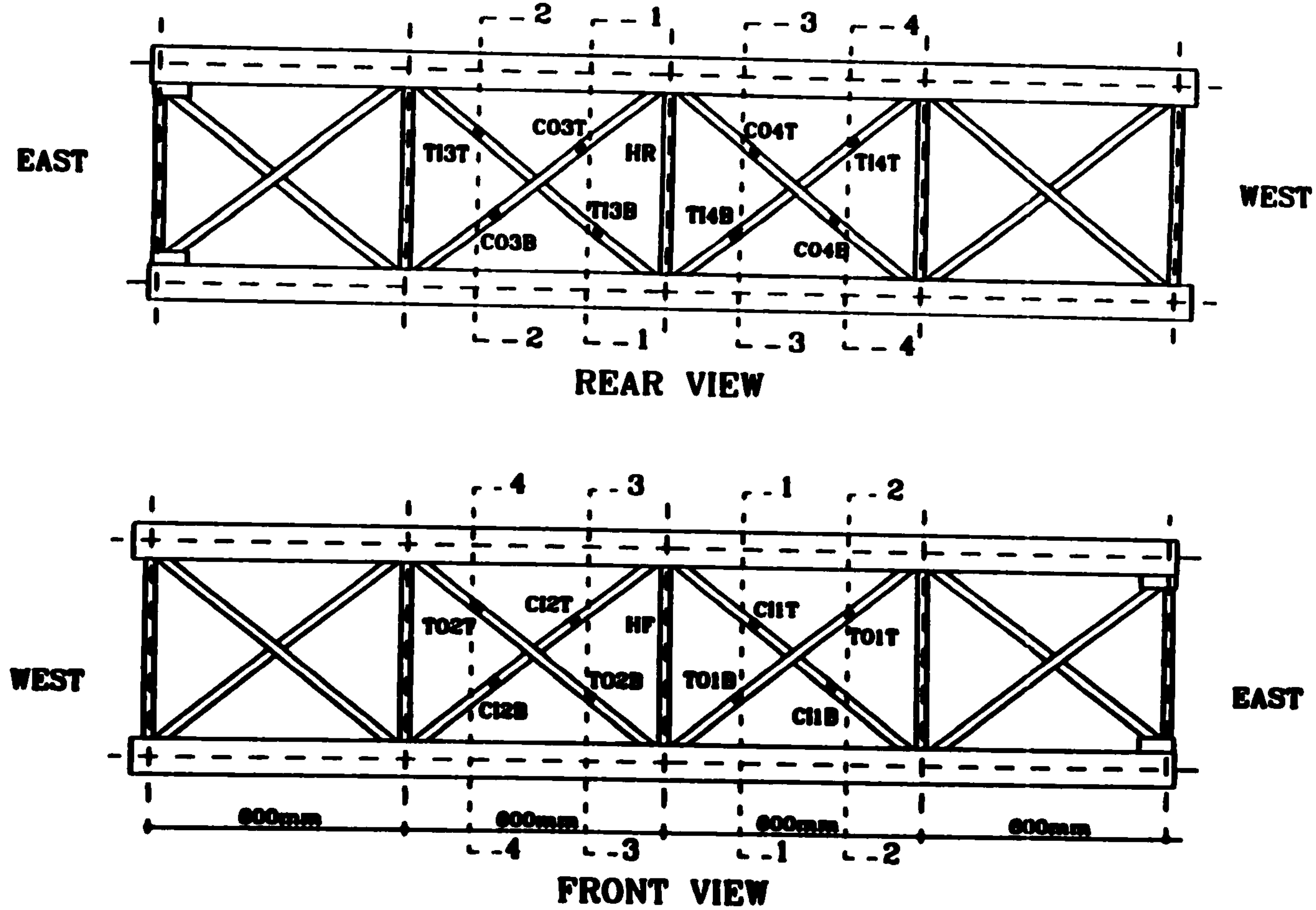
Note: Strain gauges are attached on the outside and inside faces of the diagonals at each location.

Fig. 3.28 Locations of Strain Gauges and Sections for Equilibrium Check for Specimen LR16



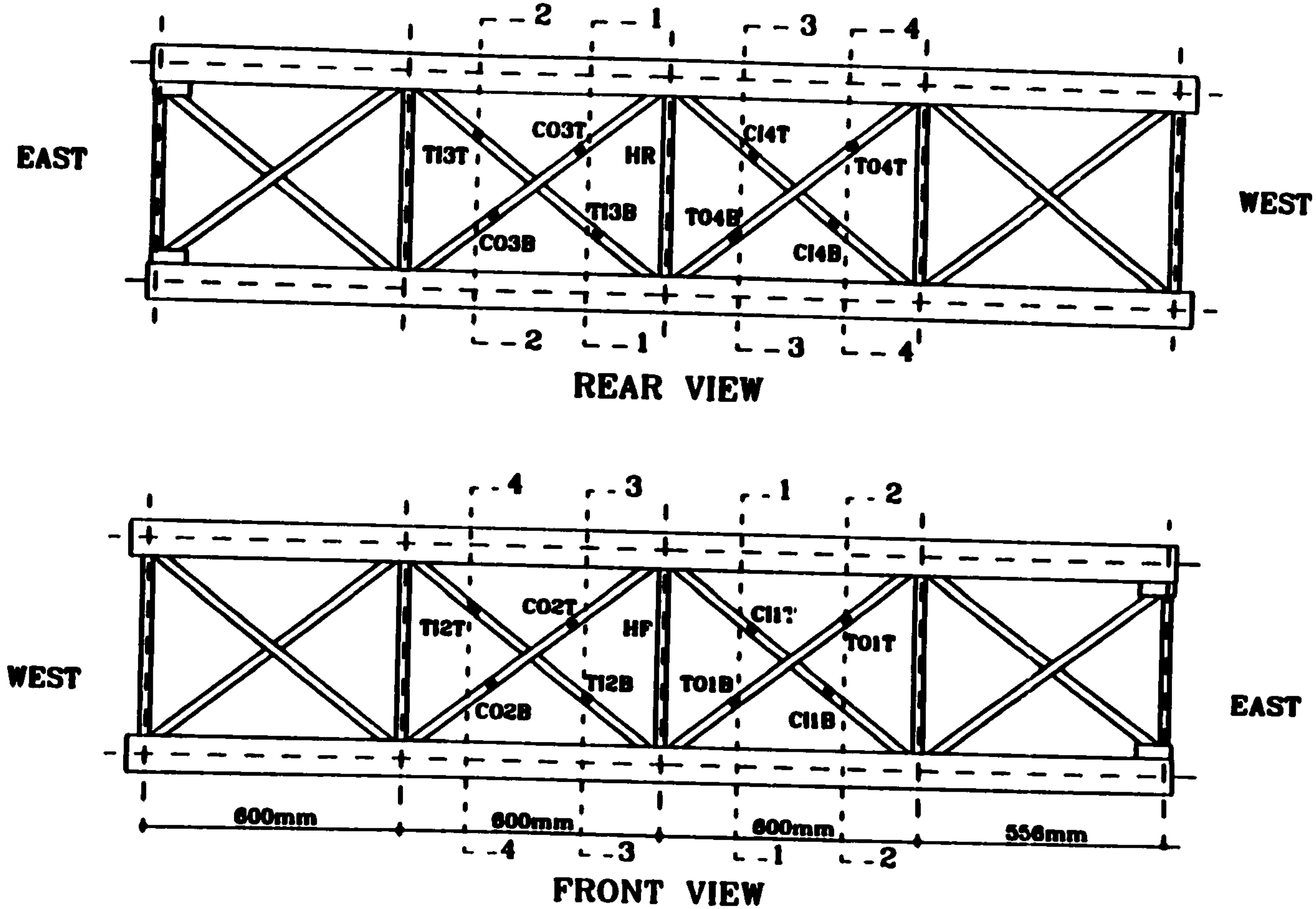
Note: Strain gauges are attached on the outside and inside faces of the diagonals at each location

Fig. 3.29 Locations of Strain Gauges and Sections for Equilibrium Check for Specimen LR17



Note: Strain gauges are attached on the outside and inside faces of the diagonals at each location

Fig. 3.30 Locations of Strain Gauges and Sections for Equilibrium Check for Specimen LR18



Note: Strain gauges are attached on the outside and inside faces of the diagonals at each location

Fig. 3.31 Locations of Strain Gauges and Sections for Equilibrium Check for Specimen LR20

