The Strength of Biaxially Loaded Beam-Columns in Flexibly Connected Steel Frames.

Volume II

A Survey of the Mechanical and Geometric Properties of Structural Steel Sections.

by

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in Flexibly Connected Steel Frames.

Volume II

Please note that due to the physical restriction on the maximum thickness of 'soft bound' theses, the appendices to Volume I have had to be temporarily located at the back of this volume. Upon completion of the assessment of this work, and the inclusion of any modifications or revisions which may be deemed necessary, all copies of both Volumes I and II will be converted to 'hard bound' binding. The increased volume thickness permitted using this technique will enable these appendices to be located in their correct and proper position - at the back of Volume I. Apologies for any confusion this may have caused.

Craig Gibbons 27/1/91

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Acknowledgements

The particular work described in this volume was part of an experimental study into the behaviour of semi-rigid steel frames with semi-rigid connections. The work was principally conducted in the Civil and Structural Engineering Department at the University of Sheffield over the period October 1987 to December 1990.

The success of the project is a measure of the high calibre, commitment and enthusiasm of those who monitored and assisted me in the execution of the work. I would like to thank my supervisors, Prof. David Nethercot and Dr. Pat Kirby, for their guidance and support throughout the project, and also the technical staff in the Department for their practical advice and assistance. Of particular note is my appreciation to Mr. John Surr who was employed as the project Technician. The large scale experimental tests were performed at the Building Research Establishment (B.R.E.), near Watford. I would like to thank the staff at B.R.E., notably Dr. David Moore, Mr. David White and Mr. Derick Jenkins, for their co-operation and technical expertise.

Financial support of the project was provided by the Science and Engineering Council (S.E.R.C.) and the Building Research Establishment. All the structural steel sections used in the project were donated by British Steel. I am of course grateful to these bodies, without whom this project would not have been possible.

Declaration

Except where specific reference has been made to the work of others, this thesis is the result of my own work. No part of this thesis has been submitted to any University for a Degree, Diploma or other qualification.

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Craig Gibbons

Summary

This volume details a study which was conducted into the properties of steel sections used in the experimental research project reported in volume I. In total there were 86 different steel specimens comprising 254x102x22UB and 152x152x23UC sections with a total weight of 6.25 tonnes. Tests were performed to establish their mechanical properties, e.g. yield stress, residual stress patterns, elastic modulus, and also their geometric properties, e.g. thickness, area, second moment of area and elastic section moduli. In addition to presenting and discussing the measured data, a description of the various test methods is also presented. One significant finding of the study is that the properties of steel sections can vary considerably from the nominal tabulated values used by steelwork designers.

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1 Introduction.

This document provides a self contained summary of the measured mechanical and geometric properties of steel elements which were used in an extensive experimental study into the performance of steel structures. This document therefore represents a supplementary volume to the author's thesis on the experimental study [1].

For clarity, the appraisal of dimensional measurement and strength measurement have been presented in separate chapters. Each chapter contains a description of the measurement methods which were used and concludes with a brief discussion of the results.

2 General arrangement and member notation.

The experimental study investigated the performance of simple semi-rigid steelwork connections in isolation, as part of limited subassemblages and in complete 3-dimensional non-sway frames. The connection and subassemblage tests were performed at the University of Sheffield whilst the larger full scale frame tests were carried out in the heavy structures test hall at the Building Research Establishment, Watford. A general arrangement drawing, highlighting the member notations which were adopted throughout the study, of a typical connection test, subassemblage test and the first frame test F1 are shown in figures 1 to 3 respectively. It should be noted that the general arrangement of frame test F2 was similar to that of F1 shown in figure 3 and that the member notation followed a similar sequence.

A total of 16 connection tests, 10 subassemblage tests and 2 frame tests were conducted. In all cases, the beam elements were constructed from 254x102x22 UB sections and the columns from 152x152x23 UC sections. Cleats cut from lengths of 80x60x8 RSA and

125x75x8 RSA were used to fabricate the beam to column connections. This represented approximately 6.25 tonnes of structural steel with a total of 86 individual beam and column elements. All the steel used in the study was nominally grade 43A and complied with BS 4360 [2].

3 Derivation of the material properties.

Tests were carried out to assess the material properties of all the members used in both the subassemblage and frame tests. The members used to perform the isolated connection tests were cut from the same lengths of steel used to fabricate the subassemblage specimens. On the assumption that the variation in the material properties of steel in a single member is very small, the material properties for the steel used in the connection study can be inferred from the results of the tests on the subassemblage steel. Tables 1, 2 and 3 categorise the particular stock steel sections used to fabricate the connection, subassemblage and frame specimens respectively.

The material properties of the column sections used in the subassemblage and frame tests were assessed by a series of isolated stub column tests. It was considered that this particular type of test was the most representative of the in-test compressive loading conditions on the column. These tests were supplemented by a limited number of tensile coupon tests. This permitted a direct check between the results of the tensile and the compressive tests but, more importantly, it established a datum from which the material properties could be compared with column tests carried out by other researchers. All beam and cleat material used in both the subassemblage and frame tests was assessed solely by tensile coupon testing.

Residual stresses occur in hot-rolled steel sections as a direct consequence of the manufac-

turing process. The stresses can influence the performance of steel members particularly in the elastic-plastic range. Tests were therefore carried out to determine the patterns of residual stress in the column sections. Due to the labour intensive nature of this particular test and the variable nature of data often obtained, principally due to the very light sections used, only a sample of the ten subassemblage columns were assessed. However, all of the columns in the active frame of both the full scale frame tests were subjected to residual stress measurement.

3.1 Stub column tests.

Tests were performed on stub column specimens in accordance with the procedure described in reference 3. Figure 4 shows the general arrangement of the experimental test set-up. Each column specimen was nominally 600mm long with a machined finish at each end to give an even bearing surface. Before carrying out the test, careful measurements were made of the column cross sectional area in the manner described in section 5.

It was essential that the specimen was located centrally beneath the loading head to minimise bending moments arising from the eccentricity of the end reaction. Obviously, the presence of such bending moments in the specimen would initiate yielding at a lower level of load, thereby limiting the axial load capacity of the section. This was overcome by positioning the specimen such that the deviation in the net strain readings from the four high resolution L.V.D.T.'s (Linear Voltage Displacement Transducers) located at the flange tips was less than 5% for an applied loading equivalent to 50% of the anticipated squash load [3]. This indicated that the strains resulting from bending action were sufficiently small when compared to the strains induced by the large axial load component.

Once correctly aligned, the test commenced and the specimen was loaded at a constant

rate equivalent to an increase in axial stress of 10 N/mm^2/minute. This loading rate was sufficiently slow to allow the static yield stress to be observed [4]. After the squash load had been reached, and an additional shortening had occurred, the column flanges buckled in a number of instances, the most dramatic of these is shown in figure 5. Figure 6 shows a typical stress strain plot from the test together with the computed values of Young's modulus, E, and the yield stress, p_y, whilst tables 4 and 5 present a summary of the stub column results obtained from the connection/subassemblage specimens and the frame specimens respectively.

3.2 Tensile Coupon Tests.

Figure 7 shows the location of tensile coupon specimens which were cut from the beam, column and cleat material. The shape and position of the test coupons complied with the current British Standard for material testing [5] (figure 8), and were cut with the axis of each coupon parallel to the axis of the member.

Before testing, the average area of the machined waist of each coupon was determined. During the elastic phase of coupon loading, an extensometer with a gauge length of 50mm and a rated accuracy of 0.002 mm was clamped to the specimen to provide a direct and continuous reading of elongation. This information was ultimately used to determine the Young's Modulus of the coupon steel. The specimen was strained at a rate of 0.1%/minute, equivalent to a stress of approximately 20N/mm^2/minute. When the plastic plateau was observed on the plot of load against time, the straining was stopped for successive intervals of two minutes. From the resulting characteristic depressions in the yield plateau the static yield stress of the material was determined. A typical load time plot is shown in figure 9 whilst tables 6,7 and 8 present a summary of all the tensile coupon results.

3.3 Discussion on the measured material strength data.

Comparison of the yield stresses for the Universal Column sections shows that the compressive static yield stresses from the stub column tests were approximately 10% higher than the equivalent tensile coupon. This is because tensile coupons are usually located remote from the edges of rolled sections where the yield stresses can be up to 15% higher due to increased rolling. Obviously, such localised areas of high yield are included in the results from stub column tests. The usual increase in the yield stress resulting from compressive tests is approximately 5% [4]. The higher figure obtained in these tests is probably due to the larger yield stress variations associated with thin plates and sections - the maximum wall thickness of the 152x152x23 UC column section was only 6.5mm. In almost all cases, the coupons from the web of the sections gave a higher yield stress than those of the flanges. This is typical of the distribution of yield stress in rolled sections [6].

Comparison of the strain plots for the two types of test show that the yield point peak in the tensile tests was very well defined, whilst in the stub column tests a progressive transition from elastic to fully plastic was observed. This was due to the presence of residual stresses in the stub column specimens which can cause localised areas of yield to occur at loads as low as 70% of the squash load. At loads above this level, the specimen exhibits a reduction in axial stiffness as the yield spread progressively across the section. Obviously, the cutting of the tensile coupons relieved any residual stresses causing the transition from elastic to plastic behaviour to be much more pronounced.

4 Measurement of residual stresses.

The method used to determine the residual stress distributions was as prescribed in reference 3, in which the change in length between a series of reference points is monitored for successive sectioning of the specimen. Initially the specimen was a minimum of 500mm long, i.e. of sufficient length to ensure that representative residual stresses were present at the specimen centre. Rather than use conventional 'stick-on' Demec reference points, which tend to become displaced during the sectioning process, Demec points were effected by drilling 1mm diameter holes at prescribed locations on the specimen. The distances between pairs of Demec points were measured initially, before any sectioning had taken place, using a hand held electronic Demec gauge manufactured by Cambridge Instruments with a stated accuracy of 0.005mm.

The specimen was cut in the first instance to retain a 120mm long stub from the centre of the specimen. The web and flanges were then sectioned to form coupons, typically 38mm x 120mm long, with each containing a pair of Demec points. The method of sectioning and the position of the Demec reference points is shown in figure 10. Following sectioning of the specimen, the distance between Demec points was re-measured. Any change observed in the gauged length was a direct result of stress relief arising from the sectioning process. The measured change in gauge length therefore gave a measure of the residual strains and hence, for a particular value of Young's Modulus, a measure of the residual stress.

Figure 11 shows the residual stress patterns derived from the tests. The departure of the results from the classic residual stress profile [7], particularly in the case of the subassemblage columns, confirms the author's suspicions that the sections had been extensively 'roller straightened'.

5 Derivation of the geometrical section properties.

Accurate measurements were made of the cross sectional dimensions of all the beam and column elements used in the subassemblage and frame tests. The aim of this exercise was to determine the actual geometric properties of the sections which can often vary quite considerably from nominal tabulated values [8]. Figure 13 shows a typical section through a member indicating the nomenclature used for the 12 measurement points. It should be noted that to measure the column web offsets, a 12.72mm thick machined piece of steel plate was used to provide a consistent reference datum. Table 9 summarises the frequency of cross sectional measurement along the length of different member types.

A computer program was written which generated the actual engineering properties of the various sections from the recorded dimensional data. The printed output from the program reproduced the measured data, tabulated the calculated section properties and presented direct comparisons with nominal tabulated values. Appendix A contains the measurement data sheets for the 56 different sections considered in the study.

Figures 14 to 19 show the frequency distribution of the measured areas and moments of inertia extracted from the data sheets. The nominal values from BS 4 [8] have been indicated on the figures for comparison. It is evident from figures 14 and 15 that the measured section areas can be significantly less than the nominally assumed values. In the case of the column sections, the smallest area measured represented a 5.2% reduction on the BS 4 value whilst that for the beams was slightly larger at 6.6%. The distribution of the measured major axis second moments of area for the column sections (figure 16) shows that in this instance the majority of specimens exceeded the nominal BS 4 value. This was attributed to the actual depth of the column sections being consistently 3% larger than the nominal 152.4 mm value. The major axis second moments of area for the beams (figure 17) show a similar pattern to that observed for the section areas with a large number of specimens having values less than nominal.

Whilst it is appreciated that this appraisal of geometric data is not extensive, figures 14 to 19 do suggest a worrying trend. It is the author's opinion that many practising Engineers are not aware of these large variations which have been observed in the geometric properties of steel sections, and would most certainly be surprised at the frequency and magnitude with which sections fall short of the requirements in BS 4.

6 Conclusions.

A series of material tests and geometric studies have been performed on a large number of structural steel sections used in a recent experimental study. The test methods used have been described and the results discussed. An appraisal of the data showed that there was a larger than expected variation in the geometric properties of the sections and a large number of instances in which the values were more onerous than those assumed in design.

References

[1] Gibbons, C., *'The strength of biaxially loaded beam columns in flexibly connected steel frames'*, Ph.D. Thesis, The University of Sheffield, U.K., December 1990.

[2] British Standard BS 4360, *'Weldable structural steels'*, The British Standards Institution, 1979.

[3] Galambos, T.V., *'Criteria to stability design criteria for metal structures'*, Structural Stability Research Council, 4th Edition, published by Wiley Interscience 1988.

[4] Transport and Road Research Laboratory, *'Recommended standard practices for structural testing of steel models'*, TRRL supplementary report 254.

[5] British Standard BS 18, *'Tensile testing of metals (including areospace materials)'*, British Standards Institution, 1987.

[6] Tall, L. and Alpsten, G.A., *'On the scatter in yield strength and residual stresses in steel members'*, IABSE Symposium, Theme IVa, London, September 1969.

[7] Lay M.G. and Ward, R., *'Residual stresses in steel sections'*, Aust. Inst. Steel Construct., Steel Construction, 3, (3), 1969, pp. 2-20

[8] British Standard BS 4, *'Structural steel sections - Part 1: Specifications for hot rolled sections'*, The British Standards Institution, 1980.

Connection test stock steel summary		
Joint Test	Column member stock reference	Beam member stock reference
J1	S1	B1
J2	S5	B1
J3	S5	B1
J4	S1	B1
J5	S2	B2
J6	S6	B2
J7	S6	B2
J8	S2	B2
J9	S3	B3
J10	S7	B3
J11	S7	B3
J12	S3	B3
J13	S4	B4
J14	S8	B4
J15	S8	B4
J16	S4	B4

Table 1: Stock steel sections used in the fabrication of the connection test specimens.

Subassemblage test stock steel summary				
Subframe Test	Column steel stock ref. number	Beam steel stock ref. number		
		Beam 1	Beam 2	Beam 3
S1	S1	B5	B5	B5
S2	S2	B6	B6	B6
S3	S3	B7	B7	B7
S4	S4	-	B8	B8
S5 *	S5	B5	B5	B5
S6 *	S6	B6	B6	B6
S7 *	S7	B7	B7	B7
S8	S8	B1	B5	B1
S9	S9	B2	B6	B2
S10	S10	B3	B7	B3

'*' - beam sections re-used from tests S1, S2 and S3

Table 2: Stock steel sections used in the fabrication of the subassemblage test specimens.

Frame test stock steel summary				
Frame Test	Member reference	Stock steel reference	Member reference	Stock steel reference
F1	C4	C4	SB1	P6
F1	C5	C5	SB2	P6
F1	C6	C6	SB3	P6
F1	PB5	P5	SB4	P4
F1	PB6	P5	SB5	P4
F1	PB7	P3	SB6	P4
F1	PB8	P3		
F2	C7	C7	SB7	P7
F2	C8	C8	SB8	P9
F2	C9	C9	SB9	P10
F2	PB9	P7	SB10	P10
F2	PB10	P8	SB11	P10
F2	PB11	P8	SB12	P11
F2	PB12	P9		

Table 3: Stock steel sections used in the fabrication of the frame test specimens.

COMPRESSIVE STUB COLUMN TESTS:			Stress rate = 10 N/mm²/min Gauge length = 300.0mm	
Subassemblage test steel:			Stub Length = 600.0mm	
Stock steel reference	Ave. area (mm²)	Squash Load (kN)	Yield stress σ_y (N/mm²)	Young's Modulus E (x1000 N/mm²)
S1	2875.0	913.1	317.6	204.6
S2	2855.0	892.0	312.5	207.6
S3	2859.0	982.1	343.5	210.6
S4	2825.0	934.7	320.9	218.3
S5	2903.0	938.5	323.3	223.0
S6	2956.0	941.5	318.5	218.7
S7	2868.0	953.6	332.5	211.4
S8	2839.0	954.8	336.3	212.3
S9	2942.0	935.1	317.8	198.6
S10	2930.0	925.1	317.8	213.0

Table 4: Summary of the material properties for the connection and subassemblage test steel derived from stub column tests.

COMPRESSIVE STUB COLUMN TESTS: Frame test steel:			Stress rate = 10 N/mm²/min Gauge length = 300.0mm Stub Length = 600.0mm	
Stock steel reference	Ave. area (mm^2)	Squash Load (kN)	Yield stress σ_y (N/mm^2)	Young's Modulus E (x1000 N/mm^2)
C4	2950.0	934.0	316.0	214.2
C5	2920.0	951.8	325.9	204.3
C6	2873.0	935.0	325.4	220.5
C7	2888.0	930.5	322.0	196.2
C8	2925.0	933.0	319.0	215.8
C9	2929.0	934.0	318.0	212.8

Table 5: Summary of the material properties for the frame test steel derived from stub column tests.

TENSILE COUPON TESTS: Subassemblage test steel:			Strain rate = 0.1%/min Gauge length = 50.0mm	
Stock steel reference	Coupon reference	Ave. Coupon Area (mm^2)	Static yield σ_y (N/mm^2)	Young's Modulus E (x1000 N/mm^2)
S1	A	83.7	275.4	-
	B	74.5	297.7	-
	C	78.2	279.3	-
S4	A	83.6	272.9	-
	B	80.0	287.6	-
	C	85.5	288.3	-
S6	A	94.0	270.6	185.3
	B	77.6	282.8	190.7
	C	90.2	273.9	181.3
B1	A	67.2	284.2	204.0
	B	61.4	316.5	192.3
	C	66.1	289.0	196.9
B2	A	89.3	287.7	196.6
	B	79.9	313.4	-
	C	82.9	277.8	189.0
B3	A	84.2	280.2	-
	B	76.4	289.6	190.0
	C	80.9	276.9	199.6
B4	A	80.2	289.8	197.4
	B	76.8	314.9	196.9
	C	84.9	292.5	198.8
B5	A	84.4	286.2	200.2
	B	78.7	311.7	190.6
	C	83.0	280.2	189.0
B6	A	82.5	290.0	196.0
	B	77.2	328.4	196.1
	C	81.7	291.9	201.5
B7	A	78.7	295.2	193.8
	B	71.2	298.6	192.5
	C	79.0	280.0	189.4
B8	A	79.8	283.3	-
	B	72.9	291.1	192.2
	C	81.5	281.4	194.7
80x60 RSA	A	74.6	251.1	176.9
	B	77.8	260.0	188.9
125x75 RSA	A	77.6	270.1	197.5
	B	80.2	269.7	202.3

Table 6: Summary of the material properties for the connection and subassemblage test steel derived from tensile coupon tests.

TENSILE COUPON TESTS: Frame test beam steel:			Strain rate = 0.1%/min Gauge length = 50.0mm	
Stock steel reference	Coupon reference	Ave. Coupon Area (mm^2)	Static yield σ_y (N/mm^2)	Young's Modulus E (x1000 N/mm^2)
P1	A	84.4	306.1	-
	B	73.7	302.5	195.4
	C	85.5	275.0	196.1
P2	A	82.2	279.8	206.4
	B	72.2	297.5	191.3
	C	80.5	282.9	204.7
P3	A	86.9	270.4	193.0
	B	73.5	348.1	224.1
	C	84.2	308.0	211.7
P4	A	84.0	294.4	190.6
	B	72.3	324.7	223.9
	C	81.2	294.4	190.6
P5	A	82.6	304.2	215.9
	B	71.9	320.0	208.3
	C	80.5	310.7	221.6
P6	A	83.0	303.9	212.1
	B	72.3	336.3	218.8
	C	80.0	286.0	191.3
P7	A	80.2	289.8	197.4
	B	76.8	314.9	196.9
	C	84.9	292.5	198.8
P8	A	81.1	273.2	191.3
	B	73.9	298.1	188.3
	C	85.1	269.1	-
P9	A	86.3	271.7	197.3
	B	74.6	305.5	219.6
	C	81.0	276.1	198.7
P10	A	84.9	271.1	189.5
	B	72.5	290.5	206.5
	C	80.9	271.1	195.2
P11	A	82.0	287.3	199.8
	B	75.8	319.4	208.3
	C	87.8	294.3	206.1

Table 7: Summary of the material properties for the frame test beam steel derived from tensile coupon tests.

TENSILE COUPON TESTS: Frame test column steel:		Strain rate = 0.1%/min Gauge length = 50.0mm		
Stock steel reference	Coupon reference	Ave. Coupon Area (mm^2)	Static yield σ_y (N/mm^2)	Young's Modulus E (x1000 N/mm^2)
C4	A	84.0	288.0	199.7
	B	73.8	299.1	-
	C	86.4	285.5	187.5
C5	A	85.3	291.7	180.2
	B	74.8	301.8	179.3
	C	86.6	284.6	204.6
C6	A	79.1	287.7	194.5
	B	74.5	301.1	197.0
	C	85.8	284.7	198.9
C7	A	83.0	282.5	186.6
	B	73.1	320.9	198.1
	C	86.9	309.9	215.4
C8	A	79.3	295.9	220.9
	B	74.5	311.8	211.2
	C	86.8	307.6	205.0
C9	A	86.8	302.8	205.2
	B	75.6	321.3	211.3
	C	79.7	302.4	209.6

Table 8: Summary of the material properties for the frame test column steel derived from tensile coupon tests.

Test type	Member type	Frequency of measurment along length
Subassemble test	Beam	3
	Column	4
Frame test	Primary beam	4
	Secondary beam	3
	Column	5

Table 9: Frequency of cross section measurement for different member types.

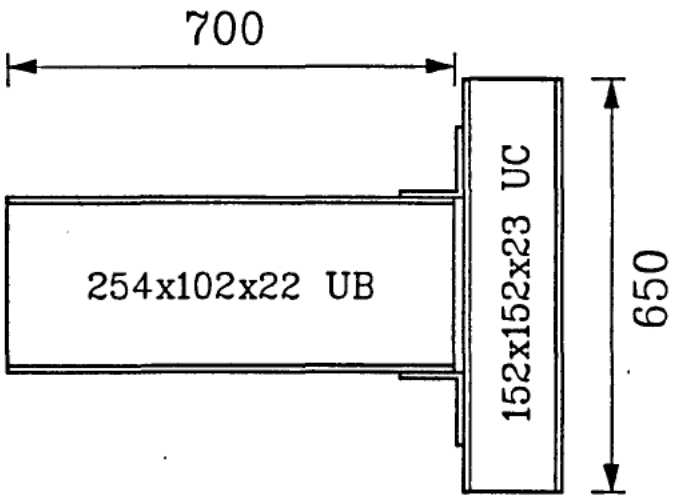


Figure 1: General arrangement of the connection test specimens.

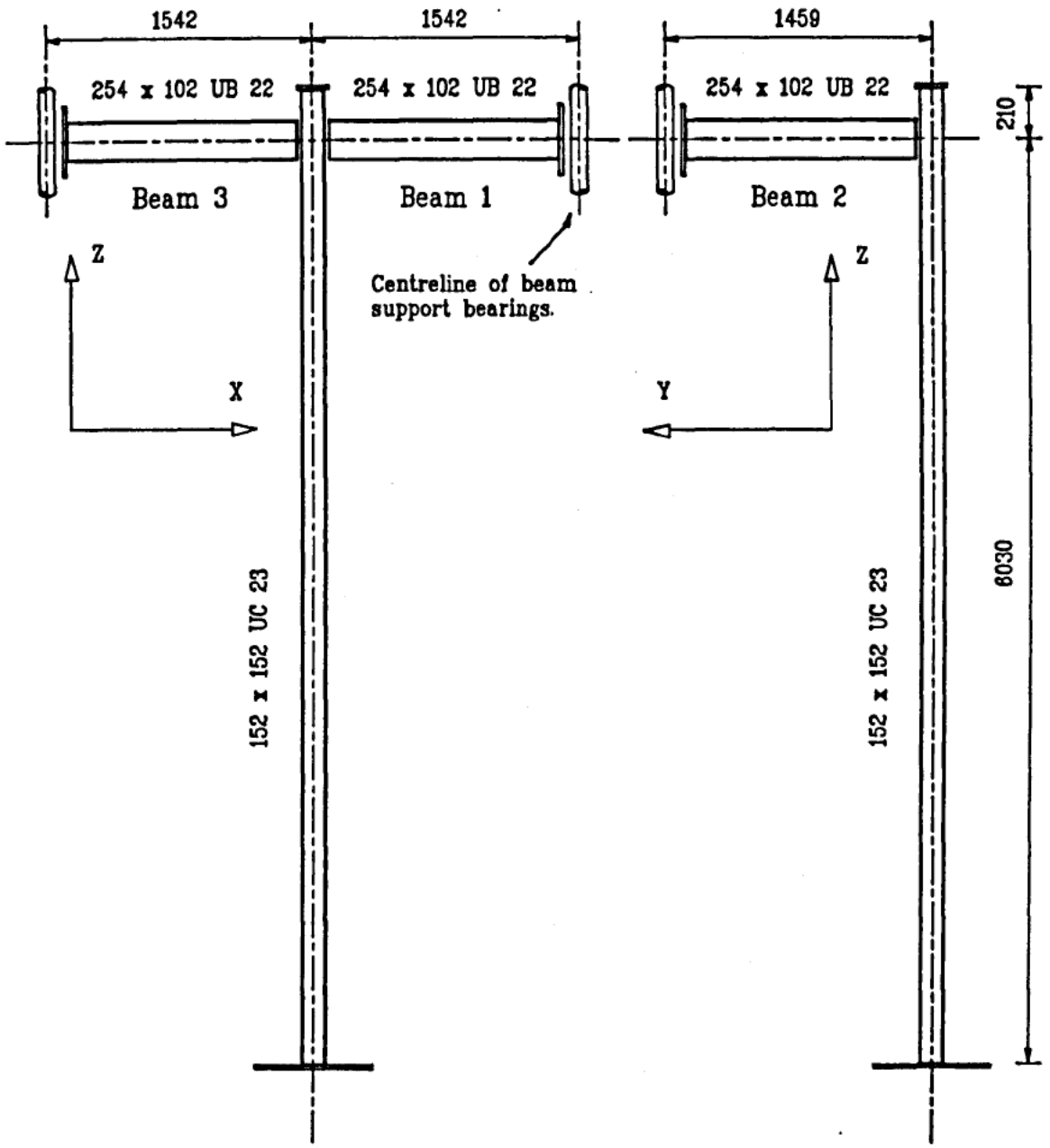


Figure 2: General arrangement of the subassemblage test specimens.

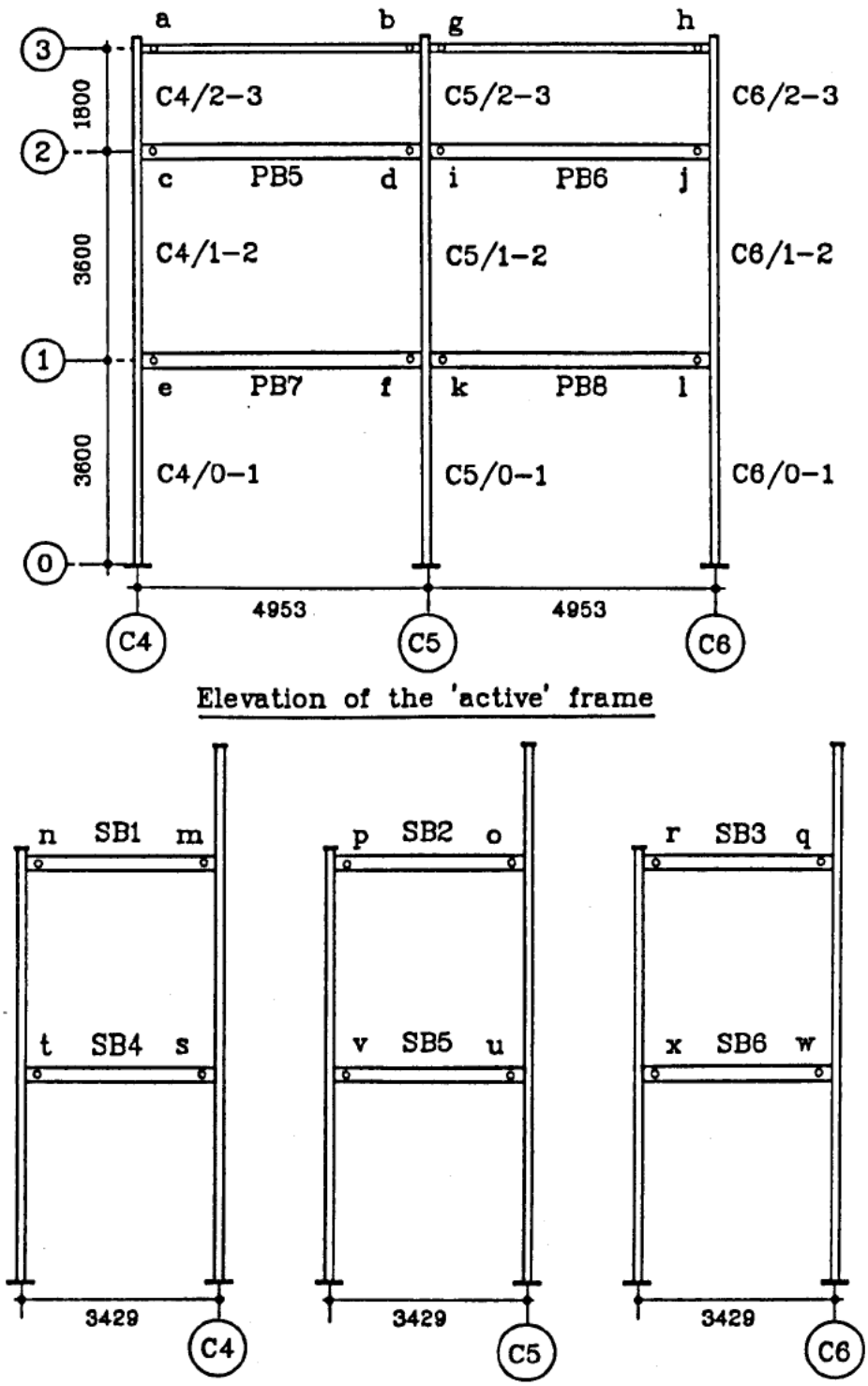


Figure 3: General arrangement of the full scale frame test specimen F1.

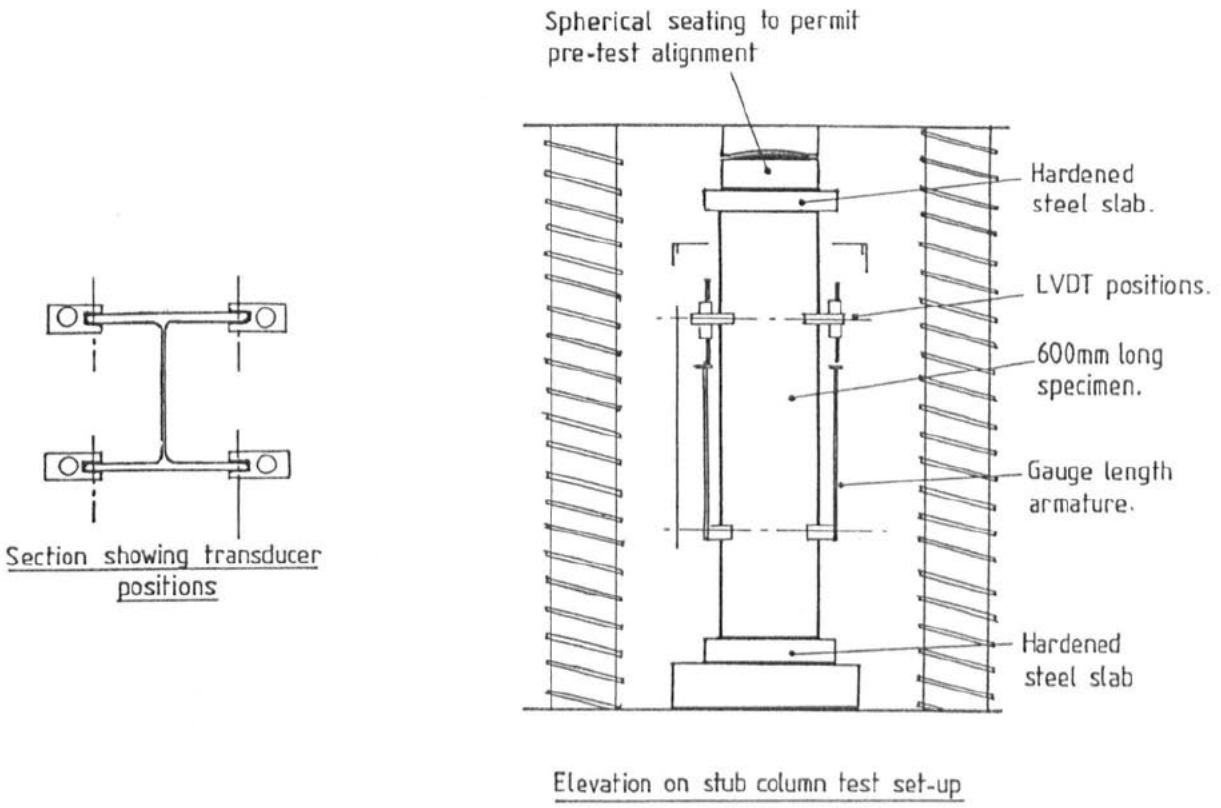


Figure 4: Experimental set-up for the stub column tests.

