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# BS476 : Part 21 Fire Resistance Tests

# Summary of Data Obtained During Tests on Bolted Beam / Column and Beam / Beam Connections

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# SUMMARY

**BS476 : PART 21 FIRE RESISTANCE TESTS**

**SUMMARY OF DATA OBTAINED DURING TESTS ON BOLTED BEAM / COLUMN AND BEAM / BEAM CONNECTIONS**

**D.E. Wainman**

During the five years 1989-1993 British Steel Technical carried out more than thirty standard fire resistance tests on hot rolled structural steel sections. All the tests were sponsored by the appropriate British Steel Marketing Departments. The range of systems / component configurations investigated in those tests was 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 a generic group of test assemblies.

This is the third report issued as part of that series. It contains detailed descriptions of the design, instrumentation and construction for each of twelve bolted beam / column and beam / beam connection assemblies, together with the data arising from them. Data are also included for an indicative column specimen in which the web was encased by blockwork.

Fire resistance periods for all twelve connection assemblies were determined for particular levels of applied loading. It was found that the connection design favourably influenced fire resistance behaviour.

KEYWORDS

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| 26 | +BS EN 10 025 |
| +BS 476 | Beams |
| Fire Resistance | Columns |
| Fire Tests | Load (Mechanical) |
| +BS 4360 | Sections (Structural) |
| +BS 5950 | Lab Reports |

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**BS476 : PART 21 FIRE RESISTANCE TESTS**

**SUMMARY OF DATA OBTAINED DURING TESTS ON BOLTED BEAM / COLUMN AND BEAM / BEAM CONNECTIONS**

## 1. INTRODUCTION

In 1987 and 1988 research staff based at British Steel Technical, Swinden Laboratories, 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 carried out in the UK since 1979 in accordance with the requirements of either BS476:Part 8:1972, or the later revision, BS476:Parts 20/21:1987[3],[4]. Only tests on hot rolled structural steel sections in which the test members were completely unprotected, or were partially protected by materials used 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 section columns, 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[5]. 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 British Steel staff and co-workers in other organisations[6]. In particular, they have been used by the Steel Construction Institute[7-10], for the preparation of Design Guides and other documents covering various forms of construction. 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 few years it was considered impractical to attempt to present the data for all of them in one document at the present time. It was therefore decided that a series of reports should be prepared, each one dealing with either a different form of construction or a generic group of test assemblies, and that these reports would eventually be combined to form a third compendium. The first report in the series was issued in September 1993[11] and included material relating to the eight flange plated slim floor beams. The second report[12], published in June 1994, presented data relating to the five web encased column assemblies.

This is the third report issued as part of that series. It contains detailed descriptions of the design, instrumentation and construction for each of twelve beam - column or beam - beam connection assemblies, together with the data arising from them which are included in Appendix 1. Also included are data from a

single indicative column specimen in which the web was protected by a blockwork infill between the flanges. 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 have already been incorporated into other publications dealing with design aspects of the various connection types[13],[14]. The numerical sequence of the data sheets has been maintained, those in this document being numbered from 112 to 124 inclusive. As in the previous compendia, the thermal data are reduced to summary values at various times throughout the duration of each test. It should be noted, however, that all the thermal and deflection data, usually recorded at one minute intervals, can be made available on PC disks. These may be obtained, on request, from British Steel, Swinden Technology Centre. Further details are given in Appendix 4.

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 EN 10025 'Hot Rolled Products of Non-Alloy Structural Steels - Technical Delivery Conditions'. BS EN 10025:1990 is the English language version of that standard. The specification requirements for those products and grades not within the scope of EN 10025 were simultaneously re-published unchanged as BS4360:1990. The requirements of the two specifications were compared in an earlier report[11].

As far as the present work is concerned it should be noted that all the tests were carried out prior to March 30th 1990 and hence the BS4360:1986 steel grades have been used throughout this document.

### 2.2 BS476:Parts 20/21:1987

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

It should be noted that the tests described in this report utilised only the general principles embodied in BS476:Part 20.

