Report No.	SL/HED/R/S2298/2/93/C
Date	7 September 1993
Classification	OPEN

BS476 : Part 21 Fire Resistance Tests

Summary of Data Obtained During Tests on Flange Plated Slim Floor Beams

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CONTENTS

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SUMMARY

BS476:PART 21 FIRE RESISTANCE TESTS

SUMMARY OF DATA OBTAINED DURING TESTS ON FLANGE PLATED SLIM FLOOR BEAMS

D. E. Wainman

During the four years 1989-1992 the Sections Commercial Division of British Steel has sponsored more than thirty standard fire resistance tests on hot rolled structural steel sections. The range of systems / component configurations investigated in these tests has been much wider than in preceding years. Data arising from the tests are being summarised in a series of reports, each one dealing with either a different form of construction or generic group of test assemblies.

This is the first report issued as part of that series. It contains detailed descriptions of the design, instrumentation and construction for each of eight flange plated slim floor beams, together with the data arising from them.

KEYWORDS

26
+BS 476
Fire Resistance
Lab Reports
Fire Tests
+Slimflor
+BS 4360
+BS EN 10 025
Beams
Columns
Load (Mechanical)
Sections (Structural)
Building Floors

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Cover Pages : 1
Text Pages : 14
Figure Pages : 37
Appendix Pages : 38

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BS476:PART 21 FIRE RESISTANCE TESTS

SUMMARY OF DATA OBTAINED DURING TESTS ON FLANGE PLATED SLIM FLOOR BEAMS

1. INTRODUCTION

In 1987 and 1988 research staff based at the Swinden Laboratories of British Steel Technical prepared and published two Compendia[1,2] in which data obtained from standard fire resistance tests were summarised. These documents covered all the British Steel sponsored fire tests which had been carried out in the UK since 1979 according to the requirements of either BS476:Part 8:1972, or the later revision, BS476:Parts 20/21:1987. Only tests on hot rolled structural steel sections in which the test members were completely unprotected, or were partially protected by materials used only in the fabric of the structure, such as concrete, brick and blockwork, were included. Taking the two documents together, details were given for a total of 62 full scale tests plus a further 31 separate indicative, i.e. unloaded, specimens.

Since the publication of the second compendium a further 40 full scale fire resistance tests have been carried out. The range of systems / component configurations which have been investigated in these tests has been much wider than in the preceding years and has included, for example, tests on:-

- 8 flange plated slim floor beams, (of which 7 were loaded and one was a full length indicative).
- 4 shelf angle floor beams, (of various types).
- 5 composite metal deck floors, (of various types).
- 6 pairs of beam / beam and beam / column connection assemblies.
- 4 composite columns with concrete infill between the flanges.
- 1 column with blockwork infill between the flanges.

Plus, amongst others, three tests on concrete filled circular hollow sections, two lattice girders formed from square hollow sections, an arched metal deck floor and two fully protected beams. Brief details of all these tests can be found in a recent Technical Note[3]. Tests have also been carried out on a number of indicative specimens. These were usually small assemblies which were included in the furnace alongside a full length member, though in some cases they were themselves full scale assemblies.

Much of the data generated from the individual test programmes have already been used extensively by co-workers in other organisations, and in particular by the Steel Construction Institute, (SCI), for the preparation of Design Guides covering various forms of construction[4,5,6]. There is, however, a need to document the test configurations and data in more detail than is usually given in such publications. Having regard to the variety and complexity of the systems examined during the last four years it has been deemed impractical to attempt to present the data for all of them in one document at the present time. It has therefore been proposed that a series of reports should be prepared, each one dealing with either a different form of construction or generic group of test assemblies, and that these will eventually be combined to form a third compendium.

This is the first report issued as part of that series. It contains detailed descriptions of the design, instrumentation and construction for each of the eight flange plated slim floor beams, together with the data arising from them which are included in an Appendix. The data are presented in a format which is generally consistent with that introduced in the previous compendia. No analyses of the data are included since these are currently being incorporated into other publications dealing with design aspects of this form of construction. The numerical sequence of the data sheets has been maintained, those in this document being numbered from 99 to 106 inclusive. As in the previous compendia, the thermal data are reduced to a summary at various time increments. It should be noted, however, that in the Autumn of

1990 an improved data logging system was commissioned. Its introduction has provided a facility whereby all the thermal data, usually recorded at one minute intervals, can be made available on PC disks. These may be obtained, on request, from British Steel Technical, Swinden Laboratories.

As before, the fire tests reported here form part of an ongoing research programme concerned with the evaluation and prediction of the performance of constructional steelwork in fire. Readers are therefore reminded to exercise caution when using any single test result and not to take it out of context with data for other tests of a similar nature.

2. CHANGES TO STANDARDS

The following changes to British Standards have occurred since the publication of the previous compendia.

2.1 BS4360:1986 'Weldable Structural Steels'

This standard was withdrawn with effect from March 30th 1990. The parts of BS4360 pertaining to hot rolled sections and plates were replaced from that date by EN10025 'Hot Rolled Products of Non-Alloy Structural Steels - Technical Delivery Conditions'. BS EN10025:1990 is the English language version of that standard. The specification requirements for those products and grades not within the scope of EN10025 have been simultaneously republished unchanged as BS4360:1990

As far as the present work is concerned it should be noted that, since all the tests were carried out after March 30th 1990, steel quality BS4360:Grade 43A should now be referred to as BS EN10025:1990 Grade Fe 430 A. However, this grade only appears in the UK edition of the standard under the heading 'Non Conflicting National Additions'. Similarly, steel quality BS4360:Grade 50B should now be referred to as BS EN10025:1990:Grade Fe 510 B.

The requirements of the two specifications are compared in Tables 1 and 2. A detailed comparison of the two standards is given in Reference 7.

2.2 BS476:Parts 20/21:1987

No changes have been made to this standard during the period covered by this report. However, discussions are ongoing concerning certain aspects of the standard fire test procedures.

3. FIRE TESTS ON SIMPLY SUPPORTED SLIM FLOOR BEAMS

In this section details are given for tests performed on seven loaded and one indicative slim floor beam assemblies. All the tests were carried out in accordance with the requirements of BS476:Parts 20/21:1987 at the Warrington Fire Research Centre, (WFRC), between September 1990 and November 1992. The major features of the tests are summarised in Table 3.

Details describing fire resistance tests on simply supported floor beams were given in the two previous compendia and it is not, therefore, proposed to cover these items again in the present report.

The design and preparation of the eight assemblies are described individually in the following sections. A number of features are, however, common to all of them and these are described here.

3.1 Features Common to all Test Assemblies

3.1.1 Steel Quality

Unless specifically indicated to the contrary, all the steel members used in the construction of the test assemblies were manufactured by British Steel and were supplied to the requirements of BS EN10025:1990 Grades Fe 430 A or Fe 510 B. Details of their chemical compositions and mechanical properties are included in the appropriate Data Sheets in Appendix 1.

3.1.2 Dimensions and Section Properties

The nominal dimensions and section properties, as specified in BS4:Part 1:1980, for the steel members used in the construction of the test assemblies are included in the Data Sheets. The actual dimensions of the members are also given, together with their calculated section properties. The loads to be applied to the various assemblies were calculated on the basis of nominal dimensions and section properties for the steel members concerned. These initial calculations were subsequently repeated to take account of the actual dimensions, mechanical and physical properties of all the materials involved in the construction. Loading calculations for each of the seven assemblies are summarised in Appendix 2.

3.1.3 Structural Calculations

In Compendium No. 1 the load calculations were based upon the generation of the required stresses in the members using the design rules given in BS449. Compendium No. 2 was published following the introduction of the new limit state design philosophy and the calculated loads were also presented in terms of BS5950. However, because it is impossible to know how a member will be used in practice, the factored loads cannot be defined and therefore the loads calculated using BS449 were presented as a proportion of the members capacity. This is referred to as the load ratio and is given by:

$$LR = M_f / M_c$$

Where M_f = the applied moment at the fire limit state
and M_c = the moment capacity at 20°C.

In calculating M_c, the design strength, p_y, corresponding to the minimum guaranteed yield strength for the grade of steel, is normally used. However, for the purpose of evaluating the effect of load ratio on limiting temperature, the influence of variations in the strength of the as-received material can be diminished by adopting the measured yield strength for p_y. These have been determined from samples removed from the members under test.

3.1.4 Fabrication

All the test assemblies were formed from 5 metre long universal column sections and pieces of 15 mm thick plate. Steel quality for the two components was always the same. The sections were used as beams and the plate was attached so as to form an extension to the lower flange. The plate width was nominally 200 mm greater than that of the column flange and the two components were positioned such that equal amounts of steel protruded from both sides of the lower flange of the section. Welding was by the MMA process using 4 mm diameter basic coated, hydrogen controlled, general purpose welding rods. All welds were continuous 8 mm fillets.

3.1.5 Instrumentation

The assemblies were instrumented such that the temperatures attained by the steel section and plate could be recorded throughout the duration of the heating period. For this purpose 3 mm diameter mineral insulated 'K' type thermocouples, (Ni-Cr/Ni-Al), with insulated hot junctions and Inconel sheaths were used. These thermocouples were embedded to the mid-thickness position of the relevant steel section. Temperatures were also monitored in other parts of the assemblies, such as, for example, the concrete infill. The thermocouples used for these situations were again 'K' type but were usually formed from glass fibre covered Ni-Cr/Ni-Al conductors.

Provision was made for monitoring the vertical deflections of the test assemblies at the mid-span position. These measurements were made using a displacement transducer connected to the data logging facility. The data are included in the appropriate Data Sheets in Appendix 1.

3.1.6 Assembly

The test assemblies were positioned so as to form part of the test furnace roof. They were simply supported on a steel loading frame, lined with refractory cement, so as to give a total effective span between the roller supports of 4500 mm. This frame was supported on the outer walls of the gas fired furnace so that the length of beam actually exposed to the heating conditions of the test was 4000 mm.

3.1.7 Failure Criteria

In all cases the performance of the test assemblies was judged against the load bearing capacity criterion outlined in Section 5 of BS476:Part 21:1987. The maximum allowable deflection and the maximum allowable rate of deflection for the test assemblies, as specified by the standard, were calculated by SPAN/20 and $(SPAN)^2/9000 \times D$, respectively, where D is the measured depth of the section and plate, (non-composite construction), or the section, plate and concrete floor slab, (composite construction). The allowable rate of deflection criterion is not applicable until the deflection exceeds a value equal to SPAN/30. Since the span was fixed at 4500 mm the values of SPAN/20 and SPAN/30 were always 225 mm and 150 mm respectively.

3.1.8 Additional Data

In some cases heating of the test assembly continued beyond the time at which 'failure' was deemed to have occurred and the load removed from the beam. This was done to enable further data to be recorded concerning the heating rates of the various members of the assembly.

3.2 Loaded Test Assemblies

The following sections describe in greater detail aspects concerning the construction, instrumentation, and loading of seven test assemblies.

3.2.1 Test WFRC 50521

A non composite construction consisting of a universal column of serial size 254 x 254 mm x 107 kg/m and a steel plate 460 mm wide x 15 mm thick. Both the column and plate were Grade Fe 430 A material. The protruding sections of the bottom plate were used to support fourteen pre-cast reinforced concrete slabs which covered the entire roof area of the furnace. These were standard hollow cored 'TEMBO' slabs manufactured by Richard Lees Ltd., and were nominally 600 mm wide x 200 mm deep x 1500 mm in length, (see Fig. 1). Each slab had one solid end extending over a length of 250 mm, this end being situated adjacent to the web of the steel section. The gap between the concrete floor units and the web was filled with fine dry sand. The upper flange of the section was also covered with dry sand to a depth of approximately 25 mm to simulate the floor screed which would normally be used in site practice. The assembly is shown schematically in Fig. 2.

The thermocouple positions in the steelwork were as shown in Fig. 3, (longitudinal arrangement), and Figs. 4(a) to 4(g), (transverse arrangements).

A total imposed load of 388 kN was applied directly to the steel section at four points along its supported length and directly over the web. The rams were spaced at 875 mm intervals along the section length as shown in Fig. 5. Loading calculations are given in Appendix 2.1. These indicate that the load ratio for this system was 0.55.

Data for this test are summarised in Data Sheet No. 99.

3.2.2 Test WFRC 50522

A composite construction consisting of a universal column of serial size 203 x 203 mm x 86 kg/m and a steel plate 425 mm wide x 15 mm thick. Both the column and plate were Grade Fe 430 A material. Two rows of shear connectors were fixed to the top surface of the section using stud welding equipment. The connectors

were nominally 19 mm diameter x 100 mm long and were located at the quarter flange width positions at 200 mm centres along the full length of the section, (see Fig. 6). A concrete floor slab which encased the whole section, but which left the lower face of the plate exposed, was cast using a nominally Grade 35 bulk supplied concrete mix. The slab contained two layers of steel reinforcement in the material above the upper flange. The first was a prefabricated 200 mm square mesh composed of 7 mm diameter rods, (Type A193). The second comprised 12 mm diameter rods, (Type T12), laid at right angles to the column and spaced at 150 mm centres. Both were located at a height of approximately 40 mm above the top surface of the upper flange. The floor slab had overall nominal dimensions of 1700 mm width x 350 mm depth and was 4500 mm in length. The assembly is shown schematically in Fig. 7. In order to ensure that the fillet weld between the section and plate was sufficiently stressed the concrete above it was weakened by cutting two 20 mm deep x 6 mm wide grooves into it. These were situated approximately 60 mm from each of the flange tips and ran the full length of the concrete slab.

The thermocouple positions in the steelwork were as shown in Fig. 3, (longitudinal arrangement), and Figs. 4(a) to 4(g), (transverse arrangements). An additional ten thermocouples were used to monitor the temperatures in the head and at the mid-height of three of the shear connectors, (see Fig. 6), and at two positions close to the mid span of the section in each type of steel reinforcement. Fourteen thermocouples were also embedded in the concrete slab at the mid-span position during casting. The positions of these thermocouples are shown in Fig. 8. The data recorded by all the additional thermocouples are shown separately in Data Sheet No. 100C.

A total imposed load of 450 kN was applied to the system at eight positions on the concrete floor slab. The rams were spaced at 530 mm intervals along the section length and were positioned on either side of it at a distance of 700 mm from the centre line, (see Figs. 7 and 9). It was necessary to concentrate the load around the mid-span of the section in order to achieve the intended load ratio of 0.56. Loading calculations are given in Appendix 2.2 and these indicate that the actual load ratio achieved was 0.58.

Data for this test are summarised in Data Sheet No. 100.

3.2.3 Test WFRC 52896

A non composite construction consisting of a universal column of serial size 203 x 203 mm x 60 kg/m and a steel plate 405 mm wide x 15 mm thick. Both the column and plate were Grade Fe 430 A material. Web stiffeners formed from 15 mm thick plate, (also Grade Fe 430 A), were welded on both sides of the section at the mid-span and roller support positions, (see Fig. 10). The protruding sections of the bottom plate were used to support simulated concrete floor slabs made up from pre-cast dense concrete blocks each 440 mm long x 140 mm wide x 215 mm deep. The space remaining between these blocks and the web of the section was filled with fine dry sand up to half the depth of the web. The assembly is shown schematically in Fig. 11.

The thermocouple positions in the steelwork were as shown in Fig. 3, (longitudinal arrangement), and Figs. 4(a) to 4(g), (transverse arrangements). One additional thermocouple was placed in the sand infill at the mid-depth, mid-width position at the centre of the supported span.

The load was applied to both the steel section and the concrete blockwork. A total imposed load of 123.88 kN was applied directly to the steel section at two points situated 970 mm either side of the mid-span position and directly over the web. In addition a total imposed load of 44.88 kN was applied to the blockwork at four positions on each side of the section. Details of the loading arrangement are shown in Figs. 11 and 12. Loading calculations are given in Appendix 2.3 and indicate that the load ratio for this system was 0.516.

Data for this test are summarised in Data Sheet No. 101.

3.2.4 Test WFRC 52897

A non composite construction consisting of a universal column of serial size 254 x 254 mm x 73 kg/m and a steel plate 455 mm wide x 15 mm thick. Both the column and plate were Grade Fe 430 A material. The

web of the section was totally encased in nominally Grade 30 concrete. The protruding sections of the bottom plate were used to support simulated concrete floor slabs made up from pre-cast dense concrete blocks each 440 mm long x 140 mm wide x 215 mm deep. The assembly is shown schematically in Fig. 13.

The thermocouple positions in the steelwork were as shown in Fig. 3, (longitudinal arrangement), and Figs. 4(a) to 4(g), (transverse arrangements).

The load was applied to both the steel section and the concrete blockwork. A total imposed load of 173.6 kN was applied directly to the steel section at two points situated 1000 mm either side of the mid-span position and directly over the web. In addition a total imposed load of 70.4 kN was applied to the blockwork at four positions on each side of the section. Details of the loading arrangements are shown in Figs. 13 and 14. The loading calculations, as given in Appendix 2.4, indicate that the load ratio for this system was 0.457.

Data for this test are summarised in Data Sheet No. 102.

3.2.5 Test WFRC 51883

A non composite construction consisting of a universal column of serial size 305 x 305 mm x 283 kg/m and a steel plate 525 mm wide x 15 mm thick. Both the column and plate were Grade Fe 430 A material. Grade 30 concrete was cast between the flanges of the section up to half the web depth. The protruding sections of the bottom plate were used to support simulated concrete floor slabs made up from pre-cast dense concrete blocks, each 440 mm long x 140 mm wide x 215 mm deep. The assembly is shown schematically in Fig. 15.

The thermocouple positions in the steelwork were as shown in Fig. 16, (longitudinal arrangement), and Figs. 17(a) to 17(i), (transverse arrangements). The overall arrangement was very similar to that used on the previous four tests but included additional locations in the bottom plate, web and fillet weld, plus two locations in the air space, (cavity), between the in-situ concrete and the underside of the top flange. The thermocouple locations in the web of the section are shown in greater detail in Fig. 18. An additional eighteen thermocouples were embedded in the concrete at the time of casting, the positions of which are shown in Fig. 19. The data recorded by these thermocouples are shown separately in Data Sheet No. 103C.

The load was applied to both the steel section and the blockwork. A total imposed load of 170.2 kN was applied directly to the steel section at two points situated 970 mm either side of the mid-span position and directly over the web. In addition a total imposed load of 221 kN was applied to the blockwork at four positions on both sides of the section. Details of the loading arrangements are shown in Fig. 20. Loading calculations given in Appendix 2.5 indicate that the load ratio for this system was 0.188.

Data for this test are summarised in Data Sheet No. 103.

3.2.6 Test No. WFRC 54278

A non composite construction consisting of a universal column of serial size 152 x 152 mm x 30 kg/m and a steel plate 355 mm wide x 15 mm thick. Both the column and plate were Grade Fe 510 B material. Grade 30 concrete was cast between the flanges of the section up to half the web depth. The protruding sections of the bottom plate were used to support simulated concrete floor slabs made up from pre-cast dense concrete blocks each 440 mm long x 140 mm wide x 215 mm deep. The assembly is shown schematically in Fig. 21.

The thermocouple positions in the steelwork were as shown in Fig. 16, (longitudinal arrangement), and Figs. 17(a) to 17(i), (transverse arrangements). The thermocouple locations in the web of the section are shown in greater detail in Fig. 22. An additional eighteen thermocouples were embedded in the concrete at the time of casting, the positions of which are shown in Fig. 19. The data recorded by these thermocouples are shown separately in Data Sheet No. 104C.

The load was applied to both the steel section and the blockwork. A total imposed load of 37.4 kN was applied directly to the steel section at two points situated 970 mm either side of the mid-span position and

directly over the web. In addition a total imposed load of 39.6 kN was applied to the blockwork at four positions on both sides of the section. Details of the loading arrangements are shown in Figs. 23 and 24. The loading calculations, given in Appendix 2.6, indicate that the load ratio for this system was 0.434.

Data for this test are summarised in Data Sheet No. 104.

3.2.7 Test No. WFRC 56867

The test assembly consisted of a universal column of serial size 254 x 254 mm x 73 kg/m and a steel plate 460 mm wide x 15 mm thick. Both the column and plate were Grade Fe 430 A material. The protruding sections of the bottom plate were used to support a galvanised sheet steel profile referred to as '210 closure flashing', the form of which is illustrated in Fig. 25. This in turn supported a 210 mm deep metal deck floor profile produced by Precision Metal Forming Ltd., (PMF), on top of which was cast a nominally 1 metre wide x 90 mm thick concrete slab incorporating A142 reinforcing mesh. A special feature of the assembly was the inclusion of four 160 mm diameter ducts passing through the web of the section. Details of the assembly are shown schematically in Figs. 26 to 28, the latter of which is reproduced with the permission of PMF.

The assembly was designed and loaded on the basis that there would be no composite action between the steel and concrete components. It was appreciated however, that in practise a significant, (but uncertain), degree of longitudinal shear transfer, (section to slab), would occur.

The five principal thermocouple positions in the steelwork were as shown in Fig. 29, (longitudinal arrangement), and Figs. 30(a) to 30(d), (transverse arrangements). A further twelve thermocouples were located in the web and lower flange of the section, in the region between the two central service ducts. Thermocouples were also located at the geometric centres of both of these ducts. The longitudinal disposition of all the additional thermocouples is shown in Fig. 31 and transverse sections are shown in Figs. 32(a) to 32(d). Seven thermocouples were embedded in the concrete infill at the mid-span position during casting. Their positions are shown in Fig. 33. The data recorded by these thermocouples are shown separately in Data Sheet No. 105D.

A total imposed load of 300 kN was applied directly to the steel section at four points along its supported length and directly over the web. The rams were spaced at 1125 mm intervals along the section length as shown in Fig. 34. The loading calculations, given in Appendix 2.7, indicate that the load ratio for this system was 0.52.

Data for this test are summarised in Data Sheet No. 105.

3.3 Indicative Test Assembly

Data were obtained for one full length indicative slim floor beam, (Test No. WFRC 51884). In terms of construction the test assembly was identical in all respects to Test No. WFRC 54278, details of which have already been given in Section 3.2.6. It was initially loaded in the manner described for that test but difficulties arose during the course of the test which rendered the fire rating outcome questionable. The thermal data which were recorded are, however, perfectly valid and these, together with other relevant test data, are summarised in Data Sheet No. 106.

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L.W.

TABLE 1
COMPARISON BETWEEN BS4360:1986 AND BS EN10025:1990 SPECIFICATIONS FOR THE STEEL GRADES USED IN THE FIRE RESISTANCE TESTS (CHEMICAL ANALYSES)

	C % max.	Si % max.	Mn % max.	P % max.	S % max.	Nb % max.	V % max.	N % max.
BS4360:1986:Grade 43A								
Ladle Analysis	0.25	0.50	1.60	0.050	0.050	-	-	-
Product Analysis	0.30	0.55	1.70	0.060	0.060	-	-	-
BS EN10025:1990:Grade Fe 430 A								
Ladle Analysis	0.25	0.50	1.60	0.050	0.050	-	-	-
Product Analysis	NOT GIVEN							
BS4360:1986:Grade 50B								
Ladle Analysis	0.20	0.50	1.50	0.050	0.050	0.10	0.10	-
Product Analysis	0.24	0.55	1.60	0.060	0.060	0.10	0.10	
BS EN10025:1990:Grade Fe 510 B								
Ladle Analysis	0.24	0.55	1.60	0.045	0.045	-	-	0.009
Product Analysis	0.27	0.60	1.70	0.055	0.055	-	-	0.014

TABLE 2
COMPARISON BETWEEN BS4360:1986 AND BS EN10025:1990 SPECIFICATIONS FOR THE STEEL GRADES USED IN THE FIRE RESISTANCE TESTS (MECHANICAL PROPERTIES)

	Thickness Range mm		Minimum Yield Strength N/mm²	Tensile Strength N/mm²	Minimum % Elongation Lo = 5.65√So
BS4360:1986 Grade 43A		≤16	275	430/580	22
	>16	≤40	265		
	>40	≤63	255		
	>63	≤100	245		
BS EN10025:1990 Grade Fe 430 A		≤3	275	430/580	22
	>3	≤16		410/560	
	>16	≤40	265		
	>40	≤63	255		21
	>63	≤80	245		20
	>80	≤100	235		
BS4360:1986 Grade 50B		≤16	355	490/640	20
	>16	≤40	345		
	>40	≤63	340		
	>63	≤100	325		
BS EN10025:1990 Grade Fe 510 B		≤3	355	510/680	22
	>3	≤16		490/630	
	>16	≤40	345		
	>40	≤63	335		21
	>63	≤80	325		20
	>80	≤100	315		

TABLE 3
SUMMARY OF THE MAJOR FEATURES OF THE SLIM FLOOR TEST BEAMS

Test Date	WFRC Test Number	Nominal Section and Plate Dimensions mm x mm x kg/m	Steel Grade	Floor Slab Details	Load Bearing Capacity mins	Nominal Load Ratio	Comments	Data Sheet Number
25.09.90	50521	254 x 254 x 107 460 x 15	Fe 430 A	7 Tembo Slabs Per Side 1500(L) x 600(W) x 200(D)	60	0.55	Dry Sand Infill between Slabs and Web. Dry Sand Cover to Top Flange. Load Applied to Steel Beam Only.	99
14.11.90	50522	203 x 203 x 86 425 x 15	Fe 430 A	Beam Encased in Cast Concrete Slab 1700(W) x 350(D)	67	0.58	2 Rows of Shear Connectors Welded to Top Flange. Load Applied to Concrete Floor. Composite Construction.	100
08.02.91	52896	203 x 203 x 60 405 x 15	Fe 430 A	Precast Concrete Blocks 440(L) x 140(W) x 215(D)	83	0.516	Web Stiffeners at Mid-Span and Roller Supports. In-Filled with Dry Sand to ½ Height of Web. Load Applied to both Steel Beam and Blockwork.	101
14.02.91	52897	254 x 254 x 73 455 x 15	Fe 430 A	Precast Concrete Blocks 440(L) x 140(W) x 215(D)	83	0.457	Concrete Infill between Flanges. Load Applied to both Steel Beam and Blockwork.	102
07.08.91	51883	305 x 305 x 283 525 x 15	Fe 430 A	Precast Concrete Blocks 440(L) x 140(W) x 215(D)	90	0.188	Concrete between Flanges to ½ Height of Web. Load Applied to both Steel Beam and Blockwork.	103
31.10.91	54278	152 x 152 x 30 355 x 15	Fe 510 B	Precast Concrete Blocks 440(L) x 140(W) x 215(D)	72	0.434	Concrete between Flanges to ½ Height of Web. Load Applied to both Steel Beam and Blockwork.	104
04.11.92	56867	254 x 254 x 73 460 x 15	Fe 430 A	PMF 210 Metal Deck Plus 90 mm Concrete Cover	62	0.52	Service Ducts Passing Through Web. Load Applied to Steel Beam Only.	105
31.07.91	51884	152 x 152 x 30 355 x 15	Fe 510 B	Precast Concrete Blocks 440(L) x 140(W) x 215(D)	FULL LENGTH INDICATIVE		Construction as for WFRC 54278.	106

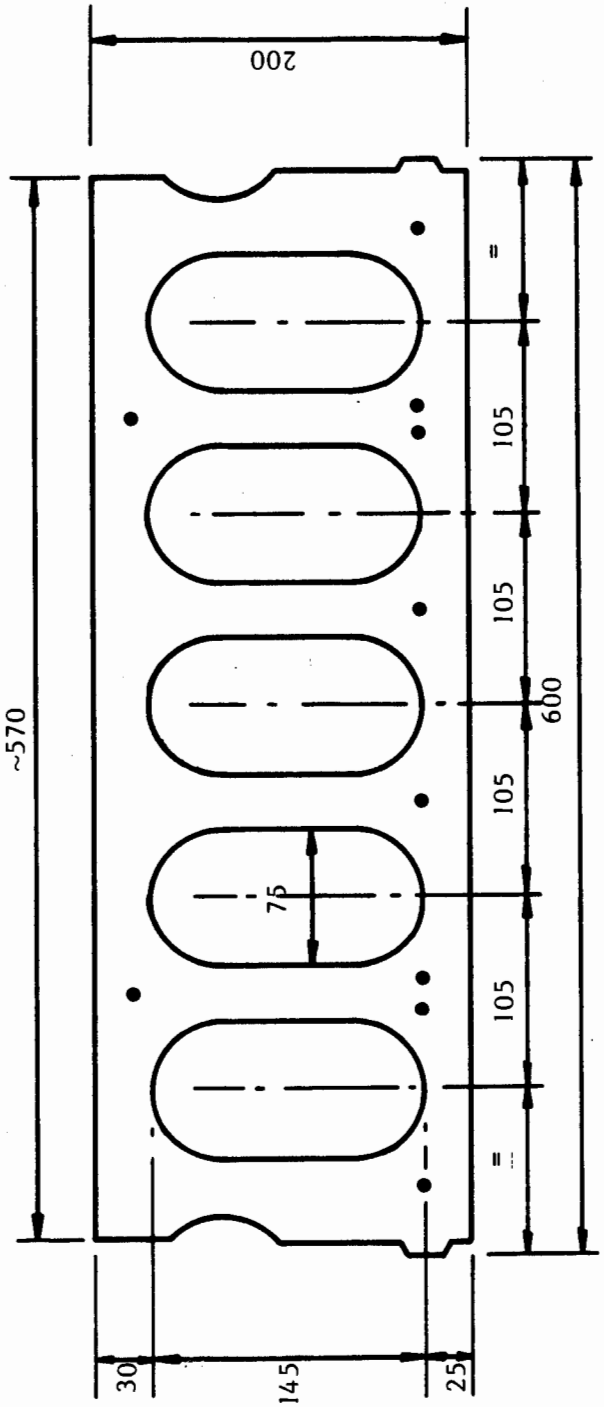


FIG. 1 NOMINAL PRINCIPAL DIMENSIONS OF RICHARD LEES 'TEMBO' REINFORCED CONCRETE FLOOR SLAB TEST NO. WFRC 50521 (R4/22)

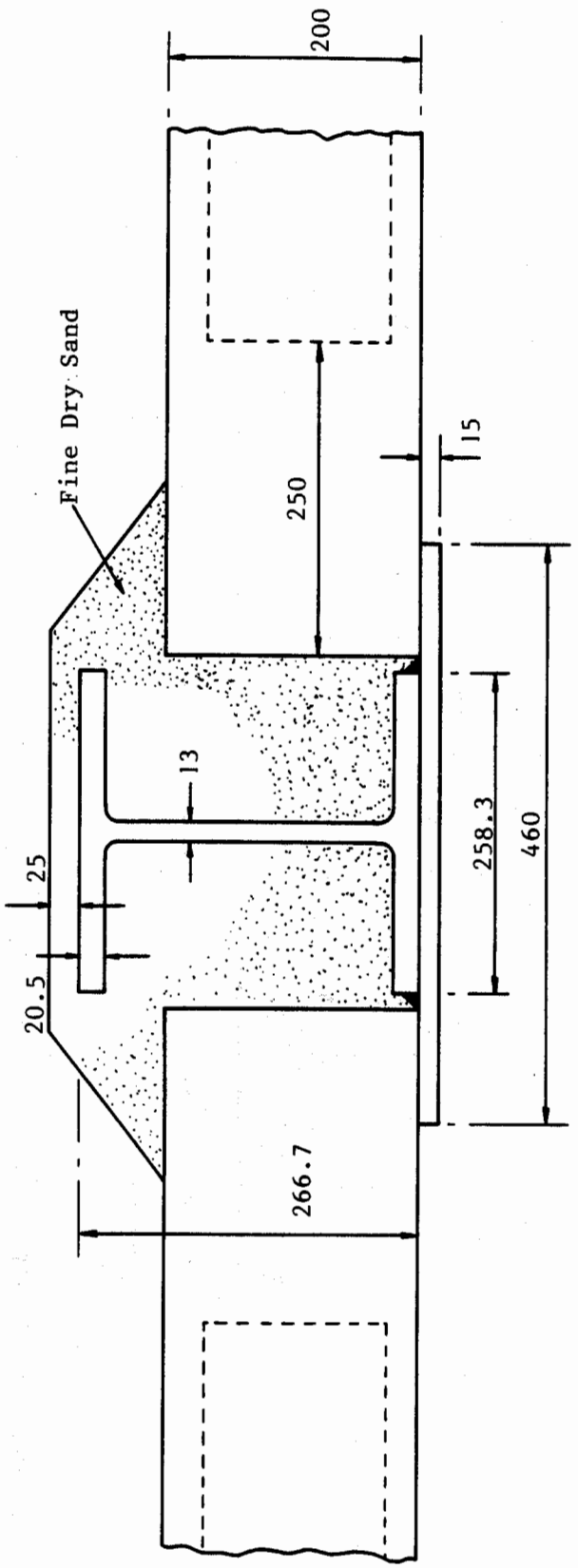


FIG. 2 SCHEMATIC ARRANGEMENT OF COMPONENTS - TEST NO. WFRC 50521 (TRANSVERSE SECTION) (R4/23)
(BASED ON NOMINAL DIMENSIONS)