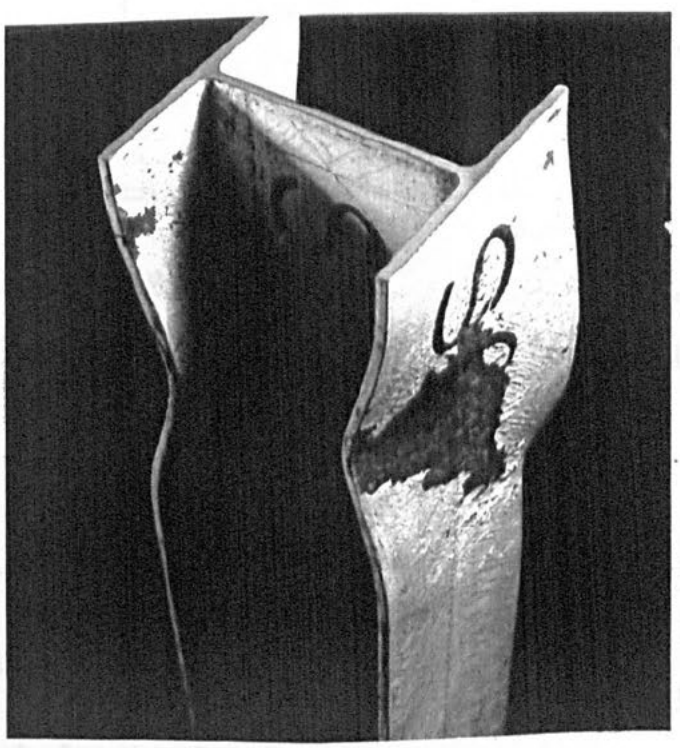


Figure 5: Photograph of a stub column specimen which exhibited excessive flange buckling.

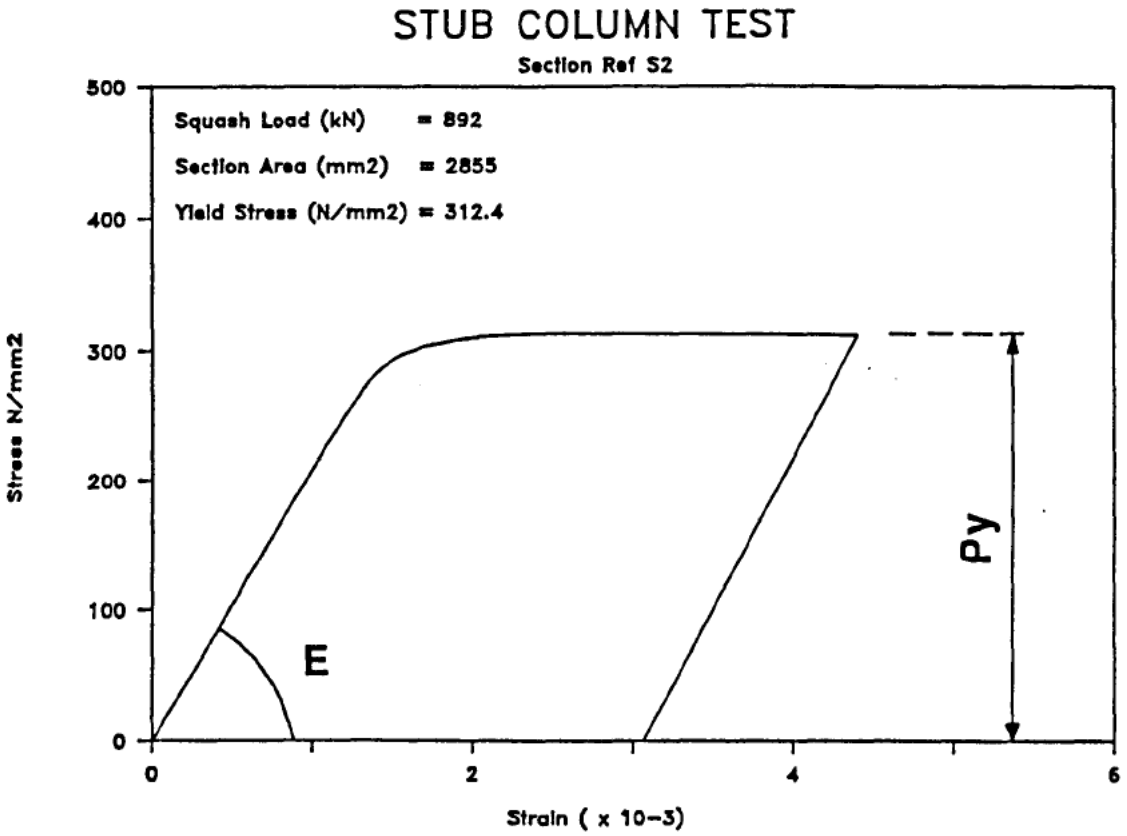


Figure 6: Typical stress-strain plot from a stub column test.

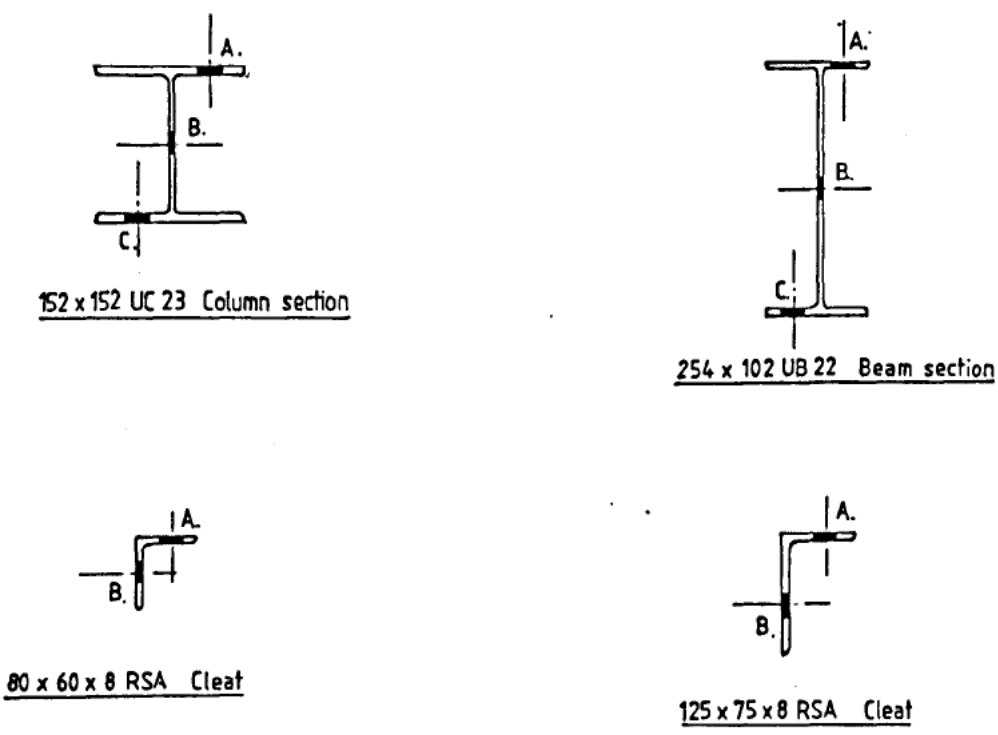
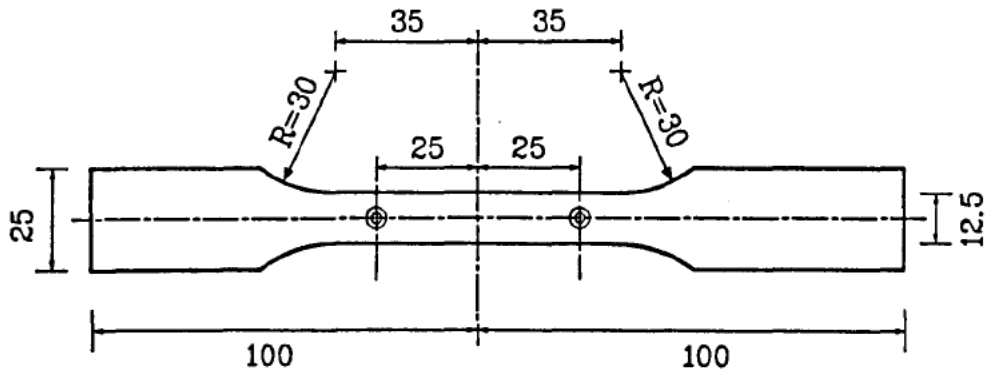


Figure 7: Location of tensile coupons cut from the members.



Tensile coupon specimen

Figure 8: Shape of the tensile test coupon.

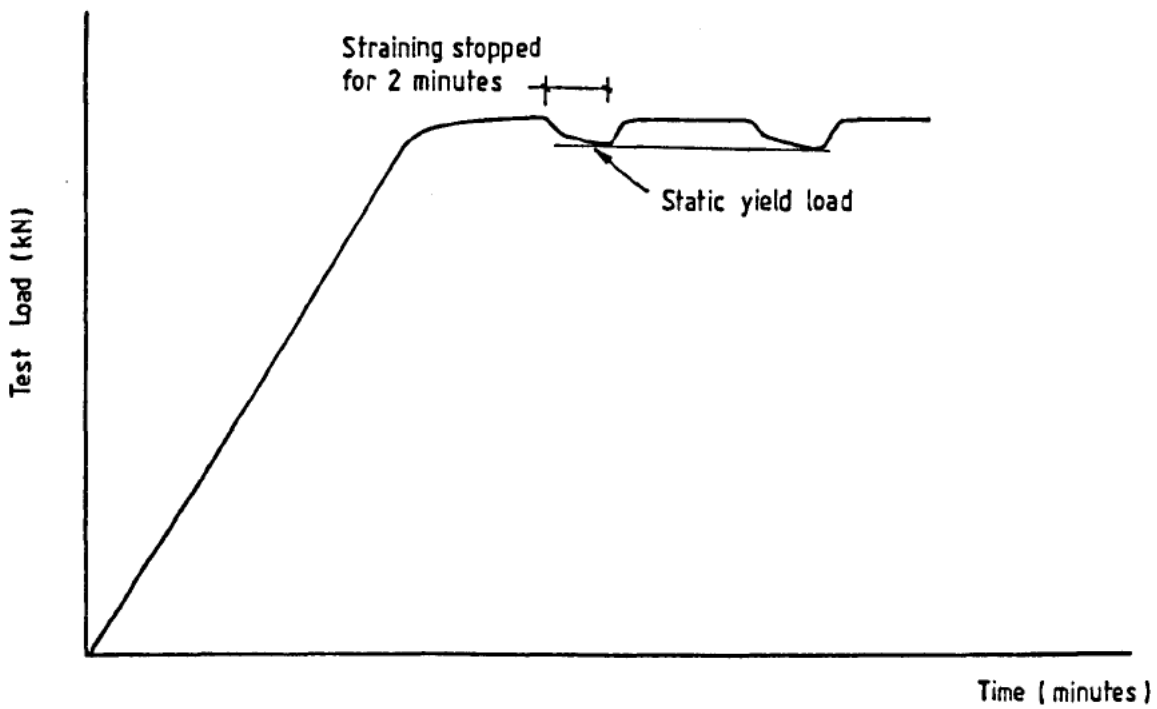


Figure 9: Typical stress-strain plot from a tensile coupon test.

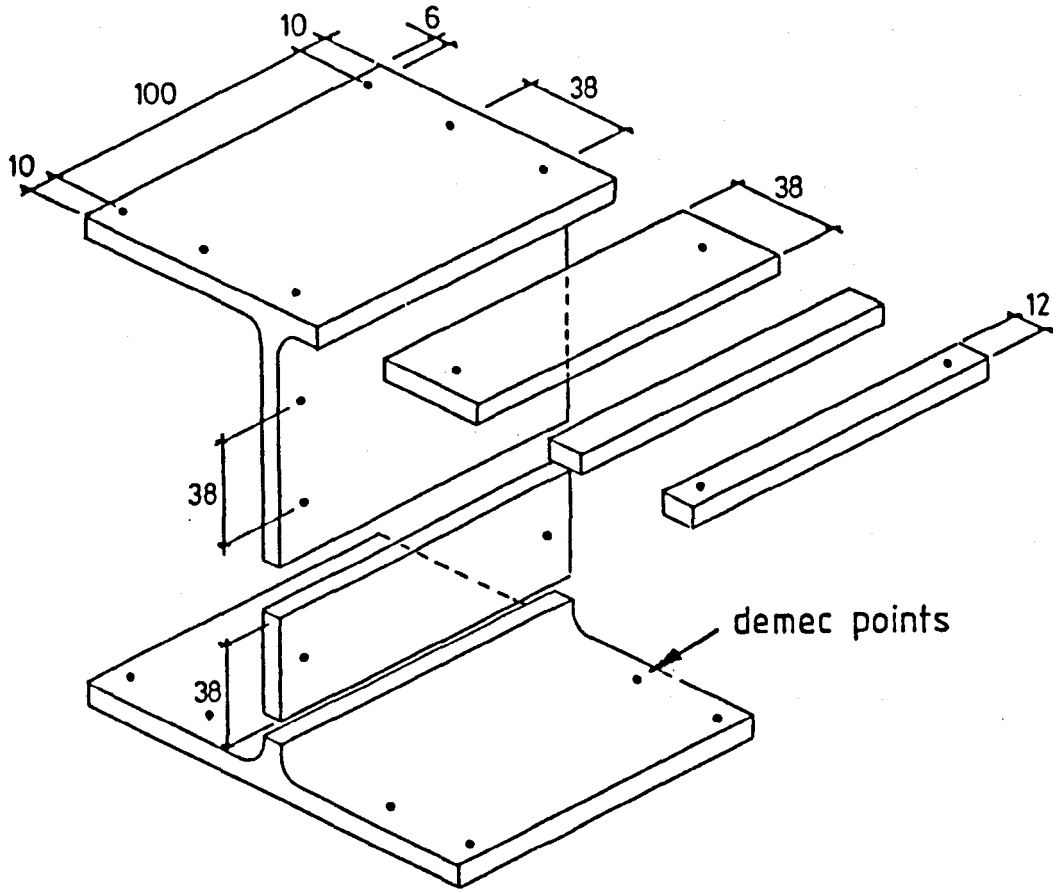


Figure 10: Location of coupons cut from a specimen to determine the residual stress patterns.

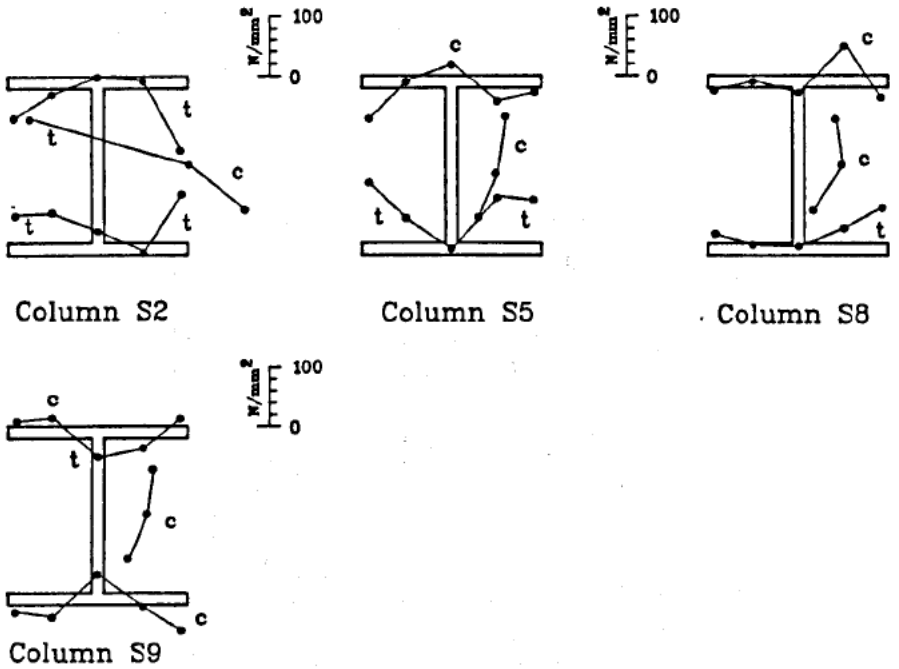


Figure 11: Residual stress patterns from column sections used in the subassemblage tests.

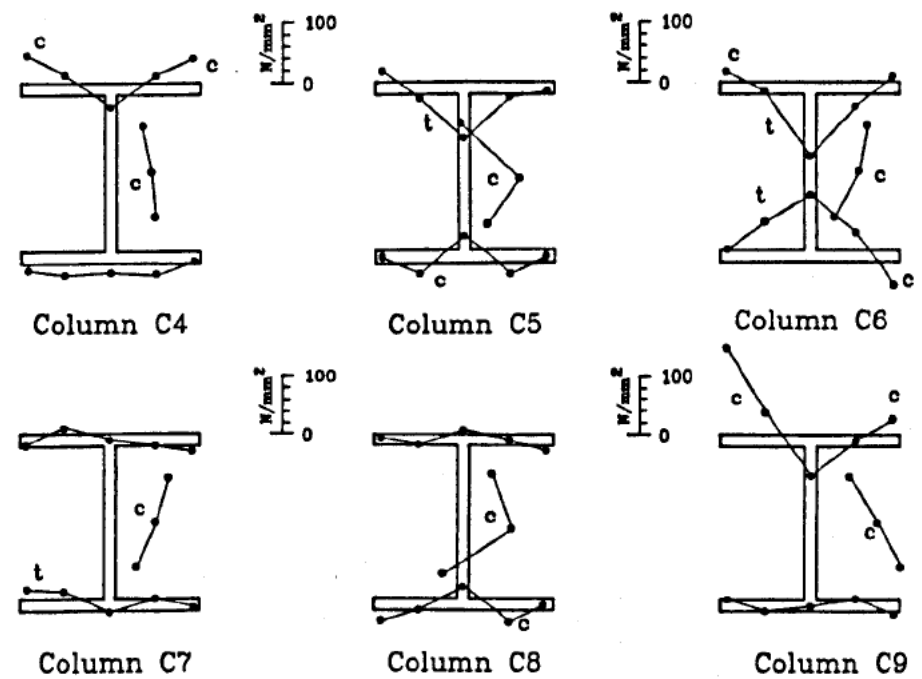


Figure 12: Residual stress patterns from column sections used in the frame tests.

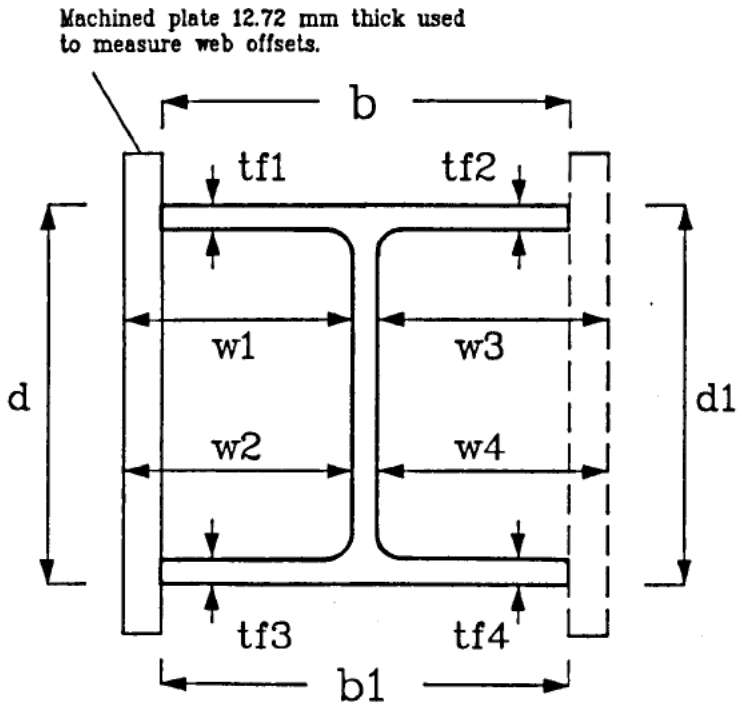


Figure 13: Locations of measurement points to determine cross sectional geometric properties.

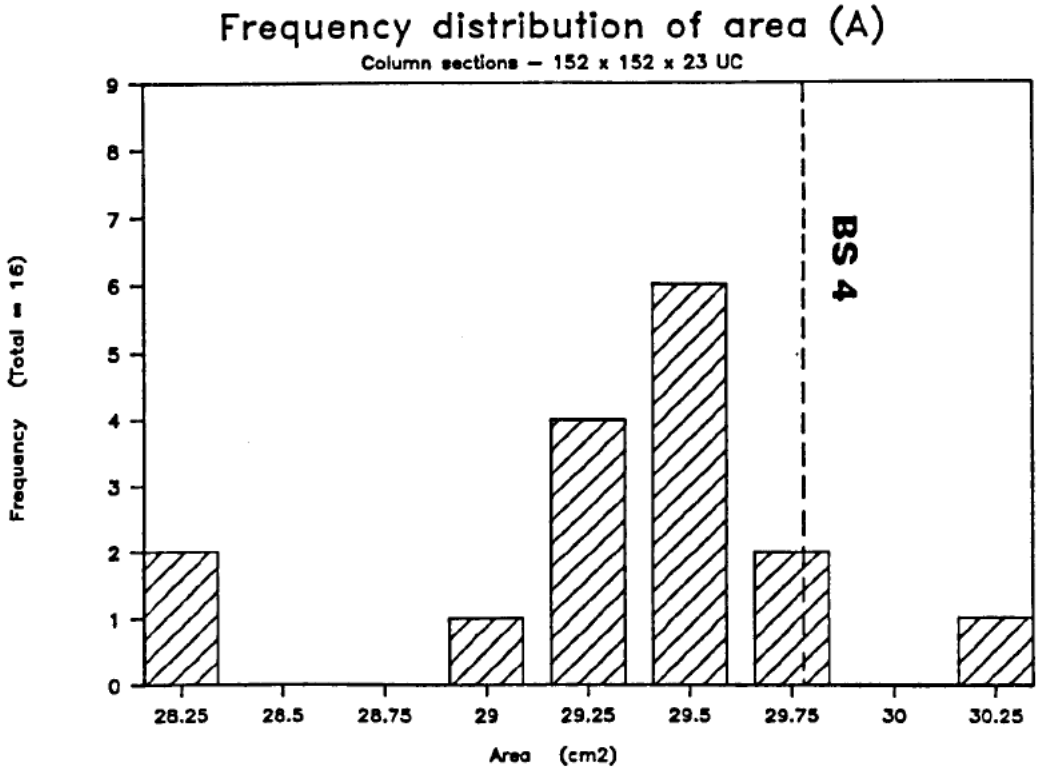


Figure 14: Frequency distribution of measured areas - column sections.

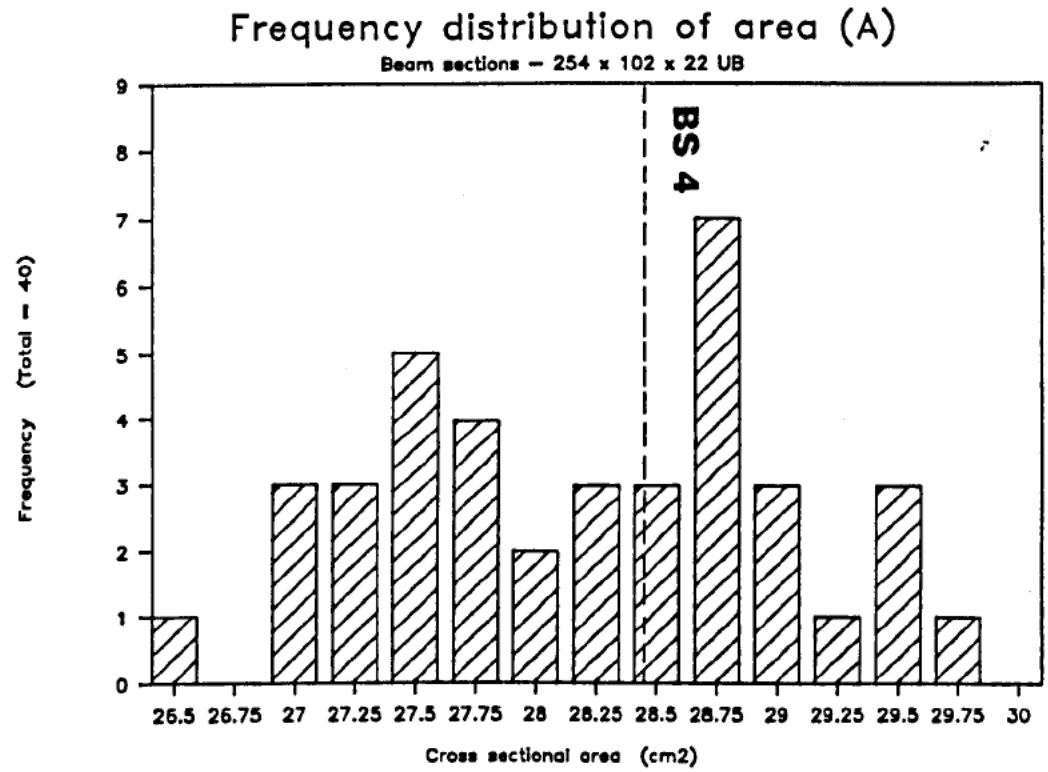


Figure 15: Frequency distribution of measured areas - beam sections.

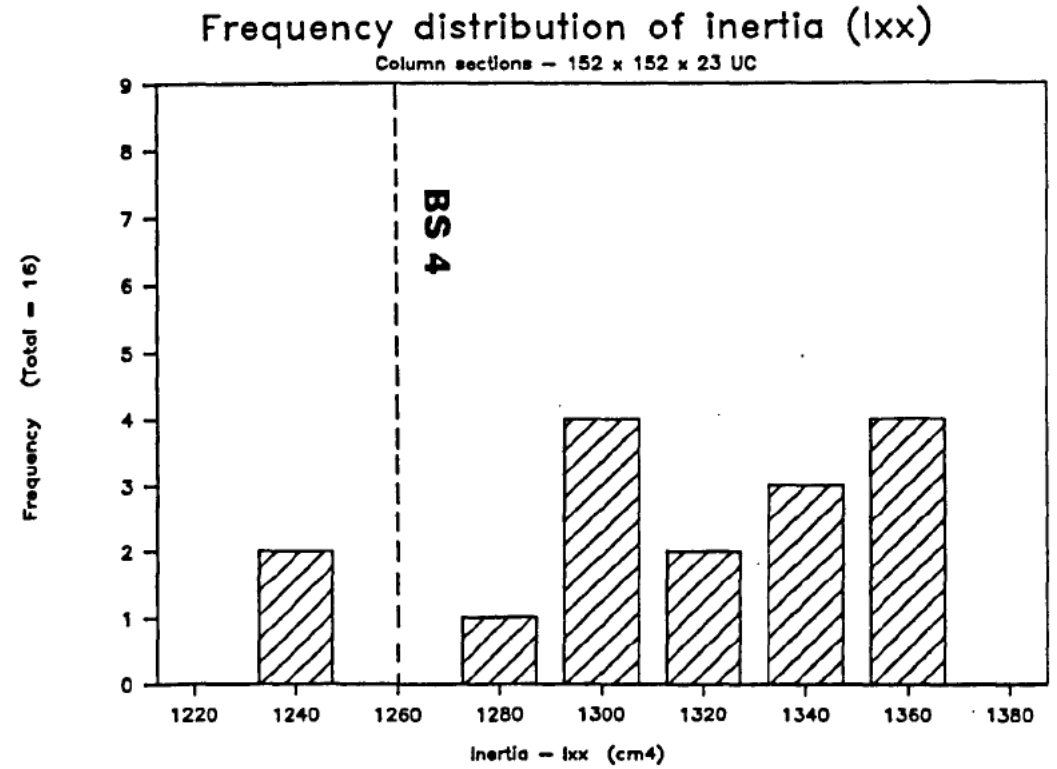


Figure 16: Frequency distribution of measured second moments of area (I_{xx}) - column sections.

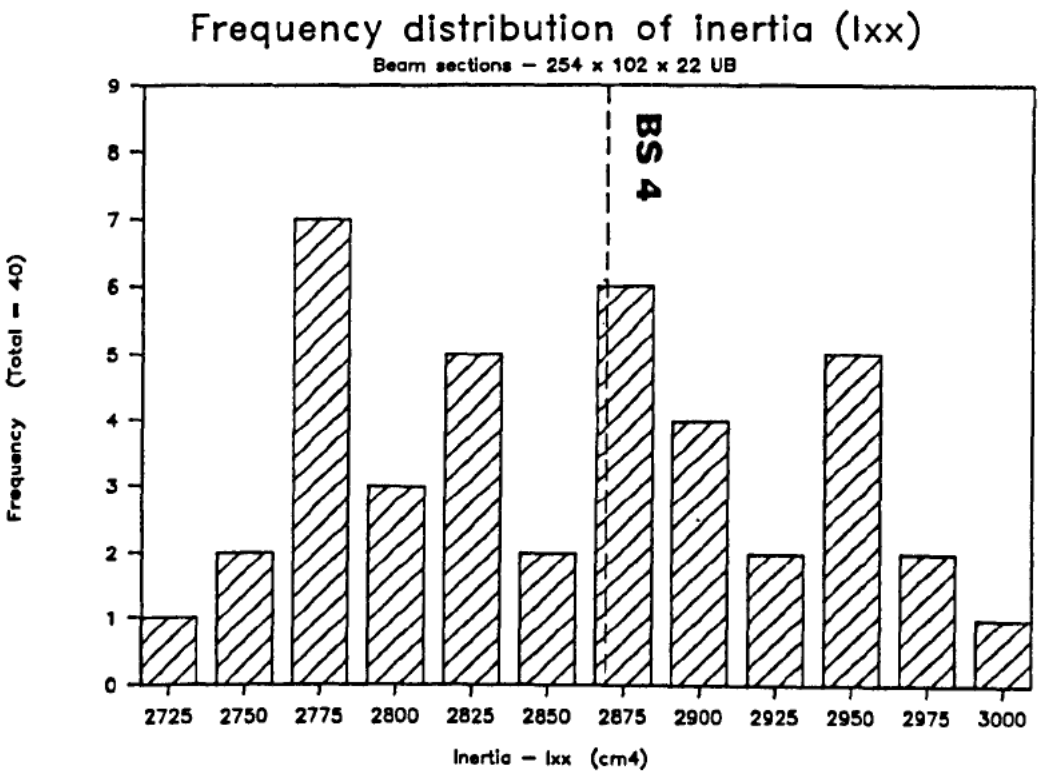


Figure 17: Frequency distribution of measured second moments of area (I_{xx}) - beam sections.