## 3. FIRE TESTS ON BOLTED CONNECTION ASSEMBLIES

In this section details are given for twelve fire tests carried out on a range of beam - column and beam - beam connection assemblies. More specifically, eight of the tests were on beam to column flange, (major axis), connections, three were on beam to beam web, (minor axis), connections and one was on a beam to column web, (minor axis), connection. Included within the test programme were four composite beam assemblies, one of which was a shelf angle floor beam. The purpose of the tests was to study the behaviour of three different types of connection under fire conditions, particularly in terms of their moment-rotation characteristics.

At the time of testing no standardised procedure existed for this purpose and so it was only possible to utilise the general principles embodied in BS476:Part 20:1987. All the tests were carried out at the Warrington Fire Research Centre, (WFRC), between December 1988 and March 1990. The major features of the tests are summarised in Tables 1 and 2.

The design and preparation of the twelve assemblies are described individually in Section 3.2. A number of features are, however, common to all of them and these are described in the following section.

### 3.1 Features Common to All of the Test Assemblies

#### 3.1.1 Steel Quality

Unless noted otherwise, all of the steel members used in the construction of the test assemblies were manufactured by British Steel and conformed to the requirements of BS4360:1986 Grade 43A. 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, (where available), together with their calculated section properties.

#### 3.1.3 Fabrication

The test assemblies were formed from various lengths of universal beam and column sections as described elsewhere in this report, (see Section 3.2). The connections utilised either flush or extended end plates, or double sided web cleats, (see Section 3.1.6). As far as fabrication work was concerned the major requirements were for welding and bolting.

#### 3.1.3.1 Welding

All welding was by the MMA process using either 3 mm or 4 mm diameter basic coated, hydrogen controlled, general purpose welding rods. The welds used to attach the 20 mm thick column end caps, (used for suspending the assemblies from the loading gantries, see Section 3.1.5), were all full profile continuous 6 mm fillets, (Assemblies 1-8), or 8 mm fillets, (Assemblies 9-12). 6 mm continuous fillets were also used for attaching:-

- the 16 mm thick flush or extended end plates to the stub beams (Assemblies 1, 2, 3, 4, 6, 8, 9, 10 and 12)
- the web stiffeners (Assemblies 1 and 3)
- the seating angles (Assembly No. 7)

In the case of the shelf angle floor beam, (Assembly No. 8), the angles were attached to the beam using 100 mm long intermittent 6 mm fillet welds. 8 mm continuous fillets were used in the fabrication of Assemblies 9-11 for attaching the cross beams to the supporting column members.

Attachment of the 19 mm diameter shear stud connectors used in the construction of the composite beams with metal decking was carried out by specialist contractors using their own equipment.

#### 3.1.3.2 Bolting

All tests used 20 mm diameter, (M20), Grade 8.8 bolts.

#### 3.1.4 Instrumentation

#### 3.1.4.1 Temperature Measurement

The test assemblies were instrumented such that the temperatures attained by the steel sections 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 600 sheaths were used. These thermocouples were embedded to the mid-thickness position of the relevant steel section. Thermocouples were also located along the central longitudinal axis of certain selected bolts used to form

the connections. These thermocouples were only 1.5 mm in diameter but otherwise were identical in type and construction to the larger ones. Each was inserted a distance equal to the bolt head thickness plus the end plate or web cleat thickness so that the hot junction was located at the interface between the connection and the section.

Temperatures were also monitored at various positions within two of the concrete floor slabs. The thermocouples used for these situations were again 'K' type but were usually formed from glass fibre covered Ni-Cr/Ni-Al conductors. The subject is covered in greater detail in Appendix 2.