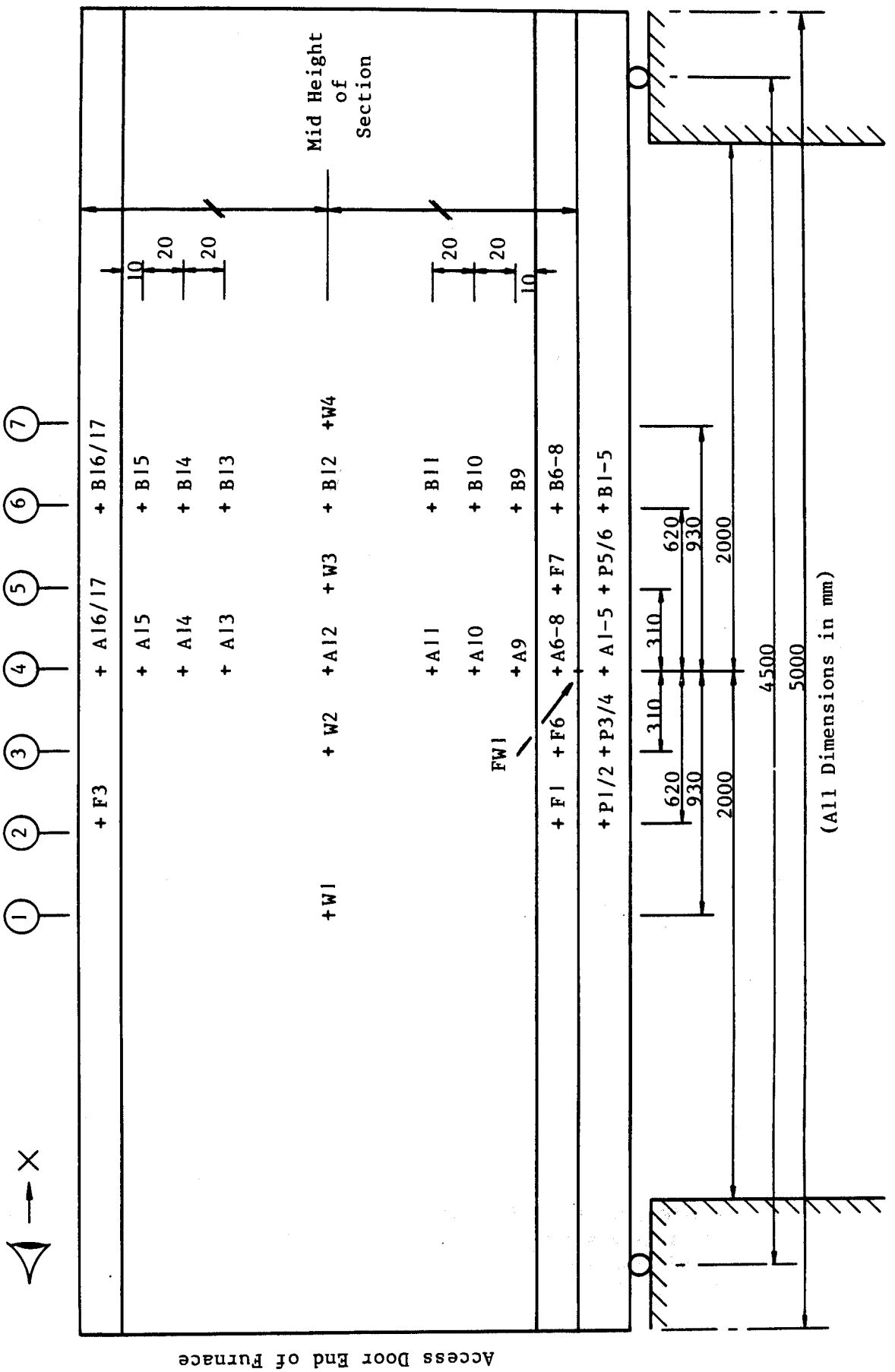
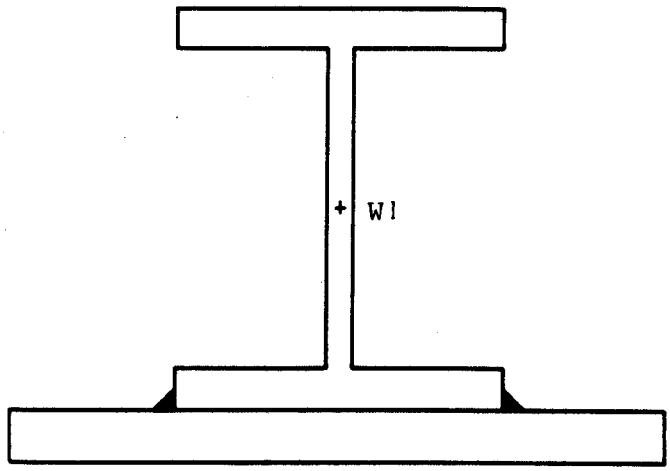
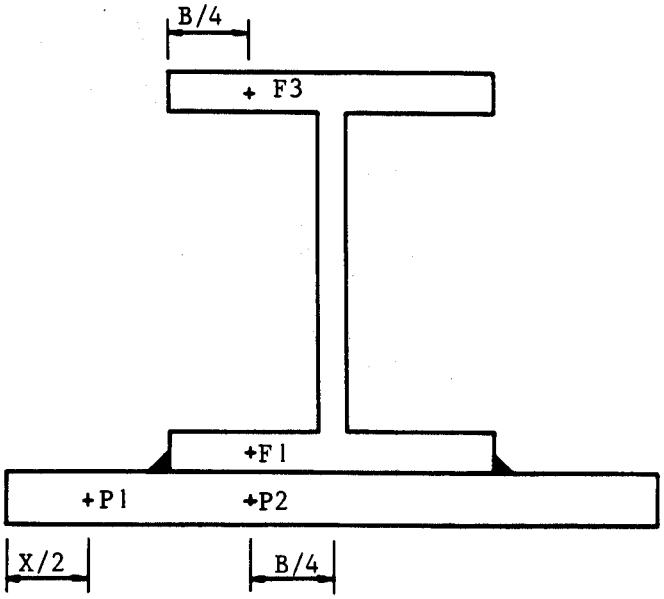


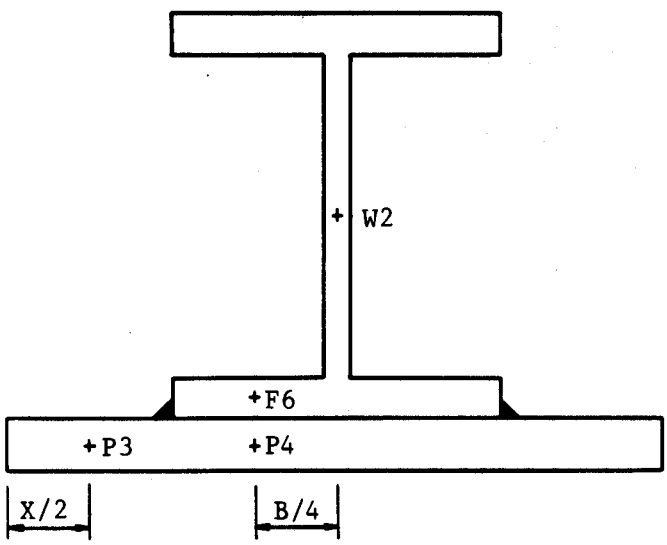
FIG. 3 THERMOCOUPLE POSITIONS IN THE STEELWORK - LONGITUDINAL ARRANGEMENT (R4/24)
APPLICABLE TO TESTS WFRC 50521, 50522, 52896 AND 52897



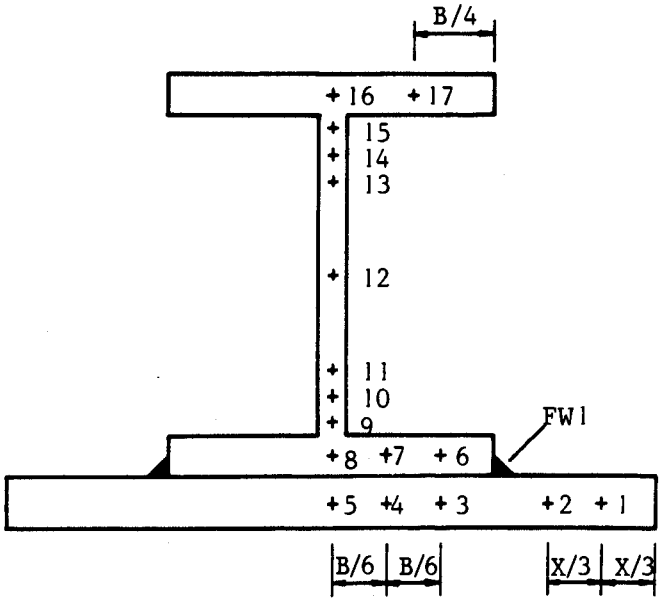
(a) Position 1



(b) Position 2

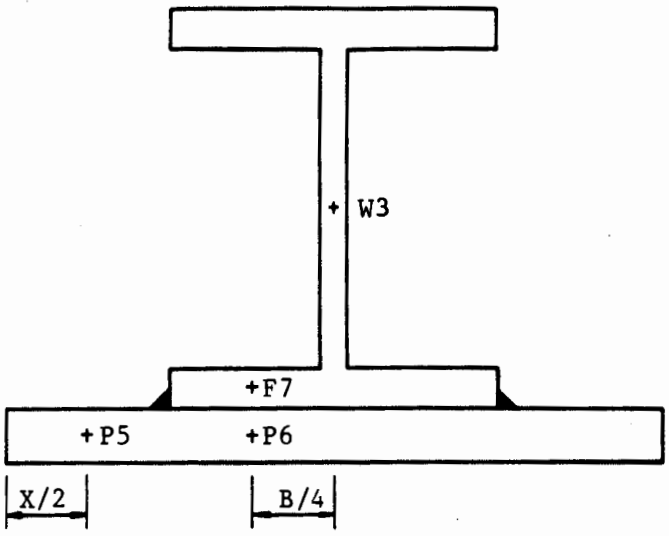


(c) Position 3

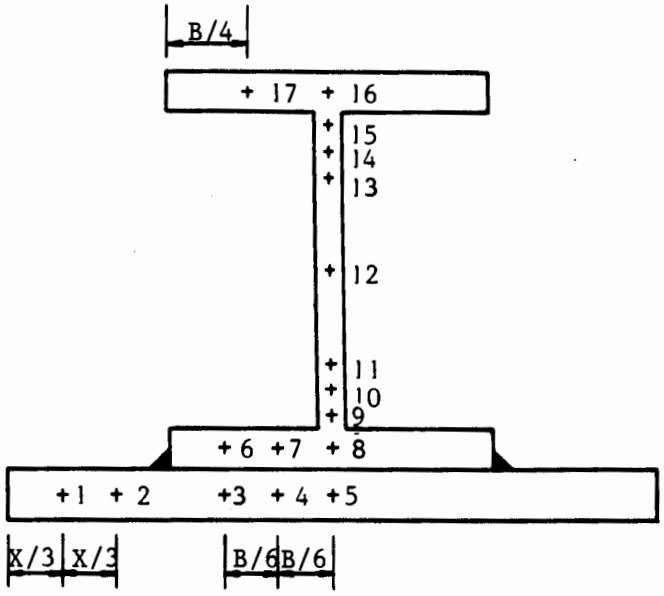


(d) Position 4 Prefix A

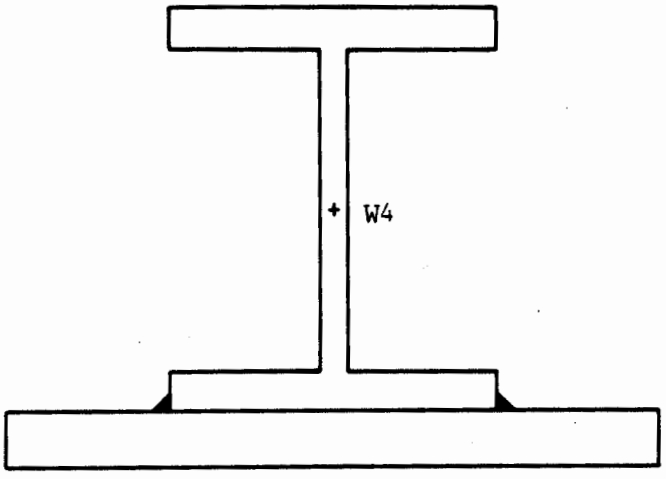
FIG. 4 (Contd...) **THERMOCOUPLE POSITIONS IN THE STEELWORK - TRANSVERSE ARRANGEMENTS AT POSITIONS 1-7 VIEWED IN DIRECTION OF ARROW X IN FIG. 3 APPLICABLE TO TESTS WFRC 50521, 50522, 52896 AND 52897** **(R4/25)**



(e) Position 5



(f) Position 6 Prefix B



(g) Position 7

FIG. 4 THERMOCOUPLE POSITIONS IN THE STEELWORK (R4/26)
- TRANSVERSE ARRANGEMENTS AT POSITIONS 1-7
VIEWED IN DIRECTION OF ARROW X IN FIG. 3
APPLICABLE TO TESTS WFRC 50521, 50522, 52896 AND 52897

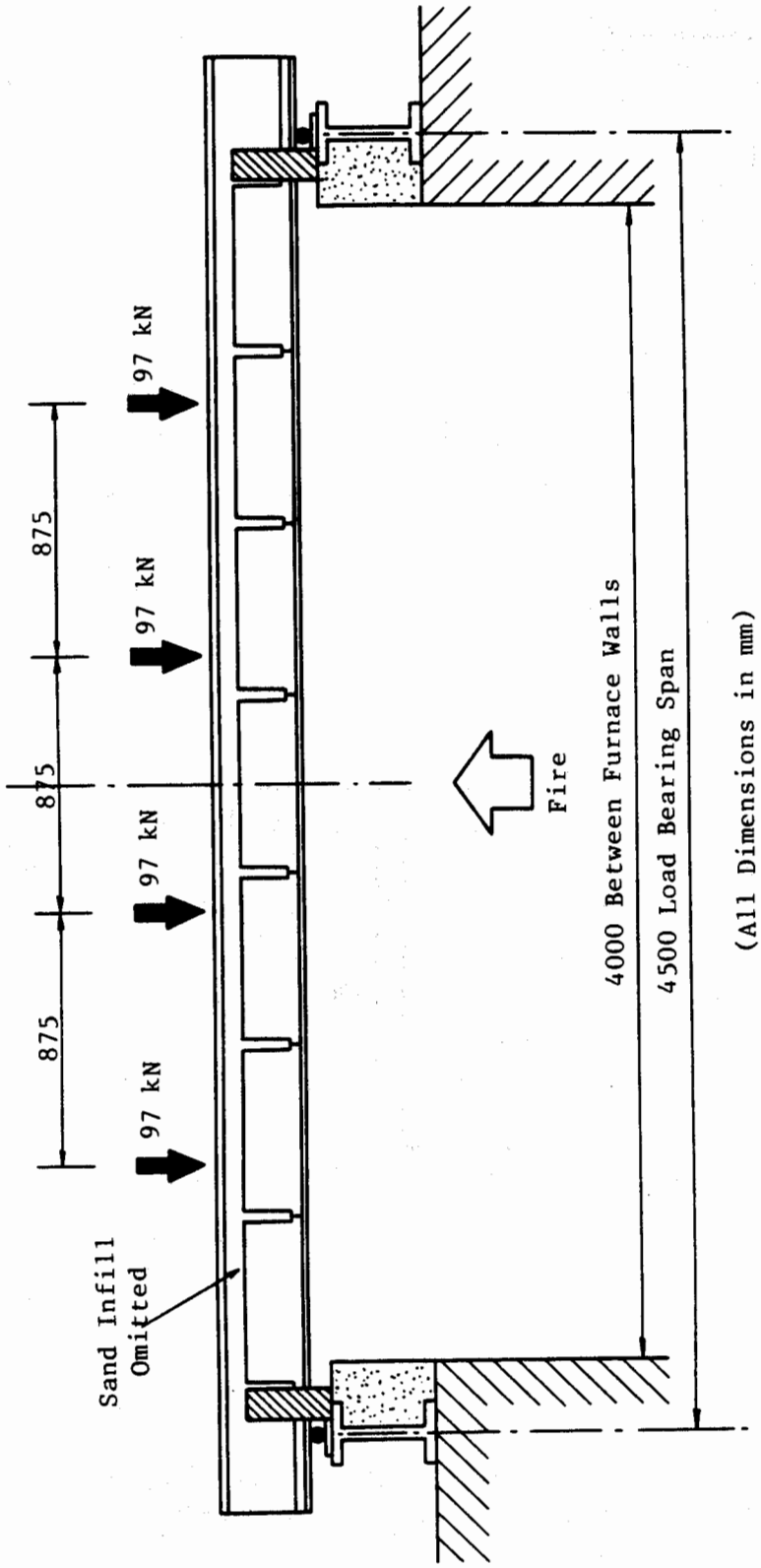
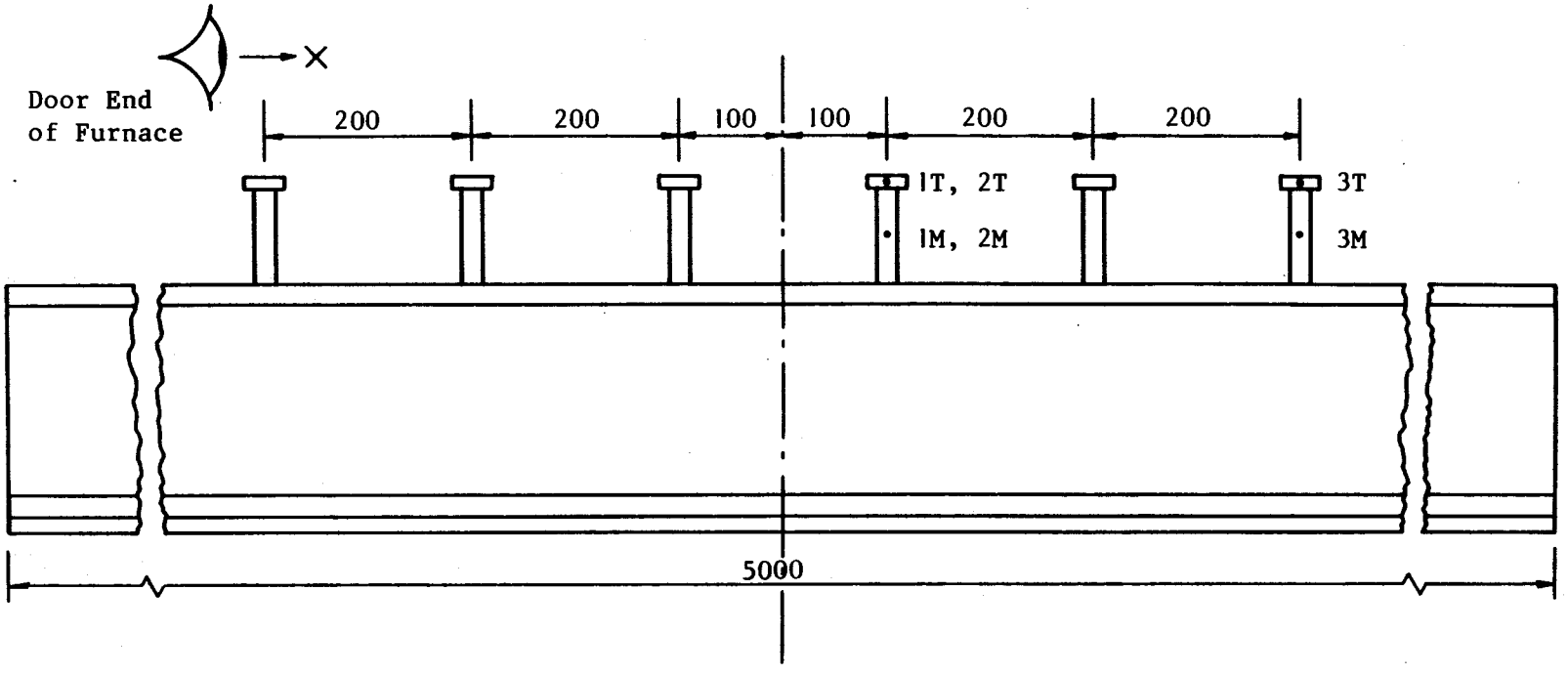
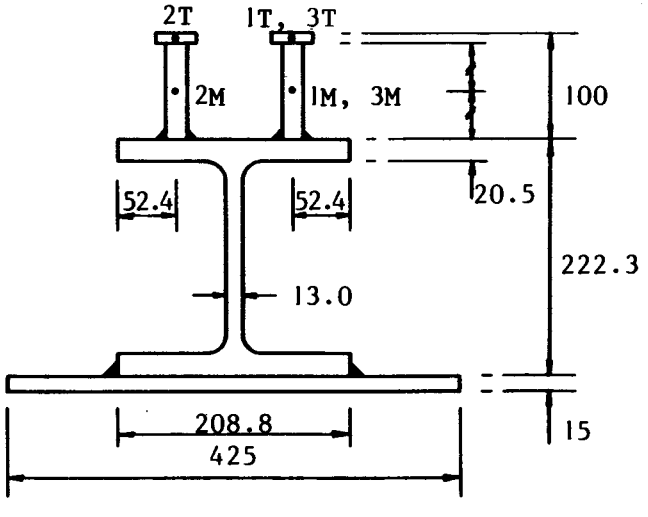


FIG. 5 APPLIED LOAD POSITIONS - LONGITUDINAL ARRANGEMENT - TEST NO. WFRC 50521 (R4/27)

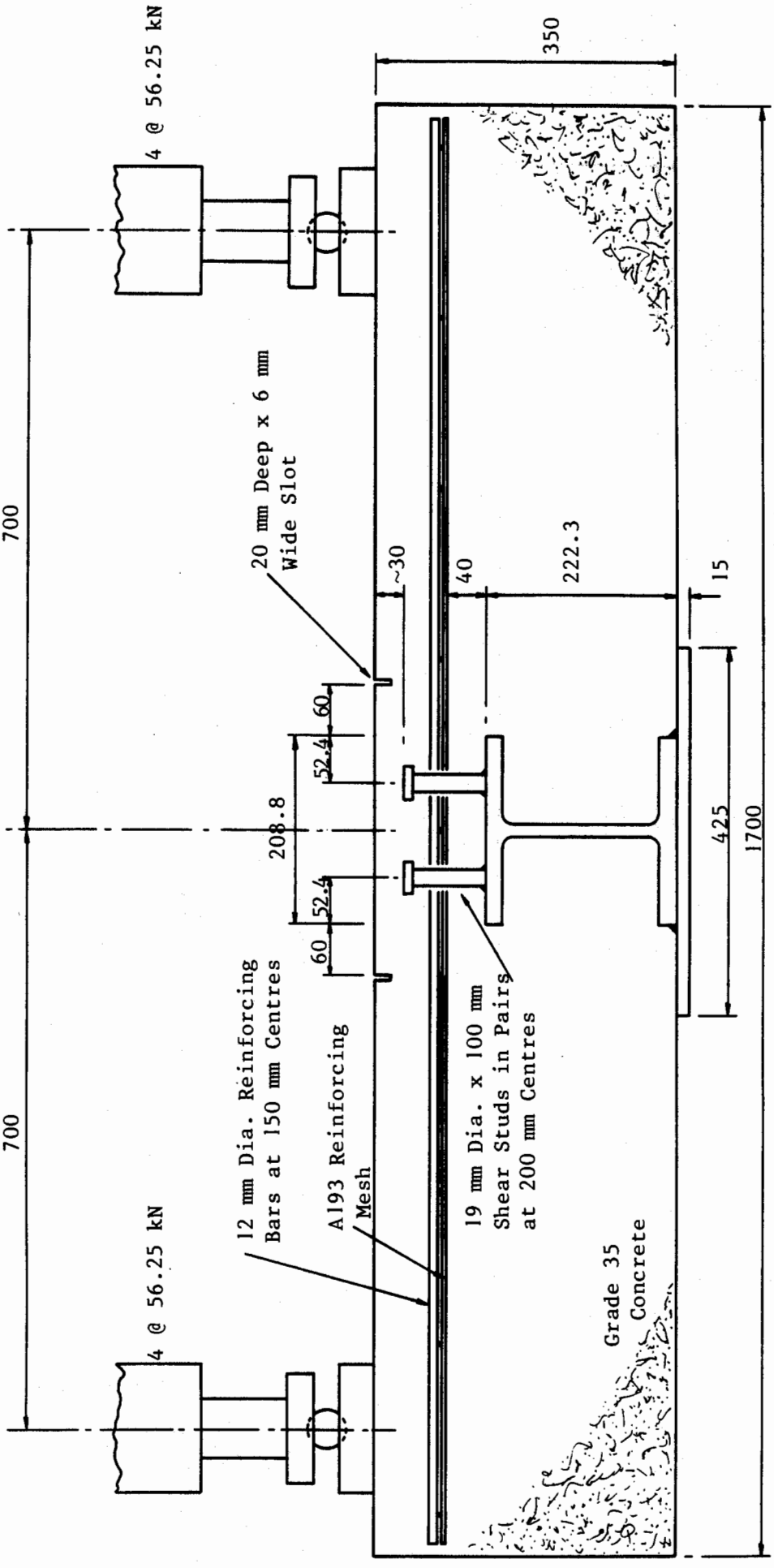


(All Dimensions in mm)



View in Direction of Arrow X

FIG. 6 POSITIONS OF THE SHEAR CONNECTORS AND THERMOCOUPLES - TEST NO. WFRC 50522 (R4/28)
(BASED ON NOMINAL DIRECTIONS)



(All Dimensions in mm)

FIG. 7 SCHEMATIC ARRANGEMENT OF COMPONENTS - TEST NO. WFRC 50522 (TRANSVERSE SECTION) (R4/29)
(BASED ON NOMINAL DIMENSIONS)

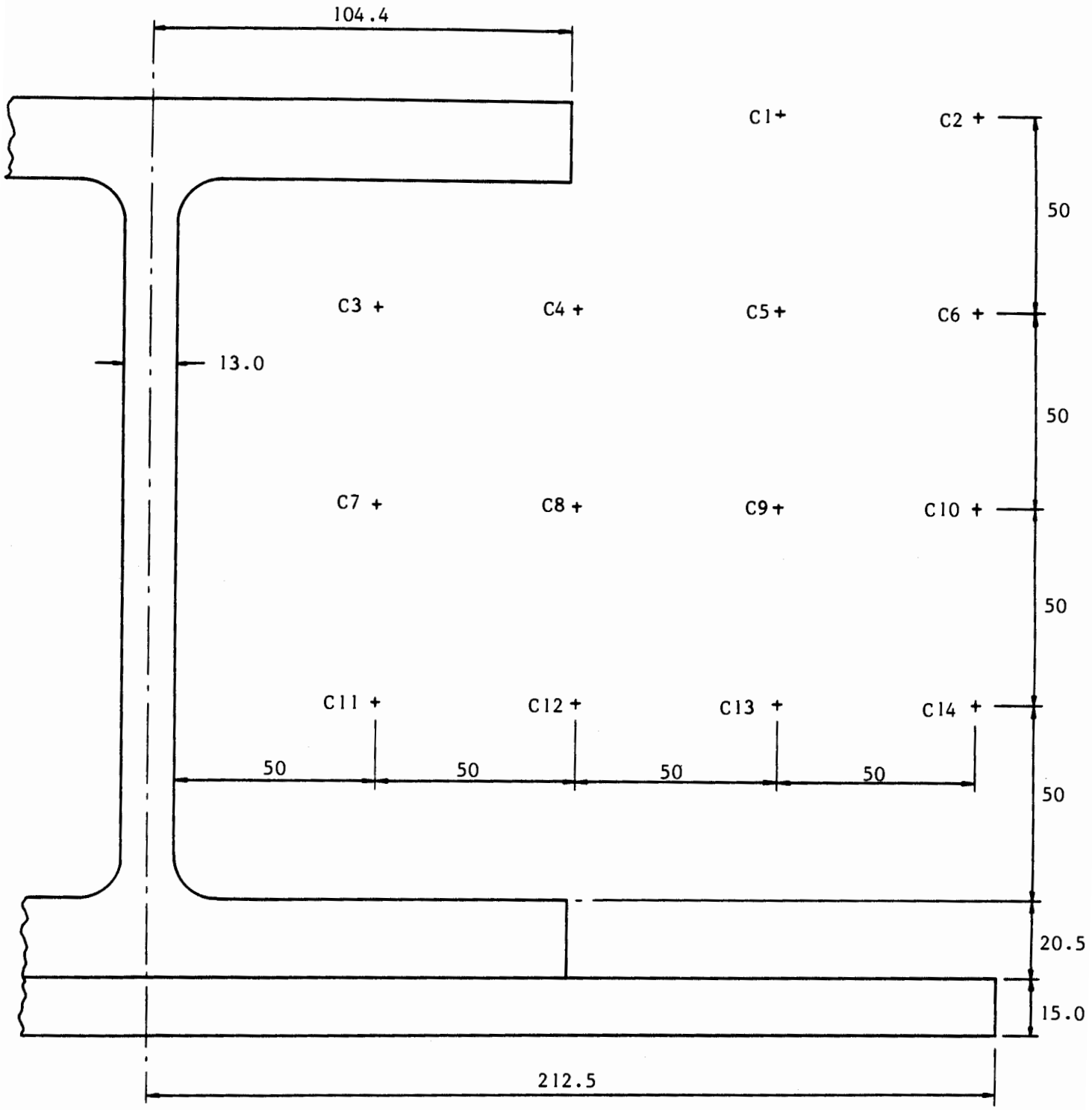
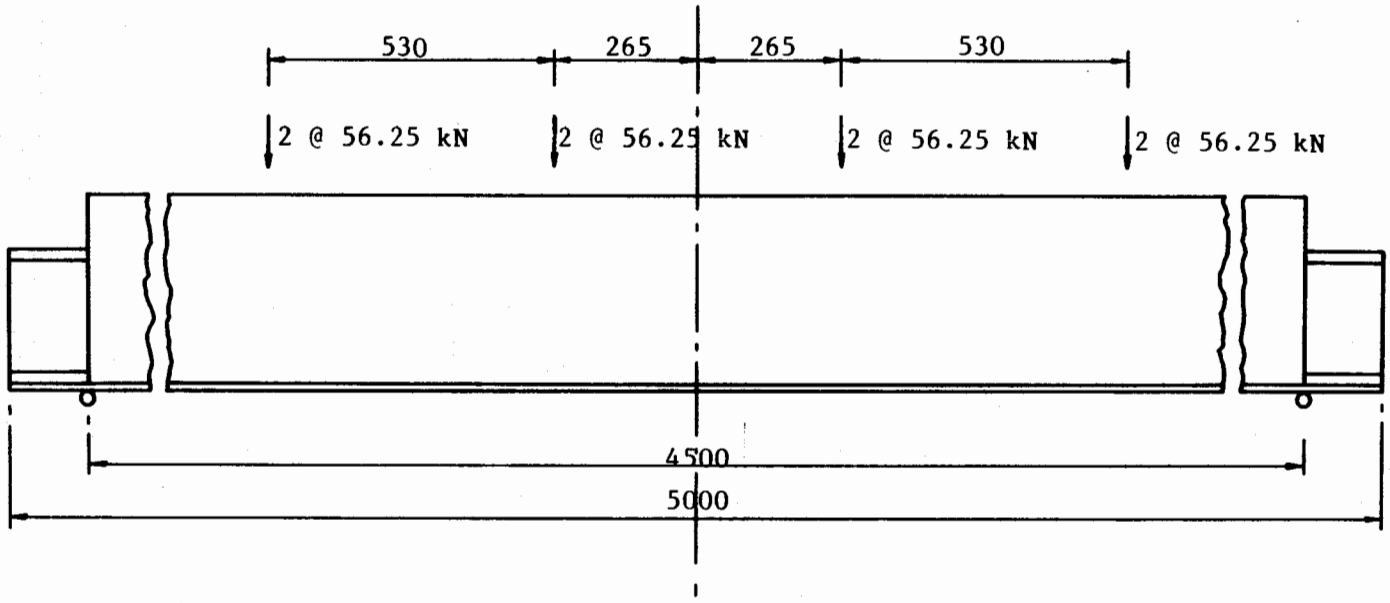