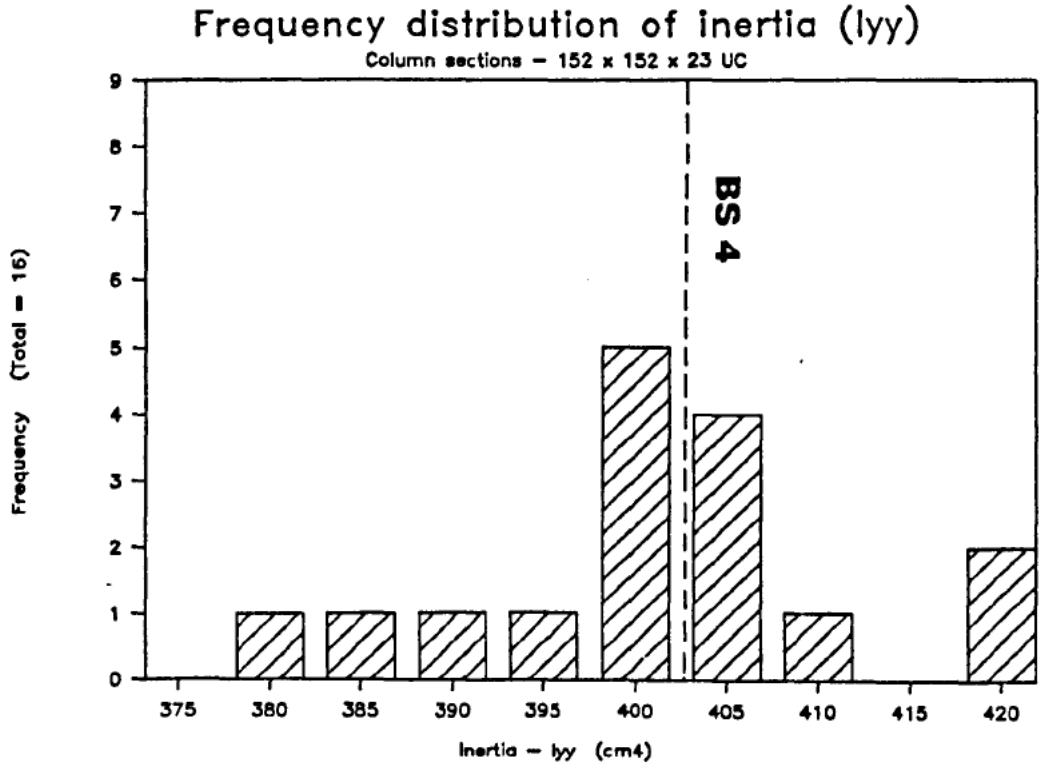


Figure 18: Frequency distribution of measured second moments of area (I_{yy}) - column sections.

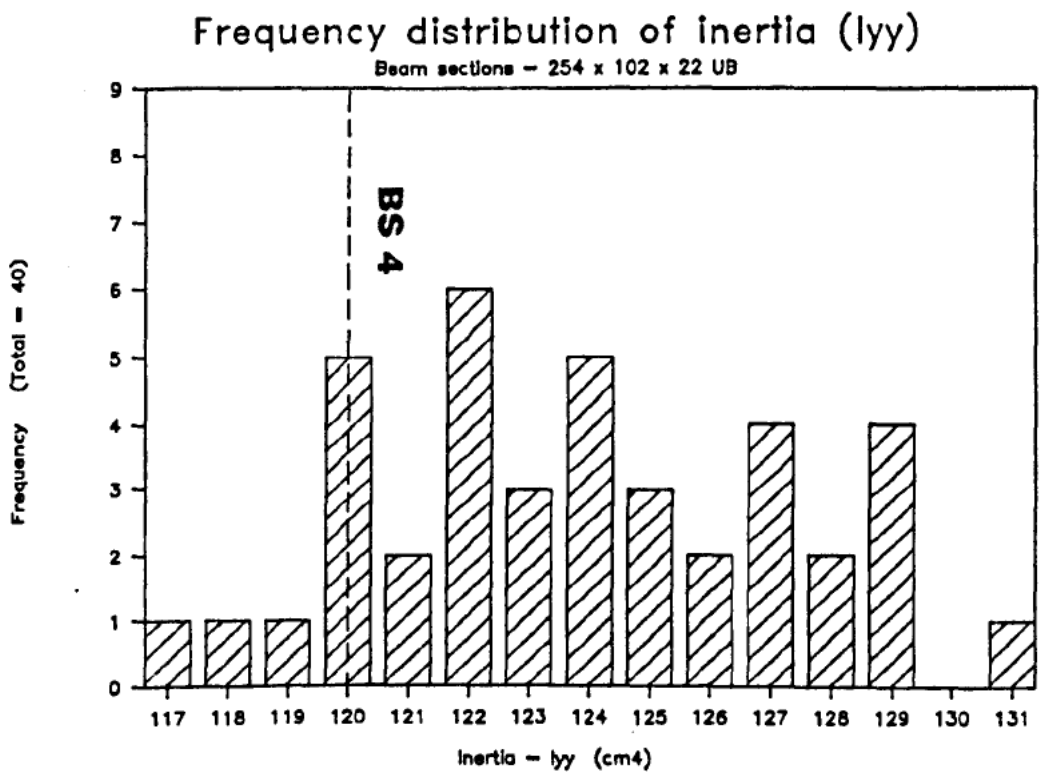


Figure 19: Frequency distribution of measured second moments of area (I_{yy}) - beam sections.

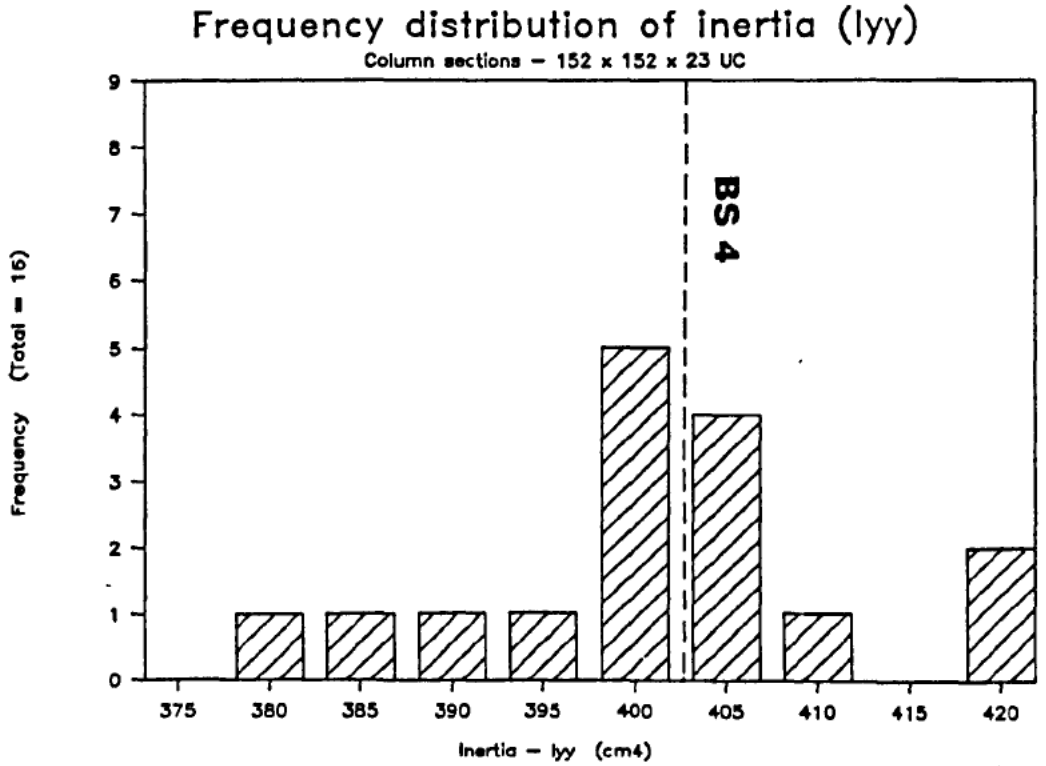


Figure 18: Frequency distribution of measured second moments of area (I_{yy}) - column sections.

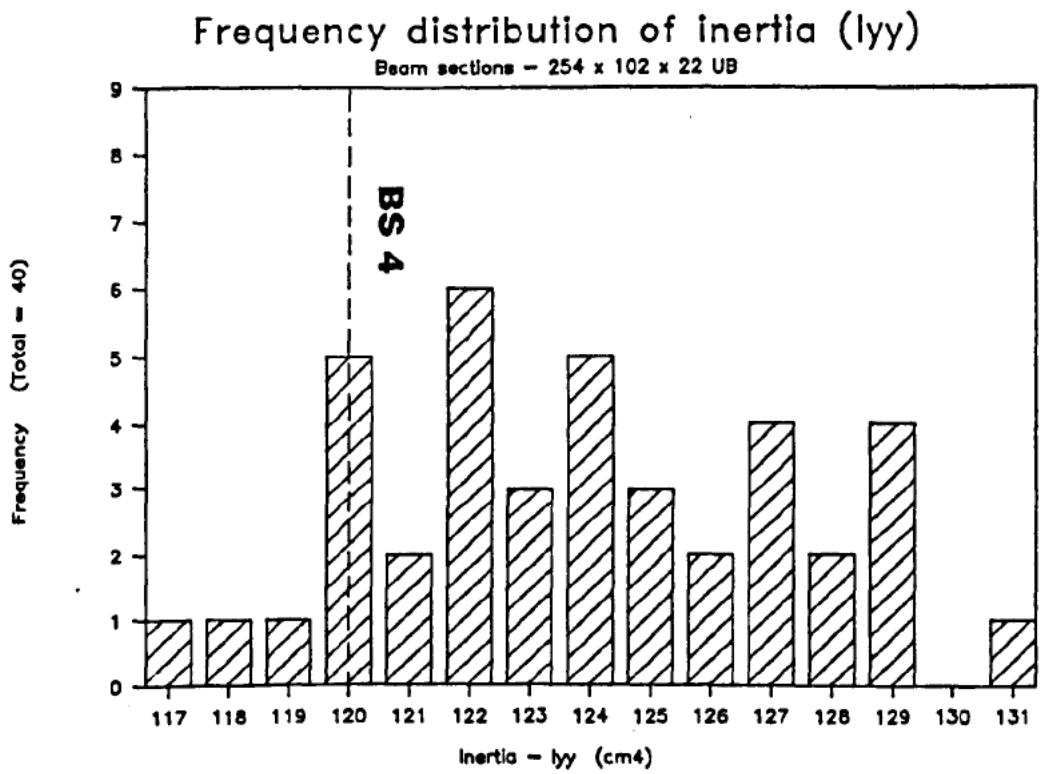


Figure 19: Frequency distribution of measured second moments of area (I_{yy}) - beam sections.

Appendix A

Geometric section data

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S1
Section ref : COL
Stock steel : S1

Date : 5/10/88
Test points: 4
Position 1 :TOP

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	151.30	151.11	151.05	151.10
Breadth (lower)	b1 =	152.33	152.21	151.97	152.33
Depth (first side)	d =	154.50	156.00	156.00	155.00
Depth (second side)	d1 =	155.50	155.00	154.50	155.00
Flange thickness	tf1 =	6.55	6.76	6.79	6.77
Flange thickness	tf2 =	6.57	6.72	6.82	6.78
Flange thickness	tf3 =	6.20	6.39	6.35	6.49
Flange thickness	tf4 =	6.42	6.63	6.77	6.71
Web offset at 1	=	85.14	86.01	84.89	85.30
Web offset at 2	=	86.25	85.84	85.50	85.85
Web offset at 3	=	86.31	84.90	85.68	85.92
Web offset at 4	=	85.32	85.73	85.89	85.68

Calculated Data

Web thickness (tw)	mm =	5.75	5.86	5.97	5.78
Sectional Area (A)	cm2 =	28.20	28.93	29.21	28.97
Inertia (Ixx)	cm4 =	1239.43	1277.97	1283.33	1276.50
Inertia (Iyy)	cm4 =	375.77	385.73	387.94	389.75
Warping Const.(Cw)	cm6 =	2.07	2.14	2.14	2.14
Torsion Const.(J)	cm4 =	4.10	4.43	4.57	4.47

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	151.05	152.33	151.68	152.40	0.85	-0.48
Depth (D)	mm	154.50	156.00	155.19	152.40	0.97	1.83
Top flange (T)	mm	6.55	6.82	6.72	6.80	4.12	-1.18
Bot flange (T)	mm	6.20	6.77	6.49	6.80	9.19	-4.49
Flange thick (T)	mm	6.20	6.82	6.61	6.80	10.00	-2.83
Web thick (t)	mm	5.75	5.97	5.84	6.10	3.92	-4.28
Area (A)	cm2	28.20	29.21	28.83	29.80	3.60	-3.26
Inertia (Ixx)	cm4	1239.43	1283.33	1269.31	1260.00	3.54	0.74
Inertia (Iyy)	cm4	375.77	389.75	384.80	403.00	3.72	-4.52
Warping (Cw)	cm6	2.07	2.14	2.12	2.14	3.37	-0.76
Torsional (J)	cm4	4.10	4.57	4.39	4.87	11.36	-9.80

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S2
Section ref : COL
Stock steel : S2

Date : 12.12.88
Test points: 4
Position 1 :BOTTOM

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	154.25	154.00	152.74	152.77
Breadth (lower)	b1 =	152.50	152.00	153.15	153.20
Depth (first side)	d =	154.50	154.00	154.50	153.50
Depth (second side)	d1 =	154.50	155.00	154.50	155.00
Flange thickness	tf1 =	6.21	6.07	6.20	6.07
Flange thickness	tf2 =	6.78	6.83	6.79	6.80
Flange thickness	tf3 =	6.30	6.45	6.44	6.31
Flange thickness	tf4 =	6.57	6.53	6.47	6.43
Web offset at 1	=	87.14	86.12	85.60	85.37
Web offset at 2	=	86.86	86.32	86.16	86.16
Web offset at 3	=	86.60	87.18	87.03	87.31
Web offset at 4	=	85.75	86.18	86.52	86.90

Calculated Data

Web thickness (tw)	mm =	5.64	5.54	5.73	5.56
Sectional Area (A)	cm2 =	28.31	28.14	28.41	27.94
Inertia (Ixx)	cm4 =	1243.64	1239.30	1244.16	1225.23
Inertia (Iyy)	cm4 =	389.43	386.78	386.72	382.73
Warping Const.(Cw)	cm6 =	2.13	2.12	2.12	2.09
Torsion Const.(J)	cm4 =	4.11	4.06	4.17	3.97

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	152.00	154.25	153.08	152.40	1.48	0.44
Depth (D)	mm	153.50	155.00	154.44	152.40	0.98	1.34
Top flange (T)	mm	6.07	6.83	6.47	6.80	12.52	-4.87
Bot flange (T)	mm	6.30	6.57	6.44	6.80	4.29	-5.33
Flange thick (T)	mm	6.07	6.83	6.45	6.80	12.52	-5.10
Web thick (t)	mm	5.54	5.73	5.62	6.10	3.43	-7.93
Area (A)	cm2	27.94	28.41	28.20	29.80	1.68	-5.37
Inertia (Ixx)	cm4	1225.23	1244.16	1238.08	1260.00	1.55	-1.74
Inertia (Iyy)	cm4	382.73	389.43	386.41	403.00	1.75	-4.12
Warping (Cw)	cm6	2.09	2.13	2.12	2.14	2.01	-1.14
Torsional (J)	cm4	3.97	4.17	4.08	4.87	4.84	-16.28

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S3
Section ref : COL
Stock steel : S3

Date : 13.1.89
Test points: 4
Position 1 :TOP

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	152.77	152.77	152.45	152.78
Breadth (lower)	b1 =	152.16	152.19	151.91	152.38
Depth (first side)	d =	154.00	154.50	154.00	154.50
Depth (second side)	d1 =	155.50	155.50	155.50	155.00
Flange thickness	tf1 =	6.41	6.50	6.63	6.51
Flange thickness	tf2 =	6.78	6.91	6.84	6.82
Flange thickness	tf3 =	6.55	6.72	6.78	6.81
Flange thickness	tf4 =	6.63	6.69	6.67	6.65
Web offset at 1	=	85.28	85.51	84.89	84.90
Web offset at 2	=	84.64	84.72	84.34	84.74
Web offset at 3	=	86.65	86.76	86.72	87.57
Web offset at 4	=	87.17	86.83	87.10	87.36

Calculated Data

Web thickness (tw)	mm =	6.04	6.01	6.10	5.74
Sectional Area (A)	cm2 =	29.14	29.45	29.59	29.04
Inertia (Ixx)	cm4 =	1269.65	1290.20	1289.00	1278.74
Inertia (Iyy)	cm4 =	390.37	397.04	396.40	397.63
Warping Const.(Cw)	cm6 =	2.14	2.18	2.17	2.18
Torsion Const.(J)	cm4 =	4.50	4.64	4.73	4.47

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	151.91	152.78	152.43	152.40	0.57	0.02
Depth (D)	mm	154.00	155.50	154.81	152.40	0.97	1.58
Top flange (T)	mm	6.41	6.91	6.68	6.80	7.80	-1.84
Bot flange (T)	mm	6.55	6.81	6.69	6.80	3.97	-1.65
Flange thick (T)	mm	6.41	6.91	6.68	6.80	7.80	-1.75
Web thick (t)	mm	5.74	6.10	5.97	6.10	6.28	-2.15
Area (A)	cm2	29.04	29.59	29.31	29.80	1.90	-1.66
Inertia (Ixx)	cm4	1269.65	1290.20	1281.90	1260.00	1.62	1.74
Inertia (Iyy)	cm4	390.37	397.63	395.36	403.00	1.86	-1.90
Warping (Cw)	cm6	2.14	2.18	2.17	2.14	1.90	1.35
Torsional (J)	cm4	4.47	4.73	4.59	4.87	5.65	-5.85

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S4
Section ref : COL
Stock steel : S4

Date : 31.1.89
Test points: 4
Position 1 :BOTTOM

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	152.39	152.36	152.67	152.56
Breadth (lower)	b1 =	151.41	151.34	151.52	151.64
Depth (first side)	d =	155.00	154.50	155.00	155.50
Depth (second side)	d1 =	154.50	155.00	155.00	154.50
Flange thickness	tf1 =	6.98	6.87	6.82	7.00
Flange thickness	tf2 =	6.71	6.65	6.44	6.66
Flange thickness	tf3 =	7.06	6.83	6.57	6.58
Flange thickness	tf4 =	6.88	6.66	6.61	6.67
Web offset at 1	=	87.10	86.56	86.33	85.89
Web offset at 2	=	87.19	86.68	86.68	86.21
Web offset at 3	=	84.47	84.69	85.53	85.52
Web offset at 4	=	84.10	84.30	84.97	85.65

Calculated Data

Web thickness (tw)	mm =	5.91	6.18	5.78	5.91
Sectional Area (A)	cm2 =	29.81	29.72	28.80	29.32
Inertia (Ixx)	cm4 =	1308.23	1291.71	1268.04	1288.22
Inertia (Iyy)	cm4 =	404.75	395.12	388.34	395.22
Warping Const.(Cw)	cm6 =	2.21	2.16	2.14	2.17
Torsion Const.(J)	cm4 =	4.87	4.80	4.37	4.61

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	151.34	152.67	151.99	152.40	0.88	-0.27
Depth (D)	mm	154.50	155.50	154.88	152.40	0.65	1.62
Top flange (T)	mm	6.44	7.00	6.77	6.80	8.70	-0.50
Bot flange (T)	mm	6.57	7.06	6.73	6.80	7.46	-0.99
Flange thick (T)	mm	6.44	7.06	6.75	6.80	9.63	-0.74
Web thick (t)	mm	5.78	6.18	5.94	6.10	6.83	-2.58
Area (A)	cm2	28.80	29.81	29.41	29.80	3.51	-1.30
Inertia (Ixx)	cm4	1268.04	1308.23	1289.05	1260.00	3.17	2.31
Inertia (Iyy)	cm4	388.34	404.75	395.86	403.00	4.23	-1.77
Warping (Cw)	cm6	2.14	2.21	2.17	2.14	3.46	1.46
Torsional (J)	cm4	4.37	4.87	4.66	4.87	11.49	-4.30

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S5
Section ref : COL
Stock steel : S5

Date : 20.2.89
Test points: 4
Position 1 :BASE

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	153.80	153.80	153.60	153.80
Breadth (lower)	b1 =	152.50	152.40	152.63	152.90
Depth (first side)	d =	154.00	155.50	155.50	155.00
Depth (second side)	d1 =	154.50	154.00	154.50	154.50
Flange thickness	tf1 =	7.42	7.87	7.44	7.39
Flange thickness	tf2 =	6.49	6.43	6.47	6.39
Flange thickness	tf3 =	6.79	7.00	6.82	6.70
Flange thickness	tf4 =	6.90	6.87	6.87	6.92
Web offset at 1	=	86.80	86.98	86.89	87.04
Web offset at 2	=	86.89	84.84	85.09	84.75
Web offset at 3	=	84.23	86.78	86.11	86.22
Web offset at 4	=	87.94	88.24	87.43	87.89

Calculated Data

Web thickness (tw)	mm =	5.66	5.12	5.80	5.84
Sectional Area (A)	cm2 =	29.58	29.26	29.81	29.74
Inertia (Ixx)	cm4 =	1301.45	1318.66	1318.40	1309.21
Inertia (Iyy)	cm4 =	413.75	421.96	413.48	412.43
Warping Const.(Cw)	cm6 =	2.25	2.30	2.27	2.26
Torsion Const.(J)	cm4 =	4.74	4.68	4.82	4.77

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	152.40	153.80	153.18	152.40	0.92	0.51
Depth (D)	mm	154.00	155.50	154.69	152.40	0.97	1.50
Top flange (T)	mm	6.39	7.87	6.99	6.80	23.16	2.76
Bot flange (T)	mm	6.70	7.00	6.86	6.80	4.48	0.86
Flange thick (T)	mm	6.39	7.87	6.92	6.80	23.16	1.81
Web thick (t)	mm	5.12	5.84	5.60	6.10	14.06	-8.14
Area (A)	cm2	29.26	29.81	29.60	29.80	1.86	-0.68
Inertia (Ixx)	cm4	1301.45	1318.66	1311.93	1260.00	1.32	4.12
Inertia (Iyy)	cm4	412.43	421.96	415.40	403.00	2.31	3.08
Warping (Cw)	cm6	2.25	2.30	2.27	2.14	2.48	5.96
Torsional (J)	cm4	4.68	4.82	4.75	4.87	2.92	-2.43

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S6
Section ref : COL
Stock steel : S6

Date : 20.3.89
Test points: 4
Position 1 :TOP

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	152.63	152.42	152.92	153.05
Breadth (lower)	b1 =	153.40	153.18	152.46	152.70
Depth (first side)	d =	155.00	155.00	155.00	155.00
Depth (second side)	d1 =	156.00	156.00	156.00	155.50
Flange thickness	tf1 =	7.11	7.14	7.13	7.15
Flange thickness	tf2 =	6.91	6.89	6.86	6.76
Flange thickness	tf3 =	6.49	6.54	6.63	6.53
Flange thickness	tf4 =	7.49	7.55	7.56	7.54
Web offset at 1	=	86.96	86.03	86.08	86.07
Web offset at 2	=	86.20	85.58	85.02	85.34
Web offset at 3	=	85.17	85.91	86.23	87.09
Web offset at 4	=	86.25	87.26	87.09	87.09

Calculated Data

Web thickness (tw)	mm =	6.17	5.85	5.92	5.52
Sectional Area (A)	cm2 =	30.64	30.25	30.38	29.68
Inertia (Ixx)	cm4 =	1350.50	1345.80	1348.77	1328.71
Inertia (Iyy)	cm4 =	418.69	418.65	418.68	417.19
Warping Const.(Cw)	cm6 =	2.31	2.31	2.31	2.29
Torsion Const.(J)	cm4 =	5.20	5.05	5.11	4.81

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	152.42	153.40	152.85	152.40	0.64	0.29
Depth (D)	mm	155.00	156.00	155.44	152.40	0.65	1.99
Top flange (T)	mm	6.76	7.15	6.99	6.80	5.77	2.85
Bot flange (T)	mm	6.49	7.56	7.04	6.80	16.49	3.55
Flange thick (T)	mm	6.49	7.87	7.02	6.80	21.26	3.20
Web thick (t)	mm	5.52	6.17	5.86	6.10	11.68	-3.87
Area (A)	cm2	29.68	30.64	30.24	29.80	3.24	1.47
Inertia (Ixx)	cm4	1328.71	1350.50	1343.44	1260.00	1.64	6.62
Inertia (Iyy)	cm4	417.19	418.69	418.30	403.00	0.36	3.80
Warping (Cw)	cm6	2.29	2.31	2.30	2.14	0.69	7.65
Torsional (J)	cm4	4.81	5.20	5.04	4.87	8.19	3.50

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : SB12
Stock steel : P11

Date : 20.GS
Test points: 3
Position 1 :-

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	104.12	103.85	103.89		
Breadth (lower)	b1 =	104.73	103.68	104.34		
Depth (first side)	d =	254.68	254.78	254.46		
Depth (second side)	d1 =	255.67	255.67	255.61		
Flange thickness	tf1 =	6.72	6.92	6.86		
Flange thickness	tf2 =	7.04	7.06	6.96		
Flange thickness	tf3 =	6.62	6.72	6.72		
Flange thickness	tf4 =	6.82	6.96	6.89		
Web offset at 1	=	62.60	62.86	62.02		
Web offset at 2	=	63.05	63.38	62.41		
Web offset at 3	=	60.70	60.14	61.78		
Web offset at 4	=	60.95	60.51	62.13		

Calculated Data

Web thickness (tw)	mm =	6.22	5.76	5.38
Sectional Area (A)	cm2 =	29.71	28.75	27.77
Inertia (Ixx)	cm4 =	2990.20	2957.05	2899.06
Inertia (Iyy)	cm4 =	130.51	130.58	129.62
Warping Const.(Cw)	cm6 =	2.01	2.01	2.00
Torsion Const.(J)	cm4 =	4.71	4.37	4.00

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	103.68	104.73	104.10	101.60	1.01	2.46
Depth (D)	mm	254.46	255.67	255.15	254.00	0.48	0.45
Top flange (T)	mm	6.72	7.06	6.93	6.80	5.06	1.86
Bot flange (T)	mm	6.62	6.96	6.79	6.80	5.14	-0.17
Flange thick (T)	mm	6.62	7.06	6.86	6.80	6.65	0.85
Web thick (t)	mm	5.38	6.22	5.79	5.80	15.41	-0.23
Area (A)	cm2	27.77	29.71	28.74	28.40	6.99	1.21
Inertia (Ixx)	cm4	2899.06	2990.20	2948.77	2870.00	3.14	2.74
Inertia (Iyy)	cm4	129.62	130.58	130.23	120.00	0.74	8.53
Warping (Cw)	cm6	2.00	2.01	2.01	1.83	0.85	9.68
Torsional (J)	cm4	4.00	4.71	4.36	4.31	17.73	1.12

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S7
Section ref : COL
Stock steel : S7

Date : 9/5/89
Test points: 4
Position 1 :TOP

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	152.10	152.24	152.63	152.48
Breadth (lower)	b1 =	151.05	151.23	151.45	151.12
Depth (first side)	d =	155.00	155.50	155.50	155.50
Depth (second side)	d1 =	156.00	156.00	154.50	155.50
Flange thickness	tf1 =	6.90	6.92	6.88	6.74
Flange thickness	tf2 =	6.63	6.59	6.55	6.91
Flange thickness	tf3 =	6.76	6.74	6.68	6.70
Flange thickness	tf4 =	6.67	6.63	6.68	6.67
Web offset at 1	=	85.04	85.10	85.41	85.90
Web offset at 2	=	85.48	85.60	85.55	85.27
Web offset at 3	=	86.35	86.60	86.40	85.52
Web offset at 4	=	85.55	85.60	86.04	85.80

Calculated Data

Web thickness (tw)	mm =	5.81	5.73	5.78	5.99
Sectional Area (A)	cm2 =	29.17	29.04	29.05	29.52
Inertia (Ixx)	cm4 =	1292.99	1293.95	1280.43	1301.42
Inertia (Iyy)	cm4 =	391.84	391.91	392.96	394.51
Warping Const.(Cw)	cm6 =	2.17	2.18	2.16	2.18
Torsion Const.(J)	cm4 =	4.56	4.49	4.49	4.70

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	151.05	152.63	151.79	152.40	1.05	-0.40
Depth (D)	mm	154.50	156.00	155.44	152.40	0.97	1.99
Top flange (T)	mm	6.55	6.92	6.77	6.80	5.65	-0.51
Bot flange (T)	mm	6.63	6.76	6.69	6.80	1.96	-1.60
Flange thick (T)	mm	6.55	6.92	6.73	6.80	5.65	-1.06
Web thick (t)	mm	5.73	5.99	5.83	6.10	4.72	-4.49
Area (A)	cm2	29.04	29.52	29.19	29.80	1.66	-2.04
Inertia (Ixx)	cm4	1280.43	1301.42	1292.20	1260.00	1.64	2.56
Inertia (Iyy)	cm4	391.84	394.51	392.80	403.00	0.68	-2.53
Warping (Cw)	cm6	2.16	2.18	2.17	2.14	0.99	1.48
Torsional (J)	cm4	4.49	4.70	4.56	4.87	4.66	-6.41

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S8
Section ref : COL
Stock steel : S8

Date : 26/7/89
Test points: 4
Position 1 :BASE

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	151.50	152.00	151.50	151.00
Breadth (lower)	b1 =	150.50	151.00	151.00	151.00
Depth (first side)	d =	154.50	154.50	155.00	154.50
Depth (second side)	d1 =	154.00	154.50	154.50	154.50
Flange thickness	tf1 =	6.83	6.95	6.69	6.83
Flange thickness	tf2 =	6.38	6.22	6.34	6.17
Flange thickness	tf3 =	6.49	6.49	6.40	6.50
Flange thickness	tf4 =	6.58	6.61	6.63	6.67
Web offset at 1	=	86.27	86.35	85.63	84.82
Web offset at 2	=	86.70	86.65	86.19	84.82
Web offset at 3	=	84.59	84.41	85.73	86.20
Web offset at 4	=	84.00	84.22	85.22	86.20

Calculated Data

Web thickness (tw)	mm =	5.66	6.13	5.31	5.42
Sectional Area (A)	cm2 =	28.32	29.05	27.72	27.92
Inertia (Ixx)	cm4 =	1238.01	1256.64	1232.30	1232.81
Inertia (Iyy)	cm4 =	377.96	381.69	376.21	376.07
Warping Const.(Cw)	cm6 =	2.06	2.09	2.07	2.06
Torsion Const.(J)	cm4 =	4.22	4.50	3.97	4.06

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	150.50	152.00	151.19	152.40	1.00	-0.80
Depth (D)	mm	154.00	155.00	154.50	152.40	0.65	1.38
Top flange (T)	mm	6.17	6.95	6.55	6.80	12.64	-3.66
Bot flange (T)	mm	6.40	6.67	6.55	6.80	4.22	-3.73
Flange thick (T)	mm	6.17	6.95	6.55	6.80	12.64	-3.69
Web thick (t)	mm	5.31	6.13	5.63	6.10	15.46	-7.75
Area (A)	cm2	27.72	29.05	28.25	29.80	4.81	-5.19
Inertia (Ixx)	cm4	1232.30	1256.64	1239.94	1260.00	1.98	-1.59
Inertia (Iyy)	cm4	376.07	381.69	377.98	403.00	1.49	-6.21
Warping (Cw)	cm6	2.06	2.09	2.07	2.14	1.46	-3.34
Torsional (J)	cm4	3.97	4.50	4.19	4.87	13.40	-14.06

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S9
Section ref : COL
Stock steel : S9

Date : 26/7/89
Test points: 4
Position 1 :BASE

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	152.25	152.54	153.50	153.47
Breadth (lower)	b1 =	152.90	152.94	152.47	152.22
Depth (first side)	d =	156.00	155.50	155.00	156.50
Depth (second side)	d1 =	156.00	154.50	155.00	155.00
Flange thickness	tf1 =	7.19	7.08	7.08	7.35
Flange thickness	tf2 =	6.47	6.60	6.47	6.65
Flange thickness	tf3 =	6.89	6.70	6.79	6.90
Flange thickness	tf4 =	6.57	6.73	6.75	6.58
Web offset at 1	=	86.10	87.11	87.45	85.64
Web offset at 2	=	86.19	87.09	86.63	84.40
Web offset at 3	=	86.46	85.19	85.69	87.32
Web offset at 4	=	86.22	85.50	85.71	87.28

Calculated Data

Web thickness (tw)	mm =	5.53	5.73	5.69	5.97
Sectional Area (A)	cm2 =	29.06	29.31	29.26	29.97
Inertia (Ixx)	cm4 =	1309.03	1296.22	1296.15	1330.19
Inertia (Iyy)	cm4 =	401.87	403.31	404.86	410.01
Warping Const.(Cw)	cm6 =	2.24	2.22	2.22	2.27
Torsion Const.(J)	cm4 =	4.49	4.59	4.56	4.87

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	152.22	153.50	152.79	152.40	0.84	0.25
Depth (D)	mm	154.50	156.50	155.44	152.40	1.29	1.99
Top flange (T)	mm	6.47	7.35	6.86	6.80	13.60	0.90
Bot flange (T)	mm	6.57	6.90	6.74	6.80	5.02	-0.90
Flange thick (T)	mm	6.47	7.35	6.80	6.80	13.60	0.00
Web thick (t)	mm	5.53	5.97	5.73	6.10	7.87	-6.09
Area (A)	cm2	29.06	29.97	29.40	29.80	3.12	-1.34
Inertia (Ixx)	cm4	1296.15	1330.19	1307.90	1260.00	2.63	3.80
Inertia (Iyy)	cm4	401.87	410.01	405.01	403.00	2.03	0.50
Warping (Cw)	cm6	2.22	2.27	2.24	2.14	2.57	4.53
Torsional (J)	cm4	4.49	4.87	4.63	4.87	8.62	-4.96

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S10
Section ref : COL
Stock steel : S10