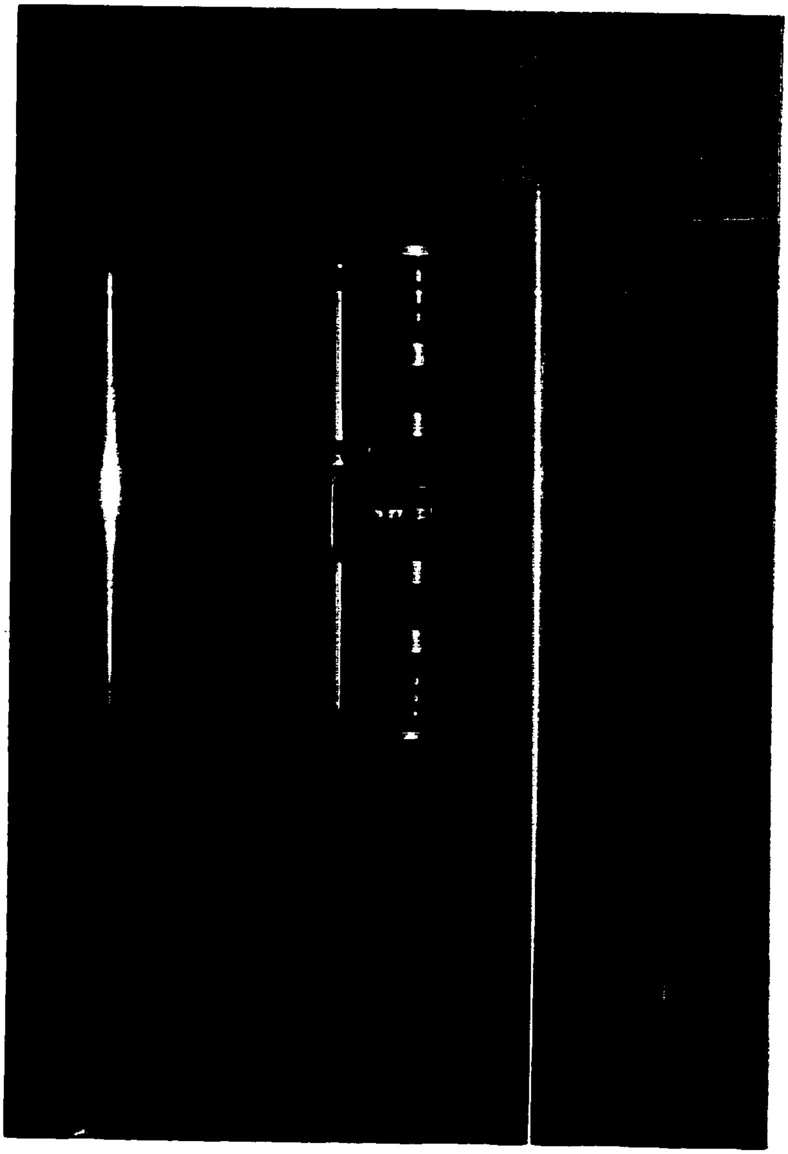


Fig. 3.32 Tension Test setup

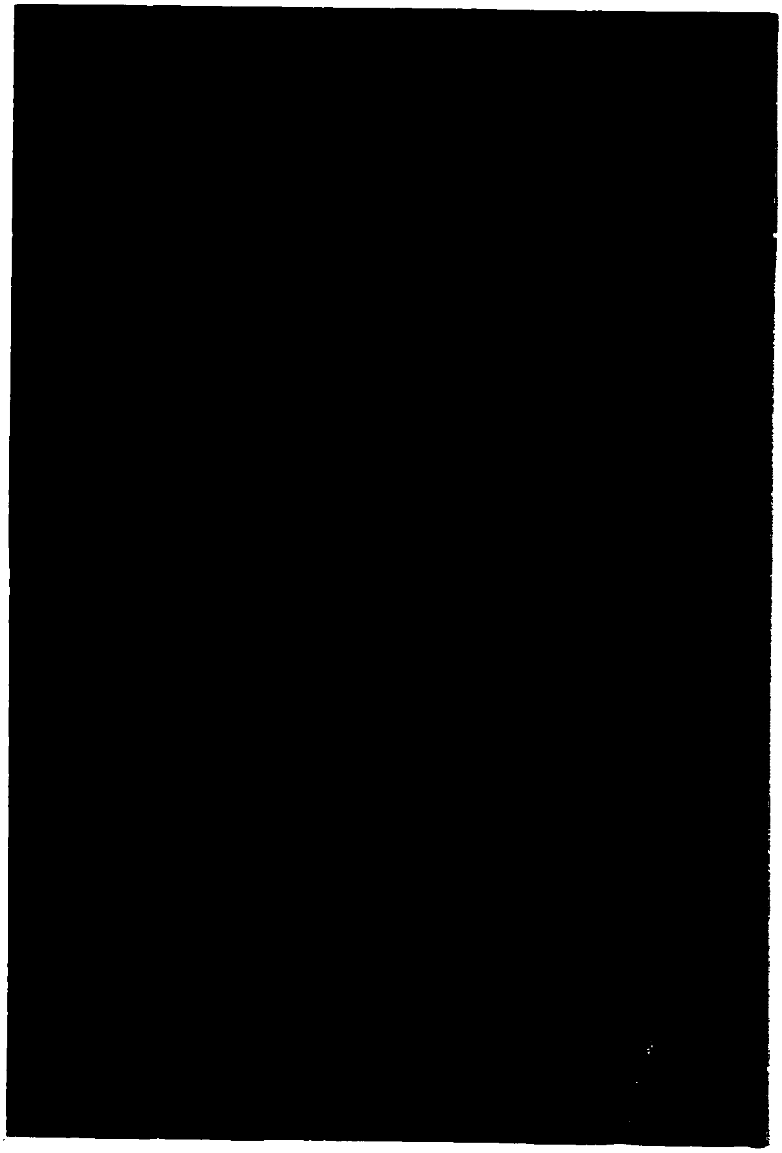


Fig. 3.33 Photograph of Specimen TR1 after Failure

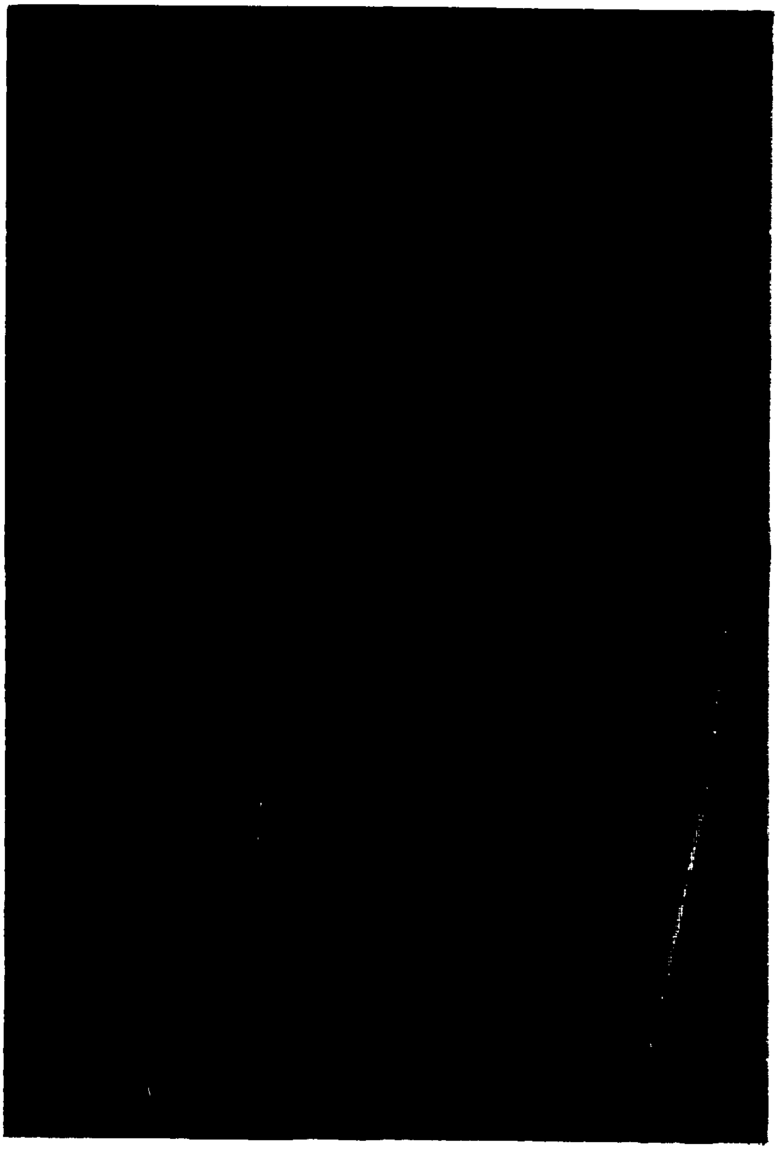


Fig. 3.34 Photograph of Specimen TR2 after Failure

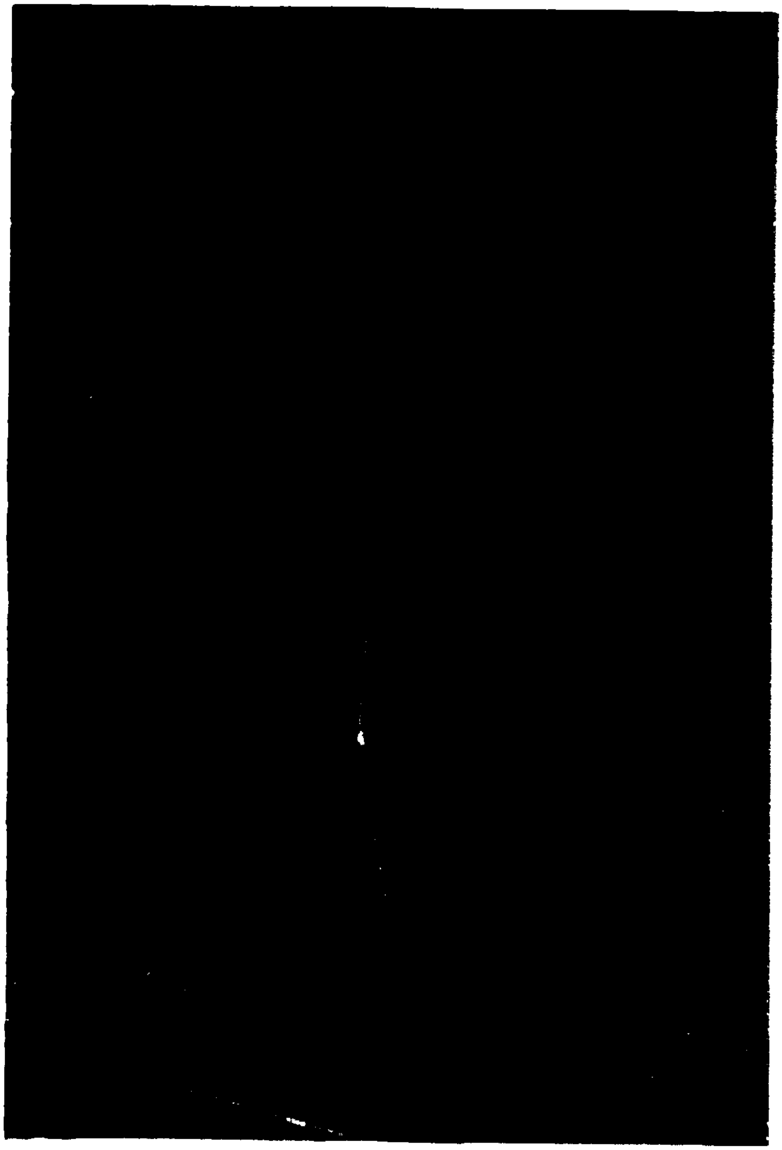


Fig. 3.35 Photograph of Specimen TR3 after Failure

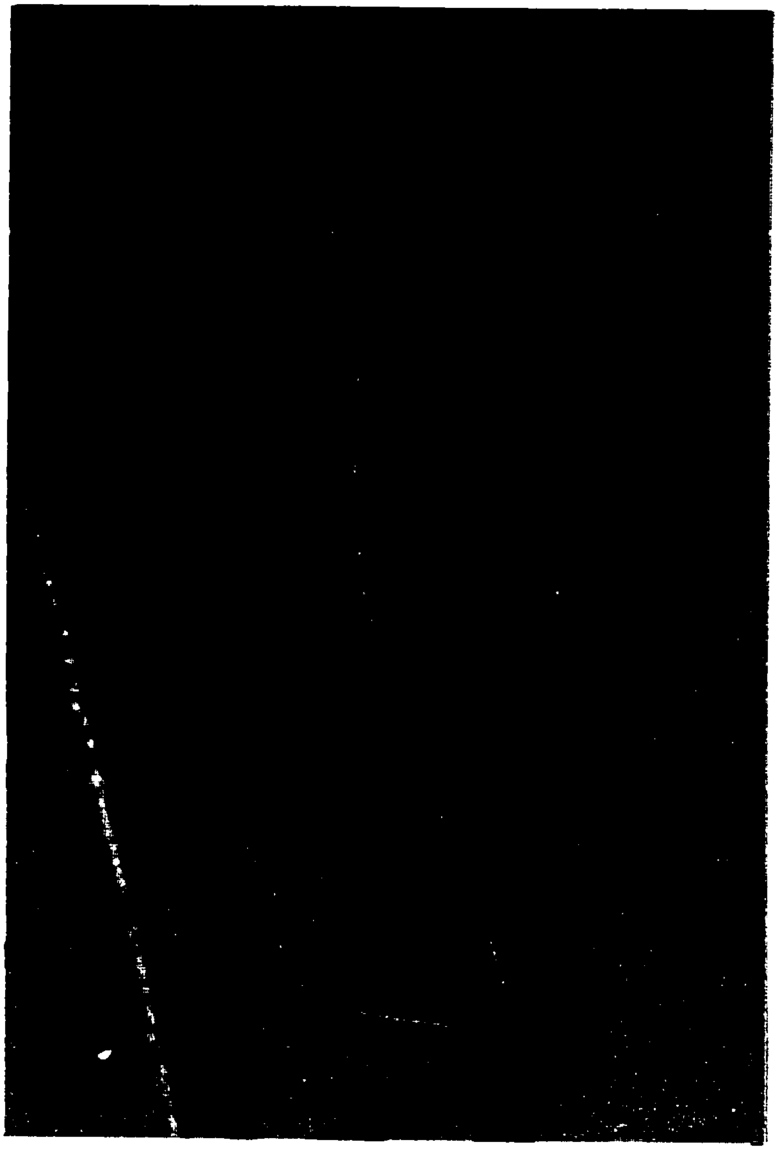


Fig. 3.36 Photograph of Specimen TR4 after Failure

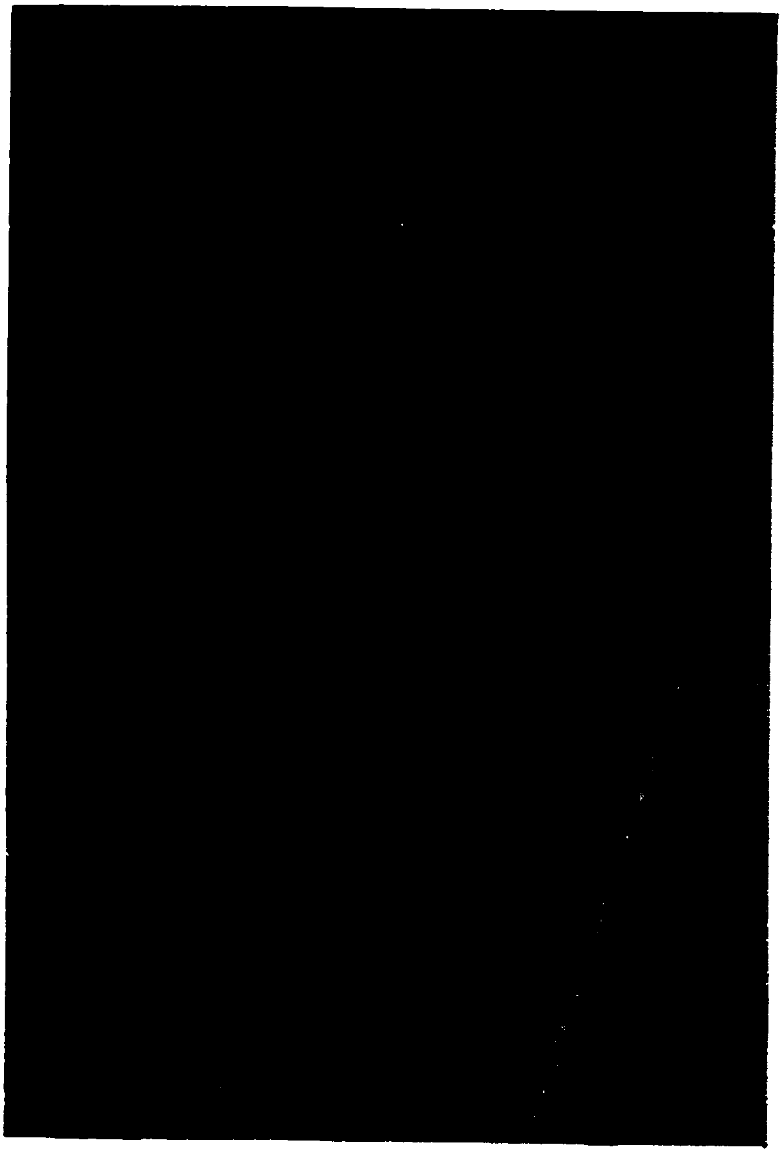


Fig. 3.37 Photograph of Specimen TR5 after Failure

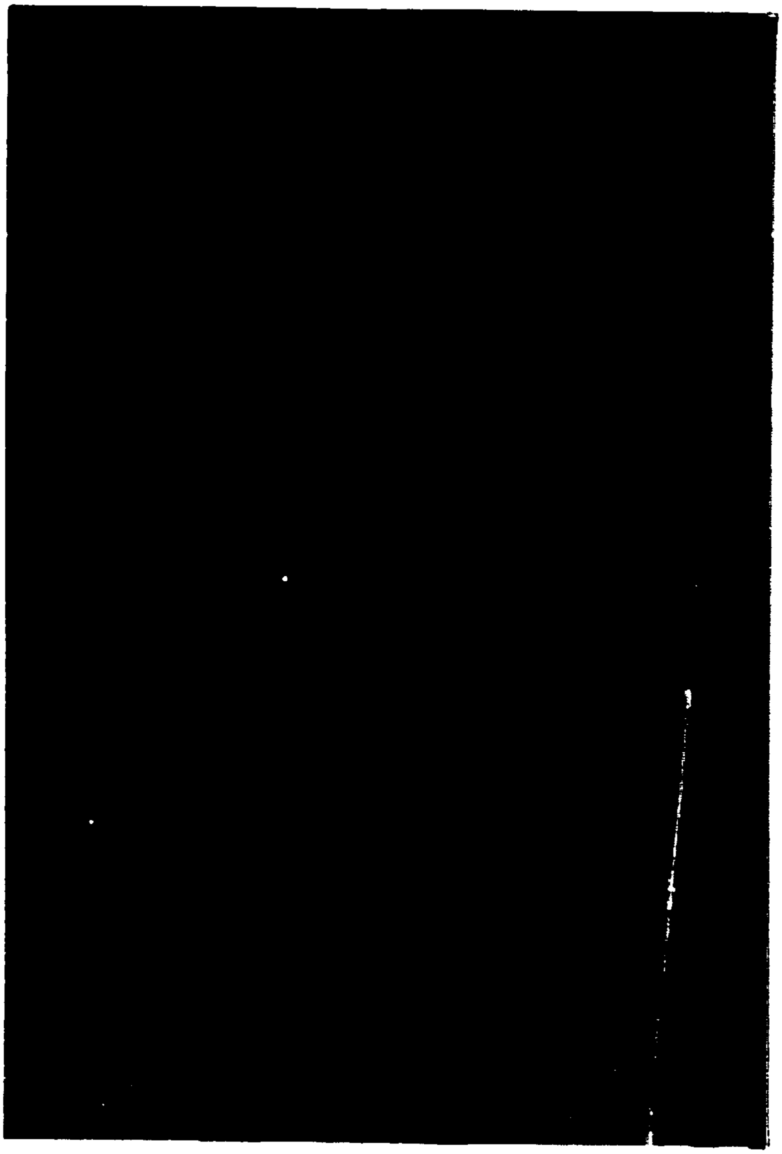


Fig. 3.38 Photograph of Specimen TR6 after Failure

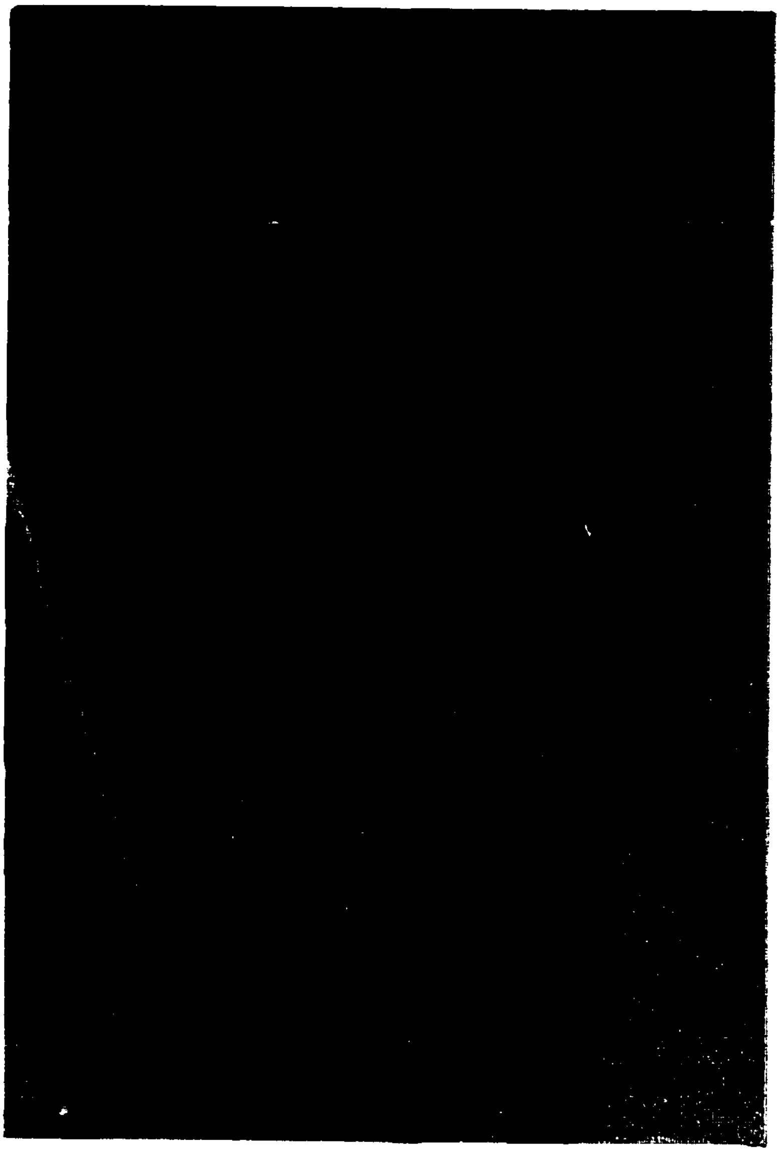


Fig. 3.39 Photograph of Specimen LR1 after Failure

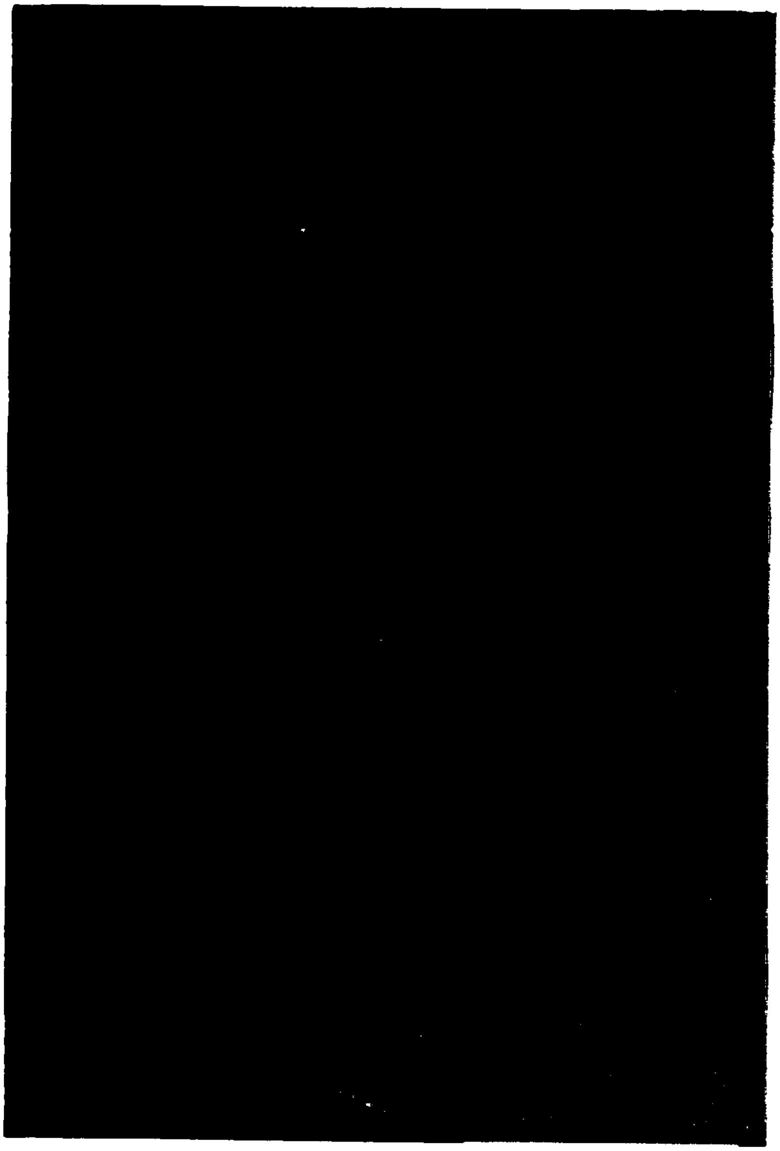


Fig. 3.40 Photograph of Specimen LR2 after Failure

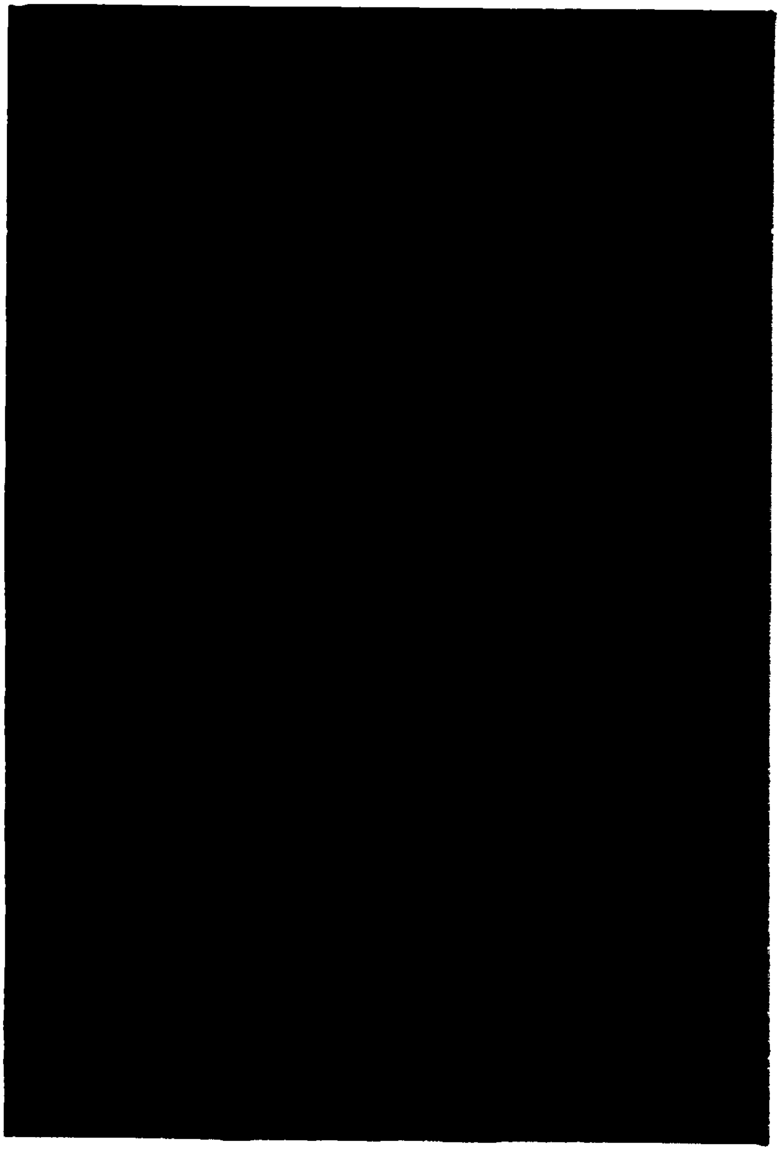


Fig. 3.41 Photograph of Specimen LR3 after Failure

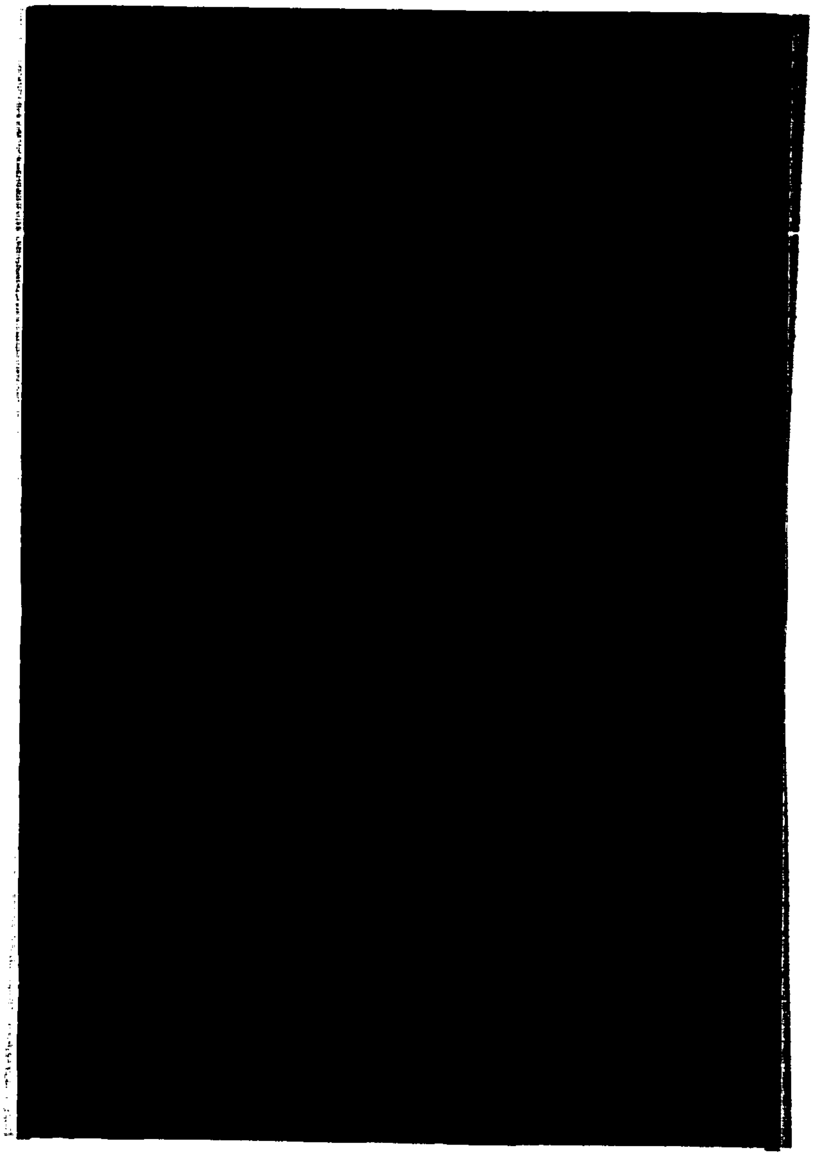


Fig. 3.42 Photograph of Specimen LR4 after Failure

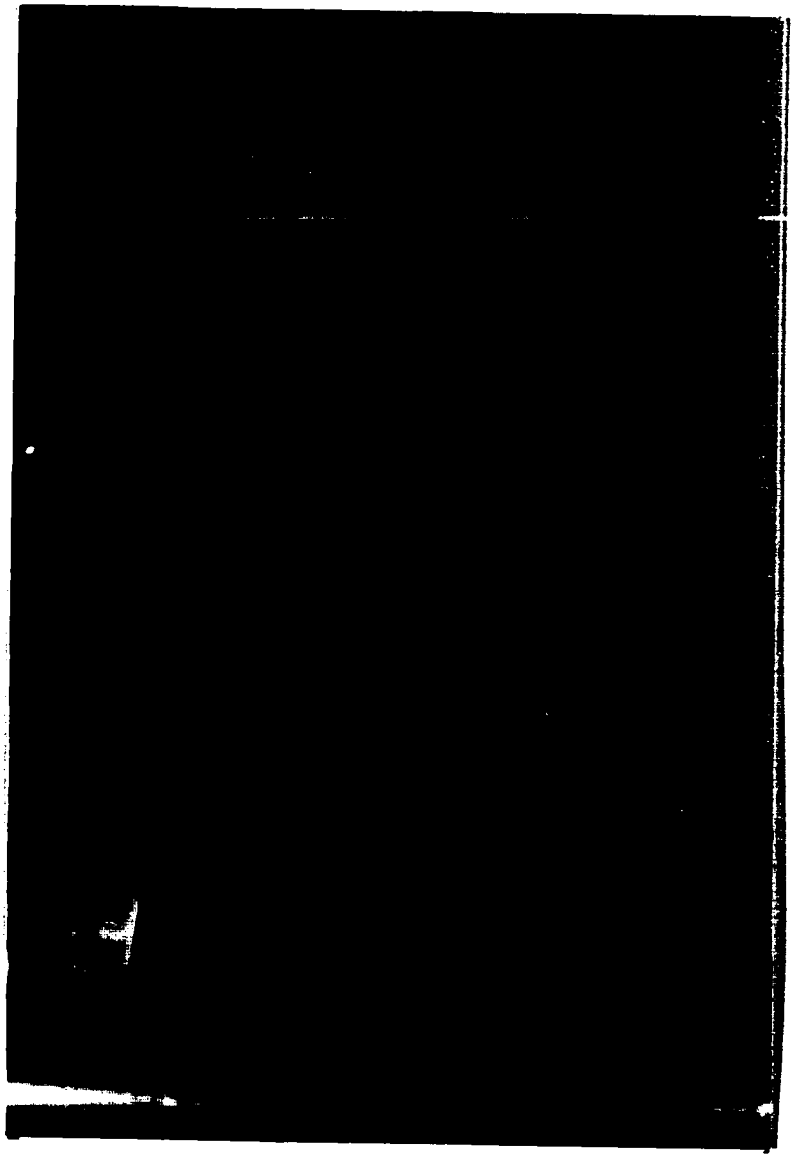


Fig. 3.43 Photograph of Specimen LR5 after Failure

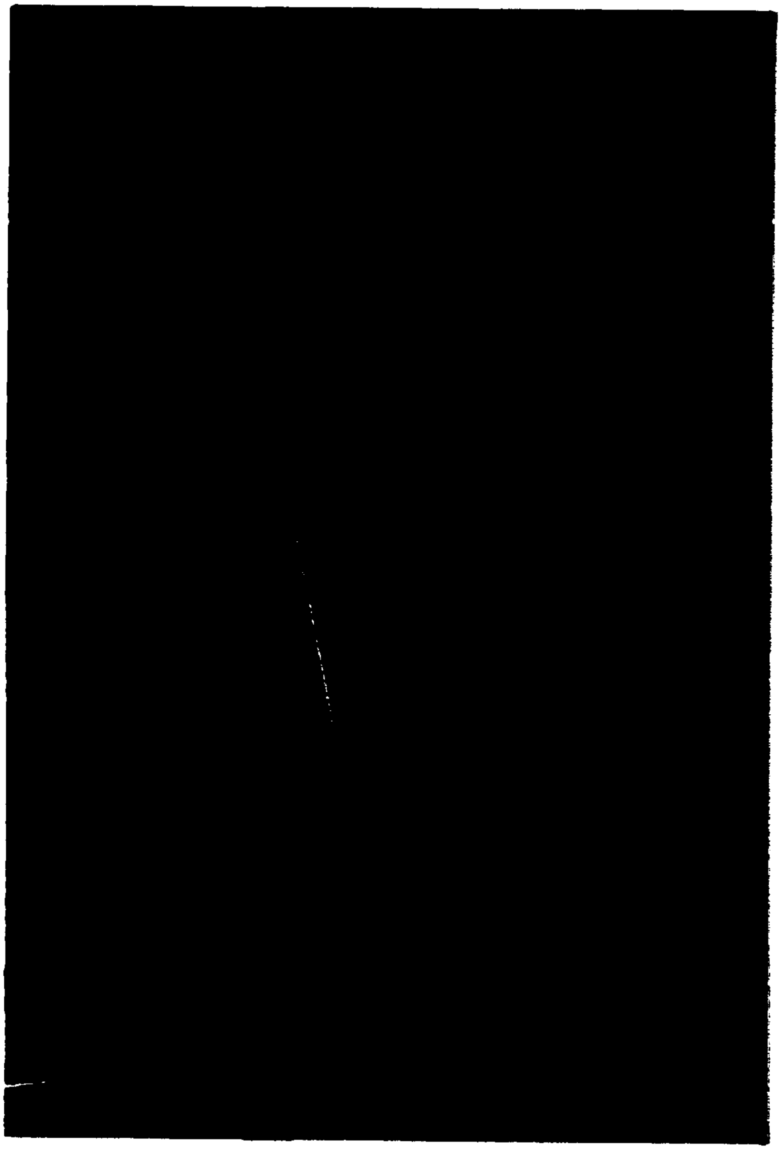


Fig. 3.44 Photograph of Specimen LR6 after Failure

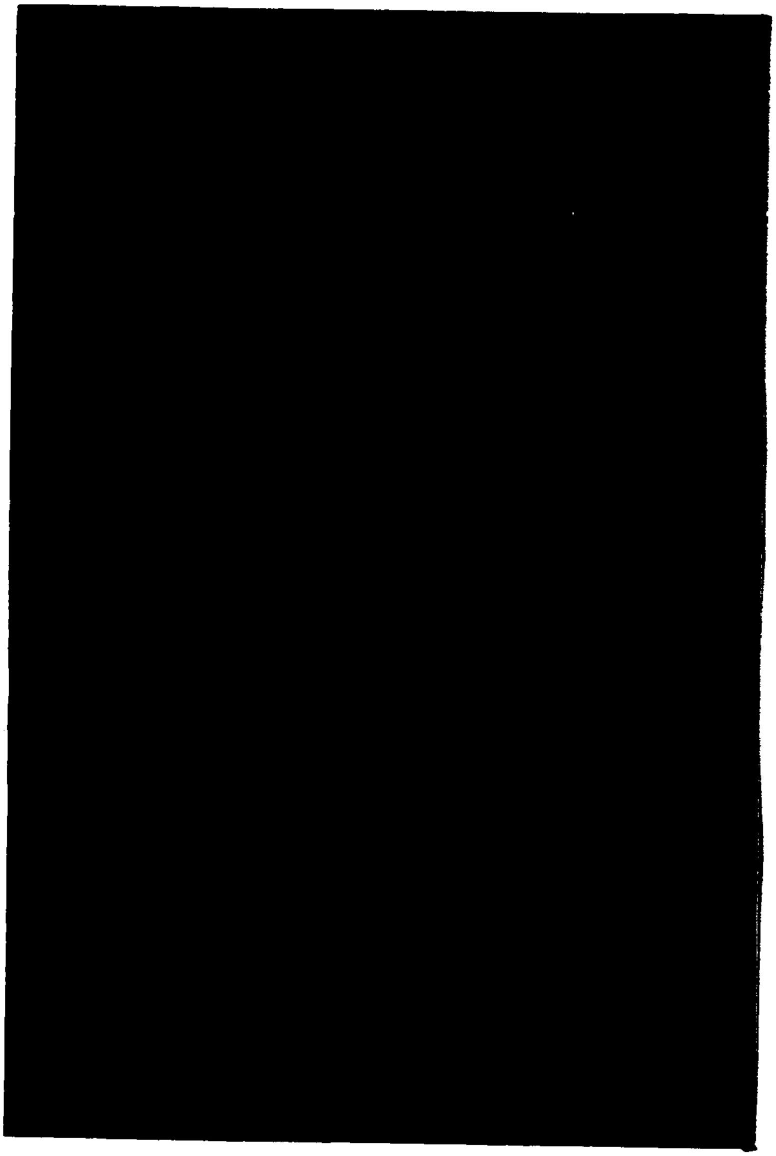


Fig. 3.45 Photograph of Specimen LR7 after Failure

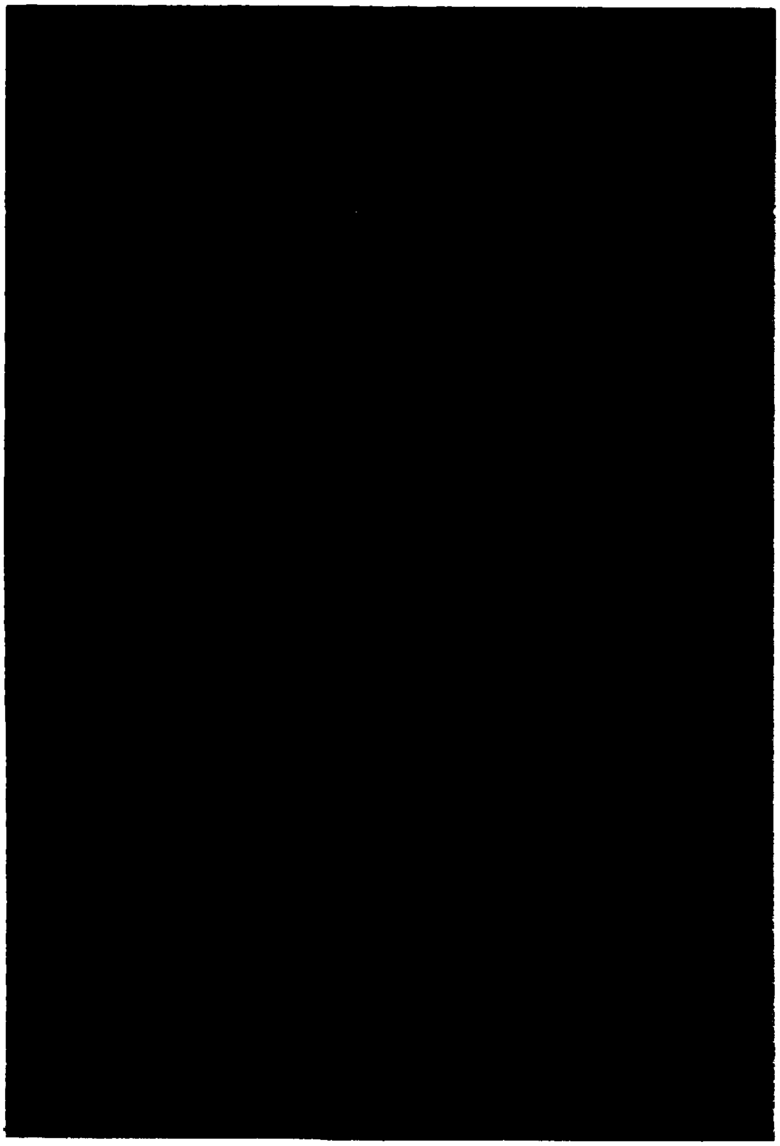


Fig. 3.46 Photograph of Specimen LR8 after Failure

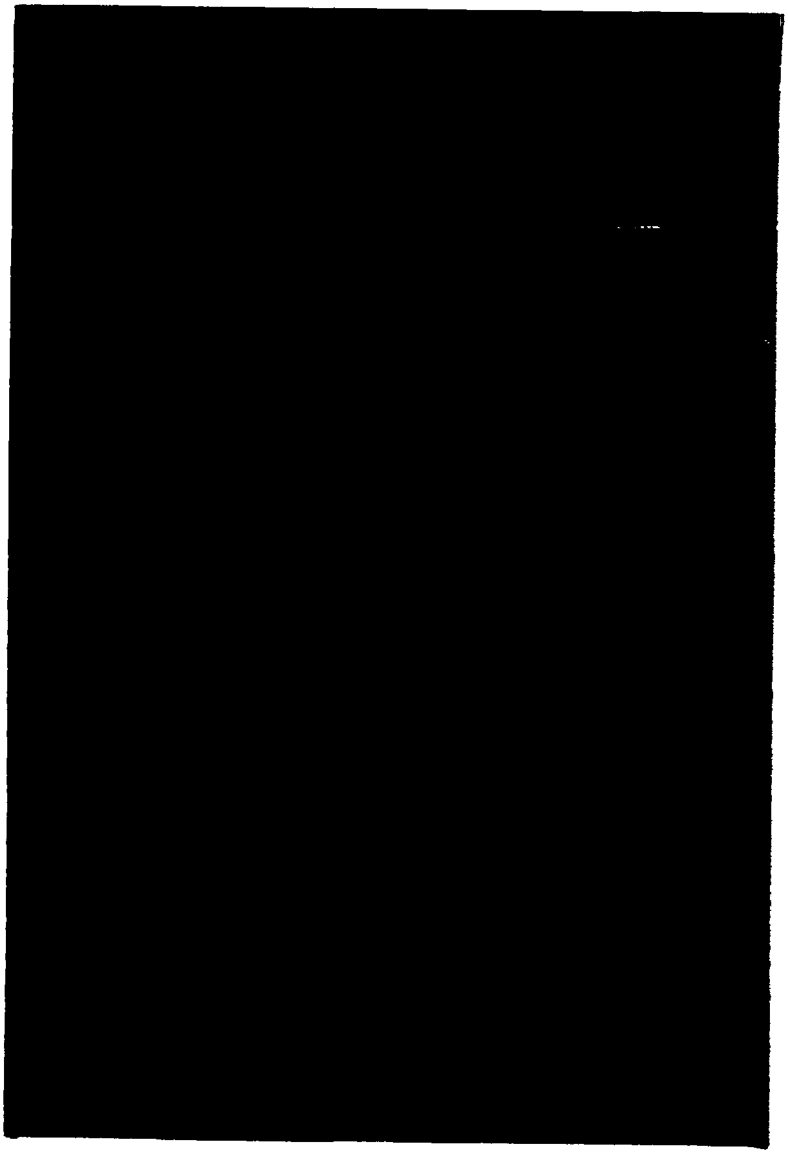


Fig. 3.47 Photograph of Specimen LR9 after Failure

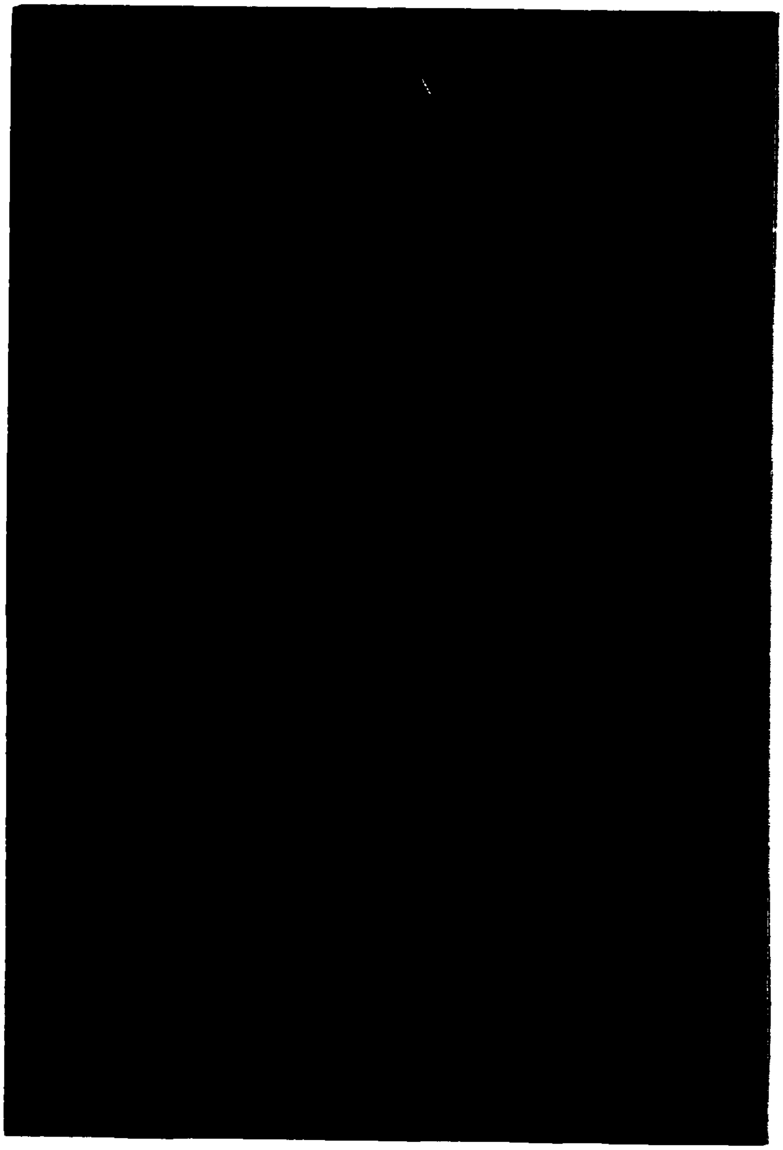


Fig. 3.48 Photograph of Specimen LR10 after Failure

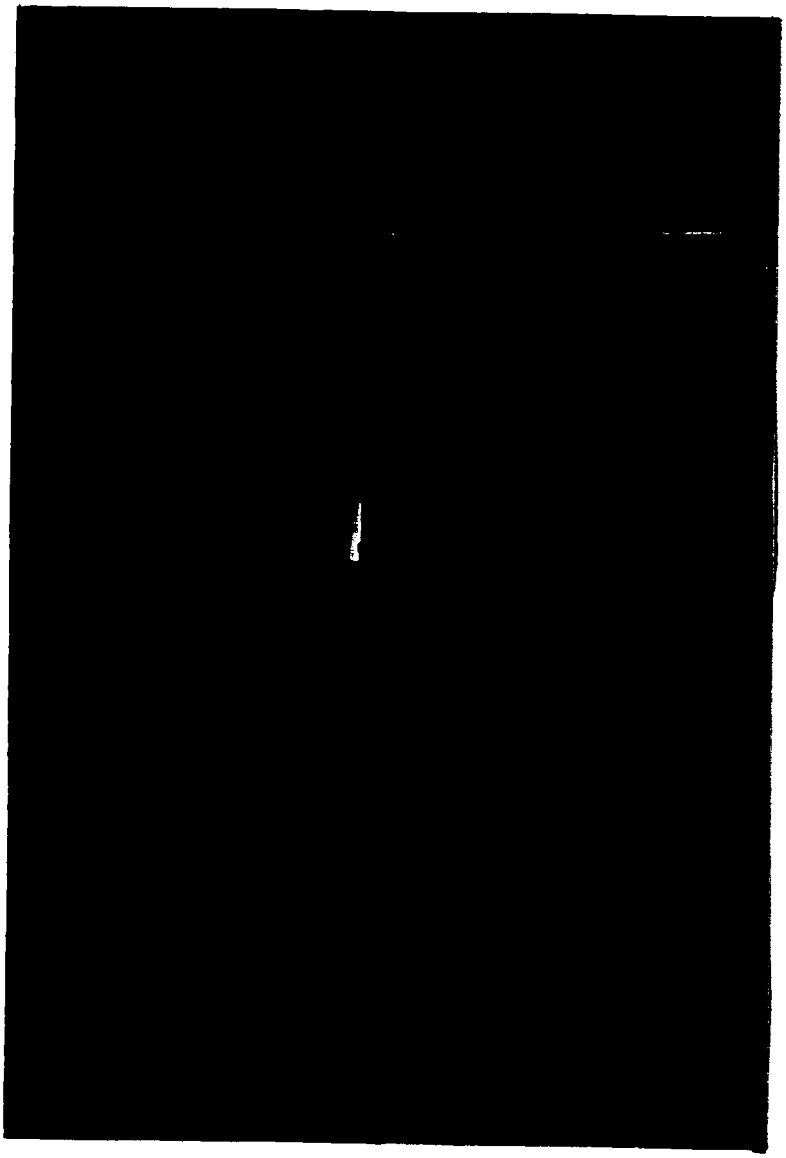


Fig. 3.49 Photograph of Specimen LR11 after Failure

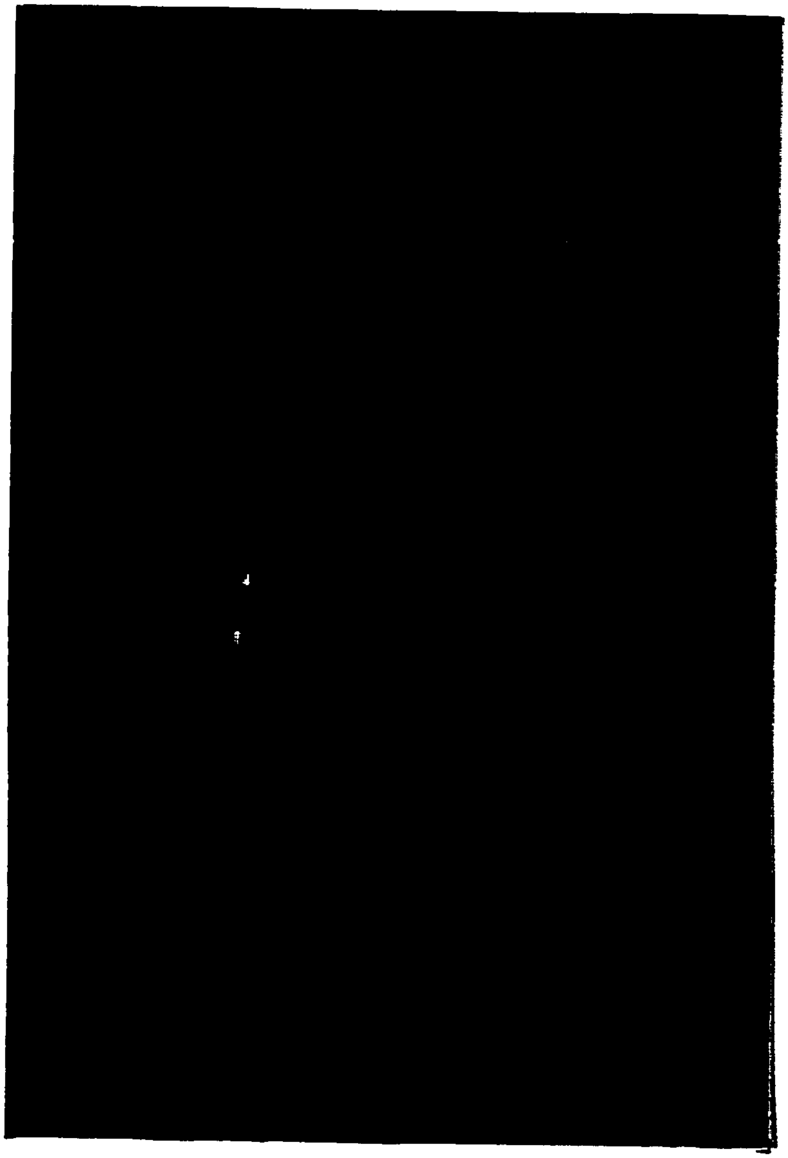


Fig. 3.50 Photograph of Specimen LR12 after Failure

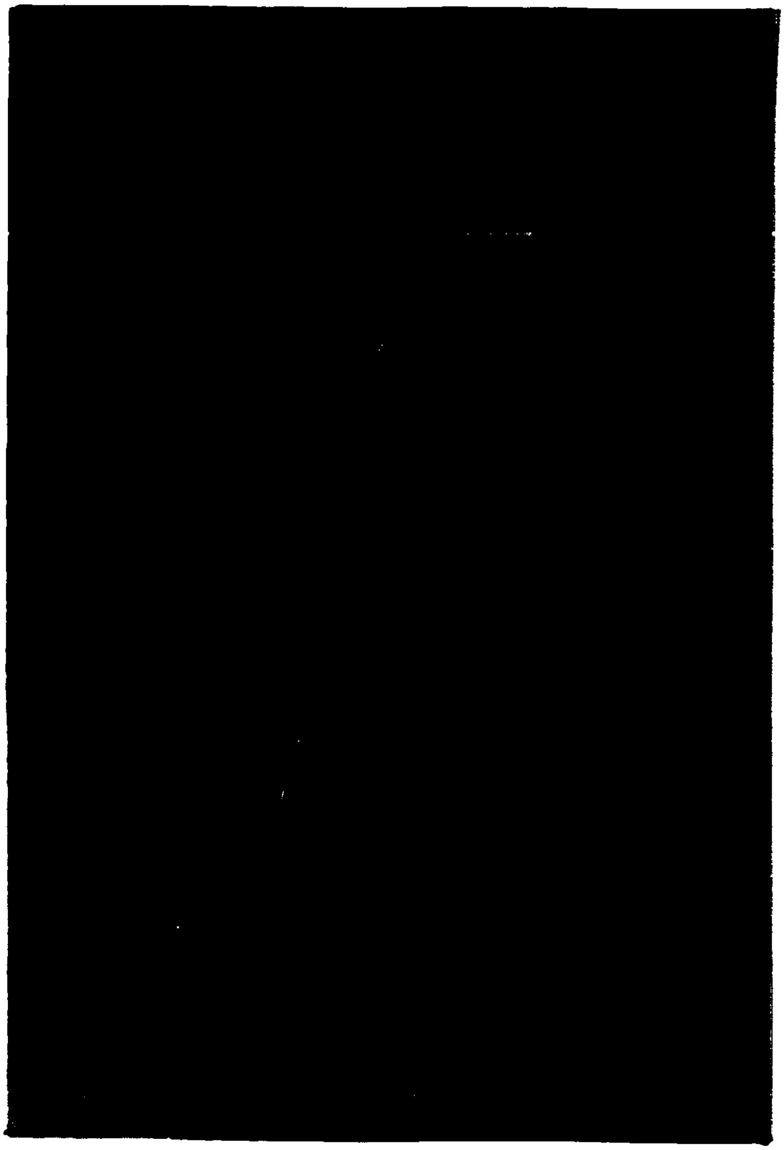


Fig. 3.51 Photograph of Specimen LR13 after Failure

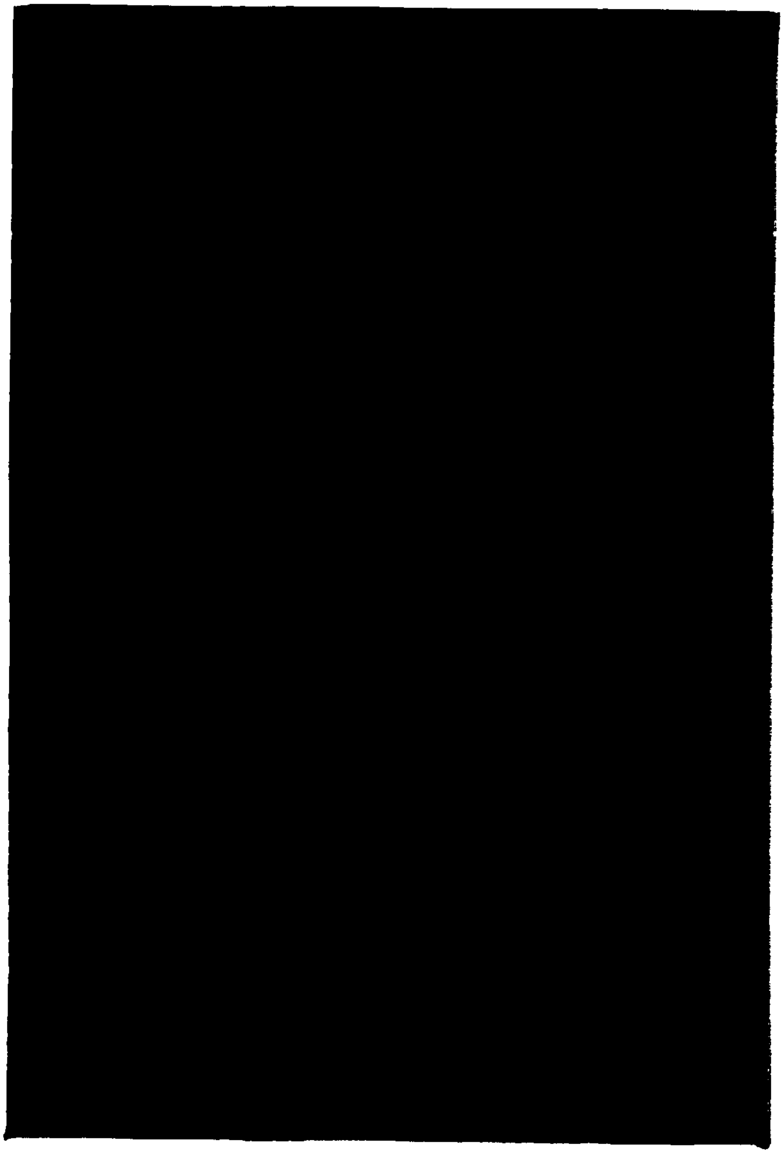


Fig. 3.52 Photograph of Specimen LR14 after Failure

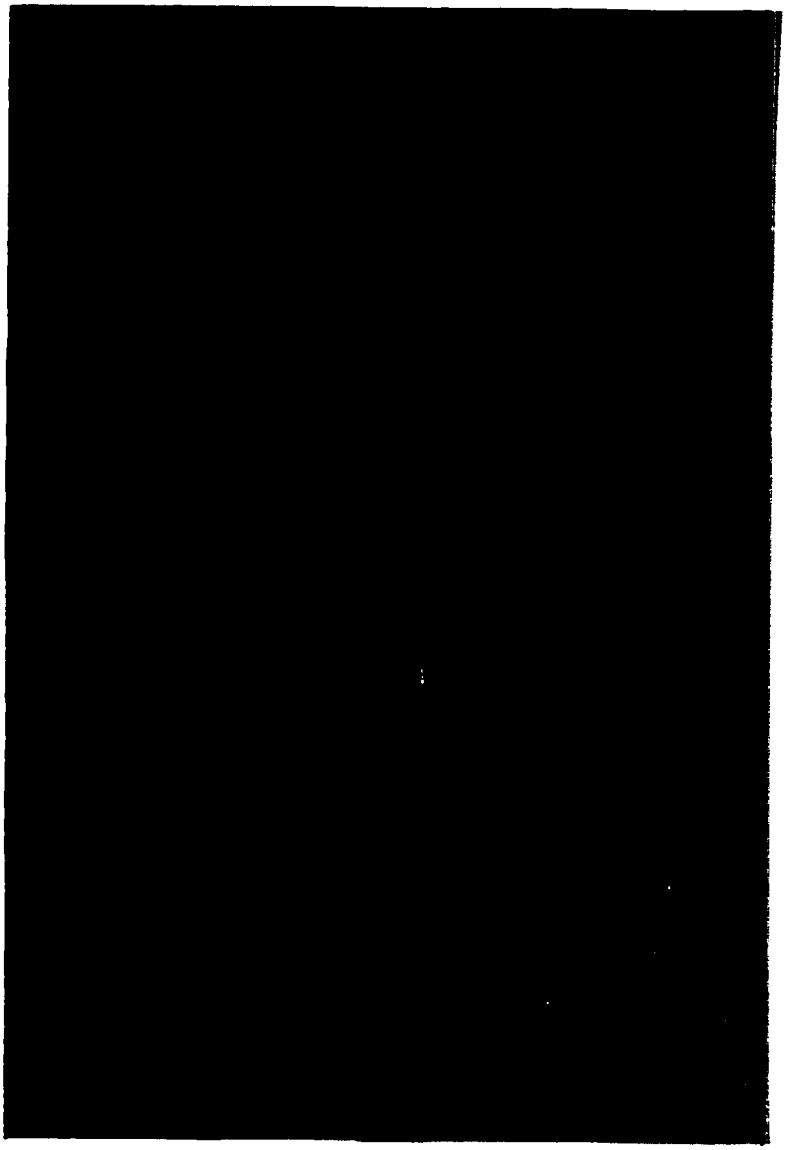


Fig. 3.53 Photograph of Specimen LR15 after Failure

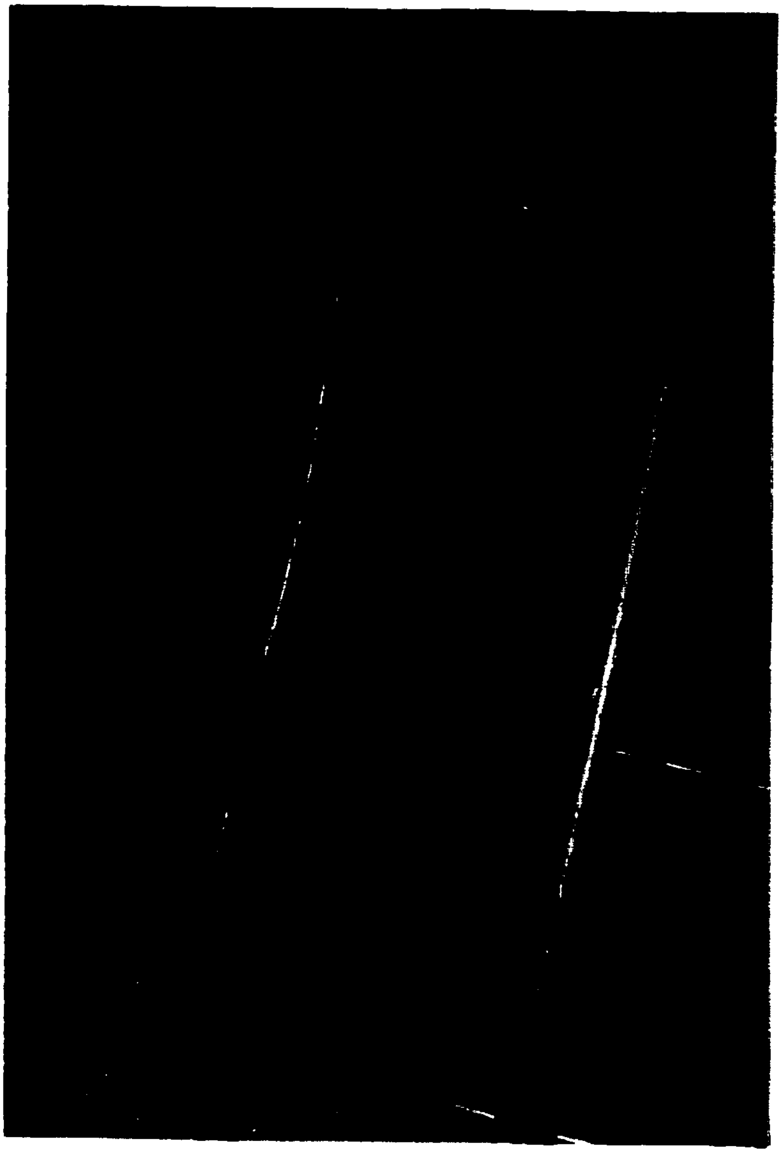


Fig. 3.54 Photograph of Specimen LR16 after Failure

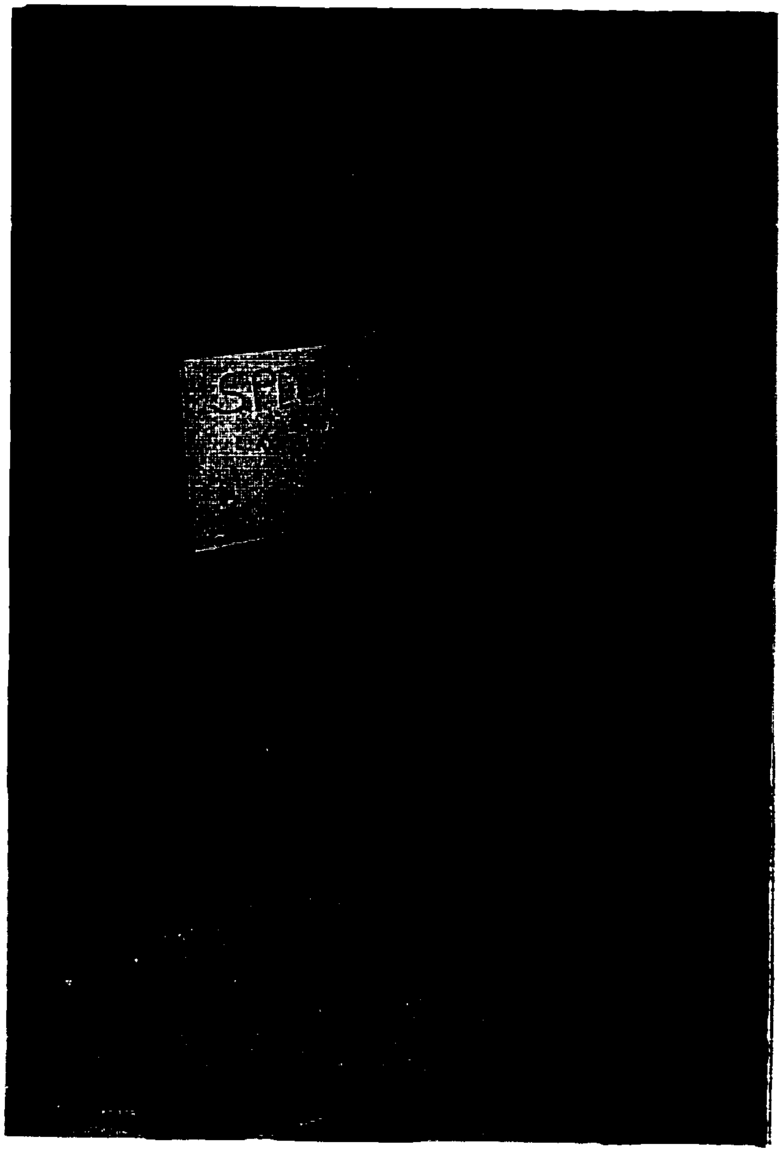


Fig. 3.55 Photograph of Specimen LR17 after Failure

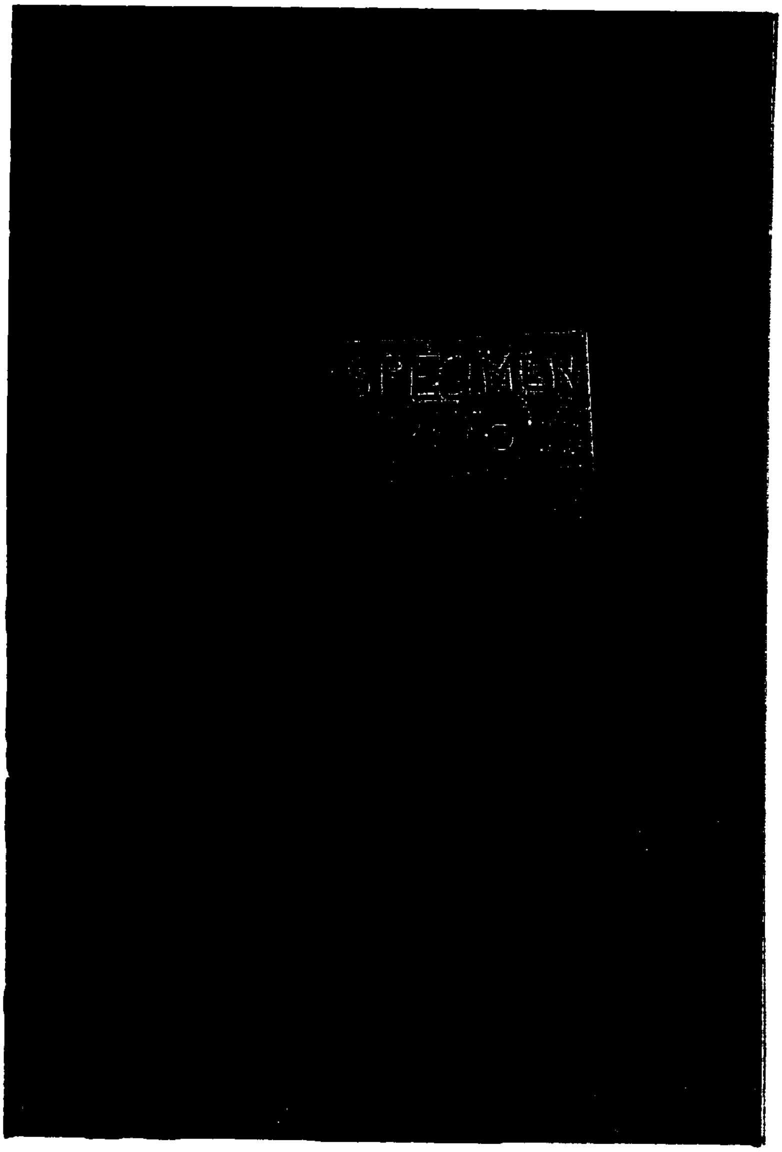


Fig. 3.56 Photograph of Specimen LR18 after Failure

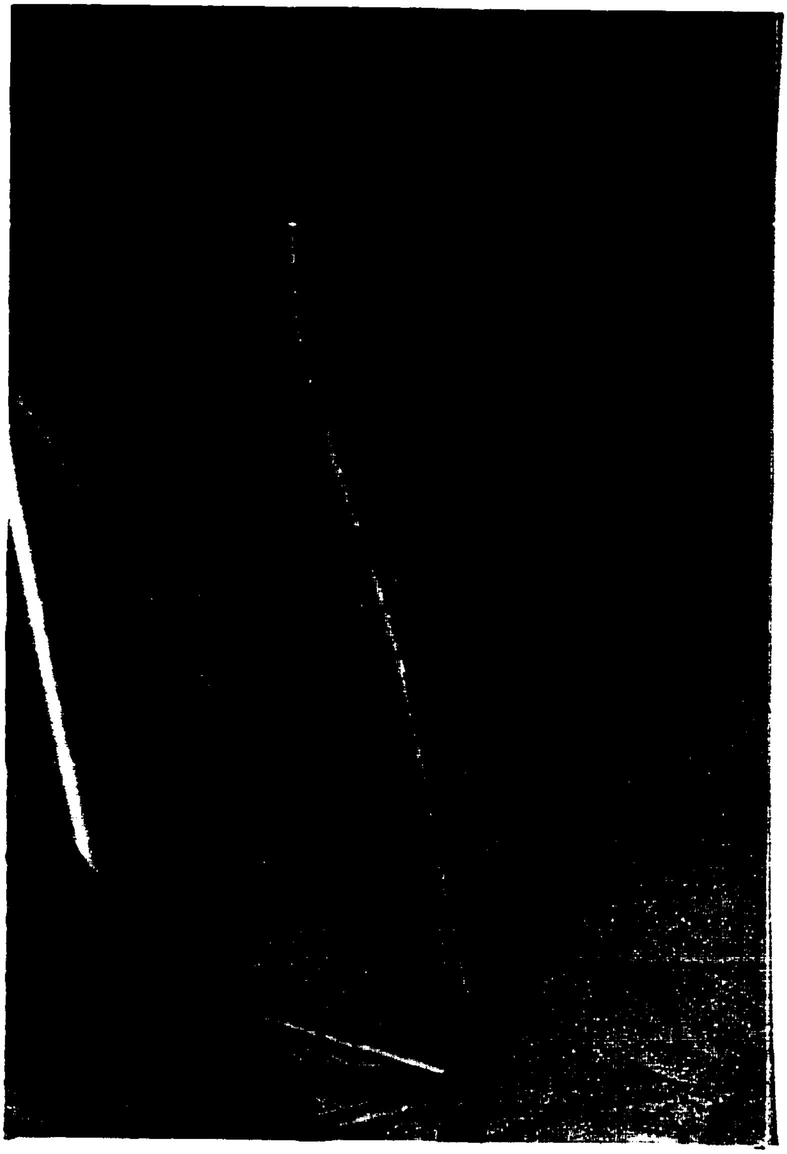


Fig. 3.57 Photograph of Specimen LR19 after Failure

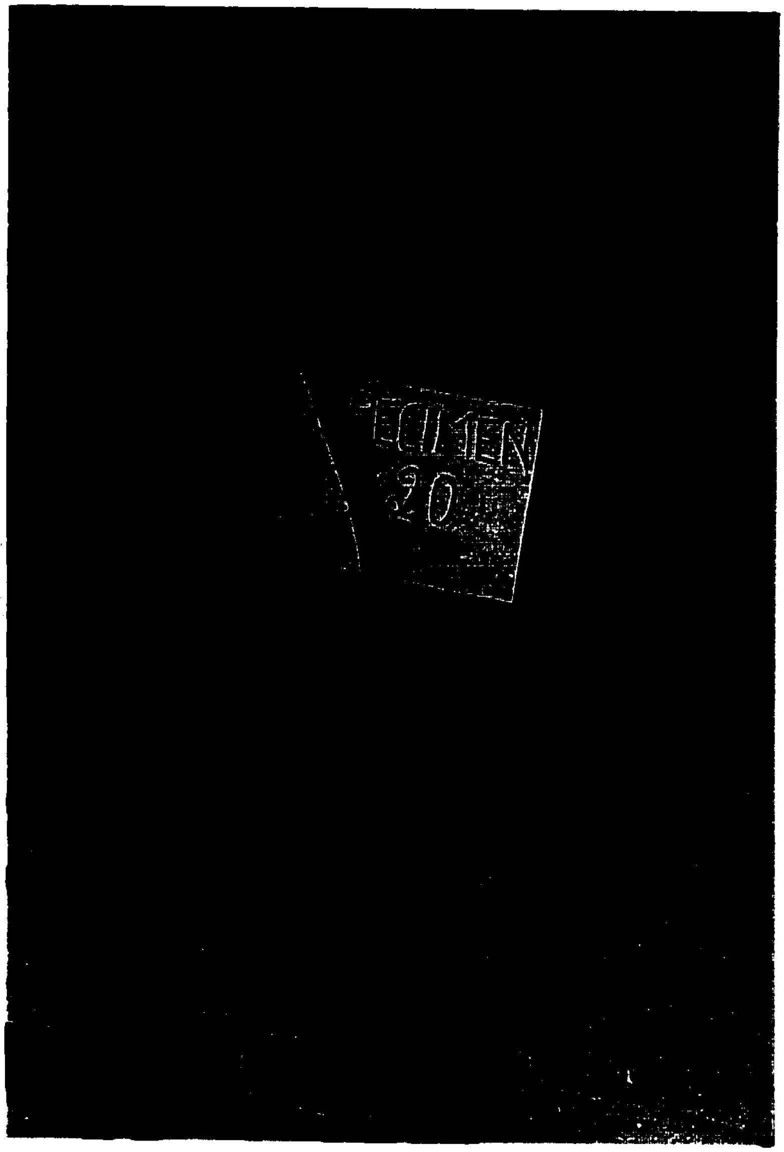


Fig. 3.58 Photograph of Specimen LR20 after Failure

APPENDIX - A

Tables of Load vs. Strain for Test Specimens TR1 to TR4 and LR10 to LR20

Table A.1 Load-Strain Data for Specimen TR1

Load (kN)	Strain Gauge Readings (μstrain)*							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached**							
	CB3T	CB3B	CB4T	CB4B	CS1T	CS1B	CS2T	CS2B
0	0	0	0	0	0	0	0	0
11.7	8	26	12	26	0	31	11	0
23.4	-37	-33	-33	-55	-38	-32	-32	-38
29.2	-75	-39	-47	-55	-50	-40	-70	-65
35.1	-80	-60	-73	-55	-79	-40	-96	-88
40.9	-119	-128	-120	-136	-150	-53	-147	-150
46.8	-200	-150	-138	-136	-152	-129	-200	-200
52.6	-212	-184	-159	-112	-166	-153	-222	-210
58.5	-240	-218	-210	-192	-220	-210	-300	-270
64.3	-256	-205	-205	-170	-212	-195	-280	-247
70.2	-257	-210	-187	-194	-210	-210	-276	-299
76.0	-370	-200	-172	-185	-188	-207	-301	-330
81.9	-397	-289	-237	-260	-265	-283	-370	-430
93.6	-411	-275	-250	-305	-246	-348	-385	-430
105	-440	-330	-300	-350	-284	-365	-470	-530
117	-500	-370	-345	-370	-320	-400	-495	-580
129	-549	-448	-360	-383	-377	-401	-547	-620
140	-560	-484	-420	-429	-415	-458	-560	-680
153	-610	-515	-430	-440	-440	-500	-634	-695
164	-624	-561	-448	-515	-470	-556	-665	-829
175	-680	-600	-510	-530	-530	-597	-749	-870
187	-720	-625	-517	-575	-560	-590	-750	-950
199	-775	-698	-550	-612	-590	-626	-748	-985
211	-842	-767	-610	-650	-605	-670	-735	-1024
222	-896	-768	-640	-708	-660	-720	-725	-1150
234	-958	-787	-680	-730	-670	-760	-580	-1295
246	-980	-810	-860	-830	-766	-842	250	-2003
257	-960	-800	-850	-900	-707	-850	408	-2087
269	-1068	-900	-950	-1002	-748	-878	480	-2064
281	-1118	-900	-950	-1070	-680	-820	590	-2300
292	-1200	-1000	-988	-1138	-730	-921	650	-2442
304	-1280	-1088	-977	-1245	-671	-848	700	-2562
316	-1309	-1260	-1009	-1372	-622	-580	807	-3203
327	-1032	-1468	1498	-1961	-686	-493	1068	-7547
304	-973	-1396	2796	-2022	-665	-475	1220	-7588
337	-961	-1436	5628	-1975	-701	-447	1320	-7479
316	-944	-1440	-	-1913	-733	-503	1419	-7479
347	-	-	-	-	-	-	-	-

* All strain gauges were at the middle of half length, on the front (outside) face of the member as shown in Fig. 3.18.

** Members are identified in Fig. 3.4.

Table A.2 Load-Strain Data for Specimen TR2

Load (kN)	Strain Gauge Readings (μstrain)							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached*							
	CB3T	CB3B	CB4T	CB4B	CS1T	CS1B	CS2T	CS2B
	Location of Strain Gauges on Members**							
	340 mm from top	360 mm from bot.	380 mm from top	375 mm from bot.	350 mm from top	350 mm from bot.	360 mm from top	370 mm from bot.
0	0	0	0	0	0	0	0	0
23.4	-200	-230	-68	-39	-9	-74	-229	-68
46.8	-378	-469	-175	-106	-58	-130	-425	-158
70.2	-500	-576	-255	-159	-69	-129	-526	-236
93.6	-580	-750	-355	-219	-97	-161	-675	-285
117	-700	-940	-515	-320	-191	-222	-961	-340
129	-718	-958	-531	-320	-160	-215	-1114	-268
140	-780	-1009	-600	-367	-196	-252	-1265	-209
146	-786	-1046	-640	-388	-208	-270	-1358	-158
152	-800	-1075	-650	-400	-209	-262	-1500	-85
158	-814	-1222	-684	-424	-214	-260	-1591	-21
164	-840	-1282	-739	-550	-236	-280	-1960	481
170	-805	-1290	-796	-480	-316	-320	-2553	2600
175	-840	-1390	-1044	-500	-266	-307	-2620	3055
181	-900	-1415	-1119	-530	-286	-366	-2670	3168
187	-851	-1447	-1090	-528	-275	-319	-2610	3686
193	-870	-1580	-1320	-551	-295	-357	-2585	4007
199	-880	-1618	-1400	-560	-300	-355	-2600	4333
205	-940	-1770	-1480	-575	-318	-374	-2615	4557
211	-925	-1830	-1540	-565	-318	-360	-2580	5025
216	-980	-1845	-1620	-570	-324	-365	-2613	5260
222	-1031	-1877	-1660	-570	-302	-347	-2615	5648
228	-1024	-1950	-1690	-570	-315	-365	-2662	5915
236	-1072	-2100	-1800	-576	-338	-368	-2650	6420
240	-1070	-2167	-1894	-585	-370	-387	-2685	6488
246	-1120	-2305	-1917	-579	-368	-392	-2700	6850
251	-1138	-2370	-1989	-582	-379	-385	-2733	6980
257	-1153	-2460	-2144	-562	-386	-366	-2760	7339
263	-1149	-2554	-2300	-558	-561	-399	-2869	7499
269	-1160	-2672	-2484	-545	-418	-336	-2777	7850
276	-1135	-2875	-2702	-515	-426	-330	-2860	8096
281	-1115	-3000	-2882	-480	-445	-210	-2968	8333
287	-1094	-3297	-3169	-439	-471	-238	-2994	8566
292	-1030	-3618	-3562	-370	-503	-145	-3020	8780
298	-967	-4058	-4224	-267	-634	187	-3112	9166
304	-765	-5386	-4932	-161	-845	676	-3256	9300
316	2558	-	-10483	950	-1300	12712	-3956	10619
322	6252	-	-11150	1594	-1319	13672	-4000	10760
327	12992	-	-	-	-1373	15598	-	-
340	18150	-	-	-	-1599	18000	-	-
343	-	-	-	-	-	-	-	-

* Members are identified in Fig.3.4.

** All strain gauges were on the front (outside) face of the member as shown in Fig. 3.19.

Table A.3a Load-Strain Data for Specimen TR3 (Strain Gauges 1 to 8)

Load	Strain Gauge Readings (μstrain)							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached*							
	CB3T	CB3B	CB4T	CB4B	CS1T	CS1B	CS2T	CS2B
	Location of Strain Gauges on Members**							
(kN)	350 mm from top	353 mm from bot.	348 mm from top	353 mm from bot.	350 mm from top	345 mm from bot.	350 mm from top	345 mm from bot.
0	0	0	0	0	0	0	0	0
23.4	-220	-272	-38	-50	-94	-98	-109	-212
46.8	-320	-432	-15	-104	-116	-57	-127	-365
70.2	-408	-595	-83	43	-80	-96	-145	-469
93.6	-557	-767	-179	-22	-142	-202	-218	-655
105	-600	-833	-227	-52	-116	-215	-169	-659
117	-654	-882	-277	-93	-122	-262	-57	-760
129	-681	-1025	-329	-136	-119	-301	75	-871
135	-695	-1074	-347	-155	-126	-320	181	-939
140	-724	-1134	-375	-180	-146	-369	318	-1077
146	-744	-1194	-440	-199	-106	-388	645	-1186
152	-747	-1232	-466	-221	-103	-397	1324	-1516
158	-692	-1284	-482	-295	-178	-398	2400	-1757
164	-703	-1345	-527	-338	-187	-430	3774	-1992
170	-715	-1400	-580	-367	-179	-473	6169	-1981
175	-731	-1464	-610	-400	-168	-500	8208	-2011
181	-752	-1534	-667	-414	-152	-530	9844	-2036
187	-767	-1604	-668	-459	-120	-554	11016	-2022
194	-762	-1673	-698	-470	-100	-580	12133	-2065
199	-778	-1726	-727	-484	-92	-600	12767	-2101
205	-795	-1807	-760	-513	-79	-631	13550	-2136
211	-814	-1848	-794	-535	-79	-667	14222	-2338
216	-835	-1900	-907	-557	-55	-700	14858	-2383
222	-864	-1984	-973	-590	-44	-717	15445	-2428
228	-887	-2024	-1015	-621	32	-757	15997	-2466
234	-905	-2115	-1118	-640	40	-772	16557	-2499
240	-935	-2206	-1164	-651	62	-810	16995	-2568
246	-961	-2291	-1215	-701	117	-848	17450	-2625
251	-982	-2381	-1272	-708	170	-873	17948	-2684
257	-1008	-2487	-1288	-768	218	-911	18434	-2798
263	-1036	-2585	-1336	-737	265	-942	18868	-2912
269	-1054	-2691	-1391	-775	359	-918	19445	-3044
275	-1070	-2773	-1458	-800	415	-930	-	-3450
281	-1082	-2925	-1548	-838	422	-933	-	-3906
287	-1088	-3037	-1739	-947	420	-969	-	-4588
298	-1035	-3467	-2064	-1058	498	-920	-	-7992
304	-988	-3738	-2315	-1045	536	-957	-	-10665
316	-717	-4654	-2862	-988	611	-905	-	-15111
322	-290	-7600	-3429	-899	635	-899	-	-16555
327	3894	-	-5190	-652	705	-934	-	-16953
333	13188	-	-8440	-168	798	-984	-	-17112
339	17979	-	-17722	794	866	-1008	-	-17994
343	-	-	-	-	894	-1032	-	-
350	-	-	-	-	1139	-1252	-	-

* Members are identified in Fig. 3.4.

** All strain gauges were on the front (outside) face of the member as shown in Fig. 3.20.

Table A.3b Load-Strain Data for specimen TR3 (Strain Gauges 9 to 12)

Load (kN)	Strain Gauge Readings (μstrain)			
	9	10	11	12
	Members on Which Strain Gauges are Attached*			
	TB2B	TB1B	TS3B	TS4B
	Location of Strain Gauges on Members**			
	265 mm from bot.	255 mm from bot.	255 mm from bot.	265 mm from bot.
0	0	0	0	0
23.4	105	-10	128	-10
46.8	194	6	263	17
70.2	275	22	391	58
93.6	351	42	512	108
105	387	54	571	136
117	425	69	630	167
129	461	83	685	200
135	482	92	715	218
140	505	99	739	235
146	536	109	765	257
152	588	119	786	278
158	674	130	818	304
164	755	143	843	335
170	822	151	865	358
175	883	162	889	382
181	941	175	924	408
187	994	185	956	432
194	1048	200	995	461
199	1084	209	1022	480
205	1128	222	1057	505
211	1168	235	1095	529
216	1211	250	1135	555
222	1250	266	1179	581
228	1286	282	1219	605
234	1319	300	1259	630
240	1346	320	1292	652
246	1382	344	1330	681
251	1415	374	1360	709
257	1455	421	1396	746
263	1485	470	1423	778
269	1503	527	1439	810
275	1522	588	1465	854
281	1529	663	1487	911
287	1539	737	1509	973
298	1542	902	1548	1126
304	1543	972	1569	1194
316	1546	1085	1635	1339
322	1526	1180	1650	1418
327	1493	1413	1642	1530
333	1521	1532	1643	1611
339	1565	1569	1644	1692
343	1572	1628	1671	18347
350	15647	1673	1682	18704

* Members are identified in Fig. 3.4.

** All strain gauges were on the front (outside) face of the memberas shown in in Fig. 3.20.

Table A.4a Load-Strain Data for Specimen TR4 (Strain Gauges 1 to 8)

Load (kN)	Strain Gauge Readings (μstrain)							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached*							
	CS2T		CS2B		TB2T		TB2B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	360 mm from top	360 mm from top	360 mm from bot.	360 mm from bot.	265 mm from top	265 mm from top	265 mm from bot.	265 mm from bot.
0	0	0	0	0	0	0	0	0
23.4	-147	-212	-121	-252	75	89	190	131
46.8	-276	-400	-201	-492	160	175	136	222
70.2	-396	-601	-263	-751	236	263	195	303
93.6	-504	-785	-305	-1006	296	338	246	389
117	-617	-941	-205	-1434	358	418	296	462
129	-700	-961	-45	-1894	398	473	331	520
135	-785	-943	81	-2128	402	508	350	540
140	-902	-871	301	-2490	418	538	360	575
146	-1104	-735	706	-3300	440	573	394	594
152	-1625	-218	2376	-7189	531	709	461	718
158	-1797	60	4028	-10848	615	801	507	829
164	-1916	277	6589	-15498	700	883	569	939
170	-1962	385	8199	-18368	760	942	599	1007
175	-1988	465	9745	-	825	966	641	1065
181	-2004	540	10808	-	878	1010	700	1105
187	-2024	585	11549	-	928	1037	745	1136
193	-2048	649	12506	-	991	1078	801	1175
199	-2081	713	13278	-	1043	1117	860	1206
205	-2092	768	13824	-	1090	1150	899	1240
211	-2116	814	14309	-	1125	1175	937	1262
216	-2130	855	14719	-	1163	1198	975	1297
222	-2155	903	15209	-	1206	1229	1010	1331
228	-2205	963	15825	-	1255	1259	1056	1357
234	-2231	990	16050	-	1280	1277	1085	1382
240	-2275	1042	16485	-	1324	1304	1124	1413
246	-2320	1087	16833	-	1365	1327	1159	1439
251	-2357	1125	17065	-	1391	1346	1184	1465
257	-2398	1178	17348	-	1430	1373	1219	1493
263	-2479	1250	17719	-	1468	1403	1258	1521
269	-2560	1319	18056	-	1506	1428	1294	1559
275	-2650	1411	18468	-	1555	1462	1342	1586
281	-2771	1536	19000	-	1600	1491	1386	1626
287	-3077	1803	19950	-	1651	1510	1404	1648
292	-3984	2775	-	-	1671	1532	1422	1673
298	-4999	3892	-	-	1684	1546	1424	1696
304	-7157	5621	-	-	1683	1555	1419	1702
310	-	-	-	-	1691	1571	1430	1713
316	-	-	-	-	1713	1578	1437	1722
322	-	-	-	-	1712	1634	1477	1756
327	-	-	-	-	-	-	8300	11000
350	-	-	-	-	-	-	-	-

* Members are identified in Fig. 3.4.

** Strain Gauges Locations are shown in Fig.3.21.

Table A.4b Load-Strain Data for Specimen TR4 (Strain Gauges 9 to 16)

Load (kN)	Strain Gauge Readings (μstrain)							
	9	10	11	12	13	14	15	16
	Members on Which Strain Gauges are Attached*							
	CB4T		CB4B		TS4T		TS4B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	355 mm from top	355 mm from top	360 mm from bot.	360 mm from bot.	265 mm from top	265 mm from top	265 mm from bot.	265 mm from bot.
0	0	0	0	0	0	0	0	0
23.4	-27	-3	-26	-8	7	22	9	17
46.8	-102	-3	-82	-27	52	55	43	61
70.2	-195	0	-147	-45	115	107	90	130
93.6	-285	5	-213	-66	180	155	139	197
117	-385	9	-286	-89	256	213	197	270
129	-444	13	-323	-101	297	246	229	312
135	-479	15	-348	-110	325	275	250	345
140	-507	15	-367	-117	345	292	266	366
146	-531	16	-389	-127	367	318	285	390
152	-589	16	-418	-144	397	352	314	430
158	-630	15	-440	-163	430	379	339	465
164	-682	9	-462	-192	473	409	371	511
170	-725	2	-481	-216	515	445	399	553
175	-758	2	-492	-239	550	468	422	589
181	-788	-2	-507	-258	587	499	446	624
187	-820	-6	-518	-277	618	507	468	652
193	-918	4	-533	-303	659	535	500	697
199	-952	179	-550	-330	707	568	532	735
205	-1008	192	-563	-346	750	590	560	778
211	-1016	202	-572	-365	792	615	587	814
216	-1045	206	-585	-384	829	632	616	842
222	-1077	221	-596	-400	877	659	649	882
228	-1261	251	-606	-433	938	689	689	932
234	-1310	261	-612	-444	969	707	709	955
240	-1390	282	-622	-468	1027	737	750	1003
246	-1475	305	-626	-483	1076	754	776	1040
251	-1572	326	-636	-499	1114	775	801	1072