FIG. 8 THERMOCOUPLE POSITIONS IN THE CONCRETE - TRANSVERSE ARRANGEMENT AT THE MID-SPAN POSITION - TEST NO. WFRC 50522 (BASED ON NOMINAL DIMENSIONS, mm) (R4/30)



(All Dimensions in mm)

FIG. 9 APPLIED LOAD POSITIONS - TEST NO. WFRC 50522 (LONGITUDINAL ARRANGEMENT) (R4/31)

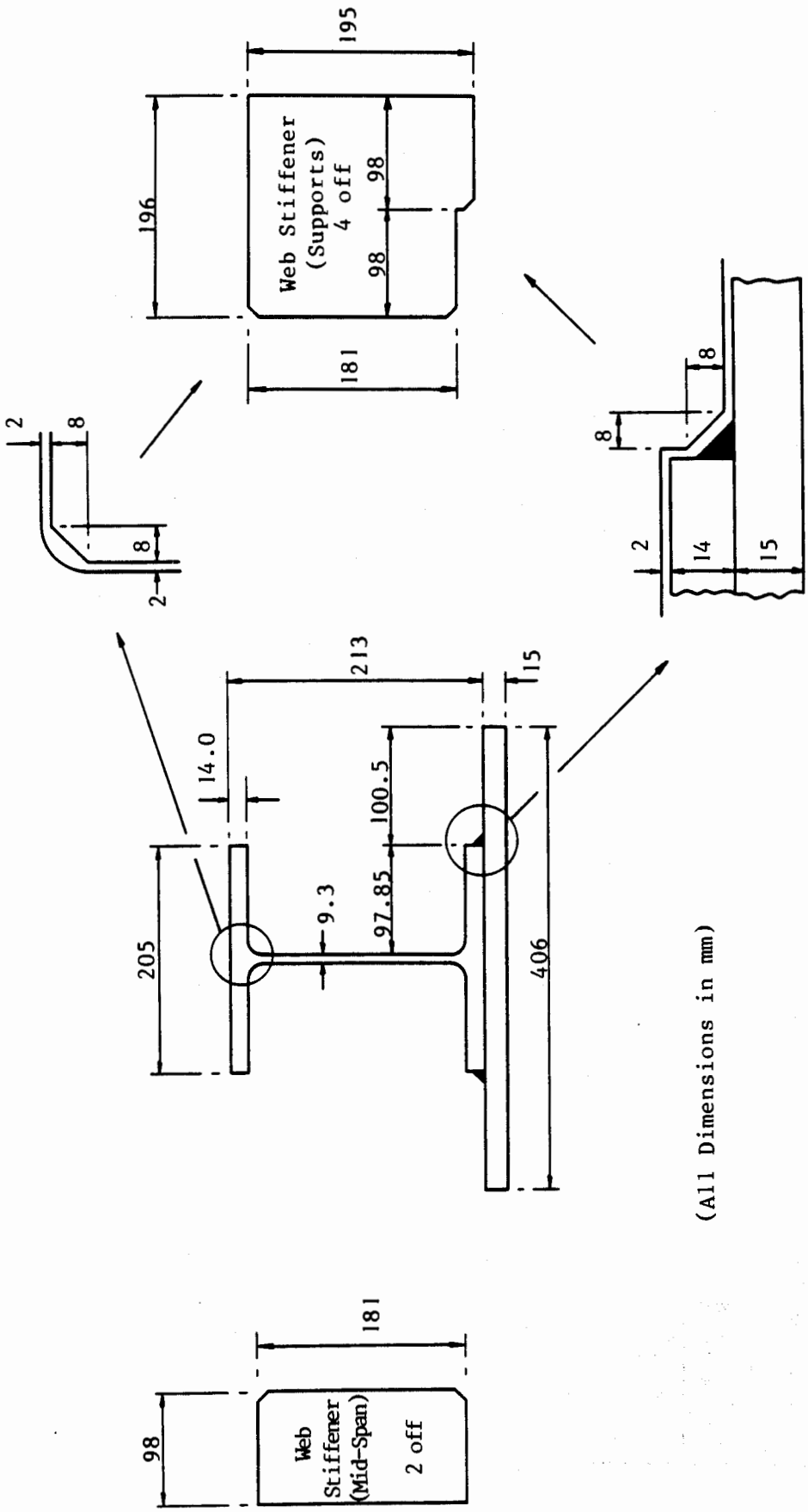


FIG. 10 DETAILS OF THE WEB STIFFENERS - TEST NO. WFRC 52896 (R4/32)
(BASED ON ACTUAL DIMENSIONS, mm)

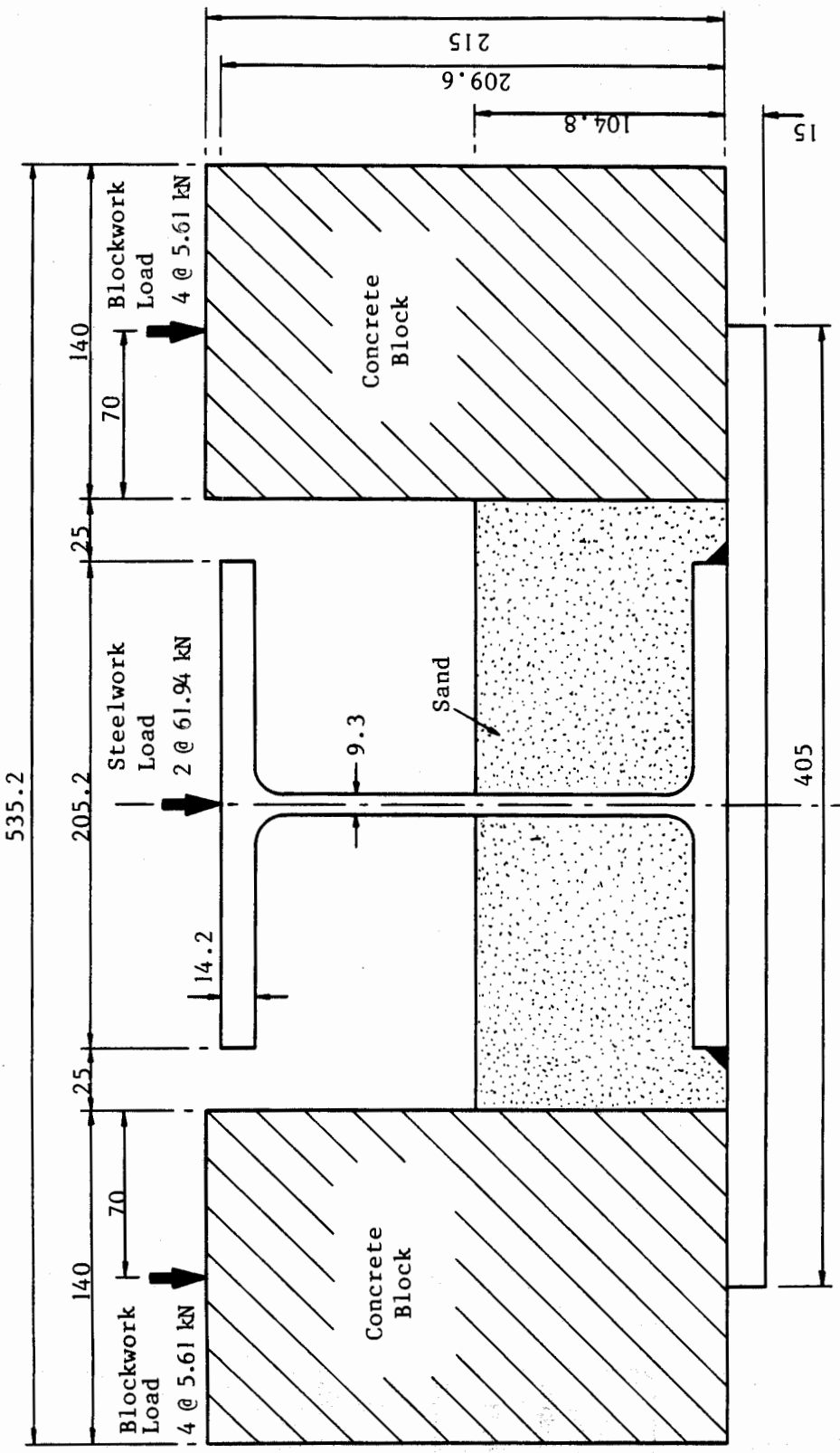


FIG. 11 SCHEMATIC ARRANGEMENT OF COMPONENTS - TEST NO. WFRC 52896 (TRANSVERSE SECTION) (R4/33)
BASED ON NOMINAL DIMENSIONS

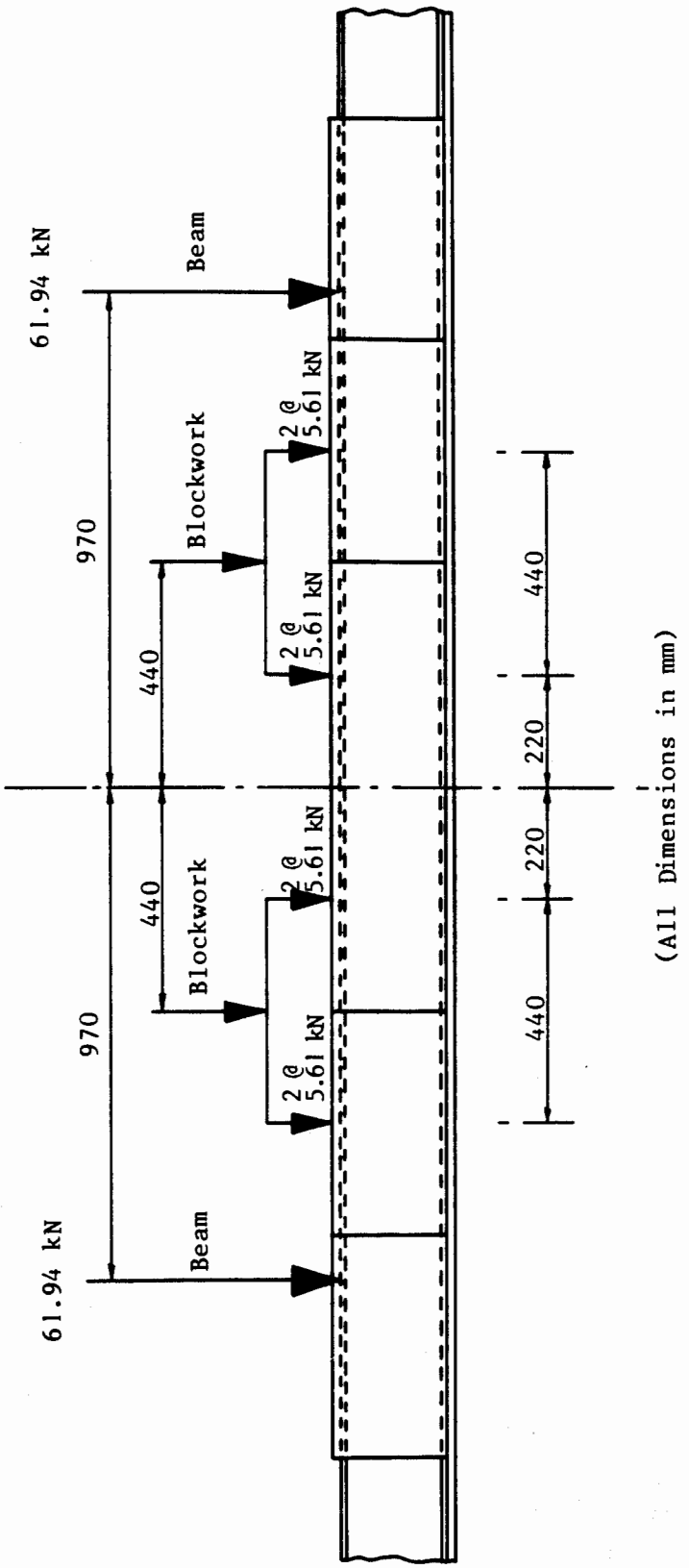
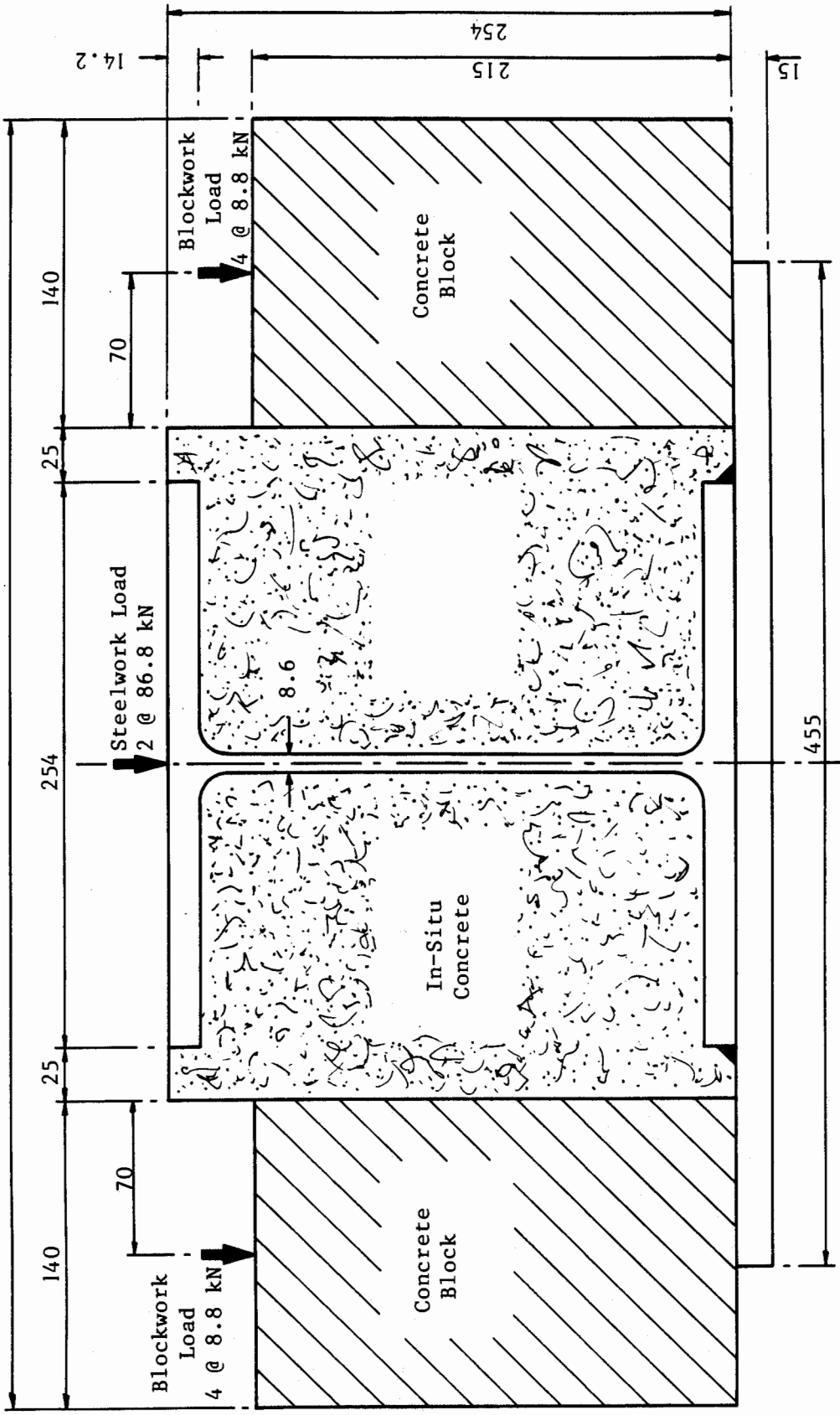


FIG. 12 APPLIED LOAD POSITIONS - LONGITUDINAL ARRANGEMENT - TEST NO. WFRC 52896 (R4/34)



(All Dimensions in mm)

FIG. 13 SCHEMATIC ARRANGEMENT OF COMPONENTS - TEST NO. WFRC 52897 (TRANSVERSE SECTION) (R4/35)
BASED ON NOMINAL DIMENSIONS

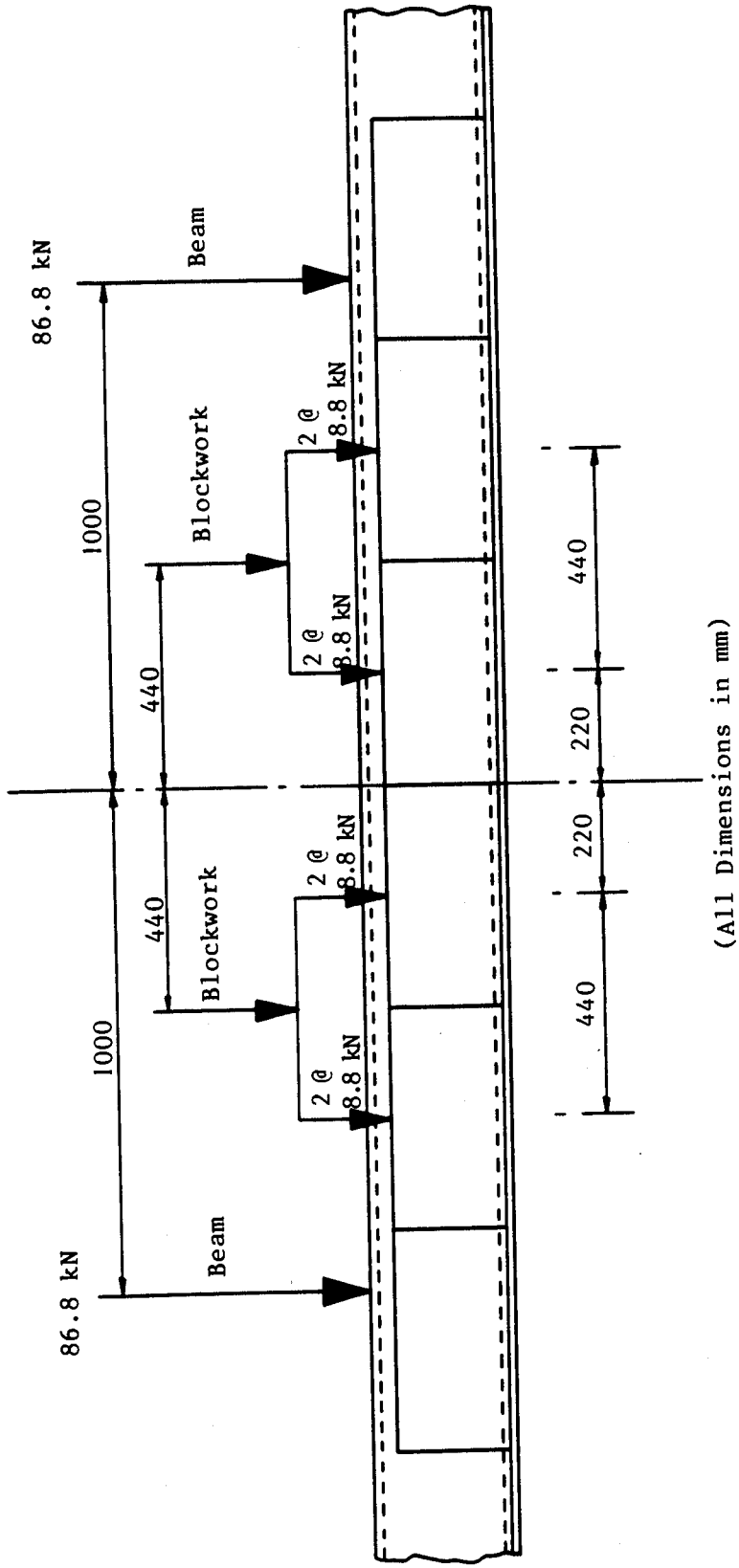


FIG. 14 APPLIED LOAD POSITIONS - LONGITUDINAL ARRANGEMENT - TEST NO. WFRC 52897 (R4/36)

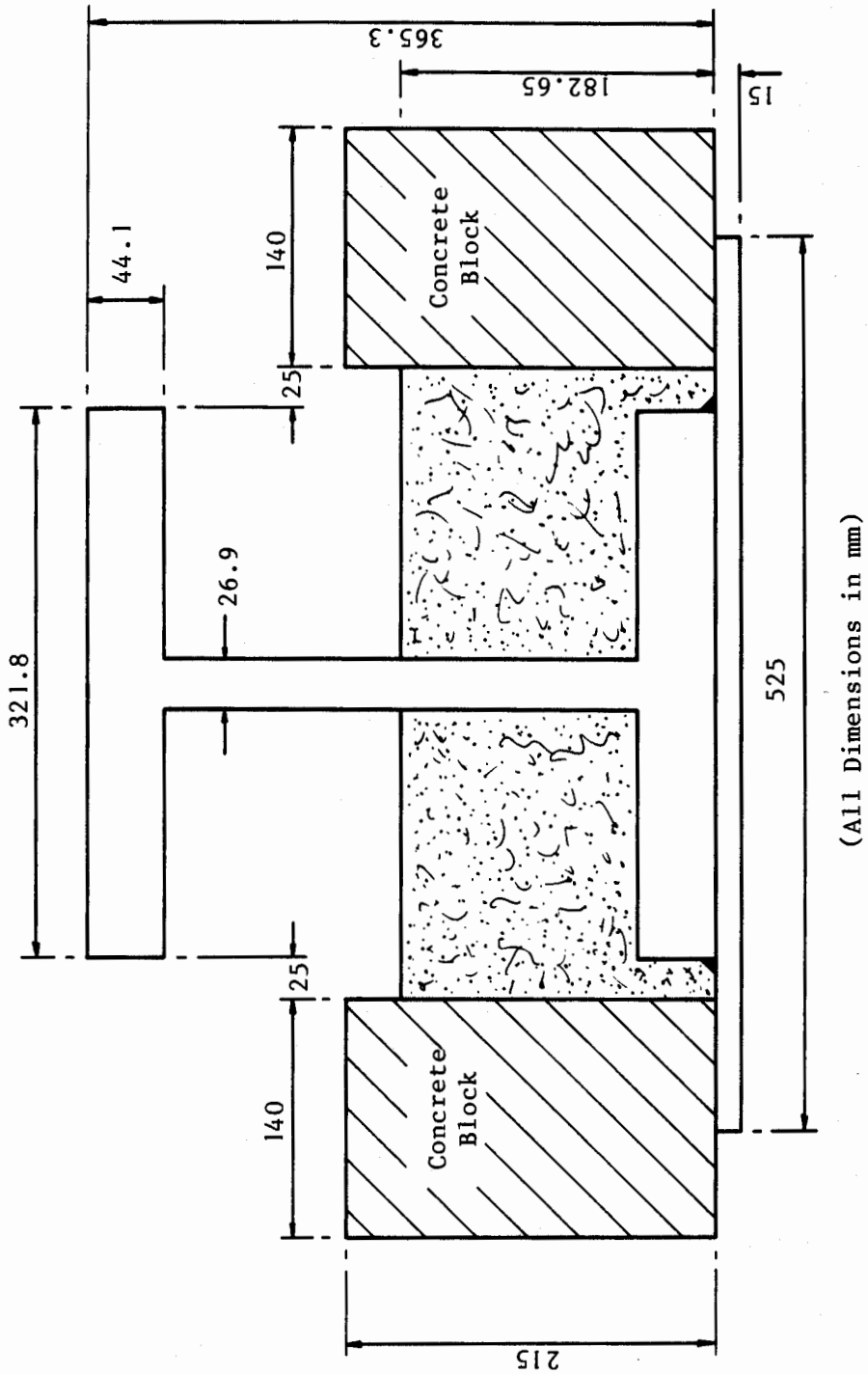


FIG. 15 SCHEMATIC ARRANGEMENT OF COMPONENTS - TEST NO. WFRC 51883 (R4/37)
BASED ON NOMINAL DIMENSIONS

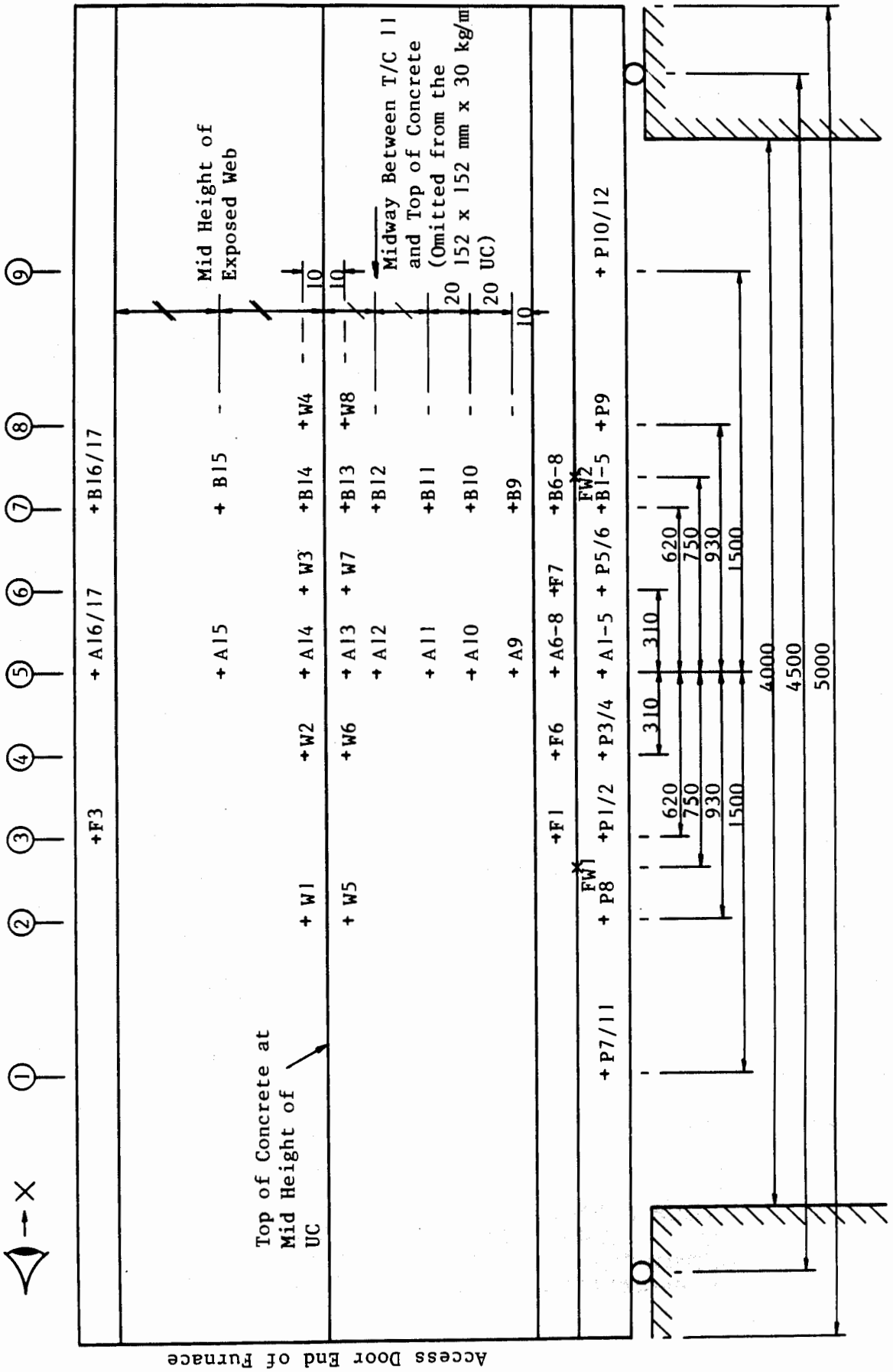
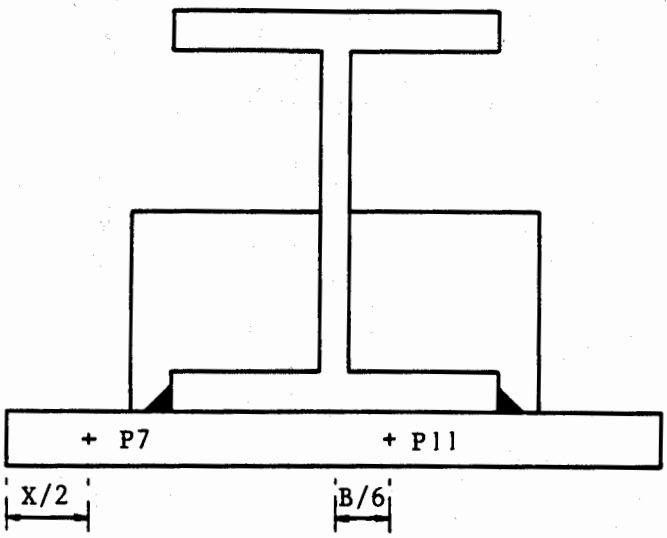
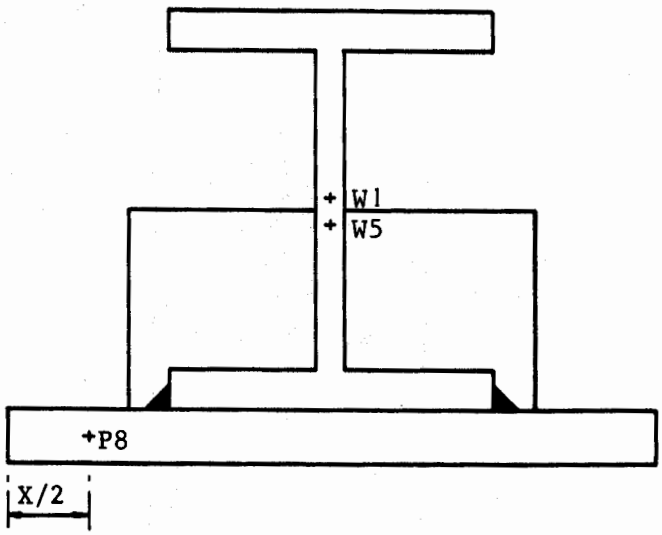