Date : 9/10/89
Test points: 4
Position 1 :BASE

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	152.00	152.16	152.10	152.93
Breadth (lower)	b1 =	153.50	153.01	152.50	152.23
Depth (first side)	d =	155.50	155.50	155.50	155.50
Depth (second side)	d1 =	154.50	154.50	155.00	154.00
Flange thickness	tf1 =	6.88	6.96	6.76	6.77
Flange thickness	tf2 =	6.91	6.78	6.84	6.91
Flange thickness	tf3 =	7.28	7.13	7.15	7.15
Flange thickness	tf4 =	6.44	6.39	6.23	6.30
Web offset at 1	=	85.34	85.68	85.83	86.08
Web offset at 2	=	86.30	86.13	86.24	86.64
Web offset at 3	=	87.10	87.05	86.22	86.20
Web offset at 4	=	86.48	86.68	85.74	85.40

Calculated Data

Web thickness (tw)	mm =	5.58	5.25	5.73	5.86
Sectional Area (A)	cm2 =	29.39	28.72	29.16	29.47
Inertia (Ixx)	cm4 =	1307.28	1289.23	1292.57	1294.09
Inertia (Iyy)	cm4 =	409.15	404.03	397.68	402.18
Warping Const.(Cw)	cm6 =	2.24	2.22	2.19	2.20
Torsion Const.(J)	cm4 =	4.66	4.39	4.53	4.67

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	152.00	153.50	152.55	152.40	0.99	0.10
Depth (D)	mm	154.00	155.50	155.00	152.40	0.97	1.71
Top flange (T)	mm	6.76	6.96	6.85	6.80	2.96	0.75
Bot flange (T)	mm	6.23	7.28	6.76	6.80	16.85	-0.61
Flange thick (T)	mm	6.23	7.35	6.81	6.80	17.98	0.07
Web thick (t)	mm	5.25	5.86	5.60	6.10	11.51	-8.11
Area (A)	cm2	28.72	29.47	29.18	29.80	2.60	-2.07
Inertia (Ixx)	cm4	1289.23	1307.28	1295.79	1260.00	1.40	2.84
Inertia (Iyy)	cm4	397.68	409.15	403.26	403.00	2.88	0.06
Warping (Cw)	cm6	2.19	2.24	2.21	2.14	2.36	3.46
Torsional (J)	cm4	4.39	4.67	4.56	4.87	6.29	-6.33

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S1
Section ref : BEAM 1
Stock steel : B5

Date : 5/10/88
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	101.67	101.77	101.87	
Breadth (lower)	b1 =	105.79	105.58	105.17	
Depth (first side)	d =	254.50	254.50	255.40	
Depth (second side)	d1 =	255.00	254.50	255.00	
Flange thickness	tf1 =	6.76	6.63	6.69	
Flange thickness	tf2 =	7.20	7.08	7.37	
Flange thickness	tf3 =	6.51	6.53	6.40	
Flange thickness	tf4 =	6.57	6.60	6.61	
Web offset at 1	=	60.33	60.36	60.06	
Web offset at 2	=	62.42	62.10	61.32	
Web offset at 3	=	61.30	61.69	61.74	
Web offset at 4	=	61.90	62.26	62.13	

Calculated Data

Web thickness (tw)	mm =	6.19	5.91	6.33
Sectional Area (A)	cm2 =	29.46	28.65	29.81
Inertia (Ixx)	cm4 =	2949.09	2894.41	2975.46
Inertia (Iyy)	cm4 =	126.52	125.45	126.13
Warping Const.(Cw)	cm6 =	1.95	1.93	1.95
Torsion Const.(J)	cm4 =	4.63	4.29	4.78

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	101.67	105.79	103.64	101.60	4.05	2.01
Depth (D)	mm	254.50	255.40	254.82	254.00	0.35	0.32
Top flange (T)	mm	6.63	7.37	6.95	6.80	11.16	2.28
Bot flange (T)	mm	6.40	6.61	6.54	6.80	3.28	-3.87
Flange thick (T)	mm	6.40	7.37	6.75	6.80	15.16	-0.80
Web thick (t)	mm	5.91	6.33	6.15	5.80	7.19	5.98
Area (A)	cm2	28.65	29.81	29.30	28.40	4.04	3.19
Inertia (Ixx)	cm4	2894.41	2975.46	2939.65	2870.00	2.80	2.43
Inertia (Iyy)	cm4	125.45	126.52	126.03	120.00	0.85	5.03
Warping (Cw)	cm6	1.93	1.95	1.94	1.83	1.07	5.95
Torsional (J)	cm4	4.29	4.78	4.57	4.31	11.37	5.96

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S1
Section ref : BEAM 2
Stock steel : B5

Date : 5/10/88
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	104.81	105.52	105.26	
Breadth (lower)	b1 =	101.59	101.54	101.82	
Depth (first side)	d =	254.00	254.50	255.00	
Depth (second side)	d1 =	255.00	255.00	255.50	
Flange thickness	tf1 =	6.37	6.33	6.48	
Flange thickness	tf2 =	6.65	6.60	6.70	
Flange thickness	tf3 =	6.75	6.68	6.71	
Flange thickness	tf4 =	7.09	7.07	7.05	
Web offset at 1	=	61.83	62.20	61.88	
Web offset at 2	=	60.27	60.44	60.61	
Web offset at 3	=	61.53	61.84	62.15	
Web offset at 4	=	61.72	61.32	61.66	

Calculated Data

Web thickness (tw) mm =	5.96	6.07	5.83	
Sectional Area (A) cm2 =	28.73	28.95	28.53	
Inertia (Ixx) cm4 =	2892.25	2905.02	2909.22	
Inertia (Iyy) cm4 =	123.75	124.10	125.37	
Warping Const.(Cw) cm6 =	1.90	1.91	1.94	
Torsion Const.(J) cm4 =	4.34	4.41	4.25	

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	101.54	105.52	103.42	101.60	3.92	1.79
Depth (D)	mm	254.00	255.50	254.83	254.00	0.59	0.33
Top flange (T)	mm	6.33	6.70	6.52	6.80	5.85	-4.09
Bot flange (T)	mm	6.68	7.09	6.89	6.80	6.14	1.35
Flange thick (T)	mm	6.33	7.09	6.71	6.80	12.01	-1.37
Web thick (t)	mm	5.83	6.07	5.95	5.80	4.12	2.67
Area (A)	cm2	28.53	28.95	28.74	28.40	1.47	1.19
Inertia (Ixx)	cm4	2892.25	2909.22	2902.16	2870.00	0.59	1.12
Inertia (Iyy)	cm4	123.75	125.37	124.41	120.00	1.31	3.68
Warping (Cw)	cm6	1.90	1.94	1.91	1.83	1.91	4.64
Torsional (J)	cm4	4.25	4.41	4.33	4.31	3.79	0.49

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S1
Section ref : BEAM 3
Stock steel : B5

Date : 5/10/88
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	104.86	104.76	105.40	
Breadth (lower)	b1 =	101.94	101.83	102.10	
Depth (first side)	d =	254.75	254.50	255.00	
Depth (second side)	d1 =	254.50	255.00	255.00	
Flange thickness	tf1 =	6.56	6.51	6.47	
Flange thickness	tf2 =	6.67	6.74	6.64	
Flange thickness	tf3 =	6.77	6.75	6.76	
Flange thickness	tf4 =	7.06	7.17	7.12	
Web offset at 1	=	61.72	61.75	61.79	
Web offset at 2	=	60.29	60.22	60.18	
Web offset at 3	=	61.81	61.31	61.87	
Web offset at 4	=	61.37	61.03	61.50	

Calculated Data

Web thickness (tw)	mm =	6.25	6.58	6.52
Sectional Area (A)	cm2 =	29.54	30.39	30.24
Inertia (Ixx)	cm4 =	2946.86	2994.84	2991.29
Inertia (Iyy)	cm4 =	125.53	125.71	126.56
Warping Const.(Cw)	cm6 =	1.93	1.93	1.95
Torsion Const.(J)	cm4 =	4.68	5.07	4.97

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	101.83	105.40	103.48	101.60	3.51	1.85
Depth (D)	mm	254.50	255.00	254.79	254.00	0.20	0.31
Top flange (T)	mm	6.47	6.74	6.60	6.80	4.17	-2.97
Bot flange (T)	mm	6.75	7.17	6.94	6.80	6.22	2.03
Flange thick (T)	mm	6.47	7.37	6.77	6.80	13.91	-0.47
Web thick (t)	mm	6.25	6.58	6.45	5.80	5.36	11.18
Area (A)	cm2	29.54	30.39	30.06	28.40	2.89	5.83
Inertia (Ixx)	cm4	2946.86	2994.84	2977.66	2870.00	1.63	3.75
Inertia (Iyy)	cm4	125.53	126.56	125.93	120.00	0.82	4.94
Warping (Cw)	cm6	1.93	1.95	1.94	1.83	1.14	5.83
Torsional (J)	cm4	4.68	5.07	4.90	4.31	8.43	13.79

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S2
Section ref : BEAM 1
Stock steel : B6

Date : 13.12.88
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	105.58	105.44	105.36	
Breadth (lower)	b1 =	102.80	102.86	103.06	
Depth (first side)	d =	254.00	254.00	254.00	
Depth (second side)	d1 =	254.00	254.00	254.00	
Flange thickness	tf1 =	6.25	6.30	6.21	
Flange thickness	tf2 =	6.50	6.62	6.60	
Flange thickness	tf3 =	6.45	6.48	6.25	
Flange thickness	tf4 =	6.86	6.72	6.86	
Web offset at 1	=	61.69	61.80	61.29	
Web offset at 2	=	60.59	60.78	60.27	
Web offset at 3	=	62.53	62.54	62.66	
Web offset at 4	=	61.92	62.28	62.31	

Calculated Data

Web thickness (tw)	mm =	6.26	5.89	6.39
Sectional Area (A)	cm2 =	29.16	28.29	29.39
Inertia (Ixx)	cm4 =	2878.11	2838.18	2882.95
Inertia (Iyy)	cm4 =	123.83	123.90	123.58
Warping Const.(Cw)	cm6 =	1.90	1.90	1.89
Torsion Const.(J)	cm4 =	4.46	4.10	4.55

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.80	105.58	104.18	101.60	2.70	2.54
Depth (D)	mm	254.00	254.00	254.00	254.00	0.00	0.00
Top flange (T)	mm	6.21	6.62	6.41	6.80	6.60	-5.69
Bot flange (T)	mm	6.25	6.86	6.60	6.80	9.76	-2.89
Flange thick (T)	mm	6.21	7.37	6.51	6.80	18.68	-4.29
Web thick (t)	mm	5.89	6.39	6.18	5.80	8.40	6.55
Area (A)	cm2	28.29	29.39	28.95	28.40	3.90	1.93
Inertia (Ixx)	cm4	2838.18	2882.95	2866.41	2870.00	1.58	-0.13
Inertia (Iyy)	cm4	123.58	123.90	123.77	120.00	0.26	3.14
Warping (Cw)	cm6	1.89	1.90	1.90	1.83	0.21	3.57
Torsional (J)	cm4	4.10	4.55	4.37	4.31	10.96	1.46

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S2
Section ref : BEAM 2
Stock steel : B6

Date : 12.12.88
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	103.10	102.97	102.91	
Breadth (lower)	b1 =	105.92	106.18	106.20	
Depth (first side)	d =	254.00	254.00	254.00	
Depth (second side)	d1 =	254.00	254.00	254.00	
Flange thickness	tf1 =	6.55	6.53	6.61	
Flange thickness	tf2 =	6.89	6.90	7.05	
Flange thickness	tf3 =	6.26	6.39	6.24	
Flange thickness	tf4 =	6.57	6.51	6.58	
Web offset at 1	=	60.41	59.87	60.67	
Web offset at 2	=	61.18	61.33	61.58	
Web offset at 3	=	62.61	62.79	62.16	
Web offset at 4	=	63.51	63.56	63.60	

Calculated Data

Web thickness (tw) mm =	6.09	6.24	5.99	
Sectional Area (A) cm2 =	28.90	29.29	28.75	
Inertia (Ixx) cm4 =	2879.54	2902.01	2882.73	
Inertia (Iyy) cm4 =	126.47	127.30	127.25	
Warping Const.(Cw) cm6 =	1.94	1.95	1.95	
Torsion Const.(J) cm4 =	4.34	4.51	4.29	

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.91	106.20	104.55	101.60	3.20	2.90
Depth (D)	mm	254.00	254.00	254.00	254.00	0.00	0.00
Top flange (T)	mm	6.53	7.05	6.76	6.80	7.96	-0.66
Bot flange (T)	mm	6.24	6.58	6.43	6.80	5.45	-5.51
Flange thick (T)	mm	6.24	7.37	6.59	6.80	18.11	-3.09
Web thick (t)	mm	5.99	6.24	6.11	5.80	4.17	5.32
Area (A)	cm2	28.75	29.29	28.98	28.40	1.86	2.04
Inertia (Ixx)	cm4	2879.54	2902.01	2888.09	2870.00	0.78	0.63
Inertia (Iyy)	cm4	126.47	127.30	127.01	120.00	0.66	5.84
Warping (Cw)	cm6	1.94	1.95	1.94	1.83	0.64	6.21
Torsional (J)	cm4	4.29	4.51	4.38	4.31	4.96	1.66

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S2
Section ref : BEAM 3
Stock steel : B6

Date : 12.12.88
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	106.05	105.88	105.88	
Breadth (lower)	b1 =	102.93	102.93	103.32	
Depth (first side)	d =	254.00	254.00	254.00	
Depth (second side)	d1 =	254.00	254.00	254.00	
Flange thickness	tf1 =	6.50	6.59	6.63	
Flange thickness	tf2 =	6.41	6.29	6.41	
Flange thickness	tf3 =	6.94	6.87	6.72	
Flange thickness	tf4 =	6.56	6.58	6.53	
Web offset at 1	=	63.32	63.58	63.83	
Web offset at 2	=	62.18	62.04	62.61	
Web offset at 3	=	61.54	61.18	61.27	
Web offset at 4	=	60.57	60.65	60.86	

Calculated Data

Web thickness (tw)	mm =	6.13	6.12	5.75
Sectional Area (A)	cm2 =	29.04	28.98	28.11
Inertia (Ixx)	cm4 =	2892.53	2884.62	2843.66
Inertia (Iyy)	cm4 =	126.75	126.17	126.75
Warping Const.(Cw)	cm6 =	1.94	1.93	1.94
Torsion Const.(J)	cm4 =	4.41	4.38	4.03

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.93	106.05	104.50	101.60	3.03	2.85
Depth (D)	mm	254.00	254.00	254.00	254.00	0.00	0.00
Top flange (T)	mm	6.29	6.63	6.47	6.80	5.41	-4.83
Bot flange (T)	mm	6.53	6.94	6.70	6.80	6.28	-1.47
Flange thick (T)	mm	6.29	7.37	6.59	6.80	17.17	-3.15
Web thick (t)	mm	5.75	6.13	6.00	5.80	6.43	3.45
Area (A)	cm2	28.11	29.04	28.71	28.40	3.32	1.08
Inertia (Ixx)	cm4	2843.66	2892.53	2873.60	2870.00	1.72	0.13
Inertia (Iyy)	cm4	126.17	126.75	126.56	120.00	0.46	5.47
Warping (Cw)	cm6	1.93	1.94	1.94	1.83	0.46	5.84
Torsional (J)	cm4	4.03	4.41	4.27	4.31	9.36	-0.85

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S3
Section ref : BEAM 1
Stock steel : B7

Date : 13.1.89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	105.19	104.69	105.08	
Breadth (lower)	b1 =	102.45	102.48	102.13	
Depth (first side)	d =	254.50	254.00	254.50	
Depth (second side)	d1 =	253.50	253.50	253.00	
Flange thickness	tf1 =	6.27	6.25	6.45	
Flange thickness	tf2 =	6.03	6.06	6.19	
Flange thickness	tf3 =	6.66	6.64	6.64	
Flange thickness	tf4 =	6.37	6.24	6.30	
Web offset at 1	=	62.98	62.55	62.71	
Web offset at 2	=	62.16	62.28	61.73	
Web offset at 3	=	61.48	61.58	61.32	
Web offset at 4	=	60.53	60.23	60.22	

Calculated Data

Web thickness (tw)	mm =	5.69	5.71	6.05
Sectional Area (A)	cm2 =	27.36	27.30	28.33
Inertia (Ixx)	cm4 =	2751.03	2732.92	2801.90
Inertia (Iyy)	cm4 =	119.07	117.63	119.66
Warping Const.(Cw)	cm6 =	1.83	1.80	1.83
Torsion Const.(J)	cm4 =	3.73	3.71	4.12

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.13	105.19	103.67	101.60	3.00	2.04
Depth (D)	mm	253.00	254.50	253.83	254.00	0.59	-0.07
Top flange (T)	mm	6.03	6.45	6.21	6.80	6.97	-8.70
Bot flange (T)	mm	6.24	6.66	6.47	6.80	6.73	-4.78
Flange thick (T)	mm	6.03	7.37	6.34	6.80	22.22	-6.74
Web thick (t)	mm	5.69	6.05	5.82	5.80	6.51	0.26
Area (A)	cm2	27.30	28.33	27.66	28.40	3.80	-2.59
Inertia (Ixx)	cm4	2732.92	2801.90	2761.95	2870.00	2.52	-3.76
Inertia (Iyy)	cm4	117.63	119.66	118.79	120.00	1.72	-1.01
Warping (Cw)	cm6	1.80	1.83	1.82	1.83	1.64	-0.60
Torsional (J)	cm4	3.71	4.12	3.86	4.31	11.09	-10.55

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S3
Section ref : BEAM 3
Stock steel : B7

Date : 13.1.89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	105.34	105.30	105.15	
Breadth (lower)	b1 =	101.75	101.76	102.02	
Depth (first side)	d =	253.50	254.00	253.50	
Depth (second side)	d1 =	254.50	254.50	254.00	
Flange thickness	tf1 =	6.21	6.06	6.07	
Flange thickness	tf2 =	6.41	6.39	6.55	
Flange thickness	tf3 =	6.50	6.41	6.62	
Flange thickness	tf4 =	6.59	6.65	6.66	
Web offset at 1	=	61.93	61.46	61.20	
Web offset at 2	=	60.82	60.47	60.41	
Web offset at 3	=	62.67	62.81	62.54	
Web offset at 4	=	61.83	62.27	61.78	

Calculated Data

Web thickness (tw)	mm =	5.36	5.47	6.06
Sectional Area (A)	cm2 =	26.73	26.89	28.50
Inertia (Ixx)	cm4 =	2734.82	2738.62	2824.15
Inertia (Iyy)	cm4 =	119.64	118.88	120.97
Warping Const.(Cw)	cm6 =	1.83	1.83	1.85
Torsion Const.(J)	cm4 =	3.54	3.58	4.20

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	101.75	105.34	103.55	101.60	3.53	1.92
Depth (D)	mm	253.50	254.50	254.00	254.00	0.39	0.00
Top flange (T)	mm	6.06	6.55	6.28	6.80	8.09	-7.62
Bot flange (T)	mm	6.41	6.66	6.57	6.80	3.90	-3.36
Flange thick (T)	mm	6.06	7.37	6.43	6.80	21.62	-5.49
Web thick (t)	mm	5.36	6.06	5.63	5.80	13.06	-2.96
Area (A)	cm2	26.73	28.50	27.37	28.40	6.62	-3.62
Inertia (Ixx)	cm4	2734.82	2824.15	2765.86	2870.00	3.27	-3.63
Inertia (Iyy)	cm4	118.88	120.97	119.83	120.00	1.76	-0.14
Warping (Cw)	cm6	1.83	1.85	1.84	1.83	1.27	0.34
Torsional (J)	cm4	3.54	4.20	3.78	4.31	18.57	-12.38

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S4
Section ref : BEAM 2
Stock steel : B8

Date : 31.1.89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	102.97	103.44	103.60	
Breadth (lower)	b1 =	102.52	102.50	102.75	
Depth (first side)	d =	254.00	254.00	254.00	
Depth (second side)	d1 =	253.50	254.00	254.00	
Flange thickness	tf1 =	6.11	6.13	6.25	
Flange thickness	tf2 =	6.42	6.42	6.33	
Flange thickness	tf3 =	6.17	6.13	6.43	
Flange thickness	tf4 =	6.51	6.47	6.56	
Web offset at 1	=	61.84	61.76	60.96	
Web offset at 2	=	61.55	61.22	60.64	
Web offset at 3	=	61.24	61.33	61.68	
Web offset at 4	=	61.46	61.74	61.56	

Calculated Data

Web thickness (tw) mm =	5.14	5.39	6.19	
Sectional Area (A) cm2 =	25.84	26.44	28.63	
Inertia (Ixx) cm4 =	2652.58	2687.44	2815.77	
Inertia (Iyy) cm4 =	114.51	115.04	117.95	
Warping Const.(Cw) cm6 =	1.75	1.76	1.81	
Torsion Const.(J) cm4 =	3.25	3.43	4.25	

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.50	103.60	102.96	101.60	1.07	1.34
Depth (D)	mm	253.50	254.00	253.92	254.00	0.20	-0.03
Top flange (T)	mm	6.11	6.42	6.28	6.80	5.07	-7.70
Bot flange (T)	mm	6.13	6.56	6.38	6.80	7.01	-6.20
Flange thick (T)	mm	6.11	7.37	6.33	6.80	20.62	-6.95
Web thick (t)	mm	5.14	6.19	5.57	5.80	20.53	-3.91
Area (A)	cm2	25.84	28.63	26.97	28.40	10.79	-5.03
Inertia (Ixx)	cm4	2652.58	2815.77	2718.59	2870.00	6.15	-5.28
Inertia (Iyy)	cm4	114.51	117.95	115.83	120.00	3.01	-3.47
Warping (Cw)	cm6	1.75	1.81	1.78	1.83	3.14	-3.00
Torsional (J)	cm4	3.25	4.25	3.65	4.31	30.84	-15.42

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S4
Section ref : BEAM 3
Stock steel : B8

Date : 30.1.89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	103.08	103.36	103.47	
Breadth (lower)	b1 =	102.55	102.62	102.52	
Depth (first side)	d =	254.00	253.00	254.00	
Depth (second side)	d1 =	254.30	254.00	254.00	
Flange thickness	tf1 =	6.36	6.19	6.22	
Flange thickness	tf2 =	6.49	6.39	6.31	
Flange thickness	tf3 =	6.25	6.21	6.61	
Flange thickness	tf4 =	6.58	6.75	6.66	
Web offset at 1	=	60.62	60.59	61.22	
Web offset at 2	=	60.76	60.89	60.47	
Web offset at 3	=	61.81	61.75	61.61	
Web offset at 4	=	61.75	61.75	62.14	

Calculated Data

Web thickness (tw)	mm =	5.78	5.94	5.71
Sectional Area (A)	cm2 =	27.66	27.95	27.56
Inertia (Ixx)	cm4 =	2772.45	2767.50	2772.11
Inertia (Iyy)	cm4 =	117.19	117.16	118.27
Warping Const.(Cw)	cm6 =	1.80	1.79	1.81
Torsion Const.(J)	cm4 =	3.88	3.99	3.85

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.52	103.47	102.93	101.60	0.93	1.31
Depth (D)	mm	253.00	254.30	253.88	254.00	0.51	-0.05
Top flange (T)	mm	6.19	6.49	6.33	6.80	4.85	-6.96
Bot flange (T)	mm	6.21	6.75	6.51	6.80	8.70	-4.26
Flange thick (T)	mm	6.19	7.37	6.42	6.80	19.06	-5.61
Web thick (t)	mm	5.71	5.94	5.81	5.80	3.94	0.23
Area (A)	cm2	27.56	27.95	27.72	28.40	1.40	-2.39
Inertia (Ixx)	cm4	2767.50	2772.45	2770.68	2870.00	0.18	-3.46
Inertia (Iyy)	cm4	117.16	118.27	117.54	120.00	0.95	-2.05
Warping (Cw)	cm6	1.79	1.81	1.80	1.83	1.30	-1.67
Torsional (J)	cm4	3.85	3.99	3.91	4.31	3.68	-9.33

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S8
Section ref : BEAM 1
Stock steel : B1

Date : 26/7/89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	103.50	103.30	103.30	
Breadth (lower)	b1 =	102.00	103.20	103.20	
Depth (first side)	d =	254.00	254.50	254.50	
Depth (second side)	d1 =	254.00	254.50	254.50	
Flange thickness	tf1 =	6.50	6.51	6.51	
Flange thickness	tf2 =	6.73	6.81	6.81	
Flange thickness	tf3 =	6.53	6.44	6.44	
Flange thickness	tf4 =	6.80	6.88	6.88	
Web offset at 1	=	60.71	60.78	60.77	
Web offset at 2	=	59.69	59.85	59.78	
Web offset at 3	=	61.69	61.85	61.44	
Web offset at 4	=	62.68	62.65	62.56	

Calculated Data

Web thickness (tw)	mm =	5.81	6.12	6.41
Sectional Area (A)	cm2 =	28.11	29.02	29.72
Inertia (Ixx)	cm4 =	2831.29	2897.56	2931.46
Inertia (Iyy)	cm4 =	121.35	123.56	123.57
Warping Const.(Cw)	cm6 =	1.86	1.90	1.90
Torsion Const.(J)	cm4 =	4.11	4.44	4.75

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.00	103.50	103.08	101.60	1.47	1.46
Depth (D)	mm	254.00	254.50	254.33	254.00	0.20	0.13
Top flange (T)	mm	6.50	6.81	6.64	6.80	4.77	-2.28
Bot flange (T)	mm	6.44	6.88	6.66	6.80	6.83	-2.03
Flange thick (T)	mm	6.44	7.37	6.65	6.80	14.44	-2.16
Web thick (t)	mm	5.81	6.41	6.11	5.80	10.51	5.43
Area (A)	cm2	28.11	29.72	28.95	28.40	5.71	1.94
Inertia (Ixx)	cm4	2831.29	2931.46	2886.77	2870.00	3.54	0.58
Inertia (Iyy)	cm4	121.35	123.57	122.83	120.00	1.83	2.35
Warping (Cw)	cm6	1.86	1.90	1.88	1.83	2.22	2.94
Torsional (J)	cm4	4.11	4.75	4.43	4.31	15.66	2.84

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S8
Section ref : BEAM 2
Stock steel : B5

Date : 26/7/89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	103.50	103.50	104.00	
Breadth (lower)	b1 =	100.50	101.00	101.50	
Depth (first side)	d =	254.00	254.00	254.50	
Depth (second side)	d1 =	253.50	253.50	254.50	
Flange thickness	tf1 =	6.56	6.54	6.60	
Flange thickness	tf2 =	6.45	6.31	6.45	
Flange thickness	tf3 =	6.99	6.93	6.90	
Flange thickness	tf4 =	6.71	6.81	6.75	
Web offset at 1	=	61.90	61.79	61.53	
Web offset at 2	=	61.32	61.23	61.35	
Web offset at 3	=	61.76	61.35	61.80	
Web offset at 4	=	60.76	60.73	60.53	

Calculated Data

Web thickness (tw)	mm =	4.57	5.14	5.59
Sectional Area (A)	cm2 =	25.10	26.44	27.68
Inertia (Ixx)	cm4 =	2676.26	2738.86	2827.82
Inertia (Iyy)	cm4 =	118.50	118.94	121.32
Warping Const.(Cw)	cm6 =	1.81	1.82	1.86
Torsion Const.(J)	cm4 =	3.20	3.56	3.95

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	100.50	104.00	102.33	101.60	3.48	0.72
Depth (D)	mm	253.50	254.50	254.00	254.00	0.39	0.00
Top flange (T)	mm	6.31	6.60	6.49	6.80	4.60	-4.63
Bot flange (T)	mm	6.71	6.99	6.85	6.80	4.17	0.71
Flange thick (T)	mm	6.31	7.37	6.67	6.80	16.80	-1.96
Web thick (t)	mm	4.57	5.59	5.10	5.80	22.21	-12.10
Area (A)	cm2	25.10	27.68	26.41	28.40	10.27	-7.02
Inertia (Ixx)	cm4	2676.26	2827.82	2747.65	2870.00	5.66	-4.26
Inertia (Iyy)	cm4	118.50	121.32	119.59	120.00	2.38	-0.34
Warping (Cw)	cm6	1.81	1.86	1.83	1.83	3.01	-0.06
Torsional (J)	cm4	3.20	3.95	3.57	4.31	23.22	-17.16

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S8
Section ref : BEAM 3
Stock steel : B1

Date : 26/7/89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	102.30	102.20	102.30	
Breadth (lower)	b1 =	104.60	104.30	103.70	
Depth (first side)	d =	254.50	254.50	254.00	
Depth (second side)	d1 =	254.50	254.50	254.50	
Flange thickness	tf1 =	6.93	6.94	6.94	
Flange thickness	tf2 =	6.55	6.76	6.62	
Flange thickness	tf3 =	6.69	6.66	6.70	
Flange thickness	tf4 =	6.43	6.34	6.65	
Web offset at 1	=	62.87	62.83	62.43	
Web offset at 2	=	62.82	62.68	62.00	
Web offset at 3	=	59.44	59.78	59.92	
Web offset at 4	=	61.09	61.03	60.81	

Calculated Data

Web thickness (tw) mm =	5.78	5.53	5.86	
Sectional Area (A) cm2 =	28.19	27.61	28.46	
Inertia (Ixx) cm4 =	2858.16	2831.63	2873.77	
Inertia (Iyy) cm4 =	124.35	123.79	123.76	
Warping Const.(Cw) cm6 =	1.91	1.90	1.90	
Torsion Const.(J) cm4 =	4.11	3.91	4.25	

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.20	104.60	103.23	101.60	2.35	1.61
Depth (D)	mm	254.00	254.50	254.42	254.00	0.20	0.16
Top flange (T)	mm	6.55	6.94	6.79	6.80	5.95	-0.15
Bot flange (T)	mm	6.34	6.70	6.58	6.80	5.68	-3.26
Flange thick (T)	mm	6.34	7.37	6.68	6.80	16.25	-1.70
Web thick (t)	mm	5.53	5.86	5.72	5.80	5.97	-1.32
Area (A)	cm2	27.61	28.46	28.09	28.40	3.09	-1.09
Inertia (Ixx)	cm4	2831.63	2873.77	2854.52	2870.00	1.49	-0.54
Inertia (Iyy)	cm4	123.76	124.35	123.97	120.00	0.48	3.31
Warping (Cw)	cm6	1.90	1.91	1.90	1.83	0.75	3.93
Torsional (J)	cm4	3.91	4.25	4.09	4.31	8.58	-5.10

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S9
Section ref : BEAM 1
Stock steel : B2

Date : 14/8/89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	103.75	103.70	103.11	
Breadth (lower)	b1 =	102.91	102.99	103.12	
Depth (first side)	d =	255.00	255.00	255.50	
Depth (second side)	d1 =	255.00	255.00	255.00	
Flange thickness	tf1 =	6.75	6.88	6.94	
Flange thickness	tf2 =	6.93	7.06	7.06	
Flange thickness	tf3 =	6.57	6.57	6.72	
Flange thickness	tf4 =	6.85	6.99	6.96	
Web offset at 1	=	62.51	62.09	61.44	
Web offset at 2	=	61.49	61.44	61.25	
Web offset at 3	=	60.65	60.98	60.68	
Web offset at 4	=	60.73	60.95	61.14	

Calculated Data

Web thickness (tw)	mm =	6.08	6.05	6.30
Sectional Area (A)	cm2 =	29.18	29.31	29.98
Inertia (Ixx)	cm4 =	2939.76	2965.36	3008.56
Inertia (Iyy)	cm4 =	125.67	127.40	127.37
Warping Const.(Cw)	cm6 =	1.94	1.96	1.96
Torsion Const.(J)	cm4 =	4.52	4.60	4.89

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.91	103.75	103.26	101.60	0.82	1.64
Depth (D)	mm	255.00	255.50	255.08	254.00	0.20	0.43
Top flange (T)	mm	6.75	7.06	6.94	6.80	4.59	2.01
Bot flange (T)	mm	6.57	6.99	6.78	6.80	6.39	-0.34
Flange thick (T)	mm	6.57	7.37	6.86	6.80	12.18	0.83
Web thick (t)	mm	6.05	6.30	6.14	5.80	4.05	5.95
Area (A)	cm2	29.18	29.98	29.49	28.40	2.74	3.83
Inertia (Ixx)	cm4	2939.76	3008.56	2971.22	2870.00	2.34	3.53
Inertia (Iyy)	cm4	125.67	127.40	126.81	120.00	1.38	5.68
Warping (Cw)	cm6	1.94	1.96	1.95	1.83	1.44	6.74
Torsional (J)	cm4	4.52	4.89	4.67	4.31	8.28	8.36

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S9
Section ref : BEAM 2
Stock steel : B6