257	-1655	352	-641	-514	1166	793	836	1111
263	-1850	398	-646	-540	1230	820	880	1160
269	-1992	426	-649	-554	1283	840	919	1204
275	-2017	472	-654	-584	1347	850	949	1241
281	-2106	507	-655	-609	1403	863	980	1279
287	-2238	565	-651	-638	1460	881	1014	1321
292	-2500	680	-623	-707	1548	926	1068	1392
298	-2729	790	-563	-783	1595	979	1113	1464
304	-3010	965	-350	-981	1663	1088	1182	1568
310	-3144	1042	-195	-1111	1705	1152	1224	1634
316	-	-	313	-1466	1783	1285	1377	1760
322	-	-	-	-	1900	1412	-	-
327	-	-	-	-	1900	1439	-	-
350	-	-	-	-	-	-	-	-

* Members are identified in Fig. 3.4.

** Strain Gauges Locations are shown in Fig.3.21.

Table A.4c Load-Strain Data for Specimen TR4 (Strain Gauges 17 to 22)

Load (kN)	Strain Gauge Readings (μstrain)					
	17	18	19	20	21	22
	Members on Which Strain Gauges are Attached*					
	CS2T outside	CS2B outside	CB3T outside	CB3B outside	CS1T outside	CS1B outside
	Location of Strain Gauges**					
	270 mm from top	270 mm from bot.	340 mm from top	340 mm from bot.	340 mm from top	340 mm from bot.
0	0	0	0	0	0	0
23.4	-223	-178	-145	-162	-5	-12
46.8	-420	-330	-290	-325	-31	-34
70.2	-626	-487	-440	-497	-62	-62
93.6	-831	-628	-553	-640	-97	-89
117	-1086	-667	-632	-709	-135	-118
129	-1283	-636	-670	-748	-163	-134
135	-1422	-626	-700	-880	-175	-147
140	-1556	-565	-705	-920	-190	-159
146	-1739	-448	-728	-964	-201	-162
152	-1987	-170	-733	-993	-211	-172
158	-2192	-33	-740	-1034	-232	-183
164	-2366	89	-754	-1140	-250	-200
170	-2488	178	-760	-1200	-265	-211
175	-2590	250	-766	-1237	-278	-224
181	-2658	305	-770	-1244	-288	-225
187	-2716	355	-747	-1267	-299	-232
193	-2791	407	-756	-1318	-309	-240
199	-2871	452	-755	-1376	-325	-250
205	-2928	487	-770	-1460	-333	-256
211	-2995	510	-770	-1514	-357	-265
216	-3039	539	-786	-1567	-369	-265
222	-3102	571	-781	-1601	-392	-269
228	-3212	605	-894	-1663	-400	-255
234	-3265	623	-925	-1690	-405	-242
240	-3352	652	-958	-1748	-427	-210
246	-3437	678	-972	-1790	-450	-182
251	-3491	698	-992	-1837	-450	-160
257	-3545	725	-1008	-1893	-473	-126
263	-3625	757	-1035	-1981	-501	-73
269	-3706	790	-1051	-2060	-538	2
275	-3821	834	-1059	-2136	-580	135
281	-3939	874	-1073	-2222	-657	362
287	-4239	960	-1055	-2322	-820	855
292	-4568	1104	-940	-2396	-1201	2327
298	-4550	1180	-790	-2482	-1301	4032
304	-4435	1265	-195	-3018	-1312	6830
310	-4420	1300	115	-3510	-1345	8150
316	-4335	1372	850	-6400	-1360	10300
322	-4205	1438	12587	-	-1453	14311
327	-4040	1690	-	-	-1533	-
350	-	-	-	-	-	-

* Members are identified in Fig. 3.4.

** Strain Gauges Locations are shown in Fig.3.21.

Table A.5a Load-Strain Data for Specimen LR10 (Strain Gauges 1 to 8)

Load	Strain Gauge Readings (μstrain)*							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached**							
	T1				C1			
(kN)	south	east	north	west	south	east	north	west
0	0	0	0	0	0	0	0	0
23.5	66	49	21	51	-201	-179	-143	-189
46.9	143	114	64	106	-368	-317	-244	-318
70.4	233	198	125	171	-548	-437	-317	-444
82.2	277	236	156	203	-659	-505	-347	-516
93.9	330	281	192	242	-815	-580	-361	-606
106	350	294	194	260	-934	-644	-364	-684
117	385	328	226	295	-1072	-698	-338	-733
129	436	379	268	328	-1330	-743	-190	-787
141	479	416	301	365	-1607	-814	-49	-865
153	528	460	338	406	-1918	-875	117	-944
164	-	-	-	-	-	-	-	-
112	580	530	460	496	-	-1510	-	-
117	701	632	560	608	-	-1372	-	-
129	805	725	651	709	-	-1168	-	-
141	916	826	747	816	-	-1007	-	-
153	1015	915	833	911	-	-860	-	-
164	1123	1012	928	1014	-	-713	-	-
176	1213	1092	1007	1104	-	-570	-	-
184	-	-	-	-	-	-	-	-
121	914	836	773	827	-	-386	-	-
131	950	871	805	860	-	73	-	-

* Four strain gauges were attached, at the middle of each diagonal member. The first strain gauge was on the outside face, the second was 90° clockwise, the third was 180° clockwise (i.e. On the inside face, opposite to the first strain gauge) and the fourth was 270° clockwise from the first strain gauge as shown in Fig. 3.22

** Members are identified in Fig. 3.3.

Table A.5b Load-Strain Data for Specimen LR10 (Strain Gauges 9 to 16)

Load (kN)	Strain Gauge Readings (μstrain)*							
	9	10	11	12	13	14	15	16
	Members on Which Strain Gauges are Attached**							
	T2				C2			
	north	west	south	east	north	west	south	east
0	0	0	0	0	0	0	0	0
23.5	203	176	201	202	-61	-34	-21	-42
46.9	325	302	343	237	-135	-72	-49	-104
70.4	472	436	488	488	-228	-121	-81	-180
82.2	542	505	564	567	-278	-145	-95	-220
93.9	622	586	647	649	-349	-180	-111	-278
106	671	639	698	704	-390	-196	-119	-310
117	728	696	760	764	-440	-218	-129	-349
129	789	752	827	828	-510	-240	-132	-396
141	850	816	892	895	-577	-265	-136	-443
153	899	871	948	949	-662	-293	-136	-501
164	-	-	-	-	-	-	-	-
112	533	506	562	572	-584	-358	-138	-346
117	572	536	600	602	-726	-435	-141	-411
129	598	561	627	628	-871	-512	-130	-469
141	623	586	655	660	-1050	-596	-100	-527
153	645	606	679	681	-1246	-676	-40	-580
164	667	629	704	714	-1507	-770	73	-632
176	687	645	723	731	-1795	-861	250	-670
184	-	-	-	-	-	-	-	-
121	752	738	842	828	-	-	-	-
131	805	798	907	888	-	-	-	-

* Four strain gauges were attached, at the middle of each diagonal member. The first strain gauge was on the outside face, the second was 90° clockwise, the third was 180° clockwise (i.e. On the inside face, opposite to the first strain gauge) and the fourth was 270° clockwise from the first strain gauge as shown in Fig. 3.22

** Members are identified in Fig. 3.3.

Table A.6a Load-Strain Data for Specimen LR11 (Strain Gauges 1 to 8)

Load	Strain Gauge Readings (μstrain)*							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached**							
	T1				C1			
(kN)	south	east	north	west	south	east	north	west
0	0	0	0	0	0	0	0	0
23.5	22	14	42	42	-180	-210	-260	-175
47.0	53	60	84	76	-313	-355	-424	-330
70.4	104	125	142	123	-438	-487	-580	-480
82.2	140	159	171	152	-494	-554	-660	-557
93.9	155	182	192	168	-544	-607	-732	-624
106	187	219	228	201	-598	-662	-806	-701
117	228	259	268	230	-658	-720	-884	-789
131	252	310	298	254	-697	-757	-958	-877
141	275	325	321	274	-732	-799	-1015	-933
154	314	376	357	307	-765	-829	-1100	-1028
164	348	402	394	338	-793	-857	-1203	-1134
176	375	440	425	365	-795	-859	-1300	-1250
188	419	484	466	401	-709	-791	-1520	-1462
200	-	-	-	-	-	-	-	-
144	533	607	616	550	-	-	-	-
156	602	685	685	615	-	-	-	-
164	665	740	740	667	-	-	-	-
176	753	824	818	747	-	-	-	-
188	823	908	899	822	-	-	-	-
200	904	990	975	893	-	-	-	-
211	992	1076	1052	967	-	-	-	-
223	1059	1154	1115	1035	-	-	-	-
235	1149	1223	1200	1122	-	-	-	-
246	1205	1287	1261	1181	-	-	-	-
257	-	-	-	-	-	-	-	-
233	1070	1167	1150	1053	-	-	-	-
245	1104	1218	1193	1091	-	-	-	-
258	1180	1280	1254	1146	-	-	-	-
270	1238	1361	1317	1212	-	-	-	-
281	-	-	-	-	-	-	-	-

* Four strain gauges were attached, at the middle of each diagonal member. The first strain gauge was on the outside face, the second was 90° clockwise, the third was 180° clockwise (i.e. On the inside face, opposite to the first strain gauge) and the fourth was 270° clockwise from the first strain gauge as shown in Fig. 3.23.

** Members are identified in Fig. 3.2.

Table A.6b Load-Strain Data for Specimen LR11 (Strain Gauges 9 to 16)

Load (kN)	Strain Gauges Readings (μstrain)*							
	9	10	11	12	13	14	15	16
	Members to Which Strain Gauges are Attached**							
	T2				C2			
	north	west	south	east	north	west	south	east
0	0	0	0	0	0	0	0	0
23.5	180	144	135	150	-46	-57	-67	-53
47.0	328	284	268	295	-88	-113	-136	-109
70.4	468	416	396	427	-144	-180	-217	-174
82.2	545	491	468	503	-161	-211	-258	-206
93.9	601	545	522	559	-187	-238	-296	-234
106	674	616	591	629	-214	-278	-347	-272
117	747	687	661	701	-244	-320	-400	-314
131	808	742	717	763	-268	-361	-452	-355
141	855	792	764	808	-285	-384	-485	-378
154	929	861	831	877	-306	-422	-533	-409
164	993	926	893	938	-334	-463	-593	-450
176	1044	974	941	988	-351	-500	-639	-482
188	1117	1049	1015	1064	-377	-549	-714	-525
200	-	-	-	-	-	-	-	-
144	777	730	722	747	-246	-522	-602	-318
156	810	761	754	783	-262	-584	-675	-346
164	829	779	772	801	-273	-639	-738	-364
176	850	805	800	830	-285	-725	-834	-384
188	886	835	825	858	-286	-816	-936	-398
200	916	856	852	882	-286	-913	-1040	-400
211	950	892	884	915	-269	-1037	-1172	-390
223	973	911	905	935	-236	-1160	-1310	-368
235	1009	947	941	975	-155	-1350	-1521	-303
246	1028	965	956	988	-48	-1520	-1719	-222
257	-	-	-	-	-	-	-	-
233	1152	1099	1100	1126	-	-	-	-
245	1265	1210	1217	1232	-	-	-	-
258	1356	1310	1327	1334	-	-	-	-
270	1440	1399	1419	1404	-	-	-	-
281	-	-	-	-	-	-	-	-

* Four strain gauges were attached, at the middle of each diagonal member. The first strain gauge was on the outside face, the second was 90° clockwise, the third was 180° clockwise (i.e. On the inside face, opposite to the first strain gauge) and the fourth was 270° clockwise from the first strain gauge as shown in Fig. 3.23.

** Members are identified in Fig. 3.3.

Table A.7a Load-Strain Data for Specimen LR12 (Strain Gauges 1 to 6)

Load	Strain Gauge Readings (μstrain)*					
	1	2	3	4	5	6
	Members on Which Strain Gauges are Attached**					
	T1		C1			
(kN)	outside	inside	south	east	north	west
0	0	0	0	0	0	0
23.5	150	178	-20	-40	-58	-41
47.0	305	344	-44	-77	-125	-84
70.4	452	500	-65	-118	-194	-130
82.2	517	565	-80	-147	-236	-159
93.9	582	636	-94	-176	-284	-186
106	665	720	-107	-210	-340	-218
114	-	-	-	-	-	-
79.8	458	492	-90	-257	-347	-167
93.9	465	497	-97	-335	-470	-209
106	488	520	-95	-390	-543	-225
117	536	560	-90	-501	-692	-258
129	553	582	-78	-589	-846	-300
141	578	605	-29	-713	-1057	-338
153	597	625	55	-830	-1290	-360
164	619	647	193	-967	-1552	-355
172	-	-	-	-	-	-
146	736	728	-	-	-	-
164	903	883	-	-	-	-
176	988	963	-	-	-	-

*1- Four strain gauges were attached at the middle of each compression diagonal member. The first strain gauge was on the outside face, the second was 90° clockwise, the third was 180° clockwise (i.e. On the inside face, opposite to the first strain gauge) and the fourth was 270° clockwise from the first strain gauge.

2- Two strain gauges were attached at the middle of each tension diagonal member. The first strain gauge was on the outside face and the other was on the opposite (inside) face. Locations of strain gauges are shown in Fig. 3.24.

** Members are identified in Fig. 3.1.

Table A.7b Load-Strain Data for Specimen LR12 (Strain Gauges 7 to 12)

Load (kN)	Strain Gauge Readings (μstrain)*					
	7	8	9	10	11	12
	Members on Which Strain Gauges are Attached**					
	T2		C2			
	outside	inside	north	west	south	east
0	0	0	0	0	0	0
23.5	12	24	-110	-219	-295	-167
47.0	36	62	-170	-436	-600	-320
70.4	70	104	-152	-655	-907	-454
82.2	88	128	-120	-760	-1059	-513
93.9	105	152	-49	-866	-1273	-567
106	137	185	25	-973	-1518	-630
114	-	-	-	-	-	-
79.8	202	338	-	-	-	-
93.9	289	460	-	-	-	-
106	350	535	-	-	-	-
117	455	651	-	-	-	-
129	542	742	-	-	-	-
141	651	846	-	-	-	-
153	744	935	-	-	-	-
164	833	1025	-	-	-	-
172	-	-	-	-	-	-
146	668	897	-	-	-	-
164	732	974	-	-	-	-
176	791	1035	-	-	-	-

*1- Four strain gauges were attached at the middle of each compression diagonal member. The first strain gauge was on the outside face, the second was 90° clockwise, the third was 180° clockwise (i.e. On the inside face, opposite to the first strain gauge) and the fourth was 270° clockwise from the first strain gauge.

2- Two strain gauges were attached at the middle of each tension diagonal member. The first strain gauge was on the outside face and the other was on the opposite (inside) face. Locations of strain gauges are shown in Fig. 3.24.

** Members are identified in Fig. 3.1.

Table A.8a Load-Strain Data for Specimen LR13 (Strain Gauges 1 to 8)

Load	Strain Gauge Readings (μstrain)							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached*							
	CO1T		CO1B		TI1T		TI1B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.
0	0	0	0	0	0	0	0	0
23.5	0	-61	-25	-51	21	-4	18	0
47.0	0	-117	-42	-91	39	-8	36	-5
70.4	0	-190	-62	-141	64	-13	59	-12
93.9	4	-282	-89	-202	98	-20	95	-24
117	8	-370	-112	-262	133	-27	132	-35
144	15	-487	-141	-350	180	-38	174	-44
164	24	-576	-164	-404	217	-48	213	-54
176	30	-637	-179	-442	241	-53	239	-60
188	39	-701	-197	-484	263	-59	262	-66
200	46	-751	-205	-522	289	-64	287	-70
214	56	-815	-220	-555	313	-71	313	-75
227	68	-885	-236	-596	342	-79	342	-81
235	78	-950	-252	-638	367	-88	365	-87
246	92	-1206	-270	-677	398	-99	400	-99
258	111	-1218	-294	-722	429	-121	422	-117
270	134	-1230	-330	-773	467	-147	450	-139
282	156	-1326	-357	-820	504	-169	477	-156
293	184	-1434	-380	-880	545	-187	508	-173
305	209	-1525	-402	-920	585	-209	542	-189
317	262	-1695	-443	-998	664	-245	610	-222
329	315	-1681	-470	-1036	713	-267	650	-241
340	412	-1772	-506	-1073	787	-302	711	-269
352	730	-2019	-560	-1118	932	-357	819	-304
364	900	-2161	-583	-1121	1006	-372	880	-308
376	1234	-2500	-596	-1100	1100	-370	948	-294
387	1500	-2950	-615	-1034	1155	-333	1001	-256
399	1618	-3092	-633	-1003	1199	-297	1047	-231
411	1896	-3477	-732	-720	1217	-41	1345	-165
423	-	-	-	-	-	-	-	-

* Members are identified in Fig. 3.10.
** Strain gauges locations are shown in Fig. 3.25.

Table A.8b Load-Strain Data for Specimen LR13 (Strain Gauges 9 to 16)

Load	Strain Gauge Readings (μstrain)							
	9	10	11	12	13	14	15	16
	Members on Which Strain Gauges are Attached*							
	CI3T		CI3B		TO3T		TO3B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.
0	0	0	0	0	0	0	0	0
23.5	-120	-6	-130	6	22	140	31	134
47.0	-217	-11	-241	9	38	252	55	242
70.4	-340	-12	-384	19	62	392	88	377
93.9	-487	-15	-541	28	95	555	126	536
117	-609	-15	-680	38	122	686	165	655
144	-759	-14	-835	50	155	836	205	799
164	-868	-11	-961	66	186	946	231	905
176	-933	-7	-1036	78	204	1011	259	968
188	-995	-4	-1112	92	225	1077	278	1037
200	-1058	-3	-1185	103	243	1133	295	1093
214	-1123	-2	-1260	115	264	1196	316	1159
227	-1189	-2	-1332	132	290	1264	344	1227
235	-1238	2	-1389	141	311	1319	363	1282
246	-1258	-6	-1426	133	336	1371	382	1342
258	-1299	-11	-	-	359	1418	400	1393
270	-1347	-6	-	-	390	1464	432	1442
282	-1369	-3	-	-	418	1500	454	1483
293	-1385	-8	-	-	458	1523	504	1498
305	-1406	-10	-	-	489	1542	530	1520
317	-1435	-10	-	-	555	1567	595	1550
329	-1445	-10	-	-	599	1578	644	1555
340	-1456	-11	-	-	655	1588	702	1563
352	-1442	-38	-	-	771	1592	822	1565
364	-1434	-67	-	-	823	1602	824	1581
376	-1383	-120	-	-	892	1606	1587	1550
387	-1302	-199	-	-	949	1594	984	1591
399	-1280	-249	-	-	980	1615	1011	1620
411	-960	-570	-	-	1070	1604	1087	1619
423	-	-	-	-	-	-	-	-

* Members are identified in Fig. 3.10.
** Strain gauges locations are shown in Fig. 3.25.