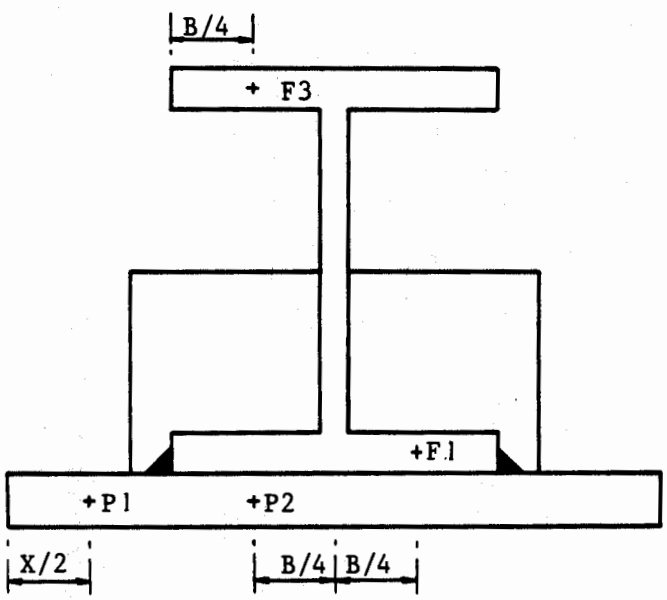
FIG. 16 THERMOCOUPLE POSITIONS IN THE STEELWORK - LONGITUDINAL ARRANGEMENT (R4/38)
APPLICABLE TO TESTS WFRC 51883, 51884 AND 54278



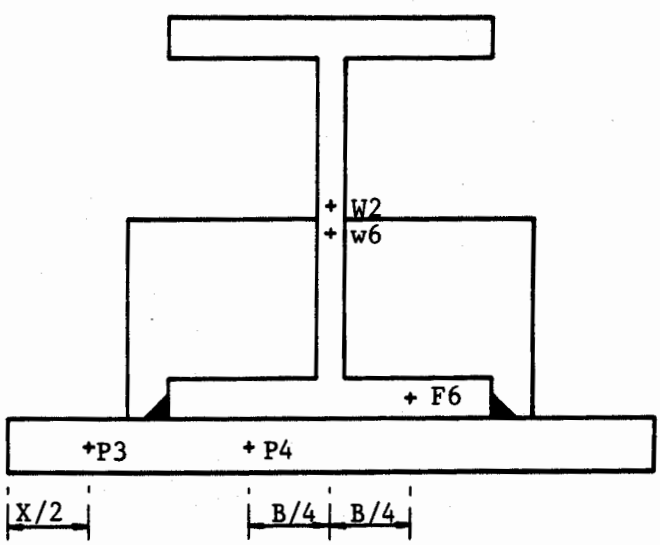
(a) Position 1



(b) Position 2

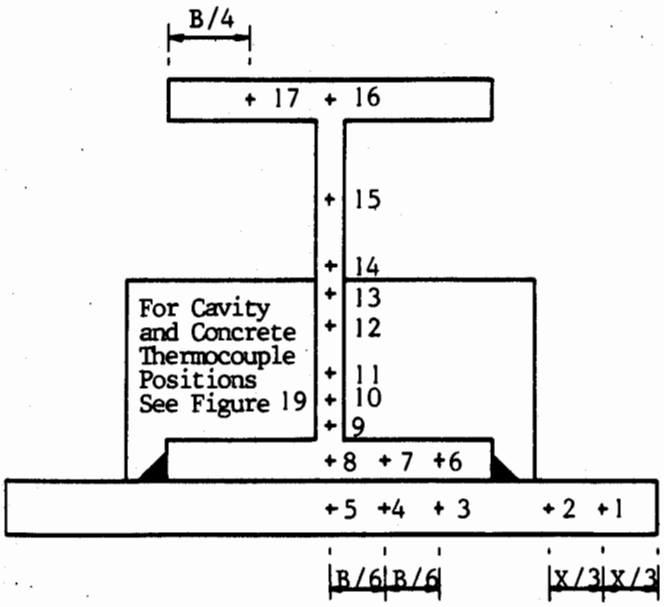


(c) Position 3

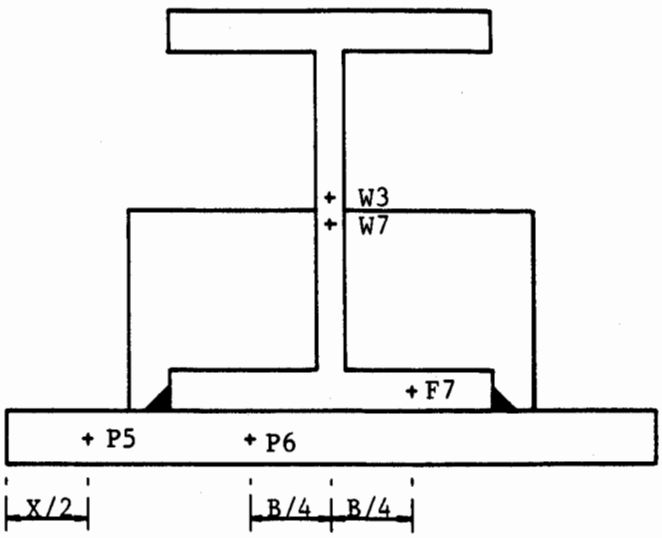


(d) Position 4

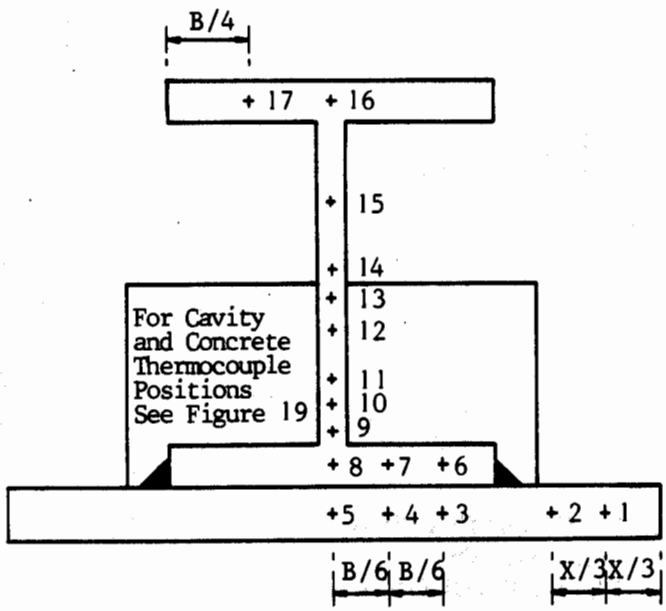
FIG. 17 (Contd...) **THERMOCOUPLE POSITIONS IN THE STEELWORK - TRANSVERSE ARRANGEMENTS AT POSITIONS 1-9 VIEWED IN DIRECTION OF ARROW X IN FIG. 16 APPLICABLE TO TESTS WFRC 51883, 51884 AND 54278** **(R4/39)**



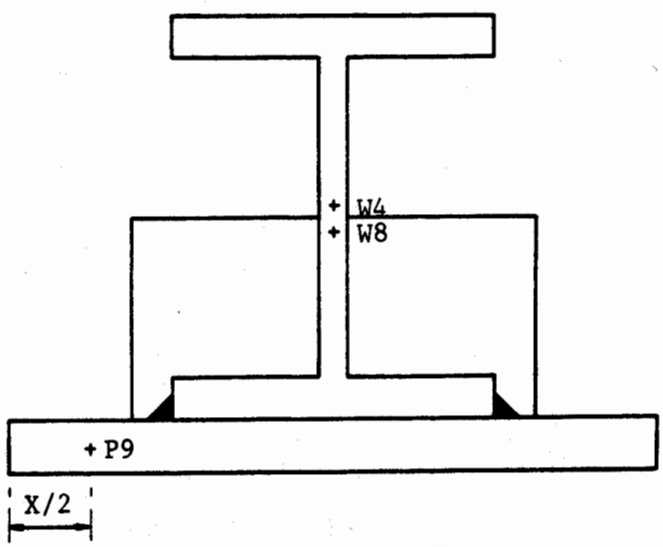
(e) Position 5 Prefix A



(f) Position 6

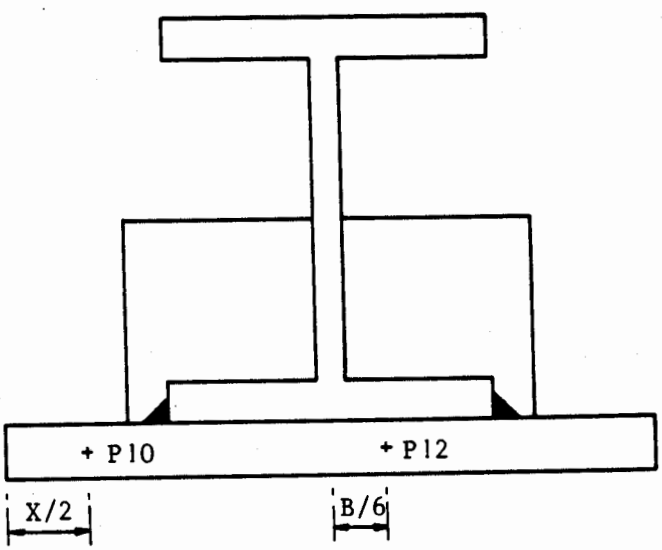


(g) Position 7 Prefix B



(h) Position 8

FIG. 17 (Contd...) **THERMOCOUPLE POSITIONS IN THE STEELWORK - TRANSVERSE ARRANGEMENTS AT POSITIONS 1-9 VIEWED IN DIRECTION OF ARROW X IN FIG. 16 APPLICABLE TO TESTS WFRC 51883, 51884 AND 54278** **(R4/40)**



(i) Position 9

FIG. 17 **THERMOCOUPLE POSITIONS IN THE STEELWORK - TRANSVERSE ARRANGEMENTS AT POSITIONS 1-9 VIEWED IN DIRECTION OF ARROW X IN FIG. 16 APPLICABLE TO TESTS WFRC 51883, 51884 AND 54278** **(R4/41)**

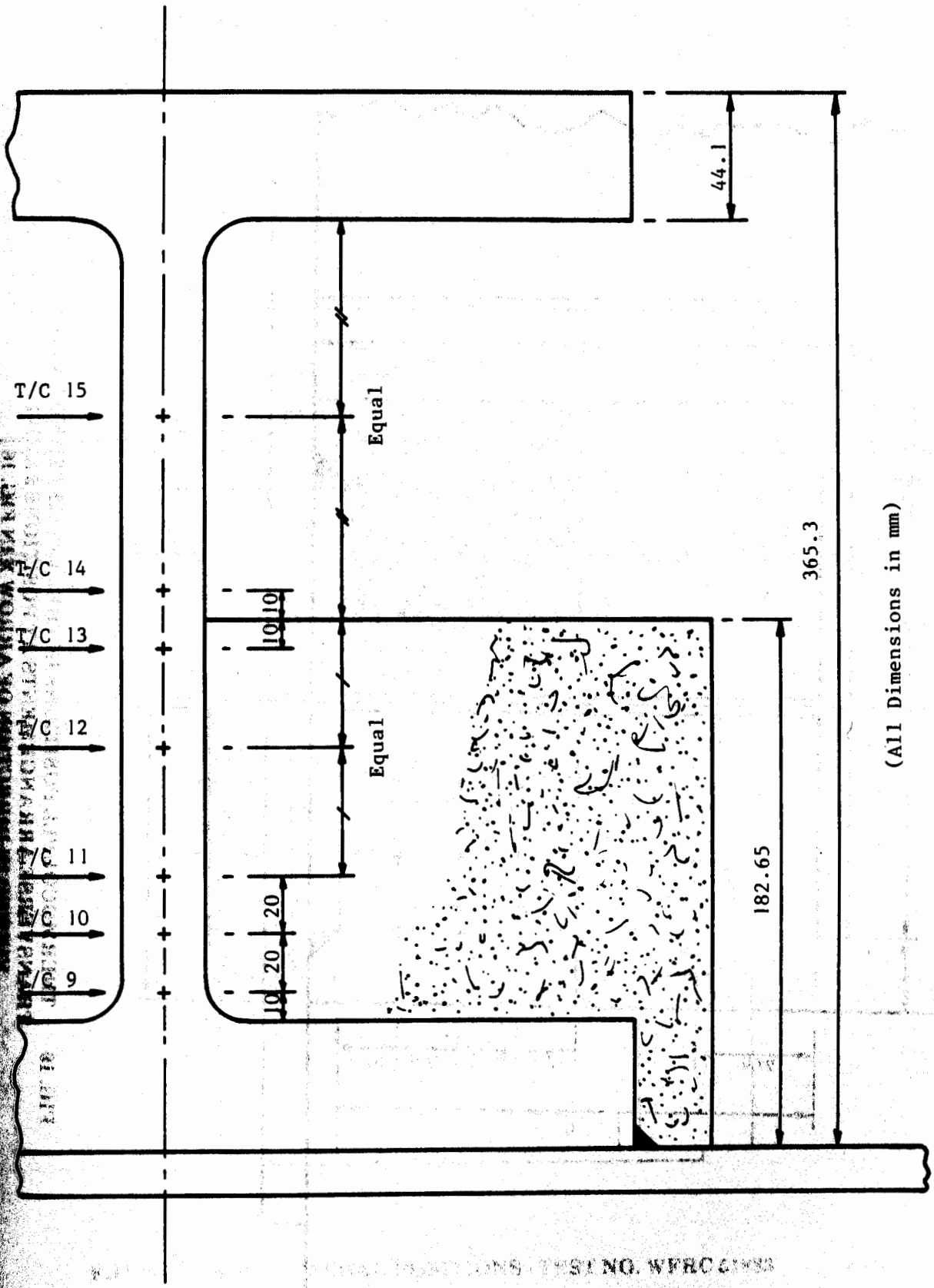


FIG. 18 **DIMENSIONAL DETAILS FOR WEB THERMOCOUPLE POSITIONS - TEST NO. WFRC 51883 (BASED ON NOMINAL DIMENSIONS)** (R4/42)

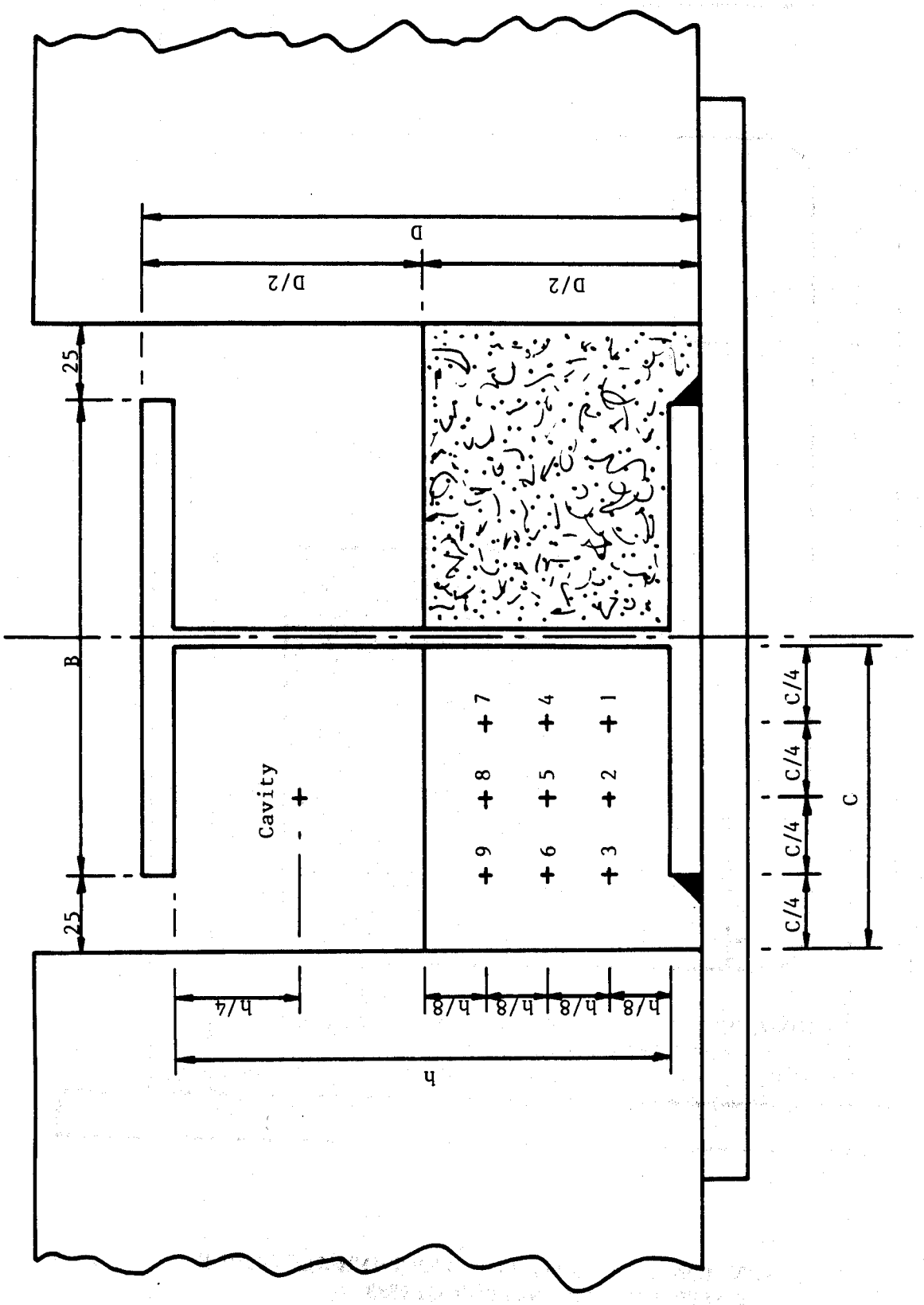


FIG. 19 THERMOCOUPLE POSITIONS IN THE CONCRETE AND CAVITY (R4/43)
TRANSVERSE ARRANGEMENTS AT POSITIONS 5 AND 7
VIEWED IN DIRECTION OF ARROW X IN FIG. 16
APPLICABLE TO TESTS WFRC 51883, 51884 AND 54278

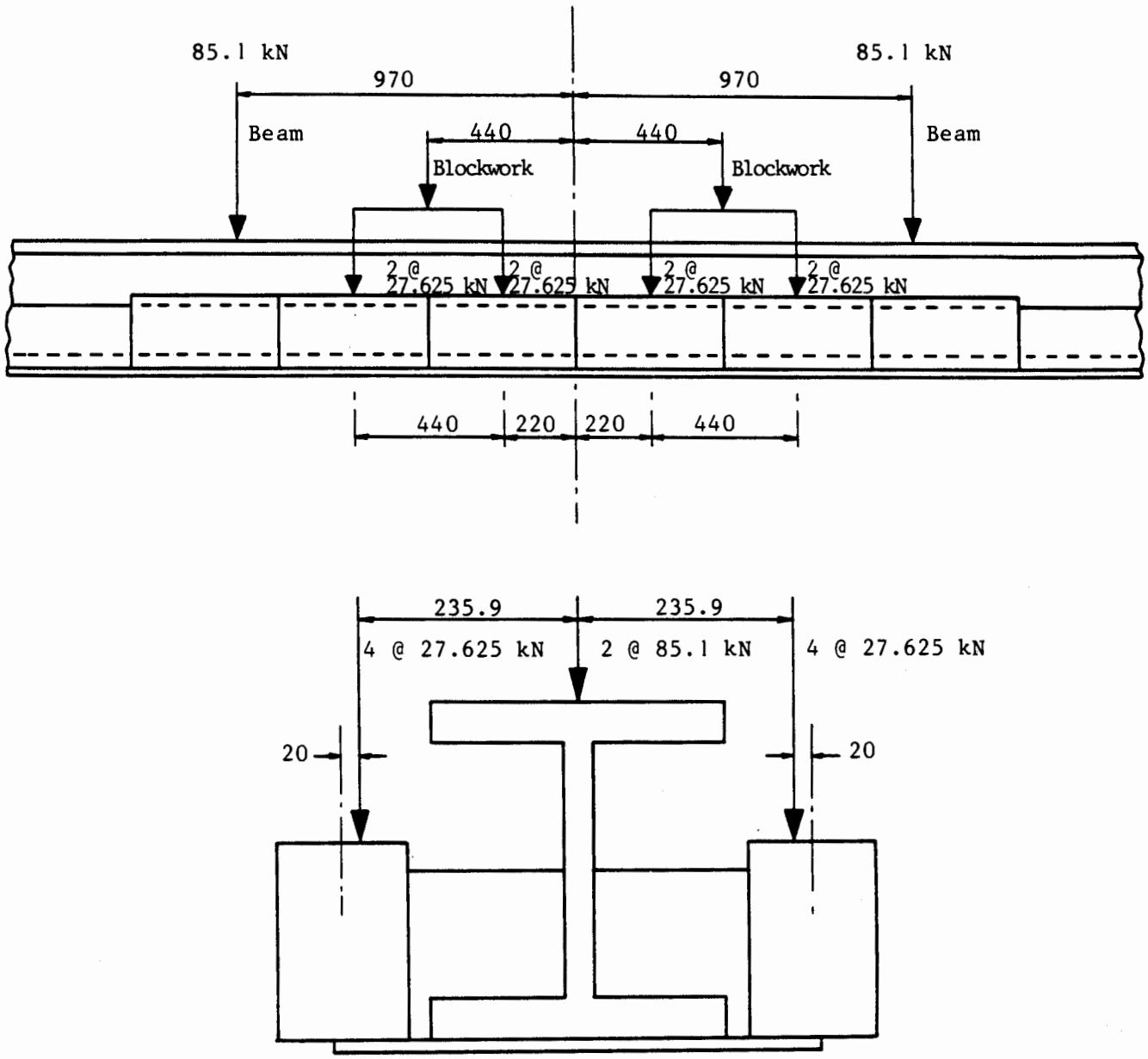


FIG. 20 APPLIED LOAD POSITIONS - TEST NO. WFRC 51883 (R4/44)

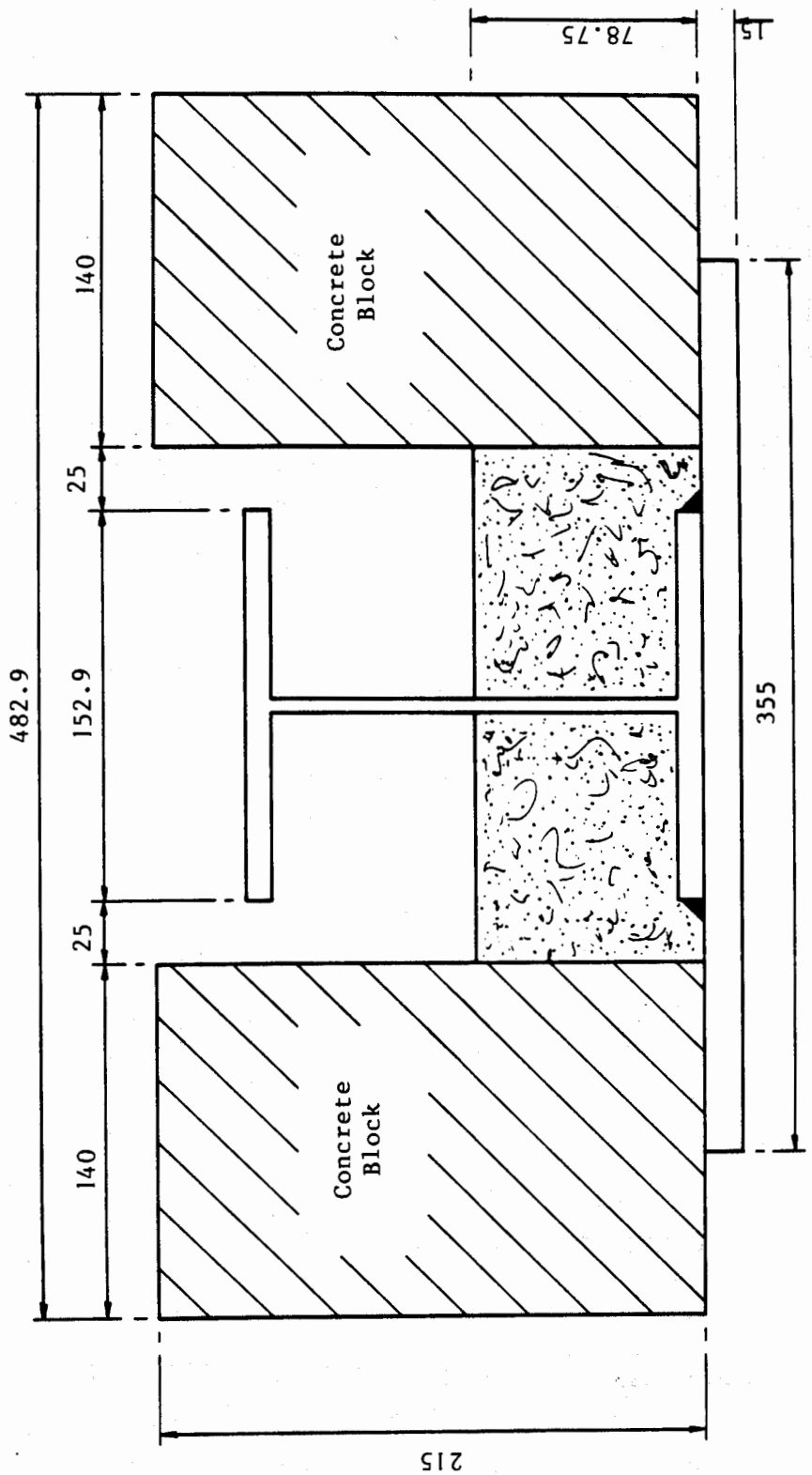


FIG. 21 SCHEMATIC ARRANGEMENT OF COMPONENTS - TRANSVERSE SECTION - TEST NO. WFRC 54278 (R4/45)
(BASED ON NOMINAL DIMENSIONS, mm)

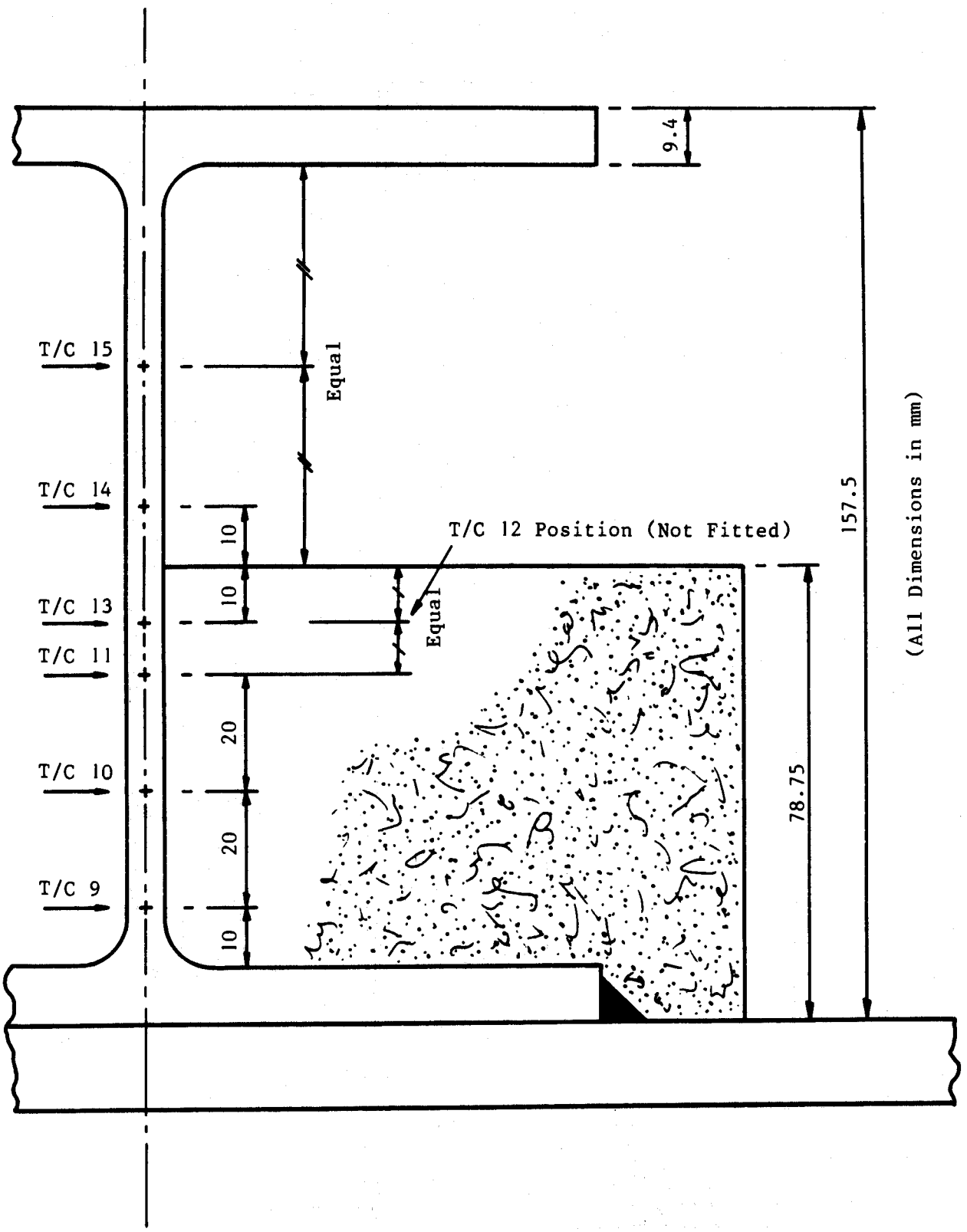


FIG. 22 **DIMENSIONAL DETAILS FOR WEB THERMOCOUPLE POSITIONS - TEST NO. WFRC 54278 (BASED ON NOMINAL DIMENSIONS, mm)** **(R4/46)**