Date : 14/8/89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	105.74	105.91	105.67	
Breadth (lower)	b1 =	103.26	103.00	103.11	
Depth (first side)	d =	254.00	254.50	255.00	
Depth (second side)	d1 =	254.00	253.50	253.50	
Flange thickness	tf1 =	6.17	6.25	6.44	
Flange thickness	tf2 =	6.46	6.45	6.57	
Flange thickness	tf3 =	6.40	6.37	6.57	
Flange thickness	tf4 =	6.75	6.74	6.85	
Web offset at 1	=	61.00	61.19	61.01	
Web offset at 2	=	60.27	60.57	59.94	
Web offset at 3	=	63.23	63.57	63.57	
Web offset at 4	=	62.79	63.11	63.04	

Calculated Data

Web thickness (tw)	mm =	6.30	5.67	6.05
Sectional Area (A)	cm2 =	29.14	27.65	28.87
Inertia (Ixx)	cm4 =	2868.01	2796.89	2890.13
Inertia (Iyy)	cm4 =	124.29	124.08	127.24
Warping Const.(Cw)	cm6 =	1.90	1.90	1.95
Torsion Const.(J)	cm4 =	4.43	3.84	4.34

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	103.00	105.91	104.45	101.60	2.83	2.80
Depth (D)	mm	253.50	255.00	254.08	254.00	0.59	0.03
Top flange (T)	mm	6.17	6.57	6.39	6.80	6.48	-6.03
Bot flange (T)	mm	6.37	6.85	6.61	6.80	7.54	-2.75
Flange thick (T)	mm	6.17	7.37	6.50	6.80	19.45	-4.39
Web thick (t)	mm	5.67	6.30	6.01	5.80	10.93	3.56
Area (A)	cm2	27.65	29.14	28.56	28.40	5.37	0.55
Inertia (Ixx)	cm4	2796.89	2890.13	2851.68	2870.00	3.33	-0.64
Inertia (Iyy)	cm4	124.08	127.24	125.20	120.00	2.54	4.34
Warping (Cw)	cm6	1.90	1.95	1.92	1.83	2.62	4.84
Torsional (J)	cm4	3.84	4.43	4.20	4.31	15.27	-2.46

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S9
Section ref : BEAM 3
Stock steel : B2

Date : 14/8/89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	103.51	103.47	103.46	
Breadth (lower)	b1 =	102.60	102.51	102.63	
Depth (first side)	d =	254.50	255.50	254.50	
Depth (second side)	d1 =	254.50	254.50	255.00	
Flange thickness	tf1 =	6.48	6.47	6.54	
Flange thickness	tf2 =	6.85	6.93	6.83	
Flange thickness	tf3 =	6.73	6.82	6.73	
Flange thickness	tf4 =	6.97	6.97	6.95	
Web offset at 1	=	61.15	61.11	61.05	
Web offset at 2	=	61.35	60.93	60.49	
Web offset at 3	=	61.00	61.21	61.28	
Web offset at 4	=	60.49	61.28	61.94	

Calculated Data

Web thickness (tw)	mm =	6.50	6.16	6.11
Sectional Area (A)	cm2 =	30.09	29.38	29.16
Inertia (Ixx)	cm4 =	2964.51	2948.72	2926.35
Inertia (Iyy)	cm4 =	124.25	124.60	124.24
Warping Const.(Cw)	cm6 =	1.91	1.92	1.91
Torsion Const.(J)	cm4 =	4.94	4.62	4.52

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.51	103.51	103.03	101.60	0.98	1.41
Depth (D)	mm	254.50	255.50	254.75	254.00	0.39	0.30
Top flange (T)	mm	6.47	6.93	6.68	6.80	7.11	-1.72
Bot flange (T)	mm	6.73	6.97	6.86	6.80	3.57	0.91
Flange thick (T)	mm	6.47	7.37	6.77	6.80	13.91	-0.40
Web thick (t)	mm	6.11	6.50	6.26	5.80	6.47	7.87
Area (A)	cm2	29.16	30.09	29.54	28.40	3.18	4.02
Inertia (Ixx)	cm4	2926.35	2964.51	2946.53	2870.00	1.30	2.67
Inertia (Iyy)	cm4	124.24	124.60	124.36	120.00	0.29	3.63
Warping (Cw)	cm6	1.91	1.92	1.91	1.83	0.66	4.47
Torsional (J)	cm4	4.52	4.94	4.69	4.31	9.11	8.90

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S10
Section ref : BEAM 1
Stock steel : B3

Date : 9/10/89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	102.65	102.74	102.61	
Breadth (lower)	b1 =	102.18	102.20	102.32	
Depth (first side)	d =	255.00	255.00	255.00	
Depth (second side)	d1 =	254.00	254.00	254.00	
Flange thickness	tf1 =	6.73	6.85	6.94	
Flange thickness	tf2 =	6.64	6.54	6.62	
Flange thickness	tf3 =	6.86	6.84	6.87	
Flange thickness	tf4 =	6.37	6.38	6.37	
Web offset at 1	=	61.62	61.19	61.04	
Web offset at 2	=	60.27	60.25	60.09	
Web offset at 3	=	60.75	60.95	60.99	
Web offset at 4	=	61.47	61.43	61.79	

Calculated Data

Web thickness (tw)	mm =	5.80	6.00	5.95
Sectional Area (A)	cm2 =	28.11	28.60	28.57
Inertia (Ixx)	cm4 =	2839.70	2864.92	2872.23
Inertia (Iyy)	cm4 =	119.81	120.13	121.01
Warping Const.(Cw)	cm6 =	1.84	1.84	1.86
Torsion Const.(J)	cm4 =	4.11	4.30	4.30

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.18	102.74	102.45	101.60	0.55	0.84
Depth (D)	mm	254.00	255.00	254.50	254.00	0.39	0.20
Top flange (T)	mm	6.54	6.94	6.72	6.80	6.12	-1.18
Bot flange (T)	mm	6.37	6.87	6.61	6.80	7.85	-2.72
Flange thick (T)	mm	6.37	7.37	6.67	6.80	15.70	-1.95
Web thick (t)	mm	5.80	6.00	5.92	5.80	3.45	2.01
Area (A)	cm2	28.11	28.60	28.43	28.40	1.76	0.09
Inertia (Ixx)	cm4	2839.70	2872.23	2858.95	2870.00	1.15	-0.39
Inertia (Iyy)	cm4	119.81	121.01	120.32	120.00	1.01	0.26
Warping (Cw)	cm6	1.84	1.86	1.85	1.83	0.97	0.96
Torsional (J)	cm4	4.11	4.30	4.23	4.31	4.65	-1.76

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S10
Section ref : BEAM 2
Stock steel : B7

Date : 9/10/89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	105.33	105.39	105.54	
Breadth (lower)	b1 =	102.12	102.13	102.21	
Depth (first side)	d =	254.50	255.00	254.00	
Depth (second side)	d1 =	254.00	254.00	254.00	
Flange thickness	tf1 =	6.32	6.35	6.28	
Flange thickness	tf2 =	6.13	6.03	6.09	
Flange thickness	tf3 =	6.64	6.68	6.66	
Flange thickness	tf4 =	6.35	6.43	6.32	
Web offset at 1	=	62.51	62.82	62.74	
Web offset at 2	=	61.80	61.79	61.59	
Web offset at 3	=	61.62	61.71	61.71	
Web offset at 4	=	60.84	60.82	60.98	

Calculated Data

Web thickness (tw)	mm =	5.78	5.63	5.81
Sectional Area (A)	cm2 =	27.65	27.32	27.67
Inertia (Ixx)	cm4 =	2774.60	2767.26	2767.59
Inertia (Iyy)	cm4 =	119.11	119.41	119.17
Warping Const.(Cw)	cm6 =	1.83	1.84	1.83
Torsion Const.(J)	cm4 =	3.84	3.72	3.84

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.12	105.54	103.79	101.60	3.35	2.15
Depth (D)	mm	254.00	255.00	254.25	254.00	0.39	0.10
Top flange (T)	mm	6.03	6.35	6.20	6.80	5.31	-8.82
Bot flange (T)	mm	6.32	6.68	6.51	6.80	5.70	-4.22
Flange thick (T)	mm	6.03	7.37	6.36	6.80	22.22	-6.52
Web thick (t)	mm	5.63	5.81	5.74	5.80	3.11	-1.06
Area (A)	cm2	27.32	27.67	27.55	28.40	1.25	-3.01
Inertia (Ixx)	cm4	2767.26	2774.60	2769.82	2870.00	0.27	-3.49
Inertia (Iyy)	cm4	119.11	119.41	119.23	120.00	0.25	-0.64
Warping (Cw)	cm6	1.83	1.84	1.83	1.83	0.58	0.09
Torsional (J)	cm4	3.72	3.84	3.80	4.31	3.25	-11.80

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL SUBFRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Subframe test : S10
Section ref : BEAM 3
Stock steel : B3

Date : 9/10/89
Test points: 3
Position 1 :COL END

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4
Breadth (upper)	b =	102.15	101.93	101.98	
Breadth (lower)	b1 =	103.02	102.97	102.65	
Depth (first side)	d =	255.00	255.00	255.00	
Depth (second side)	d1 =	254.00	254.00	254.00	
Flange thickness	tf1 =	6.77	6.80	6.94	
Flange thickness	tf2 =	6.33	6.31	6.30	
Flange thickness	tf3 =	6.72	6.64	6.68	
Flange thickness	tf4 =	6.58	6.53	6.58	
Web offset at 1	=	60.05	60.19	59.81	
Web offset at 2	=	61.48	61.38	61.13	
Web offset at 3	=	61.56	61.34	61.78	
Web offset at 4	=	60.60	60.67	61.27	

Calculated Data

Web thickness (tw)	mm =	6.18	6.10	5.76
Sectional Area (A)	cm2 =	28.95	28.68	27.95
Inertia (Ixx)	cm4 =	2873.68	2853.15	2825.97
Inertia (Iyy)	cm4 =	119.64	118.59	119.15
Warping Const.(Cw)	cm6 =	1.84	1.82	1.83
Torsion Const.(J)	cm4 =	4.43	4.32	4.04

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	101.93	103.02	102.45	101.60	1.07	0.84
Depth (D)	mm	254.00	255.00	254.50	254.00	0.39	0.20
Top flange (T)	mm	6.30	6.94	6.57	6.80	10.16	-3.31
Bot flange (T)	mm	6.53	6.72	6.62	6.80	2.91	-2.62
Flange thick (T)	mm	6.30	7.37	6.60	6.80	16.98	-2.97
Web thick (t)	mm	5.76	6.18	6.01	5.80	7.29	3.68
Area (A)	cm2	27.95	28.95	28.53	28.40	3.58	0.44
Inertia (Ixx)	cm4	2825.97	2873.68	2850.93	2870.00	1.69	-0.66
Inertia (Iyy)	cm4	118.59	119.64	119.13	120.00	0.88	-0.73
Warping (Cw)	cm6	1.82	1.84	1.83	1.83	0.86	0.01
Torsional (J)	cm4	4.04	4.43	4.26	4.31	9.48	-1.09

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F1
Section ref : PB5
Stock steel : P5

Date : 22/9/89
Test points: 4
Position 1 :Joint D

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	102.92	102.69	102.87	102.55	
Breadth (lower)	b1 =	103.66	103.07	103.42	103.37	
Depth (first side)	d =	253.00	253.00	252.50	253.00	
Depth (second side)	d1 =	254.50	254.00	253.50	254.00	
Flange thickness	tf1 =	6.65	6.62	6.62	6.72	
Flange thickness	tf2 =	6.65	6.59	6.64	6.72	
Flange thickness	tf3 =	6.43	6.45	6.43	6.49	
Flange thickness	tf4 =	6.87	6.56	6.70	6.61	
Web offset at 1	=	62.70	61.70	61.46	61.25	
Web offset at 2	=	62.81	61.73	61.38	61.06	
Web offset at 3	=	60.79	61.10	61.36	61.26	
Web offset at 4	=	60.78	61.55	61.99	61.97	

Calculated Data

Web thickness (tw)	mm =	5.19	5.28	5.49	5.63
Sectional Area (A)	cm2 =	26.71	26.68	27.27	27.68
Inertia (Ixx)	cm4 =	2767.39	2736.53	2765.44	2800.95
Inertia (Iyy)	cm4 =	123.20	119.58	121.32	121.40
Warping Const.(Cw)	cm6 =	1.88	1.82	1.84	1.85
Torsion Const.(J)	cm4 =	3.62	3.59	3.79	3.95

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.55	103.66	103.07	101.60	1.08	1.45
Depth (D)	mm	252.50	254.50	253.44	254.00	0.79	-0.22
Top flange (T)	mm	6.59	6.72	6.65	6.80	1.97	-2.19
Bot flange (T)	mm	6.43	6.87	6.57	6.80	6.84	-3.42
Flange thick (T)	mm	6.43	7.10	6.61	6.80	10.42	-2.80
Web thick (t)	mm	5.19	5.63	5.40	5.80	8.48	-6.94
Area (A)	cm2	26.68	27.68	27.09	28.40	3.78	-4.63
Inertia (Ixx)	cm4	2736.53	2800.95	2767.58	2870.00	2.35	-3.57
Inertia (Iyy)	cm4	119.58	123.20	121.37	120.00	3.03	1.15
Warping (Cw)	cm6	1.82	1.88	1.85	1.83	3.16	1.02
Torsional (J)	cm4	3.59	3.95	3.74	4.31	10.08	-13.32

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F1
Section ref : PB6
Stock steel : P5

Date : 22/9/89
Test points: 4
Position 1 :Joint I

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	104.06	103.20	103.95	103.90	
Breadth (lower)	b1 =	102.92	102.75	102.20	102.20	
Depth (first side)	d =	253.00	252.50	253.00	253.50	
Depth (second side)	d1 =	254.00	255.00	254.50	254.50	
Flange thickness	tf1 =	6.36	6.46	6.89	6.46	
Flange thickness	tf2 =	6.48	6.59	6.60	6.67	
Flange thickness	tf3 =	6.58	6.48	6.54	6.64	
Flange thickness	tf4 =	6.48	6.48	6.43	6.46	
Web offset at 1	=	62.48	62.00	62.34	61.83	
Web offset at 2	=	63.15	62.28	62.61	62.65	
Web offset at 3	=	61.28	60.91	60.82	61.40	
Web offset at 4	=	60.40	60.39	60.34	60.05	

Calculated Data

Web thickness (tw)	mm =	5.27	5.62	5.46	5.52
Sectional Area (A)	cm2 =	26.59	27.43	27.27	27.32
Inertia (Ixx)	cm4 =	2725.45	2770.02	2784.76	2781.68
Inertia (Iyy)	cm4 =	120.70	119.33	121.94	120.59
Warping Const.(Cw)	cm6 =	1.84	1.82	1.86	1.85
Torsion Const.(J)	cm4 =	3.52	3.82	3.79	3.79

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.20	104.06	103.15	101.60	1.82	1.52
Depth (D)	mm	252.50	255.00	253.75	254.00	0.99	-0.10
Top flange (T)	mm	6.36	6.89	6.56	6.80	8.33	-3.47
Bot flange (T)	mm	6.43	6.64	6.51	6.80	3.27	-4.25
Flange thick (T)	mm	6.36	7.10	6.54	6.80	11.64	-3.86
Web thick (t)	mm	5.27	5.62	5.47	5.80	6.64	-5.67
Area (A)	cm2	26.59	27.43	27.15	28.40	3.17	-4.40
Inertia (Ixx)	cm4	2725.45	2784.76	2765.48	2870.00	2.18	-3.64
Inertia (Iyy)	cm4	119.33	121.94	120.64	120.00	2.19	0.53
Warping (Cw)	cm6	1.82	1.86	1.84	1.83	2.09	0.72
Torsional (J)	cm4	3.52	3.82	3.73	4.31	8.53	-13.48

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F1
Section ref : PB7
Stock steel : P3

Date : 22/9/89
Test points: 4
Position 1 :Joint F

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.32	104.40	104.05	103.85	
Breadth (lower)	b1 =	103.85	103.99	103.85	104.09	
Depth (first side)	d =	253.50	254.00	254.00	253.50	
Depth (second side)	d1 =	255.00	255.00	255.00	255.25	
Flange thickness	tf1 =	6.50	6.47	6.47	6.51	
Flange thickness	tf2 =	6.81	6.78	6.87	7.07	
Flange thickness	tf3 =	7.03	7.01	7.05	6.98	
Flange thickness	tf4 =	6.88	6.86	6.82	6.69	
Web offset at 1	=	62.36	63.06	62.12	62.87	
Web offset at 2	=	62.85	63.12	62.52	63.43	
Web offset at 3	=	60.83	60.94	61.49	61.12	
Web offset at 4	=	61.02	60.77	61.13	60.61	

Calculated Data

Web thickness (tw)	mm =	5.49	5.69	5.76	5.39
Sectional Area (A)	cm2 =	27.82	28.33	28.51	27.65
Inertia (Ixx)	cm4 =	2865.46	2900.09	2909.60	2867.20
Inertia (Iyy)	cm4 =	127.11	129.20	128.21	128.92
Warping Const.(Cw)	cm6 =	1.95	1.98	1.97	1.98
Torsion Const.(J)	cm4 =	4.02	4.17	4.25	3.95

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	103.32	104.40	103.93	101.60	1.05	2.29
Depth (D)	mm	253.50	255.25	254.41	254.00	0.69	0.16
Top flange (T)	mm	6.47	7.07	6.68	6.80	9.27	-1.69
Bot flange (T)	mm	6.69	7.05	6.91	6.80	5.38	1.69
Flange thick (T)	mm	6.47	7.10	6.80	6.80	9.74	-0.00
Web thick (t)	mm	5.39	5.76	5.59	5.80	6.77	-3.71
Area (A)	cm2	27.65	28.51	28.08	28.40	3.12	-1.13
Inertia (Ixx)	cm4	2865.46	2909.60	2885.59	2870.00	1.54	0.54
Inertia (Iyy)	cm4	127.11	129.20	128.36	120.00	1.65	6.96
Warping (Cw)	cm6	1.95	1.98	1.97	1.83	1.87	7.51
Torsional (J)	cm4	3.95	4.25	4.10	4.31	7.60	-4.88

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F1
Section ref : PB8
Stock steel : P3

Date : 22/9/89
Test points: 4
Position 1 :Joint L

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	104.61	103.88	104.61	104.30	
Breadth (lower)	b1 =	104.15	103.59	103.95	103.94	
Depth (first side)	d =	253.00	253.00	253.00	253.00	
Depth (second side)	d1 =	255.00	255.00	255.00	255.00	
Flange thickness	tf1 =	6.38	6.54	6.41	6.55	
Flange thickness	tf2 =	6.69	6.68	6.78	6.78	
Flange thickness	tf3 =	6.83	6.88	6.87	6.95	
Flange thickness	tf4 =	6.85	6.77	6.77	6.79	
Web offset at 1	=	63.04	62.14	62.79	62.33	
Web offset at 2	=	63.24	62.50	62.98	62.76	
Web offset at 3	=	61.38	61.40	61.33	61.43	
Web offset at 4	=	60.99	60.76	60.67	60.68	

Calculated Data

Web thickness (tw)	mm =	5.50	5.77	5.83	5.96
Sectional Area (A)	cm2 =	27.68	28.32	28.52	28.92
Inertia (Ixx)	cm4 =	2841.82	2869.69	2884.95	2913.20
Inertia (Iyy)	cm4 =	127.90	125.91	128.00	128.41
Warping Const.(Cw)	cm6 =	1.96	1.92	1.96	1.96
Torsion Const.(J)	cm4 =	3.92	4.17	4.23	4.40

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	103.59	104.61	104.13	101.60	0.98	2.49
Depth (D)	mm	253.00	255.00	254.00	254.00	0.79	0.00
Top flange (T)	mm	6.38	6.78	6.60	6.80	6.27	-2.92
Bot flange (T)	mm	6.77	6.95	6.84	6.80	2.66	0.57
Flange thick (T)	mm	6.38	7.10	6.72	6.80	11.29	-1.18
Web thick (t)	mm	5.50	5.96	5.77	5.80	8.46	-0.58
Area (A)	cm2	27.68	28.92	28.36	28.40	4.49	-0.14
Inertia (Ixx)	cm4	2841.82	2913.20	2877.41	2870.00	2.51	0.26
Inertia (Iyy)	cm4	125.91	128.41	127.55	120.00	1.98	6.29
Warping (Cw)	cm6	1.92	1.96	1.95	1.83	1.94	6.55
Torsional (J)	cm4	3.92	4.40	4.18	4.31	12.48	-3.00

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F1
Section ref : SB1
Stock steel : P6

Date : 22/9/89
Test points: 3
Position 1 :Joint M

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.39	102.94	103.32		
Breadth (lower)	b1 =	104.27	103.93	104.42		
Depth (first side)	d =	255.00	255.00	255.00		
Depth (second side)	d1 =	252.50	253.00	253.00		
Flange thickness	tf1 =	6.65	6.68	6.65		
Flange thickness	tf2 =	6.79	6.79	6.87		
Flange thickness	tf3 =	6.63	6.72	6.70		
Flange thickness	tf4 =	6.35	6.44	6.43		
Web offset at 1	=	61.73	61.47	61.53		
Web offset at 2	=	62.23	62.01	62.61		
Web offset at 3	=	61.67	61.65	61.70		
Web offset at 4	=	61.83	61.57	61.76		

Calculated Data

Web thickness (tw)	mm =	5.54	5.53	5.51
Sectional Area (A)	cm2 =	27.54	27.57	27.60
Inertia (Ixx)	cm4 =	2805.99	2817.54	2826.02
Inertia (Iyy)	cm4 =	123.87	123.44	125.09
Warping Const.(Cw)	cm6 =	1.89	1.89	1.91
Torsion Const.(J)	cm4 =	3.86	3.89	3.89

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.94	104.42	103.71	101.60	1.44	2.08
Depth (D)	mm	252.50	255.00	253.92	254.00	0.99	-0.03
Top flange (T)	mm	6.65	6.87	6.74	6.80	3.31	-0.91
Bot flange (T)	mm	6.35	6.72	6.54	6.80	5.83	-3.75
Flange thick (T)	mm	6.35	6.87	6.64	6.80	8.19	-2.33
Web thick (t)	mm	5.51	5.54	5.53	5.80	0.54	-4.74
Area (A)	cm2	27.54	27.60	27.57	28.40	0.22	-2.94
Inertia (Ixx)	cm4	2805.99	2826.02	2816.51	2870.00	0.71	-1.86
Inertia (Iyy)	cm4	123.44	125.09	124.13	120.00	1.34	3.45
Warping (Cw)	cm6	1.89	1.91	1.90	1.83	1.33	3.69
Torsional (J)	cm4	3.86	3.89	3.88	4.31	0.86	-9.94

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F1
Section ref : SB2
Stock steel : P6

Date : 22/9/89
Test points: 3
Position 1 :Joint O

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.38	103.17	103.05		
Breadth (lower)	b1 =	104.20	104.21	103.92		
Depth (first side)	d =	255.00	255.00	255.00		
Depth (second side)	d1 =	253.00	253.00	253.50		
Flange thickness	tf1 =	6.64	6.61	6.71		
Flange thickness	tf2 =	6.86	6.82	6.85		
Flange thickness	tf3 =	6.62	6.64	6.63		
Flange thickness	tf4 =	6.37	6.50	6.43		
Web offset at 1	=	61.52	61.54	61.68		
Web offset at 2	=	62.36	62.48	62.41		
Web offset at 3	=	61.78	61.57	61.75		
Web offset at 4	=	61.66	61.51	61.65		

Calculated Data

Web thickness (tw)	mm =	5.57	5.58	5.18
Sectional Area (A)	cm2 =	27.65	27.70	26.75
Inertia (Ixx)	cm4 =	2820.01	2824.88	2783.97
Inertia (Iyy)	cm4 =	124.06	124.11	123.49
Warping Const.(Cw)	cm6 =	1.90	1.90	1.89
Torsion Const.(J)	cm4 =	3.90	3.93	3.62

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	103.05	104.21	103.65	101.60	1.13	2.02
Depth (D)	mm	253.00	255.00	254.08	254.00	0.79	0.03
Top flange (T)	mm	6.61	6.86	6.75	6.80	3.78	-0.76
Bot flange (T)	mm	6.37	6.64	6.53	6.80	4.24	-3.95
Flange thick (T)	mm	6.37	6.87	6.64	6.80	7.85	-2.35
Web thick (t)	mm	5.18	5.58	5.44	5.80	7.72	-6.15
Area (A)	cm2	26.75	27.70	27.37	28.40	3.56	-3.64
Inertia (Ixx)	cm4	2783.97	2824.88	2809.62	2870.00	1.47	-2.10
Inertia (Iyy)	cm4	123.49	124.11	123.89	120.00	0.51	3.24
Warping (Cw)	cm6	1.89	1.90	1.90	1.83	0.31	3.63
Torsional (J)	cm4	3.62	3.93	3.82	4.31	8.50	-11.43

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F1
Section ref : SB3
Stock steel : P6

Date : 22/9/89
Test points: 3
Position 1 :Joint Q

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.18	102.86	103.29		
Breadth (lower)	b1 =	104.11	103.68	104.77		
Depth (first side)	d =	254.50	255.00	254.50		
Depth (second side)	d1 =	252.50	253.50	253.00		
Flange thickness	tf1 =	6.60	6.68	6.65		
Flange thickness	tf2 =	6.78	7.10	6.85		
Flange thickness	tf3 =	6.59	6.70	6.62		
Flange thickness	tf4 =	6.31	6.38	6.41		
Web offset at 1	=	61.37	61.40	61.34		
Web offset at 2	=	62.51	62.15	62.90		
Web offset at 3	=	61.77	61.60	61.92		
Web offset at 4	=	61.60	61.45	62.16		

Calculated Data

Web thickness (tw)	mm =	5.46	5.41	5.31
Sectional Area (A)	cm2 =	27.24	27.39	27.06
Inertia (Ixx)	cm4 =	2776.73	2823.27	2791.06
Inertia (Iyy)	cm4 =	122.54	123.86	125.03
Warping Const.(Cw)	cm6 =	1.87	1.90	1.91
Torsion Const.(J)	cm4 =	3.76	3.85	3.71

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.86	104.77	103.65	101.60	1.86	2.02
Depth (D)	mm	252.50	255.00	253.83	254.00	0.99	-0.07
Top flange (T)	mm	6.60	7.10	6.78	6.80	7.58	-0.34
Bot flange (T)	mm	6.31	6.70	6.50	6.80	6.18	-4.39
Flange thick (T)	mm	6.31	7.10	6.64	6.80	12.52	-2.37
Web thick (t)	mm	5.31	5.46	5.39	5.80	2.82	-7.01
Area (A)	cm2	27.06	27.39	27.23	28.40	1.21	-4.12
Inertia (Ixx)	cm4	2776.73	2823.27	2797.02	2870.00	1.68	-2.54
Inertia (Iyy)	cm4	122.54	125.03	123.81	120.00	2.03	3.18
Warping (Cw)	cm6	1.87	1.91	1.89	1.83	2.18	3.36
Torsional (J)	cm4	3.71	3.85	3.77	4.31	3.96	-12.50

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F1
Section ref : SB4
Stock steel : P4

Date : 22/9/89
Test points: 3
Position 1 :Joint S

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.01	103.30	102.74		
Breadth (lower)	b1 =	103.75	104.29	103.68		
Depth (first side)	d =	255.00	255.00	255.00		
Depth (second side)	d1 =	253.00	252.30	253.00		
Flange thickness	tf1 =	6.58	6.57	6.67		
Flange thickness	tf2 =	6.83	6.79	6.93		
Flange thickness	tf3 =	6.69	6.68	6.71		
Flange thickness	tf4 =	6.39	6.36	6.44		
Web offset at 1	=	61.26	61.55	61.18		
Web offset at 2	=	62.27	62.57	62.27		
Web offset at 3	=	61.66	61.90	61.76		
Web offset at 4	=	61.52	61.40	61.38		

Calculated Data

Web thickness (tw) mm =	5.47	5.53	5.35	
Sectional Area (A) cm2 =	27.34	27.48	27.18	
Inertia (Ixx) cm4 =	2799.58	2799.63	2801.61	
Inertia (Iyy) cm4 =	122.59	123.67	123.14	
Warping Const.(Cw) cm6 =	1.88	1.89	1.88	
Torsion Const.(J) cm4 =	3.81	3.84	3.78	

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.74	104.29	103.46	101.60	1.51	1.83
Depth (D)	mm	252.30	255.00	253.88	254.00	1.07	-0.05
Top flange (T)	mm	6.57	6.93	6.73	6.80	5.48	-1.05
Bot flange (T)	mm	6.36	6.71	6.55	6.80	5.50	-3.75
Flange thick (T)	mm	6.36	7.10	6.64	6.80	11.64	-2.40
Web thick (t)	mm	5.35	5.53	5.45	5.80	3.17	-6.06
Area (A)	cm2	27.18	27.48	27.34	28.40	1.09	-3.74
Inertia (Ixx)	cm4	2799.58	2801.61	2800.27	2870.00	0.07	-2.43
Inertia (Iyy)	cm4	122.59	123.67	123.13	120.00	0.89	2.61
Warping (Cw)	cm6	1.88	1.89	1.88	1.83	0.62	2.83
Torsional (J)	cm4	3.78	3.84	3.81	4.31	1.64	-11.61

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F1
Section ref : SB5
Stock steel : P4

Date : 22/9/89
Test points: 3
Position 1 :Joint U

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	104.10	103.66	103.80		
Breadth (lower)	b1 =	103.02	102.93	102.81		
Depth (first side)	d =	253.00	253.50	253.00		
Depth (second side)	d1 =	255.00	255.00	254.50		
Flange thickness	tf1 =	6.34	6.40	6.38		
Flange thickness	tf2 =	6.72	6.68	6.76		
Flange thickness	tf3 =	6.75	6.81	6.74		
Flange thickness	tf4 =	6.60	6.66	6.66		
Web offset at 1	=	61.69	61.39	61.23		
Web offset at 2	=	61.67	61.69	61.51		
Web offset at 3	=	62.14	62.03	62.19		
Web offset at 4	=	61.54	61.49	61.63		

Calculated Data

Web thickness (tw)	mm =	5.48	5.44	5.47
Sectional Area (A)	cm2 =	27.37	27.30	27.35
Inertia (Ixx)	cm4 =	2799.28	2804.94	2795.23
Inertia (Iyy)	cm4 =	122.86	122.55	122.59
Warping Const.(Cw)	cm6 =	1.88	1.88	1.87
Torsion Const.(J)	cm4 =	3.80	3.80	3.82

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.81	104.10	103.39	101.60	1.25	1.76
Depth (D)	mm	253.00	255.00	254.00	254.00	0.79	0.00
Top flange (T)	mm	6.34	6.76	6.55	6.80	6.62	-3.73
Bot flange (T)	mm	6.60	6.81	6.70	6.80	3.18	-1.42
Flange thick (T)	mm	6.34	7.10	6.62	6.80	11.99	-2.57
Web thick (t)	mm	5.44	5.48	5.46	5.80	0.83	-5.86
Area (A)	cm2	27.30	27.37	27.34	28.40	0.22	-3.74
Inertia (Ixx)	cm4	2795.23	2804.94	2799.82	2870.00	0.35	-2.45
Inertia (Iyy)	cm4	122.55	122.86	122.67	120.00	0.25	2.22
Warping (Cw)	cm6	1.87	1.88	1.88	1.83	0.45	2.55
Torsional (J)	cm4	3.80	3.82	3.81	4.31	0.51	-11.69

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F1
Section ref : SB6
Stock steel : P4

Date : 22/9/89
Test points: 3
Position 1 :Joint S

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.98	103.54	104.23		
Breadth (lower)	b1 =	102.99	102.66	102.83		
Depth (first side)	d =	254.50	254.00	254.00		
Depth (second side)	d1 =	253.00	253.00	253.00		
Flange thickness	tf1 =	6.74	6.69	6.66		
Flange thickness	tf2 =	6.36	6.45	6.37		
Flange thickness	tf3 =	6.58	6.54	6.63		
Flange thickness	tf4 =	6.67	6.73	6.78		
Web offset at 1	=	62.41	61.91	62.28		
Web offset at 2	=	61.27	61.15	61.81		
Web offset at 3	=	61.63	61.26	61.64		
Web offset at 4	=	62.01	61.72	61.67		

Calculated Data

Web thickness (tw)	mm =	5.27	5.52	5.27
Sectional Area (A)	cm2 =	26.80	27.37	26.84
Inertia (Ixx)	cm4 =	2762.30	2782.03	2763.73
Inertia (Iyy)	cm4 =	122.27	121.25	122.85
Warping Const.(Cw)	cm6 =	1.87	1.85	1.87
Torsion Const.(J)	cm4 =	3.62	3.83	3.64