Table A.8c Load-Strain Data for Specimen LR13 (Strain Gauges 17 to 24)

Load	Strain Gauge Readings (μstrain)							
	17	18	19	20	21	22	23	24
	Members on Which Strain Gauges are Attached*							
	CO2T		CO2B		TI2T		TI2B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.
0	0	0	0	0	0	0	0	0
23.5	-52	-170	-45	-201	125	-24	119	0
47.0	-97	-293	-73	-341	220	-42	209	0
70.4	-142	-440	-100	-513	333	-58	314	-4
93.9	-187	-615	-125	-720	468	-84	445	-7
117	-221	-760	-135	-888	572	-99	541	-13
144	-254	-926	-142	-1087	693	-115	653	-20
164	-270	-1056	-140	-1244	779	-132	737	-24
176	-276	-1137	-131	-1344	821	-131	785	-24
188	-284	-1224	-111	-1461	856	-135	836	-22
200	-287	-1295	-88	-1565	893	-143	884	-24
214	-302	-1369	-54	-1685	942	-149	933	-30
227	-313	-1430	-9	-1809	1005	-154	1005	-40
235	-335	-1445	28	-1888	1054	-157	1081	-46
246	-336	-1457	118	-1992	1113	-133	1150	-18
258	-373	-1353	307	-2117	1168	-64	1174	94
270	-447	-1151	-	-	1291	49	1189	272
282	-521	-988	-	-	1435	117	1225	384
293	-577	-889	-	-	1528	162	1255	460
305	-617	-816	-	-	1584	212	1276	526
317	-700	-683	-	-	1655	303	1301	640
329	-747	-620	-	-	1693	357	1310	703
340	-812	-526	-	-	1726	426	1319	787
352	-927	-372	-	-	1763	558	1315	932
364	-975	-321	-	-	1787	600	1319	987
376	-1042	-235	-	-	1800	675	1321	1068
387	-1095	-172	-	-	1816	727	1311	1126
399	-1130	-143	-	-	1836	762	1337	1164
411	-1252	5	-	-	1837	870	1320	1284
423	-	-	-	-	-	-	-	-

* Members are identified in Fig. 3.10.
** Strain gauges locations are shown in Fig. 3.25.

Table A.8d Load-Strain Data for Specimen LR13 (Strain Gauges 25 to 32)

Load (kN)	Strain Gauge Readings (μstrain)							
	25	26	27	28	29	30	31	32
	Members on Which Strain Gauges are Attached*							
	CI4T		CI4B		TO4T		TO4B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.
0	0	0	0	0	0	0	0	0
23.5	-37	-4	-22	-12	-23	17	-19	10
47.0	-69	-4	-52	-25	-50	47	-31	31
70.4	-115	-6	-88	-40	-73	76	-45	59
93.9	-185	-5	-140	-59	-96	110	-60	97
117	-247	-3	-190	-72	-110	155	-70	140
144	-333	4	-258	-92	-127	219	-81	197
164	-406	11	-314	-105	-141	258	-90	243
176	-453	18	-350	-110	-150	289	-95	274
188	-501	24	-390	-119	-158	322	-100	306
200	-550	32	-423	-122	-166	356	-105	336
214	-606	41	-459	-132	-176	391	-111	370
227	-668	51	-505	-135	-187	431	-117	410
235	-721	60	-547	-147	-197	472	-121	447
246	-788	74	-595	-159	-208	515	-125	488
258	-867	91	-645	-172	-218	569	-130	540
270	-950	111	-696	-196	-233	632	-140	601
282	-1025	127	-740	-212	-241	682	148	650
293	-1101	144	-785	-227	-249	729	-154	698
305	-1175	166	-828	-240	-258	774	-159	741
317	-1304	203	-901	-258	-272	849	-167	815
329	-1378	228	-945	-271	-281	894	-174	860
340	-1469	260	-995	-283	-291	950	-180	914
352	-1622	295	-1089	-311	-310	1046	-194	1006
364	-1730	325	-1126	-324	-319	1091	-198	1050
376	-	-	-1173	-337	-329	1146	-207	1104
387	-	-	-1205	-353	-350	1183	-224	1140
399	-	-	-1246	-367	-360	1221	-234	1170
411	-	-	-1262	-390	-242	1232	-150	1200
423	-	-	-	-	-	-	-	-

* Members are identified in Fig. 3.10.

** Strain gauges locations are shown in Fig. 3.25.

Table A.9a Load-Strain Data for Specimen LR14 (Strain Gauges 1 to 8)

Load	Strain Gauge Readings (μstrain)							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached*							
	CF1T		CF1B		TC1T		TC1B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-81	-69	-81	-69	23	50	55	30
93.9	-167	-143	-169	-137	47	92	84	86
141	-255	-218	-261	-209	78	157	108	143
188	-345	-295	-358	-275	110	209	145	205
235	-440	-393	-470	-351	156	275	183	275
282	-526	-489	-589	-420	204	351	234	350
305	-574	-544	-652	-458	233	392	256	389
329	-633	-621	-743	-506	277	447	294	445
352	-688	-693	-825	-546	318	489	332	492
376	-741	-766	-913	-586	360	531	367	538
399	-801	-848	-1010	-630	402	575	405	585
423	-901	-1075	-1250	-720	411	570	408	580
434	-924	-1131	-1309	-741	422	572	416	582
446	-949	-1212	-1399	-758	431	573	419	590
458	-970	-1322	-1528	-759	458	587	433	621
469	-982	-1418	-1652	-741	490	599	439	654
485	-	-	-	-	-	-	-	-
428	-	-	-	-	1014	812	582	1161
413	-	-	-	-	977	724	503	1098
352	-	-	-	-	770	424	189	891

* Members are identified in fig. 3.9.
** Strain Gauge Locations are shown in Fig. 3.26

Table A.9b Load-Strain Data for Specimen LR14 (Strain Gauges 9 to 16)

Load	Strain Gauge Readings (μstrain)							
	9	10	11	12	13	14	15	16
	Members on Which Strain Gauges are Attached*							
	CC3T		CC3B		TF3T		TF3B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-183	-198	-217	-152	162	120	144	111
93.9	-316	-387	-414	-286	294	207	255	241
141	-457	-586	-621	-420	419	318	388	367
188	-591	-779	-836	-530	537	420	490	457
235	-715	-975	-1057	-631	642	536	622	565
282	-818	-1165	-1297	-707	743	638	726	644
305	-886	-1252	-1405	-736	784	678	781	688
329	-925	-1356	-1540	-763	827	739	839	726
352	-971	-1443	-1660	-777	861	787	897	768
376	-1011	-1527	-1783	-781	894	823	942	796
399	-1051	-1612	-1897	-794	932	854	980	826
423	-1107	-1606	-1891	-850	928	866	986	828
434	-1130	-1619	-1906	-869	935	877	994	836
446	-1155	-1622	-1905	-898	934	888	998	846
458	-1180	-1612	-1890	-928	933	891	982	836
469	-1219	-1591	-1872	-965	917	886	981	841
485	-	-	-	-	-	-	-	-
428	-	-	-	-	1389	927	1122	1298
413	-	-	-	-	1360	927	1101	1292
352	-	-	-	-	1165	892	1004	1151

* Members are identified in fig. 3.9.
** Strain Gauge Locations are shown in Fig. 3.26

Table A.9c Load-Strain Data for Specimen LR14 (Strain Gauges 17 to 24)

Load	Strain Gauge Readings (μstrain)							
	17	18	19	20	21	22	23	24
	Members on Which Strain Gauges are Attached*							
	CF2T		CF2B		TC2T		TC2B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-204	-205	-196	-175	171	155	162	149
93.9	-361	-356	-374	-320	305	285	274	244
141	-528	-513	-548	-477	443	412	412	373
188	-697	-670	-727	-620	565	530	528	478
235	-839	-818	-884	-759	680	637	641	580
282	-982	-980	-1054	-889	778	738	732	660
305	-1039	-1050	-1129	-947	821	775	774	700
329	-1100	-1142	-1218	-1013	857	806	805	739
352	-1139	-1229	-1293	-1063	900	828	838	777
376	-1174	-1313	-1371	-1101	940	852	862	806
399	-1180	-1414	-1464	-1107	985	876	873	857
423	-405	-1560	-	-	1348	1112	1069	1183
434	-310	-1590	-	-	1366	1185	1092	1241
446	-170	-1612	-	-	1369	1264	1119	1294
458	5	-1636	-	-	1282	1378	1120	1319
469	171	-1675	-	-	1294	1394	1128	1324
485	-	-	-	-	-	-	-	-
428	688	-1605	-	-	1059	1066	888	1058
413	736	-1588	-	-	980	930	795	962
352	792	-1552	-	-	742	485	462	652

* Members are identified in fig. 3.9.

** Strain Gauge Locations are shown in Fig. 3.26

Table A.9d Load-Strain Data for Specimen LR14 (Strain Gauges 25 to 32)

Load (kN)	Strain Gauge Readings (μstrain)							
	25	26	27	28	29	30	31	32
	Members on Which Strain Gauges are Attached*							
	CC4T		CC4B		TF4T		TF4B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-51	-79	-51	-60	6	13	15	13
93.9	-157	-154	-123	-114	13	34	31	39
141	-185	-243	-193	-182	41	60	52	73
188	-243	-337	-275	-250	78	86	75	106
235	-305	-435	-374	-327	114	128	106	154
282	-392	-537	-486	-407	151	178	140	215
305	-431	-587	-539	-451	191	208	166	248
329	-485	-656	-618	-513	228	254	202	295
352	-542	-713	-685	-568	271	294	232	342
376	-606	-773	-757	-620	304	338	268	389
399	-677	-839	-832	-680	344	387	309	438
423	-833	-923	-915	-833	407	520	397	551
434	-873	-956	-939	-881	436	550	424	581
446	-919	-999	-966	-941	464	586	451	612
458	-980	-1070	-1000	-1045	509	655	504	674
469	-1059	-1139	-1010	-1151	558	710	550	727
485	-	-	-	-	-	-	-	-
428	-1291	-1188	-715	-1719	367	757	489	649
413	-1255	-1208	-572	-1846	322	768	487	641
352	-1108	-1143	-310	-1906	225	784	414	633

* Members are identified in fig. 3.9.

** Strain Gauge Locations are shown in Fig. 3.26

Table A.10a Load-Strain Data for Specimen LR15 (Strain Gauges 1 to 8)

Load	Strain Gauge Readings (μstrain)							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached*							
	CC1T		CC1B		TF1T		TF1B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
49.3	-58	-80	-70	-67	9	28	24	14
96.2	-111	-160	-141	-130	20	62	48	31
141	-165	-250	-216	-192	43	100	82	60
188	-226	-350	-303	-268	69	142	120	92
235	-280	-454	-390	-338	101	185	162	124
282	-337	-568	-488	-410	137	232	204	161
329	-400	-692	-602	-484	183	293	261	212
352	-435	-762	-669	-522	211	330	295	243
376	-473	-835	-745	-561	242	375	336	281
396	-	-	-	-	-	-	-	-
377	-565	-873	-796	-639	262	480	392	348
387	-585	-912	-830	-667	277	502	410	366
399	-611	-950	-863	-696	292	526	426	384
411	-640	-1000	-906	-732	319	565	462	420
423	-669	-1072	-954	-786	355	608	500	466
434	-699	-1182	-1015	-866	409	672	551	534
446	-703	-1268	-1064	-907	437	704	577	567
458	-705	-1321	-1093	-935	457	727	594	592
469	-680	-1454	-1149	-984	502	777	634	650
481	-	-	-	-	-	-	-	-
477	-	-	-1733	83	844	1064	890	1004
487	-	-	-1911	388	1048	1226	1067	1189
493	-	-	-1940	450	1118	1273	1129	1244
505	-	-	-1978	638	1296	1373	1272	1375
516	-	-	-	-	-	-	-	-
493	-	-	-1889	642	1277	1363	1262	1358
507	-	-	-	-	-	-	-	-
479	-	-	-1932	744	1243	1320	1256	1288

* Members are identified in Fig. 3.7.
** Strain gauge locations are shown in Fig. 3.27.

Table A.10b Load-Strain Data for Specimen LR15 (Strain Gauges 9 to 16)

Load	Strain Gauge Readings (μstrain)							
	9	10	11	12	13	14	15	16
	Members on Which Strain Gauges are Attached*							
	CF3T		CF3B		TC3T		TC3B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
49.3	-165	-214	-222	-165	157	145	149	149
96.2	-312	-412	-410	-297	283	262	266	275
141	-441	-582	-606	-428	412	379	383	400
188	-584	-790	-819	-550	548	505	508	537
235	-711	-987	-1030	-667	672	625	623	664
282	-831	-1179	-1238	-766	783	729	720	776
329	-944	-1360	-1460	-831	888	817	811	878
352	-973	-1450	-1567	-847	932	853	849	922
376	-850	-1644	-1690	-822	977	900	890	985
396	-	-	-	-	-	-	-	-
377	-	-	-	-	1320	1218	1127	1435
387	-	-	-	-	1362	1259	1166	1484
399	-	-	-	-	1421	1303	1204	1559
411	-	-	-	-	1496	1341	1230	1811
423	-	-	-	-	1558	1369	1258	1894
434	-	-	-	-	1575	1409	1330	1876
446	-	-	-	-	1580	1427	1340	1902
458	-	-	-	-	1600	1440	1347	1911
469	-	-	-	-	1604	1458	1362	1937
481	-	-	-	-	-	-	-	-
477	-	-	-	-	1559	1464	1336	1914
487	-	-	-	-	1586	1429	1349	1891
493	-	-	-	-	1588	1459	1365	1908
505	-	-	-	-	1582	1480	1380	1924
516	-	-	-	-	-	-	-	-
493	-	-	-	-	1555	1432	1328	1908
507	-	-	-	-	-	-	-	-
479	-	-	-	-	1486	1377	1260	1843

* Members are identified in Fig. 3.7.
** Strain gauge locations are shown in Fig. 3.27.

Table A.10c Load-Strain Data for Specimen LR15 (Strain Gauges 17 to 24)

Load	Strain Gauge Readings (μstrain)							
	17	18	19	20	21	22	23	24
	Members on Which Strain Gauges are Attached*							
	CC2T		CC2B		TF2T		TF2B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
49.3	-184	-209	-217	-192	184	152	213	132
96.2	-340	-386	-400	-344	331	279	381	238
141	-488	-565	-503	-484	467	397	540	344
188	-647	-761	-675	-628	620	520	703	456
235	-802	-952	-879	-773	760	642	857	564
282	-936	-1126	-1063	-899	878	748	988	667
329	-1047	-1288	-1236	-1008	986	845	1104	763
352	-1096	-1354	-1318	-1046	1034	888	1154	803
376	-1150	-1399	-1390	-1081	1075	935	1206	853
396	-	-	-	-	-	-	-	-
377	-1180	-1309	-1323	-1076	1045	927	1173	838
387	-1204	-1327	-1347	-1089	1056	944	1189	845
399	-1235	-1339	-1425	-1104	1064	961	1222	884
411	-1277	-1310	-1458	-1085	1075	977	1222	884
423	-1328	-1250	-1484	1043	1081	1000	1238	900
434	-1376	-1206	-1400	-1033	1077	1007	1238	901
446	-1190	-1321	-1115	-1217	1146	1044	1291	952
458	-1196	-1324	-1078	-1239	1143	1050	1299	959
469	-1213	-1310	-1135	-1258	1144	1059	1304	963
481	-	-	-	-	-	-	-	-
477	-1230	-1311	-1130	-1269	1099	1015	1264	906
487	-1200	-1336	-1056	-1310	1102	1021	1280	907
493	-1183	-1371	-1042	-1327	1111	1030	1297	917
505	-1031	-1460	-1110	-1175	1168	1050	1354	933
516	-	-	-	-	-	-	-	-
493	-1040	-1400	-1070	-1135	1191	1097	1404	645
507	-	-	-	-	-	-	-	-
479	-1522	-108	-210	-1155	1353	1367	1682	1070

* Members are identified in Fig. 3.7.
** Strain gauge locations are shown in Fig. 3.27.

Table A.10d Load-Strain Data for Specimen LR15 (Strain Gauges 25 to 32)

Load (kN)	Strain Gauge Readings (μstrain)							
	25	26	27	28	29	30	31	32
	Members on Which Strain Gauges are Attached*							
	CF4T		CF4B		TC4T		TC4B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
49.3	-48	-65	-38	-58	0	27	0	21
96.2	-81	-122	-83	-125	5	40	10	45
141	-138	-189	-133	-200	21	70	25	77
188	-214	-275	-189	-294	85	110	44	112
235	-277	-352	-244	-382	103	140	63	147
282	-360	-434	-311	-487	146	189	95	197
329	-456	-534	-380	-602	199	239	137	252
352	-515	-583	-419	-667	242	268	165	288
376	-559	-632	-462	-742	279	293	196	323
396	-	-	-	-	-	-	-	-
377	-602	-786	-531	-856	272	275	198	285
387	-614	-828	-553	-899	311	291	214	295
399	-639	-865	-581	-940	322	289	224	307
411	-676	-911	-607	-993	333	300	240	321
423	-712	-965	-649	-1055	256	318	261	349
434	-756	-1050	-708	-1127	294	343	284	385
446	-794	-1093	-734	-1186	320	349	303	413
458	-817	-1120	-756	-1215	330	365	315	427
469	-867	-1185	-804	-1277	363	378	337	460
481	-	-	-	-	-	-	-	-
477	-905	-1203	-841	-1305	382	396	334	486
487	-854	-1364	-909	-1350	437	421	362	533
493	-797	-1456	-936	-1362	450	440	373	554
505	-608	-1690	-1024	-1324	489	469	397	605
516	-	-	-	-	-	-	-	-
493	-	-	-1703	227	785	671	571	933
507	-	-	-	-	-	-	-	-
479	-	-	-1630	386	854	781	670	1028

* Members are identified in Fig. 3.7.
** Strain gauge locations are shown in Fig. 3.27.

Table A.11a Load-Strain Data for Specimen LR16 (Strain Gauges 1 to 8)

Load (kN)	1	2	3	4	5	6	7	8
	Strain Gauge Readings (μstrain)							
	Members on Which Strain Gauges are Attached*							
	CC1T		CC1B		TF1T		TF1B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-50	-89	-76	-67	13	50	27	38
93.9	-123	-183	-168	-134	44	108	62	86
141	-189	-280	-263	-206	80	172	105	142
188	-265	-390	-375	-283	125	241	156	204
235	-349	-507	-498	-359	183	314	216	275
282	-428	-640	-633	-438	253	396	279	355
329	-513	-787	-789	-516	330	487	353	445
352	-556	-865	-875	-555	369	533	398	491
376	-599	-944	-958	-591	408	582	440	540
387	-622	-991	-1013	-609	434	608	460	568
399	-642	-1035	-1061	-626	455	629	482	592
411	-670	-1087	-1113	-644	480	658	504	618
423	-	-	-	-	-	-	-	-
413	-669	-1222	-1229	-674	478	649	518	592
423	-681	-1276	-1280	-691	496	662	536	608
434	-700	-1332	-1334	-706	508	681	552	619
446	-707	-1410	-1407	-727	527	703	574	640
458	-718	-1465	-1462	-738	545	720	585	657
472	-648	-1540	-1635	-675	599	742	632	695
481	-	-	-	-	-	-	-	-
471	-	-	-	-	1101	712	953	814
481	-	-	-	-	1287	801	1113	923
493	-	-	-	-	1456	960	1285	1075
505	-	-	-	-	1651	1161	1476	1254
519	-	-	-	-	-	-	-	-
493	-	-	-	-	1855	1273	1598	1387
503	-	-	-	-	-	-	-	-
491	-	-	-	-	1913	1316	1597	1425
446	-	-	-	-	1747	1144	1414	1265

* Members are identefied in Fig. 3.8.

**Strain gauge locations are shown in Fig. 3.28.

Table A.11b Load-Strain Data for Specimen LR16 (Strain Gauges 9 to 16)

	Strain Gauge Readings (μstrain)							
	9	10	11	12	13	14	15	16
	Members on Which Strain Gauges are Attached*							
	CF3T		CF3B		TC3T		TC3B	
	outside	inside	outside	inside	outside	inside	outside	inside
Load	Location of Strain Gauges**							
(kN)	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-168	-173	-210	-175	115	117	127	118
93.9	-326	-339	-390	-309	241	246	255	241
141	-476	-511	-580	-440	363	364	380	364
188	-611	-677	-771	-565	468	475	476	458
235	-737	-845	-945	-665	575	585	576	569
282	-853	-1006	-1136	-754	670	689	674	679
329	-940	-1167	-1315	-824	740	780	750	767
352	-977	-1245	-1405	-861	772	818	776	800
376	-1012	-1330	-1515	-884	800	858	810	837
387	-1032	-1383	-1554	-875	838	897	852	890
399	-1050	-1420	-1632	-903	831	899	842	885
411	-1058	-1468	-1654	-888	862	933	882	939
423	-	-	-	-	-	-	-	-
413	-1077	-1391	-1589	-887	842	934	853	932
423	-1100	-1410	-1618	-904	856	948	868	950
434	-1118	-1429	-1650	-919	861	959	870	958
446	-1144	-1451	-1685	-919	883	993	906	991
458	-1163	-1466	-1722	-928	888	1001	915	1000
472	-1198	-1490	-1765	-944	911	1026	946	1027
481	-	-	-	-	-	-	-	-
471	-1288	-1433	-1737	-1009	908	1090	964	1054
481	-1366	-1386	-1726	-1046	931	1118	999	1073
493	-1504	-1224	-1721	-1030	972	1100	1034	1060
505	-1560	-1120	-1630	-1078	1025	1094	1096	1041
519	-	-	-	-	-	-	-	-
493	-1656	-160	268	-1589	1269	1393	1416	1267
503	-	-	-	-	-	-	-	-
491	-1782	311	197	-1710	1342	1566	1489	1422
446	-1855	651	571	-1795	1176	1476	1341	1321

* Members are identefied in Fig. 3.8.

**Strain gauge locations are shown in Fig. 3.28.

Table A.11c Load-Strain Data for Specimen LR16 (Strain Gauges 17 to 24)

Load (kN)	Strain Gauge Readings (μstrain)							
	17	18	19	20	21	22	23	24
	Members on Which Strain Gauges are Attached*							
	CC2T		CC2B		TF2T		TF2B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.
47.0	-206	-214	-212	-170	155	142	162	142
93.9	-337	-390	-400	-287	289	272	299	266
141	-470	-574	-557	-418	416	400	429	388
188	-617	-757	-767	-529	527	517	543	499
235	-711	-916	-952	-614	631	630	650	604
282	-794	-1085	-1116	-716	727	732	747	701
329	-881	-1242	-1275	-786	805	815	827	784
352	-924	-1320	-1352	-830	842	856	864	822
376	-976	-1411	-1433	-870	884	897	901	867
387	-944	-1435	-1460	-865	910	921	922	895
399	-985	-1499	-1524	-879	935	939	935	924
411	-880	-1552	-1546	-839	986	961	959	964
423	-	-	-	-	-	-	-	-
413	-	-	-	-	1413	1019	1254	1146
423	-	-	-	-	1488	1067	1322	1200
434	-	-	-	-	1526	1103	1380	1250
446	-	-	-	-	1548	1147	1446	1387
458	-	-	-	-	1590	1189	1494	1444
472	-	-	-	-	1954	1267	1576	1526
481	-	-	-	-	-	-	-	-
471	-	-	-	-	2111	1338	1634	1570
481	-	-	-	-	2081	1510	1728	1605
493	-	-	-	-	2121	1548	1878	1574
505	-	-	-	-	2112	1598	1926	1577
519	-	-	-	-	-	-	-	-
493	-	-	-	-	2048	1543	1853	1533
503	-	-	-	-	-	-	-	-
491	-	-	-	-	2049	1540	1852	1532
446	-	-	-	-	1927	1396	1722	1399

* Members are identefied in Fig. 3.8.
**Strain gauge locations are shown in Fig. 3.28.

Table A.11d Load-Strain Data for Specimen LR16 (Strain Gauges 25 to 32)

Load (kN)	Strain Gauge Readings (μstrain)							
	25	26	27	28	29	30	31	32
	Members on Which Strain Gauges are Attached*							
	CF4T		CF4B		TC4T		TC4B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-50	-57	-64	-52	6	32	28	18
93.9	-118	-123	-134	-116	30	80	73	63
141	-193	-199	-219	-189	59	125	110	100
188	-297	-285	-319	-273	112	185	163	149
235	-410	-376	-425	-366	173	245	221	205
282	-524	-473	-545	-465	235	308	285	270
329	-654	-577	-673	-571	319	384	375	346
352	-718	-629	-738	-626	361	424	417	384
376	-791	-681	-804	-684	405	461	459	427
387	-828	-710	-839	-717	430	486	489	452
399	-855	-735	-875	-746	451	506	511	473
411	-899	-758	-908	-785	472	532	530	496
423	-	-	-	-	-	-	-	-
413	-988	-728	-911	-846	486	604	558	553
423	-1031	-742	-933	-880	503	631	577	573
434	-1070	-753	-950	-910	520	653	600	595
446	-1128	-775	-984	-956	543	682	623	622
458	-1173	-793	-1009	-992	560	700	644	644
472	-1255	-815	-1041	-1061	596	748	683	687
481	-	-	-	-	-	-	-	-
471	-1280	-752	-985	-1080	572	763	665	695
481	-1369	-762	-980	-1180	609	811	705	740
493	-1495	-792	-954	-1349	662	872	769	794
505	-1651	-815	-884	-1592	716	936	834	846
519	-	-	-	-	-	-	-	-
493	-1744	-600	-569	-1793	925	920	1079	795
503	-	-	-	-	-	-	-	-
491	-1835	-158	-85	-1931	1064	1085	1234	943
446	-1569	-187	-81	-1697	975	1029	1136	895

* Members are identefied in Fig. 3.8.

**Strain gauge locations are shown in Fig. 3.28.

Table A.12a Load-Strain Data for Specimen LR17 (Strain Gauges 1 to 8)

Load (kN)	Strain Gauge Readings (μstrain)							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached*							
	CI1T		CI1B		TO1T		TO1B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-67	-40	-77	-30	16	20	24	14
93.9	-155	-74	-185	-44	47	56	72	42
141	-255	-99	-302	-56	98	115	138	89
188	-370	-136	-448	-55	146	168	183	122
211	-428	-162	-526	-56	170	188	208	136
223	-460	-161	-560	-53	194	216	236	155
235	-483	-179	-598	-49	194	219	227	146
246	-520	-175	-637	-50	218	249	280	184
258	-557	-183	-680	-56	241	268	307	206
270	-600	-206	-740	-50	254	279	303	198
282	-636	-200	-779	-53	296	315	364	241
293	-687	-220	-849	-46	312	330	400	270
305	-734	-220	-910	-52	350	362	460	315
317	-787	-236	-978	-40	374	384	485	335
329	-835	-235	-1030	-38	405	418	525	366
340	-889	-241	-1099	-33	436	446	552	390
352	-956	-230	-1164	-24	473	488	597	434
364	-1010	-237	-1236	-7	509	514	610	460
376	-1070	-228	-1298	3	563	564	675	516
387	-1114	-230	-1353	12	605	600	718	555
399	-1160	-219	-1409	23	653	640	773	600
411	-1210	-206	-1461	51	703	683	811	642
423	-1238	-205	-1506	61	758	728	862	692
434	-1255	-205	-1548	95	810	774	918	733
446	-1271	-186	-1583	132	876	832	1000	799
458	-1260	-218	-1623	165	929	897	1041	842
469	-1235	-231	-1613	163	1002	977	1136	946
481	-1238	-239	-1648	180	1063	1055	1200	1017
493	-1215	-273	-1689	216	1123	1137	1260	1100
505	-1130	-365	-1725	300	1215	1253	1364	1213
516	-1000	-516	-1764	351	1289	1353	1449	1313
529	-	-	-	-	-	-	-	-
511	-677	-840	-1773	424	1330	1436	1508	1348

* Members are identefied in Fig. 3.11.
**Strain gauge locations are shown in Fig. 3.29.

Table A.12b Load-Strain Data for Specimen LR17 (Strain Gauges 9 to 16)

Load	Strain Gauge Readings (μstrain)							
	9	10	11	12	13	14	15	16
	Members on Which Strain Gauges are Attached*							
	CI3T		CI3B		TO3T		TO3B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-333	73	-209	-45	235	170	197	198
93.9	-650	150	-420	-94	457	321	385	378
141	-984	217	-621	-130	665	442	568	523
188	-1330	318	-833	-146	877	549	744	665
211	-1480	380	-927	-147	971	595	820	735
223	-1590	360	-965	-153	1020	639	867	780
235	-1652	427	-995	-169	1085	680	918	835
246	-1662	470	-1000	-197	1130	722	957	888
258	-1731	448	-992	-217	1183	751	992	935
270	-1712	520	-976	-241	1227	783	1028	977
282	-1769	525	-955	-269	1273	813	1058	1021
293	-1775	594	-938	-294	1309	852	1088	1064
305	-1790	635	-915	-317	1345	890	1118	1106
317	-1835	692	-891	-345	1377	928	1152	1145
329	-1885	727	-864	-382	1415	969	1188	1187
340	-1927	773	-824	-423	1433	999	1215	1217
352	-1986	807	-776	-464	1461	1036	1247	1250
364	-2037	835	-732	-514	1477	1063	1272	1275
376	-2058	889	-672	-571	1505	1094	1300	1302
387	-2080	943	-611	-634	1532	1126	1329	1332
399	-2140	977	-546	-694	1560	1163	1362	1365
411	-2175	1087	-468	-777	1580	1187	1387	1384
423	-	-	-384	-860	1615	1221	1424	1410
434	-	-	-286	-956	1641	1240	1456	1426
446	-	-	-151	-1071	1681	1270	1491	1455
458	-	-	1	-1221	1688	1288	1502	1479
469	-	-	273	-1485	1688	1294	1500	1492
481	-	-	586	-1800	1710	1326	1519	1515
493	-	-	1094	-2460	1699	1328	1521	1513
505	-	-	1940	-7300	1677	1350	1528	1506
516	-	-	6000	-9900	1691	1331	1512	1526
529	-	-	-	-	-	-	-	-
511	-	-	-	-	1583	1270	1449	1442

* Members are identefied in Fig. 3.11.
**Strain gauge locations are shown in Fig. 3.29.

Table A.12c Load-Strain Data for Specimen LR17 (Strain Gauges 17 to 24)

Load	Strain Gauge Readings (μstrain)							
	17	18	19	20	21	22	23	24
	Members on Which Strain Gauges are Attached*							
	CO2T		CO2B		TI2T		TI2B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-57	-326	-76	-318	159	110	105	146
93.9	-104	-652	-141	-653	303	220	207	287
141	-145	-963	-153	-960	425	321	295	415
188	-159	-1243	-159	-1255	527	430	364	550
211	-175	-1350	-185	-1349	570	485	389	620
223	-180	-1389	-190	-1389	597	520	403	662
235	-181	-1439	-204	-1420	631	565	427	721
246	-172	-1486	-206	-1450	661	606	452	770
258	-149	-1512	-200	-1464	690	640	475	811
270	-120	-1544	-193	-1478	724	694	500	881
282	-37	-1581	-170	-1451	755	747	528	943
293	86	-1626	-148	-1397	795	799	564	1007
305	199	-1652	-148	-1340	849	839	615	1055
317	258	-1677	-149	-1314	904	880	664	1104
329	312	-1679	-137	-1311	947	908	705	1137
340	345	-1706	-155	-1285	986	936	743	1173
352	388	-1727	-160	-1259	1018	960	774	1200
364	413	-1750	-187	-1230	1045	982	801	1225
376	456	-1764	-225	-1169	1077	1010	840	1257
387	-	-	-255	-1116	1107	1040	872	1285
399	-	-	-294	-1077	1144	1070	910	1318
411	-	-	-344	-1026	1175	1103	950	1351
423	-	-	-406	-962	1210	1135	990	1383
434	-	-	-456	-906	1245	1168	1030	1415
446	-	-	-510	-828	1273	1195	1061	1440
458	-	-	-565	-777	1304	1225	1100	1468
469	-	-	-642	-713	1332	1250	1132	1488
481	-	-	-675	-646	1365	1275	1173	1512
493	-	-	-720	-600	1386	1296	1203	1529
505	-	-	-788	-511	1405	1316	1227	1540
516	-	-	-857	-434	1434	1338	1259	1561
529	-	-	-	-	-	-	-	-
511	-	-	-807	-426	1431	1341	1278	1541

* Members are identefied in Fig. 3.11.
**Strain gauge locations are shown in Fig. 3.29.

Table A.12d Load-Strain Data for Specimen LR17 (Strain Gauges 25 to 32)

Load	Strain Gauge Readings (µstrain)							
	25	26	27	28	29	30	31	32
	Members on Which Strain Gauges are Attached*							
	CI4T		CI4B		TO4T		TO4B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-62	-14	-65	-13	-2	40	2	33
93.9	-152	-31	-157	-32	10	85	19	73
141	-258	-46	-260	-44	37	141	50	124
188	-403	-64	-408	-62	100	220	116	199
211	-477	-72	-483	-73	133	258	149	234
223	-526	-76	-527	-76	154	284	169	255
235	-561	-78	-563	-79	162	306	185	272
246	-614	-83	-614	-85	186	332	210	296
258	-659	-89	-654	-89	202	356	231	320
270	-705	-91	-698	-96	223	385	255	345
282	-756	-97	-746	-107	251	411	282	375
293	-820	-104	-800	-124	290	445	313	405
305	-882	-109	-854	-136	325	474	345	437
317	-950	-113	-915	-148	368	502	380	470
329	-1006	-116	-968	-144	400	528	414	500
340	-1070	-120	-1028	-161	443	558	453	533
352	-1143	-116	-1095	-163	487	590	491	565
364	-1220	-104	-1168	-155	539	626	543	600
376	-1263	-109	-1209	-165	593	655	592	638
387	-1295	-115	-1244	-170	639	672	646	670
399	-1324	-127	-1268	-183	708	696	698	708
411	-1350	-120	-1285	-185	788	707	751	751
423	-1369	-123	-1297	-188	877	725	808	795
434	-1375	-132	-1319	-188	965	741	860	850
446	-1388	-129	-1338	-175	1055	766	915	910
458	-1394	-126	-1358	-157	1132	786	958	964
469	-1394	-133	-1386	-135	1214	823	1009	1031
481	-1395	-136	-1411	-111	1272	863	1053	1090
493	-1394	-144	-1445	-89	1335	911	1104	1143
505	-1378	-165	-1496	-44	1381	962	1143	1197
516	-1334	-217	-1565	28	1412	1006	1175	1235
529	-	-	-	-	-	-	-	-
511	-1022	-474	-1740	264	1388	952	1137	1194

* Members are identefied in Fig. 3.11.
**Strain gauge locations are shown in Fig. 3.29.

Table A.13a Load-Strain Data for Specimen LR18 (Strain Gauges 1 to 8)

Load	Strain Gauge Readings (μstrain)							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached*							
	CI1T		CI1B		TO1T		TO1B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	255 mm from top	255 mm from top	255 mm from bot.	255 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-50	-38	-96	7	6	57	40	22
93.9	-105	-63	-200	22	32	134	92	68
141	-170	-103	-331	41	65	225	167	122
188	-238	-146	-470	61	92	327	242	175
211	-287	-177	-561	72	98	403	290	195
235	-335	-206	-660	86	112	504	357	243
246	-366	-227	-721	91	127	559	402	275
258	-390	-249	-767	89	138	586	425	284
270	-410	-261	-817	101	163	619	458	317
282	-440	-287	-889	111	190	653	499	340
293	-477	-313	-957	118	212	685	535	348
305	-497	-338	-1026	135	245	721	579	380
317	-528	-362	-1099	155	278	756	624	410
329	-559	-390	-1191	177	311	791	673	434
340	-593	-421	-1274	204	350	827	727	455
352	-625	-450	-1374	234	386	861	770	472
364	-647	-480	-1471	275	431	895	827	502
376	-677	-505	-1577	317	478	934	892	532
387	-703	-540	-1713	382	529	974	959	552
399	-718	-589	-1841	447	590	1005	1032	573
411	-705	-678	-1995	520	677	1052	1138	611
423	-540	-905	-2169	638	835	1099	1290	667
435	-	-	-	-	-	-	-	-
389	-36	-1345	-	-	873	1048	1303	625

* Members are identefied in Fig. 3.12.
**Strain gauge locations are shown in Fig. 3.30.

Table A.13b Load-Strain Data for Specimen LR18 (Strain Gauges 9 to 16)

Load	Strain Gauge Readings (μstrain)							
	9	10	11	12	13	14	15	16
	Members on Which Strain Gauges are Attached*							
	CO3T		CO3B		TI3T		TI3B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	255 mm from top	255 mm from top	255 mm from bot.	255 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-98	-311	-65	-353	124	97	123	96
93.9	-168	-629	-110	-705	237	187	238	187
141	-207	-958	-125	-1065	344	282	347	276
188	-252	-1233	-159	-1360	448	388	461	374
211	-269	-1334	-134	-1472	486	517	535	458
235	-200	-1336	-33	-1519	520	723	713	521
246	-140	-1292	84	-1544	626	822	886	558
258	-116	-1270	150	-1550	730	863	980	602
270	-92	-1240	212	-1569	820	914	1053	663
282	-70	-1230	283	-1603	890	964	1121	724
293	-69	-1214	338	-1627	956	1015	1184	775
305	-68	-1190	370	-1656	1009	1057	1234	814
317	-81	-1161	413	-1677	1053	1097	1281	852
329	-106	-1115	447	-1693	1099	1139	1331	888
340	-130	-1085	473	-1710	1137	1170	1371	918
352	-169	-1049	497	-1731	1173	1204	1408	942
364	-210	-992	526	-1746	1213	1235	1453	973
376	-253	-945	558	-1770	1247	1265	1487	996
387	-302	-885	588	-1800	1278	1291	1523	1019
399	-339	-839	-	-	1298	1310	1554	1028
411	-370	-796	-	-	1294	1315	1585	993
423	-402	-746	-	-	1261	1299	1578	945
435	-	-	-	-	-	-	-	-
389	-461	-629	-	-	1039	1090	1336	748

* Members are identefied in Fig. 3.12.
**Strain gauge locations are shown in Fig. 3.30.

Table A.13c Load-Strain Data for Specimen LR18 (Strain Gauges 17 to 24)

Load (kN)	Strain Gauge Readings (μstrain)							
	17	18	19	20	21	22	23	24
	Members on Which Strain Gauges are Attached*							
	CI2T		CI2B		TO2T		TO2B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	255 mm from top	255 mm from top	255 mm from bot.	255 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-240	-32	-330	48	200	214	214	214
93.9	-467	-52	-657	92	386	405	400	408
141	-685	-74	-982	156	568	589	583	596
188	-880	-104	-1300	233	748	773	765	785
211	-928	-147	-1417	245	837	883	860	893
235	-926	-209	-1477	251	915	987	949	987
246	-913	-242	-1522	261	968	1064	1010	1055
258	-899	-269	-1566	286	999	1114	1052	1097
270	-880	-316	-1574	313	1040	1173	1099	1147
282	-824	-363	-1619	363	1076	1238	1153	1198
293	-756	-430	-1663	416	1104	1320	1212	1259
305	-690	-495	-1699	495	1133	1386	1251	1309
317	-610	-570	-1736	532	1166	1450	1290	1366
329	-511	-657	-1764	573	1197	1505	1331	1414
340	-430	-730	-	-	1234	1554	1371	1457
352	-355	-818	-	-	1265	1595	1410	1494
364	-251	-914	-	-	1301	1634	1448	1538
376	-140	-1017	-	-	1334	1676	1486	1573
387	35	-1195	-	-	1363	1723	1522	1617
399	387	-1525	-	-	1389	1728	1535	1630
411	-	-	-	-	1448	1730	1579	1640
423	-	-	-	-	1475	1695	1607	1593
435	-	-	-	-	-	-	-	-
389	-	-	-	-	1363	1573	1506	1448

* Members are identefied in Fig. 3.12.
**Strain gauge locations are shown in Fig. 3.30.

Table A.13d Load-Strain Data for Specimen LR18 (Strain Gauges 25 to 32)

Load (kN)	Strain Gauge Readings (μstrain)							
	25	26	27	28	29	30	31	32
	Members on Which Strain Gauges are Attached*							
	CO4T		CO4B		TI4T		TI4B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	255 mm from top	255 mm from top	255 mm from bot.	255 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-21	-64	-25	-63	0	8	0	4
93.9	-40	-181	-54	-165	0	25	16	9
141	-61	-313	-90	-283	17	53	42	18
188	-77	-447	-122	-403	27	82	68	23
211	-88	-549	-144	-491	30	102	88	24
235	-100	-661	-175	-582	25	119	105	24
246	-101	-738	-196	-646	30	129	115	27
258	-104	-802	-208	-698	30	143	127	32
270	-102	-880	-222	-764	32	160	138	40
282	-100	-944	-229	-818	80	175	151	46
293	-98	-1025	-237	-890	78	208	168	55
305	-91	-1097	-238	-955	89	232	186	65
317	-83	-1185	-241	-1036	93	261	210	76
329	-79	-1267	-242	-1108	105	291	234	88
340	-71	-1356	-246	-1188	114	318	256	100
352	-49	-1498	-244	-1264	124	352	282	114
364	17	-1604	-244	-1345	142	384	312	128
376	86	-1784	-242	-1426	156	422	345	146
387	152	-1955	-237	-1488	183	476	392	172
399	-	-	-277	-1417	207	621	502	240
411	-	-	-482	-870	273	1075	742	520
423	-	-	-645	-484	540	1325	1049	742
435	-	-	-	-	-	-	-	-
389	-	-	-676	-215	635	1374	1115	820

* Members are identefied in Fig. 3.12.
**Strain gauge locations are shown in Fig. 3.30.