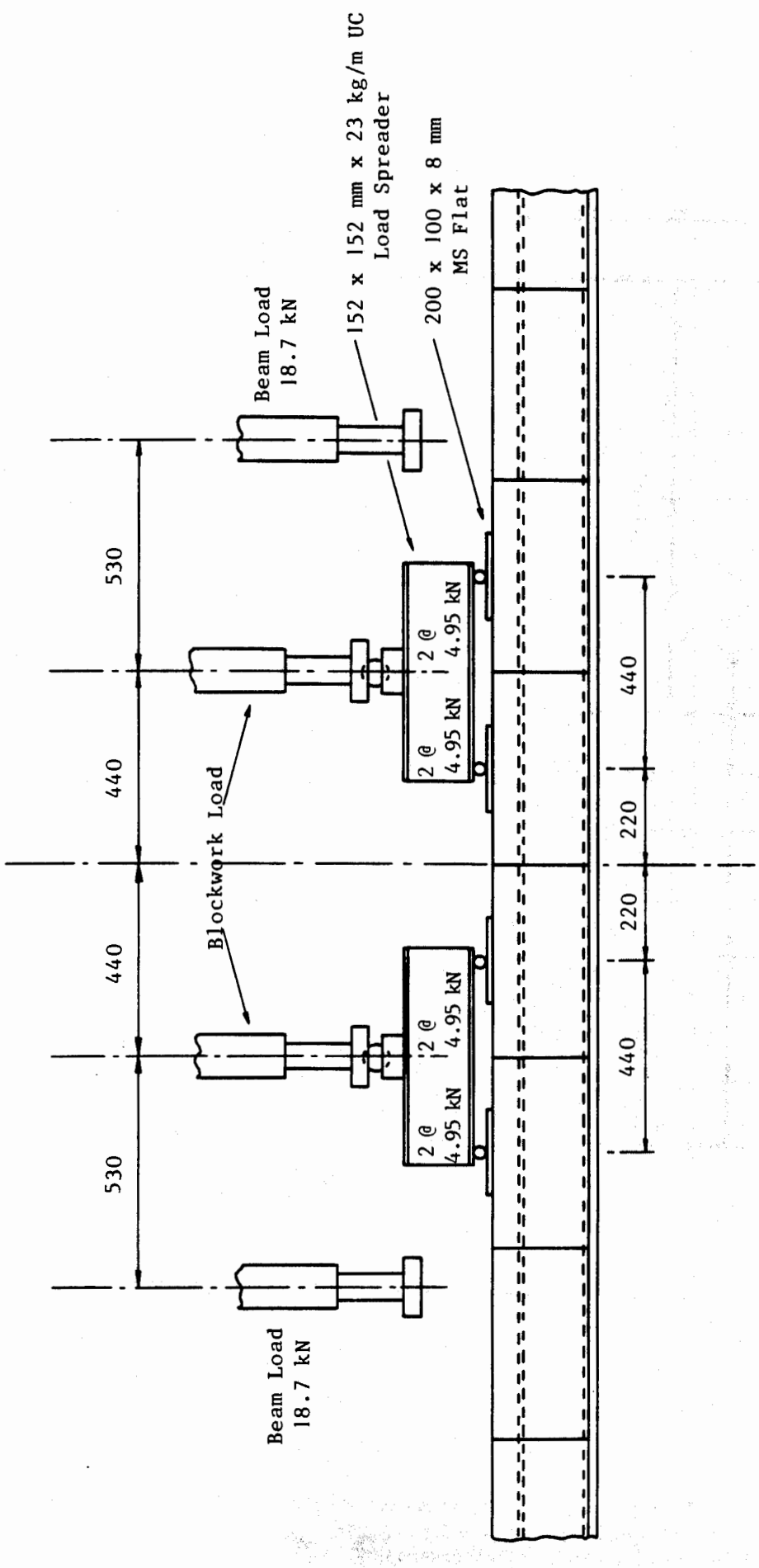


FIG. 23 APPLIED LOAD POSITIONS - LONGITUDINAL ARRANGEMENT - TEST NO. WFRC 54278 (R4/47)

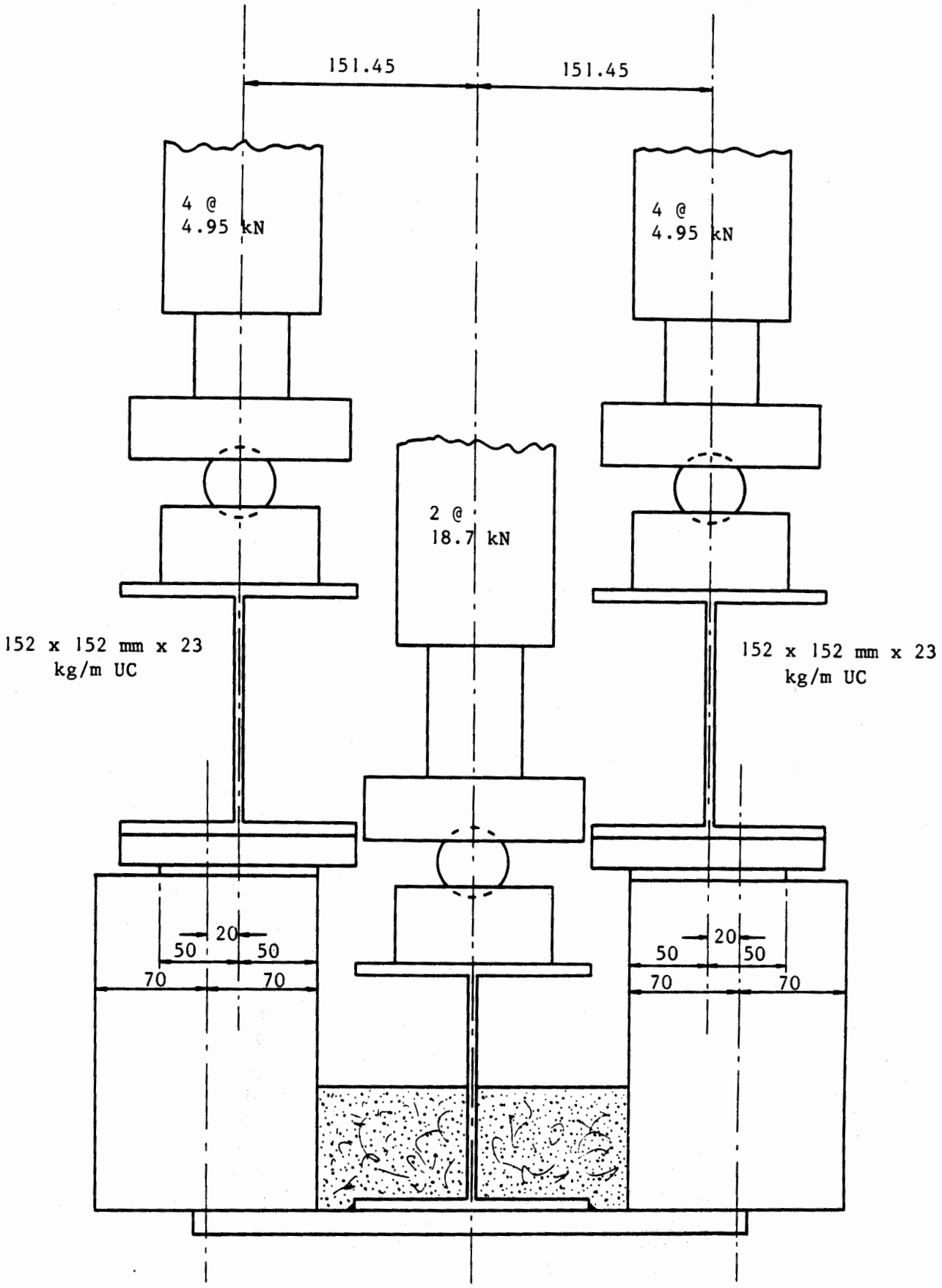


FIG. 24 APPLIED LOAD POSITIONS - TRANSVERSE ARRANGEMENT - TEST NO. WFRC 54278 **(R4/48)**

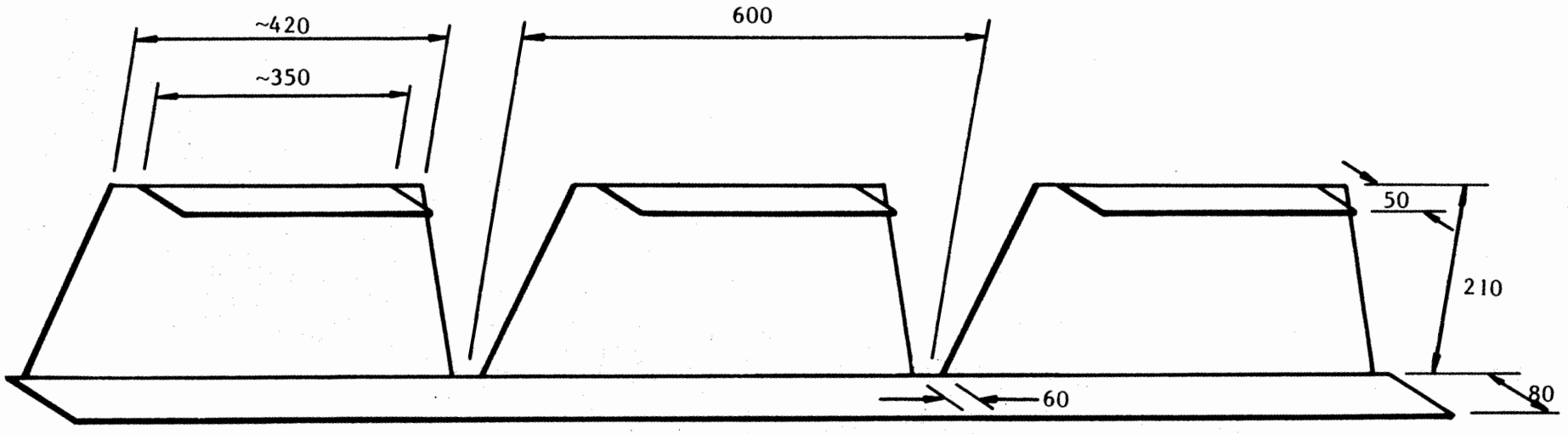


FIG. 25 **DIMENSIONAL DETAILS OF PMF 210 mm DEEP CLOSURE FLASHING - TEST NO. WFRC 56867** **(R4/49)**

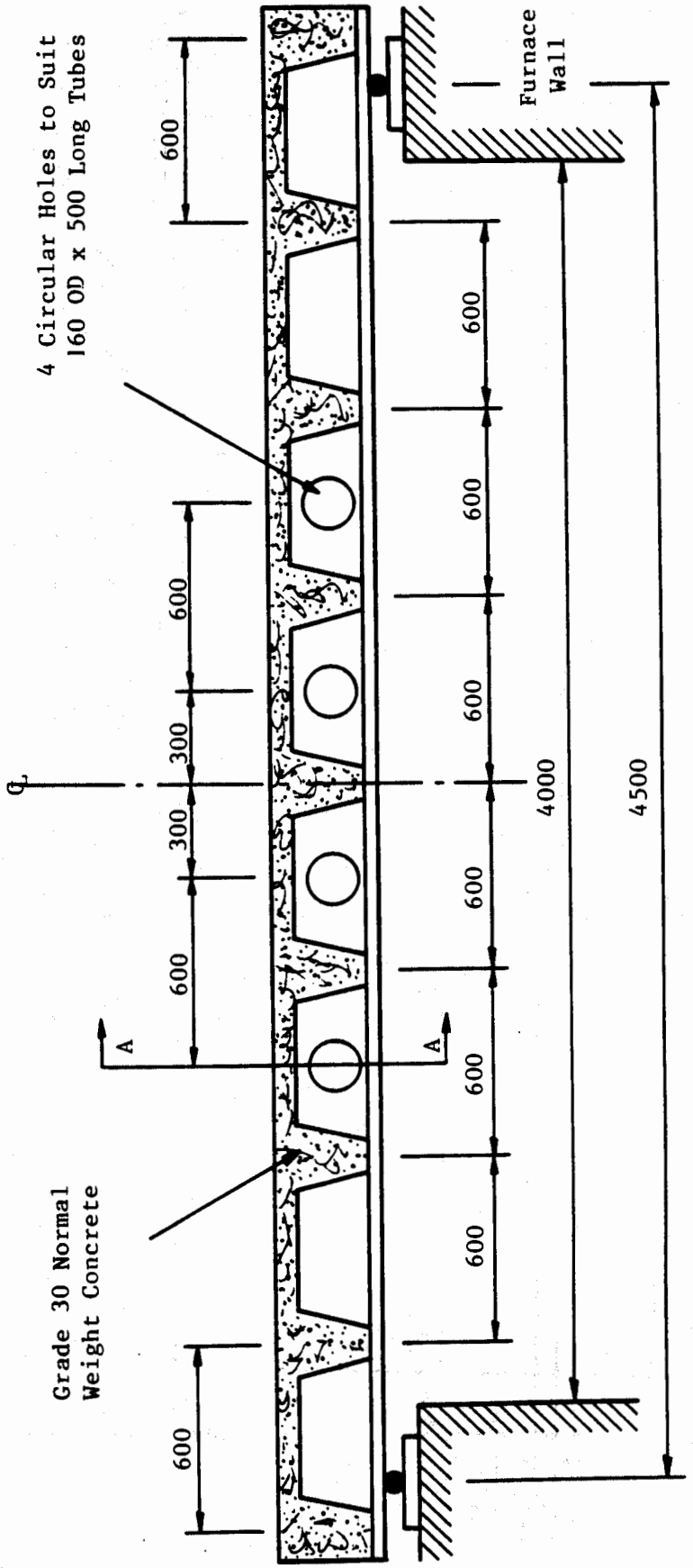


FIG. 26 SCHEMATIC ARRANGEMENT OF COMPONENTS - LONGITUDINAL ARRANGEMENT (R4/50)
TEST NO. WFRC 56867

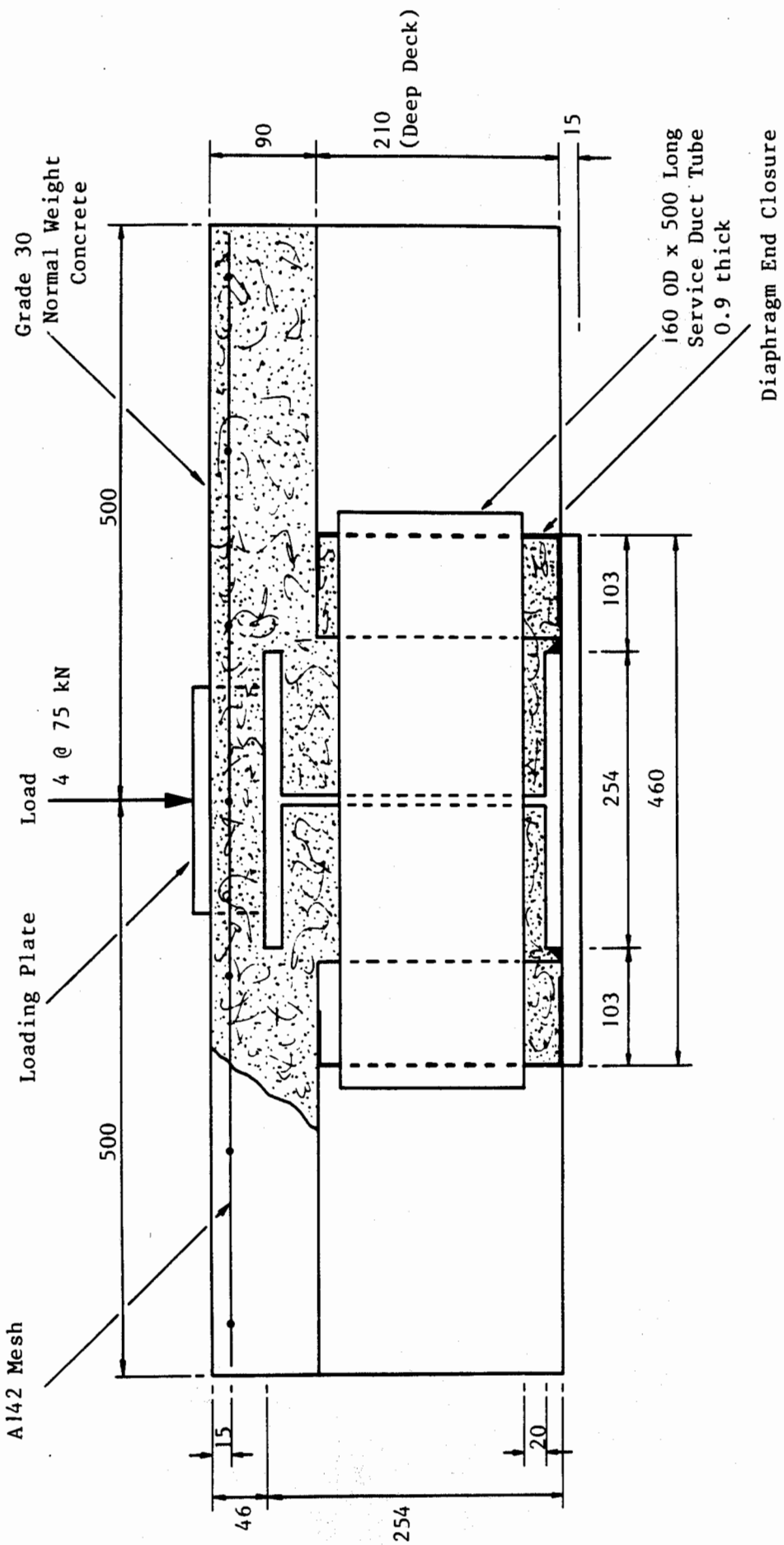


FIG. 27 SCHEMATIC ARRANGEMENT OF COMPONENTS - TRANSVERSE SECTION AT A-A IN FIG. 26 (R4/51)
TEST NO. WFRC 56867

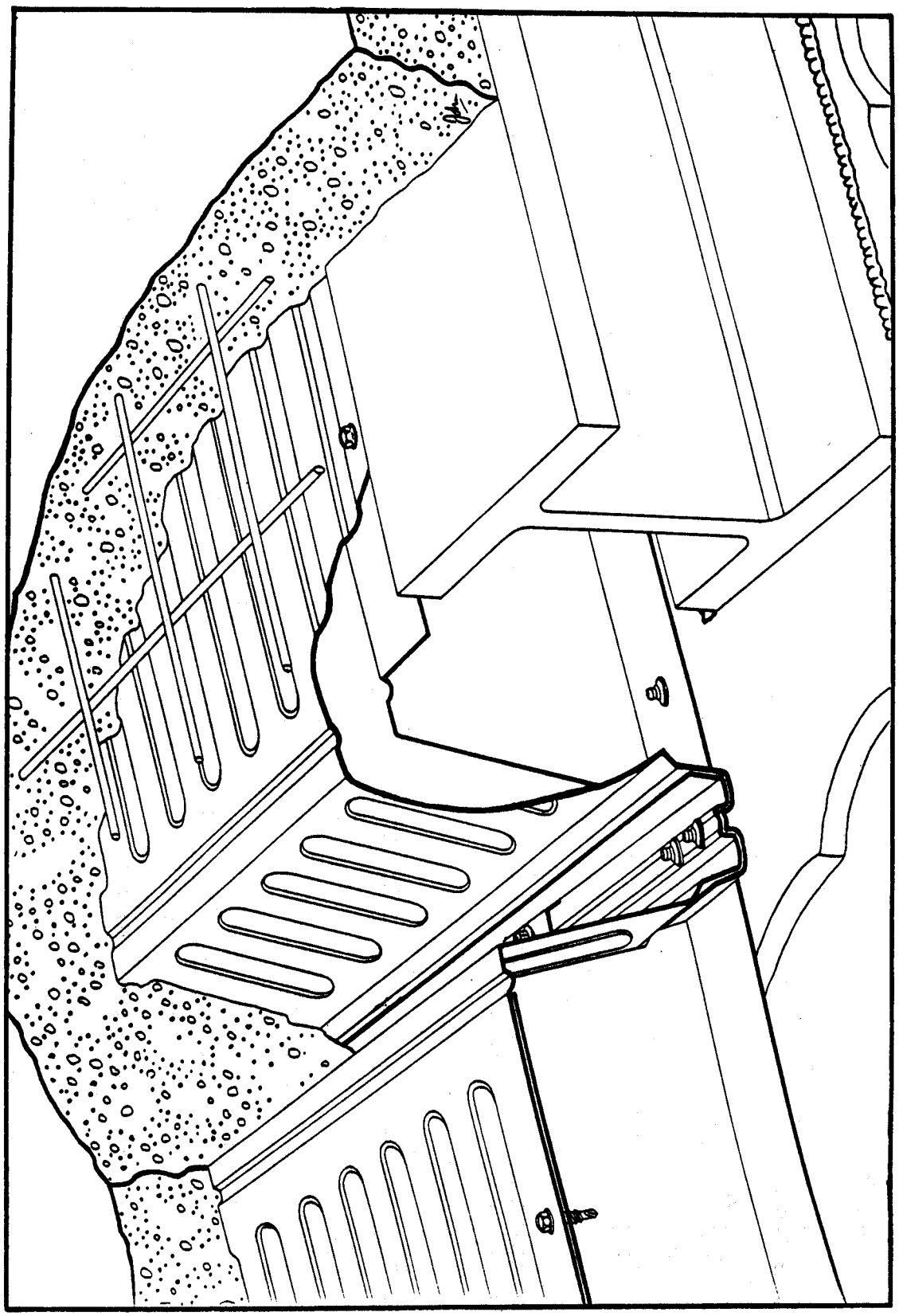


FIG. 28 GENERAL ARRANGEMENT OF COMPONENTS - TEST NO. WFRC 56867

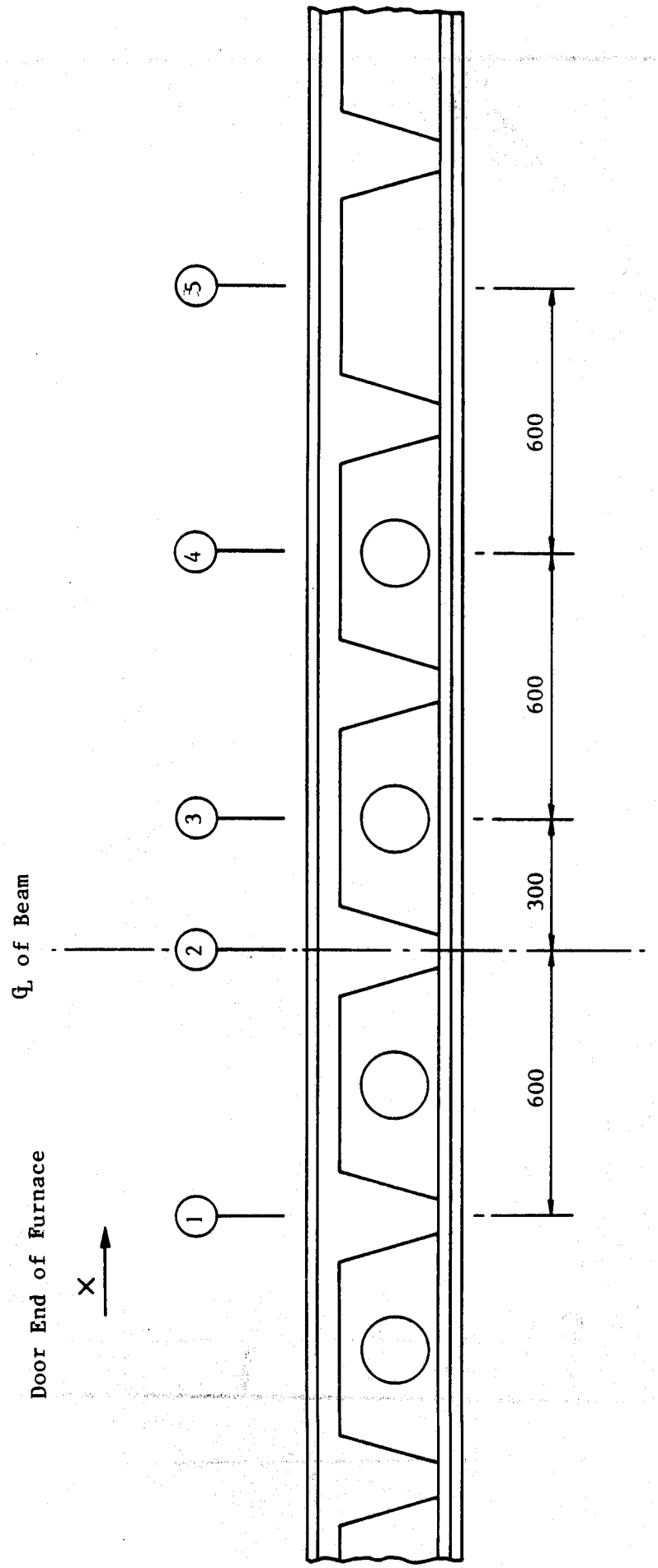
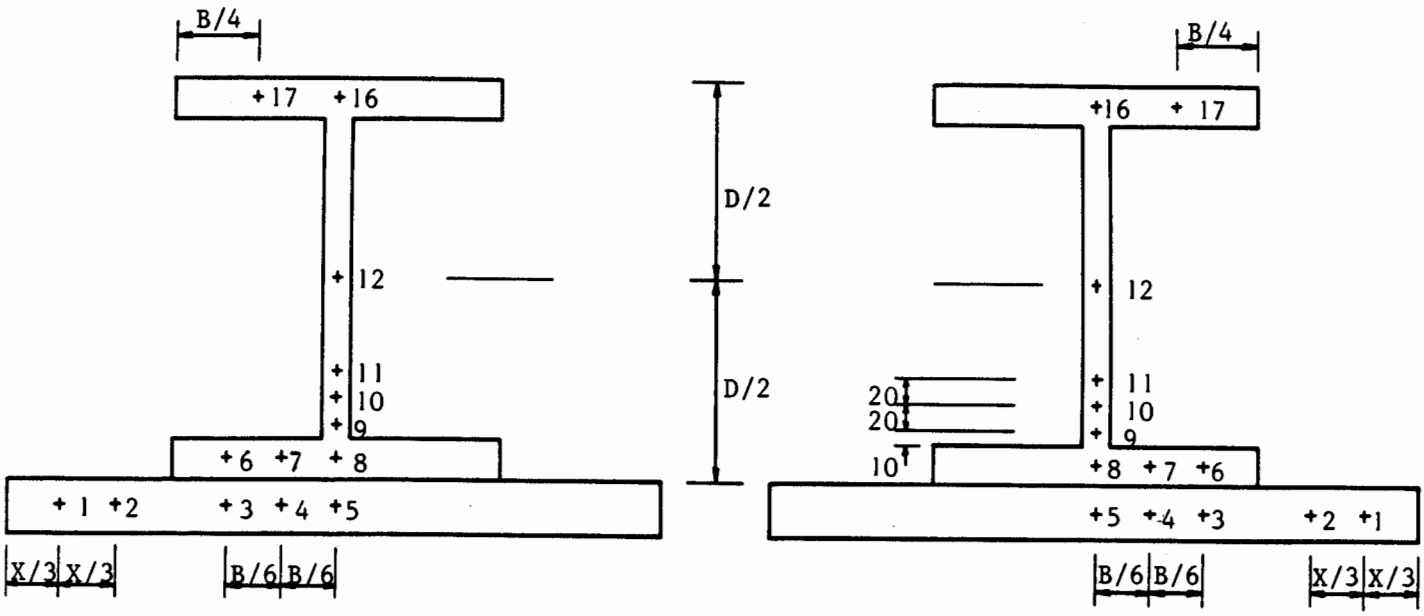
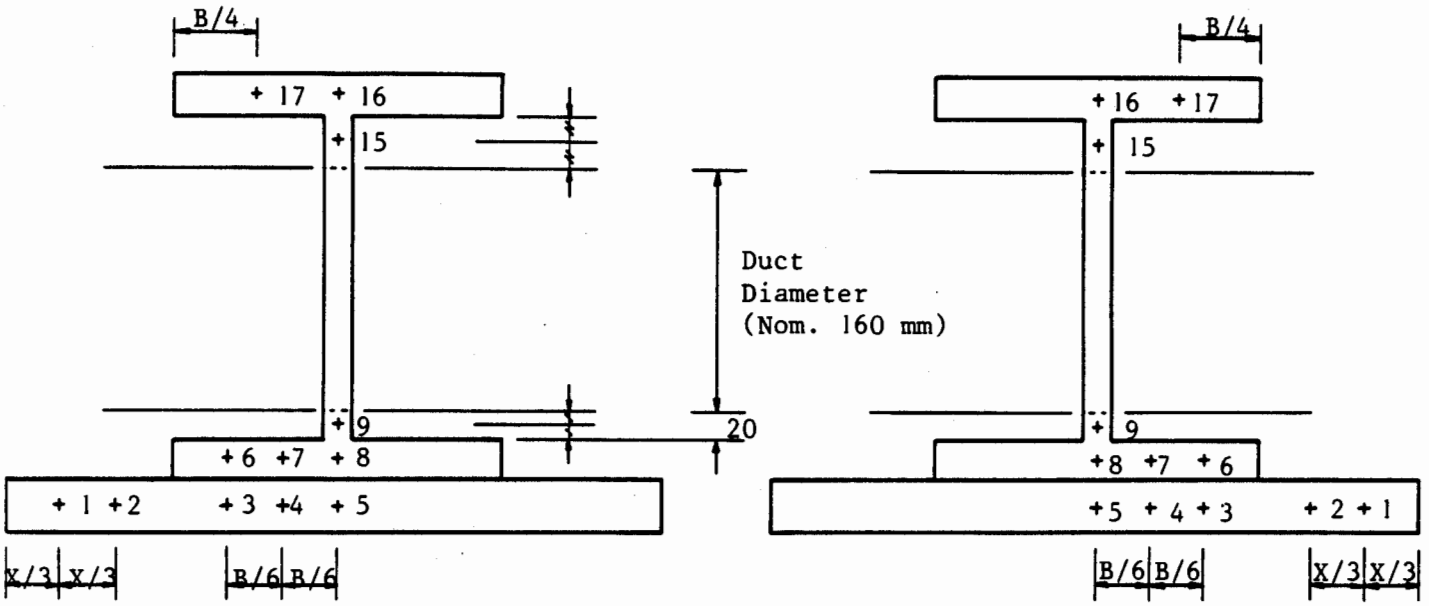


FIG. 29 THERMOCOUPLE POSITIONS IN THE STEELWORK - LONGITUDINAL ARRANGEMENT (R4/52)
TEST NO. WFRC 56867



(a) Position 1 Prefix 'B' and
Position 5 Prefix 'E'

(b) Position 2 Prefix 'A'



(c) Position 3 Prefix 'C'

(d) Position 4 Prefix 'D'

FIG. 30 THERMOCOUPLE POSITIONS IN THE STEELWORK (R4/53)
- TRANSVERSE ARRANGEMENTS AT POSITIONS 1-5
VIEWED IN DIRECTION OF ARROW X IN FIG. 29
TEST NO. WFRC 56867