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.66	104.23	103.37	101.60	1.53	1.74
Depth (D)	mm	253.00	254.50	253.58	254.00	0.59	-0.16
Top flange (T)	mm	6.36	6.74	6.55	6.80	5.97	-3.75
Bot flange (T)	mm	6.54	6.78	6.66	6.80	3.67	-2.13
Flange thick (T)	mm	6.36	7.10	6.60	6.80	11.64	-2.94
Web thick (t)	mm	5.27	5.52	5.35	5.80	4.84	-7.73
Area (A)	cm2	26.80	27.37	27.00	28.40	2.16	-4.91
Inertia (Ixx)	cm4	2762.30	2782.03	2769.35	2870.00	0.71	-3.51
Inertia (Iyy)	cm4	121.25	122.85	122.12	120.00	1.31	1.77
Warping (Cw)	cm6	1.85	1.87	1.86	1.83	1.31	1.77
Torsional (J)	cm4	3.62	3.83	3.70	4.31	5.75	-14.27

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : C7
Stock steel : C7

Date : 20.7.90
Test points: 5
Position 1 :TOP

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	153.05	152.57	152.56	153.05	153.01
Breadth (lower)	b1 =	152.83	152.70	152.59	152.86	153.01
Depth (first side)	d =	157.61	157.91	157.76	157.79	156.11
Depth (second side)	d1 =	156.99	158.37	157.43	157.14	156.52
Flange thickness	tf1 =	6.79	6.76	6.75	6.86	6.73
Flange thickness	tf2 =	6.40	6.59	6.47	6.42	6.51
Flange thickness	tf3 =	6.96	7.09	6.99	6.62	6.90
Flange thickness	tf4 =	6.59	6.66	6.65	6.57	6.59
Web offset at 1	=	85.46	85.21	85.12	85.46	85.70
Web offset at 2	=	86.00	85.82	85.99	85.91	86.29
Web offset at 3	=	87.27	86.82	87.61	86.90	87.15
Web offset at 4	=	86.71	86.11	86.65	86.88	86.41

Calculated Data

Web thickness (tw)	mm =	5.66	6.10	5.33	5.82	5.67
Sectional Area (A)	cm2 =	29.09	29.99	28.67	29.13	29.06
Inertia (Ixx)	cm4 =	1324.91	1363.06	1323.98	1321.85	1307.12
Inertia (Iyy)	cm4 =	399.25	402.26	398.19	395.38	399.58
Warping Const.(Cw)	cm6 =	2.26	2.30	2.27	2.25	2.24
Torsion Const.(J)	cm4 =	4.44	4.83	4.30	4.43	4.44

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	152.56	153.05	152.78	152.40	0.32	0.25
Depth (D)	mm	156.99	158.37	157.63	152.40	0.88	3.43
Top flange (T)	mm	6.40	6.86	6.63	6.80	7.19	-2.50
Bot flange (T)	mm	6.57	7.09	6.77	6.80	7.91	-0.50
Flange thick (T)	mm	6.40	7.61	6.70	6.80	18.91	-1.50
Web thick (t)	mm	5.33	6.10	5.72	6.10	14.35	-6.30
Area (A)	cm2	28.67	29.99	29.19	29.80	4.60	-2.05
Inertia (Ixx)	cm4	1307.12	1363.06	1328.19	1260.00	4.28	5.41
Inertia (Iyy)	cm4	395.38	402.26	398.93	403.00	1.74	-1.01
Warping (Cw)	cm6	2.24	2.30	2.26	2.14	3.02	5.80
Torsional (J)	cm4	4.30	4.83	4.49	4.87	12.31	-7.90

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : C8
Stock steel : C8

Date : 20.7.90
Test points: 5
Position 1 :TOP

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations			1	2	3	4	5
Breadth (upper)	b	=	152.09	152.49	152.64	152.31	152.61
Breadth (lower)	b1	=	152.25	152.66	152.36	152.60	152.69
Depth (first side)	d	=	157.29	157.51	157.45	157.24	157.31
Depth (second side)	d1	=	157.51	157.81	157.91	157.87	157.20
Flange thickness	tf1	=	7.00	6.90	6.97	7.02	6.92
Flange thickness	tf2	=	6.73	6.73	7.11	6.91	6.89
Flange thickness	tf3	=	6.46	6.33	6.44	6.49	6.37
Flange thickness	tf4	=	6.77	6.82	6.91	6.97	6.83
Web offset at 1		=	84.26	85.31	85.38	86.48	87.06
Web offset at 2		=	85.35	86.24	85.72	86.88	87.36
Web offset at 3		=	87.52	86.83	86.59	85.82	85.40
Web offset at 4		=	86.66	86.31	86.01	85.27	85.23

Calculated Data

Web thickness (tw)	mm	=	5.71	5.67	6.09	5.67	5.57
Sectional Area (A)	cm2	=	29.23	29.11	30.18	29.53	29.11
Inertia (Ixx)	cm4	=	1330.59	1330.62	1365.53	1350.84	1329.71
Inertia (Iyy)	cm4	=	396.80	396.92	406.06	405.03	401.13
Warping Const.(Cw)	cm6	=	2.25	2.26	2.31	2.30	2.27
Torsion Const.(J)	cm4	=	4.53	4.45	4.94	4.67	4.47

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	152.09	152.66	152.43	152.40	0.37	0.02
Depth (D)	mm	157.24	157.91	157.57	152.40	0.43	3.39
Top flange (T)	mm	6.73	7.11	6.92	6.80	5.65	1.78
Bot flange (T)	mm	6.33	6.97	6.65	6.80	10.11	-2.22
Flange thick (T)	mm	6.33	7.61	6.78	6.80	20.22	-0.22
Web thick (t)	mm	5.57	6.09	5.74	6.10	9.43	-5.87
Area (A)	cm2	29.11	30.18	29.43	29.80	3.69	-1.24
Inertia (Ixx)	cm4	1329.71	1365.53	1341.46	1260.00	2.69	6.47
Inertia (Iyy)	cm4	396.80	406.06	401.19	403.00	2.34	-0.45
Warping (Cw)	cm6	2.25	2.31	2.28	2.14	2.56	6.48
Torsional (J)	cm4	4.45	4.94	4.61	4.87	10.98	-5.29

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : C9
Stock steel : C9

Date : 20.6.90
Test points: 5
Position 1 :TOP

Section type : 152 x 152 UC 23 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	152.69	153.12	153.10	152.73	152.60
Breadth (lower)	b1 =	152.96	152.36	152.34	152.59	151.84
Depth (first side)	d =	157.58	157.46	157.80	157.61	157.21
Depth (second side)	d1 =	157.35	157.62	158.24	157.42	156.66
Flange thickness	tf1 =	6.96	7.00	7.00	7.61	7.03
Flange thickness	tf2 =	6.48	6.55	6.34	6.63	6.54
Flange thickness	tf3 =	6.77	6.83	6.65	6.83	6.79
Flange thickness	tf4 =	6.97	6.81	6.74	6.81	6.65
Web offset at 1	=	84.93	84.94	85.27	85.21	85.62
Web offset at 2	=	85.14	85.27	85.41	85.96	86.00
Web offset at 3	=	87.72	87.61	87.71	87.19	86.65
Web offset at 4	=	87.53	86.56	86.90	86.26	86.00

Calculated Data

Web thickness (tw)	mm =	5.61	5.99	5.52	5.79	5.53
Sectional Area (A)	cm2 =	29.33	29.88	28.88	30.09	28.98
Inertia (Ixx)	cm4 =	1342.49	1353.19	1332.69	1373.15	1319.53
Inertia (Iyy)	cm4 =	405.32	404.65	397.55	413.99	397.51
Warping Const.(Cw)	cm6 =	2.30	2.30	2.28	2.35	2.24
Torsion Const.(J)	cm4 =	4.56	4.79	4.35	4.93	4.44

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	152.34	153.12	152.74	152.40	0.51	0.22
Depth (D)	mm	157.35	158.24	157.64	152.40	0.57	3.44
Top flange (T)	mm	6.34	7.61	6.82	6.80	20.03	0.31
Bot flange (T)	mm	6.65	6.97	6.80	6.80	4.81	0.02
Flange thick (T)	mm	6.34	7.61	6.81	6.80	20.03	0.17
Web thick (t)	mm	5.52	5.99	5.69	6.10	8.61	-6.80
Area (A)	cm2	28.88	30.09	29.43	29.80	4.17	-1.23
Inertia (Ixx)	cm4	1319.53	1373.15	1344.21	1260.00	4.06	6.68
Inertia (Iyy)	cm4	397.51	413.99	403.80	403.00	4.15	0.20
Warping (Cw)	cm6	2.24	2.35	2.29	2.14	4.65	7.13
Torsional (J)	cm4	4.35	4.93	4.61	4.87	13.23	-5.24

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : PB9
Stock steel : P7

Date : 20.7.90
Test points: 4
Position 1 :-

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.43	103.58	103.38	103.80	
Breadth (lower)	b1 =	102.74	102.49	102.82	102.83	
Depth (first side)	d =	253.61	253.26	253.30	253.53	
Depth (second side)	d1 =	254.21	254.62	255.21	255.04	
Flange thickness	tf1 =	6.36	6.40	6.50	6.42	
Flange thickness	tf2 =	6.57	6.68	6.62	6.60	
Flange thickness	tf3 =	6.65	6.73	6.68	6.65	
Flange thickness	tf4 =	6.61	6.58	6.74	6.60	
Web offset at 1	=	61.32	61.10	61.17	61.17	
Web offset at 2	=	61.57	61.39	61.17	61.29	
Web offset at 3	=	62.35	61.64	61.90	61.64	
Web offset at 4	=	60.34	61.00	61.46	60.77	

Calculated Data

Web thickness (tw)	mm =	5.73	5.91	5.69	6.32
Sectional Area (A)	cm2 =	27.80	28.32	27.89	29.31
Inertia (Ixx)	cm4 =	2801.61	2835.77	2830.18	2889.87
Inertia (Iyy)	cm4 =	120.25	121.04	121.92	121.60
Warping Const.(Cw)	cm6 =	1.84	1.85	1.87	1.87
Torsion Const.(J)	cm4 =	3.96	4.17	4.01	4.55

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.49	103.80	103.13	101.60	1.28	1.51
Depth (D)	mm	253.26	255.21	254.10	254.00	0.77	0.04
Top flange (T)	mm	6.36	6.68	6.52	6.80	5.03	-4.14
Bot flange (T)	mm	6.58	6.74	6.65	6.80	2.43	-2.13
Flange thick (T)	mm	6.36	7.61	6.59	6.80	19.65	-3.13
Web thick (t)	mm	5.69	6.32	5.91	5.80	11.07	1.96
Area (A)	cm2	27.80	29.31	28.33	28.40	5.40	-0.25
Inertia (Ixx)	cm4	2801.61	2889.87	2839.36	2870.00	3.15	-1.07
Inertia (Iyy)	cm4	120.25	121.92	121.20	120.00	1.39	1.00
Warping (Cw)	cm6	1.84	1.87	1.86	1.83	1.60	1.43
Torsional (J)	cm4	3.96	4.55	4.17	4.31	15.02	-3.21

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : PB10
Stock steel : P8

Date : 20.7.90
Test points: 4
Position 1 :-

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.93	104.21	104.57	104.17	
Breadth (lower)	b1 =	103.26	103.44	103.65	103.50	
Depth (first side)	d =	253.69	253.69	254.35	253.69	
Depth (second side)	d1 =	254.98	254.97	255.46	255.67	
Flange thickness	tf1 =	6.53	6.55	6.48	6.54	
Flange thickness	tf2 =	6.93	6.78	6.72	6.70	
Flange thickness	tf3 =	6.86	6.83	6.81	6.73	
Flange thickness	tf4 =	6.78	6.74	6.74	6.68	
Web offset at 1	=	61.26	61.00	61.94	62.23	
Web offset at 2	=	61.87	61.44	61.97	62.11	
Web offset at 3	=	62.15	61.75	62.01	61.68	
Web offset at 4	=	61.40	61.51	61.53	60.95	

Calculated Data

Web thickness (tw) mm =	5.70	6.42	5.83	5.79	
Sectional Area (A) cm2 =	28.25	29.91	28.49	28.31	
Inertia (Ixx) cm4 =	2882.55	2956.85	2898.43	2875.73	
Inertia (Iyy) cm4 =	126.25	126.39	126.51	125.15	
Warping Const.(Cw) cm6 =	1.93	1.94	1.95	1.92	
Torsion Const.(J) cm4 =	4.16	4.82	4.20	4.14	

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	103.26	104.57	103.84	101.60	1.27	2.21
Depth (D)	mm	253.69	255.67	254.56	254.00	0.78	0.22
Top flange (T)	mm	6.48	6.93	6.65	6.80	6.94	-2.15
Bot flange (T)	mm	6.68	6.86	6.77	6.80	2.69	-0.42
Flange thick (T)	mm	6.48	7.61	6.71	6.80	17.44	-1.29
Web thick (t)	mm	5.70	6.42	5.93	5.80	12.64	2.26
Area (A)	cm2	28.25	29.91	28.74	28.40	5.90	1.19
Inertia (Ixx)	cm4	2875.73	2956.85	2903.39	2870.00	2.82	1.16
Inertia (Iyy)	cm4	125.15	126.51	126.07	120.00	1.09	5.06
Warping (Cw)	cm6	1.92	1.95	1.94	1.83	1.25	5.80
Torsional (J)	cm4	4.14	4.82	4.33	4.31	16.52	0.49

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : PB11
Stock steel : P8

Date : 20.7.90
Test points: 4
Position 1 :-

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	104.44	104.85	104.06	104.78	
Breadth (lower)	b1 =	103.99	103.87	103.82	103.79	
Depth (first side)	d =	255.21	255.35	255.42	255.28	
Depth (second side)	d1 =	253.41	253.97	253.93	253.98	
Flange thickness	tf1 =	6.75	6.66	6.73	6.75	
Flange thickness	tf2 =	6.60	6.64	6.89	6.50	
Flange thickness	tf3 =	6.81	6.72	6.73	6.77	
Flange thickness	tf4 =	6.86	6.74	6.99	6.84	
Web offset at 1	=	61.68	61.91	61.78	61.82	
Web offset at 2	=	61.10	61.47	61.33	61.23	
Web offset at 3	=	62.11	61.78	62.00	61.89	
Web offset at 4	=	62.61	62.08	62.18	62.01	

Calculated Data

Web thickness (tw)	mm =	5.91	6.18	5.73	6.25
Sectional Area (A)	cm2 =	28.79	29.37	28.53	29.58
Inertia (Ixx)	cm4 =	2913.49	2939.47	2920.41	2952.32
Inertia (Iyy)	cm4 =	128.32	127.59	128.68	127.81
Warping Const.(Cw)	cm6 =	1.97	1.96	1.98	1.96
Torsion Const.(J)	cm4 =	4.34	4.55	4.27	4.65

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	103.79	104.85	104.20	101.60	1.02	2.56
Depth (D)	mm	253.41	255.42	254.57	254.00	0.79	0.22
Top flange (T)	mm	6.50	6.89	6.69	6.80	6.00	-1.62
Bot flange (T)	mm	6.72	6.99	6.81	6.80	4.02	0.11
Flange thick (T)	mm	6.50	7.61	6.75	6.80	17.08	-0.75
Web thick (t)	mm	5.73	6.25	6.02	5.80	8.98	3.75
Area (A)	cm2	28.53	29.58	29.07	28.40	3.68	2.35
Inertia (Ixx)	cm4	2913.49	2952.32	2931.42	2870.00	1.33	2.14
Inertia (Iyy)	cm4	127.59	128.68	128.10	120.00	0.85	6.75
Warping (Cw)	cm6	1.96	1.98	1.97	1.83	0.75	7.47
Torsional (J)	cm4	4.27	4.65	4.45	4.31	8.98	3.31

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : PB12
Stock steel : P9

Date : 20.7.90
Test points: 4
Position 1 :-

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	104.76	104.27	104.49	103.65	
Breadth (lower)	b1 =	103.88	103.66	104.18	103.69	
Depth (first side)	d =	255.30	255.24	255.10	255.34	
Depth (second side)	d1 =	253.70	254.08	253.95	253.82	
Flange thickness	tf1 =	6.71	6.73	6.78	6.77	
Flange thickness	tf2 =	6.45	6.53	6.86	6.57	
Flange thickness	tf3 =	6.81	6.86	6.79	6.94	
Flange thickness	tf4 =	6.89	6.94	6.81	6.94	
Web offset at 1	=	60.80	60.54	61.40	60.75	
Web offset at 2	=	60.61	60.46	61.06	60.80	
Web offset at 3	=	62.34	62.86	62.98	62.38	
Web offset at 4	=	61.91	62.84	62.83	62.36	

Calculated Data

Web thickness (tw)	mm =	6.93	6.06	5.64	5.97
Sectional Area (A)	cm2 =	31.21	29.16	28.29	28.98
Inertia (Ixx)	cm4 =	3028.85	2937.88	2906.55	2930.53
Inertia (Iyy)	cm4 =	128.48	128.30	129.98	127.52
Warping Const.(Cw)	cm6 =	1.97	1.97	1.99	1.96
Torsion Const.(J)	cm4 =	5.43	4.50	4.16	4.44

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	103.65	104.76	104.07	101.60	1.07	2.43
Depth (D)	mm	253.70	255.34	254.57	254.00	0.65	0.22
Top flange (T)	mm	6.45	6.86	6.68	6.80	6.36	-1.84
Bot flange (T)	mm	6.79	6.94	6.87	6.80	2.21	1.07
Flange thick (T)	mm	6.45	7.61	6.77	6.80	17.98	-0.39
Web thick (t)	mm	5.64	6.93	6.15	5.80	22.87	5.99
Area (A)	cm2	28.29	31.21	29.41	28.40	10.31	3.56
Inertia (Ixx)	cm4	2906.55	3028.85	2950.95	2870.00	4.21	2.82
Inertia (Iyy)	cm4	127.52	129.98	128.57	120.00	1.93	7.14
Warping (Cw)	cm6	1.96	1.99	1.97	1.83	1.88	7.85
Torsional (J)	cm4	4.16	5.43	4.63	4.31	30.42	7.49

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : SB7
Stock steel : P7

Date : 20.7.90
Test points: 3
Position 1 :-

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.38	102.38	103.20		
Breadth (lower)	b1 =	104.02	103.21	103.96		
Depth (first side)	d =	253.22	254.48	252.91		
Depth (second side)	d1 =	254.33	255.66	254.74		
Flange thickness	tf1 =	6.58	6.72	6.69		
Flange thickness	tf2 =	6.52	6.59	6.74		
Flange thickness	tf3 =	6.25	6.48	6.32		
Flange thickness	tf4 =	6.61	6.65	6.55		
Web offset at 1	=	61.72	61.45	61.92		
Web offset at 2	=	61.47	61.10	61.96		
Web offset at 3	=	60.92	60.79	61.94		
Web offset at 4	=	61.64	61.73	61.71		

Calculated Data

Web thickness (tw)	mm =	6.26	5.70	5.25
Sectional Area (A)	cm2 =	29.04	27.87	26.76
Inertia (Ixx)	cm4 =	2855.91	2839.12	2761.24
Inertia (Iyy)	cm4 =	121.51	120.37	122.35
Warping Const.(Cw)	cm6 =	1.86	1.86	1.87
Torsion Const.(J)	cm4 =	4.43	3.99	3.60

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.38	104.02	103.36	101.60	1.60	1.73
Depth (D)	mm	252.91	255.66	254.22	254.00	1.09	0.09
Top flange (T)	mm	6.52	6.74	6.64	6.80	3.37	-2.35
Bot flange (T)	mm	6.25	6.65	6.48	6.80	6.40	-4.75
Flange thick (T)	mm	6.25	6.74	6.56	6.80	7.84	-3.55
Web thick (t)	mm	5.25	6.26	5.74	5.80	19.22	-1.03
Area (A)	cm2	26.76	29.04	27.89	28.40	8.51	-1.79
Inertia (Ixx)	cm4	2761.24	2855.91	2818.76	2870.00	3.43	-1.79
Inertia (Iyy)	cm4	120.37	122.35	121.41	120.00	1.64	1.17
Warping (Cw)	cm6	1.86	1.87	1.86	1.83	0.66	1.73
Torsional (J)	cm4	3.60	4.43	4.01	4.31	22.92	-7.07

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : SB8
Stock steel : P9

Date : 20.7.90
Test points: 3
Position 1 :-

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.73	104.12	103.92		
Breadth (lower)	b1 =	104.84	103.86	104.57		
Depth (first side)	d =	253.88	253.75	256.07		
Depth (second side)	d1 =	255.24	255.93	255.55		
Flange thickness	tf1 =	6.87	6.93	7.03		
Flange thickness	tf2 =	6.73	7.06	6.74		
Flange thickness	tf3 =	6.56	6.57	6.57		
Flange thickness	tf4 =	6.70	6.77	6.53		
Web offset at 1	=	62.69	62.79	62.68		
Web offset at 2	=	62.31	62.41	62.55		
Web offset at 3	=	60.90	60.63	61.02		
Web offset at 4	=	61.81	61.07	61.67		

Calculated Data

Web thickness (tw)	mm =	5.87	5.98	5.72
Sectional Area (A)	cm2 =	28.65	29.13	28.38
Inertia (Ixx)	cm4 =	2906.02	2953.78	2921.83
Inertia (Iyy)	cm4 =	127.86	129.30	127.74
Warping Const.(Cw)	cm6 =	1.96	1.99	1.98
Torsion Const.(J)	cm4 =	4.27	4.49	4.15

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	103.73	104.84	104.17	101.60	1.07	2.53
Depth (D)	mm	253.75	256.07	255.07	254.00	0.91	0.42
Top flange (T)	mm	6.73	7.06	6.89	6.80	4.90	1.37
Bot flange (T)	mm	6.53	6.77	6.62	6.80	3.68	-2.70
Flange thick (T)	mm	6.53	7.06	6.76	6.80	8.12	-0.66
Web thick (t)	mm	5.72	5.98	5.86	5.80	4.45	1.01
Area (A)	cm2	28.38	29.13	28.72	28.40	2.65	1.13
Inertia (Ixx)	cm4	2906.02	2953.78	2927.21	2870.00	1.64	1.99
Inertia (Iyy)	cm4	127.74	129.30	128.30	120.00	1.22	6.92
Warping (Cw)	cm6	1.96	1.99	1.98	1.83	1.26	8.07
Torsional (J)	cm4	4.15	4.49	4.31	4.31	8.25	-0.10

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : SB9
Stock steel : P10

Date : 20.7.90
Test points: 3
Position 1 :-

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.10	102.87	102.56		
Breadth (lower)	b1 =	103.75	102.91	103.34		
Depth (first side)	d =	253.18	253.16	253.06		
Depth (second side)	d1 =	254.77	255.76	255.11		
Flange thickness	tf1 =	6.70	6.81	7.07		
Flange thickness	tf2 =	6.62	6.68	6.62		
Flange thickness	tf3 =	6.40	6.28	6.36		
Flange thickness	tf4 =	6.45	6.55	6.53		
Web offset at 1	=	62.60	61.72	62.09		
Web offset at 2	=	62.63	61.35	61.88		
Web offset at 3	=	60.36	60.61	60.63		
Web offset at 4	=	61.05	60.87	60.84		

Calculated Data

Web thickness (tw) mm =	5.55	6.06	5.67
Sectional Area (A) cm2 =	27.39	28.65	27.83
Inertia (Ixx) cm4 =	2786.50	2858.43	2822.98
Inertia (Iyy) cm4 =	121.77	120.35	121.72
Warping Const.(Cw) cm6 =	1.86	1.85	1.86
Torsion Const.(J) cm4 =	3.80	4.29	3.99

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.56	103.75	103.09	101.60	1.16	1.46
Depth (D)	mm	253.06	255.76	254.17	254.00	1.07	0.07
Top flange (T)	mm	6.62	7.07	6.75	6.80	6.80	-0.74
Bot flange (T)	mm	6.28	6.55	6.43	6.80	4.30	-5.47
Flange thick (T)	mm	6.28	7.07	6.59	6.80	12.58	-3.10
Web thick (t)	mm	5.55	6.06	5.76	5.80	9.20	-0.75
Area (A)	cm2	27.39	28.65	27.95	28.40	4.61	-1.57
Inertia (Ixx)	cm4	2786.50	2858.43	2822.64	2870.00	2.58	-1.65
Inertia (Iyy)	cm4	120.35	121.77	121.28	120.00	1.18	1.07
Warping (Cw)	cm6	1.85	1.86	1.86	1.83	0.81	1.56
Torsional (J)	cm4	3.80	4.29	4.03	4.31	12.94	-6.56

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : SB10
Stock steel : P10

Date : 20.7.90
Test points: 3
Position 1 :-

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	103.88	103.15	103.14		
Breadth (lower)	b1 =	103.08	102.65	102.68		
Depth (first side)	d =	254.20	254.67	254.60		
Depth (second side)	d1 =	253.41	253.21	253.34		
Flange thickness	tf1 =	6.39	7.03	6.48		
Flange thickness	tf2 =	6.36	6.37	6.45		
Flange thickness	tf3 =	6.58	6.75	6.62		
Flange thickness	tf4 =	6.77	6.86	6.85		
Web offset at 1	=	61.27	61.86	61.68		
Web offset at 2	=	61.38	61.36	61.42		
Web offset at 3	=	62.22	60.65	60.72		
Web offset at 4	=	62.36	60.50	60.68		

Calculated Data

Web thickness (tw)	mm =	5.31	6.16	6.10
Sectional Area (A)	cm2 =	26.77	29.19	28.77
Inertia (Ixx)	cm4 =	2750.35	2904.81	2856.79
Inertia (Iyy)	cm4 =	121.20	123.61	120.80
Warping Const.(Cw)	cm6 =	1.85	1.89	1.85
Torsion Const.(J)	cm4 =	3.59	4.56	4.35

Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.65	103.88	103.10	101.60	1.20	1.47
Depth (D)	mm	253.21	254.67	253.90	254.00	0.58	-0.04
Top flange (T)	mm	6.36	7.03	6.51	6.80	10.53	-4.22
Bot flange (T)	mm	6.58	6.86	6.74	6.80	4.26	-0.91
Flange thick (T)	mm	6.36	7.03	6.63	6.80	10.53	-2.56
Web thick (t)	mm	5.31	6.16	5.85	5.80	16.02	0.92
Area (A)	cm2	26.77	29.19	28.24	28.40	9.04	-0.55
Inertia (Ixx)	cm4	2750.35	2904.81	2837.32	2870.00	5.62	-1.14
Inertia (Iyy)	cm4	120.80	123.61	121.87	120.00	2.33	1.56
Warping (Cw)	cm6	1.85	1.89	1.86	1.83	2.18	1.80
Torsional (J)	cm4	3.59	4.56	4.16	4.31	26.91	-3.37

EXPERIMENTAL STUDIES OF THE BEHAVIOUR OF STEEL FRAMES

Steel Section Survey - Dimensional Properties

Basic Section Details

Frame test : F2
Section ref : SB11
Stock steel : P10

Date : 20.7.90
Test points: 3
Position 1 :-

Section type : 254 x 102 UB 22 - GRADE 43

Measurement Locations		1	2	3	4	5
Breadth (upper)	b =	102.88	102.43	102.68		
Breadth (lower)	b1 =	103.43	103.26	103.75		
Depth (first side)	d =	254.60	255.28	254.31		
Depth (second side)	d1 =	253.23	253.83	253.19		
Flange thickness	tf1 =	6.49	6.51	6.61		
Flange thickness	tf2 =	6.83	6.80	6.84		
Flange thickness	tf3 =	6.63	6.70	6.52		
Flange thickness	tf4 =	6.39	6.42	6.34		
Web offset at 1	=	61.34	61.31	62.09		
Web offset at 2	=	61.61	61.83	62.45		
Web offset at 3	=	61.47	61.16	61.05		
Web offset at 4	=	61.75	60.88	60.85		

Calculated Data

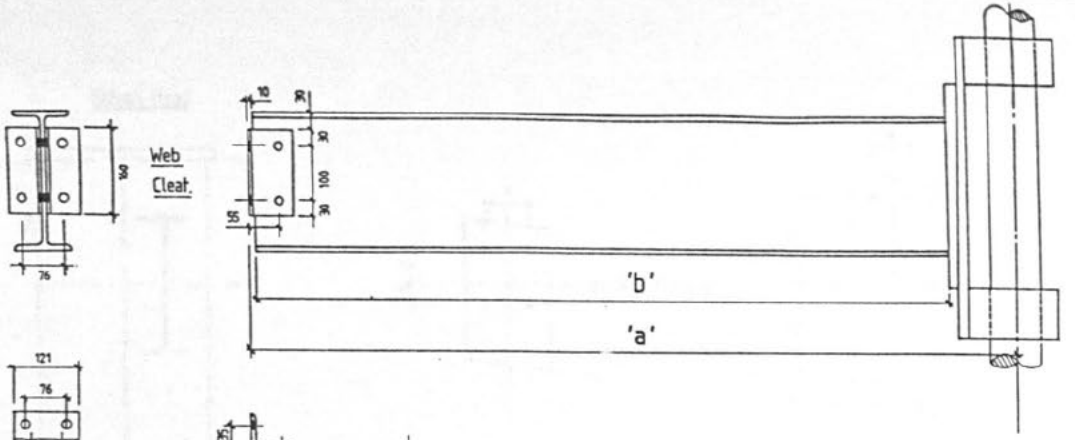
Web thickness (tw)	mm =	5.51	5.70	5.44
Sectional Area (A)	cm2 =	27.35	27.83	27.15
Inertia (Ixx)	cm4 =	2787.55	2825.57	2773.55
Inertia (Iyy)	cm4 =	121.12	120.54	121.37
Warping Const.(Cw)	cm6 =	1.85	1.85	1.85
Torsion Const.(J)	cm4 =	3.80	3.98	3.74

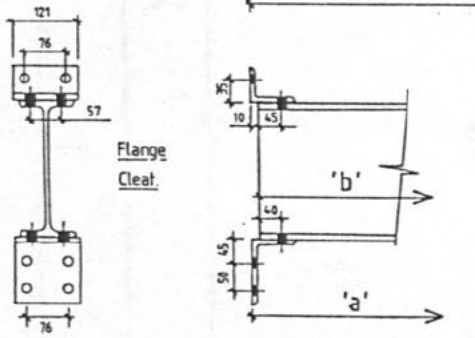
Section Paramters		Min Value	Max Value	Ave Value	Nom Value	Max/Min % diff	Ave/Nom % diff
Breadth (B)	mm	102.43	103.75	103.07	101.60	1.29	1.45
Depth (D)	mm	253.19	255.28	254.07	254.00	0.83	0.03
Top flange (T)	mm	6.49	6.84	6.68	6.80	5.39	-1.76
Bot flange (T)	mm	6.34	6.70	6.50	6.80	5.68	-4.41
Flange thick (T)	mm	6.34	6.84	6.59	6.80	7.89	-3.09
Web thick (t)	mm	5.44	5.70	5.55	5.80	4.78	-4.37
Area (A)	cm2	27.15	27.83	27.44	28.40	2.51	-3.38
Inertia (Ixx)	cm4	2773.55	2825.57	2795.56	2870.00	1.88	-2.59
Inertia (Iyy)	cm4	120.54	121.37	121.01	120.00	0.69	0.84
Warping (Cw)	cm6	1.85	1.85	1.85	1.83	0.08	1.25
Torsional (J)	cm4	3.74	3.98	3.84	4.31	6.56	-10.90

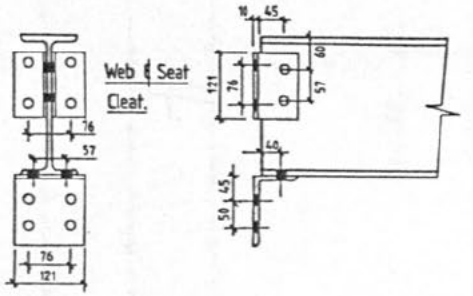
Appendix A

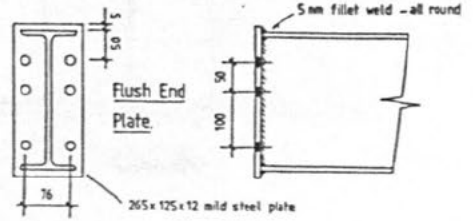
Subassemblage fabrictaion drawings.

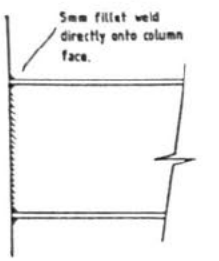
APPENDIX TO VOLUME I











Section Sizes

Beams : 254 x 102 UB 22

Cleats : 80 x 60 x 8 RSA
125 x 75 x 8 RSA

Plate : 265 x 175 x 12

All steel to be grade 43

Subassemblage Test Reference	Beam 1 & 3 Dimensions (mm)		Beam 2 Dimensions (mm)		Stock Length Reference			Connection Type
	'a'	'b'	'a'	'b'	Beam 1	Beam 2	Beam 3	Beams 1, 2 & 3
S1	1542	1418	1459	1335	B5	B5	B5	Web Cleat
S2	1542	1418	1459	1335	B6	B6	B6	Flange Cleat
S3	1542	1418	1459	1335	B7	B7	B7	Web & Seat Cleat
S4	1542	1416	1459	1333	—	B8	B8	Flush End Plate
S5	1469	1345	1532	1408	—	—	—	Web Cleat
S6	1469	1345	1532	1408	—	—	—	Flange Cleat
S7	1469	1345	1532	1408	—	—	—	Web & Seat Cleat
S8	1469	1343	1532	1406	B1	B5	B1	Flush End Plate
S9	1542	1418	1459	1335	B2	B6	B2	Web Cleat
S10	1542	1428	1459	1345	B3	B7	B3	Fully Welded

NOTES

1. Dimension 'a' is the distance from the centreline of the support bearing to the face of the column.
2. Dimension 'b' is the length of the 254 x 102 x 22 UB cutting.
3. All holes are 18mm diameter for 16mm diameter grade 8.8 bolts.