Table A.14a Load-Strain Data for Specimen LR19 (Strain Gauges 1 to 8)

	Strain Gauge Readings (μstrain)							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached*							
	CC1T		CC1B		TF1T		TF1B	
	outside	inside	outside	inside	outside	inside	outside	inside
Load	Location of Strain Gauges**							
(kN)	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	255 mm from top	255 mm from top	255 mm from bot.	255 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-106	-100	-87	-123	51	69	69	53
93.9	-210	-200	-170	-243	101	136	134	105
141	-313	-300	-251	-368	155	203	201	155
189	-424	-409	-335	-500	211	274	267	212
236	-539	-519	-422	-638	277	353	344	274
282	-655	-629	-505	-780	344	426	418	339
329	-778	-745	-590	-932	416	508	497	407
352	-841	-800	-629	-1009	451	548	536	442
376	-900	-858	-671	-1087	486	585	575	475
399	-967	-923	-713	-1173	529	632	622	521
412	-	-	-	-	-	-	-	-
404	-997	-977	-751	-1219	534	635	629	519
412	-1017	-1008	-771	-1251	549	650	645	534
423	-1030	-1061	-800	-1288	564	664	662	545
436	-	-	-	-	-	-	-	-
426	-977	-1109	-806	-1278	558	671	659	549
434	-1000	-1140	-821	-1316	571	685	670	561
446	-916	-1294	-863	-1343	594	716	707	585
458	-	-	-	-	-	-	-	-
444	-	-	-1706	112	873	919	915	875
460	-	-	-	-	-	-	-	-
437	-	-	-1528	669	1093	1098	1100	1092
446	-	-	-1562	720	1135	1143	1145	1139
458	-	-	-1557	888	1267	1242	1270	1265
467	-	-	-1600	1121	1448	1355	1412	1425
482	-	-	-	-	-	-	-	-

* Members are identefied in Fig. 3.7.
**Strain gauge locations are shown in Fig. 3.27.

Table A.14b Load-Strain Data for Specimen LR19 (Strain Gauges 9 to 16)

Load (kN)	Strain Gauge Readings (µstrain)							
	9	10	11	12	13	14	15	16
	Members on Which Strain Gauges are Attached*							
	CF3T		CF3B		TC3T		TC3B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	255 mm from top	255 mm from top	255 mm from bot.	255 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-146	-143	-150	-140	95	100	117	78
93.9	-286	-280	-295	-272	187	199	227	155
141	-423	-421	-442	-404	279	294	335	235
189	-568	-569	-597	-540	378	397	452	322
236	-691	-704	-734	-661	462	487	552	395
282	-811	-837	-870	-780	543	574	647	468
329	-929	-973	-1007	-900	625	662	745	541
352	-994	-1032	-1074	-959	665	707	793	578
376	-1067	-1080	-1134	-1017	707	750	843	618
399	-1156	-1092	-1203	-1053	749	788	892	649
412	-	-	-	-	-	-	-	-
404	-1168	-1070	-1190	-1057	743	788	889	647
412	-1195	-1087	-1208	-1080	755	803	903	659
423	-1233	-1082	-1220	-1102	770	820	924	673
436	-	-	-	-	-	-	-	-
426	-1310	-1065	-1233	-1145	776	822	957	648
434	-1365	-1048	-1242	-1177	789	838	982	658
446	-1482	-955	-1242	-1202	813	863	1025	665
458	-	-	-	-	-	-	-	-
444	-1597	-842	-1189	-1266	802	922	1049	687
460	-	-	-	-	-	-	-	-
437	-	-	-	-	1260	1315	1525	1073
446	-	-	-	-	1328	1369	1582	1142
458	-	-	-	-	1479	1482	1655	1332
467	-	-	-	-	1552	1518	1649	1448
482	-	-	-	-	-	-	-	-

* Members are identefied in Fig. 3.7.
**Strain gauge locations are shown in Fig. 3.27.

Table A.14c Load-Strain Data for Specimen LR19 (Strain Gauges 17 to 24)

Load	Strain Gauge Readings (μstrain)							
	17	18	19	20	21	22	23	24
	Members on Which Strain Gauges are Attached*							
	CC2T		CC2B		TF2T		TF2B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	255 mm from top	255 mm from top	255 mm from bot.	255 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-201	-96	-166	-128	112	109	125	100
93.9	-391	-182	-309	-254	214	209	238	192
141	-593	-260	-457	-381	320	314	353	290
189	-807	-330	-601	-516	428	421	470	391
236	-1002	-381	-723	-635	517	514	567	475
282	-1208	-423	-849	-757	605	606	665	563
329	-1425	-453	-964	-877	691	700	761	647
352	-1546	-460	-1020	-944	734	747	810	692
376	-1707	-398	-1045	-1015	785	795	863	742
399	-1870	-330	-1073	-1088	833	848	916	788
412	-	-	-	-	-	-	-	-
404	-	-	-202	-1557	1032	1021	1128	936
412	-	-	-85	-1636	1085	1069	1185	974
423	-	-	80	-1709	1170	1132	1268	1036
436	-	-	-	-	-	-	-	-
426	-	-	453	-2072	1288	1239	1382	1140
434	-	-	559	-2147	1351	1283	1437	1192
446	-	-	902	-2291	1485	1367	1519	1322
458	-	-	-	-	-	-	-	-
444	-	-	1348	-2574	1562	1430	1555	1417
460	-	-	-	-	-	-	-	-
437	-	-	1742	-2904	1530	1421	1522	1402
446	-	-	1788	-2997	1552	1448	1553	1420
458	-	-	1993	-3255	1618	1500	1609	1465
467	-	-	2515	-3510	1665	1550	1673	1474
482	-	-	-	-	-	-	-	-

* Members are identefied in Fig. 3.7.
**Strain gauge locations are shown in Fig. 3.27.

Table A.14d Load-Strain Data for Specimen LR19 (Strain Gauges 25 to 32)

Load (kN)	Strain Gauge Readings (μstrain)							
	25	26	27	28	29	30	31	32
	Members on Which Strain Gauges are Attached*							
	CF4T		CF4B		TC4T		TC4B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	340 mm from top	340 mm from top	340 mm from bot.	340 mm from bot.	255 mm from top	255 mm from top	255 mm from bot.	255 mm from bot.
0	0	0	0	0	0	0	0	0
47.0	-72	-131	-88	-115	44	58	56	48
93.9	-141	-263	-176	-231	91	116	111	95
141	-210	-395	-262	-352	135	175	162	141
189	-273	-546	-348	-478	187	232	215	189
236	-341	-707	-444	-617	242	296	276	247
282	-405	-867	-530	-757	305	367	341	306
329	-465	-1041	-622	-907	363	433	406	368
352	-493	-1129	-665	-983	392	467	437	398
376	-1512	-1223	-698	-1054	452	499	468	432
399	-540	-1320	-745	-1145	483	538	506	468
412	-	-	-	-	-	-	-	-
404	-524	-1400	-741	-1209	513	555	518	498
412	-522	-1450	-761	-1253	520	571	532	514
423	-502	-1521	-769	-1291	540	593	546	538
436	-	-	-	-	-	-	-	-
426	-	-	-1403	-250	742	757	670	790
434	-	-	-1517	-60	807	826	720	878
446	-	-	-1651	231	935	973	820	1052
458	-	-	-	-	-	-	-	-
444	-	-	-1568	373	979	1053	850	1150
460	-	-	-	-	-	-	-	-
437	-	-	-1711	624	1075	1125	934	1236
446	-	-	-1726	682	1125	1165	979	1282
458	-	-	-2251	825	1255	1263	1100	1395
467	-	-	-2286	1002	1462	1400	1240	1605
482	-	-	-	-	-	-	-	-

* Members are identefied in Fig. 3.7.
**Strain gauge locations are shown in Fig. 3.27.

Table A.15a Load-Strain Data for Specimen LR20 (Strain Gauges 1 to 8)

Load	Strain Gauge Readings (μstrain)							
	1	2	3	4	5	6	7	8
	Members on Which Strain Gauges are Attached*							
	CI1T		CI1B		TO1T		TO1B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
48.4	-72	-40	-85	-22	27	47	35	33
93.9	-162	-78	-192	-40	68	104	84	70
141	-262	-116	-310	-55	107	171	146	120
188	-378	-148	-440	-68	167	254	224	180
211	-437	-165	-506	-76	195	294	263	211
235	-507	-186	-589	-82	228	340	307	247
246	-544	-202	-643	-85	255	362	330	255
258	-584	-217	-694	-82	266	382	353	286
270	-631	-230	-753	-84	297	414	381	312
282	-712	-240	-837	-91	348	466	434	359
293	-770	-243	-891	-98	388	501	468	393
305	-860	-238	-963	-107	438	550	520	444
317	-919	-230	-1008	-110	476	577	558	480
331	-996	-215	-1062	-120	533	617	602	519
340	-1065	-198	-1101	-134	593	656	654	566
352	-1134	-170	-1134	-145	664	672	697	598
364	-1208	-147	-1167	-151	737	703	758	665
376	-1262	-121	-1187	-161	801	715	808	706
387	-1325	-91	-1216	-159	873	736	847	756
399	-1372	-57	-1225	-168	955	795	893	818
411	-1430	-3	-1225	-172	1040	795	943	872
423	-1473	39	-1220	-179	1095	837	985	946
434	-1500	41	-1208	-202	1144	886	1015	992
446	-1532	95	-1182	-219	1200	954	1067	1064
458	-1570	123	-1152	-255	1244	1011	1113	1120
469	-1568	119	-1108	-301	1298	1073	1170	1176
481	-1597	158	-1035	-366	1351	1137	1225	1242
493	-1636	182	-996	-417	1395	1183	1266	1293
505	-1676	214	-930	-493	1451	1238	1312	1352
516	-1720	260	-827	-596	1508	1291	1355	1414
528	-1770	307	-680	-743	1561	1343	1404	1486
540	-	-	-444	-972	1624	1412	1454	1563
552	-	-	40	-1423	1667	1494	1517	1635
564	-	-	-	-	-	-	-	-
533	-	-	-	-	1597	1556	1465	1585

* Members are identefied in Fig. 3.13.
**Strain gauge locations are shown in Fig. 3.31.

Table A.15b Load-Strain Data for Specimen LR20 (Strain Gauges 9 to 16)

Load	Strain Gauge Readings (μstrain)							
	9	10	11	12	13	14	15	16
	Members on Which Strain Gauges are Attached*							
	CO3T		CO3B		TI3T		TI3B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
48.4	-101	-268	-93	-285	122	155	127	147
93.9	-183	-513	-166	-540	220	280	221	270
141	-253	-775	-227	-810	325	416	326	402
188	-286	-1069	-254	-1107	418	571	409	544
211	-268	-1229	-235	-1271	443	645	438	620
235	-230	-1371	-199	-1413	465	741	473	699
246	-229	-1401	-174	-1460	476	787	505	729
258	-201	-1428	-138	-1503	491	833	530	760
270	-139	-1475	-100	-1525	512	892	580	788
282	-50	-1512	-36	-1551	536	950	648	817
293	15	-1520	-6	-1532	580	981	707	844
305	67	-1499	36	-1486	651	1025	771	884
317	96	-1510	65	-1498	705	1047	816	914
331	123	-1525	92	-1505	763	1097	870	953
340	155	-1525	102	-1497	767	1090	876	965
352	183	-1543	120	-1494	814	1135	919	996
364	225	-1565	112	-1505	839	1165	960	1034
376	253	-1580	129	-1497	876	1199	993	1070
387	279	-1596	124	-1488	914	1234	1041	1105
399	308	-1608	124	-1469	954	1275	1093	1142
411	337	-1620	112	-1445	999	1315	1133	1172
423	358	-1633	98	-1425	1021	1355	1177	1210
434	369	-1659	80	-1403	1080	1394	1219	1243
446	398	-1663	45	-1352	1122	1431	1273	1276
458	428	-1687	7	-1317	1153	1464	1311	1306
469	455	-1713	-30	-1282	1187	1493	1349	1336
481	493	-1739	-79	-1217	1230	1529	1394	1368
493	528	-1776	-124	-1181	1264	1559	1430	1395
505	566	-1800	-187	-1117	1309	1596	1486	1420
516	614	-1832	-265	-1021	1337	1619	1511	1447
528	652	-1852	-371	-914	1374	1655	1558	1478
540	710	-1890	-514	-764	1404	1680	1604	1500
552	852	-1941	-769	-496	1436	1704	1648	1523
564	-	-	-	-	-	-	-	-
533	-	-	-	-	1517	1665	1654	1561

* Members are identefied in Fig. 3.13.
**Strain gauge locations are shown in Fig. 3.31.

Table A.15c Load-Strain Data for Specimen LR20 (Strain Gauges 17 to 24)

Load	Strain Gauge Readings (μstrain)							
	17	18	19	20	21	22	23	24
	Members on Which Strain Gauges are Attached*							
	CO2T		CO2B		TI2T		TI2B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
(kN)	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
48.4	-91	-342	-88	-338	117	114	104	130
93.9	-150	-656	-145	-652	215	211	191	244
141	-180	-970	-170	-977	314	314	280	363
188	-206	-1251	-103	-1349	405	432	371	482
211	-246	-1317	-11	-1551	440	512	418	551
235	-236	-1338	177	-1741	443	651	459	650
246	-205	-1268	388	-1844	434	764	467	754
258	-177	-1196	550	-1895	488	834	522	818
270	-144	-1158	663	-1908	550	874	578	861
282	-133	-1157	-	-	619	925	640	913
293	-128	-1142	-	-	653	952	670	943
305	-117	-1112	-	-	703	993	714	983
317	-116	-1104	-	-	735	1022	741	1017
331	-111	-1066	-	-	771	1053	773	1053
340	-121	-1082	-	-	800	1079	798	1078
352	-114	-1036	-	-	838	1115	833	1119
364	-154	-1038	-	-	880	1148	869	1161
376	-150	-1013	-	-	918	1184	904	1200
387	-174	-1007	-	-	961	1218	937	1236
399	-189	-972	-	-	1000	1254	973	1275
411	-220	-943	-	-	1040	1282	1005	1308
423	-247	-901	-	-	1079	1313	1035	1342
434	-280	-849	-	-	1114	1348	1071	1374
446	-324	-779	-	-	1149	1374	1102	1410
458	-380	-735	-	-	1191	1399	1139	1440
469	-439	-676	-	-	1232	1425	1170	1470
481	-497	-608	-	-	1281	1452	1208	1506
493	-560	-544	-	-	1326	1478	1242	1534
505	-634	-460	-	-	1374	1502	1282	1565
516	-720	-370	-	-	1414	1521	1318	1595
528	-817	-275	-	-	1462	1549	1352	1624
540	-943	-142	-	-	1497	1565	1378	1649
552	-1145	59	-	-	1521	1583	1400	1659
564	-	-	-	-	-	-	-	-
533	-1210	217	-	-	1449	1490	1319	1584

* Members are identefied in Fig. 3.13.

**Strain gauge locations are shown in Fig. 3.31.

Table A.15d Load-Strain Data for Specimen LR20 (Strain Gauges 25 to 32)

Load (kN)	Strain Gauge Readings (μstrain)							
	25	26	27	28	29	30	31	32
	Members on Which Strain Gauges are Attached*							
	CI4T		CI4B		TO4T		TO4B	
	outside	inside	outside	inside	outside	inside	outside	inside
	Location of Strain Gauges**							
	344 mm from top	344 mm from top	344 mm from bot.	344 mm from bot.	257 mm from top	257 mm from top	257 mm from bot.	257 mm from bot.
0	0	0	0	0	0	0	0	0
48.4	-92	3	-60	-15	-9	59	21	36
93.9	-182	8	-133	-25	11	126	65	85
141	-290	14	-218	-36	39	200	114	145
188	-411	15	-330	-54	85	291	177	213
211	-476	13	-388	-65	111	340	214	252
235	-571	14	-462	-83	151	411	268	307
246	-636	15	-496	-93	182	452	303	344
258	-689	16	-550	-117	208	487	335	374
270	-750	14	-582	-122	241	513	369	400
282	-823	9	-662	-143	290	552	418	443
293	-875	9	-708	-152	324	574	449	467
305	-956	9	-785	-165	371	607	493	502
317	-1015	14	-826	-174	405	632	526	528
331	-1090	19	-878	-179	454	665	570	566
340	-1135	21	-925	-193	488	687	607	594
352	-1191	18	-981	-205	534	718	650	629
364	-1235	14	-1008	-220	583	751	694	662
376	-1280	12	-1043	-234	630	775	741	691
387	-1315	10	-1076	-250	678	794	780	725
399	-1350	7	-1098	-257	734	819	827	754
411	-1373	9	-1115	-256	785	827	878	774
423	-1397	11	-1146	-258	845	856	936	804
434	-1423	15	-1174	-274	904	882	989	836
446	-1455	23	-1190	-259	974	907	1046	875
458	-1456	26	-1182	-277	1033	938	1097	918
469	-1459	18	-1171	-294	1097	993	1154	978
481	-1453	8	-1155	-317	1158	1039	1198	1039
493	-1472	16	-1138	-336	1196	1084	1237	1086
505	-1484	17	-1124	-356	1239	1140	1280	1140
516	-1509	43	-1124	-375	1273	1199	1324	1193
528	-1532	50	-1126	-392	1303	1264	1368	1244
540	-1568	80	-1126	-420	1345	1338	1422	1306
552	-	-	-1095	-450	1365	1410	1468	1354
564	-	-	-	-	-	-	-	-
533	-	-	-967	-421	1254	1366	1372	1280

* Members are identefied in Fig. 3.13.
**Strain gauge locations are shown in Fig. 3.31.

APPENDIX - B

Tables of Load vs. Deflection for Test Specimens TR1 to TR4 and LR1 to LR20

Table B.1 Load-Deflection Data for Specimen TR1

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
11.7	0.65		
23.4	1.60		
29.2	1.88		
35.1	2.15		
40.9	2.43		
46.8	2.70		
52.6	2.95		
58.5	3.23		
64.3	3.44		
70.2	3.72		
76.0	4.21		
81.9	4.50		
93.6	5.00		
105	5.49		
117	6.01		
129	6.57		
140	7.09		
153	7.62		
164	8.07		
175	8.65		
187	9.17		
199	9.67		
211	10.17		
222	10.67		
234	11.37		
246	12.41		
269	13.01		
281	13.55		
292	14.17		
304	14.92		
316	15.87		
327	17.22		
304	21.52		
337	22.37		
316	26.17		
347	36.67	At the end of the test, the distances of maximum deflection of the buckled members were measured and they were as follows	
		CS2T out-of-plane (outside)	365 mm from top
		CS2B out-of-plane (inside)	355 mm from bot.
		CB3T out-of-plane (outside)	325 mm from top
		CB3B out-of-plane (inside)	410 mm from bot.
		CB4T out-of-plane (outside)	350 mm from top
		CB4B out-of-plane (inside)	375 mm from bot.

*For location of members CS2T, CS2B, CB3T, CB3B, CB4T, and CB4B refer to Fig. 3.4.

Table B.2 Load-Deflection Data for Specimen TR2

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
23.4	1.76		
46.8	2.94		
70.2	4.13		
93.6	5.27		
117	6.35		
140	7.42		
152	7.95		
164	8.50		
175	9.37		
181	9.67		
187	10.00		
193	10.42		
199	10.77		
205	11.07		
211	11.47		
216	11.76		
222	12.12		
228	12.44		
236	12.90		
240	13.07		
246	13.37		
251	13.65		
257	13.97		
263	14.27		
269	14.55		
276	14.93		
281	15.27		
287	15.62		
292	16.01		
298	16.41		
304	16.80		
310	18.47		
316	19.57		
322	21.37		
335	27.27		
340	31.27		
343	35.23	At the end of the test, the distances of maximum deflection of the buckled members were measured and they were as follows:	
		CS1B out-of-plane (outside)	340 mm from bot.
		CS2T out-of-plane (inside)	355 mm from top
		CS2B out-of-plane (outside)	345 mm from bot.
		CB3T out-of-plane (outside)	345 mm from top
		CB3B out-of-plane (inside)	345 mm from bot.
		CB4T out-of-plane (inside)	365 mm from top
		CB4B out-of-plane (outside)	360 mm from bot.

* For location of members CS1B, CS2T, CS2B, CB3T, CB3B, CB4T, and CB4B refer to Fig. 3.4.

Table B.3 Load-Deflection Data for Specimen TR3

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
23.4	3.11		
46.8	4.61		
70.2	5.87		
93.6	7.06		
117	8.21		
140	9.26		
152	9.84		
164	10.56		
175	11.26		
187	11.96		
194	12.39		
199	12.64		
205	12.97		
211	13.31		
216	13.61		
222	13.91		
228	14.26		
234	14.60		
240	14.88		
246	15.16		
251	15.54		
257	15.91		
263	16.26		
269	16.68		
275	17.11		
281	17.61		
287	18.11		
298	19.19		
304	19.63		
316	20.76		
322	21.36		
327	22.96		
333	23.96		
339	24.96		
343	32.86		
350	-	At the end of the test, the distances of maximum deflection of the buckled members were measured and they were as follows:	
		CS1T out-of-plane (outside)	410 mm from top
		CS1B out-of-plane (inside)	280 mm from bot.
		CS2T out-of-plane (outside)	345 mm from top
		CS2B out-of-plane (inside)	355 mm from bot.
		CB3T out-of-plane (outside)	345 mm from top
		CB3B out-of-plane (inside)	350 mm from bot.
		CB4T out-of-plane (inside)	355 mm from top
		CB4B out-of-plane (outside)	350 mm from bot.

* For location of members CS1T, CS1B, CS2T, CS2B, CB3T, CB3B, CB4T, and CB4B refer to Fig. 3.4.

Table B.4 Load-Deflection Data for Specimen TR4

Load (kN)	Deflection of Top Chord (mm)	Remarks	Loaction of Point of Max. Deflection of Buckled Member
0	0		
23.4	1.64		
46.8	2.89		
70.2	4.20		
93.6	5.57		
117	6.50		
140	7.61		
146	7.84	According to strain gauge readings, CS2 buckled	
152	8.27		
158	8.63		
164	9.03		
170	9.33		
175	9.67		
181	9.97		
187	10.21		
193	10.53		
199	10.86		
205	11.14		
211	11.41		
216	11.65		
222	11.93		
228	12.22		
234	12.50		
240	12.83		
246	13.11		
251	13.32		
257	13.62		
263	13.98		
269	14.32		
275	14.67		
281	15.14		
287	15.51		
292	16.74		
298	17.32		
304	18.41	According to strain gauge readings, CB4 buckled	
310	19.32		
316	20.57		
322	28.97		
350	-	At the end of the test, the locations of maximum deflection of the buckled members were measured and they were as follows	
		CS1T out-of-plane (inside)	335 mm from top
		CS1B out-of-plane (outside)	340 mm from bot.
		CS2T out-of-plane (inside)	355 mm from top
		CS2B out-of-plane (outside)	355 mm from bot.
		CB3T out-of-plane (outside)	335 mm from top
		CB3B out-of-plane (inside)	355 mm from bot.
		CB4T out-of-plane (inside)	360 mm from top
		CB4B out-of-plane (outside)	350 mm from bot.

* For location of members CS1T, CS1B, CS2T, CS2B, CB3T, CB3B, CB4T, and CB4B refer to Fig. 3.4.

Table B.5 Load-Deflection Data for Specimen LR1

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
23.5	1.98		
46.9	2.71		
70.4	3.41		
93.9	4.10		
117	4.77		
141	5.38		
164	6.01		
190	6.66		
211	7.21		
235	7.86		
258	8.45		
282	9.06		
305	9.61		
329	10.21		
352	10.81		
376	11.46		
399	-	Sudden failure occured, where	
		HF buckled in and out-of-plane (inside)	406 mm from top
		CC1T buckled in-plane	241 mm from top
		CC2B bucked out-of-plane (inside) and	254 mm from bot.
		load dropped to 249 kN, reloaded	
249	-		
271	-	HR buckled out-of-plane (outside),	419 mm from top
		CF3T out-of-plane (outside),	305 mm from top
		CF4T out-of-plane (outside) and	305 mm from top
		load dropped to 200 kN, reloaded	
200	20.51		
188	27.69		

* For location of members HF, CC1T, CC2B, HR, CF3T, and CF4T refer to Fig. 3.7.

Table B.6 Load-Deflection Data for Specimen LR2

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
27.0	1.21		
46.9	1.94		
70.4	2.75		
93.9	3.56		
117	4.30		
141	5.05		
164	5.74		
190	6.45		
211	7.14		
235	7.83		
246	8.27	The horiz. member at end panel started to buckle, so it was strengthenend by bolted angles, reloaded	
258	8.57		
270	8.94		
282	9.30		
293	9.64		
305	10.05		
313	-	Sudden failure occured, where	
		HF buckled out-of-plane (inside),	420 mm from top
		CC1T in-plane and out-of-plane (inside),	260 mm from top
		CC2T out-of-plane (inside),	250 mm from top
		and load dropped to 192 kN,	
		reloaded	
192	20.82	HR buckled out-of-plane (outside) load dropped, reloaded	410 mm from top
159	23.15	Top chord went out-of-plane	

* For location of members HF, CC1T, CC2T, and HR refer to Fig. 3.7.

Table B.7 Load-Deflection Data for Specimen LR3

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Points of Max. Deflection of Buckled Member
0	0		
23.5	1.72		
46.9	2.75		
70.4	3.76		
93.9	4.79		
111	-	HR (horizontal member at face of tension diagonals) buckled in-plane and out-of-plane (outside), load dropped to 72.8 kN, reloaded	420 mm from top
72.8	-		
103	8.26		
117	9.44		
129	10.50		
141	11.85		
150	-	C2 buckled out-of-plane (outside), load dropped to 120 kN, reloaded	550 mm from top
120	13.36		
139	-	C1 buckled in-plane and out-of-plane (inside), load dropped to 121 kN, reloaded	520 mm from top
121	15.70		
153	-	HF (horiz. member at face of comp. Diagonals) buckled out-of-plane (outside), and load dropped to 103 kN, reloaded	475 mm from top
103	24.78		
120	32.50		

* For locations of members HR, C2, C1, and HF refer to Fig. 3.1.

Table B.8 Load-Deflection Data for Specimen LR4

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
23.5	1.24		
46.9	2.24		
70.4	3.21		
93.9	4.14		
106	4.61		
117	5.01		
129	-	HR (horizontal member at face of tension diagonals) buckled in-plane and out-of-plane (outside), at space between bolted (stiffening) angles, load dropped to 77.9 kN, reloaded	420 mm from top
77.9	5.77		
93.9	6.62		
106	7.24		
129	7.79		
129	9.45		
141	10.89		
153	-	C2 buckled out-of-plane (inside), load dropped to 110 kN, reloaded	470 mm from top
110	12.59		
129	14.35		
141	-	C1 buckled in-plane (towards centre) and out-of-plane (inside), load dropped to 124 kN, reloaded	480 mm from top
124	16.74		
141	21.45		
153	26.78		

* For locations of members HR, C1, and C2 refer to Fig. 3.1.

Table B.9 Load-Deflection Data for Specimen LR5

Load (kN)	Deflection of Top Chord (mm)	Remarks	Loaction of Point of Max. Deflection of Buckled Member
0	0		
46.9	1.45		
93.9	2.78		
141	4.02		
188	5.23		
235	6.44		
258	6.96		
282	7.47		
305	7.98		
329	8.51		
352	9.10		
364	9.52		
376	9.80		
387	10.10		
399	10.43		
411	10.78		
423	11.16		
434	11.73		
446	12.53		
451	-	Horiz.member at support buckled out-of-plane at lower part (inside), and due to that comp. Diagonal at same face buckled out-of-plane (inside), load dropped to 423 kN, reloaded	
423	-		
446	14.54		
458	-	Horiz. member at opposite face buckled out-of-plane at lower part (inside), and comp. Diagonal at same face buckled out-of-plane (inside), load dropped to 383 kN	
383	18.68		

Table B.10 Load-Deflection Data for Specimen LR6

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
46.9	1.81		
93.9	3.49		
141	4.93		
188	6.37		
235	7.72		
282	9.02		
293	9.30		
305	9.65		
317	9.92		
329	10.25		
340	10.62		
352	10.89		
364	11.32		
376	11.64		
387	12.02		
399	12.40		
411	12.90	Indication of buckling (visually) of the diagonal CC3, where	
		CC3T buckled out-of-plane (outside) and	370 mm from top
		CC3B out-of-plane (inside)	290 mm from bot.
423	13.15		
434	13.59		
446	13.96		
458	14.65		
469	15.25		
481	15.87		
491	16.40		
495	17.25		
505	-	CC4T buckled out-of-plane (outside)	270 mm from top
513	21.03	The horiz. member HF(in-plane of diagonals CF1 and CF2) buckled in-plane, for lack of welding, and due to that members CF1 and CF2 buckled, where	
		CF2B buckled out-of-plane (outside),	300 mm from top
		CF1B buckled out-of-plane (outside)	380 mm from bot.

* For location of members CC3T, CC3B, CC4T, HF, CF2B, and CF1B refer to Fig. 3.9.

Table B.11 Load-Deflection Data for Specimen LR7

Load (kN)	Deflection of Top Chord (mm)	Remarks	Loaction of Point of Max. Deflection of Buckled Member
0	0		
23.5	1.20		
46.9	2.13		
70.4	3.00		
82.2	3.45		
93.9	3.89		
106	4.30		
117	4.75		
129	5.19		
141	5.60		
153	6.05		
164	6.48		
176	7.00		
184	-	C1 buckled out-of-plane (inside) and in-plane (towards centre), load dropped to 145 kN, reloaded	515 mm from bot.
145	7.30		
153	7.95		
164	8.65		
176	9.38		
188	10.10		
200	10.96		
211	11.77		
223	12.78		
235	14.15		
244	-	C2 buckled out-of-plane (outside) and in-plane (towards centre), load dropped to 223 kN, reloaded	515 mm from bot.
223	15.10		
235	16.72		
246	18.27		

* For location of members C1, and C2 refer to Fig. 3.2.

Table B.12 Load-Deflection Data for Specimen LR8

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
27.0	1.34		
46.9	2.05		
70.4	2.89		
82.2	3.31		
93.9	3.74		
106	4.15		
117	4.57		
129	4.97		
141	5.37		
153	5.74		
164	6.16		
176	6.60		
184	-	C2 buckled out-of-plane (outside), load dropped to 135 kN, reloaded	520 mm from bot.
135	7.25		
141	7.63		
153	8.35		
164	-	C1 buckled out-of-plane (outside) and in-plane (towards centre), load dropped to 136 kN, reloaded	520 mm from bot.
136	9.32		
176	-		

* For location of members C1, and C2 refer to Fig. 3.1.

Table B.13 Load-Deflection Data for Specimen LR9

Load (kN)	Deflection of Top Chord (mm)	Remarks	Loaction of Point of Max. Deflection of Buckled Member
0	0		
23.5	1.18		
46.9	2.23		
70.4	3.23		
82.2	3.74		
93.9	4.27		
106	4.76		
117	5.29		
129	5.78		
141	6.30		
153	6.83		
164	7.36		
175	7.87		
179	-	C1 buckled out-of-plane (inside) and in-plane (towards centre), load dropped to 112 kN, reloaded	525 mm from bot.
112	8.53		
117	8.93		
129	9.43		
141	10.03		
153	10.68		
164	11.32		
176	12.01		
184	-	Compression diagonal at end panel near end without pipe connection buckled out-of-plane (outside) despite stiffening it by bolted angles, load dropped to 121 kN, reloaded	
121	13.15		
131	-		

* For location of member C1 refer to Fig. 3.3.

Table B.14 Load-Deflection Data for Specimen LR10

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
23.5	1.31		
46.9	2.32		
70.4	3.39		
82.2	3.94		
93.9	4.59		
106	4.99		
117	5.43		
129	6.01		
141	6.55		
153	7.06		
164	-	C1 buckled out-of-plane (inside), load dropped to 112 kN, reloaded	505 mm from bot.
112	7.79		
117	8.68		
129	9.50		
141	10.33		
153	11.10		
164	11.94		
176	12.74		
184	-	C2 buckled out-of-plane (inside), load dropped to 121 kN, reloaded	515 mm from bot.
149	13.51		
153	14.89		
154	15.66		

* For location of members C1 and C2 refer to Fig. 3.3.

Table B.15 Load-Deflection Data for Specimen LR11

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
23.5	1.55		
46.9	2.63		
70.4	3.67		
82.2	4.19		
93.9	4.60		
106	5.09		
117	5.63		
131	6.12		
141	6.44		
154	6.94		
164	7.43		
176	7.82		
188	8.34		
200	-	C1 buckled out-of-plane (outside) and in-plane (away from centre), load dropped to 144 kN, reloaded	515 mm from bot.
144	8.61		
156	8.99		
164	9.35		
176	9.89		
188	10.42		
200	10.94		
211	11.54		
223	12.06		
235	12.76		
246	14.24		
257	-	C2 buckled out-of-plane (outside) and in-plane (towards centre), load dropped to 233 kN, reloaded	515 mm from bot.
233	13.97		
245	15.19		
258	16.94		
270	20.27		
281	22.17	Our weldings started to fail and load dropped	

* For loction of members C1 and C2 refer to Fig. 3.2.

Table B.16 Load-Deflection Data for Specimen LR12

Load (kN)	Deflection of Top Chord (mm)	Remarks	Locaton of Point of Max. Deflection of Buckled Member
0	0		
23.5	1.78		
46.9	2.91		
70.4	3.89		
82.2	4.35		
93.9	4.70		
106	5.35		
114	-	C2 buckled out-of-plane (outside), load dropped to 80 kN, reloaded	510 mm from bot.
80	6.05		
94	7.02		
106	7.76		
117	8.95		
129	9.66		
141	10.51		
153	11.28		
164	12.00		
172	-	C1 buckled out-of-plane (outside), load dropped to 146 kN, reloaded	510 mm from bot.
146	12.91		
164	15.76		
176	18.20		

* For location of members C1 and C2 refer to Fig. 3.1.

Table B.17 Load-deflection Data for Specimen LR13

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of point of Max. Deflection of Buckled Member
0	0		
23.5	0.85		
46.9	1.81		
70.4	2.57		
93.9	3.45		
117	4.14		
144	4.94		
164	5.57		
176	6.00		
188	6.44		
200	6.82		
214	7.27		
227	7.74		
235	8.19		
246	8.66	C2 buckled out-of plane (outside)	425 mm from bot.
258	9.17		
270	9.77		
282	10.27		
293	10.66		
305	11.03		
317	11.64	C1 buckled out-of-plane (outside)	630 mm from bot.
329	11.99		
340	12.45		
352	13.30		
364	13.67		
376	14.33		
387	14.73		
399	15.10		
411	16.52	C3 buckled out-of-plane (inside)	330 mm from bot.
423	24.78	C4 buckled out-of-plane (outside)	680 mm from bot.
425	-	Applying more load led to failure of horiz. member (in-plane of members C3 and C4)	

* For location of members C1, C2, C3, and C4 refer to Fig. 3.10.

Table B.18 Load-Deflection Data for Specimen LR14

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
46.9	2.01		
93.9	3.43		
141	4.78		
188	6.04		
235	7.29		
282	8.49		
305	9.01		
329	9.61		
352	10.15		
376	10.65		
399	11.17		
423	12		
434	12.25	C2 buckled out-of-plane (outside) at connection of plate (used for passing cables through in actual tower).	775 mm from bot.
446	12.56		
458	13.01		
469	13.47		
485	13.99	C1 buckled out-of-plane (inside), load dropped to 462 kN, reloaded	280 mm from bot.
462	-		
469	-	C3 buckled out-of-plane (outside), load dropped to 428 kN, reloaded	665 mm from bot.
428	13.74		
444	-	Load dropped to 413 kN, and according to strain gauges readings member C4 buckled, but it was not clear visually.	
413	17.39	horiz. Member in-plane of members C1 and C2 buckled in-plane due to lack of welding, load dropped down when reloaded	
352	18.02		

* For location of members C1, C2, C3, and C4 refer to Fig. 3.9.

Table B.19 Load-Deflection Data for Specimen LR15

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
49.3	1.45		
96.2	2.75		
141	4.02		
188	5.37		
235	6.65		
282	7.79		
329	8.95		
352	9.47		
376	10.03		
396	-	Member C3 buckled , where	
		C3 top buckled out-of-plane (outside)	730 mm from bot.
		C3 bot. buckled out-of-plane (inside),	395 mm from bot.
		and load dropped to 377 kN, reloaded	
377	10.54		
387	10.77		
399	11.03		
411	11.35		
423	11.77		
434	12.30		
446	12.66		
458	12.87		
469	13.30		
481	-	C1 buckled out-of-plane (outside), load dropped to 467 kN, reloaded	740 mm from bot.
467	-		
477	14.07		
487	14.80		
493	15.19		
505	15.85		
516	-	C4 buckled out-of-plane (outside), load dropped to 493 kN, reloaded	735 mm from bot.
493	16.24		
507	-	C2 buckled out-of-plane (outside), load dropped to 479 kN, reloaded	240 mm from bot.
479	16.72		

* For location of members C1, C2, C3 and C4 refer to Fig. 3.7.

Table B.20 Load-Deflection Data for Specimen LR16

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
46.9	1.73		
93.9	7.60		
141	9.01		
188	10.32		
235	11.50		
282	12.75		
329	13.85		
352	14.37		
376	14.97		
387	15.27		
399	15.55		
411	15.85		
423	-	C2 buckled out-of-plane (outside) at connection of plate (used for passing cables through in actual tower), load dropped to 413 kN, reloaded	750 mm from bot.
413	16.14		
423	16.37		
434	16.59		
446	16.91		
458	17.15		
472	17.63		
481	-	C1 buckled out-of-plane (outside), load dropped to 471 kN, reloaded	745 mm from bot.
471	17.90		
481	18.44		
493	19.15		
505	20.10		
519	-	C3 buckled out-of-plane (inside), load dropped to 493 kN, reloaded	760 mm from bot.
493	21.02		
503	-	C4 buckled out-of-plane (inside), load dropped to 491 kN, reloaded	800 mm from bot.
491	21.85		
505	-	buckling of upper leg was noticed at middle of panel containing members C1, T1, C3 and T3,load dropped to 446kN	
446	22.67		

* For location of members C1, C2, C3, C4, T1, and T3 refer to Fig. 3.8.

Table B.21 Load-Deflection Data for Specimen LR17

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
46.9	1.89		
93.9	3.54		
141	5.01		
188	6.46		
211	7.12		
223	7.47		
235	7.93		
246	8.23		
258	8.64		
270	9.02	C2 buckled out-of-plane (outside)	635 mm from bot.
282	9.33	C3 buckled out-of-plane (inside), and at the end of the test the buckled shape of member C2 was clearly S-shape where,	
		C3 top buckled out-of-plane (inside) and	670 mm from bot.
		C3 bot. buckled out-of-plane (outside)	340 mm from bot.
293	9.76		
305	10.11		
317	10.51		
329	10.90		
340	11.27		
352	11.65		
364	12.04		
376	12.45		
387	12.83		
399	13.23		
411	13.64		
423	14.08		
434	14.55		
446	15.03		
458	15.58	C1 buckled out-of-plane (inside)	not clear
469	16.23		
481	16.87		
493	17.61		
505	18.63		
516	19.89	C4 buckled out-of-plane (inside)	not clear
529	-	Horizontal member in-plane of C3, T3, C4 and T4 buckled with the welded (stiffening) angles, load dropped to 511 kN	
511	21.48		

* For location of members C1, C2, C3, C4, T3, and T4 refer to Fig. 3.11.

Table B.22 Load-Deflection Data for Specimen LR18

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
46.9	1.85		
93.9	3.51		
141	5.13		
188	6.75		
211	7.64	C3 buckled out-of-plane (outside)	425 mm from bot.
235	8.58		
246	9.35		
258	9.82		
270	10.37	C2 buckled out-of-plane (inside), at the end of the test the buckled shape was S-shape, where	
		C2 top buckled out-of-plane (outside), and	655 mm from bot.
		C2 bot. Buckled out-of-plane (inside)	375 mm from bot.
282	10.87		
293	11.44		
305	11.86		
317	12.34		
329	12.80		
340	13.24		
352	13.66		
364	14.18		
376	14.63		
387	15.17	C4 buckled out-of-plane (outside)	630 mm from bot.
399	15.87		
411	17.14		
423	18.76	C1 buckled out-of-plane (inside)	450 mm from bot.
435	-	Top chord buckled at centre of panel, containing members C1, T1, C3 and T3, load dropped to 389 kN	
389	20.55		

*For location of members C1, C2, C3, C4, T1, and T3 refer to Fig. 3.12.