#### 3.1.4.2 Beam Rotation

Provision was made for monitoring the vertical and horizontal displacements of each of the stub beams throughout each test. The measurements were made using a variety of devices including dial gauges, displacement transducers and inclinometers. The calculated angular rotations of the connections are included in the appropriate Data Sheets in Appendix 1. Three sets of data are presented representing the rotations of the two connections in each test and their mean value. The basic shape of the rotation-time curves is similar for all the tests with the rate of deflection increasing rapidly during the last few minutes of the test.

Deformation of the beams was very small relative to that of the connection at the later stages of the test and could be neglected.

### 3.1.5 Test Assemblies

The twelve test assemblies were designed to fit within the 4 metre long × 3 metre wide floor furnace at WFRC. Two tests were carried out in each use of the furnace and this tended to dictate the maximum size of members which could be used. The tests were carried out in two separate series, the first of which comprised eight beam to column, (major axis), assemblies. In the second series the behaviour of three beam to beam, (minor axis), and one beam to column, (minor axis), connections were investigated.

The order in which the assemblies were tested is shown in the table below.

| Test Date | WFRC Test No. | Assemblies Tested |
|---|---|---|
| 07.12.88 | 44521 | No. 2 and No. 4 |
| 11.01.89 | 44519 | No. 5 and No. 6 |
| 18.01.89 | 44175 | No. 1 and No. 7 |
| 25.01.89 | 44992* | No. 3 and No. 8 |
| 27.02.90 | 46733 | No. 9 and No. 10 |
| 01.03.90 | 46736 | No. 11 and No. 12 |

* Also included an indicative blocked in column specimen, (see Section 4).

The general arrangement of a beam / column test assembly within the WFRC furnace is shown in Fig. 1 and is described in the schedule of components, Table 3. Where reference is made to the left or right hand side of a test assembly this is in accordance with the usual convention in which the direction of viewing is assumed to be from the door end of the test furnace.

#### 3.1.5.1 1st Test Series, (Assemblies 1-8)

The test configuration for all of these was a cruciform comprising two stub beams connected symmetrically to a column as shown in Fig. 1. The beam size used was 305 × 165 mm × 40 kg/m and the column size was 203 × 203 mm × 52 kg/m. All the beams supported 120 mm thick concrete or composite floor slabs. The non-composite concrete slabs had movement joints adjacent to the columns to prevent transfer of

moment through the slab. The composite slabs had mesh reinforcement and were continuous i.e. there were no movement joints.

The cruciform specimens were suspended from the underside of the loading gantry by bolting through a plate welded to the top of the 203 × 203 mm column section. Dimensional data for the column top plate are given in Fig. 2. The hydraulic jacks applying the load to the test beams reacted against the gantry and formed a self-equilibriating system. The stub beams were subject to hogging, (negative), moment. The lower part of the column which was in the furnace was unstressed.

#### 3.1.5.2 2nd Test Series, (Assemblies 9-12)

The general concepts outlined in the previous section also applied in the second series of tests. However, in order to enable the stub beams to be connected into the web of a beam or column it was necessary to create arrangements of the types shown in Figs. 3(a) and 3(b).

The test configuration for Assemblies 9-11 consisted of a steel section acting as a column with a cross member welded to its lower end. The stub beams framed into and connected with the web of this cross member. In the case of Assembly 12 the stub beams connected directly into the web of the column member. For Assemblies 9-11 the column member was a 305 × 165 mm × 40 kg/m UB whilst for Assembly 12 it was a 254 × 254 mm × 73 kg/m UC. These members were attached to the underside of the loading gantry by means of welded on top plates, the dimensions of which are shown in Fig. 4.

The cross beams used in Assemblies 9-11 were 1 metre long pieces of 406 × 178 mm × 60 kg/m UB. In all four assemblies the stub beams were formed from lengths of 305 × 165 mm × 40 kg/m UB.

The concrete floor slabs in Assemblies 9-11 were terminated approximately 25 mm from the flange tips of the 305 × 165 mm support member and the gap filled with mineral fibre packing. In Assembly 12, 20 mm thick fibre board strips were placed adjacent to the flange tips of the 254 × 254 mm support member to form a movement joint and so prevent transfer of moment through the slab.