Item No.	No. Off	Description	Material	Remarks

UNIVERSITY OF SHEFFIELD
ENGINEERING DEPARTMENTS

Title: Subassemblage Fabrication. - Beam details.

Scale: 1 : 5

Date: 14th September

Drawn: [illegible]

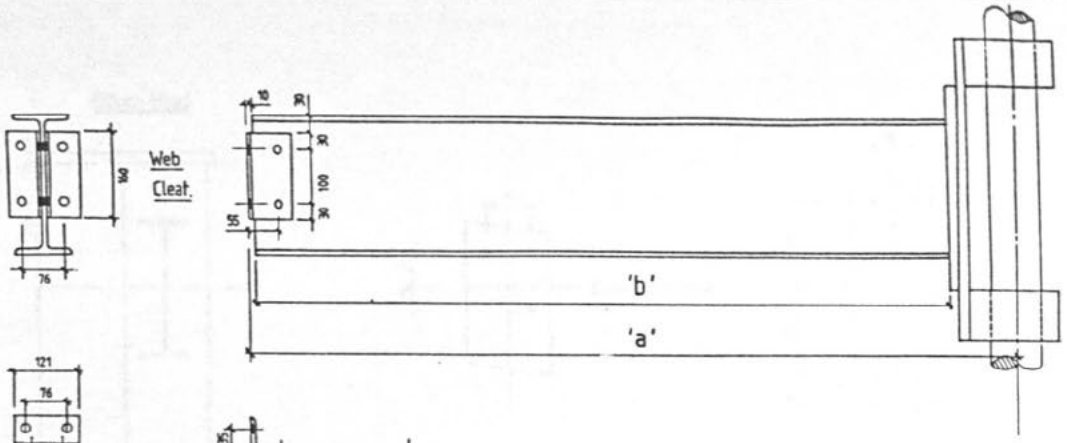
Traced: —

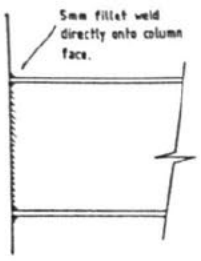
Checked: —

C

Dwg No. 70688/20

Figure A.1: Subassemblage fabrication drawing 70688/20.





Fully Welded

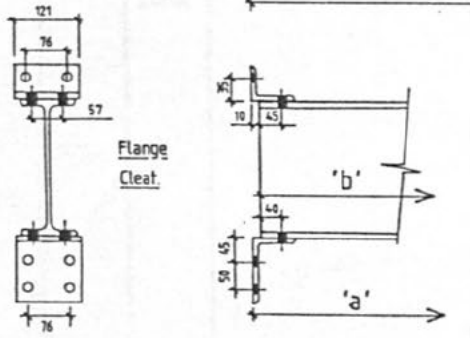
Section Sizes

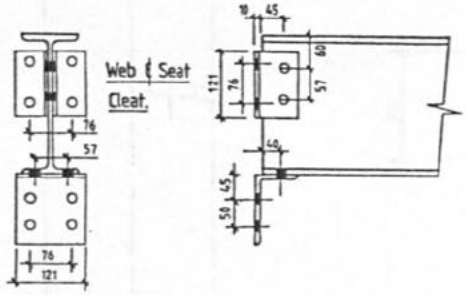
Beams : 254 x 102 UB 22

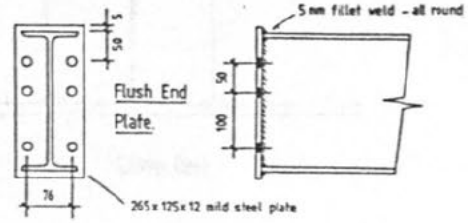
Cleats : 80 x 60 x 8 RSA
125 x 75 x 8 RSA

Plate : 265 x 175 x 12

All steel to be grade 43







Subassemblage Test Reference	Beam 1 & 3 Dimensions (mm)		Beam 2 Dimensions (mm)		Stock Length Reference			Connection Type
	'a'	'b'	'a'	'b'	Beam 1	Beam 2	Beam 3	Beams 1, 2 & 3
S1	1542	1418	1459	1335	B5	B5	B5	Web Cleat
S2	1542	1418	1459	1335	B6	B6	B6	Flange Cleat
S3	1542	1418	1459	1335	B7	B7	B7	Web & Seat Cleat
S4	1542	1416	1459	1333	—	B8	B8	Flush End Plate
S5	1469	1345	1532	1408	—	—	—	Web Cleat
S6	1469	1345	1532	1408	—	—	—	Flange Cleat
S7	1469	1345	1532	1408	—	—	—	Web & Seat Cleat
S8	1469	1343	1532	1406	B1	B5	B1	Flush End Plate
S9	1542	1418	1459	1335	B2	B6	B2	Web Cleat
S10	1542	1428	1459	1345	B3	B7	B3	Fully Welded

NOTES

1. Dimension 'a' is the distance from the centreline of the support bearing to the face of the column.
2. Dimension 'b' is the length of the 254 x 102 x 22 UB cutting.
3. All holes are 18mm diameter for 16mm diameter grade 8.8 bolts.

Item No.	No. Off	Description	Material	Remarks

UNIVERSITY OF SHEFFIELD
ENGINEERING DEPARTMENTS

Scale: 1 : 5

Date: 14th September 88

Title: Subassemblage Fabrication. - Beam details.

Drawn: Griffiths

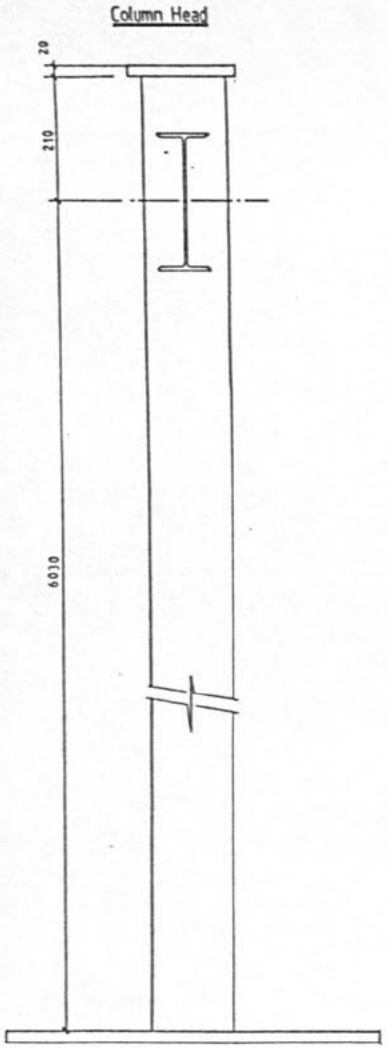
Traced: —

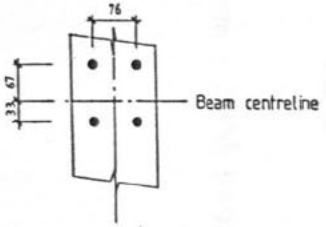
Checked: —

C

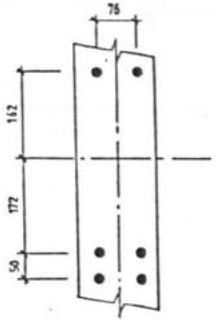
Dwg No. 70688/20

Figure A.1: Subassemblage fabrication drawing 70688/20.

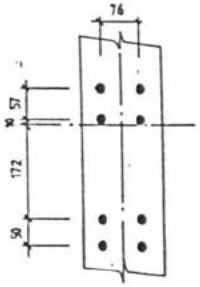




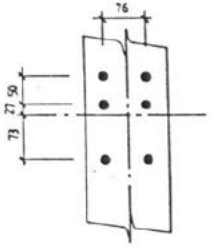
Web Cleat
Tests: S1, S5, S9



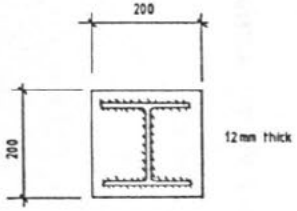
Flange Cleat
Tests: S2, S6



Web & Seat Cleat
Tests: S3, S7



Flush End Plate
Tests: S4, S8



Column Head Plate
Details

COLUMN DRILLING SCHEDULE

NOTE: All column webs to be drilled, tests S1, S2, S3, S4, S9 to have ONE flange drilled only, tests S5, S6, S7, S8 to have BOTH flanges drilled

NOTES	Item No.	No. Off	Description	Material	Remarks
1. All holes to be 18mm diameter for 16mm diameter bolts. 2. See drawing number 70688/20 for details of beam fabrication. 3. See drawing number 70688/21 for details of column base plate fabrication. 4. All steel to be grade 43 mild steel. 5. All column sections to be 152 × 152 × 23 UC.					

UNIVERSITY OF SHEFFIELD ENGINEERING DEPARTMENTS	Scale	1:5	Date 15th Sept 1988
Title: Subassemblage Fabrication – Column details:	Drawn	Duplicate	Dwg. No. 70688/22
	Traced	–	C
	Checked	–	

Figure A.2: Subassemblage fabrication drawing 70688/22.

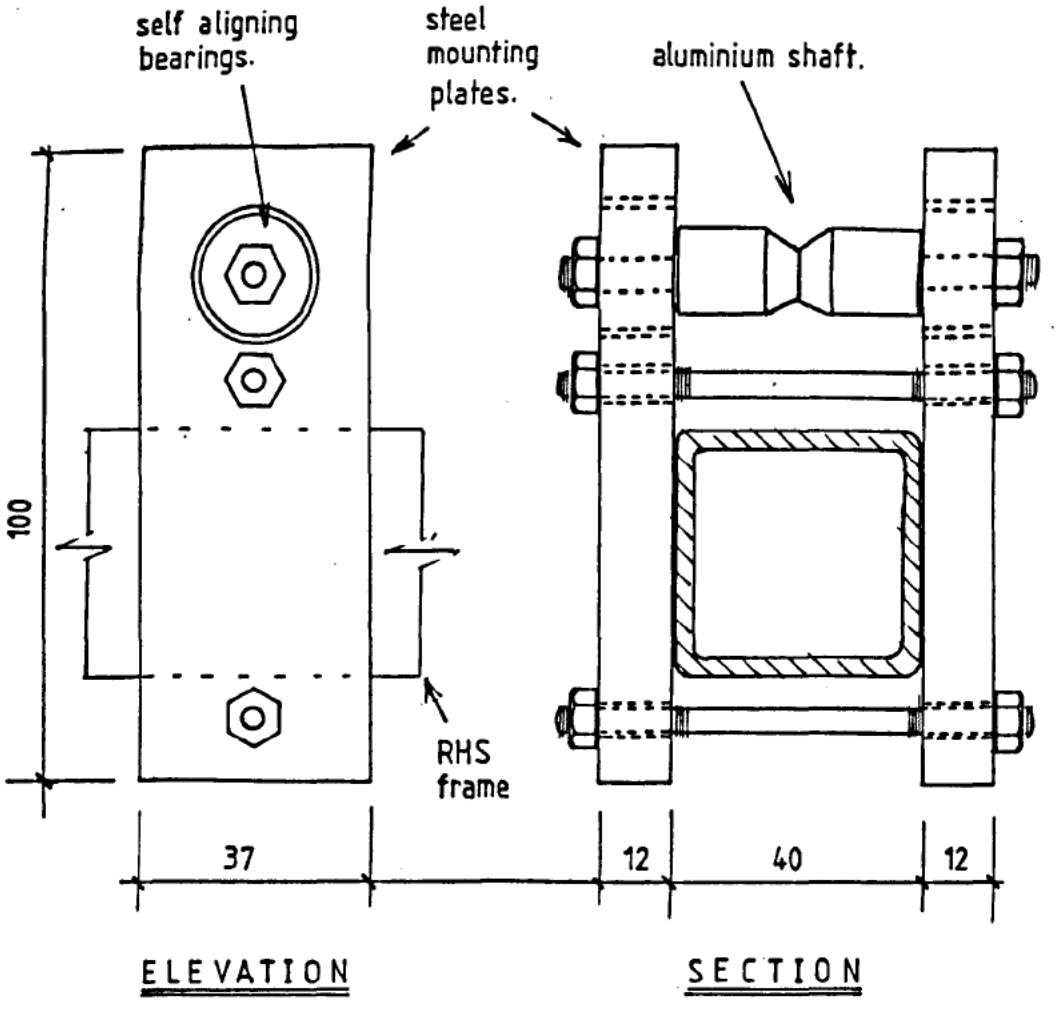


Figure A.3: Fabrication of pulley mechanisms used in the subassemblage tests.

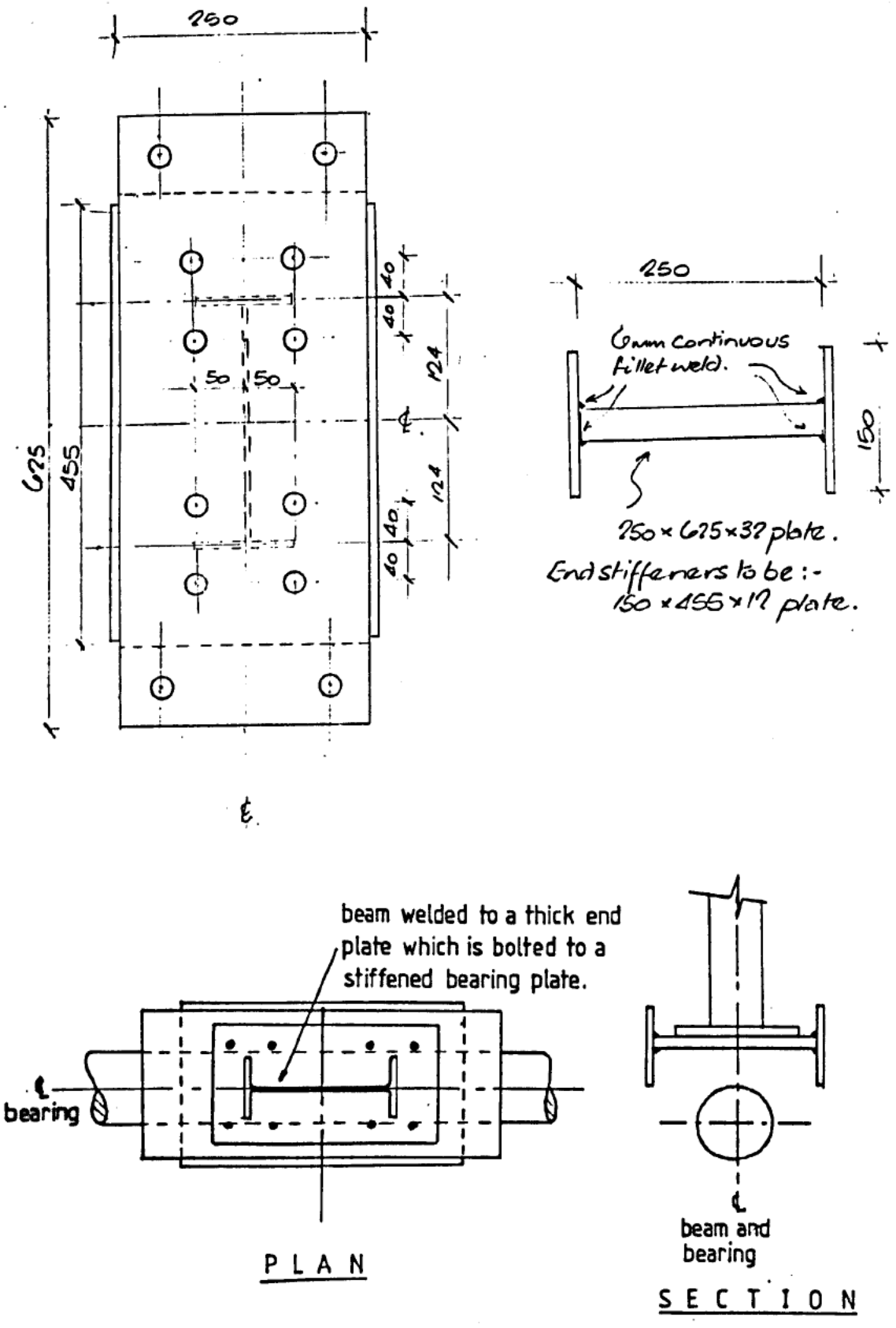
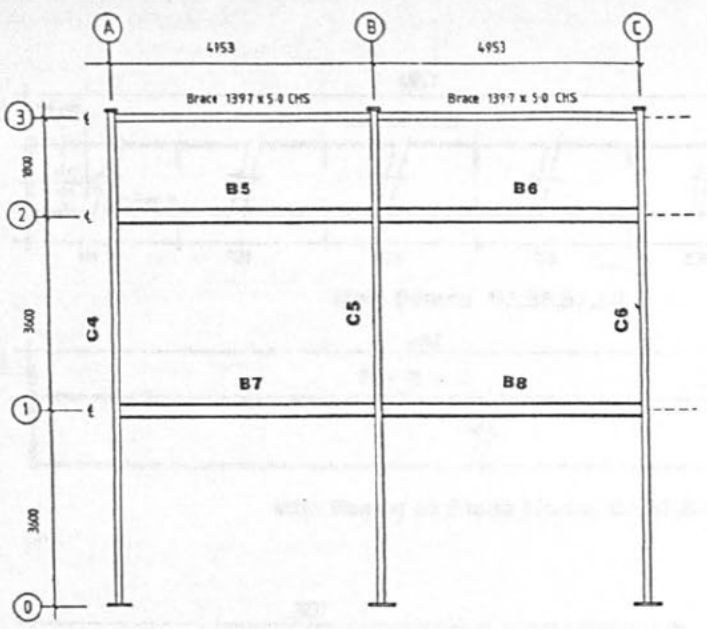


Figure A.4: Fabrication of beam supports used in the subassemblage tests.

Appendix B

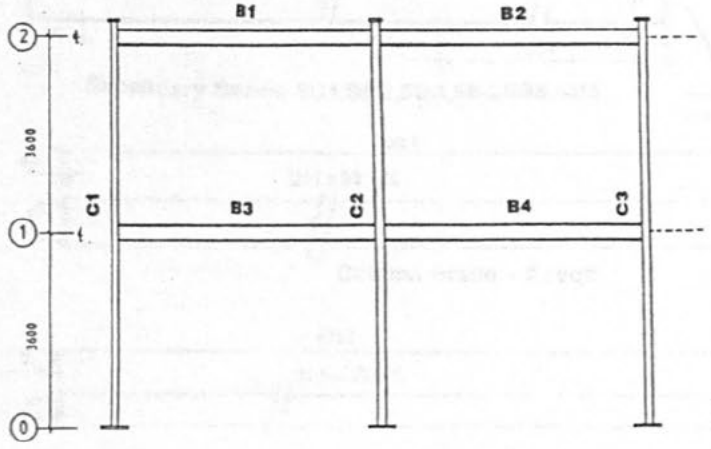
Frame test fabrication drawings.

APPENDIX TO VOLUME I



Elevation on Active Frame

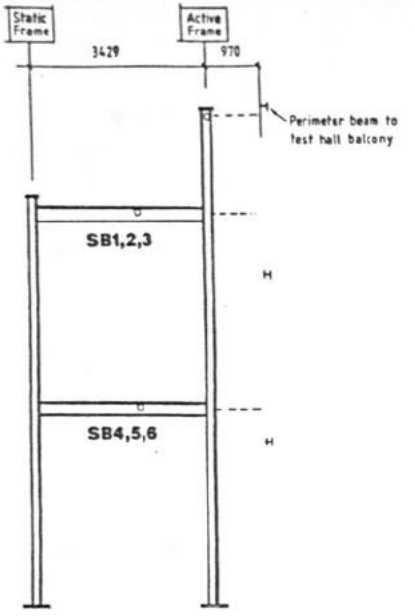
[for test frame 1]



Elevation on Static Frame

1 Reqd. only

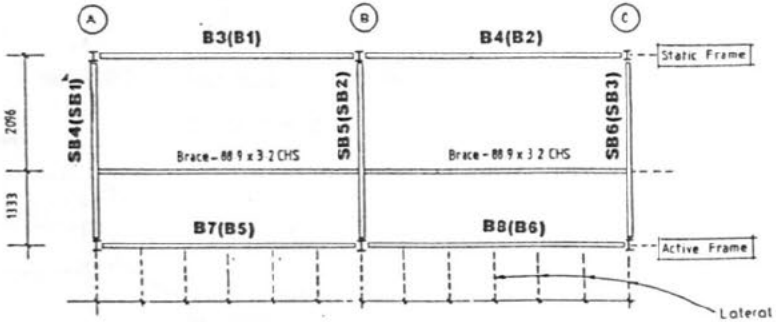
(Same frame to be used in both tests)



Section

All beams to be 254 x 102 UB 22
All columns to be 152 x 152 UC 23
unless stated otherwise

NOTE : Before commencing fabrication, see the member cutting schedule on Drg No 70688/F8



Plan at level 1 and (level 2)

GENERAL ARRANGEMENT TEST FRAME 1

Item No	No. Off	Description	Material	Remarks

UNIVERSITY OF SHEFFIELD
ENGINEERING DEPARTMENTS

Title

Scale: NOT TO SCALE
Date: [illegible]
Drawn
Traced
Checked
C
Dwg No: 70688/F1

Figure B.1: Test frame fabrication drawing 70688/F1

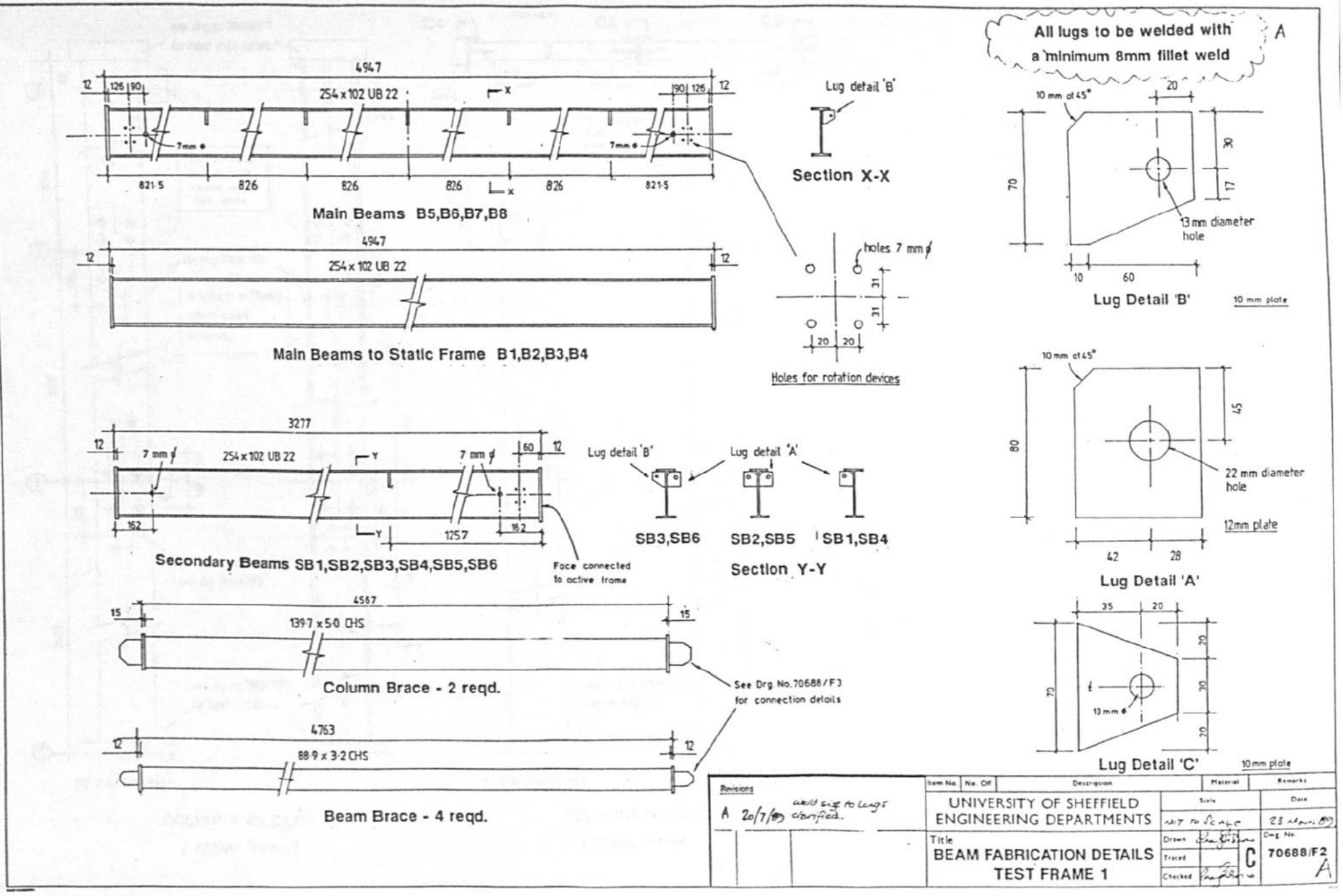


Figure B.2: Test frame fabrication drawing 70688/F2

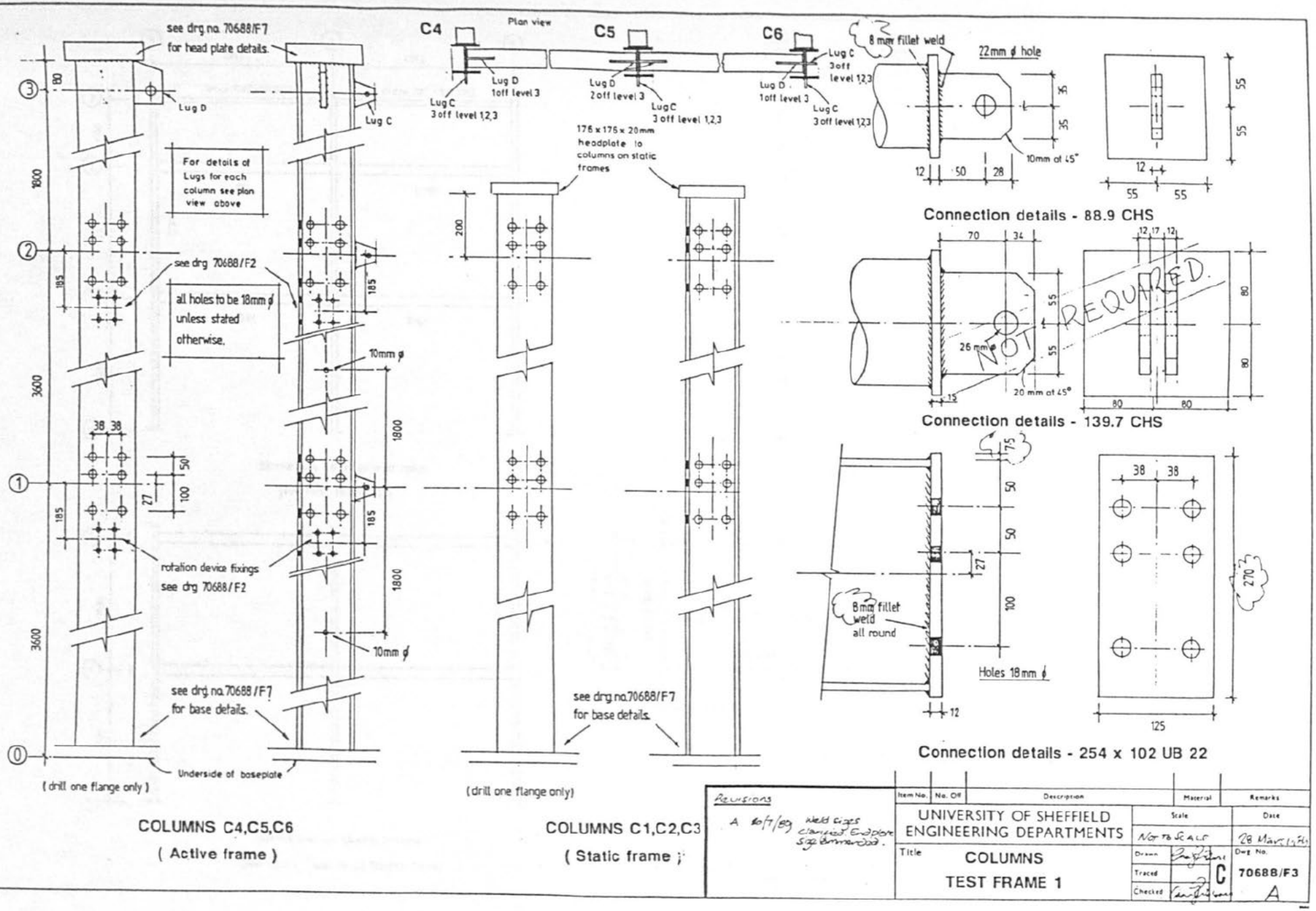
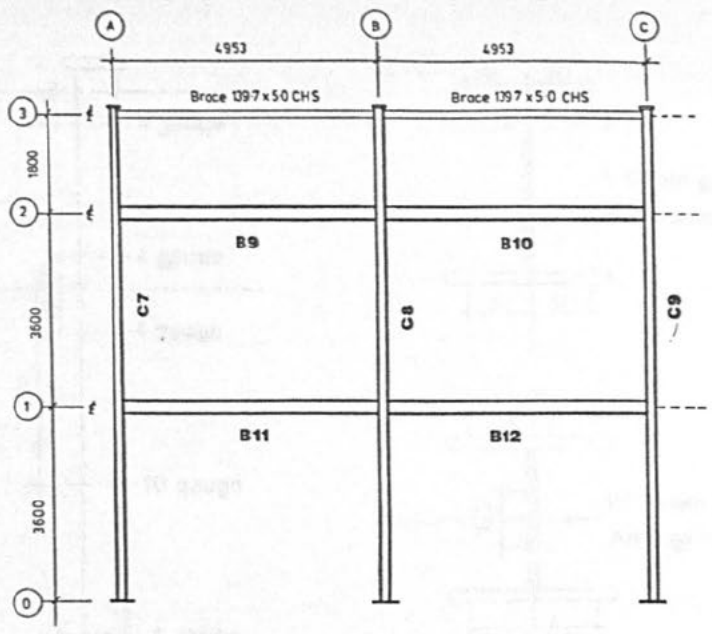
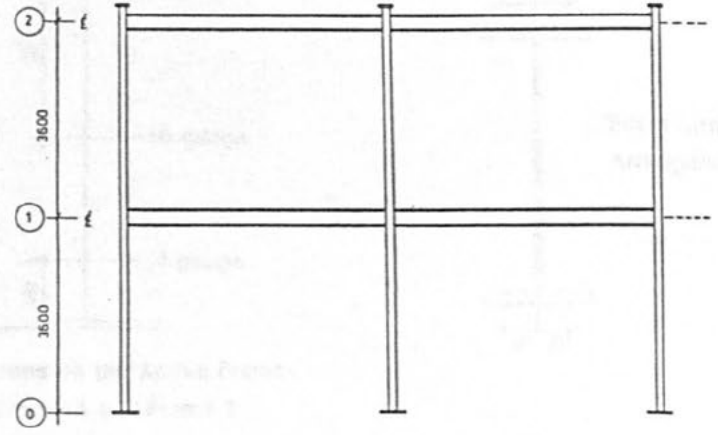


Figure B.3: Test frame fabrication drawing 70688/F3A



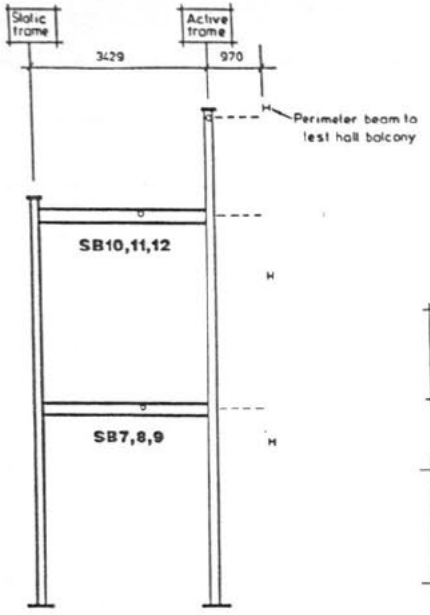
Elevation on active frame

[for test frame 2]