Table B.23 Load-Deflection Data for Specimen LR19

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
46.9	1.81		
93.9	3.16		
141	4.37		
189	5.59		
236	6.71		
282	7.73		
329	8.76		
352	9.25		
376	9.72		
399	10.24		
412	-	C2 buckled out-of-plane and at the end of the test the buckled shape was S-shape, where	
		C2 top buckled out-pf-plane (inside) and	720 mm from bot.
		C2 bot. Buckled out-of-plane (outside)	400 mm from bot.
		load dropped to 404 kN, reloaded	
404	10.48		
412	10.65		
423	10.90		
436	-	C4 buckled out-of-plane (outside), load dropped to 426 kN, reloaded	705 mm from bot.
426	11.28		
434	11.53		
446	12.01		
458	-	C1 buckled out-of-plane (outside), load dropped to 444 kN, reloaded	740 mm from bot.
444	12.48		
460	-	C3 buckled out-of-plane (inside), load dropped to 437 kN, reloaded	730 mm from bot.
437	13.23		
446	13.58		
458	14.36		
467	15.67		
482	-	Horizontal member started buckling in-plane with the welded (stiffening angle)	

* For location of members C1, C2, C3, and C4 refer to Fig. 3.7.

Table B.24 Load-Deflection Data for Specimen LR20

Load (kN)	Deflection of Top Chord (mm)	Remarks	Location of Point of Max. Deflection of Buckled Member
0	0		
48.4	1.73		
93.9	3.31		
141	4.85		
188	6.34		
211	7.08		
235	7.85	C2 buckled according to strain gauges readings, at the end of the test the buckled shape was clearer, out-of-plane (outside)	400 mm from bot.
246	8.27		
258	8.68	C3 buckled according to strain gauges readings, at the end of the test the buckled shape was clearer, out-of-plane (outside)	635 mm from bot.
270	9.10		
282	9.66		
293	10.01		
305	10.50		
317	10.83		
331	11.28		
340	11.62		
352	12.01		
364	12.45		
376	12.82		
387	13.22		
399	13.63		
411	13.99		
423	14.43		
434	14.83		
446	15.32		
458	15.80		
469	16.34		
481	16.93		
493	17.42		
505	18.00	C1 buckled according to strain gauges readings, at the end of the test the buckled shape was clearer, S-shape, where	
		C1 top buckled out-of-plane (inside) and	650 mm from bot.
		C1 bot. Buckled out-of-plane (outside)	325 mm from bot.
516	18.64		
528	19.33		
540	20.20	C4 buckled according to strain gauges readings	not clear
552	21.40		
564	-	Maximum load reached, load dropped to 533 kN	
533	24.22		

APPENDIX - C

Tables of Axial Forces in Bracing Diagonals for Specimens TR4, LR1 to LR20

Table C.1a Axial Forces in Bracing Diagonals for Specimen TR4 (Section 1)*

Load (kN)	Axial Force in Member (kN)**				Shear resisted by Member (kN)***				Total Shear (kN)
	CS2T	TB2B	CB4T	TS4B	CS2T	TB2B	CB4T	TS4B	
0	0	0	0	0	0	0	0	0	0
23.4	10.2	9.20	0.90	0.80	6.30	5.68	0.56	0.49	13.0
46.8	19.3	10.2	3.00	3.00	11.9	6.30	1.85	1.85	21.9
70.2	28.4	14.2	5.60	6.30	17.5	8.77	3.46	3.89	33.7
93.6	36.7	18.1	8.00	9.60	22.7	11.2	4.94	5.93	44.7
117	44.4	21.6	10.7	13.3	27.4	13.3	6.61	8.22	55.6
129	47.4	24.3	12.3	15.4	29.3	15.0	7.60	9.51	61.4
136	49.3	25.4	13.2	17.0	30.5	15.7	8.15	10.5	64.8
140	50.5	26.7	14.0	18.0	31.2	16.5	8.65	11.1	67.5
146	52.4	28.3	14.7	19.2	32.4	17.5	9.08	11.9	70.8
152	52.4	33.6	16.4	21.2	32.4	20.8	10.1	13.1	76.4
158	49.4	38.1	17.5	22.9	30.5	23.5	10.8	14.1	79.0
164	46.2	43.0	19.2	25.1	28.6	26.6	11.9	15.5	82.5
170	44.3	45.8	20.6	27.1	27.4	28.3	12.7	16.7	85.1
175	42.7	48.6	21.6	28.8	26.4	30.0	13.3	17.8	87.5
181	41.0	51.5	22.5	30.5	25.3	31.8	13.9	18.8	89.9
187	40.2	53.6	23.5	31.9	24.8	33.1	14.5	19.7	92.2
193	39.0	56.3	22.0	34.1	24.1	34.8	13.6	21.1	93.5
199	37.9	58.9	26.1	36.1	23.4	36.4	16.1	22.3	98.3
205	36.7	61.0	23.3	38.1	22.6	37.7	14.4	23.5	98.3
211	35.9	62.7	23.2	39.9	22.2	38.7	14.3	24.6	99.9
216	35.1	64.8	23.9	41.6	21.7	40.0	14.8	25.7	102
222	34.3	66.7	24.4	43.6	21.2	41.2	15.1	26.9	104
228	33.8	68.8	28.8	46.2	20.9	42.5	17.8	28.5	110
234	33.6	70.3	29.9	47.4	20.8	43.4	18.5	29.3	112
240	33.2	72.3	31.6	50	20.5	44.7	19.5	30.9	116
246	32.9	74.1	33.4	51.8	20.3	45.8	20.6	32.0	119
251	32.6	75.5	35.5	53.4	20.2	46.6	21.9	33.0	122
257	32.0	77.3	37.1	55.5	19.8	47.8	22.9	34.3	125
263	31.7	79.2	41.2	58.2	19.6	48.9	25.4	36.0	130
269	31.5	81.3	43.9	60.5	19.4	50.2	27.1	37.4	134
275	30.7	83.5	43.2	62.4	19.0	51.6	26.7	38.5	136
281	29.6	85.9	44.3	64.4	18.3	53.0	27.3	39.8	138
287	28.0	87.0	45.5	66.5	17.3	53.7	28.1	41.1	140
292	20.3	88.2	47.4	70.1	12.5	54.5	29.3	43.3	140
298	14.4	88.7	48.5	73.5	8.91	54.8	29.9	45.4	139
304	14.1	88.7	48.4	78.4	8.71	54.8	29.9	48.4	142
310	-	89.2	48.4	81.5	-	55.1	29.9	50.3	-
316	-	89.6	-	88.6	-	55.3	-	54.7	-
322	-	91.0	-	-	-	56.2	-	-	-
327	-	93.4	-	-	-	57.7	-	-	-

* Section at Which Forces are computed is identified in Fig. 3.21.

** The axial forces are calculated from strain data

*** Shear resisted by each member= axial force in member x Sin 60° x 763/1070

Note: Shaded numbers are max. forces resisted by compression diagonal.

Table C.1b Axial Forces in Bracing Diagonals for Specimen TR4 (Section 2)*

Load (kN)	Axial Force in Member (kN)**				Shear resisted by Member (kN)***				Total Shear (kN)
	CS2B	TB2T	CB4B	TS4T	CS2B	TB2T	CB4B	TS4T	
23.4	10.6	4.7	1	0.8	6.5	2.9	0.6	0.5	10.6
46.8	19.8	9.6	3.1	3.1	12.2	5.9	1.9	1.9	22.0
70.2	28.9	14.2	5.5	6.3	17.9	8.8	3.4	3.9	33.9
93.6	37.4	18.1	8	9.6	23.1	11.2	4.9	5.9	45.2
117	46.7	22.1	10.7	13.4	28.8	13.7	6.6	8.3	57.4
129	54.8	24.8	12.1	15.5	33.8	15.3	7.5	9.6	66.2
136	56.5	25.9	13.1	17.1	34.9	16.0	8.1	10.6	69.5
140	57.2	27.3	13.8	18.2	35.3	16.9	8.5	11.2	72.0
146	58.4	28.9	14.7	19.5	36.1	17.9	9.1	12.0	75.0
152	55.8	35.3	16	21.4	34.5	21.8	9.9	13.2	79.4
158	52.0	40.3	17.2	23.1	32.1	24.9	10.6	14.3	81.9
164	46.4	45.1	18.6	25.1	28.7	27.9	11.5	15.5	83.5
170	44.2	48.5	19.9	27.4	27.3	30.0	12.3	16.9	86.5
175	-	51.1	20.8	29	-	31.6	12.8	17.9	-
181	-	53.8	21.8	31	-	33.2	13.5	19.2	-
187	-	56	22.7	32.1	-	34.6	14.0	19.8	-
193	-	59	23.8	34	-	36.4	14.7	21.0	-
199	-	61.6	25.1	36.3	-	38.1	15.5	22.4	-
205	-	63.9	25.9	38.2	-	39.5	16.0	23.6	-
211	-	65.6	26.7	40.1	-	40.5	16.5	24.8	-
216	-	67.3	27.6	41.7	-	41.6	17.1	25.8	-
222	-	69.4	28.4	43.8	-	42.9	17.5	27.1	-
228	-	71.7	29.6	46.4	-	44.3	18.3	28.7	-
234	-	72.9	30.1	47.8	-	45.0	18.6	29.5	-
240	-	74.9	31	50.3	-	46.3	19.2	31.1	-
246	-	76.7	31.6	52.2	-	47.4	19.5	32.2	-
251	-	78	32.3	53.9	-	48.2	20.0	33.3	-
257	-	79.9	32.9	55.8	-	49.4	20.3	34.5	-
263	-	81.8	33.8	58.4	-	50.5	20.9	36.1	-
269	-	83.6	34.4	60.5	-	51.7	21.3	37.4	-
275	-	86.0	35.3	62.6	-	53.1	21.8	38.7	-
281	-	88.1	36	64.6	-	54.4	22.2	39.9	-
287	-	90.1	36.7	66.7	-	55.7	22.7	41.2	-
292	-	91.2	37.9	70.5	-	56.3	23.4	43.6	-
298	-	91.7	38.4	73.4	-	56.7	23.7	45.3	-
304	-	92.0	37.9	78.4	-	56.8	23.4	48.4	-
310	-	92.4	37.2	81.3	-	57.1	23.0	50.2	-
316	-	92.8	32.9	86.6	-	57.3	20.3	53.5	-
322	-	93.4	-	90.9	-	57.7	-	56.2	-
327	-	-	-	91.4	-	-	-	56.5	-

* Section at Which Forces are computed is identified in Fig. 3.21.

** The axial forces are calculated from strain data

*** Shear resisted by each member= axial force in member x Sin 60° x 763/1070.

Note: Shaded numbers are max. forces resisted by compression diagonal.

Table C.2a Axial Forces in Bracing Diagonals for Specimen LR10 (Section 1)*

Load	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	C1		T1		C1		T1				
(kN)	normal	inplane	normal	inplane	normal	inplane	normal	inplane	(kN)	C	T
0	0	0	0	0	0	0	0	0	0	0	0
23.5	13.4	14.3	3.38	3.88	9.50	10.2	2.41	2.76	12.4	8.28	7.37
46.9	23.8	24.6	8.03	8.53	16.9	17.5	5.71	6.07	23.1	16.6	14.7
70.4	33.6	34.2	13.9	14.3	23.9	24.3	9.88	10.2	34.1	24.8	22.1
82.2	39.0	39.6	16.8	17.0	27.8	28.2	12.0	12.1	40.0	29.0	25.8
93.9	45.6	46.0	20.3	20.3	32.5	32.7	14.4	14.4	47.0	33.1	29.5
106	50.4	51.5	21.1	21.5	35.8	36.7	15.0	15.3	51.4	37.2	33.2
117	54.7	55.5	23.7	24.2	38.9	39.5	16.9	17.2	56.3	41.4	36.9
129	59.0	59.4	27.3	27.4	42.0	42.2	19.4	19.5	61.6	45.5	40.5
141	64.3	65.1	30.3	30.3	45.7	46.4	21.5	21.6	67.6	49.7	44.2
153	69.2	70.6	33.6	33.6	49.3	50.2	23.9	23.9	73.6	-	-
158	-	-	-	-	-	-	-	-	-	-	-
106	-	-	40.4	39.8	-	-	28.7	28.3	-	-	-
117	-	-	48.9	48.1	-	-	34.8	34.2	-	-	-
129	-	-	56.5	55.6	-	-	40.2	39.6	-	-	-
141	-	-	64.5	63.7	-	-	45.9	45.3	-	-	-
153	-	-	71.7	70.9	-	-	51.0	50.4	-	-	-
164	-	-	79.6	78.6	-	-	56.6	55.9	-	-	-
176	-	-	86.1	85.2	-	-	61.3	60.6	-	-	-
183	-	-	-	-	-	-	-	-	-	-	-
149	-	-	65.5	64.5	-	-	46.6	45.9	-	-	-
153	-	-	68.1	67.2	-	-	48.5	47.8	-	-	-
154	-	-	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.22.

** The axial force in each diagonal is calculated from strain gauge readings twice; once normal to the plane of the bracing and second in-plane of the bracing.

*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020

Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.2b Axial Forces in Bracing Diagonals for Specimen LR10 (Section 2)*

Load	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	C2		T2		C2		T2				
(kN)	normal	inplane	normal	inplane	normal	inplane	normal	inplane	(kN)	C	T
0	0	0	0	0	0	0	0	0	0	0	0
23.5	3.18	2.95	15.7	14.7	2.26	2.10	11.2	10.4	13.0	8.28	7.37
46.9	7.14	6.83	25.9	24.8	5.08	4.86	18.4	17.6	23.0	16.6	14.7
70.4	12.0	11.7	37.3	35.9	8.53	8.31	26.5	25.5	34.4	24.8	22.1
82.2	14.5	14.2	42.9	41.6	10.3	10.1	30.5	29.6	40.3	29.0	25.8
93.9	17.9	17.8	49.2	47.9	12.7	12.6	35.0	34.1	47.2	33.1	29.5
106	19.8	19.6	53.1	52.1	14.1	14.0	37.8	37.1	51.4	37.2	33.2
117	22.1	22.0	57.7	56.7	15.7	15.7	41.1	40.3	56.4	41.4	36.9
129	24.9	24.7	62.7	61.3	17.7	17.6	44.6	43.6	61.8	45.5	40.5
141	27.7	27.5	67.6	66.4	19.7	19.5	48.1	47.2	67.3	49.7	44.2
153	31.0	30.8	71.7	70.6	22.0	21.9	51.0	50.2	72.6	-	-
158	-	-	-	-	-	-	-	-	-	-	-
106	28.0	27.3	42.5	41.8	19.9	19.4	30.2	29.8	49.7	-	-
117	33.6	32.8	45.5	44.2	23.9	23.4	32.4	31.4	55.5	-	-
129	38.8	38.1	47.5	46.1	27.6	27.1	33.8	32.8	60.7	-	-
141	44.6	43.6	49.6	48.3	31.8	31.0	35.3	34.4	66.2	-	-
153	49.9	48.7	51.4	49.9	35.5	34.7	36.6	35.5	71.1	-	-
164	55.6	54.4	53.2	52.1	39.6	38.7	37.8	37.1	76.6	-	-
176	59.8	59.4	54.7	53.4	42.6	42.3	38.9	38.0	80.9	-	-
183	-	-	-	-	-	-	-	-	-	-	-
149	-	-	61.8	60.8	-	-	44.0	43.2	-	-	-
153	-	-	66.4	65.4	-	-	47.3	46.6	-	-	-
154	-	-	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.22.

** The axial force in each diagonal is calculated from strain gauge readings twice; once normal to the plane of the bracing and second in-plane of the bracing.

*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020

Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.3a Axial Forces in Bracing Diagonals for Specimen LR11 (Section 1)*

Load	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	C1		T1		C1		T1				
(kN)	normal	inplane	normal	inplane	normal	inplane	normal	inplane	(kN)	C	T
0	0	0	0	0	0	0	0	0	0	0	0
23.5	16.3	14.9	2.48	2.17	11.7	10.7	1.77	1.55	12.8	8.28	7.37
46.9	28.6	26.6	5.32	5.28	20.5	19.0	3.81	3.78	23.5	16.6	14.7
70.4	39.5	37.5	9.54	9.62	28.3	26.8	6.82	6.88	34.4	24.8	22.1
82.2	44.8	43.1	12.1	12.1	32.0	30.8	8.63	8.63	40.1	29.0	25.8
93.9	49.5	47.8	13.5	13.6	35.4	34.2	9.63	9.71	44.5	33.1	29.5
106	54.5	52.9	16.1	16.3	39.0	37.8	11.5	11.7	50.0	37.2	33.2
117	59.8	58.6	19.2	19.0	42.8	41.9	13.7	13.6	56.0	41.4	36.9
131	64.2	63.4	21.3	21.9	45.9	45.4	15.3	15.7	61.1	46.4	41.3
141	67.8	67.2	23.1	23.2	48.5	48.1	16.5	16.6	64.9	49.7	44.2
154	72.4	72.1	26.0	26.5	51.8	51.5	18.6	19.0	70.4	54.2	48.3
164	77.4	77.3	28.8	28.7	55.4	55.3	20.6	20.5	75.9	57.9	51.6
176	81.3	81.8	31.0	31.2	58.1	58.5	22.2	22.3	80.6	62.1	55.3
188	86.5	87.4	34.3	34.3	61.9	62.5	24.6	24.6	86.8	66.2	59.0
200	-	-	-	-	-	-	-	-	-	-	-
144	-	-	44.6	44.9	-	-	31.9	32.1	-	-	-
154	-	-	49.9	50.4	-	-	35.7	36.1	-	-	-
164	-	-	54.5	54.6	-	-	39.0	39.1	-	-	-
176	-	-	61.0	61.0	-	-	43.6	43.6	-	-	-
188	-	-	66.8	67.1	-	-	47.8	48.0	-	-	-
200	-	-	72.9	73.1	-	-	52.1	52.3	-	-	-
214	-	-	79.3	79.3	-	-	56.7	56.7	-	-	-
223	-	-	84.4	84.9	-	-	60.3	60.8	-	-	-
235	-	-	91.1	91.0	-	-	65.2	65.1	-	-	-
246	-	-	95.7	95.8	-	-	68.4	68.5	-	-	-
257	-	-	-	-	-	-	-	-	-	-	-
233	-	-	86.1	86.1	-	-	61.6	61.6	-	-	-
245	-	-	89.1	89.6	-	-	63.8	64.1	-	-	-
258	-	-	94.4	94.1	-	-	67.6	67.3	-	-	-
270	-	-	99.1	99.8	-	-	70.9	71.4	-	-	-
281	-	-	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.23.

** The axial force in each diagonal is calculated from strain gauge readings twice; once normal to the plane of the bracing and second in-plane of the bracing.

*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030.

Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.3b Axial Forces in Bracing Diagonals for Specimen LR11 (Section 2)*

Load	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	C2		T2		C2		T2				
(kN)	normal	inplane	normal	inplane	normal	inplane	normal	inplane	(kN)	C	T
0	0	0	0	0	0	0	0	0	0	0	0
23.5	4.38	4.27	11.5	11.4	3.13	3.05	8.19	8.16	11.3	8.28	7.37
46.9	8.69	8.61	23.1	22.5	6.22	6.16	16.5	16.1	22.5	16.6	14.7
70.4	14.0	13.7	33.5	32.7	10.0	9.82	24.0	23.4	33.6	24.8	22.1
82.2	16.3	16.2	39.3	38.6	11.6	11.6	28.1	27.6	39.5	29.0	25.8
93.9	18.7	18.3	43.6	42.8	13.4	13.1	31.2	30.6	44.2	33.1	29.5
106	21.8	21.3	49.1	48.3	15.6	15.3	35.1	34.6	50.3	37.2	33.2
117	25.0	24.6	54.6	53.9	17.9	17.6	39.1	38.5	56.5	41.4	36.9
131	27.9	27.8	59.2	58.4	20.0	19.9	42.3	41.8	62.0	46.4	41.3
141	29.9	29.6	62.8	62.1	21.4	21.1	44.9	44.4	65.9	49.7	44.2
154	32.6	32.2	68.3	67.4	23.3	23.1	48.9	48.2	71.7	54.2	48.3
164	36.0	35.4	73.2	72.3	25.7	25.3	52.3	51.7	77.6	57.9	51.6
176	38.4	38.1	77.0	76.1	27.5	27.3	55.1	54.5	82.1	62.1	55.3
188	42.3	41.7	82.7	82.0	30.3	29.8	59.2	58.6	89.0	66.2	59.0
200	-	-	-	-	-	-	-	-	-	-	-
144	32.9	32.6	58.2	57.3	23.5	23.3	41.6	41.0	64.7	-	-
154	36.4	36.1	60.7	59.9	26.0	25.8	43.4	42.9	69.0	-	-
164	39.2	38.9	62.1	61.3	28.1	27.8	44.4	43.9	72.1	-	-
176	43.4	43.0	64.0	63.4	31.1	30.8	45.8	45.4	76.5	-	-
188	47.4	47.1	66.4	65.7	33.9	33.7	47.5	47.0	81.0	-	-
200	51.5	50.9	68.6	67.5	36.8	36.4	49.1	48.3	85.3	-	-
214	55.9	55.4	71.2	70.1	40.0	39.6	50.9	50.2	90.3	-	-
223	60.0	59.3	72.9	71.6	42.9	42.4	52.1	51.2	94.3	-	-
235	65.0	64.1	75.7	74.6	46.5	45.9	54.1	53.3	99.9	-	-
246	68.6	67.6	77.0	75.8	49.0	48.4	55.1	54.2	103	-	-
257	-	-	-	-	-	-	-	-	-	-	-
233	-	-	87.4	86.3	-	-	62.5	61.8	-	-	-
245	-	-	96.3	94.8	-	-	68.9	67.8	-	-	-
258	-	-	104	103	-	-	74.5	73.4	-	-	-
270	-	-	111	109	-	-	79.3	77.8	-	-	-
281	-	-	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.23.

** The axial force in each diagonal is calculated from strain gauge readings twice; once normal to the plane of the bracing and second in-plane of the bracing.

*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030.

Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.4a Axial Forces in Bracing Diagonals for Specimen LR12 (Section 1)*

Load (kN)	Axial Force in Member ** (kN) C1 normal	C1 in-plane	T1 normal	Shear resisted by Member*** (kN) C1 normal	C1 in-plane	T1 normal	Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN) C	T
0	0	0	0	0	0	0	0	0	0
23.5	3.03	3.14	12.7	2.16	2.23	9.06	11.3	8.28	7.37
46.9	6.56	6.25	25.2	4.67	4.45	17.9	22.5	16.6	14.7
70.4	10.1	9.62	36.9	7.15	6.85	26.3	33.3	24.8	22.1
82.2	12.3	11.9	42.0	8.72	8.45	29.9	38.5	29.0	25.8
93.9	14.7	14.1	47.3	10.4	10.0	33.6	43.8	33.1	29.5
106	17.3	16.6	53.7	12.3	11.8	38.2	50.3	37.2	33.2
114	-	-	-	-	-	-	-	-	-
79.8	17.0	16.5	36.9	12.1	11.7	26.2	38.1	-	-
93.9	22.0	21.1	37.3	15.7	15.0	26.6	41.9	-	-
106	24.8	23.9	39.1	17.6	17.0	27.8	45.1	-	-
117	30.3	29.5	42.5	21.6	21.0	30.3	51.5	-	-
129	35.6	34.5	44.0	25.3	24.5	31.3	56.3	-	-
141	42.1	40.8	45.9	30.0	29.0	32.7	62.2	-	-
153	47.9	46.2	47.4	34.1	32.9	33.7	67.2	-	-
164	52.7	51.3	49.1	37.5	36.5	35.0	72.0	-	-
172	-	-	-	-	-	-	-	-	-
146	-	-	56.8	-	-	40.4	-	-	-
164	-	-	69.3	-	-	49.3	-	-	-
176	-	-	75.7	-	-	53.9	-	-	-
189	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.24.

** The axial force in compression diagonals is calculated from strain gauge readings twice; once normal to the plane of the bracing and second in-plane of the bracing, while the axial force in tension diagonals is calculated only normal to the plane of the bracing.

*** Shear resisted by each member= axial force in member x SIN 60° x 838.1/1020.

Note: Shaded numbers are max. forces resisted by compression diagonal.

Table C.4b Axial Forces in Bracing Diagonals for Specimen LR12 (Section 2)*

Load	Axial Force in Member ** (kN)			Shear resisted by Member*** (kN)			Total Shear	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	C2		T2	C2		T2			
(kN)	normal	in-plane	normal	normal	in-plane	normal	(kN)	C	T
0	0	0	0	0	0	0	0	0	0
23.5	15.7	15.0	1.40	11.2	10.7	1.00	11.9	8.28	7.37
46.9	29.9	29.3	3.80	21.3	20.9	2.70	23.8	16.6	14.7
70.4	41.1	43.0	6.75	29.2	30.6	4.80	34.7	24.8	22.1
82.2	45.7	49.4	8.38	32.5	35.1	5.96	39.8	29.0	25.8
93.9	51.3	55.6	10.0	36.5	39.6	7.09	45.1	33.1	29.5
106	57.9	62.2	12.5	41.2	44.3	8.89	51.6	37.2	33.2
114	-	-	-	-	-	-	-	-	-
79.8	-	-	21.0	-	-	14.9	-	-	-
93.9	-	-	29.1	-	-	20.7	-	-	-
106	-	-	34.3	-	-	24.4	-	-	-
117	-	-	42.9	-	-	30.5	-	-	-
129	-	-	49.8	-	-	35.5	-	-	-
141	-	-	58.1	-	-	41.3	-	-	-
153	-	-	65.1	-	-	46.4	-	-	-
164	-	-	72.1	-	-	51.3	-	-	-
172	-	-	-	-	-	-	-	-	-
146	-	-	60.7	-	-	43.2	-	-	-
164	-	-	66.2	-	-	47.1	-	-	-
176	-	-	70.9	-	-	50.4	-	-	-
189	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.24.

** The axial force in compression diagonals is calculated from strain gauge readings twice; once normal to the plane of the bracing and second in-plane of the bracing, while the axial force in tension diagonals is calculated only normal to the plane of the bracing.

*** Shear resisted by each member= axial force in member x SIN 60° x 838.1/1020.

Note: Shaded numbers are max. forces resisted by compression diagonal.

Table C.5a Axial Forces in Bracing Diagonals for Specimen LR13 (Section 1)*

Load (kN)	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear (kN)
	CO1T	TI1B	CI3T	TO3B	CO1T	TI1B	CI3T	TO3B	
0	0	0	0	0	0	0	0	0	0
23.5	2.37	0.70	4.89	6.40	1.69	0.50	3.48	4.55	10.2
46.9	4.54	1.20	8.85	11.5	3.23	0.85	6.30	8.20	18.6
70.4	7.37	1.82	13.7	18.0	5.24	1.30	9.72	12.8	29.1
93.9	10.8	2.75	19.5	25.7	7.68	1.96	13.9	18.3	41.8
117	14.1	3.76	24.2	31.8	10.0	2.68	17.2	22.6	52.5
144	18.3	5.01	30.0	38.6	13.0	3.57	21.3	27.5	65.4
164	21.4	6.13	34.1	44.1	15.2	4.36	24.3	31.4	75.2
176	23.6	6.95	36.5	47.6	16.8	4.95	26.0	33.9	81.5
188	25.7	7.60	38.8	51.0	18.3	5.41	27.6	36.3	87.6
200	27.4	8.42	41.2	53.9	19.5	5.99	29.3	38.3	93.1
214	29.5	9.20	43.7	57.2	21.0	6.55	31.1	40.7	99.3
227	31.7	10.1	46.2	61.0	22.6	7.21	32.9	43.4	106
235	33.8	10.8	48.1	63.8	24.1	7.68	34.2	45.4	111
246	36.2	11.7	49.0	66.9	25.8	8.31	34.9	47.6	117
258	39.1	11.8	50.8	69.6	27.8	8.42	36.2	49.5	122
270	42.5	12.1	52.5	72.7	30.3	8.59	37.4	51.7	128
282	45.4	12.5	53.2	75.2	32.3	8.86	37.9	53.5	133
293	48.5	13.0	54.1	77.7	34.5	9.25	38.5	55.3	137
305	51.1	13.7	55.0	79.5	36.3	9.75	39.1	56.6	142
317	55.6	15.1	56.1	83.2	39.6	10.7	39.9	59.2	149
329	53.0	15.9	56.5	85.3	37.7	11.3	40.2	60.7	150
340	52.7	17.2	56.9	87.9	37.5	12.2	40.5	62.5	153
352	49.3	20.0	57.4	92.6	35.1	14.2	40.9	65.9	156
364	47.5	22.2	58.2	95.3	33.8	15.8	41.4	67.8	159
376	45.1	25.4	58.3	98.0	32.1	18.1	41.5	69.7	161
387	47.0	28.9	58.2	99.9	33.4	20.6	41.4	71.1	167
399	46.1	31.7	59.3	102	32.8	22.5	42.2	72.6	170
411	44.8	45.8	59.4	105	31.9	32.6	42.2	74.7	181
425	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.25.

** The axial forces are calculated from strain gauge readings.

*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.

Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.5b Axial Forces in Bracing Diagonals for Specimen LR13 (Section 2)*

Load (kN)	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear (kN)
	CO1B	TI1T	CI3B	TO3T	CO1B	TI1T	CI3B	TO3T	
0	0	0	0	0	0	0	0	0	0
23.5	2.95	0.66	4.81	6.29	2.10	0.47	3.42	4.48	10.5
46.9	5.16	1.20	9.00	11.3	3.67	0.85	6.40	8.01	18.9
70.4	7.88	1.98	14.2	17.6	5.61	1.41	10.1	12.5	29.6
93.9	11.3	3.03	19.9	25.2	8.03	2.16	14.2	17.9	42.3
117	14.5	4.11	24.9	31.4	10.3	2.92	17.7	22.3	53.3
144	19.1	5.51	30.5	38.5	13.6	3.92	21.7	27.4	66.5
164	22.0	6.56	34.7	43.9	15.7	4.67	24.7	31.3	76.3
176	24.1	7.29	37.2	47.1	17.1	5.19	26.4	33.5	82.3
188	26.4	7.92	39.6	50.5	18.8	5.64	28.2	35.9	88.5
200	28.2	8.73	42.0	53.4	20.1	6.21	29.9	38.0	94.1
214	30.1	9.39	44.4	56.7	21.4	6.68	31.6	40.3	100
227	32.3	10.2	46.6	60.3	23.0	7.26	33.1	42.9	106
235	34.5	10.8	48.4	63.2	24.6	7.70	34.5	45.0	112
246	36.7	11.6	50.2	66.2	26.1	8.25	35.7	47.1	117
258	39.4	12.0	-	69.0	28.1	8.50	-	49.1	-
270	42.8	12.4	-	71.9	30.5	8.84	-	51.2	-
282	45.7	13.0	-	74.4	32.5	9.25	-	53.0	-
293	48.9	13.9	-	76.9	34.8	9.88	-	54.7	-
305	51.3	14.6	-	78.8	36.5	10.4	-	56.1	-
317	55.9	16.3	-	82.3	39.8	11.6	-	58.6	-
329	-	17.3	-	84.5	-	12.3	-	60.1	-
340	-	18.8	-	87.0	-	13.4	-	61.9	-
352	-	22.3	-	91.7	-	15.9	-	65.2	-
364	-	24.6	-	94.1	-	17.5	-	67.0	-
376	-	28.3	-	96.9	-	20.2	-	69.0	-
387	-	31.9	-	98.7	-	22.7	-	70.2	-
399	-	35.0	-	101	-	24.9	-	71.8	-
411	-	45.6	-	104	-	32.5	-	73.8	-
425	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.25.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.
Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.5c Axial Forces in Bracing Diagonals for Specimen LR13 (Section 3)*

Load (kN)	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear (kN)
	CO2T	TI2B	CI4T	TO4B	CO2T	TI2B	CI4T	TO4B	
0	0	0	0	0	0	0	0	0	0
23.5	8.61	4.62	1.59	-0.35	6.13	3.29	1.13	-0.25	10.3
46.9	15.1	8.11	2.83	0.00	10.77	5.77	2.01	0.00	18.6
70.4	22.6	12.0	4.69	0.54	16.07	8.56	3.34	0.38	28.3
93.9	31.1	17.0	7.37	1.44	22.1	12.1	5.24	1.02	40.5
117	38.1	20.5	9.70	2.72	27.1	14.6	6.90	1.94	50.5
144	45.8	24.6	12.8	4.50	32.6	17.5	9.08	3.20	62.3
164	51.5	27.7	15.3	5.94	36.6	19.7	10.9	4.23	71.4
176	54.8	29.5	16.9	6.95	39.0	21.0	12.0	4.95	77.0
188	58.5	31.6	18.5	7.99	41.6	22.5	13.2	5.69	83.0
200	61.4	33.4	20.1	8.96	43.7	23.7	14.3	6.38	88.1
214	64.8	35.0	21.9	10.1	46.1	24.9	15.6	7.15	93.8
227	67.6	37.4	23.9	11.4	48.1	26.6	17.0	8.09	99.9
235	69.1	40.2	25.7	12.7	49.1	28.6	18.3	9.00	105
246	69.6	43.9	27.7	14.1	49.5	31.3	19.7	10.0	110
258	67.0	49.2	30.1	15.9	47.7	35.0	21.4	11.3	115
270	62.0	56.7	32.6	17.9	44.1	40.3	23.2	12.7	120
282	58.6	62.4	34.8	19.5	41.7	44.4	24.8	13.9	125
293	56.9	66.5	37.1	21.1	40.5	47.3	26.4	15.0	129
305	55.6	69.9	39.2	22.6	39.6	49.8	27.9	16.1	133
317	53.7	75.3	42.7	25.1	38.2	53.6	30.4	17.9	140
329	53.0	78.1	44.6	26.6	37.7	55.6	31.8	18.9	144
340	51.9	81.7	46.9	28.5	36.9	58.1	33.4	20.3	149
352	50.4	87.2	51.5	31.5	35.9	62.0	36.6	22.4	157
364	50.3	89.5	54.4	33.1	35.8	63.7	38.7	23.5	162
376	49.6	92.7	60.6	34.8	35.3	66.0	43.1	24.8	169
387	49.2	94.6	63.9	35.5	35.0	67.3	45.5	25.3	173
399	49.4	97.0	68.0	36.3	35.1	69.1	48.4	25.8	178
411	48.4	101	74.1	40.7	34.4	71.9	52.7	29.0	188
425	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.25.

** The axial forces are calculated from strain gauge readings.

*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.

Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.5d Axial Forces in Bracing Diagonals for Specimen LR13 (Section 4)*

Load	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear
(kN)	CO2B	TI2T	CI4B	TO4T	CO2B	TI2T	CI4B	TO4T	(kN)
0	0	0	0	0	0	0	0	0	0
23.5	9.54	3.92	1.32	-0.23	6.79	2.79	0.94	-0.16	10.4
46.9	16.1	6.91	2.99	-0.12	11.4	4.92	2.13	-0.09	18.4
70.4	23.8	10.7	4.97	0.12	16.9	7.59	3.54	0.09	28.1
93.9	32.8	14.9	7.72	0.54	23.3	10.6	5.49	0.38	39.8
117	39.7	18.4	10.2	1.75	28.2	13.1	7.24	1.25	49.8
144	47.7	22.4	13.6	3.57	33.9	16.0	9.66	2.54	62.1
164	53.7	25.1	16.3	4.54	38.2	17.9	11.6	3.23	70.9
176	57.2	26.8	17.9	5.39	40.7	19.0	12.7	3.84	76.3
188	61.0	28.0	19.8	6.36	43.4	19.9	14.1	4.53	81.9
200	64.1	29.1	21.2	7.37	45.6	20.7	15.1	5.24	86.6
214	67.5	30.8	22.9	8.34	48.0	21.9	16.3	5.93	92.2
227	70.4	33.0	24.8	9.47	50.1	23.5	17.7	6.74	98.0
235	71.8	34.8	26.9	10.7	51.1	24.8	19.2	7.59	103
246	71.9	38.0	29.3	11.9	51.2	27.1	20.8	8.47	108
258	68.7	42.8	31.7	13.6	48.9	30.5	22.6	9.69	112
270	-	52.0	34.6	15.5	-	37.0	24.6	11.0	-
282	-	60.2	36.9	17.1	-	42.9	26.3	12.2	-
293	-	65.6	39.3	18.6	-	46.7	27.9	13.2	-
305	-	69.7	41.4	20.0	-	49.6	29.5	14.2	-
317	-	76.0	45.0	22.4	-	54.1	32.0	15.9	-
329	-	79.5	47.2	23.8	-	56.6	33.6	16.9	-
340	-	83.5	49.6	25.6	-	59.4	35.3	18.2	-
352	-	90.0	54.3	28.6	-	64.0	38.7	20.3	-
364	-	92.5	56.3	30.0	-	65.8	40.0	21.3	-
376	-	95.9	58.6	31.7	-	68.2	41.7	22.6	-
387	-	98.4	60.5	32.3	-	70.0	43.0	23.0	-
399	-	100	62.6	33.4	-	71.5	44.5	23.8	-
411	-	105	64.1	38.4	-	74.4	45.6	27.3	-
425	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.25.

** The axial forces are calculated from strain gauge readings.

*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.

Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.6a Axial Forces in Bracing Diagonals for Specimen LR14 (Section 1)*

Load (kN)	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear (kN)
	CF1T	TC1B	CC3T	TF3B	CF1T	TC1B	CC3T	TF3B	
0	0	0	0	0	0	0	0	0	0
46.9	5.82	3.30	14.8	9.89	4.16	2.36	10.6	7.07	24.2
93.9	12.0	6.60	27.3	19.2	8.61	4.72	19.5	13.8	46.6
141	18.4	9.7	40.5	29.3	13.1	6.97	29.0	21.0	70.0
188	24.8	13.6	53.2	36.7	17.8	9.71	38.0	26.3	91.8
235	32.4	17.8	65.6	46.1	23.2	12.7	46.9	32.9	116
282	39.4	22.7	76.9	53.2	28.2	16.2	55.0	38.0	137
305	43.4	25.0	83.0	57.0	31.0	17.9	59.3	40.8	149
329	48.7	28.7	88.5	60.7	34.8	20.5	63.3	43.4	162
352	53.6	32.0	93.7	64.6	38.3	22.9	67.0	46.2	174
376	58.5	35.1	98.5	67.4	41.8	25.1	70.4	48.2	186
399	64.0	38.4	103	70.1	45.8	27.5	73.9	50.1	197
423	76.7	38.3	105	70.4	54.8	27.4	75.3	50.3	208
434	79.7	38.7	107	71.0	57.0	27.7	76.2	50.8	212
446	83.8	39.2	108	71.6	60.0	28.0	77.0	51.2	216
458	88.9	40.9	108	70.5	63.6	29.3	77.4	50.5	221
469	93.1	42.4	109	70.7	66.6	30.3	78.0	50.6	225
481	-	-	-	-	-	-	-	-	-
428	-	67.6	-	93.9	-	48.4	-	67.2	-
444	-	-	-	-	-	-	-	-	-
413	-	62.1	-	92.9	-	44.4	-	66.4	-
352	-	41.9	-	83.6	-	30.0	-	59.8	-

* Section at which forces are computed is identified in Fig. 3.26.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030
Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.6b Axial Forces in Bracing Diagonals for Specimen LR14 (Section 2)*

Load (kN)	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear (kN)
	CF1B	TC1T	CC3B	TF3T	CF1B	TC1T	CC3B	TF3T	
0	0	0	0	0	0	0	0	0	0
46.9	5.82	2.83	14.3	10.9	4.16	2.02	10.2	7.83	24.3
93.9	11.9	5.39	27.2	19.4	8.49	3.86	19.4	13.9	45.7
141	18.2	9.12	40.4	28.3	13.0	6.52	28.9	20.2	68.7
188	24.6	12.4	53.0	37.1	17.6	8.86	37.9	26.6	90.9
235	31.9	16.7	65.5	45.7	22.8	12.0	46.8	32.7	114
282	39.2	21.5	77.8	53.6	28.0	15.4	55.6	38.3	137
305	43.1	24.3	83.1	56.7	30.8	17.3	59.4	40.6	148
329	48.5	28.1	89.4	60.8	34.7	20.1	63.9	43.5	162
352	53.2	31.3	94.4	63.9	38.0	22.4	67.5	45.7	174
376	58.2	34.6	98.4	66.6	41.6	24.7	70.4	47.7	184
399	63.6	37.9	102	69.3	45.5	27.1	72.8	49.6	195
423	76.4	38.1	104	69.6	54.7	27.2	74.1	49.8	206
434	79.5	38.6	105	70.3	56.9	27.6	74.8	50.3	210
446	83.7	39.0	106	70.7	59.9	27.9	75.5	50.6	214
458	88.7	40.6	106	70.8	63.5	29.0	76.0	50.6	219
469	92.7	42.3	107	70.0	66.3	30.2	76.7	50.0	223
481	-	-	-	-	-	-	-	-	-
428	-	70.9	-	89.9	-	50.7	-	64.3	-
444	-	-	-	-	-	-	-	-	-
413	-	66.0	-	88.7	-	47.2	-	63.5	-
352	-	46.3	-	79.8	-	33.1	-	57.1	-

* Section at which forces are computed is identified in Fig. 3.26.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030
Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.6c Axial Forces in Bracing Diagonals for Specimen LR14 (Section 3)*

Load (kN)	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear (kN)
	CF2T	TC2B	CC4T	TF4B	CF2T	TC2B	CC4T	TF4B	
0	0	0	0	0	0	0	0	0	0
46.9	15.9	12.1	5.04	1.09	11.4	8.63	3.61	0.78	24.4
93.9	27.8	20.1	12.1	2.72	19.9	14.4	8.63	1.95	44.9
141	40.4	30.5	16.6	4.85	28.9	21.8	11.9	3.47	66.0
188	53.0	39.0	22.5	7.02	37.9	27.9	16.1	5.02	87.0
235	64.0	47.4	28.7	10.1	45.8	33.9	20.5	7.22	107
282	76.1	54.0	36.0	13.8	54.5	38.6	25.8	9.85	129
305	81.1	57.2	39.5	16.1	58.0	40.9	28.3	11.5	139
329	87.0	59.9	44.3	19.3	62.2	42.9	31.7	13.8	151
352	91.9	62.7	48.7	22.3	65.7	44.8	34.8	15.9	161
376	96.5	64.7	53.5	25.5	69.0	46.3	38.3	18.2	172
399	101	67.1	58.8	29.0	72.0	48.0	42.1	20.7	183
423	76.2	87.4	68.1	36.8	54.5	62.5	48.7	26.3	192
434	73.7	90.5	71.0	39.0	52.7	64.8	50.8	27.9	196
446	69.1	93.6	74.4	41.2	49.5	67.0	53.2	29.5	199
458	63.3	94.6	79.5	45.7	45.2	67.7	56.9	32.7	203
469	58.3	95.1	85.3	49.6	41.7	68.1	61.0	35.4	206
481	-	-	-	-	-	-	-	-	-
428	35.6	75.5	96.2	44.2	25.4	54.0	68.8	31.6	180
444	-	-	-	-	-	-	-	-	-
413	33.1	68.2	95.6	43.8	23.6	48.8	68.4	31.3	172
352	29.5	43.2	87.3	40.6	21.1	30.9	62.5	29.1	144

* Section at which forces are computed is identified in Fig. 3.26.