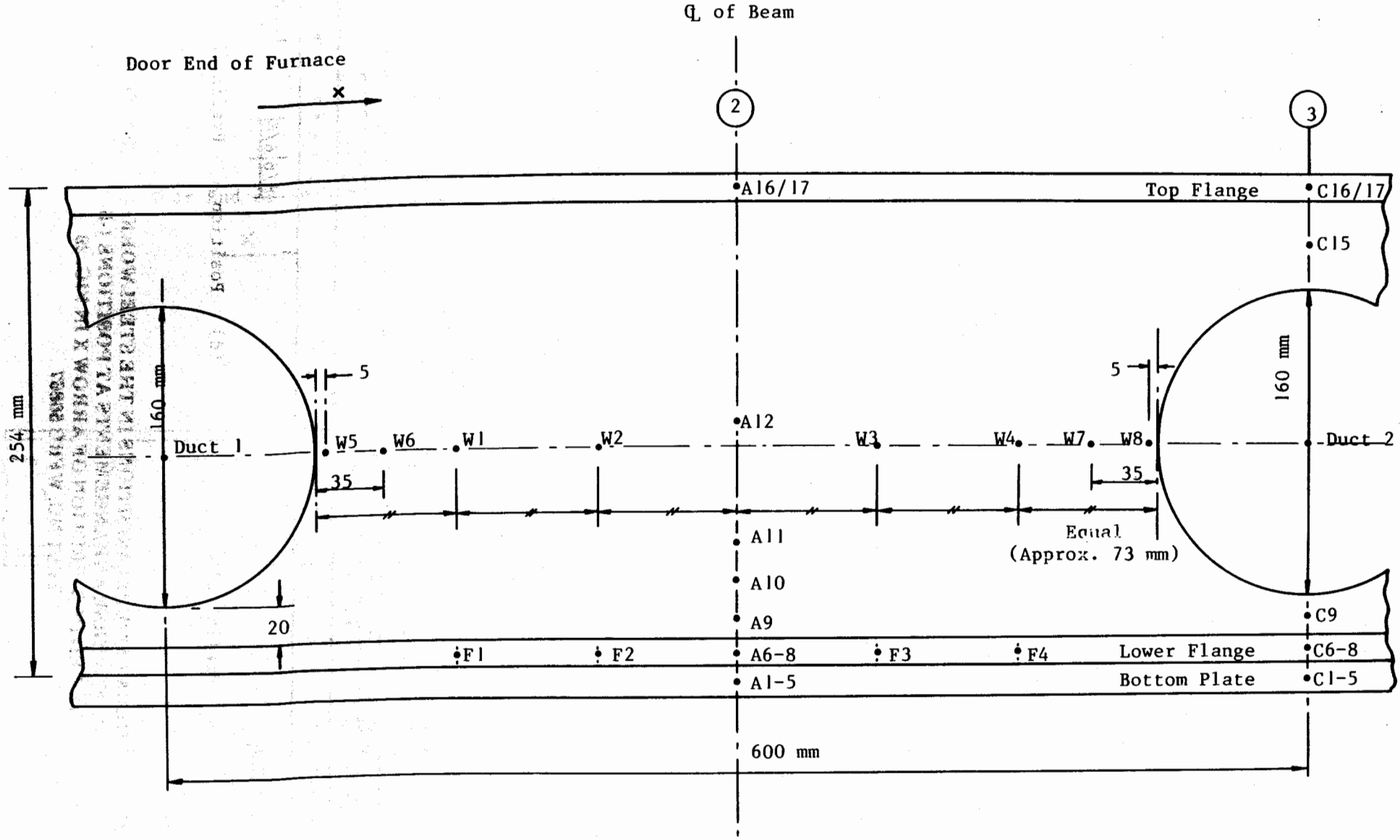


FIG. 31 THERMOCOUPLE POSITIONS IN THE STEELWORK - LONGITUDINAL ARRANGEMENT IN THE CENTRAL 600 mm OF THE BEAM - TEST NO. WFRC 56867 (R4/54)

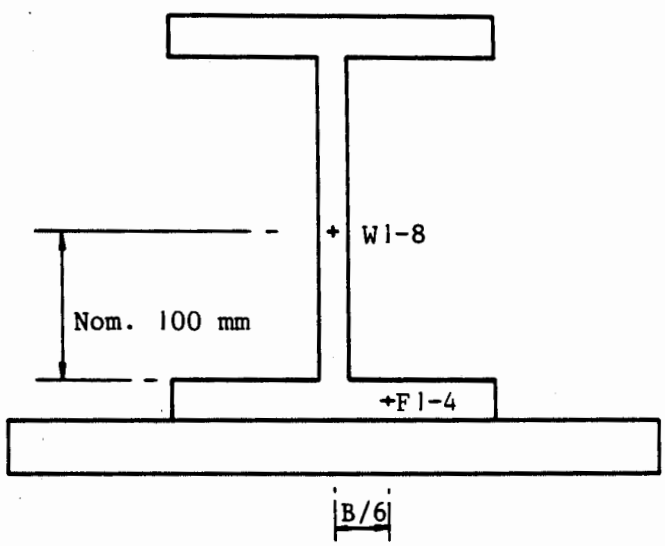


FIG. 32 **THERMOCOUPLE POSITIONS IN THE STEELWORK - TRANSVERSE ARRANGEMENTS AT POSITIONS IN THE CENTRAL 600 mm OF THE BEAM VIEWED IN DIRECTION OF ARROW X IN FIG. 31 - TEST NO. WFRC 56867** **(R4/55)**

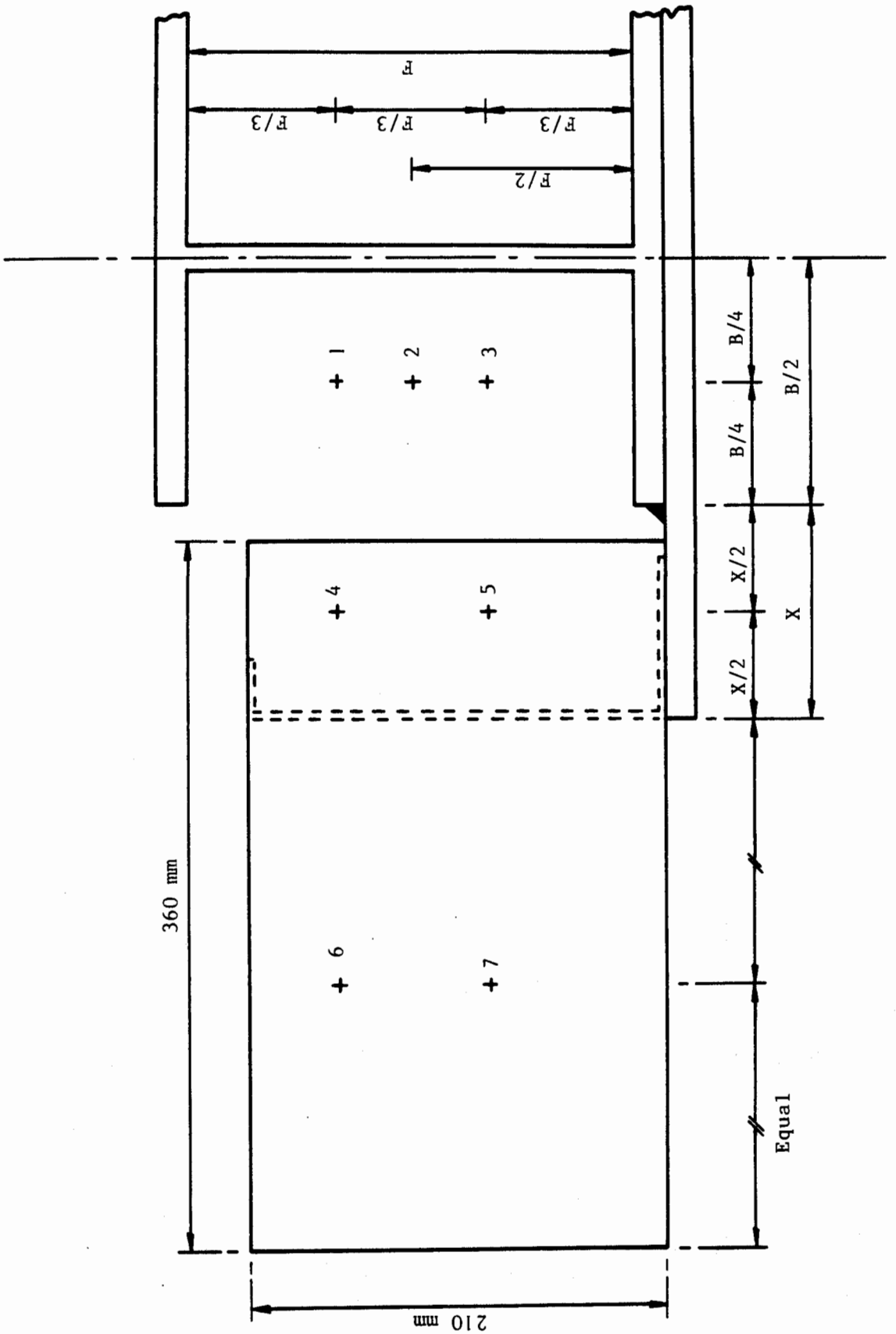


FIG. 33 THERMOCOUPLE POSITIONS IN THE CONCRETE - TRANSVERSE ARRANGEMENT AT THE MID-SPAN POSITION VIEWED IN DIRECTION OF ARROW X IN FIG. 31 - TEST NO WFRC 56867 (R4/56)

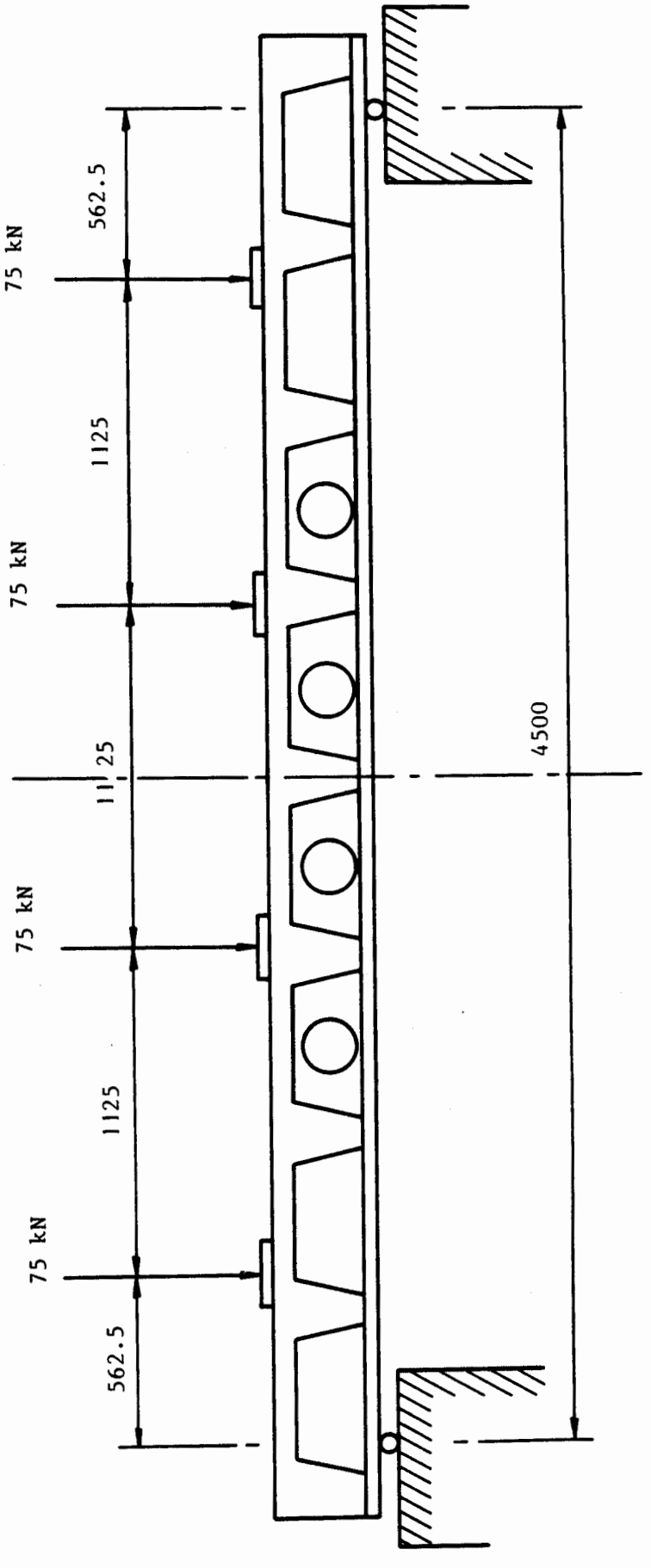


FIG. 34 APPLIED LOAD POSITIONS - LONGITUDINAL ARRANGEMENT - TEST NO. WFRC 56867 (R4/57)

APPENDIX 1

DATA SHEET NUMBERS 99-106

DATA SHEET NUMBER **99A**

SLIM FLOOR BEAM

DIMENSIONS AND PROPERTIES

Section Serial Size and Type mm	Dimensions and Properties	Depth of Section mm	Width of Section mm	Mass Per Metre kg	Thickness		Elastic Modulus		Plastic Modulus		Moment of Inertia	
					Web mm	Flange mm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^4	Axis y-y cm^4
254 x 254 Column	Nominal Actual	266.7 268	258.3 258	107 107.3	13.0 13.0	20.5 20.5	1313 1319	456.9 455.3	1485 1492	695.5 693.2	17510 17673	5901 5873
460 x 15 Plate	Nominal Actual	15.0 15.0	460 460	54.2 54.2								
UC & Plate Combined	Nominal (a) Actual (a)			161.9 162.0			1473 1481	790.1 789.2	1830 1839	1497 1495	26651 26912	18172 18151

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

Product	Steel Quality	C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu	Nb	Al	N
Column	Fe 430 A	0.16	0.29	0.73	0.021	0.028	0.08	0.011	0.07	<0.005	0.11	<0.005	<0.005	0.0045
Plate	Fe 430 A	0.19	0.30	0.80	0.013	0.012	<0.02	<0.005	0.02	<0.005	0.02	<0.005	0.029	0.0048

ROOM TEMPERATURE TENSILE PROPERTIES

Position	LYS N/mm^2	TS N/mm^2	Elong. %
Column	275	457	26.5
Plate	310	496	29.0

TEST CONDITIONS

NOTES

(a) Including the 8 mm fillet weld.

(b) Initial ambient temperature = 15°C.

(c) Based on an initial ambient temperature of 20°C.

(d) Heating continued with no applied load.

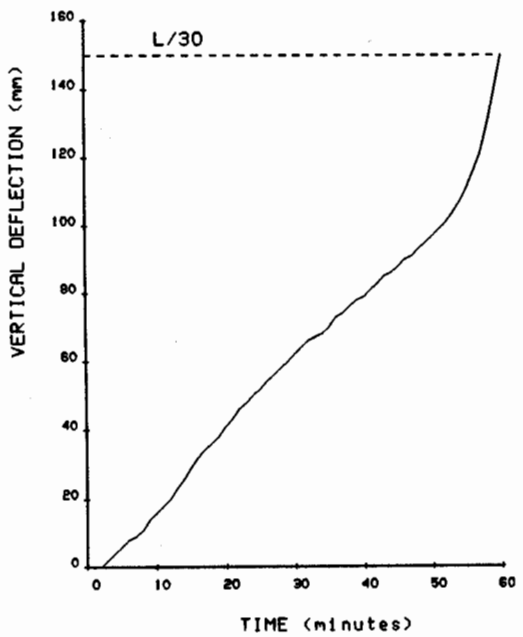
TEST CENTRE	: WARRINGTON RESEARCH
TEST DATE	: 25th SEPTEMBER 1990
TEST NUMBER	: WFRC 50521

BS476 : PARTS 20 & 21 : 1987 RESULTS

TIME TO L/30	: 60 MINUTES
TIME TO $L^2/9000D$	: 58 MINUTES
RE-LOAD TEST	: NOT CARRIED OUT
LOAD BEARING CAPACITY	: 60 MINUTES
FIRE RESISTANCE	: 60 MINUTES

DATA SHEET NUMBER **99B**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	35	40	45	50	55	60	70	80	90
Upper Flange	18	18	18	17	17	18	18	18	19	20	22	24	27	31	36	42	72	95	103
UF/Web Junction	17	18	17	17	17	17	18	19	20	22	24	28	33	39	46	54	91	103	116
Web																			
10 mm from UF	18	18	18	18	18	19	20	22	23	25	29	34	41	49	58	67	99	111	130
30 mm from UF	18	18	17	18	18	20	22	24	27	30	36	45	54	68	80	90	103	129	154
50 mm from UF	17	18	17	18	19	22	24	27	31	36	45	56	71	90	100	106	108	152	178
Mid-Height	18	18	18	23	29	34	41	49	59	71	96	114	136	156	176	194	224	259	289
50 mm from LF	18	19	23	42	54	66	82	101	122	145	183	224	262	297	330	359	409	449	487
30 mm from LF	18	21	29	60	72	88	111	136	163	192	241	292	340	381	420	455	511	555	595
10 mm from LF	18	24	37	80	90	113	141	174	209	244	306	371	428	477	522	563	622	668	711
LF/Web Junction	19	26	43	92	102	128	160	195	233	271	338	409	469	520	568	610	670	715	761
Lower Flange																			
B/6 from C/L	20	34	62	101	127	159	194	234	275	317	388	462	523	575	622	662	717	770	826
B/4 from C/L	22	41	78	111	142	177	214	253	294	336	407	479	538	589	635	675	725	778	836
B/3 from C/L	25	50	94	127	165	204	245	287	330	372	444	515	573	623	666	700	751	811	866
Plate																			
Mid-Width	97	165	234	269	362	435	495	547	588	624	669	697	729	761	778	790	840	890	928
B/6 from C/L	98	165	234	277	364	433	492	543	585	622	668	699	732	766	784	799	852	901	939
B/4 from C/L	123	186	244	293	371	431	487	533	573	606	645	678	717	754	777	793	849	899	936
B/3 from C/L	93	155	211	275	350	413	469	519	559	597	647	683	722	759	780	800	854	908	945
Plate Extension																			
x/3 from FL. Tip	81	149	218	281	348	404	459	506	547	588	646	695	739	775	801	833	887	932	964
x/2 from FL. Tip	80	161	232	295	362	421	474	522	563	601	658	707	750	785	815	844	895	936	967
2x/3 from FL. Tip	90	166	241	306	374	431	484	532	572	611	669	718	761	791	823	853	905	944	972
Fillet Weld	38	79	129	180	227	281	327	371	411	449	515	575	628	674	710	740	802	860	908
Furnace Gas (b)	532	603	671	690	733	755	789	810	831	852	876	900	922	940	942	955	985	1011	1034
Standard Curve (c)	502	603	663	705	739	766	789	809	826	842	865	885	902	918	932	945	968	988	1006
Deflection mm	2	8	14	20	29	36	43	50	56	62	70	79	88	97	111	150 (d)			
Deflection Rate mm/min	2	2	3	2	3	2	2	2	2	2	2	1	2	2	4	12			



DATA SHEET NUMBER **100A**

SLIM FLOOR BEAM

DIMENSIONS AND PROPERTIES

Section Serial Size and Type mm	Dimensions and Properties	Depth of Section mm	Width of Section mm	Mass Per Metre kg	Thickness		Elastic Modulus		Plastic Modulus		Moment of Inertia	
					Web mm	Flange mm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^4	Axis y-y cm^4
203 x 203 Column	Nominal	222.3	208.8	86	13.0	20.5	851.5	298.7	978.8	455.9	9462	3119
	Actual	226	210	83.8	12.4	19.7	847.4	289.9	969.5	442.3	9576	3044
425 x 15 Plate	Nominal	15.0	425	50.0								
	Actual	15.0	428	50.4								
UC & Plate Combined	Nominal (a)			137.0			980.1	601.6	1246	1140	15183	12783
	Actual (a)			134.7			974.0	603.7	1234	1136	15436	12919

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt.%)

Product	Steel Quality	C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu	Nb	Al	N
Column	Fe 430 A	0.18	0.02	1.16	0.021	0.023	0.03	<0.005	0.02	<0.005	<0.02	<0.005	<0.005	0.0033
Plate	Fe 430 A	0.19	0.29	0.82	0.008	0.013	<0.02	<0.005	0.02	<0.005	<0.02	<0.005	0.039	0.0040

ROOM TEMPERATURE TENSILE PROPERTIES

Position	LYS N/mm^2	TS N/mm^2	Elong. %
Column	265	465	23.0
Plate	306	479	30.5

TEST CONDITIONS

NOTES

(a) Including the 8 mm fillet weld.

(b) Initial ambient temperature = 19°C.

(c) Based on an initial ambient temperature of 20°C.

(d) Heating continued with no applied load.

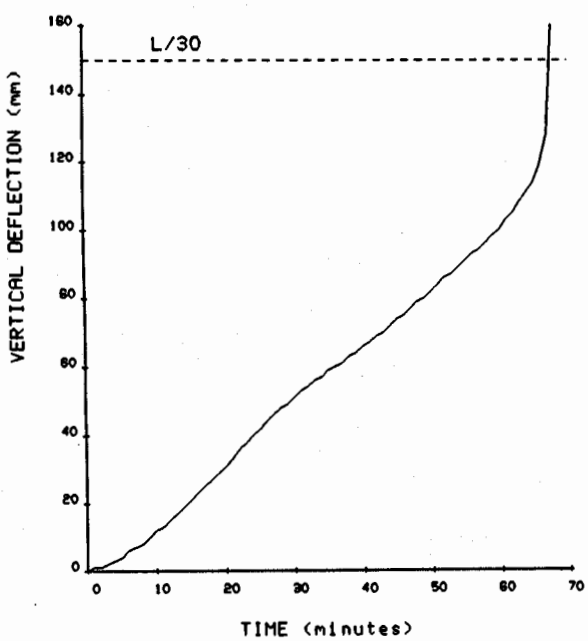
TEST CENTRE	: WARRINGTON RESEARCH
TEST DATE	: 14th NOVEMBER 1990
TEST NUMBER	: WFRC 50522

BS476 : PARTS 20 & 21 : 1987 RESULTS

TIME TO L/30	: >67, <68 MINUTES
TIME TO $L^2/9000D$	: 67 MINUTES
RE-LOAD TEST	: NOT CARRIED OUT
LOAD BEARING CAPACITY	: 67 MINUTES
FIRE RESISTANCE	: 67 MINUTES

DATA SHEET NUMBER **100B**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	35	40	45	50	60	67	70	80	90
Upper Flange	26	26	26	26	26	26	26	26	31	48	73	80	85	89	94	99	99	102	104
UF/Web Junction	26	26	26	26	26	26	26	26	36	55	81	89	93	95	97	101	103	107	112
Web																			
10 mm from UF	26	26	26	26	26	26	26	33	55	75	94	98	99	100	104	113	115	121	129
30 mm from UF	26	26	26	26	26	26	31	57	82	94	100	100	100	100	122	136	137	148	160
50 mm from UF	26	26	26	26	26	27	40	73	91	99	100	100	100	100	135	152	157	173	189
Mid-Height	25	25	25	25	32	42	73	92	99	100	100	103	108	130	185	211	219	246	270
50 mm from LF	26	26	26	37	48	71	91	98	100	101	106	143	175	211	270	302	312	350	383
30 mm from LF	26	26	33	51	63	91	100	101	104	113	135	192	234	276	345	384	396	441	479
10 mm from LF	26	27	45	69	84	101	103	112	130	150	195	257	318	366	448	493	505	554	595
LF/Web Junction	26	30	52	78	93	103	112	124	143	168	215	302	365	419	507	554	567	617	659
Lower Flange																			
B/6 from C/L	26	38	67	92	105	122	140	166	195	223	287	351	417	474	564	612	624	676	716
B/4 from C/L	26	40	70	95	116	146	175	202	230	260	312	382	443	495	578	624	635	686	729
B/3 from C/L	26	48	82	103	125	151	172	208	244	279	337	399	456	509	597	644	655	705	750
Plate																			
Mid-Width	59	103	143	186	268	332	392	449	496	532	576	605	629	661	729	757	773	820	862
B/6 from C/L	65	116	151	202	279	339	399	453	499	534	579	611	639	673	741	769	784	832	873
B/4 from C/L	56	100	143	201	273	330	387	437	478	509	551	582	615	653	725	757	772	818	861
B/3 from C/L	50	83	116	173	239	292	346	397	443	480	531	570	606	644	720	751	767	815	861
Plate Extension																			
x/3 from FL. Tip	55	95	138	186	236	283	336	389	438	483	550	604	651	693	753	794	810	858	896
x/2 from FL. Tip	61	107	156	207	263	315	372	425	470	511	570	619	665	707	760	799	815	859	900
2x/3 from FL. Tip	72	120	166	217	271	316	373	428	478	523	588	641	686	727	783	822	837	879	914
Fillet Weld	39	70	106	150	200	249	300	351	397	438	497	545	591	634	706	739	755	803	850
Furnace Gas (b)	528	596	641	690	714	726	767	774	794	809	832	851	872	892	921	938	944	964	992
Standard Curve (c)	502	603	663	705	739	766	789	809	826	842	865	885	902	918	945	962	968	988	1006
Deflection mm	2	6	10	15	21	27	33	40	46	51	59	66	74	82	100	128 (d)			
Deflection Rate mm/min	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	9			



TEST CENTRE : WARRINGTON RESEARCH
TEST DATE : 14th NOVEMBER 1990
TEST NUMBER : WFRC 50522

DATA SHEET NUMBER **100C**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	35	40	45	50	60	67	70	80	90
Shear Connectors																			
1 Top	27	27	27	27	27	27	27	27	27	27	27	27	31	34	41	46	49	56	61
2 Top	27	27	27	27	27	27	27	27	27	27	27	27	27	31	39	44	44	48	60
3 Top	25	25	25	25	25	25	25	25	25	25	26	31	34	38	44	48	49	54	61
Mean	26	26	26	26	26	26	26	26	26	26	27	28	31	34	41	46	47	53	61
1 Mid-Height	27	27	27	27	27	27	27	27	27	27	44	51	56	61	66	70	73	78	83
2 Mid-Height	27	27	27	27	27	27	27	27	27	27	27	35	42	48	56	60	62	69	75
3 Mid-Height	25	25	25	25	25	25	25	25	30	46	56	61	64	67	71	74	74	80	88
Mean	26	26	26	26	26	26	26	26	28	33	42	49	54	59	64	68	70	76	82
Reinforcement																			
T12 Bar 1	27	27	27	27	27	27	27	27	27	27	27	27	28	33	42	48	51	58	65
2	27	27	27	27	27	27	27	27	27	27	27	27	27	27	34	49	51	56	61
Mean	27	27	27	27	27	27	27	27	27	27	27	27	28	30	38	49	51	57	63
A193 Mesh 1	27	27	27	27	27	27	27	27	27	27	27	27	27	31	40	46	49	57	63
2	27	27	27	27	27	27	27	27	27	27	27	27	27	27	39	61	58	59	63
Mean	27	27	27	27	27	27	27	27	27	27	27	27	27	29	40	54	54	58	63
Concrete at Mid-Span																			
C/C 1	27	27	27	27	27	27	27	27	27	27	58	72	81	83	85	87	87	90	92
C/C 2	27	27	27	27	27	27	27	27	27	27	27	27	37	58	65	87	82	87	91
C/C 3	27	27	27	27	27	27	27	27	35	52	76	84	89	93	96	98	99	100	101
C/C 4	26	26	26	26	26	26	26	26	35	49	83	88	91	93	96	98	99	100	101
C/C 5	27	27	27	27	27	27	27	27	27	27	58	72	79	85	91	93	95	99	100
C/C 6	26	26	26	26	26	26	26	26	26	26	26	39	78	88	94	96	98	100	101
C/C 7	26	26	26	26	26	26	26	26	34	45	61	72	80	88	98	100	100	102	108
C/C 8	25	25	25	25	25	25	25	25	27	36	53	66	76	85	96	100	101	102	102
C/C 9	27	27	27	27	27	27	27	27	27	27	37	56	81	91	98	100	100	102	102
C/C 10	27	27	27	27	27	27	27	27	27	27	31	46	69	82	98	101	101	101	101
C/C 11	25	25	25	25	27	35	45	53	61	68	81	93	104	109	123	150	164	211	257
C/C 12	26	26	26	26	26	30	37	45	52	59	73	89	99	104	111	119	124	146	178
C/C 13	27	27	27	27	27	29	34	41	47	52	64	81	100	105	109	116	115	139	173
C/C 14	27	27	27	27	27	27	27	32	39	46	60	73	88	100	111	112	107	111	119

DATA SHEET NUMBER **101A**

SLIM FLOOR BEAM

DIMENSIONS AND PROPERTIES

Section Serial Size and Type mm	Dimensions and Properties	Depth of Section mm	Width of Section mm	Mass Per Metre kg	Thickness		Elastic Modulus		Plastic Modulus		Moment of Inertia	
					Web mm	Flange mm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^4	Axis y-y cm^4
203 x 203 Column	Nominal Actual	209.6 213	205.2 205	60 59.3	9.3 9.3	14.2 14.0	581.1 587.4	199.0 196.3	652.0 658.8	302.8 298.8	6088 6256	2041 2012
405 x 15 Plate	Nominal Actual	15.0 15.0	405 406	47.7 47.8								
UC & Plate Combined	Nominal (a) Actual (a)			107.9 107.6			670.7 676.6	514.6 514.7	839.5 847.2	925.3 923.7	10391 10666	10421 10448

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt.%)

Product	Steel Quality	C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu	Nb	Al	N
Column	Fe 430 A	0.17	0.18	0.69	0.019	0.033	<0.02	<0.005	0.04	<0.005	0.03	<0.005	<0.005	0.0097
Plate	Fe 430 A	0.18	0.31	0.74	0.016	0.010	<0.02	0.007	0.02	<0.005	<0.02	<0.005	0.064	0.0049

ROOM TEMPERATURE TENSILE PROPERTIES

Position	LYS N/mm^2	TS N/mm^2	Elong. %
Column	292	481	29.5
Plate	299	474	32.5

TEST CONDITIONS

NOTES

(a) Including the 8 mm fillet weld.

(b) Initial ambient temperature = 17°C.

(c) Based on an initial ambient temperature of 20°C.

(d) Loads applied to both beam and blockwork were increased after 83 min.