Elevation on static frame

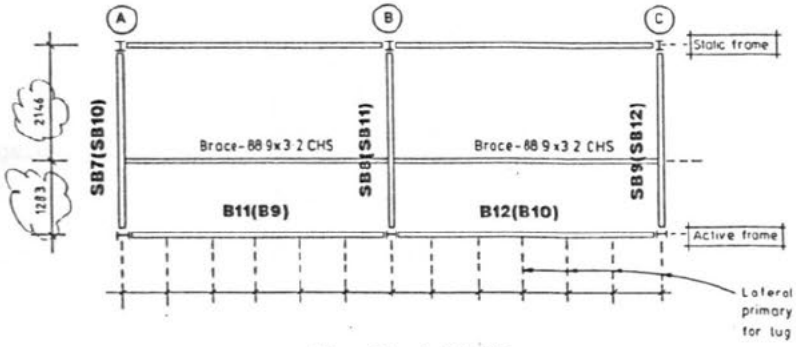
(Re-used from first frame test)



Section

All beams to be 254 x 102 UB 22
All columns to be 152 x 152 UC 23
Unless stated otherwise

Note: Before commencing fabrication, see the member cutting schedule on Drg No 70688/F8



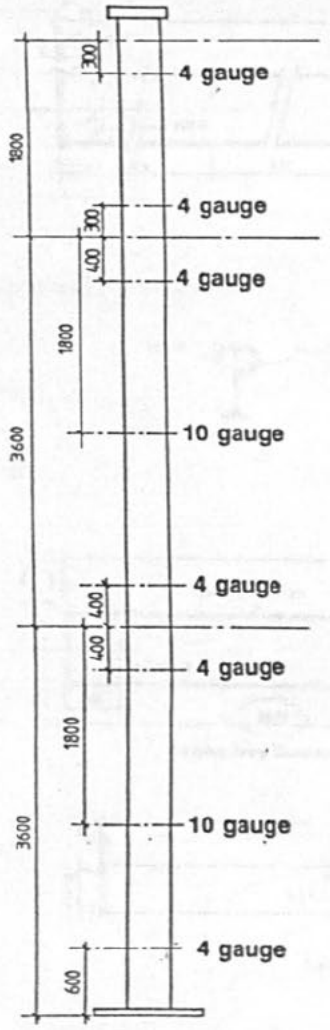
Plan at levels 1 & (2)

Item No.	No. Off	Description	Material	Remarks

UNIVERSITY OF SHEFFIELD ENGINEERING DEPARTMENTS	Scale		Date 22-5-89
Title GENERAL ARRANGEMENT TEST FRAME 2	Drawn D.J.B	C	Dwg. No. 70688/F4/A
	Traced		
	Checked		

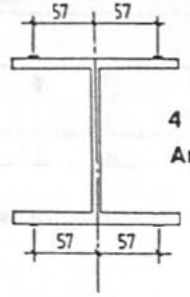
Revision A – Brace to secondary beams moved 15/5/90

Figure B.4: Test frame fabrication drawing 70688/F4A

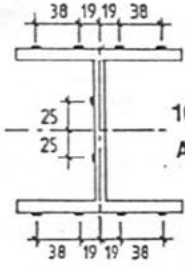


Columns on the Active Frame

Frame 1 and Frame 2

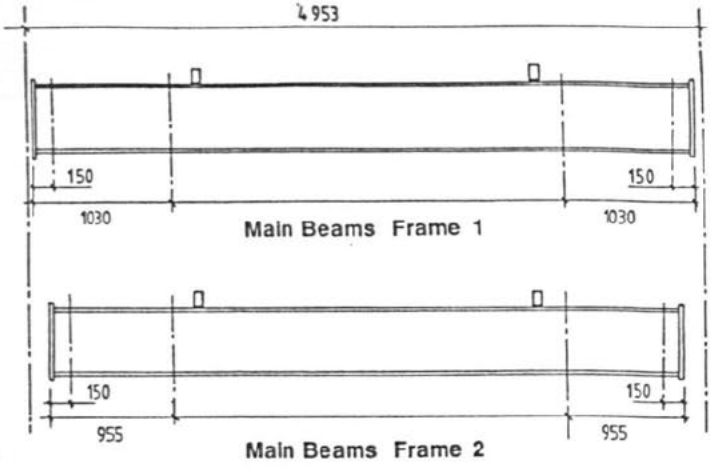


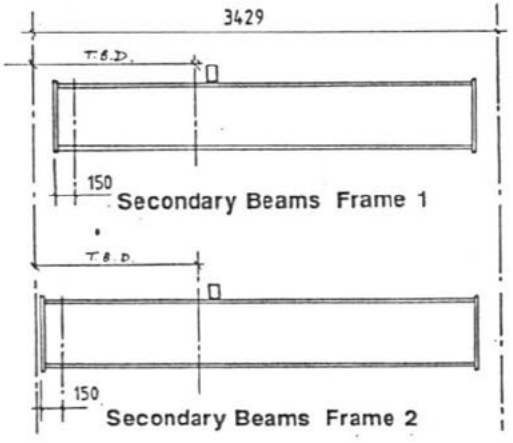
4 Strain gauge Arrangement



10 Strain gauge Arrangement

Beam strain gauge Arrangement





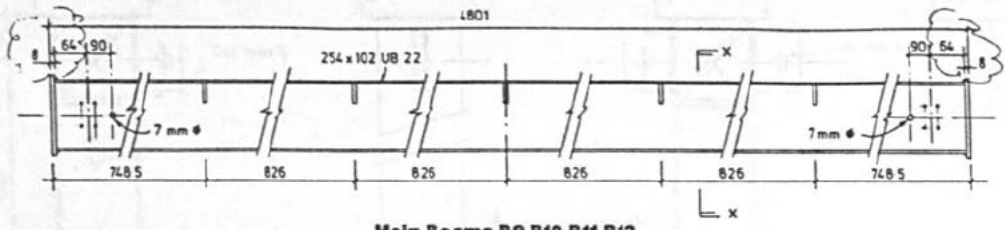
Revision A – 31/01/89 – Gauge added to Secondary beams

Item No.	No. Off	Description	Material	Remarks
UNIVERSITY OF SHEFFIELD ENGINEERING DEPARTMENTS			Scale N.T.S.	Date 21.7.89
Title			Drawn	Dwg No. 70688/F6
			Traced	C
			Checked	A

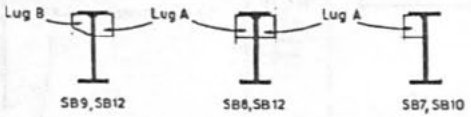
DISTRIBUTION OF STRAIN GAUGES

44 × 5
16 × 4:
4 × 6. /220 × (450)

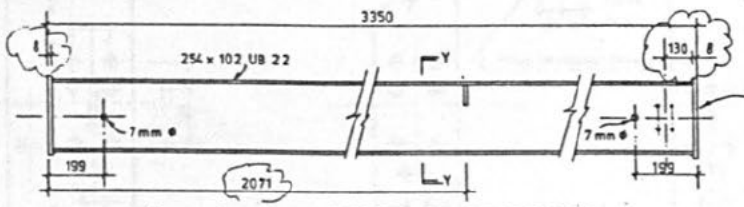
Figure B.5: Test frame fabrication drawing 70688/F6A



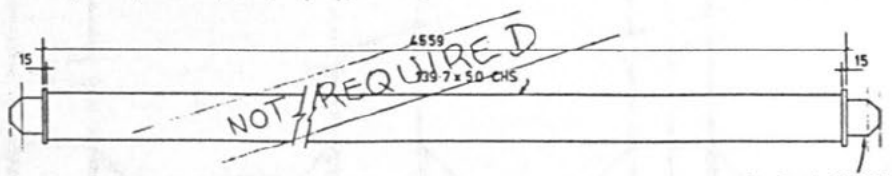
Main Beams B9,B10,B11,B12



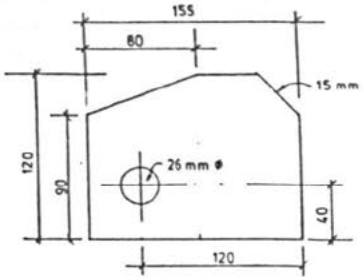
SECTION Y-Y



Secondary Beams SB7,SB8,SB9,S10,SB11,SB12



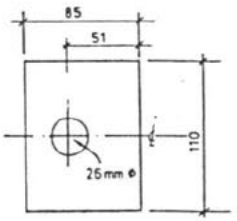
Column Brace (Frame 2) 2 reqd.



15 mm plate

Lug Detail D

(10mm fillet weld)



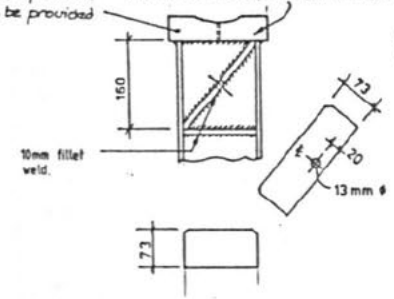
15 mm plate

Lug Detail E

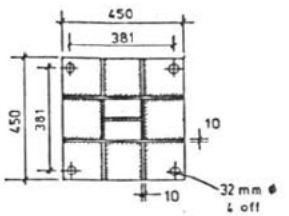
(10mm fillet weld)

Alternatively, fabricate head plate from a series of thin plates to give a total thickness of 60mm minimum. Material cast to be 50mm radius and a depth of 15mm. Through locating bolts to be provided as previous.

Column C7,C8,C9

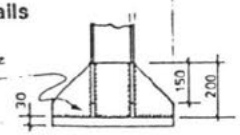


Detail showing stiffeners on 'balcony' side



Column Base Details

Fillet welds to base to be 10mm minimum.



Revisions			Item No.	No. Off	Description	Material	Remarks
A	20/7/89	weld of head plate details clarified.					
B	15/5/90	Change endplate to 8mm thick.					

UNIVERSITY OF SHEFFIELD ENGINEERING DEPARTMENTS

Scale | Date

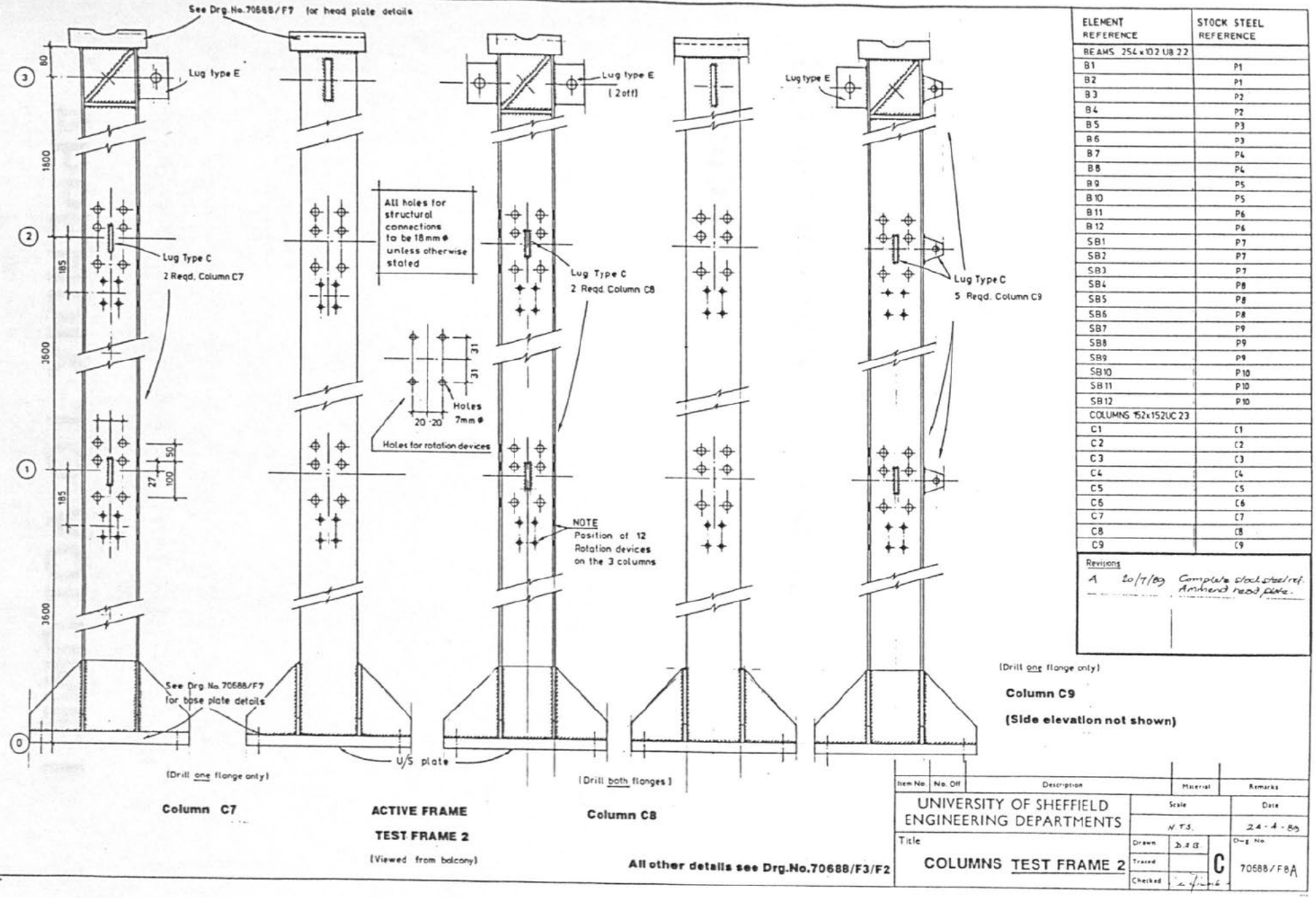
Title: BEAM FABRICATION TEST FRAME 2

Drawn: D.J.E. | Traced | Checked

C

Dwg. No. 70688/F7B

Figure B.6: Test frame fabrication drawing 70688/F7B



ELEMENT REFERENCE	STOCK STEEL REFERENCE
BEAMS 254 x 102 UB 22	
B1	P1
B2	P1
B3	P2
B4	P2
B5	P3
B6	P3
B7	P4
B8	P4
B9	P5
B10	P5
B11	P6
B12	P6
SB1	P7
SB2	P7
SB3	P7
SB4	P8
SB5	P8
SB6	P8
SB7	P9
SB8	P9
SB9	P9
SB10	P10
SB11	P10
SB12	P10
COLUMNS 152x152UC 23	
C1	C1
C2	C2
C3	C3
C4	C4
C5	C5
C6	C6
C7	C7
C8	C8
C9	C9

Revisions

A 20/7/89 Complete stock steel ref. Amend head plate.

Item No.	No. Off	Description	Material	Remarks

UNIVERSITY OF SHEFFIELD ENGINEERING DEPARTMENTS

Scale: N.T.S. Date: 24-4-89

Title: COLUMNS TEST FRAME 2

Drawn: D.S.B. Traced: Checked: C

Drg. No. 70688/F8A

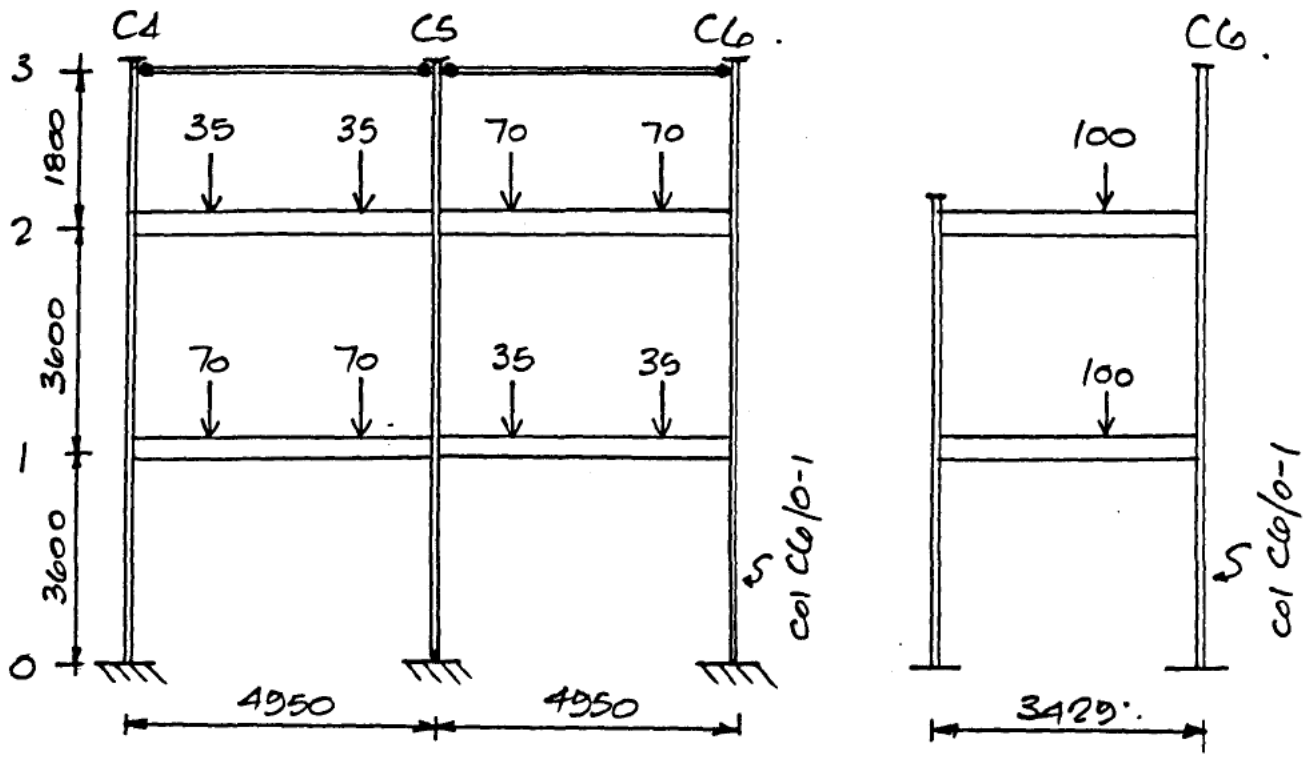
Figure B.7: Test frame fabrication drawing 70688/F8A

Appendix C

Semi-rigid frame design calculations.

APPENDIX TO VOLUME I

PROJECT: Full Scale Frame Tests.	Job No. —	Prepared C. Gibbons	Date 31/10/90
SUBJECT: Design of column C6/0-1.		Checked	Approved



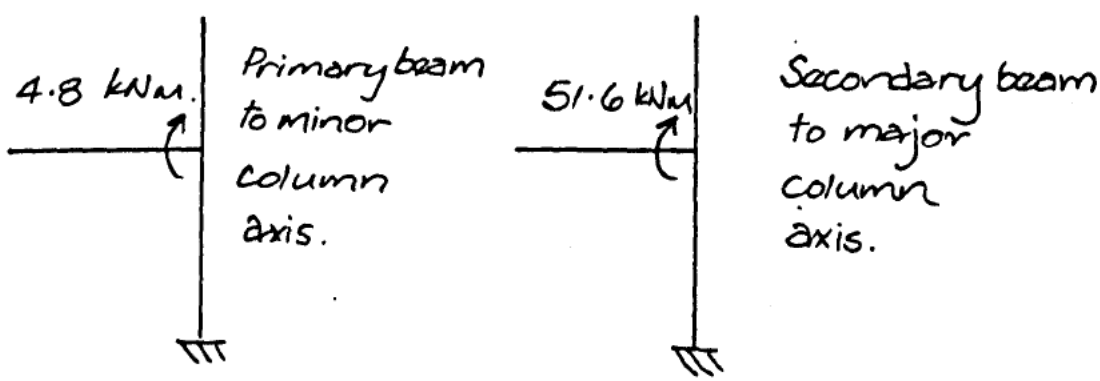
Elevation. Section.

All beam sections – 254 × 102 UB22 – grade 43.

All column sections – 152 × 152 UC23 – grade 43.

Design of column C6/0-1.

From a linear elastic rigid-frame analysis of the frame, the bending moments at the connection with column C6/0-1 are:-



PROJECT: Full scale frame tests.	Job No. –	Prepared C.Gibbons	Date 31/10/00
SUBJECT: Design of column C6/0-1.		Checked	Approved

From experimental data, the linear connection stiffness of a 254×102 UB22 with a 12mm flush end plate connected to a 152×152 UC23 are:-

Minor axis connection C_{ko} = 2000 kNm/rad.

Major axis connection C_{ko} = 4500 kNm/rad.

From standard equations for deflection:-

ϕ_{pin} = 0.0066 radians - primary beam.

ϕ_{pin} = 0.013 radians - secondary beam.

$$\mu = \left(1 + \frac{M_{rigid}}{\phi_{pin} C_{ko}}\right)^{-1}$$

$$\therefore \mu_{minor} = \left(1 + \frac{4.8}{0.0066 . 2000}\right)^{-1} = 0.73$$

$$\mu_{major} = \left(1 + \frac{51.6}{0.013 . 4500}\right)^{-1} = 0.53$$

$\therefore$ Semi-rigid moments:-

$M_{SR\,minor} = \mu . M_{rigid} = 0.73 . 4.8 = 3.5$ kNm.

$M_{SR\,major} = 0.53 . 51.6 = 27.3$ kNm.

PROJECT: Full scale frame tests	Job No. –	Prepared C. Gibbons	Date 31/10/90
SUBJECT: Design of column C6/0-1		Checked	Approved

Assuming that these applied disturbing moments will be distributed equally to the upper and lower column segments, the design distribution of moments will be:-

minor axis

major axis.

Determine effective length for column. (minor axis)

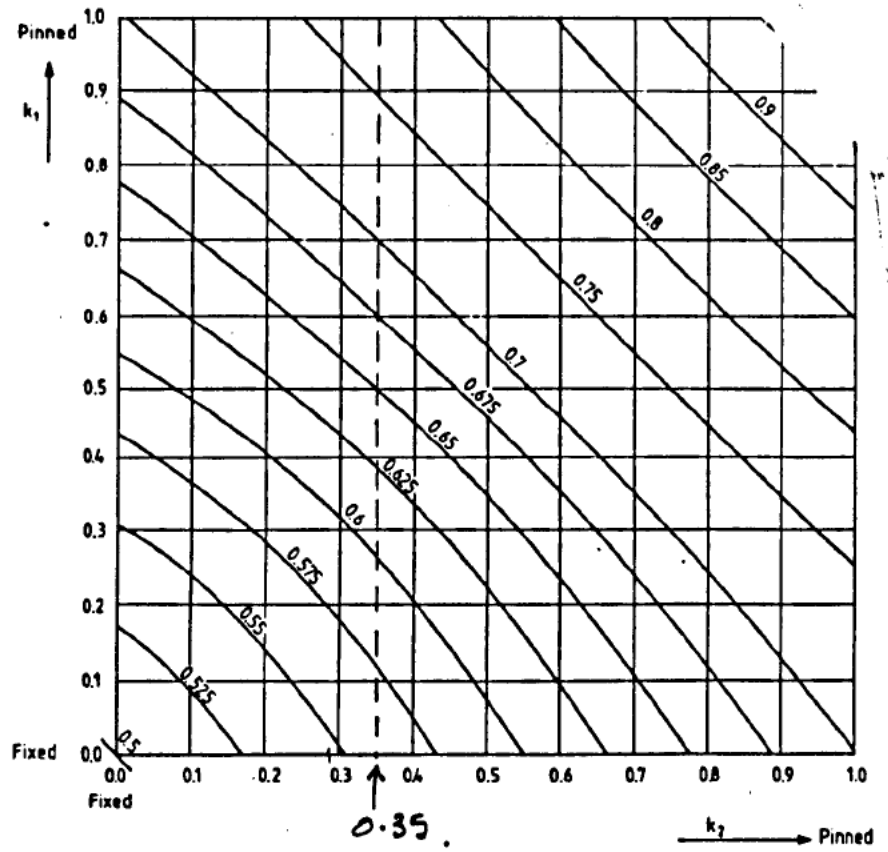
$k_2 = 0.0$ (fixed base)

$$k_1 = \frac{\sum I_c/L_c}{\frac{I_b}{L_b}\cdot\mu + \sum I_c/L_c}$$

$$= \frac{2 \times 403/3600}{\frac{2870 \cdot 0.73}{4950} + \frac{2 \cdot 403}{3600}} = 0.35.$$

From the alignment chart in appendix E of BS5950: Part 1.

PROJECT: Full scale frame tests.	Job No. –	Prepared C. Gibbons	Date 31/10/90
SUBJECT: Design of column C6/0-1.		Checked	Approved



$$L_{ey} = 0.56L = 0.56 \cdot 3600 = \underline{2016 \text{ mm}}.$$

Using the interaction equation in clause 4.8.3.3.1 of BS 5950:-

$$\frac{F}{A_g p_c} + \frac{m M_x}{M_b} + \frac{m M_y}{p_y Z_y} \leq 1.0$$

where:-

$A_g = \underline{2980} \text{ mm}^2$

$Z_y = \underline{52.9 \times 10^3} \text{ mm}^3$ } BS4.

$m = \underline{0.43}$ (Table 18: BS5950)

PROJECT: Full scale frame tests.	Job No. —	Prepared C. Gibbons	Date 31/10/90
SUBJECT: Design of column C6/0-1.		Checked	Approved

$p_y = 320\ N/mm^2$ (from experimental tests).

$\lambda = \frac{L_e}{r_{yy}} = \frac{2016}{36.8} = \underline{54.8}.$

$\underline{p_c = 232\ N/mm^2}$ (Table 27(c): BS5950 Part 1).

λ (for lateral torsional buckling) $= 0.8L/r_{yy}$.

$\lambda_{LT} = \eta . u . v . \lambda = 1.0 . 0.837 . 0.92 . 78.2 = \underline{60}.$

$\therefore p_b = 242\ N/mm^2$ (Table 11 BS5950: Part 1).

$\therefore \underline{M_b = 44.5\ kNm.}$

Substituting into the interaction equation :-

$$\frac{F}{2980 . 232 \times 10^{-3}} + \frac{0.43 . 13.7}{44.5} + \frac{0.43 . 1.8}{320 . 52.9 \times 10^{-3}} \leq 1.0.$$

$$\frac{F}{691.4} + \frac{5.9}{44.5} + \frac{0.8}{16.9} \leq 1.0$$

$$\underline{\underline{F \leq 567\ kN}}.$$

This compares with a test ultimate load of 756 kN.

$\therefore \frac{P_{test}}{P_{des}} = 1.33.$

PROJECT: Full scale frame tests.	Job No. –	Prepared C. Gibbons	Date 31/10/90
SUBJECT: Design of column C6/0-1.		Checked	Approved

As an alternative, use the 'more exact' interaction equation in BS5950:-

ie. $\frac{mM_x}{Max} + \frac{mM_y}{May} \leq 1.0$ (cl. 4.8.3.3.2. BS5950).

where:- Max is the lesser of:-

a) $\frac{M_{cx}\left(1 - F/P_{cx}\right)}{\left(1 + 0.5F/P_{cx}\right)}$

or:-

b) $M_b\left(1 - F/P_{cy}\right)$

and where:-

$$M_{ay} = \frac{M_{cy}\left(1 - \frac{F}{P_{cy}}\right)}{\left(1 + \frac{0.5F}{P_{cy}}\right)}$$

By inspection the case b) for M_{ax} is more critical in this instance.

P_{cx} = 840 kN (using an effective length = 0.8L).

P_{cy} = 691.4 kN (as before).

M_b = 44.5 kN (as before).

PROJECT: Full scale frame tests.	Job No. —	Prepared C. Gibbons	Date 31/10/90
SUBJECT: Design of column CC6/0-1.		Checked	Approved

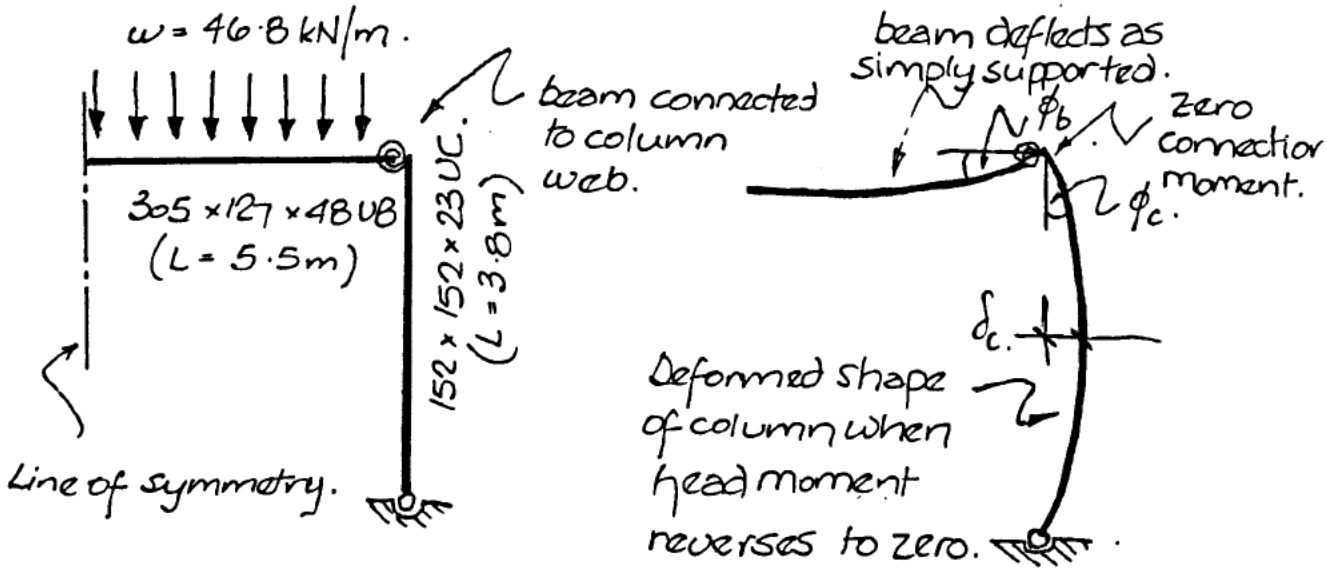
$$\therefore \quad \frac{mM_x}{M_{ax}} + \frac{mM_y}{M_{ay}} = \frac{5.9}{44.5\left(1-\frac{F}{691.4}\right)} + \frac{0.8}{25.8\left(1-\frac{F}{691.4}\right)\left(1+\frac{0.5F}{691.4}\right)}$$

$$= \frac{1}{7.54\left(1-\frac{F}{691.4}\right)} + \frac{1+\frac{F}{1382}}{32.25\left(1-\frac{F}{691.4}\right)} \leq 1.0$$

iterative solution of the above equation gives

$$F_{ult} = 570\ kN.$$

PROJECT: Parametric study. — case 6A - one way span.	Job No. —	Prepared C. Gibbons	Date 20/11/90
SUBJECT: Proposed 'simple' design method.		Checked	Approved



Beam load = 46·8 kN/m.

∴ Beam support rotation = $\frac{wL_b^3}{24EI_b}$

$= \frac{46{\cdot}8 \times 5500^3}{24 \times 210 \times 10^3 \times 9500 \times 10^4} = \underline{0{\cdot}016 \text{ rads}}$

If the moment at the column head has reversed to zero,

$\phi_b \approx \phi_c$.

∴ Deformation at column centre (assuming a half-sine-wave)

$$\delta_c = \frac{L}{\pi} \cdot \phi_c = \frac{3800}{\pi} \cdot 0{\cdot}016 = \underline{19{\cdot}6\text{mm}}.$$

{ Note: this compares with δ_c = 20·3 mm from the finite element program }

Total deflection at the column centre:-

$$\delta = \delta_c + \delta_i = 19{\cdot}6 + \frac{L}{1000} = 19{\cdot}6 + \frac{3800}{1000} = \underline{23{\cdot}4\text{mm}}$$

PROJECT: Parametric study – case 6A – one way span.	Job No. –	Prepared C. Gibbons	Date 20/11/90
SUBJECT: Proposed 'simple' design method.		Checked	Approved

In this instance, major axis moment = zero.

∴ Strength check:-

$$\frac{P}{P_{squash}} + \frac{P\delta.}{M_{py}} \leq 1.0.$$

$$P\left(\frac{1}{890} + \frac{0.0234.}{14}\right) \leq 1.0.$$

$$\therefore \underline{\underline{P \leq 358\ kN.}}$$

[Note: this compares with a load of 400kN from program at point of zero head moment, and an ultimate load of 420kN]

(At this axial load, the moment at the column centre, $P\delta$, = 8.4 kNm. This compares with an 'actual' moment at this load level of 7.8 kNm. and a moment of 9.1 kNm. at the point where the column head moment reverses to zero.)

Check residual stiffness.

Design axial load = 358 kN.

Euler load = $\frac{\pi^2 EI}{L^2}$ = 578 kN.

As design load < Euler load, the design represents a stable condition. ∴ Satisfactory.