** The axial forces are calculated from strain gauge readings.

*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030

Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.6d Axial Forces in Bracing Diagonals for Specimen LR14 (Section 4)*

Load (kN)	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear (kN)
	CF2B	TC2T	CC4B	TF4T	CF2B	TC2T	CC4B	TF4T	
0	0	0	0	0	0	0	0	0	0
46.9	14.4	12.7	4.31	0.74	10.3	9.05	3.08	0.53	23.0
93.9	26.9	22.9	9.20	1.82	19.3	16.4	6.58	1.30	43.5
141	39.8	33.2	14.6	3.92	28.4	23.7	10.4	2.80	65.4
188	52.3	42.5	20.4	6.36	37.4	30.4	14.6	4.55	86.9
235	63.6	51.1	27.2	9.39	45.5	36.6	19.5	6.72	108
282	75.4	58.8	34.7	12.8	53.9	42.1	24.8	9.13	130
305	80.6	61.9	38.4	15.5	57.6	44.3	27.5	11.1	140
329	86.6	64.5	43.9	18.7	61.9	46.2	31.4	13.4	153
352	91.4	67.0	48.6	21.9	65.4	48.0	34.8	15.7	164
376	95.9	69.5	53.4	24.9	68.6	49.7	38.2	17.8	174
399	99.8	72.2	58.7	28.4	71.4	51.7	42.0	20.3	185
423	71.3	95.5	67.8	36.0	51.0	68.3	48.5	25.7	194
434	64.5	99.0	70.6	38.3	46.1	70.8	50.5	27.4	195
446	62.2	102	74.0	40.7	44.5	73.1	52.9	29.1	200
458	59.8	103	79.3	45.2	42.8	73.8	56.8	32.3	206
469	54.6	104	83.8	49.2	39.1	74.6	60.0	35.2	209
481	-	-	-	-	-	-	-	-	-
428	40.5	82.5	94.0	43.6	29.0	59.0	67.2	31.2	186
444	-	-	-	-	-	-	-	-	-
413	39.0	74.1	92.4	42.3	27.9	53.0	66.1	30.3	177
352	36.0	47.6	84.3	39.0	25.8	34.1	60.3	27.9	148

* Section at which forces are computed is identified in Fig. 3.26.

** The axial forces are calculated from strain gauge readings.

*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030

Note: Shaded numbers are max. forces resisted by compression diagonals.

Table C.7a Axial Forces in Bracing Diagonals for Specimen LR15 (Section 1)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CC1T	TF1B	CF3T	TC3B	CC1T	TF1B	CF3T	TC3B		C	T
0	0	0	0	0	0	0	0	0	0	0	0
49.3	5.35	1.47	14.7	11.6	3.83	1.05	10.5	8.27	23.7	8.60	8.60
96.2	10.5	3.07	28.1	21.0	7.52	2.20	20.1	15.0	44.8	16.8	16.8
141	16.1	5.51	39.7	30.4	11.5	3.94	28.4	21.7	65.6	24.6	24.6
188	22.4	8.23	53.3	40.6	16.0	5.89	38.1	29.0	89.0	32.8	32.8
235	28.5	11.1	65.9	49.9	20.4	7.94	47.1	35.7	111	41.0	41.0
282	35.1	14.2	78.0	58.0	25.1	10.1	55.8	41.5	133	49.1	49.1
329	42.4	18.4	89.4	65.5	30.3	13.1	63.9	46.9	154	57.3	57.3
352	46.4	20.9	94.0	68.7	33.2	14.9	67.3	49.2	165	61.4	61.4
376	50.8	23.9	96.6	72.8	36.3	17.1	69.1	52.0	175	65.5	65.5
396	-	-	-	-	-	-	-	-	-	-	-
377	55.8	28.7	78.6	99.4	39.9	20.5	56.2	71.1	188	-	-
387	58.1	30.1	77.4	103	41.5	21.5	55.4	73.6	192	-	-
399	60.6	31.4	75.5	107	43.3	22.5	54.0	76.7	196	-	-
411	63.6	34.2	-	114	45.5	24.5	-	81.9	-	-	-
423	67.6	37.5	-	116	48.3	26.8	-	83.2	-	-	-
434	73.0	42.1	-	118	52.2	30.1	-	84.3	-	-	-
446	76.5	44.4	-	118	54.7	31.8	-	84.6	-	-	-
458	78.6	46.0	-	118	56.2	32.9	-	84.8	-	-	-
469	82.8	49.8	-	119	59.2	35.6	-	85.1	-	-	-
481	-	-	-	-	-	-	-	-	-	-	-
477	-	73.5	-	118	-	52.6	-	84.6	-	-	-
487	-	87.5	-	118	-	62.6	-	84.7	-	-	-
493	-	92.1	-	119	-	65.9	-	85.0	-	-	-
505	-	103	-	119	-	73.5	-	85.3	-	-	-
516	-	-	-	-	-	-	-	-	-	-	-
493	-	102	-	118	-	72.7	-	84.5	-	-	-
507	-	-	-	-	-	-	-	-	-	-	-
479	-	98.7	-	116	-	70.6	-	82.8	-	-	-

* Section at which forces are computed is identified in Fig. 3.27.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030.
Note: Shaded numbers are for max. forces in compression diagonals.

Table C.7b Axial Forces in Bracing Diagonals for Specimen LR15 (Section 2)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CC1B	TF1T	CF3B	TC3T	CC1B	TF1T	CF3B	TC3T		C	T
0	0	0	0	0	0	0	0	0	0	0	0
49.3	5.32	1.44	15.0	11.7	3.81	1.03	10.7	8.38	24.0	8.60	8.60
96.2	10.5	3.18	27.4	21.2	7.52	2.27	19.6	15.1	44.5	16.8	16.8
141	15.8	5.55	40.1	30.7	11.3	3.97	28.7	22.0	65.9	24.6	24.6
188	22.2	8.19	53.1	40.9	15.8	5.86	38.0	29.2	88.9	32.8	32.8
235	28.3	11.1	65.8	50.3	20.2	7.94	47.1	36.0	111	41.0	41.0
282	34.8	14.3	77.8	58.7	24.9	10.2	55.6	42.0	133	49.1	49.1
329	42.1	18.5	88.9	66.2	30.1	13.2	63.6	47.3	154	57.3	57.3
352	46.2	21.0	93.7	69.3	33.1	15.0	67.0	49.5	165	61.4	61.4
376	50.7	23.9	97.1	72.8	36.2	17.1	69.4	52.1	175	65.5	65.5
396	-	-	-	-	-	-	-	-	-	-	-
377	55.7	28.8	-	98.5	39.8	20.6	-	70.4	-	-	-
387	58.1	30.2	-	102	41.5	21.6	-	72.7	-	-	-
399	60.5	31.7	-	106	43.3	22.7	-	75.6	-	-	-
411	63.6	34.3	-	110	45.5	24.5	-	78.8	-	-	-
423	67.5	37.4	-	114	48.3	26.7	-	81.2	-	-	-
434	73.0	41.9	-	116	52.2	30.0	-	82.8	-	-	-
446	76.5	44.3	-	117	54.7	31.7	-	83.4	-	-	-
458	78.7	45.9	-	118	56.3	32.9	-	84.2	-	-	-
469	82.8	49.6	-	118	59.2	35.5	-	84.7	-	-	-
481	-	-	-	-	-	-	-	-	-	-	-
477	63.7	74.0	-	117	45.6	53.0	-	83.9	-	-	-
487	58.0	88.2	-	117	41.5	63.1	-	83.6	-	-	-
493	56.6	92.8	-	118	40.5	66.4	-	84.4	-	-	-
505	50.6	104	-	119	36.2	74.1	-	84.9	-	-	-
516	-	-	-	-	-	-	-	-	-	-	-
493	47.6	102	-	116	34.0	73.3	-	82.9	-	-	-
507	-	-	-	-	-	-	-	-	-	-	-
479	45.1	99.4	-	111	32.2	71.1	-	79.5	-	-	-

* Section at which forces are computed is identified in Fig. 3.27.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030.
Note: Shaded numbers are for max. forces in compression diagonals.

Table C.7c Axial Forces in Bracing Diagonals for Specimen LR15 (Section 3)*

Load	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
(kN)	CC2T	TF2B	CF4T	TC4B	CC2T	TF2B	CF4T	TC4B	(kN)	C	T
0	0	0	0	0	0	0	0	0	0	0	0
49.3	15.3	13.4	4.38	0.81	10.9	9.58	3.13	0.58	24.2	8.60	8.60
96.2	28.2	24.0	7.88	2.13	20.2	17.2	5.64	1.52	44.5	16.8	16.8
141	40.9	34.3	12.7	3.96	29.2	24.5	9.08	2.83	65.7	24.6	24.6
188	54.6	45.0	19.0	6.05	39.1	32.2	13.6	4.33	89.1	32.8	32.8
235	68.1	55.1	24.4	8.15	48.7	39.4	17.5	5.83	111	41.0	41.0
282	80.0	64.2	30.8	11.3	57.2	45.9	22.0	8.10	133	49.1	49.1
329	90.6	72.4	38.4	15.1	64.8	51.8	27.5	10.8	155	57.3	57.3
352	95.1	75.9	42.6	17.6	68.0	54.3	30.5	12.6	165	61.4	61.4
376	98.9	79.9	46.2	20.1	70.7	57.1	33.1	14.4	175	65.5	65.5
396	-	-	-	-	-	-	-	-	-	-	-
377	96.6	78.0	53.9	18.7	69.1	55.8	38.5	13.4	177	-	-
387	98.2	78.9	56.0	19.8	70.2	56.5	40.0	14.1	181	-	-
399	99.9	80.3	58.4	20.6	71.4	57.5	41.7	14.7	185	-	-
411	100	81.7	61.6	21.8	71.8	58.5	44.0	15.6	190	-	-
423	100	83.0	65.1	23.7	71.5	59.3	46.5	16.9	194	-	-
434	100	83.0	70.1	26.0	71.7	59.4	50.1	18.6	200	-	-
446	97.4	87.0	73.2	27.8	69.7	62.3	52.4	19.9	204	-	-
458	97.8	87.6	75.2	28.8	69.9	62.7	53.8	20.6	207	-	-
469	97.9	88.0	79.6	30.9	70.0	62.9	57.0	22.1	212	-	-
481	-	-	-	-	-	-	-	-	-	-	-
477	98.6	84.2	81.8	31.8	70.5	60.2	58.5	22.8	212	-	-
487	98.4	84.9	86.1	34.7	70.4	60.7	61.6	24.8	217	-	-
493	99.1	85.9	87.4	36.0	70.9	61.4	62.5	25.7	221	-	-
505	96.7	88.7	88.9	38.9	69.1	63.5	63.6	27.8	224	-	-
516	-	-	-	-	-	-	-	-	-	-	-
493	94.7	91.1	-	58.4	67.7	65.2	-	41.7	-	-	-
507	-	-	-	-	-	-	-	-	-	-	-
479	63.2	106	-	65.9	45.2	76.0	-	47.1	-	-	-

* Section at which forces are computed is identified in Fig. 3.27.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030.
Note: Shaded numbers are for max. forces in compression diagonals.

Table C.7d Axial Forces in Bracing Diagonals for Specimen LR15 (Section 4)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CC2B	TF2T	CF4B	TC4T	CC2B	TF2T	CF4B	TC4T		C	T
0	0	0	0	0	0	0	0	0	0	0	0
49	15.9	13.0	3.72	1.05	11.4	9.33	2.66	0.75	24.1	8.60	8.60
96	28.9	23.7	8.07	1.75	20.7	16.9	5.77	1.25	44.6	16.8	16.8
141	38.3	33.5	12.9	3.53	27.4	24.0	9.24	2.53	63.1	24.6	24.6
188	50.6	44.2	18.7	7.57	36.2	31.6	13.4	5.42	86.6	32.8	32.8
235	64.1	54.4	24.3	9.43	45.9	38.9	17.4	6.75	109	41.0	41.0
282	76.1	63.1	31.0	13.0	54.5	45.1	22.1	9.30	131	49.1	49.1
329	87.1	71.0	38.1	17.0	62.3	50.8	27.3	12.2	153	57.3	57.3
352	91.7	74.6	42.1	19.8	65.6	53.3	30.1	14.2	163	61.4	61.4
376	95.9	78.0	46.7	22.2	68.6	55.8	33.4	15.9	174	65.5	65.5
396	-	-	-	-	-	-	-	-	-	-	-
377	93.1	76.5	53.8	21.2	66.6	54.7	38.5	15.2	175	-	-
387	94.5	77.6	56.3	23.4	67.6	55.5	40.3	16.7	180	-	-
399	98.1	78.6	59.0	23.7	70.2	56.2	42.2	17.0	186	-	-
411	98.7	79.6	62.1	24.6	70.6	57.0	44.4	17.6	190	-	-
423	98.1	80.7	66.1	22.3	70.1	57.8	47.3	15.9	191	-	-
434	94.4	80.9	71.2	24.7	67.5	57.8	50.9	17.7	194	-	-
446	90.5	85.0	74.5	26.0	64.7	60.8	53.3	18.6	197	-	-
458	89.9	85.1	76.5	27.0	64.3	60.9	54.7	19.3	199	-	-
469	92.9	85.5	80.7	28.8	66.4	61.1	57.8	20.6	206	-	-
481	-	-	-	-	-	-	-	-	-	-	-
477	93.1	82.0	83.3	30.2	66.6	58.7	59.6	21.6	206	-	-
487	91.8	82.4	87.7	33.3	65.7	58.9	62.7	23.8	211	-	-
493	91.9	83.1	89.2	34.5	65.7	59.4	63.8	24.7	214	-	-
505	88.7	86.1	91.1	37.2	63.4	61.6	65.2	26.6	217	-	-
516	-	-	-	-	-	-	-	-	-	-	-
493	85.6	88.8	57.1	56.5	61.2	63.5	40.9	40.4	206	-	-
507	-	-	-	-	-	-	-	-	-	-	-
479	53.0	105.5	48.2	63.4	37.9	75.5	34.5	45.4	193	-	-

* Section at which forces are computed is identified in Fig. 3.27.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030.
Note: Shaded numbers are for max. forces in compression diagonals.

Table C.8a Axial Forces in Bracing Diagonals for Specimen LR16 (Section 1)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CC1T	TF1B	CF3T	TC3B	CC1T	TF1B	CF3T	TC3B		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	5.39	2.52	13.2	9.51	3.84	1.79	9.41	6.77	21.8	8.19	8.19
93.9	11.9	5.74	25.8	19.2	8.45	4.08	18.4	13.7	44.6	16.4	16.4
141	18.2	9.58	38.3	28.9	13.0	6.82	27.2	20.5	67.6	24.6	24.6
188	25.4	14.0	50.0	36.2	18.1	9.94	35.6	25.8	89.4	32.8	32.8
235	33.2	19.1	61.4	44.4	23.6	13.6	43.7	31.6	112	41.0	41.0
282	41.4	24.6	72.1	52.5	29.5	17.5	51.3	37.4	136	49.1	49.1
329	50.4	31.0	81.8	58.9	35.9	22.0	58.2	41.9	158	57.3	57.3
352	55.1	34.5	86.2	61.2	39.2	24.5	61.3	43.5	169	61.4	61.4
376	59.9	38.0	90.9	63.9	42.6	27.1	64.7	45.5	180	65.5	65.5
387	62.6	39.9	93.7	67.6	44.5	28.4	66.7	48.1	188	67.6	67.6
399	65.1	41.7	95.8	67.0	46.3	29.7	68.2	47.7	192	69.6	69.6
411	68.2	43.5	98.0	70.7	48.5	31.0	69.7	50.3	199	-	-
423	-	-	-	-	-	-	-	-	-	-	-
413	73.4	43.1	95.8	69.3	52.2	30.6	68.1	49.3	200	-	-
423	75.9	44.4	97.4	70.5	54.0	31.6	69.3	50.2	205	-	-
434	78.8	45.4	98.8	70.9	56.1	32.3	70.3	50.5	209	-	-
446	82.1	47.1	101	73.6	58.4	33.5	71.6	52.4	216	-	-
458	84.7	48.2	102	74.3	60.3	34.3	72.6	52.9	220	-	-
472	87.1	51.5	104	76.6	62.0	36.6	74.2	54.5	227	-	-
481	-	-	-	-	-	-	-	-	-	-	-
471	-	68.6	106	78.3	-	48.8	75.1	55.7	-	-	-
481	-	79.0	107	80.4	-	56.2	76.0	57.2	-	-	-
493	-	91.6	106	81.3	-	65.2	75.3	57.8	-	-	-
505	-	106	104	82.9	-	75.4	74.0	59.0	-	-	-
519	-	-	-	-	-	-	-	-	-	-	-
493	-	116	70.5	104	-	82.4	50.1	74.1	-	-	-
503	-	-	-	-	-	-	-	-	-	-	-
491	-	117	57.1	113	-	83.4	40.6	80.4	-	-	-
505	-	-	-	-	-	-	-	-	-	-	-
446	-	104	46.7	103	-	74.0	33.2	73.5	-	-	-

* Section at which forces are computed is identified in Fig. 3.28.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.
Note: Shaded numbers are max. forces in compession diagonals.

Table C.8b Axial Forces in Bracing Diagonals for Specimen LR16 (Section 2)*

Load	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
(kN)	CC1B	TF1T	CF3B	TC3T	CC1B	TF1T	CF3B	TC3T	(kN)	C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	5.55	2.44	14.9	9.00	3.95	1.74	10.6	6.40	22.7	8.19	8.19
93.9	11.7	5.90	27.1	18.9	8.34	4.20	19.3	13.4	45.3	16.4	16.4
141	18.2	9.78	39.6	28.2	13.0	6.96	28.2	20.1	68.1	24.6	24.6
188	25.5	14.2	51.8	36.6	18.2	10.1	36.9	26.0	91.2	32.8	32.8
235	33.3	19.3	62.5	45.0	23.7	13.7	44.5	32.0	114	41.0	41.0
282	41.6	25.2	73.3	52.7	29.6	17.9	52.2	37.5	137	49.1	49.1
329	50.6	31.7	83.0	59.0	36.0	22.6	59.1	42.0	160	57.3	57.3
352	55.5	35.0	87.9	61.7	39.5	24.9	62.6	43.9	171	61.4	61.4
376	60.1	38.4	93.1	64.3	42.8	27.3	66.2	45.8	182	65.5	65.5
387	62.9	40.4	94.2	67.3	44.8	28.8	67.1	47.9	189	67.6	67.6
399	65.5	42.1	98.4	67.1	46.6	29.9	70.0	47.8	194	69.6	69.6
411	68.2	44.2	98.6	69.6	48.5	31.4	70.2	49.6	200	-	-
423	-	-	-	-	-	-	-	-	-	-	-
413	73.8	43.7	96.1	68.9	52.5	31.1	68.4	49.0	201	-	-
423	76.5	44.9	97.9	70.0	54.4	32.0	69.6	49.8	206	-	-
434	79.2	46.1	99.7	70.6	56.3	32.8	70.9	50.2	210	-	-
446	82.8	47.7	101	72.8	58.9	34.0	71.9	51.8	217	-	-
458	85.4	49.1	103	73.3	60.7	34.9	73.2	52.2	221	-	-
472	89.0	52.0	105	75.2	63.3	37.0	74.8	53.5	229	-	-
481	-	-	-	-	-	-	-	-	-	-	-
471	-	70.3	107	77.5	-	50.1	75.8	55.2	-	-	-
481	-	81.0	108	79.5	-	57.6	76.6	56.6	-	-	-
493	-	93.7	107	80.4	-	66.7	76.0	57.2	-	-	-
505	-	109	105	82.2	-	77.6	74.8	58.5	-	-	-
519	-	-	-	-	-	-	-	-	-	-	-
493	-	121	72.1	103	-	86.3	51.3	73.5	-	-	-
503	-	-	-	-	-	-	-	-	-	-	-
491	-	125	58.7	113	-	88.9	41.8	80.3	-	-	-
505	-	-	-	-	-	-	-	-	-	-	-
446	-	112	47.5	103	-	79.8	33.8	73.2	-	-	-

* Section at which forces are computed is identified in Fig. 3.28.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.
Note: Shaded numbers are max. forces in compession diagonals.

Table C.8c Axial Forces in Bracing Diagonals for Specimen LR16 (Section 3)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CC2T	TF2B	CF4T	TC4B	CC2T	TF2B	CF4T	TC4B		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	16.3	11.8	4.15	1.78	11.6	8.39	2.95	1.27	24.2	8.19	8.19
93.9	28.2	21.9	9.35	5.28	20.1	15.6	6.65	3.76	46.1	16.4	16.4
141	40.5	31.7	15.2	8.15	28.8	22.6	10.8	5.80	68.0	24.6	24.6
188	53.3	40.4	22.6	12.1	37.9	28.8	16.1	8.62	91.4	32.8	32.8
235	63.1	48.7	30.5	16.5	44.9	34.6	21.7	11.8	113	41.0	41.0
282	72.9	56.2	38.7	21.5	51.9	40.0	27.5	15.3	135	49.1	49.1
329	82.4	62.5	47.8	28.0	58.6	44.5	34.0	19.9	157	57.3	57.3
352	87.1	65.4	52.3	31.1	62.0	46.6	37.2	22.1	168	61.4	61.4
376	92.6	68.6	57.1	34.4	65.9	48.8	40.6	24.5	180	65.5	65.5
387	92.3	70.5	59.7	36.5	65.7	50.2	42.5	26.0	184	67.6	67.6
399	96.4	72.1	61.7	38.2	68.6	51.3	43.9	27.2	191	69.6	69.6
411	94.4	74.6	64.3	39.8	67.1	53.1	45.7	28.3	194	-	-
423	-	-	-	-	-	-	-	-	-	-	-
413	-	93.1	66.6	43.1	-	66.3	47.4	30.7	-	-	-
423	-	97.9	68.8	44.6	-	69.6	48.9	31.8	-	-	-
434	-	102	70.7	46.4	-	72.6	50.3	33.0	-	-	-
446	-	110	73.8	48.3	-	78.2	52.5	34.4	-	-	-
458	-	114	76.3	50.0	-	81.1	54.3	35.6	-	-	-
472	-	120	80.3	53.2	-	85.6	57.1	37.8	-	-	-
481	-	-	-	-	-	-	-	-	-	-	-
471		124	78.8	52.8	-	88.5	56.1	37.6	-	-	-
481	-	129	82.7	56.1	-	92.0	58.8	39.9	-	-	-
493	-	134	88.7	60.6	-	95.1	63.1	43.2	-	-	-
505	-	135	95.7	65.2	-	96.0	68.1	46.4	-	-	-
519	-	-	-	-	-	-	-	-	-	-	-
493	-	131	90.9	72.7	-	93.4	64.7	51.7	-	-	-
503	-	-	-	-	-	-	-	-	-	-	-
491	-	131	77.3	84.5	-	93.4	55.0	60.1	-	-	-
505	-	-	-	-	-	-	-	-	-	-	-
446	-	121	68.1	78.8	-	86.2	48.5	56.1	-	-	-

* Section at which forces are computed is identified in Fig. 3.28.

** The axial forces are calculated from strain gauge readings.

*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.

Note: Shaded numbers are max. forces in compession diagonals.

Table C.8d Axial Forces in Bracing Diagonals for Specimen LR16 (Section 4)*

Load	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
(kN)	CC2B	TF2T	CF4B	TC4T	CC2B	TF2T	CF4B	TC4T	(kN)	C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	14.8	11.5	4.5	1.5	10.5	8.2	3.2	1.0	23.0	8.19	8.19
93.9	26.7	21.8	9.7	4.3	19.0	15.5	6.9	3.0	44.4	16.4	16.4
141	37.8	31.7	15.8	7.1	26.9	22.5	11.3	5.1	65.8	24.6	24.6
188	50.3	40.5	23.0	11.5	35.8	28.8	16.3	8.2	89.1	32.8	32.8
235	60.8	48.9	30.7	16.2	43.2	34.8	21.8	11.5	111	41.0	41.0
282	71.1	56.6	39.2	21.1	50.6	40.3	27.9	15.0	134	49.1	49.1
329	80.0	62.9	48.3	27.3	56.9	44.7	34.3	19.4	155	57.3	57.3
352	84.7	65.9	52.9	30.5	60.2	46.9	37.7	21.7	166	61.4	61.4
376	89.4	69.1	57.7	33.6	63.6	49.2	41.1	23.9	178	65.5	65.5
387	90.2	71.0	60.4	35.5	64.2	50.6	43.0	25.3	183	67.6	67.6
399	93.2	72.7	62.9	37.1	66.3	51.7	44.8	26.4	189	69.6	69.6
411	92.5	75.5	65.7	39.0	65.9	53.8	46.7	27.7	194	-	-
423	-	-	-	-	-	-	-	-	-	-	-
413	-	94.4	68.2	42.3	-	67.1	48.5	30.1	-	-	-
423	-	99.1	70.3	44.0	-	70.5	50.1	31.3	-	-	-
434	-	102	72.2	45.5	-	72.6	51.4	32.4	-	-	-
446	-	105	75.3	47.5	-	74.4	53.6	33.8	-	-	-
458	-	108	77.6	48.9	-	76.7	55.2	34.8	-	-	-
472	-	124	81.6	53.5	-	88.5	58.0	38.1	-	-	-
481	-	-	-	-	-	-	-	-	-	-	-
471	-	130	80.1	51.8	-	92.8	57.0	36.9	-	-	-
481	-	135	83.8	55.1	-	96.3	59.6	39.2	-	-	-
493	-	137	89.4	59.5	-	97.4	63.6	42.4	-	-	-
505	-	138	96.1	64.1	-	98.2	68.4	45.6	-	-	-
519	-	-	-	-	-	-	-	-	-	-	-
493	-	136	91.6	71.6	-	96.7	65.2	50.9	-	-	-
503	-	-	-	-	-	-	-	-	-	-	-
491	-	136	78.1	83.4	-	96.6	55.6	59.3	-	-	-
505	-	-	-	-	-	-	-	-	-	-	-
446	-	128	69.0	77.8	-	91.4	49.1	55.3	-	-	-

* Section at which forces are computed is identified in Fig. 3.28.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.
Note: Shaded numbers are max. forces in compession diagonals.

Table C.9a Axial Forces in Bracing Diagonals for Specimen LR17 (Section 1)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CI1T	TO1B	CI3T	TO3B	CI1T	TO1B	CI3T	TO3B		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	4.15	1.47	10.1	15.3	2.97	1.05	7.22	11.0	22.2	8.19	8.19
93.9	8.88	4.42	19.4	29.6	6.35	3.16	13.9	21.2	44.6	16.4	16.4
141	13.7	8.81	29.8	42.3	9.82	6.30	21.3	30.3	67.7	24.6	24.6
188	19.6	11.8	39.3	54.7	14.0	8.46	28.1	39.1	89.7	32.8	32.8
211	22.9	13.4	42.7	60.3	16.4	9.55	30.6	43.2	99.6	36.9	36.9
223	24.1	15.2	48.5	63.9	17.2	10.9	34.7	45.7	108	38.9	38.9
235	25.7	14.5	47.5	68.0	18.4	10.4	34.0	48.7	111	41.0	41.0
246	27.0	18.0	46.3	71.6	19.3	12.9	33.1	51.2	116	43.0	43.0
258	28.7	19.9	47.8	74.8	20.5	14.2	34.2	53.5	122	45.0	45.0
270	31.3	19.4	46.2	77.8	22.4	13.9	33.1	55.6	125	47.1	47.1
282	32.4	23.5	48.2	80.7	23.2	16.8	34.5	57.7	132	-	-
293	35.2	26.0	45.7	83.5	25.2	18.6	32.7	59.7	136	-	-
305	37.0	30.1	44.7	86.3	26.5	21.5	32.0	61.7	142	-	-
317	39.7	31.8	44.1	89.1	28.4	22.8	31.6	63.8	146	-	-
329	41.5	34.6	44.6	92.2	29.7	24.7	31.9	65.9	152	-	-
340	43.8	36.6	44.3	94.4	31.4	26.1	31.7	67.5	157	-	-
352	46.0	40.0	45.0	96.9	32.9	28.6	32.2	69.3	163	-	-
364	48.4	41.5	45.6	98.8	34.6	29.7	32.6	70.7	168	-	-
376	50.4	46.2	44.3	101	36.0	33.1	31.7	72.2	173	-	-
387	52.2	49.4	42.9	103	37.3	35.3	30.7	73.9	177	-	-
399	53.5	53.3	43.5	106	38.3	38.1	31.1	75.7	183	-	-
411	54.9	56.4	40.5	108	39.3	40.3	29.0	76.9	186	-	-
423	56.0	60.3	-	110	40.1	43.1	-	78.7	-	-	-
434	56.7	64.1	-	112	40.5	45.8	-	80.0	-	-	-
446	56.5	69.8	-	114	40.4	49.9	-	81.8	-	-	-
458	57.3	73.1	-	116	41.0	52.3	-	82.7	-	-	-
469	56.9	80.8	-	116	40.7	57.8	-	83.0	-	-	-
481	57.3	86.0	-	118	41.0	61.5	-	84.2	-	-	-
493	57.7	91.6	-	118	41.3	65.5	-	84.2	-	-	-
505	58.0	100	-	118	41.5	71.5	-	84.2	-	-	-
516	58.8	107	-	118	42.1	76.7	-	84.3	-	-	-
529	-	-	-	-	-	-	-	-	-	-	-
511	58.9	111	-	112	42.1	79.3	-	80.2	-	-	-

* Section at which forces are computed is identified in Fig. 3.29.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030
Note: Shaded numbers are max. forces in compression diagonals.

Table C.9b Axial Forces in Bracing Diagonals for Specimen LR17 (Section 2)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CI1B	TO1T	CI3B	TO3T	CI1B	TO1T	CI3B	TO3T		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	4.15	1.40	9.85	15.7	2.97	1.00	7.05	11.2	22.3	8.19	8.19
93.9	8.88	4.00	19.9	30.2	6.35	2.86	14.3	21.6	45.1	16.4	16.4
141	13.9	8.26	29.1	43.0	9.94	5.91	20.8	30.7	67.4	24.6	24.6
188	19.5	12.2	38.0	55.3	14.0	8.71	27.2	39.6	89.4	32.8	32.8
211	22.6	13.9	41.7	60.8	16.2	9.94	29.8	43.5	99.4	36.9	36.9
223	23.8	15.9	43.4	64.4	17.0	11.4	31.0	46.0	105	38.9	38.9
235	25.1	16.0	45.2	68.5	18.0	11.5	32.3	49.0	111	41.0	41.0
246	26.7	18.1	46.4	71.9	19.1	13.0	33.2	51.4	117	43.0	43.0
258	28.6	19.8	46.9	75.0	20.4	14.1	33.6	53.7	122	45.0	45.0
270	30.7	20.7	47.2	78.0	21.9	14.8	33.8	55.8	126	47.1	47.1
282	32.3	23.7	47.5	80.9	23.1	17.0	34.0	57.9	132	-	-
293	34.7	24.9	47.8	83.8	24.8	17.8	34.2	60.0	137	-	-
305	37.3	27.6	47.8	86.7	26.7	19.8	34.2	62.0	143	-	-
317	39.5	29.4	48.0	89.4	28.3	21.0	34.3	64.0	148	-	-
329	41.4	31.9	48.3	92.5	29.6	22.8	34.6	66.2	153	-	-
340	43.9	34.2	48.4	94.4	31.4	24.5	34.6	67.5	158	-	-
352	46.1	37.3	48.1	96.9	33.0	26.7	34.4	69.3	163	-	-
364	48.2	39.7	48.3	98.6	34.5	28.4	34.6	70.5	168	-	-
376	50.2	43.7	48.2	101	35.9	31.3	34.5	72.1	174	-	-
387	52.0	46.8	48.3	103	37.2	33.4	34.6	73.8	179	-	-
399	53.8	50.2	48.1	106	38.5	35.9	34.4	75.6	184	-	-
411	54.7	53.8	48.3	107	39.1	38.5	34.6	76.9	189	-	-
423	56.1	57.7	48.3	110	40.1	41.2	34.5	78.7	195	-	-
434	56.4	61.5	48.2	112	40.3	44.0	34.5	80.0	199	-	-
446	56.3	66.3	47.4	114	40.3	47.4	33.9	81.9	203	-	-
458	56.6	70.9	47.3	115	40.5	50.7	33.9	82.5	208	-	-
469	56.3	76.8	47.0	116	40.2	54.9	33.6	82.7	212	-	-
481	57.0	82.2	47.0	118	40.7	58.8	33.6	84.1	217	-	-
493	57.1	87.7	48.5	117	40.9	62.7	34.7	83.9	222	-	-
505	55.3	95.8	47.7	117	39.5	68.5	34.1	84.0	226	-	-
516	54.8	103	-	117	39.2	73.3	-	83.8	-	-	-
529	-	-	-	-	-	-	-	-	-	-	-
511	52.3	107	-	111	37.4	76.8	-	79.2	-	-	-

* Section at which forces are computed is identified in Fig. 3.29.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030
Note: Shaded numbers are max. forces in compression diagonals.

Table C.9c Axial Forces in Bracing Diagonals for Specimen LR17 (Section 3)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CO2T	TI2B	CI4T	TO4B	CO2T	TI2B	CI4T	TO4B		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	14.9	9.74	2.95	1.36	10.6	6.97	2.11	0.97	20.7	8.19	8.19
93.9	29.3	19.2	7.10	3.57	21.0	13.7	5.08	2.55	42.3	16.4	16.4
141	43.0	27.6	11.8	6.75	30.8	19.7	8.43	4.83	63.7	24.6	24.6
188	54.4	35.5	18.1	12.2	38.9	25.4	13.0	8.74	86.0	32.8	32.8
211	59.2	39.2	21.3	14.9	42.3	28.0	15.2	10.6	96.2	36.9	36.9
223	60.9	41.3	23.4	16.5	43.6	29.6	16.7	11.8	102	38.9	38.9
235	62.9	44.5	24.8	17.7	45.0	31.9	17.7	12.7	107	41.0	41.0
246	64.3	47.4	27.0	19.6	46.0	33.9	19.3	14.0	113	43.0	43.0
258	64.5	49.9	29.0	21.4	46.1	35.7	20.8	15.3	118	45.0	45.0
270	64.6	53.6	30.9	23.3	46.2	38.3	22.1	16.7	123	47.1	47.1
282	63.1	57.1	33.1	25.5	45.1	40.8	23.7	18.2	128	-	-
293	59.8	61.0	35.9	27.9	42.7	43.6	25.6	19.9	132	-	-
305	56.4	64.8	38.5	30.3	40.3	46.3	27.5	21.7	136	-	-
317	55.1	68.6	41.2	33.0	39.4	49.1	29.5	23.6	142	-	-
329	53.0	71.5	43.5	35.5	37.9	51.1	31.1	25.4	146	-	-
340	52.8	74.3	46.2	38.3	37.8	53.2	33.0	27.4	151	-	-
352	51.9	76.6	48.9	41.0	37.1	54.8	34.9	29.3	156	-	-
364	51.8	78.6	51.4	44.4	37.1	56.2	36.7	31.7	162	-	-
376	50.7	81.4	53.2	47.7	36.2	58.2	38.1	34.1	167	-	-
387	-	83.7	54.7	51.1	-	59.9	39.1	36.5	-	-	-
399	-	86.4	56.3	54.6	-	61.8	40.3	39.0	-	-	-
411	-	89.3	57.0	58.3	-	63.9	40.8	41.7	-	-	-
423	-	92.1	57.9	62.2	-	65.9	41.4	44.5	-	-	-
434	-	94.9	58.5	66.4	-	67.9	41.8	47.5	-	-	-
446	-	97.0	58.9	70.8	-	69.4	42.1	50.7	-	-	-
458	-	99.6	59.0	74.6	-	71.3	42.2	53.3	-	-	-
469	-	102	59.3	79.2	-	72.7	42.4	56.6	-	-	-
481	-	104	59.4	83.2	-	74.5	42.5	59.5	-	-	-
493	-	106	59.7	87.2	-	75.8	42.7	62.4	-	-	-
505	-	107	59.9	90.8	-	76.8	42.8	64.9	-	-	-
516	-	109	60.2	93.5	-	78.3	43.0	66.9	-	-	-
529	-	-	-	-	-	-	-	-	-	-	-
511	-	109	58.0	90.4	-	78.2	41.5	64.7	-	-	-

* Section at which forces are computed is identified in Fig. 3.29.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030
Note: Shaded numbers are max. forces in compression diagonals.

Table C.9d Axial Forces in Bracing Diagonals for Specimen LR17 (Section 4)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CO2B	TI2T	CI4B	TO4T	CO2B	TI2T	CI4B	TO4T		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	15.3	10.4	3.03	1.47	10.9	7.47	2.17	1.05	21.6	8.19	8.19
93.9	30.8	20.3	7.33	3.69	22.0	14.5	5.24	2.64	44.4	16.4	16.4
141	43.2	28.9	11.8	6.91	30.9	20.7	8.43	4.94	65.0	24.6	24.6
188	54.9	37.1	18.2	12.4	39.2	26.6	13.0	8.88	87.7	32.8	32.8
211	59.5	40.9	21.6	15.2	42.6	29.3	15.4	10.9	98.1	36.9	36.9
223	61.3	43.3	23.4	17.0	43.8	31.0	16.7	12.2	104	38.9	38.9
235	63.0	46.4	24.9	18.2	45.1	33.2	17.8	13.0	109	41.0	41.0
246	64.3	49.2	27.1	20.1	46.0	35.2	19.4	14.4	115	43.0	43.0
258	64.6	51.6	28.8	21.7	46.2	36.9	20.6	15.5	119	45.0	45.0
270	64.8	55.0	30.8	23.6	46.4	39.4	22.0	16.9	125	47.1	47.1
282	62.9	58.3	33.1	25.7	45.0	41.7	23.7	18.4	129	-	-
293	59.9	61.9	35.9	28.5	42.9	44.2	25.6	20.4	133	-	-
305	57.7	65.5	38.4	31.0	41.3	46.8	27.5	22.2	138	-	-
317	56.8	69.2	41.2	33.8	40.6	49.5	29.5	24.2	144	-	-
329	56.2	72.0	43.1	36.0	40.2	51.5	30.9	25.8	148	-	-
340	55.9	74.6	46.1	38.8	40.0	53.3	33.0	27.8	154	-	-
352	55.1	76.7	48.8	41.8	39.4	54.9	34.9	29.9	159	-	-
364	55.0	78.7	51.3	45.2	39.3	56.3	36.7	32.3	165	-	-
376	54.1	81.0	53.3	48.4	38.7	57.9	38.1	34.6	169	-	-
387	53.2	83.3	54.9	50.9	38.0	59.6	39.2	36.4	173	-	-
399	53.2	85.9	56.3	54.5	38.0	61.4	40.3	39.0	179	-	-
411	53.2	88.4	57.0	58.0	38.0	63.2	40.8	41.5	184	-	-
423	53.1	91.0	57.6	62.2	38.0	65.1	41.2	44.5	189	-	-
434	52.8	93.6	58.5	66.2	37.8	67.0	41.8	47.3	194	-	-
446	52.3	95.8	58.7	70.7	37.4	68.5	42.0	50.5	198	-	-
458	52.1	98.1	58.8	74.4	37.2	70.2	42.0	53.2	203	-	-
469	52.6	100	59.0	79.0	37.6	71.7	42.2	56.5	208	-	-
481	51.3	102	59.1	82.8	36.7	73.3	42.2	59.3	211	-	-
493	51.2	104	59.5	87.1	36.6	74.4	42.6	62.3	216	-	-
505	50.4	106	59.8	90.9	36.1	75.5	42.7	65.0	219	-	-
516	50.1	108	59.6	93.8	35.8	76.9	42.7	67.1	223	-	-
529	-	-	-	-	-	-	-	-	-	-	-
511	47.8	108	57.2	90.8	34.2	76.9	40.9	64.9	217	-	-

* Section at which forces are computed is identified in Fig. 3.29.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030
Note: Shaded numbers are max. forces in compression diagonals.