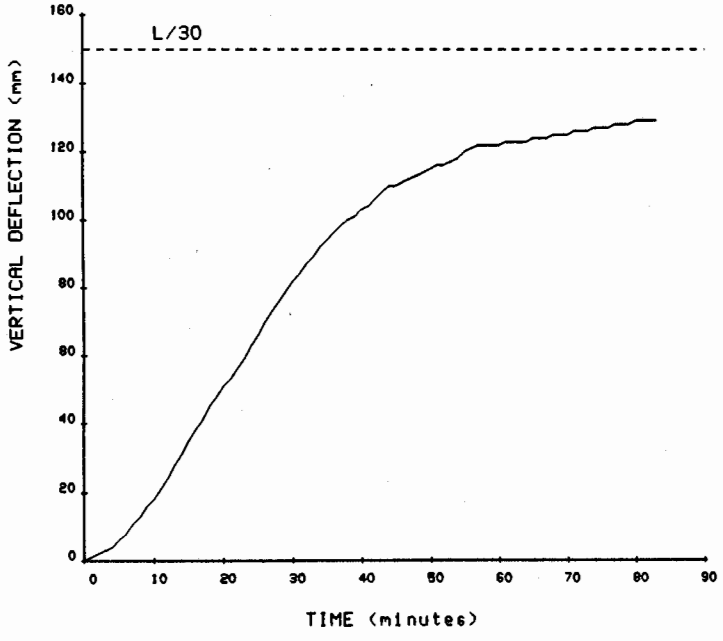
TEST CENTRE	: WARRINGTON RESEARCH
TEST DATE	: 8th FEBRUARY 1991
TEST NUMBER	: WFRC 52896

BS476 : PARTS 20 & 21 : 1987 RESULTS

TIME TO L/30	: NOT ATTAINED
TIME TO L2/9000D	: NOT ATTAINED
RE-LOAD TEST	: NOT CARRIED OUT
LOAD BEARING CAPACITY	: 83 MINUTES
FIRE RESISTANCE	: 83 MINUTES

DATA SHEET NUMBER **101B**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	40	50	60	70	80	83	90	100	116
Upper Flange	10	9	10	12	14	19	23	29	34	42	78	130	179	223	280	296	331	363	401
UF/Web Junction	10	10	11	13	17	22	29	37	44	52	104	164	214	260	308	334	373	423	453
Web																			
10 mm from UF	9	9	10	12	16	22	29	37	46	55	104	165	222	268	326	344	380	427	467
30 mm from UF	9	9	10	13	17	24	33	42	51	63	115	179	235	282	342	361	395	441	482
50 mm from UF	10	10	12	15	20	28	37	48	60	74	132	194	253	299	363	381	414	460	500
Mid-Height	9	10	12	18	26	38	54	71	89	110	186	254	315	366	422	438	466	497	541
50 mm from LF	10	11	17	27	42	61	83	108	135	164	261	341	407	464	515	532	566	608	670
30 mm from LF	10	14	23	40	61	88	119	151	186	224	340	426	495	552	602	618	650	693	758
10 mm from LF	11	16	31	53	81	115	154	193	236	285	419	512	585	644	695	711	740	789	855
LF/Web Junction	11	19	37	64	97	135	177	220	269	324	468	564	639	697	752	768	796	847	907
Lower Flange																			
B/6 from C/L	12	23	44	75	112	155	202	248	301	360	511	610	685	745	807	822	844	895	947
B/4 from C/L	13	25	50	83	123	168	215	262	315	374	529	625	699	762	822	835	851	899	943
B/3 from C/L	14	27	53	84	125	169	216	263	315	372	522	623	694	760	820	832	849	898	947
Plate																			
Mid-Width	55	108	171	235	305	365	416	469	518	553	659	752	812	854	889	893	915	976	1013
B/6 from C/L	55	106	166	229	297	357	409	462	512	549	660	753	815	860	897	901	922	980	1015
B/4 from C/L	61	113	174	237	303	362	413	466	519	559	671	764	833	880	913	916	933	990	1023
B/3 from C/L	49	96	154	216	283	342	394	449	500	542	661	754	818	869	907	912	929	986	1021
Plate Extension																			
x/3 from FL. Tip	48	105	165	227	294	353	407	464	520	568	691	773	848	897	929	929	941	996	1026
x/2 from FL. Tip	74	135	198	264	330	390	442	498	555	602	718	804	874	914	939	938	950	1005	1032
2x/3 from FL. Tip	51	107	175	241	312	374	428	486	544	592	710	793	865	907	935	934	945	1000	1028
Fillet Weld	26	56	105	159	221	278	331	385	443	498	634	725	803	860	903	908	920	978	1013
Sand Infill	9	13	18	21	27	32	38	41	48	60	104	147	226	283	447	463	502	556	596
Furnace Gas (b)	467	621	649	708	735	748	758	796	818	834	874	926	946	969	978	973	1003	1037	1049
Standard Curve (c)	502	603	663	705	739	766	789	809	826	842	885	918	945	968	988	994	1006	1022	1044
Deflection mm	3	8	16	24	35	45	53	63	73	82	103	115	122	125	129	129 (d)			
Deflection Rate mm/min	1	2	3	3	4	4	2	4	3	3	2	1	0	0	1	0			



DATA SHEET NUMBER **102A**

SLIM FLOOR BEAM

DIMENSIONS AND PROPERTIES

Section Serial Size and Type mm	Dimensions and Properties	Depth of Section mm	Width of Section mm	Mass Per Metre kg	Thickness		Elastic Modulus		Plastic Modulus		Moment of Inertia	
					Web mm	Flange mm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^4	Axis y-y cm^4
254 x 254 Column	Nominal Actual	254.0 245	254.0 254	73 72.3	8.6 8.6	14.2 14.2	894.5 857.2	305.0 305.5	988.6 947.9	462.4 463.1	11360 10501	3873 3880
455 x 15 Plate	Nominal Actual	15.0 15.0	455 460	53.6 54.2								
UC & Plate Combined	Nominal (a) Actual (a)			127.0 127.0			1006 964.5	692.9 702.4	1225 1175	1248 1265	18533 17208	15762 16155

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt.%)

Product	Steel Quality	C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu	Nb	Al	N
Column	Fe 430 A	0.095	0.23	0.59	0.038	0.027	0.22	0.034	0.20	<0.005	0.58	<0.005	0.007	0.0140
Plate	Fe 430 A	0.18	0.30	0.73	0.015	0.010	<0.02	0.007	0.02	<0.005	<0.02	<0.005	0.065	0.0054

ROOM TEMPERATURE TENSILE PROPERTIES

Position	LYS N/mm^2	TS N/mm^2	Elong. %
Column	347	489	30.5
Plate	302	475	35.5

TEST CONDITIONS

NOTES

(a) Including the 8 mm fillet weld.

(b) Initial ambient temperature = 17°C.

(c) Based on an initial ambient temperature of 20°C.

(d) Load applied to beam was removed and load applied to blockwork increased after 83 min.

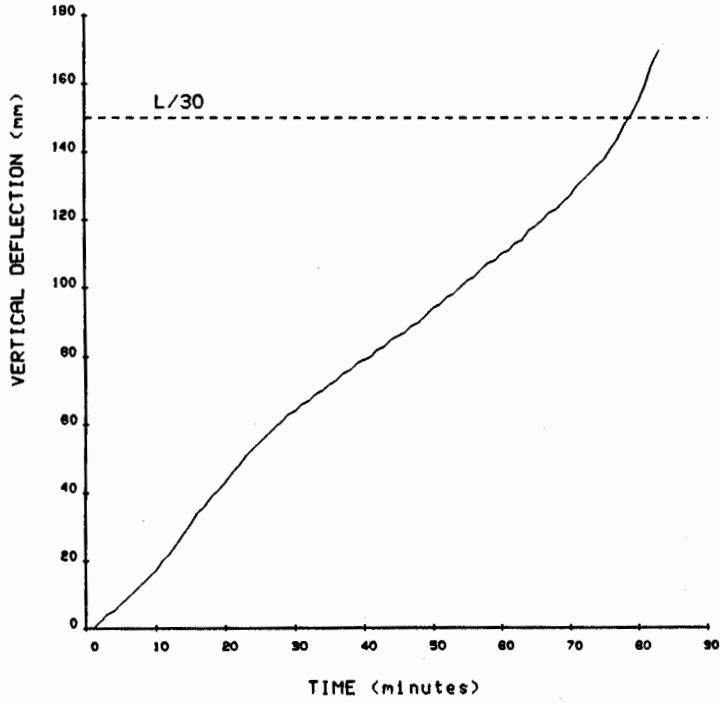
TEST CENTRE	: WARRINGTON RESEARCH
TEST DATE	: 14th FEBRUARY 1991
TEST NUMBER	: WFRC 52897

BS476 : PARTS 20 & 21 : 1987 RESULTS

TIME TO L/30	: 79 MINUTES
TIME TO $L^2/9000D$	: NOT ATTAINED
RE-LOAD TEST	: NOT CARRIED OUT
LOAD BEARING CAPACITY	: 83 MINUTES
FIRE RESISTANCE	: 83 MINUTES

DATA SHEET NUMBER **102B**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	40	50	60	70	79	83	90	100	110
Upper Flange	18	18	18	19	19	19	19	19	19	19	19	27	37	46	51	54	59	66	73
UF/Web Junction	18	18	18	19	19	19	19	19	19	19	19	27	38	49	55	60	65	72	81
Web																			
10 mm from UF	19	19	19	20	20	20	20	20	20	20	21	32	45	55	63	67	73	82	90
30 mm from UF	19	19	20	20	20	20	20	20	20	20	25	40	55	67	76	80	86	95	101
50 mm from UF	19	19	20	20	20	20	20	20	20	20	27	44	61	75	85	91	101	108	116
Mid-Height	18	18	19	19	19	19	19	21	26	36	81	97	104	127	147	156	165	184	201
50 mm from LF	18	18	18	19	23	32	42	59	85	98	123	181	241	296	336	347	387	424	457
30 mm from LF	19	19	19	23	33	47	62	87	100	104	175	256	332	397	443	460	499	540	572
10 mm from LF	19	19	22	34	50	69	90	106	123	147	251	354	444	519	568	588	631	672	705
LF/Web Junction	19	19	25	40	59	81	105	121	151	180	298	411	511	592	644	664	712	755	789
Lower Flange																			
B/6 from C/L	20	21	36	56	79	107	136	165	195	227	358	475	578	662	715	737	776	819	851
B/4 from C/L	18	25	44	67	96	124	155	188	221	255	381	494	591	674	729	750	813	855	887
B/3 from C/L	19	34	59	88	117	156	192	231	268	306	428	541	639	717	770	791	828	867	895
Plate																			
Mid-Width	66	122	189	254	327	387	443	499	544	581	647	715	772	831	866	883	900	942	972
B/6 from C/L	79	127	192	256	327	386	441	495	541	577	646	719	778	839	874	891	910	951	981
B/4 from C/L	62	114	176	238	309	367	421	476	522	560	634	710	772	837	875	893	918	953	982
B/3 from C/L	60	109	170	232	301	360	414	468	515	554	631	713	778	843	883	899	920	960	990
Plate Extension																			
x/3 from FL. Tip	97	147	211	269	334	386	437	487	532	570	666	753	830	892	921	934	954	983	1009
x/2 from FL. Tip	63	116	178	238	306	364	417	471	519	560	663	747	837	892	921	934	956	984	1008
2x/3 from FL. Tip	74	131	199	263	336	394	448	503	550	591	690	770	853	911	935	947	965	992	1018
Fillet Weld	37	76	126	180	241	295	345	396	442	484	588	682	763	837	879	895	922	957	987
Furnace Gas (b)	550	552	625	675	717	730	761	786	799	813	852	909	943	967	975	985	998	1021	1039
Standard Curve (c)	502	603	663	705	739	766	789	809	826	842	885	918	945	968	986	994	1006	1022	1036
Deflection mm	4	9	15	22	31	39	46	53	59	64	79	94	110	127	151	170 (d)			
Deflection Rate mm/min	2	2	2	2	3	3	3	2	2	1	1	2	2	2	3	4			



DATA SHEET NUMBER **103A**

SLIM FLOOR BEAM

DIMENSIONS AND PROPERTIES

Section Serial Size and Type mm	Dimensions and Properties	Depth of Section mm	Width of Section mm	Mass Per Metre kg	Thickness		Elastic Modulus		Plastic Modulus		Moment of Inertia	
					Web mm	Flange mm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^4	Axis y-y cm^4
305 x 305 Column	Nominal Actual	365.3 368	321.8 320	283 281.2	26.9 27.3	44.1 43.7	4314 4314	1525 1495	5101 5100	2337 2293	78777 79378	24545 23920
525 x 15 Plate	Nominal Actual	15.0 16.95	525 525	61.8 69.9								
UC & Plate Combined	Nominal (a) Actual (a)			345.2 351.6			4716 4761	1631 1696	6027 6104	3381 3471	102316 105938	42803 44528

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt.%)

Product	Steel Quality	C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu	Nb	Al	N
Column	Fe 430 A	0.16	0.28	1.00	0.023	0.018	0.15	<0.005	0.02	<0.005	<0.02	<0.005	0.038	0.0070
Plate (b)	Fe 430 A	0.12	0.33	0.94	0.014	0.014	0.02	<0.005	<0.02	<0.005	<0.02	<0.005	0.052	0.0068

ROOM TEMPERATURE TENSILE PROPERTIES

Position	LYS N/mm^2	TS N/mm^2	Elong. %
Column	284	474	34.0
Plate	279	439	35.0

TEST CONDITIONS

NOTES

(a) Including the 8 mm fillet weld.

(b) Manufactured by Huta Czestochowa, Poland.

(c) Initial ambient temperature = 21°C.

(d) Based on an initial ambient temperature of 20°C.

(e) Load applied to the blockwork was removed after 90 min. Heating continued with load applied to beam only.

TEST CENTRE	: WARRINGTON RESEARCH
TEST DATE	: 7th AUGUST 1991
TEST NUMBER	: WFRC 51883

BS476 : PARTS 20 & 21 : 1987 RESULTS

TIME TO L/30	: NOT ATTAINED
TIME TO L²/9000D	: NOT ATTAINED
RE-LOAD TEST	: NOT CARRIED OUT
LOAD BEARING CAPACITY	: 90 MINUTES
FIRE RESISTANCE	: 90 MINUTES

DATA SHEET NUMBER **103B**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	40	50	60	70	80	90	100	110	120
Upper Flange	27	27	27	27	27	27	27	27	27	27	30	38	49	59	66	72	80	86	94
UF/Web Junction	27	27	27	27	27	27	27	27	27	27	30	38	48	59	67	76	85	94	103
Web																			
Mid-height of exposed portion	28	28	28	28	29	29	29	29	29	30	45	60	77	95	111	128	143	158	172
10 mm above concrete	28	28	28	28	29	29	29	29	33	37	64	85	110	134	157	180	201	221	239
10 mm below concrete	28	28	28	28	29	29	29	31	36	42	75	97	126	153	179	204	228	249	269
Mid-distance TC11 to top of concrete	28	28	28	28	29	29	34	40	45	52	94	116	156	189	220	249	277	303	326
50 mm from LF	28	28	28	28	32	40	50	58	67	79	109	171	223	267	306	345	382	415	443
30 mm from LF	28	28	28	29	38	49	61	70	82	95	131	204	263	313	358	403	445	482	512
10 mm from LF	27	27	27	33	47	60	74	85	99	114	167	246	313	370	422	475	524	563	594
LF/Web Junction	27	27	33	44	64	83	96	115	135	156	225	306	381	445	504	564	617	660	689
Lower Flange																			
B/6 from C/L	27	27	34	45	62	83	101	125	147	169	246	330	405	471	531	592	647	690	718
B/4 from C/L	27	27	36	50	67	90	115	138	161	186	271	361	436	503	566	632	687	727	754
B/3 from C/L	27	28	41	62	83	105	131	156	180	205	290	374	448	513	573	637	692	733	758
Plate																			
Mid-Width	55	106	171	231	291	334	388	450	503	545	640	687	726	759	792	819	834	888	904
B/6 from C/L	53	103	171	232	290	340	385	439	490	530	619	669	718	764	803	840	846	906	922
B/4 from C/L	50	95	151	192	258	326	385	436	486	527	620	669	713	749	778	806	827	885	910
B/4 from C/L (1500 mm)	54	102	167	231	294	356	407	455	503	544	642	697	735	771	812	848	864	912	916
B/4 overall	51	98	157	208	272	338	394	444	493	534	629	680	722	757	791	823	842	895	912
B/3 from C/L	48	94	154	206	263	322	369	413	458	497	592	645	694	735	766	795	816	867	893
Plate Extension																			
x/3 from FL. Tip	52	98	157	209	264	316	360	402	446	484	590	667	725	781	833	879	906	950	955
x/2 from FL. Tip	54	107	173	229	286	344	393	440	488	530	641	714	770	827	877	918	942	986	986
x/2 from FL. Tip (930 mm)	53	105	169	227	284	341	392	439	488	530	642	717	777	836	886	924	943	984	983
x/2 from FL. Tip (1500 mm)	49	94	155	210	263	317	365	409	454	496	608	690	749	809	860	904	925	966	966
x/2 overall	52	103	167	223	279	335	385	431	478	520	632	708	766	824	875	916	937	980	979
2x/3 from FL. Tip	57	114	182	241	300	356	403	447	495	536	645	720	779	835	886	928	947	988	986
Fillet Weld	33	59	97	136	178	221	260	295	333	367	465	543	608	666	720	773	817	866	886
Cavity	27	27	31	34	35	33	34	38	39	40	45	54	60	64	74	84	94	108	117
Furnace Gas (c)	465	572	664	680	727	752	764	797	824	839	888	923	954	984	1006	1026	1000	1045	1043
Standard Curve (d)	502	603	663	705	739	766	789	809	826	842	885	918	945	968	988	1006	1022	1036	1049
Deflection mm	1	3	5	8	10	11	13	15	17	19	25	33	39	46	52	58 (e)			
Deflection Rate mm/min	1	1	1	1	0	0	0	0	0	1	0	1	0	0	0	1			

TEST CENTRE : WARRINGTON RESEARCH
TEST DATE : 7th AUGUST 1991
TEST NUMBER : WFRC 51883

DATA SHEET NUMBER **103C**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	40	50	60	70	80	90	100	110	120
Concrete																			
CCA1	29	29	29	29	29	29	34	39	51	90	99	101	106	159	198	240	286	329	367
CCB1	27	27	27	27	28	28	32	36	41	46	74	92	104	132	166	198	238	277	314
CCA2	27	27	27	27	28	28	32	36	45	97	99	101	101	101	153	200	236	269	303
CCB2	27	27	27	27	28	28	30	33	38	43	61	80	101	104	133	165	188	212	240
CCA3	29	29	29	29	29	34	41	49	61	87	98	101	102	103	119	182	226	261	294
CCB3	27	27	27	27	28	30	37	44	50	57	76	97	102	107	139	165	186	215	245
CCA4	29	29	29	29	29	29	29	29	31	44	92	98	103	114	133	153	178	208	239
CCB4	27	27	27	27	28	28	28	28	28	30	49	66	80	99	110	122	138	154	176
CCA5	27	27	27	27	28	28	28	28	28	29	92	97	99	100	102	105	119	135	148
CCB5	27	27	27	27	28	28	28	28	28	28	37	52	72	87	101	107	119	130	138
CCA6	27	27	27	27	28	28	28	30	35	42	99	100	101	101	102	102	108	126	142
CCB6	27	27	27	27	28	28	28	28	30	35	52	67	82	91	99	106	111	119	131
CCA7	29	29	29	29	29	29	29	29	29	29	92	98	100	101	103	111	124	140	158
CCB7	27	27	27	27	28	28	28	28	28	28	39	59	73	84	100	108	116	125	139
CCA8	27	27	27	27	28	28	28	28	28	28	73	90	94	96	98	100	98	103	110
CCB8	27	27	27	27	28	28	28	28	28	28	28	38	53	70	80	92	101	104	109
CCA9	27	27	27	27	28	28	28	28	28	30	76	94	96	98	98	99	90	96	104
CCB9	27	27	27	27	28	28	28	28	28	28	36	51	63	78	83	91	99	103	105

DATA SHEET NUMBER **104A**

SLIM FLOOR BEAM

DIMENSIONS AND PROPERTIES

Section Serial Size and Type mm	Dimensions and Properties	Depth of Section mm	Width of Section mm	Mass Per Metre kg	Thickness		Elastic Modulus		Plastic Modulus		Moment of Inertia	
					Web mm	Flange mm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^4	Axis y-y cm^4
152 x 152 Column	Nominal Actual	157.5 160	152.9 152	30 29.5	6.6 6.6	9.4 9.1	221.2 219.7	73.06 70.14	247.1 245.3	111.2 106.9	1742 1757	558.0 533.1
355 x 15 Plate	Nominal Actual	15.0 15.0	355 358	41.8 42.2								
UC & Plate Combined	Nominal (a) Actual (a)			72.4 72.1			265.2 262.9	348.9 352.4	341.0 338.9	589.3 592.6	3422 3463	6193 6308

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

Product	Steel Quality	C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu	Nb	Al	N
Column	Fe 510 B	0.17	0.01	1.52	0.015	0.017	<0.02	<0.005	0.02	<0.005	<0.02	0.032	<0.005	0.0036
Plate	Fe 510 B	0.11	0.36	1.34	0.018	0.008	0.02	<0.005	0.02	<0.005	<0.02	0.030	0.043	0.0037

ROOM TEMPERATURE TENSILE PROPERTIES

Position	LYS N/mm^2	TS N/mm^2	Elong. %
Column	439	550	26.0
Plate	413	539	33.5

TEST CONDITIONS

NOTES

(a) Including the 8 mm fillet weld.

(b) Initial ambient temperature = 20°C.

(c) Based on an initial ambient temperature of 20°C.

(d) Loads applied to both beam and blockwork were increased after 69 min.

(*) Data considered to be unreliable.

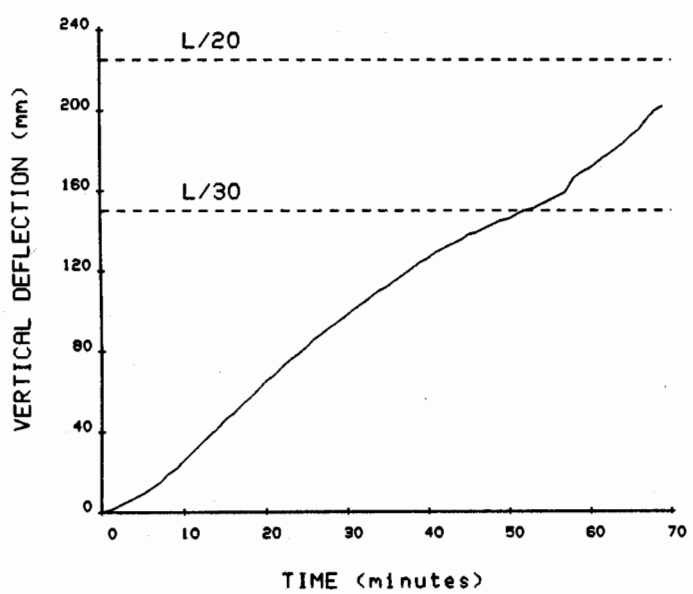
TEST CENTRE	: WARRINGTON RESEARCH
TEST DATE	: 30th OCTOBER 1991
TEST NUMBER	: WFRC 54278

BS476:PARTS 20 & 21:1987 RESULTS

TIME TO L/30	: 52 MINUTES
TIME TO $L^2/9000D$	: NOT ATTAINED
RE-LOAD TEST	: NOT CARRIED OUT
LOAD BEARING CAPACITY	: 69 MINUTES
FIRE RESISTANCE	: 69 MINUTES

DATA SHEET NUMBER **104B**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	35	40	45	52	55	60	65	69	72
Upper Flange	17	18	19	20	25	31	37	46	54	62	71	80	92	111	120	133	149	166	184
UF/Web Junction	17	19	21	23	26	30	37	45	53	59	66	73	80	97	106	121	144	162	186
Web																			
Mid-Height of Exposed Portion	18	18	20	25	32	41	51	64	77	88	105	122	141	166	177	195	216	234	257
10 mm above concrete	18	18	22	31	41	54	70	89	106	117	139	164	188	218	229	247	264	280	294
10 mm below concrete	18	19	26	38	52	69	92	110	127	143	173	203	234	270	284	306	325	342	355
50 mm from LF	18	20	28	41	56	78	99	120	142	165	203	240	279	322	338	364	387	405	418
30 mm from LF	18	26	39	61	84	108	135	165	196	224	272	317	365	414	431	460	485	505	519
10 mm from LF	21	34	57	89	120	155	194	235	276	315	377	438	499	553	573	603	630	653	665
LF/Web Junction	40	68	107	149	202	252	300	347	392	435	500	556	602	666	689	717	744	769	784
Lower Flange																			
B/6 from C/L	38	65	104	146	199	250	299	347	391	435	501	558	607	670	691	720	748	776	791
B/4 from C/L	39	69	113	161	215	268	319	369	415	458	520	578	628	684	703	731	757	783	801
B/3 from C/L	42	74	117	166	221	273	323	372	418	436	528	586	636	697	718	749	776	801	818
Plate																			
Mid-Width	72	120	169	219	269	322	370	417	464	505	569	621	663	726	748	773	803	829	845
B/6 from C/L	57	95	142	189	247	301	351	399	445	488	553	607	650	713	735	763	791	819	836
B/4 from C/L	70	118	174	229	286	342	398	448	495	538	597	642	690	744	761	788	813	839	855
B/4 from C/L (1500 mm)	55	94	144	197	249	302	352	400	445	486	539	591	632	687	708	735	759	787	803
B/4 overall	62	106	159	213	267	322	375	424	470	512	568	617	661	715	734	761	786	813	829
B/3 from C/L	57	98	146	198	254	309	361	410	456	500	565	621	666	727	747	778	806	834	849
Plate Extension																			
x/3 from FL. Tip	52	97	153	213	274	334	390	445	494	540	606	665	712	764	786	818	843	871	885
x/2 from FL. Tip	69	124	186	248	308	368	426	480	529	573	636	692	735	782	803	831	855	883	897
x/2 from FL. Tip (930 mm)	57	106	165	225	284	342	399	454	502	547	613	672	717	769	791	823	848	876	891
x/2 from FL. Tip (1500 mm)	59	105	165	224	279	334	387	440	487	530	594	653	701	752	772	804	830	858	873
x/2 overall	63	113	174	234	292	351	407	461	509	553	618	675	720	769	791	821	846	874	888
2x/3 from FL. Tip	61	117	180	245	308	370	430	485	534	579	643	698	741	794	815	843	866	894	906
Fillet Weld	31	56	92	130	172	219	267	315	361	405	475	537	587	647	668	700	726	751	767
Cavity	18	22	23	24	29	34	45	51	55	68	70	73	78	96	99	100	120	139	186
Furnace Gas (b)	449	568	623	670	696	729	762	776	793	818	836	869	892	917	927	930	952	972	971
Standard Curve (c)	502	603	663	705	739	766	789	809	826	842	865	885	902	924	932	945	957	966	973
Defection mm	5	12	22	34	46	57	68	79	89	98	112	126	138	150	155	171	187	202 (d)	
Deflection Rate mm/min	2	3	3	4	4	4	3	3	3	3	2	2	3	2	2	2	4	2	



TEST CENTRE : WARRINGTON RESEARCH
TEST DATE : 31st OCTOBER 1991
TEST NUMBER : WFRC 54278

DATA SHEET NUMBER **104C**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	35	40	45	52	55	60	65	69	72
Concrete																			
CCA1	19	22	34	52	73	94	102	111	129	155	203	252	306	368	390	425	457	482	501
CCB1	19	22	32	47	65	85	100	105	120	143	189	240	293	358	382	416	447	471	488
CCA2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCB2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCA3	21	37	58	82	102	116	145	173	205	239	295	350	401	463	487	524	559	586	606
CCB3	19	23	35	54	76	97	101	108	126	148	190	236	281	338	359	392	422	445	463
CCA4	19	19	21	29	41	56	75	99	101	102	103	123	161	214	232	263	293	317	336
CCB4	19	19	20	25	34	47	65	85	97	101	102	117	147	192	210	241	270	292	309
CCA5	19	19	22	30	41	55	74	93	101	102	103	119	156	208	227	258	288	312	330
CCB5	18	18	19	24	34	46	63	84	94	100	101	111	136	176	192	219	247	268	284
CCA6	19	24	34	43	56	75	93	101	101	106	132	171	211	265	287	322	357	384	404
CCB6	18	18	20	30	44	60	77	89	94	97	101	110	129	169	185	211	237	258	273
CCA7	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCB7	18	18	18	20	25	32	46	72	87	93	99	102	113	137	146	167	191	211	226
CCA8	19	19	20	25	33	43	57	77	99	101	102	102	119	159	174	200	227	251	270
CCB8	18	18	18	20	25	33	53	86	94	97	100	101	106	134	146	164	186	203	217
CCA9	19	22	30	38	46	55	72	91	97	99	104	126	153	199	219	252	286	313	333
CCB9	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

DATA SHEET NUMBER **105A**

SLIM FLOOR BEAM

DIMENSIONS AND PROPERTIES

Section Serial Size and Type mm	Dimensions and Properties	Depth of Section mm	Width of Section mm	Mass Per Metre kg	Thickness		Elastic Modulus		Plastic Modulus		Moment of Inertia	
					Web mm	Flange mm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^4	Axis y-y cm^4
254 x 254 Column	Nominal Actual	254.0 254	254.0 256	73 70.0	8.6 8.9	14.2 13.2	894.5 854.5	305.0 288.5	988.6 944.3	462.4 438.1	11360 10852	3873 3693
460 x 15 Plate	Nominal Actual	15.0 15.1	460 458	54.2 54.3								
UC & Plate Combined	Nominal (a) Actual (a)			127.6 124.8			1006 964.7	702.4 694.0	1226 1182	1265 1238	18578 17946	16155 15892

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

Product	Steel Quality	C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu	Nb	Al	N
Column (b)	Fe 430 A	0.20	0.26	0.58	0.027	0.021	0.05	0.005	0.04	<0.005	0.06	<0.005	0.050	0.0057
Plate (c)	Fe 430 A	0.14	0.27	0.94	0.024	0.022	0.11	0.016	0.06	<0.005	0.08	<0.005	0.016	0.0046

ROOM TEMPERATURE TENSILE PROPERTIES

Position	LYS N/mm^2	TS N/mm^2	Elong. %
Column	307	486	35.0
Plate	317	472	35.5

TEST CONDITIONS

NOTES

(a) Including the 8 mm fillet weld.

(b) Manufactured by Unimetal, France.

(c) Manufactured by Huta Czestochowa, Poland.

(d) Initial ambient temperature = 15°C

(e) Based on an initial ambient temperature of 20°C.

(*) Data considered to be unreliable.