Table C.10a Axial Forces in Bracing Diagonals for Specimen LR18 (Section 1)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CI1T	TO1B	CO3T	TI3B	CI1T	TO1B	CO3T	TI3B		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	3.41	2.41	15.9	8.50	2.43	1.71	11.3	6.05	21.5	8.19	8.19
93.9	6.52	6.21	30.9	16.5	4.64	4.42	22.0	11.7	42.8	16.4	16.4
141	10.6	11.2	45.2	24.2	7.54	7.98	32.2	17.2	64.9	24.6	24.6
188	14.9	16.2	57.6	32.4	10.6	11.5	41.0	23.1	86.2	32.8	32.8
211	18.0	18.8	62.2	38.5	12.8	13.4	44.3	27.4	97.9	36.9	36.9
235	21.0	23.3	59.6	47.9	14.9	16.6	42.4	34.1	108	-	-
246	23.0	26.3	55.6	56.0	16.4	18.7	39.5	39.9	114	-	-
258	24.8	27.5	53.8	61.4	17.6	19.6	38.3	43.7	119	-	-
270	26.0	30.1	51.7	66.6	18.5	21.4	36.8	47.4	124	-	-
282	28.2	32.6	50.4	71.6	20.1	23.2	35.9	50.9	130	-	-
293	30.7	34.3	49.8	76.0	21.8	24.4	35.4	54.1	136	-	-
305	32.4	37.2	48.8	79.5	23.1	26.5	34.7	56.5	141	-	-
317	34.5	40.1	48.2	82.8	24.6	28.5	34.3	58.9	146	-	-
329	36.8	43.0	47.4	86.1	26.2	30.6	33.7	61.3	152	-	-
340	39.3	45.9	47.1	88.8	28.0	32.6	33.5	63.2	157	-	-
352	41.7	48.2	47.3	91.2	29.7	34.3	33.6	64.9	162	-	-
364	43.7	51.6	46.6	94.1	31.1	36.7	33.2	67.0	168	-	-
376	45.9	55.3	46.5	96.3	32.6	39.3	33.1	68.6	174	-	-
387	48.2	58.6	46.1	98.6	34.3	41.7	32.8	70.2	179	-	-
399	50.7	62.3	45.7	100	36.1	44.3	32.5	71.3	184	-	-
411	53.7	67.9	45.2	100	38.2	48.3	32.2	71.2	190	-	-
423	56.1	75.9	44.5	97.9	39.9	54.0	31.7	69.7	195	-	-
435	-	-	-	-	-	-	-	-	-	-	-
389	53.6	74.8	42.3	80.9	38.1	53.2	30.1	57.5	179	-	-

* Section at which forces are computed is identified in Fig. 3.30.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.
Note: Shaded numbers are max. forces in compression diagonals.

Table C.10b Axial Forces in Bracing Diagonals for Specimen LR18 (Section 2)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CI1B	TO1T	CO3B	TI3T	CI1B	TO1T	CO3B	TI3T		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	3.45	2.44	16.2	8.57	2.45	1.74	11.5	6.10	21.8	8.19	8.19
93.9	6.91	6.44	31.6	16.5	4.92	4.58	22.5	11.7	43.7	16.4	16.4
141	11.3	11.3	46.2	24.3	8.01	8.01	32.9	17.3	66.1	24.6	24.6
188	15.9	16.3	58.9	32.4	11.3	11.6	41.9	23.1	87.9	32.8	32.8
211	19.0	19.4	62.3	38.9	13.5	13.8	44.3	27.7	99.4	36.9	36.9
235	22.3	23.9	60.2	48.2	15.8	17.0	42.9	34.3	110	-	-
246	24.4	26.6	56.7	56.2	17.4	18.9	40.3	40.0	117	-	-
258	26.3	28.1	54.3	61.8	18.7	20.0	38.7	44.0	121	-	-
270	27.8	30.3	52.7	67.3	19.8	21.6	37.5	47.9	127	-	-
282	30.2	32.7	51.2	71.9	21.5	23.3	36.4	51.2	132	-	-
293	32.6	34.8	50.0	76.5	23.2	24.8	35.6	54.4	138	-	-
305	34.6	37.5	49.9	80.2	24.6	26.7	35.5	57.0	144	-	-
317	36.6	40.1	49.0	83.4	26.1	28.5	34.9	59.4	149	-	-
329	39.3	42.8	48.3	86.8	28.0	30.4	34.4	61.8	155	-	-
340	41.5	45.7	48.0	89.5	29.5	32.5	34.1	63.7	160	-	-
352	44.2	48.4	47.8	92.2	31.5	34.4	34.0	65.6	166	-	-
364	46.4	51.5	47.3	95.0	33.0	36.6	33.6	67.6	171	-	-
376	48.9	54.8	46.9	97.5	34.8	39.0	33.4	69.4	177	-	-
387	51.6	58.3	46.9	99.7	36.7	41.5	33.4	70.9	183	-	-
399	53.8	61.9	-	101	38.3	44.0	-	72.0	-	-	-
411	56.3	67.1	-	101	40.0	47.7	-	72.0	-	-	-
423	57.2	75.0	-	99.3	40.7	53.4	-	70.7	-	-	-
435	-	-	-	-	-	-	-	-	-	-	-
389	-	74.5	-	82.6	-	53.0	-	58.8	-	-	-

* Section at which forces are computed is identified in Fig. 3.30.

** The axial forces are calculated from strain gauge readings.

*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.

Note: Shaded numbers are max. forces in compression diagonals.

Table C.10c Axial Forces in Bracing Diagonals for Specimen LR18 (Section 3)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CI2T	TO2B	CO4T	TI4B	CI2T	TO2B	CO4T	TI4B		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	10.6	16.6	3.30	0.16	7.51	11.8	2.35	0.11	21.8	8.19	8.19
93.9	20.1	31.4	8.57	0.97	14.3	22.3	6.10	0.69	43.4	16.4	16.4
140.8	29.5	45.7	14.5	2.33	21.0	32.5	10.3	1.66	65.5	24.6	24.6
187.8	38.2	60.1	20.3	3.53	27.2	42.8	14.5	2.51	86.9	32.8	32.8
211	41.7	68.0	24.7	4.35	29.7	48.4	17.6	3.10	98.8	36.9	36.9
235	44.0	75.1	29.5	5.01	31.3	53.4	21.0	3.57	109	-	-
246	44.8	80.1	32.6	5.51	31.9	57.0	23.2	3.92	116	-	-
258	45.3	83.4	35.2	6.17	32.2	59.3	25.0	4.39	121	-	-
270	46.4	87.1	38.1	6.91	33.0	62.0	27.1	4.92	127	-	-
282	46.1	91.2	40.5	7.64	32.8	64.9	28.8	5.44	132	-	-
293	46.0	95.9	43.6	8.65	32.7	68.2	31.0	6.16	138	-	-
305	46.0	99.3	46.1	9.74	32.7	70.7	32.8	6.93	143	-	-
317	45.8	103	49.2	11.1	32.6	73.3	35.0	7.90	149	-	-
329	45.3	107	52.2	12.5	32.2	75.8	37.2	8.89	154	-	-
340	45.0	110	55.4	13.8	32.0	78.1	39.4	9.83	159	-	-
352	45.5	113	60.0	15.4	32.4	80.2	42.7	10.9	166	-	-
364	45.2	116	61.6	17.1	32.2	82.4	43.8	12.1	171	-	-
376	44.9	119	65.7	19.1	31.9	84.5	46.8	13.6	177	-	-
387	45.0	122	69.0	21.9	32.0	86.7	49.1	15.6	183	-	-
399	44.2	123	-	28.8	31.4	87.4	-	20.5	-	-	-
411	31.5	125	-	49.0	22.4	88.9	-	34.8	-	-	-
423	-	124	-	69.5	-	88.4	-	49.4	-	-	-
435	-	-	-	-	-	-	-	-	-	-	-
389	-	115	-	75.1	-	81.6	-	53.4	-	-	-

* Section at which forces are computed is identified in Fig. 3.30.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.
Note: Shaded numbers are max. forces in compression diagonals.

Table C.10d Axial Forces in Bracing Diagonals for Specimen LR18 (Section 4)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CI2B	TO2T	CO4B	TI4T	CI2B	TO2T	CO4B	TI4T		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	10.9	16.1	3.41	0.3	7.78	11.4	2.43	0.22	21.9	8.19	8.19
93.9	21.9	30.7	8.50	0.97	15.6	21.8	6.05	0.69	44.2	16.4	16.4
141	32.1	44.9	14.5	2.72	22.8	31.9	10.3	1.94	67.0	24.6	24.6
188	41.4	59.0	20.4	4.23	29.5	42.0	14.5	3.01	89.0	32.8	32.8
211	45.5	66.7	24.6	5.12	32.4	47.5	17.5	3.64	101	36.9	36.9
235	47.6	73.8	29.4	5.59	33.9	52.5	20.9	3.98	111	-	-
246	48.9	78.8	32.7	6.17	34.8	56.1	23.2	4.39	119	-	-
258	49.7	82.0	35.2	6.71	35.3	58.3	25.0	4.77	123	-	-
270	48.9	85.9	38.3	7.45	34.8	61.1	27.2	5.30	128	-	-
282	48.7	89.8	40.6	9.89	34.7	63.9	28.9	7.04	135	-	-
293	48.4	94.1	43.7	11.1	34.4	66.9	31.1	7.90	140	-	-
305	46.7	97.7	46.3	12.5	33.2	69.5	32.9	8.86	145	-	-
317	46.7	102	49.6	13.7	33.2	72.2	35.3	9.77	150	-	-
329	46.1	105	52.4	15.4	32.8	74.6	37.3	10.9	156	-	-
340	-	108	55.6	16.8	-	77.0	39.6	11.9	-	-	-
352	-	111	58.5	18.5	-	79.0	41.6	13.1	-	-	-
364	-	114	61.7	20.4	-	81.0	43.9	14.5	-	-	-
376	-	117	64.7	22.4	-	83.1	46.1	16.0	-	-	-
387	-	119	66.9	25.6	-	84.9	47.6	18.2	-	-	-
399	-	120	65.7	32.1	-	85.7	46.8	22.9	-	-	-
411	-	123	52.5	52.3	-	87.2	37.3	37.2	-	-	-
423	-	123	43.8	72.4	-	87.3	31.2	51.5	-	-	-
435	-	-	-	-	-	-	-	-	-	-	-
389	-	114	34.6	78.0	-	81.1	24.6	55.5	-	-	-

* Section at which forces are computed is identified in Fig. 3.30.

** The axial forces are calculated from strain gauge readings.

*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.

Note: Shaded numbers are max. forces in compression diagonals.

Table C.11a Axial Forces in Bracing Diagonals for Specimen LR19 (Section 1)*

Load	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
(kN)	CC1T	TF1B	CF3T	TC3B	CC1T	TF1B	CF3T	TC3B	(kN)	C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	7.99	4.73	11.2	7.57	5.69	3.37	7.98	5.39	22.4	8.19	8.19
93.9	15.9	9.27	22.0	14.8	11.3	6.60	15.6	10.5	44.1	16.4	16.4
141	23.8	13.8	32.8	22.1	16.9	9.83	23.3	15.7	65.8	24.6	24.6
189	32.3	18.6	44.1	30.0	23.0	13.2	31.4	21.4	89.0	33.0	33.0
236	41.1	24.0	54.1	36.7	29.2	17.1	38.5	26.1	111	41.1	41.1
282	49.8	29.4	63.9	43.3	35.5	20.9	45.5	30.8	133	49.1	49.1
329	59.1	35.1	73.8	49.9	42.0	25.0	52.5	35.5	155	57.3	57.3
352	63.7	38.0	78.6	53.2	45.3	27.0	55.9	37.8	166	61.4	61.4
376	68.2	40.7	83.3	56.7	48.5	29.0	59.3	40.3	177	65.5	65.5
399	73.3	44.4	87.2	59.8	52.2	31.6	62.1	42.5	188	69.6	69.6
412	-	-	-	-	-	-	-	-	-	-	-
404	76.6	44.5	86.8	59.6	54.5	31.7	61.8	42.4	190	-	-
412	78.6	45.7	88.5	60.6	55.9	32.5	63.0	43.1	195	-	-
423	81.1	46.8	89.8	62.0	57.7	33.3	63.9	44.1	199	-	-
436	-	-	-	-	-	-	-	-	-	-	-
426	80.9	46.9	92.2	62.3	57.6	33.4	65.6	44.3	201	-	-
434	83.0	47.8	93.6	63.6	59.1	34.0	66.6	45.3	205	-	-
446	85.8	50.1	94.6	65.6	61.0	35.7	67.3	46.7	211	-	-
458	-	-	-	-	-	-	-	-	-	-	-
444	-	69.5	94.6	67.4	-	49.4	67.3	47.9	-	-	-
460	-	-	-	-	-	-	-	-	-	-	-
437	-	85.1	-	101	-	60.5	-	71.7	-	-	-
446	-	88.6	-	106	-	63.1	-	75.2	-	-	-
458	-	98.4	-	116	-	70.0	-	82.3	-	-	-
467	-	110	-	120	-	78.3	-	85.3	-	-	-
482	-	-	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.27.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.
Note: Shaded numbers are max. forces for compression diagonals.

Table C.11b Axial Forces in Bracing Diagonals for Specimen LR19 (Section 2)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CC1B	TF1T	CF3B	TC3T	CC1B	TF1T	CF3B	TC3T		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	8.15	4.66	11.3	7.57	5.80	3.32	8.01	5.39	22.5	8.19	8.19
93.9	16.0	9.20	22.0	15.0	11.4	6.55	15.7	10.7	44.3	16.4	16.4
141	24.0	13.9	32.8	22.2	17.1	9.88	23.4	15.8	66.1	24.6	24.6
189	32.4	18.8	44.1	30.1	23.1	13.4	31.4	21.4	89.2	33.0	33.0
236	41.1	24.4	54.1	36.8	29.3	17.4	38.5	26.2	111	41.1	41.1
282	49.9	29.9	64.0	43.3	35.5	21.3	45.6	30.8	133	49.1	49.1
329	59.1	35.9	74.0	49.9	42.0	25.5	52.7	35.5	156	57.3	57.3
352	63.6	38.8	78.9	53.2	45.2	27.6	56.1	37.9	167	61.4	61.4
376	68.2	41.6	83.5	56.5	48.5	29.6	59.4	40.2	178	65.5	65.5
399	73.2	45.1	87.5	59.6	52.1	32.1	62.3	42.4	189	69.6	69.6
412	-	-	-	-	-	-	-	-	-	-	-
404	76.4	45.4	87.2	59.4	54.4	32.3	62.0	42.3	191	-	-
412	78.5	46.5	88.8	60.5	55.8	33.1	63.2	43.0	195	-	-
423	81.0	47.7	90.1	61.7	57.6	33.9	64.1	43.9	200	-	-
436	-	-	-	-	-	-	-	-	-	-	-
426	80.9	47.7	92.3	62.0	57.5	33.9	65.7	44.1	201	-	-
434	82.9	48.7	93.9	63.1	59.0	34.7	66.8	44.9	205	-	-
446	85.6	50.8	94.8	65.0	60.9	36.2	67.5	46.3	211	-	-
458	-	-	-	-	-	-	-	-	-	-	-
444	61.8	69.5	95.3	66.9	44.0	49.5	67.8	47.6	209	-	-
460	-	-	-	-	-	-	-	-	-	-	-
437	33.3	85.0	-	99.9	23.7	60.5	-	71.1	-	-	-
446	32.7	88.4	-	105	23.2	62.9	-	74.5	-	-	-
458	26.0	97.4	-	115	18.5	69.3	-	81.7	-	-	-
467	18.6	109	-	119	13.2	77.4	-	84.8	-	-	-
482	-	-	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.27.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.
Note: Shaded numbers are max. forces for compression diagonals.

Table C.11c Axial Forces in Bracing Diagonals for Specimen LR19 (Section 3)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CC2T	TF2B	CF4T	TC4B	CC2T	TF2B	CF4T	TC4B		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	11.5	8.73	7.88	4.04	8.20	6.21	5.61	2.87	22.9	8.19	8.19
93.9	22.2	16.7	15.7	7.99	15.8	11.9	11.2	5.69	44.5	16.4	16.4
141	33.1	25.0	23.5	11.8	23.6	17.8	16.7	8.37	66.4	24.6	24.6
189	44.1	33.4	31.8	15.7	31.4	23.8	22.6	11.2	88.9	33.0	33.0
236	53.7	40.4	40.7	20.3	38.2	28.8	28.9	14.4	110	41.1	41.1
282	63.3	47.7	49.4	25.1	45.0	33.9	35.1	17.9	132	49.1	49.1
329	72.9	54.6	58.4	30.0	51.8	38.9	41.6	21.4	154	57.3	57.3
352	77.8	58.3	62.9	32.4	55.4	41.5	44.8	23.1	165	61.4	61.4
376	81.6	62.3	67.3	34.9	58.0	44.3	47.9	24.8	175	65.5	65.5
399	84.4	66.1	72.2	37.8	60.0	47.0	51.4	26.9	185	69.6	69.6
412	-	-	-	-	-	-	-	-	-	-	-
404	-	80.1	74.7	39.4	-	57.0	53.1	28.1	-	-	-
412	-	83.8	76.5	40.6	-	59.6	54.4	28.9	-	-	-
423	-	89.4	78.5	42.1	-	63.6	55.9	29.9	-	-	-
436	-	-	-	-	-	-	-	-	-	-	-
426	-	97.9	-	56.7	-	69.6	-	40.3	-	-	-
434	-	102	-	62.0	-	72.6	-	44.1	-	-	-
446	-	110	-	72.6	-	78.4	-	51.7	-	-	-
458	-	-	-	-	-	-	-	-	-	-	-
444	-	113	-	77.6	-	80.7	-	55.2	-	-	-
460	-	-	-	-	-	-	-	-	-	-	-
437	-	115	-	84.2	-	82.1	-	59.9	-	-	-
446	-	115	-	87.7	-	82.1	-	62.4	-	-	-
458	-	119	-	96.8	-	84.9	-	68.9	-	-	-
467	-	121	-	110	-	86.4	-	78.5	-	-	-
482	-	-	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.27.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.
Note: Shaded numbers are max. forces for compression diagonals.

Table C.11d Axial Forces in Bracing Diagonals for Specimen LR19 (Section 4)*

Load (kN)	Axial Force in Member** (kN)				Shear Resisted by Member*** (kN)				Total Shear (kN)	Forces in Diagonals Obtained from ANSYS and S-frame (kN)	
	CC2B	TF2T	CF4B	TC4T	CC2B	TF2T	CF4B	TC4T		C	T
0	0	0	0	0	0	0	0	0	0	0	0
46.9	11.4	8.57	7.88	3.96	8.12	6.10	5.61	2.82	22.6	8.19	8.19
93.9	21.8	16.4	15.8	8.03	15.5	11.7	11.2	5.71	44.2	16.4	16.4
141	32.9	24.6	23.8	12.0	23.4	17.5	16.9	8.56	66.4	24.6	24.6
189	43.3	32.9	32.1	16.3	30.8	23.4	22.8	11.6	88.7	33.0	33.0
236	52.7	40.0	41.2	20.9	37.5	28.5	29.3	14.9	110	41.1	41.1
282	62.3	47.0	49.9	26.1	44.3	33.4	35.5	18.6	132	49.1	49.1
329	71.4	54.0	59.3	30.9	50.8	38.4	42.2	22.0	153	57.3	57.3
352	76.2	57.5	63.9	33.3	54.2	40.9	45.5	23.7	164	61.4	61.4
376	79.9	61.3	68.0	36.9	56.9	43.6	48.4	26.3	175	65.5	65.5
399	83.8	65.2	73.3	39.6	59.7	46.4	52.2	28.2	186	69.6	69.6
412	-	-	-	-	-	-	-	-	-	-	-
404	68.3	79.7	75.7	41.4	48.6	56.7	53.8	29.5	189	-	-
412	66.8	83.6	78.1	42.3	47.5	59.5	55.6	30.1	193	-	-
423	63.1	89.3	79.9	44.0	44.9	63.6	56.9	31.3	197	-	-
436	-	-	-	-	-	-	-	-	-	-	-
426	60.9	98.1	64.1	58.2	43.3	69.8	45.6	41.4	200	-	-
434	59.1	102	61.2	63.4	42.1	72.7	43.5	45.1	203	-	-
446	50.4	111	55.1	74.0	35.9	78.7	39.2	52.7	207	-	-
458	-	-	-	-	-	-	-	-	-	-	-
444	41.6	116	46.4	78.8	29.6	82.6	33.0	56.1	201	-	-
460	-	-	-	-	-	-	-	-	-	-	-
437	35.6	115	42.1	85.4	25.3	81.5	30.0	60.7	198	-	-
446	36.2	116	40.4	88.9	25.7	82.8	28.8	63.2	201	-	-
458	35.1	121	52.2	97.7	25.0	86.1	37.1	69.5	218	-	-
467	24.7	124	46.6	111	17.6	88.0	33.1	79.0	218	-	-
482	-	-	-	-	-	-	-	-	-	-	-

* Section at which forces are computed is identified in Fig. 3.27.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 838.1/1020.
Note: Shaded numbers are max. forces for compression diagonals.

Table C.12a Axial Forces in Bracing Diagonals for Specimen LR20 (Section 1)*

Load (kN)	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear (kN)
	CI1T	TO1B	CO3T	TI3B	CI1T	TO1B	CO3T	TI3B	
0	0	0	0	0	0	0	0	0	0
46.9	4.35	2.64	14.3	10.6	3.11	1.89	10.2	7.60	22.8
93.9	9.31	5.98	27.0	19.1	6.66	4.28	19.3	13.6	43.9
141	14.7	10.3	39.9	28.3	10.5	7.38	28.5	20.2	66.6
188	20.4	15.7	52.6	37.0	14.6	11.2	37.6	26.5	89.9
211	23.4	18.4	58.1	41.1	16.7	13.2	41.5	29.4	101
235	26.9	21.5	62.1	45.5	19.2	15.4	44.4	32.5	112
246	28.9	22.7	63.2	47.9	20.7	16.2	45.2	34.3	116
258	31.1	24.8	63.2	50.1	22.2	17.7	45.2	35.8	121
270	33.4	26.9	62.6	53.1	23.9	19.2	44.8	38.0	126
282	36.9	30.8	60.6	56.8	26.4	22.0	43.4	40.7	132
293	39.3	33.4	58.4	60.2	28.1	23.9	41.8	43.0	137
305	42.6	37.4	55.6	64.2	30.5	26.8	39.7	45.9	143
317	44.6	40.3	54.9	67.1	31.9	28.8	39.2	48.0	148
331	47.0	43.5	54.4	70.7	33.6	31.1	38.9	50.6	154
340	49.0	47.3	53.2	71.4	35.1	33.9	38.0	51.1	158
352	50.6	50.2	52.8	74.3	36.2	35.9	37.7	53.2	163
364	52.6	55.2	52.0	77.4	37.6	39.5	37.2	55.3	170
376	53.7	58.7	51.5	80.0	38.4	42.0	36.8	57.3	174
387	54.9	62.2	51.1	83.3	39.3	44.5	36.6	59.6	180
399	55.4	66.4	50.4	86.7	39.7	47.5	36.1	62.0	185
411	55.6	70.4	49.8	89.4	39.8	50.4	35.6	64.0	190
423	55.6	74.9	49.5	92.6	39.8	53.6	35.4	66.2	195
434	56.6	77.9	50.1	95.5	40.5	55.7	35.8	68.3	200
446	55.8	82.7	49.1	98.9	39.9	59.1	35.1	70.7	205
458	56.2	86.6	48.8	102	40.2	62.0	34.9	72.6	210
469	56.2	91.0	48.8	104	40.2	65.1	34.9	74.5	215
481	55.8	95.7	48.3	107	39.9	68.5	34.6	76.7	220
493	56.4	99.3	48.3	110	40.4	71.0	34.6	78.4	224
505	56.8	103	47.7	113	40.6	73.9	34.2	80.7	229
516	56.6	107	47.1	115	40.5	76.9	33.7	82.1	233
528	56.7	112	46.3	118	40.5	80.2	33.1	84.3	238
540	-	117	45.4	120	-	83.7	32.5	86.2	-
552	-	112	41.7	123	-	80.3	29.8	88.0	-
564	-	-	-	-	-	-	-	-	-
533	-	118	-	125	-	84.7	-	89.2	-

* Section at which forces are computed is identified in Fig. 3.31.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030
Note: Shaded numbers are max. forces for compression diagonals.

Table C.12b Axial Forces in Bracing Diagonals for Specimen LR20 (Section 2)*

Load (kN)	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear (kN)
	CI1B	TO1T	CO3B	TI3T	CI1B	TO1T	CO3B	TI3T	
0	0	0	0	0	0	0	0	0	0
46.9	4.15	2.87	14.7	10.8	2.97	2.05	10.5	7.69	23.2
93.9	9.00	6.67	27.4	19.4	6.44	4.77	19.6	13.9	44.7
141	14.2	10.8	40.2	28.8	10.1	7.72	28.8	20.6	67.2
188	19.7	16.3	52.8	38.4	14.1	11.7	37.8	27.4	91.0
211	22.6	19.0	58.4	42.2	16.2	13.6	41.8	30.2	102
235	26.0	22.0	62.5	46.8	18.6	15.8	44.7	33.5	113
246	28.3	23.9	63.4	49.0	20.2	17.1	45.4	35.1	118
258	30.1	25.1	63.7	51.4	21.5	18.0	45.5	36.7	122
270	32.5	27.6	63.1	54.5	23.2	19.7	45.1	39.0	127
282	36.0	31.6	61.6	57.7	25.8	22.6	44.0	41.2	134
293	38.4	34.5	59.7	60.6	27.4	24.7	42.7	43.3	138
305	41.5	38.3	56.3	65.0	29.7	27.4	40.2	46.5	144
317	43.4	40.9	55.6	68.0	31.0	29.2	39.8	48.6	149
331	45.9	44.6	54.8	72.2	32.8	31.9	39.2	51.6	156
340	47.9	48.5	54.1	72.1	34.3	34.7	38.7	51.5	159
352	49.6	51.8	53.3	75.6	35.5	37.1	38.1	54.1	165
364	51.1	55.9	54.1	77.8	36.6	40.0	38.7	55.6	171
376	52.3	58.8	53.1	80.5	37.4	42.1	38.0	57.6	175
387	53.4	62.4	52.9	83.3	38.2	44.7	37.9	59.6	180
399	54.1	66.5	52.2	86.5	38.7	47.6	37.3	61.9	185
411	54.2	71.2	51.7	89.8	38.8	50.9	37.0	64.2	191
423	54.3	75.0	51.5	92.2	38.8	53.6	36.8	65.9	195
434	54.7	78.8	51.3	96.0	39.1	56.3	36.7	68.7	201
446	54.4	83.6	50.7	99.1	38.9	59.8	36.3	70.9	206
458	54.6	87.5	50.8	102	39.1	62.6	36.4	72.6	211
469	54.7	92.0	50.9	104	39.1	65.8	36.4	74.4	216
481	54.4	96.5	50.3	107	38.9	69.1	36.0	76.6	220
493	54.8	100	50.6	110	39.2	71.5	36.2	78.4	225
505	55.2	104	50.6	113	39.5	74.6	36.2	80.6	231
516	55.2	109	49.9	115	39.5	77.7	35.7	82.0	235
528	55.2	113	49.9	118	39.5	80.6	35.7	84.1	240
540	54.9	118	49.6	120	39.3	84.3	35.5	85.5	245
552	53.7	123	49.0	122	38.4	87.7	35.1	86.9	248
564	-	-	-	-	-	-	-	-	-
533	-	122	-	123	-	87.5	-	88.3	-

* Section at which forces are computed is identified in Fig. 3.31.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030
Note: Shaded numbers are max. forces for compression diagonals.

Table C.12c Axial Forces in Bracing Diagonals for Specimen LR20 (Section 3)*

Load	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear
(kN)	CO2T	TI2B	CI4T	TO4B	CO2T	TI2B	CI4T	TO4B	(kN)
0	0	0	0	0	0	0	0	0	0
46.9	16.8	9.08	3.45	2.21	12.0	6.50	2.47	1.58	22.6
93.9	31.3	16.9	6.75	5.82	22.4	12.1	4.83	4.16	43.4
141	44.6	25.0	10.7	10.1	31.9	17.8	7.66	7.19	64.6
188	56.5	33.1	15.4	15.1	40.4	23.7	11.0	10.8	85.9
211	60.6	37.6	18.0	18.1	43.4	26.9	12.8	12.9	96.1
235	61.1	43.0	21.6	22.3	43.7	30.8	15.5	16.0	106
246	57.2	47.4	24.1	25.1	40.9	33.9	17.2	18.0	110
258	53.3	52.0	26.1	27.5	38.1	37.2	18.7	19.7	114
270	50.5	55.8	28.6	29.8	36.1	39.9	20.4	21.3	118
282	50.1	60.3	31.6	33.4	35.8	43.1	22.6	23.9	125
293	49.3	62.6	33.6	35.5	35.2	44.8	24.0	25.4	129
305	47.7	65.8	36.7	38.6	34.1	47.1	26.3	27.6	135
317	47.3	68.2	38.8	40.9	33.9	48.8	27.8	29.3	140
331	45.7	70.9	41.6	44.1	32.7	50.7	29.7	31.5	145
340	46.7	72.8	43.2	46.6	33.4	52.1	30.9	33.3	150
352	44.6	75.7	45.5	49.6	31.9	54.2	32.6	35.5	154
364	46.3	78.8	47.4	52.6	33.1	56.3	33.9	37.6	161
376	45.1	81.6	49.2	55.6	32.3	58.4	35.2	39.7	166
387	45.8	84.3	50.6	58.4	32.8	60.3	36.2	41.8	171
399	45.1	87.2	52.1	61.3	32.2	62.4	37.3	43.9	176
411	45.1	89.7	52.9	64.1	32.3	64.2	37.9	45.9	180
423	44.5	92.2	53.8	67.5	31.9	66.0	38.5	48.3	185
434	43.8	94.9	54.6	70.8	31.3	67.9	39.1	50.7	189
446	42.8	97.5	55.6	74.5	30.6	69.7	39.7	53.3	193
458	43.3	100	55.5	78.2	30.9	71.6	39.7	55.9	198
469	43.3	102	55.9	82.7	30.9	73.3	40.0	59.2	203
481	42.9	105	56.1	86.8	30.7	75.3	40.1	62.1	208
493	42.8	108	56.5	90.1	30.6	77.1	40.4	64.5	213
505	42.5	110	56.9	93.9	30.4	79.0	40.7	67.2	217
516	42.3	113	56.9	97.7	30.3	80.8	40.7	69.9	222
528	42.4	115	57.5	101	30.3	82.6	41.1	72.5	227
540	42.1	117	57.7	106	30.1	84.0	41.3	75.7	231
552	42.1	119	-	109	30.1	85.3	-	78.3	-
564	-	-	-	-	-	-	-	-	-
533	38.5	113	-	103	27.6	80.6	-	73.6	-

* Section at which forces are computed is identified in Fig. 3.31.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030
Note: Shaded numbers are max. forces for compression diagonals.

Table C.12d Axial Forces in Bracing Diagonals for Specimen LR20 (Section 4)*

Load (kN)	Axial Force in Member (kN)**				Shear Resisted by Member (kN)***				Total Shear (kN)
	CO2B	TI2T	CI4B	TO4T	CO2B	TI2T	CI4B	TO4T	
0	0	0	0	0	0	0	0	0	0
46.9	16.5	8.96	2.91	1.94	11.8	6.41	2.08	1.39	21.7
93.9	30.9	16.5	6.13	5.32	22.1	11.8	4.39	3.81	42.1
141	44.5	24.4	9.85	9.27	31.8	17.4	7.05	6.63	62.9
188	56.3	32.5	14.9	14.6	40.3	23.2	10.7	10.4	84.6
211	60.6	36.9	17.6	17.5	43.4	26.4	12.6	12.5	94.9
235	60.6	42.5	21.2	21.8	43.4	30.4	15.1	15.6	104
246	56.2	46.5	22.9	24.6	40.2	33.2	16.3	17.6	107
258	51.8	51.3	25.9	27.0	37.0	36.7	18.5	19.3	112
270	47.9	55.3	27.3	29.3	34.2	39.5	19.5	20.9	114
282	-	59.9	31.2	32.7	-	42.9	22.3	23.4	-
293	-	62.3	33.4	34.8	-	44.5	23.9	24.9	-
305	-	65.8	36.9	38.0	-	47.1	26.4	27.1	-
317	-	68.2	38.8	40.2	-	48.8	27.8	28.8	-
331	-	70.8	41.0	43.4	-	50.6	29.3	31.1	-
340	-	72.9	43.4	45.6	-	52.1	31.0	32.6	-
352	-	75.8	46.0	48.6	-	54.2	32.9	34.8	-
364	-	78.7	47.7	51.8	-	56.3	34.1	37.0	-
376	-	81.6	49.6	54.5	-	58.3	35.4	39.0	-
387	-	84.5	51.5	57.1	-	60.5	36.8	40.9	-
399	-	87.5	52.6	60.3	-	62.6	37.6	43.1	-
411	-	90.1	53.2	62.5	-	64.4	38.0	44.7	-
423	-	92.8	54.5	66.0	-	66.4	39.0	47.2	-
434	-	95.5	56.2	69.3	-	68.3	40.2	49.6	-
446	-	97.9	56.2	73.0	-	70.0	40.2	52.2	-
458	-	100	56.6	76.5	-	71.9	40.5	54.7	-
469	-	103	56.8	81.1	-	73.7	40.7	58.0	-
481	-	106	57.1	85.2	-	75.9	40.9	61.0	-
493	-	109	57.2	88.5	-	77.8	40.9	63.3	-
505	-	112	57.4	92.3	-	79.8	41.1	66.0	-
516	-	114	58.2	95.9	-	81.5	41.6	68.6	-
528	-	117	58.9	99.6	-	83.6	42.1	71.2	-
540	-	119	60.0	104	-	85.0	42.9	74.5	-
552	-	120	59.9	108	-	86.2	42.9	77.0	-
564	-	-	-	-	-	-	-	-	-
533	-	114	53.9	102	-	81.6	38.5	72.7	-

* Section at which forces are computed is identified in Fig. 3.31.
** The axial forces are calculated from strain gauge readings.
*** Shear resisted by each member= axial force in member x Sin 60° x 850.8/1030
Note: Shaded numbers are max. forces for compression diagonals.

APPENDIX - D

Calculation of Forces in Diagonal Members from Strain Gauge Readings

Calculation of Forces in Members from Strain Gauge Readings

a. Strains at Opposite Ends not having Same Signs (Tension at one end and compression at the other end)

From Fig. D.1a:

If the cross-section is divided into 200 slices, 'Y_1' for slice 'm' is given by

$$Y_1 = \frac{D}{2} - (m-1)dy - \frac{dy}{2} \quad \text{(D.1)}$$

in which $dy = \frac{D}{200}$, and m=1 to 200

The width 'B' of the fibre at distance 'Y_1' from the centroidal axis

$$B = 2\sqrt{\left(\frac{D}{2}\right)^2 - (Y_1)^2} \quad \text{(D.2)}$$

The depth of the neutral axis 'X' is calculated as:

$$X = \frac{\varepsilon_1 D}{|\varepsilon_1| + |\varepsilon_2|} \quad \text{(D.3)}$$

Strain 'ε' in fibre, distance 'Y_1' from centroidal axis

$$\varepsilon = \frac{\varepsilon_1}{X}\left[Y_1 - \left(\frac{D}{2} - X\right)\right] \quad \text{(D.4)}$$

After calculating ε at any strip of the cross-section, the stress is calculated from Hooke's law:

$$\sigma = \varepsilon E \quad \text{(D.5)}$$

Then the stress obtained is compared with the actual yield stress of the member:

If $\sigma < F_y$, then $P = \sigma B\, dy$ (D.6) and if $\sigma > F_y$, then $P = F_y B\, dy$ (D.7)

where P is the force in that strip of the cross-section. Summing the forces in all slices of the cross-section will give the force in the member.

b. Strains at Opposite Ends having Same Signs (Both tension or compression)

From Fig. D.1b:

The distance 'Y_2' of slice 'm' from top:

$$Y_2 = (m-1)\,dy + \frac{dy}{2} \tag{D.8}$$

where, $dy = \dfrac{D}{200}$

and $m = 1$ to 200

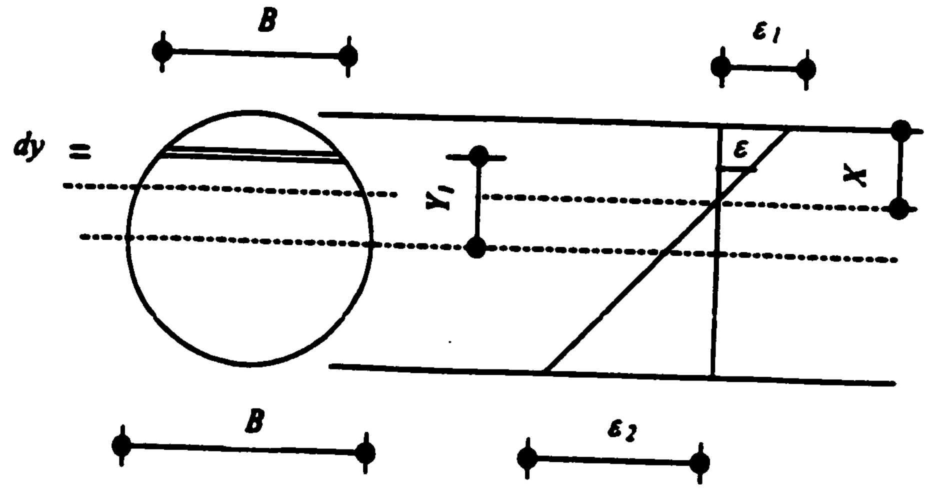
The width B of the fibre at distance 'Y_2' from the top:

$$B = 2\sqrt{\left(\frac{D}{2}\right)^2 - \left(\frac{D}{2} - Y_2\right)^2} \tag{D.9}$$

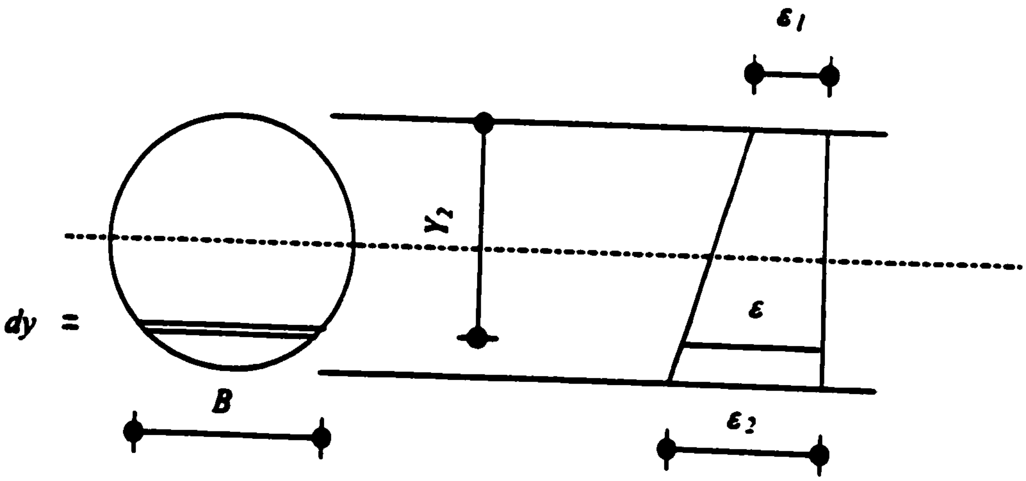
Strain ε at any distance 'Y_2' from top

$$\varepsilon = \frac{Y_2}{D}(\varepsilon_2 - \varepsilon_1) + \varepsilon_1 \tag{D.10}$$

After determining the strains, the stresses and the forces are calculated using Eq. D.5, D.6, and D.7. The forces are added for all the strips to obtain the force in the member.



(a) Tension at one extreme fibre and Compression at the other extreme



(b) Same type of strain at top and bottom

Fig. D.1 Strain Variation at a Cross-section of the Diagonal

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