TEST CENTRE	: WARRINGTON RESEARCH
TEST DATE	: 4th NOVEMBER 1992
TEST NUMBER	: WFRC 56867

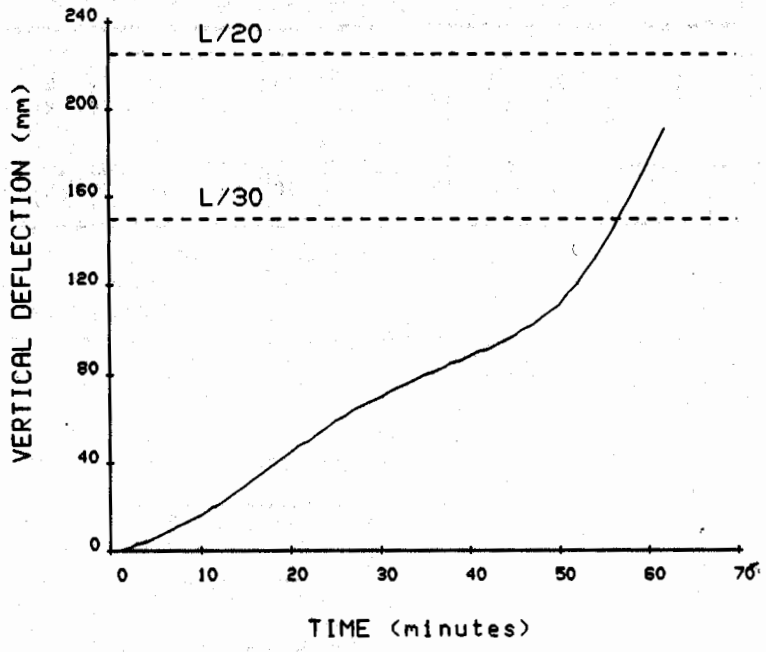
BS476 : PARTS 20 & 21 : 1987 RESULTS

TIME TO L/30	: 56 MINUTES
TIME TO $L^2/9000D$	: 62 MINUTES
RE-LOAD TEST	: NOT CARRIED OUT
LOAD BEARING CAPACITY	: 62 MINUTES
FIRE RESISTANCE	: 62 MINUTES

DATA SHEET NUMBER **105B**

THERMOCOUPLE LOCATION		TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
		3	6	9	12	15	18	21	24	27	30	35	40	45	50	56	62	70	80	90
Upper Flange	Mean A17, B17	23	23	24	24	24	24	24	24	27	34	46	64	70	73	77	86	96	99	99
	D17	23	24	24	24	24	24	26	31	36	41	50	58	66	75	88	100	101	102	109
	E17	23	23	23	23	23	23	23	23	23	25	35	43	53	67	92	100	100	101	101
UF/Web Junction	Mean A16, B16	24	24	25	25	25	25	25	34	46	57	73	84	86	89	93	98	100	102	105
	Mean C16, D16	23	24	24	24	24	27	31	36	43	49	57	63	70	79	90	97	102	109	122
	E16	23	23	23	23	23	23	23	23	30	40	54	70	85	94	98	100	100	101	103
Web, Between Duct and UF	D15	23	23	27	30	36	41	48	56	63	68	78	81	86	91	96	101	121	143	167
Web, Mid Height of Section	Mean A12, B12	24	25	25	25	25	60	97	102	102	104	116	133	144	146	160	179	200	219	236
	E12	23	23	23	23	23	25	89	100	101	101	101	109	120	134	146	157	174	190	210
Web Between Centre Ducts	Mean W5, W8	25	26	31	38	53	97	102	102	107	119	147	152	167	184	207	238	275	311	344
	Mean W6, W7	25	25	25	29	39	98	100	101	103	108	139	125	134	145	186	218	253	286	316
	Mean W1, W4	24	24	24	24	32	96	99	100	101	103	124	111	115	106	151	180	213	240	264
	Mean W2, W3	24	25	25	25	30	84	100	101	101	103	121	124	126	123	147	178	206	229	248
Web, 50 mm From LF	Mean A11, B11	23	24	24	35	46	63	94	100	108	142	198	239	269	305	335	369	408	444	475
	E11	23	23	23	27	40	87	98	100	101	102	139	188	207	210	270	304	340	387	428
Web, 30 mm From LF	Mean A10, B10	24	25	29	53	67	74	98	112	149	195	255	308	374	407	447	*	*	*	*
	E10	23	23	24	36	58	94	99	100	111	141	203	259	291	309	355	395	436	496	540
Web, 10 mm From LF	Mean A9, B9	24	25	40	73	90	93	104	137	197	247	320	384	440	479	534	581	*	*	*
	Mean C9, D9	23	27	44	67	103	128	165	208	256	303	382	462	531	587	646	692	733	796	850
	E9	23	23	32	51	84	98	103	104	135	182	258	326	374	414	463	511	556	629	674
LF/Web Junction	A8	23	23	38	68	98	99	115	176	237	286	358	424	480	528	579	623	*	*	*
	Mean C8, D8	23	26	44	68	102	132	172	216	264	313	393	473	544	601	660	707	748	814	868
	E8	23	23	34	54	90	101	103	106	140	192	268	341	392	434	485	531	576	650	695
Flange Between Centre Ducts	Mean F1, F4	23	29	49	86	112	144	186	235	285	331	401	468	526	578	634	685	733	785	832
LF B/6 From C/L	Mean A7, B7	24	27	45	85	102	105	116	165	221	270	348	419	482	538	599	659	*	*	*
	Mean C7, D7	23	31	53	80	114	152	195	241	292	342	425	509	578	634	692	734	785	850	898
	E7	23	27	47	72	102	118	117	137	189	242	314	395	455	503	554	599	642	714	759
LF B/3 From C/L	Mean A6, B6	24	41	72	107	144	174	199	271	329	379	453	520	575	622	672	707	754	806	849
	Mean C6, D6	23	43	75	103	146	192	239	289	340	391	472	555	618	670	723	765	820	878	918
	E6	23	42	78	100	129	170	199	234	276	321	392	469	528	574	620	660	699	761	806
Plate, Mid Width	Mean A5, B5	68	135	199	239	332	426	495	552	599	636	682	715	741	756	780	807	843	893	932
	Mean C5, D5	72	140	212	287	354	434	498	555	602	638	685	717	746	768	807	838	884	919	958
	E5	70	124	187	251	302	372	444	505	556	594	646	676	700	723	749	767	815	834	880
Plate, B/6 From C/L	Mean A4, B4	69	139	211	260	342	430	496	554	601	639	686	720	748	766	794	822	862	907	945
	D4	81	146	216	289	360	433	494	549	596	634	683	716	750	773	814	845	894	929	969
	E4	87	151	211	269	336	399	460	519	566	607	661	693	721	745	768	790	836	855	899
Plate, B/3 From C/L	Mean A3, B3	66	125	190	255	327	404	468	526	576	617	669	708	740	763	796	825	867	912	949
	Mean C3, D3	80	138	202	274	347	416	477	535	584	625	679	719	754	782	824	856	907	941	976
	E3	64	108	159	220	290	354	416	475	526	569	627	664	699	728	757	783	830	853	900
Plate Extension, x/3 From Flange Tip	Mean A2, B2	66	122	180	244	315	385	445	504	559	606	670	719	757	791	833	864	906	935	966
	Mean C2, D2	66	117	173	237	306	375	440	502	561	610	678	732	774	818	862	893	932	959	988
	E2	47	90	136	190	249	310	371	429	484	533	602	658	706	741	782	815	859	895	931
Plate Extension, 2x/3 From Flange Tip	Mean A1, B1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Mean C1, D1	87	149	209	274	344	415	479	543	602	650	716	762	808	847	888	911	945	966	992
	E1	60	110	159	211	269	327	388	450	507	558	629	684	732	766	812	844	887	921	954
Services Duct	Mean Duct 1, Duct 2	319	358	417	456	496	528	533	559	547	573	572	596	620	631	641	663	686	709	745
Furnace Gas (d)		480	565	623	665	720	748	768	801	824	840	863	883	910	919	938	944	972	984	1005
Standard Curve (e)		502	603	663	705	739	766	789	809	826	842	865	885	902	918	935	950	968	988	1006
Deflection	mm	3	8	14	21	30	39	48	56	64	70	80	88	97	111	144	191			
Deflection Rate	mm/min	2	2	2	2	3	3	3	3	3	2	2	2	2	3	6	8			

DATA SHEET NUMBER **105C**



TEST CENTRE : WARRINGTON RESEARCH
TEST DATE : 4th NOVEMBER 1992
TEST NUMBER : WFRC 56867

DATA SHEET NUMBER **105D**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	35	40	45	50	56	62	70	80	90
Concrete at Mid-Span																			
C/C 1	23	23	24	24	24	24	24	24	26	32	40	48	56	64	71	77	83	91	97
C/C 2	23	23	24	24	24	24	24	26	32	37	46	55	63	71	79	85	92	100	102
C/C 3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
C/C 4	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
C/C 5	23	23	24	24	24	26	32	38	45	52	62	72	81	91	103	107	110	122	152
C/C 6	25	25	25	25	25	28	33	39	46	54	85	107	112	112	109	109	117	163	217
C/C 7	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

DATA SHEET NUMBER **106A**

INDICATIVE SLIM FLOOR BEAM

DIMENSIONS AND PROPERTIES

Section Serial Size and Type mm	Dimensions and Properties	Depth of Section mm	Width of Section mm	Mass Per Metre kg	Thickness		Elastic Modulus		Plastic Modulus		Moment of Inertia	
					Web mm	Flange mm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^4	Axis y-y cm^4
152 x 152 Column	Nominal	157.5	152.9	30	6.6	9.4	221.2	73.06	247.1	111.2	1742	558.0
	Actual	158	152	29.7	6.6	9.25	219.0	71.30	244.6	108.6	1730	541.9
355 x 15 Plate	Nominal	15.0	355	41.8								
	Actual	15.2	360	43.0								
UC & Plate Combined	Nominal (a)			72.4			265.2	348.9	341.0	589.3	3422	6193
	Actual (a)			73.1			262.4	360.6	338.7	606.1	3422	6491

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

Product	Steel Quality	C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu	Nb	Al	N
Column	Fe 510 B	0.17	0.02	1.43	0.015	0.015	<0.02	<0.005	0.02	<0.005	0.01	0.032	<0.005	0.0025
Plate	Fe 510 B	0.13	0.36	1.39	0.016	0.007	<0.02	<0.005	0.02	<0.005	0.01	0.031	0.043	0.0050

ROOM TEMPERATURE TENSILE PROPERTIES

Position	LYS N/mm^2	TS N/mm^2	Elong. %
Column	420	561	29.5
Plate	402	545	32.5

TEST CONDITIONS

NOTES

(a) Including the 8 mm fillet weld.

(b) Initial ambient temperature = 21°C.

(c) Based on an initial ambient temperature of 20°C.

(*) Data considered to be unreliable.

TEST CENTRE	: WARRINGTON RESEARCH
TEST DATE	: 31st JULY 1991
TEST NUMBER	: WFRC 51884

INDICATIVE SLIM FLOOR BEAM

FURNACE TYPE	: FLOOR FURNACE
POSITION IN FURNACE	: FULL LENGTH MEMBER

DATA SHEET NUMBER **106B**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	35	40	45	50	55	60	70	80	88
Upper Flange	25	27	32	36	41	48	57	60	64	70	89	108	125	140	153	165	194	247	407
UF/Web Junction	25	29	37	42	49	57	69	71	74	82	104	127	147	163	176	189	217	261	370
Web																			
Mid-Height of Exposed Portion	27	32	40	47	58	73	90	94	100	116	148	176	198	216	232	248	278	318	395
10 mm above concrete	26	28	36	46	59	76	96	113	125	140	170	196	217	237	254	271	304	345	407
10 mm below concrete	27	28	38	52	68	88	112	133	149	167	199	229	254	277	299	318	357	398	448
50 mm from LF	27	29	41	57	76	100	126	151	172	193	232	267	297	323	346	366	404	438	475
30 mm from LF	27	34	50	71	96	118	150	182	209	239	290	335	373	408	437	463	510	551	591
10 mm from LF	29	46	74	108	148	189	234	281	319	363	426	477	521	556	584	609	653	694	734
LF/Web Junction	45	74	119	167	218	267	323	370	412	465	527	580	627	663	688	708	755	802	844
Lower Flange																			
B/6 from C/L	52	85	135	187	241	292	351	398	442	497	560	612	660	696	721	742	792	844	882
B/4 from C/L	46	79	130	185	242	296	356	405	447	500	561	612	656	686	710	731	780	828	864
B/3 from C/L	49	81	130	182	236	286	344	392	436	491	557	612	659	695	720	744	796	849	888
Plate																			
Mid-Width	62	99	153	207	260	312	374	416	461	514	574	624	671	707	732	751	801	851	892
B/6 from C/L	78	119	177	231	284	333	393	435	479	534	592	641	688	723	747	767	815	863	901
B/4 from C/L	64	105	165	226	285	341	409	453	498	552	606	655	698	727	747	764	809	855	893
B/4 from C/L (1500 mm)	57	92	144	196	251	303	363	408	451	502	561	607	652	688	717	737	776	823	860
B/4 overall	60	99	154	211	268	322	390	435	479	532	588	636	680	712	735	753	796	842	880
B/3 from C/L	61	98	153	208	264	316	378	423	469	524	586	639	686	721	747	772	824	875	911
Plate Extension																			
x/3 from FL. Tip	60	103	167	226	287	344	413	464	509	567	632	684	723	751	781	810	861	905	934
x/2 from FL. Tip	67	116	184	250	315	374	444	493	534	593	653	699	732	757	785	812	858	900	928
x/2 from FL. Tip (930 mm)	67	117	183	246	309	368	437	487	528	585	648	696	730	758	785	811	858	900	927
x/2 from FL. Tip (1500 mm)	82	128	190	251	313	370	434	476	516	572	631	682	720	746	771	797	843	887	916
x/2 overall	71	119	185	249	312	371	439	486	527	584	645	693	728	754	781	807	853	896	924
2x/3 from FL. Tip	70	120	190	254	319	379	451	499	541	603	668	715	748	780	811	839	887	925	950
Fillet Weld	41	71	116	165	217	266	323	375	417	472	539	593	638	781	696	721	770	819	853
Cavity	25	36	45	55	65	86	101	57	58	98	133	146	*	*	*	*	*	*	*
Furnace Gas (b)	497	589	668	710	729	762	805	755	821	852	863	886	901	918	930	943	970	992	1004
Standard Curve (c)	502	603	663	705	739	766	789	809	826	842	865	885	902	918	932	945	968	988	1003

TEST CENTRE : WARRINGTON RESEARCH
TEST DATE : 31st JULY 1992
TEST NUMBER : WFRC 51884

DATA SHEET NUMBER **106C**

THERMOCOUPLE LOCATION	TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES)																		
	3	6	9	12	15	18	21	24	27	30	35	40	45	50	55	60	70	80	88
Concrete																			
CCA1	26	26	29	39	56	87	97	96	97	101	114	148	182	217	252	285	349	409	463
CCB1	26	32	48	70	96	104	126	158	193	235	305	363	411	455	491	520	569	618	658
CCA2	26	33	51	75	87	98	122	135	164	208	268	322	373	421	463	498	565	632	692
CCB2	26	30	45	66	90	99	106	133	165	196	258	301	348	395	436	469	524	582	629
CCA3	26	33	52	75	94	101	130	163	186	215	273	329	382	430	472	509	576	638	690
CCB3	26	28	40	60	81	96	100	120	141	164	211	254	309	357	394	425	480	535	582
CCA4	26	26	33	51	81	99	100	97	99	111	158	211	263	310	350	384	448	510	571
CCB4	26	26	29	40	65	95	96	92	100	114	153	203	247	295	335	367	422	478	539
CCA5	26	26	33	50	70	87	96	91	94	102	125	169	220	270	311	347	413	483	552
CCB5	26	26	27	37	54	74	88	97	99	100	109	126	159	210	256	289	345	401	452
CCA6	26	26	36	49	64	86	99	101	103	107	147	185	230	277	319	356	421	484	536
CCB6	26	26	29	40	55	70	83	93	97	101	106	124	177	219	255	284	336	387	431
CCA7	26	33	50	79	96	105	117	183	223	263	334	395	449	497	534	567	627	690	744
CCB7	26	26	26	29	37	82	93	82	86	99	100	105	132	168	201	232	292	348	410
CCA8	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCB8	26	26	26	26	33	48	65	76	77	99	100	100	100	107	140	166	218	277	328
CCA9	26	26	31	40	52	66	86	97	97	100	100	137	164	203	243	278	340	402	456
CCB9	26	26	26	28	36	50	67	69	69	79	96	97	100	112	135	157	207	261	310

APPENDIX 2

LOAD CALCULATION SUMMARY SHEETS

A2.1 TEST WFRC 50521 : NON-COMPOSITE SLIM FLOOR BEAM

A2.1.1 Geometry

Figures 1, 2 and 5 give relevant details.

A2.1.2 Material Properties

(a) Steel

The steel grade for both beam and plate was specified as Fe 430 A. See data sheet 99A in Appendix 1 for measured properties.

(b) Concrete

The maximum moisture content of the concrete, measured on the day of the test, was found to be 4.7%. The characteristic strength of the concrete was accepted as being 60 N/mm^2 and the density as 1200 kg/m^3. (50% of normal weight concrete, viz 2400 kg/m^3).

A2.1.3 Load Calculations

A2.1.3.1 Locate PNA

The balance of yield strengths and areas reveals that the PNA is located in the lower flange of the UC section at a distance of 0.912 mm from the upper face.

A2.1.3.2 Assess M_p

Calculations involving the force, (material strength x element areas), multiplied by the lever arm about the PNA reveal that the plastic moment of resistance of the section is 510.7 kN m.

A2.1.3.3 Assess Applied Moment

(a) UC Section and Plate dead load moment M_{ds} = 4.075 kN m

(b) Concrete Slab dead load moment M_{dc} = 9.11 kN m

(c) Sand fill dead load moment = Negligible by Inspection

(d) Imposed live load moment

4 No. point loads arranged symmetrically about centre span

M_{max} = 267.3 kN m

Total Applied Moment = 280.5 kN m

A2.1.3.4 Assess Local Buckling Classification

(a) Flange outstand:

$b/T = 258.3/(20.5 \times 2)$ = 6.3

$6.3 < 9.2, \therefore$ Class 1

(b) Web (subject to compression throughout)

$d/t_w = 200.2/13.0$ = 15.4

$15.4 < 30.5, \therefore$ Class 1

(c) Therefore the section is Class 1 for local buckling

A2.1.3.5 Assess LTB Resistance Moment (BS5950: Pt. 1: 1990)

This calculation was based upon the assumption that the loading positions do not offer any lateral restraint to the compression flange of the beam:

M_b = 408 kN m

A2.1.3.6 Load Ratios

(a) Assuming load points as positions of lateral restraint:

R = 0.55

(b) Assuming load points do not provide positions of lateral restraint:

R = 0.69

A2.2 TEST WFRC 50522 : COMPOSITE SLIM FLOOR BEAM

A2.2.1 Geometry

Figures 6, 7 and 9 give relevant details.

A2.2.2 Material Properties

(a) Steel

The steel grade for both beam and plate was specified as Fe 430 A. See data sheet 100A in Appendix 1 for measured properties.

(b) Concrete

The maximum moisture content of the concrete, measured on the day of the test, was found to be 4.1%. The characteristic strength of the concrete was accepted as being 35 N/mm^2 and its density as 2400 kg/m^3.

A2.2.3 Load Calculations

A2.2.3.1 Locate PNA

The balance of yield strengths and areas reveals that the PNA is located at a distance of 255.8 mm from the top of the concrete slab.

A2.2.3.2 Assess M_p

Calculations involving the force, (material strength x element areas), multiplied by the lever arm about the PNA reveal that the plastic moment of resistance of the section is 799 kN m.

A2.2.3.3 Assess Applied Moment

(a)	UC Section and Plate dead load moment M_{ds}	= 3.44 kN m
(b)	Concrete Slab dead load moment M_{dc}	= 36.45 kN m
(c)	Sand fill dead load moment	= Not applicable
(d)	Imposed live load moment	
	8 No. point loads arranged symmetrically about centre span	
	M_{max}	= 426.9 kN m
	Total Applied Moment	= 466.79 kN m

A2.2.3.4 Load Ratio

Assuming load points as positions of lateral restraint:

$R = 0.58$

A2.3 TEST WFRC 52896 : NON-COMPOSITE SLIM FLOOR BEAM

A2.3.1 Geometry

Figures 10, 11 and 12 gives relevant details.

A2.3.2 Material Properties

(a) Steel

The steel grade for both beam and plate was specified as Fe 430 A. See data sheet 101A in Appendix 1 for measured properties.

(b) Concrete

The maximum moisture contents of the sand and precast concrete blocks, measured on the day of the test, were found to be 1.5% and 1.9% respectively. The measured density of the precast concrete blocks was 1870 kg/m^3.

A2.3.3 Load Calculations

A2.3.3.1 Locate PNA

The balance of yield strengths and areas reveals that the PNA is located in the lower flange of the UC section at a distance of 10.7 mm from the upper face.

A2.3.3.2 Assess M_p

Calculations involving the force, (material strength x element areas), multiplied by the lever arm about the PNA reveal that the plastic moment of resistance of the section is 245.13 kN m.

A2.3.3.3 Assess Applied Moment

(a) UC Section and Plate dead load moment M_{ds} = 2.7 kN m

(b) Concrete Slab dead load moment M_{dc} = 4.05 kN m

(c) Sand fill dead load moment = included in concrete dead load

(d) Imposed live load moment

6 No. point loads arranged symmetrically about centre span

M_{max} = 119.9 kN m

Total Applied Moment = 126.65 kN m

A2.3.3.4 Assess Local Buckling Classification

(a) Flange outstand:

$(b/2)/T = 102.5/14$ = 7.32

$7.32 < 9.2, \therefore$ Class 1

(b) Web (subject to compression throughout)

$d/t_w = 160.8/9.3$ = 17.3

$17.3 < 30.5, \therefore$ Class 1

(c) Therefore the section is Class 1 for local buckling.

A2.3.3.5 Assess LTB Resistance Moment (BS5950: Pt. 1: 1990)

This calculation was based upon the assumption that the loading positions do not offer any lateral restraint to the compression flange of the beam:

M_b = 137.6 kN m

A2.3.3.6 Load Ratios

(a) Assuming load points as positions of lateral restraint:

R = 0.516

(b) Assuming load points do not provide positions of lateral restraint:

R = 0.920

A2.4 TEST WFRC 52897 : NON-COMPOSITE SLIM FLOOR BEAM

A2.4.1 Geometry

Figures 13 and 14 give relevant details.

A2.4.2 Material Properties

(a) Steel

The steel grade for both beam and plate was specified as Fe 430 A. See data sheet 102A in Appendix 1 for measured properties.

(b) Concrete

The maximum moisture contents of the in situ concrete and precast concrete blocks, measured on the day of the test, were found to be 4.1% and 1.9% respectively. The characteristic strength of the in situ concrete was accepted as being 30 N/mm^2 and its density as 2400 kg/m^3. The measured density of the precast concrete blocks was 1870 kg/m^3.

A2.4.3 Load Calculations

A2.4.3.1 Locate PNA

The balance of yield strengths and areas reveals that the PNA is located in the lower flange of the UC section at a distance of 7.72 mm from the upper face.

A2.4.3.2 Assess M_p

Calculations involving the force, (material strength x element areas), multiplied by the lever arm about the PNA reveal that the plastic moment of resistance of the section is 398 kN m.

A2.4.3.3 Assess Applied Moment

(a) UC Section and Plate dead load moment M_{ds} = 3.189 kN m

(b) Concrete Slab dead load moment M_{dc} = 6.78 kN m

(c) Sand fill dead load moment = Not applicable

(d) Imposed live load moment

6 No. point loads arranged symmetrically about centre span

M_{max} = 172.23 kN m

Total Applied Moment = 182.2 kN m

A2.4.3.4 Assess Local Buckling Classification

(a) Flange outstand:

$(b/2)/T = 127/14.2 = 8.9$
$8.9 < 9.2, \therefore$ Class 1

(b) Web (subject to compression throughout)

$d/t_w = 200.2/8.6 = 23.2$
$23.2 < 30.5, \therefore$ Class 1

(c) Therefore the section is Class 1 for local buckling

A2.4.3.5 Assess LTB Resistance Moment (BS5950: Pt. 1: 1990)

This calculation was based upon the assumption that the loading positions do not offer any lateral restraint to the compression flange of the beam:

$M_b = 220$ kN m

A2.4.3.6 Load Ratios

(a) Assuming load points as positions of lateral restraint:

$R = 0.457$

(b) Assuming load points do not provide positions of lateral restraint:

$R = 0.828$

A2.5 TEST WFRC 51883 : NON-COMPOSITE SLIM FLOOR BEAM

A2.5.1 Geometry

Figures 15 and 20 give relevant details.

A2.5.2 Material Properties

(a) Steel

The steel grade for both beam and plate was specified as Fe 430 A. See data sheet 103A in Appendix 1 for measured properties.

(b) Concrete

The maximum moisture contents of the in situ concrete and precast concrete blocks, measured on the day of the test, were found to be 4.0% and 3.2% respectively. The characteristic strength of the in situ concrete was accepted as being 30 N/mm^2 and its density as 2400 kg/m^3. The measured density of the precast concrete blocks was 1920 kg/m^3.

A2.5.3 Load Calculations

A2.5.3.1 Locate PNA

The balance of yield strengths and areas reveals that the PNA is located in the lower flange of the UC section at a distance of 0.975 mm from the upper face.

A2.5.3.2 Assess M_p

Calculations involving the force, (material strength x element areas), multiplied by the lever arm about the PNA reveal that the plastic moment of resistance of the section is 1722.7 kN m.

A2.5.3.3 Assess Applied Moment

(a) UC Section and Plate dead load moment M_{ds} = 8.88 kN m
(b) Concrete Slab dead load moment M_{dc} = 5.82 kN m
(c) Sand fill dead load moment = Not applicable
(d) Imposed live load moment
6 No. point loads arranged symmetrically about centre span
M_{max} = 308.9 kN m
Total Applied Moment = 323.6 kN m

A2.5.3.4 Assess Local Buckling Classification

(a) Flange outstand:

$(b/2)/T = 160/43.7$ = 3.66
$3.66 < 9.2, \therefore$ Class 1

(b) Web (subject to compression throughout)

$d/t_w = 246.6/27.3$ = 9.03
$9.03 < 30.5, \therefore$ Class 1

(c) Therefore the section is Class 1 for local buckling

A2.5.3.5 Assess LTB Resistance Moment (BS5950: Pt. 1: 1990)

This calculation was based upon the assumption that the loading positions do not offer any lateral restraint to the compression flange of the beam:

M_b = 1686.1 kN m

A2.5.3.6 Load Ratios

(a) Assuming load points as positions of lateral restraint:
R = 0.188

(b) Assuming load points do not provide positions of lateral restraint:
R = 0.192

A2.6 TEST WFRC 54278 : NON-COMPOSITE SLIM FLOOR BEAM

A2.6.1 Geometry

Figures 21, 23 and 24 give relevant details.

A2.6.2 Material Properties

(a) **Steel**

The steel grade for both beam and plate was specified as Fe 510 B. See data sheet 104A in Appendix 1 for measured properties.

(b) Concrete

The maximum moisture contents of the in situ concrete and precast concrete blocks, measured on the day of the test, were found to be 3.9% and 2.5% respectively. The characteristic strength of the in situ concrete was accepted as being 30 N/mm^2 and its density as 2400 kg/m^3. The measured density of the precast concrete blocks was 1890 kg/m^3.

A2.6.3 Load Calculations

A2.6.3.1 Locate PNA

The balance of yield strengths and areas reveals that the PNA is located in the lower flange plate at a distance of 1.83 mm from the upper face.

A2.6.3.2 Assess M_p

Calculations involving the force, (material strength x element areas), multiplied by the lever arm about the PNA reveal that the plastic moment of resistance of the section is 150.3 kN m.

A2.6.3.3 Assess Applied Moment

(a)	UC Section and Plate dead load moment M_{ds}	= 1.8 kN m
(b)	Concrete Slab dead load moment M_{dc}	= 3.72 kN m
(c)	Sand fill dead load moment	= Not applicable
(d)	Imposed live load moment	
	6 No. point loads arranged symmetrically about centre span	
	M_{max}	= 59.78 kN m
	Total Applied Moment	= 65.3 kN m

A2.6.3.4 Assess Local Buckling Classification

(a) Flange outstand:

$(b/2)/T = 76/9.1$ = 8.35

$8.35 < 9.2, \therefore$ Class 1

(b) Web (subject to compression throughout)

$d/t_w = 123.4/6.6$ = 18.69

$18.69 < 30.5, \therefore$ Class 1

(c) Therefore the section is Class 1 for local buckling

A2.6.3.5 Assess LTB Resistance Moment (BS5950: Pt. 1: 1990)

This calculation was based upon the assumption that the loading positions do not offer any lateral restraint to the compression flange of the beam:

M_b = 80.1 kN m

A2.6.3.6 Load Ratios

(a) Assuming load points as positions of lateral restraint:

R = 0.434

(b) Assuming load points do not provide positions of lateral restraint:

R = 0.815

A2.7 TEST WFRC 56867 : NON-COMPOSITE DEEP METAL DECK SLIM FLOOR BEAM

A2.7.1 Geometry

Figures 26, 27, 28 and 34 give relevant details.

A2.7.2 Material Properties

(a) Steel

The steel grade for both beam and plate was specified as Fe 430 A. See data sheet 105A in Appendix 1 for measured properties.

(b) Concrete

The maximum moisture content of the concrete, measured on the day of the test, was found to be 4.3%. The characteristic strength of the concrete was accepted as being 30 N/mm^2 and its density as 2400 kg/m^3.

A2.7.3 Load Calculations

A2.7.3.1 Locate PNA

The balance of yield strengths and areas reveals that the PNA is located in the lower flange of the UC section at a distance of 9 mm from the upper face.

A2.7.3.2 Assess M_p

Calculations involving the force, (material strength x element areas), multiplied by the lever arm about the PNA reveal that the plastic moment of resistance of the section is 358.3 kN m.

A2.7.3.3 Assess Applied Moment

(a)	UC Section and Plate dead load moment M_{ds}	= 3.146 kN m
(b)	Concrete Slab dead load moment M_{dc}	= 12.65 kN m
(c)	Sand fill dead load moment	= Not applicable
(d)	Imposed live load moment	
	4 No. point loads arranged symmetrically about centre span	
	M_{max}	= 168.76 kN m
	Total Applied Moment	= 184.55 kN m

A2.7.3.4 Assess Local Buckling Classification

(a) Flange outstand:

$(b/2)/T = 128/13.2$ = 9.6

$9.6 < 10.2, \therefore$ Class 2

(b) Web (subject to compression throughout)

$d/t_w = 200.2/8.9$ = 22.5

$22.5 < 30.5, \therefore$ Class 1

(c) Therefore the section is Class 1 for local buckling

A2.7.3.5 Assess LTB Resistance Moment (BS5950: Pt. 1: 1990)

This calculation was based upon the assumption that the loading positions do not offer any lateral restraint to the compression flange of the beam:

$$M_b = 202 \text{ kN m}$$

A2.7.3.6 Load Ratios

(a) Assuming load points as positions of lateral restraint:

$$R = 0.52$$

(b) Assuming load points do not provide positions of lateral restraint:

$$R = 0.913$$

APPENDIX 3

PC DISK VERSION OF DATA

As mentioned in the Introduction to this report the data recorded during each of the eight fire tests are available on PC disks. The following section gives a brief outline of the material available and its format. The reader may find it useful to additionally consult reference 1.

The data are held on the disks in the form of ASCII text files. This format has been chosen since the majority of commercial software packages can import files of this type. The format allows the data to be referenced either via the screen, (or printer), or read directly by PC based software. The data are initially being made available on 3½ inch DSDD, 720 KB, floppy disks, but other disk sizes and formats can be supplied on request. The data files have been designated 'read only' in order to safeguard the user from accidentally corrupting or erasing them.

The data files are identified by reference to the DATA SHEET NUMBER sequence, i.e. from 099.DAT to 106.DAT inclusive. This numbering system is consistent with that introduced in reference 1. Thus, for example, data from test number WFRC 50521 can be found in data file 099.DAT. For each individual fire test the thermal data have been sub-divided into 'SETS' which reflect the thermocouple positions in the steelwork, and other materials. Mean temperature values are also included in these data sub-sets where it is considered valid to do so. In order that the columns of data in any particular 'SET' can be related to the corresponding thermocouple positions a 'README' file is associated with each data file. By way of example, README.099, which relates to data in file 099.DAT, is shown in Fig. A3.1.

It may be seen by reference to the data presented in Appendix 1 that there have been occasions when no temperature data were recorded. Such occurrences are indicated in the printed tables by the use of an asterisk. Since the use of such a character could cause problems if the software is expecting a numeric input, it has been replaced with the value zero in the disk held data files. It is obviously important for the user to ensure that any data have been read correctly by the particular software or program being used.

REFERENCE

1. D. E. Wainman: 'Compendia of UK Standard Fire Test Data - Unprotected Structural Steel Nos. 1 and 2, PC Disk Version', British Steel Technical, Report SL/HED/R/S2298/1/92/C.

TABLE A3.1
README FILE ASSOCIATED WITH DATA FILE 099.DAT

Data file 099.DAT contains data recorded during the standard fire resistance test number WFRC 50521 which is described in report number SL/HED/R/S2298/2/93/C "SUMMARY OF DATA OBTAINED DURING TESTS ON FLANGE PLATED SLIM FLOOR BEAMS" and should be used in conjunction with that document.

There are 60 items of data which, together with their mean values, are grouped in sets as shown below.

SET NUMBER	ITEMS IN COLUMNS
SET001.DAT	TIME, F3, A17, B17, MEAN.
SET002.DAT	TIME, A16, B16, MEAN.
SET003.DAT	TIME, A15, B15, MEAN.
SET004.DAT	TIME, A14, B14, MEAN.
SET005.DAT	TIME, A13, B13, MEAN.
SET006.DAT	TIME, W1, W2, W3, W4, A12, B12, MEAN.
SET007.DAT	TIME, A11, B11, MEAN.
SET008.DAT	TIME, A10, B10, MEAN.
SET009.DAT	TIME, A9, B9, MEAN.
SET010.DAT	TIME, A8, B8, MEAN.
SET011.DAT	TIME, A7, B7, MEAN.
SET012.DAT	TIME, F1, F6, F7, MEAN.
SET013.DAT	TIME, A6, B6, MEAN.
SET014.DAT	TIME, A5, B5, MEAN.
SET015.DAT	TIME, A4, B4, MEAN.
SET016.DAT	TIME, P2, P4, P6, MEAN.
SET017.DAT	TIME, A3, B3, MEAN.
SET018.DAT	TIME, A2, B2, MEAN.
SET019.DAT	TIME, P1, P3, P5, MEAN.
SET020.DAT	TIME, A1, B1, MEAN.
SET021.DAT	TIME, FW1.
SET022.DAT	TIME, ISO, AT1, AT2, AT3, AT4, AT5, AT6, AT7, AT8, MEAN.
SET023.DAT	TIME, DEFLECTION, DEFLECTION RATE.