### 3.1.6 Connection Types

Three types of connection were selected as being typical of those used in practice. These were:

- Type 1 - a 'rigid' connection using an extended end plate.
- Type 2 - a 'semi-rigid' connection using a flush end plate.
- Type 3 - a 'flexible' connection using double sided web cleats.

#### 3.1.6.1 1st Test Series, (Assemblies 1-8)

Connection types 1 and 2 were tested as unprotected connections, (Assemblies 1, 2 and 3) and connection types 2 and 3 were tested as protected connections with protected beams and columns, (Assemblies 4 and 5). Type 2 and 3 tests were repeated to investigate the influence of composite action, (Assemblies 6 and 7). An additional unprotected test was carried out on a shelf angle floor beam configuration using a type 2 connection, (Assembly No. 8).

In total, four unprotected and four protected connections were tested. The fire protection material used was MANDOLITE P20, a cementitious vermiculite spray. This was applied to a nominal thickness of 20 mm and was intended to provide 60 minutes fire protection, (at a limiting temperature of 550°C), according to reference 15.

In three of the unprotected tests, (Assemblies 1, 2 and 8), the space between the column flanges was filled with light-weight blockwork, (THERMALITE). This was a practical means of providing 30 minutes fire resistance to the columns and was compatible with the 'target' fire resistance of the unprotected beams. In the fourth of these tests, (Assembly No. 3), the column was protected with 50 mm thick VICUCLAD board.

It should be noted that after the first unprotected beam test, (Assembly No. 2), it was found that the beam failed before the connection had suffered any significant deformation. It was speculated that if a beam with a lower section factor had been used then this failure may not have occurred. It was decided that for subsequent unprotected tests of this type, (Assemblies Nos. 1 and 3), the beam would be protected with ceramic fibre blanket but the area in the region of the connection would be left exposed. In this way the connection would be subjected to high temperatures and the beam should not fail prematurely.

#### 3.1.6.2 2nd Test Series, (Assemblies 9-12)

Connection types 2 and 3 were tested as unprotected connections framed into an unprotected beam web, (Assemblies 9 and 11). The type 2 connection test was repeated to investigate the influence of composite action, (Assembly No. 10). A type 2 test was also carried out on an unprotected connection framed into an unprotected column web, (Assembly No. 12).

### 3.1.7 Loading Details

#### 3.1.7.1 1st Test Series, (Assemblies 1-8)

Configuration and loading details for all eight tests are summarised in Table 4(a). The plastic moment capacity of the test beams was 171.6 kN m, for a design yield stress of 275 N/mm$^2$, according to BS5950:Part 1[16]. The mean material yield strength was recorded as 295 N/mm$^2$, (the same material was used in the construction of all 8 assemblies).

In Table 4(a) the test moment is expressed relative to the plastic moment capacity of the beam, $M_p$, using the nominal yield strength of the steel. This test moment should be reduced by about 7% when expressed in terms of the plastic moment capacity of the beam using the mean measured strength of the steel. The applied moment in the tests was equivalent to approximately two thirds of the moment capacity of the connections. The load applied via the hydraulic jacks was set to a magnitude that would be representative of the shear force that the beam may experience in fire conditions. The position of the jack force was adjusted to give the appropriate moment for the particular connection under investigation.

Summaries of the calculations involved in calculating the hydraulic ram loads are given in Appendix 3.

#### 3.1.7.2 2nd Test Series, (Assemblies 9-12)

Configuration and loading details for the four tests are summarised in Table 4(b). Similar considerations were applied in this test series as for the earlier one.

### 3.1.8 Failure Criteria

In the standard fire resistance test, (BS476:Parts 20/21), members in bending are deemed to have failed when their central vertical deflection exceeds SPAN/20, or when the rate of deflection exceeds a specified value for deflections greater than SPAN/30. For most unprotected beams failure occurs rapidly once deflections exceed SPAN/30. However, for protected beams, or special forms of construction such as slim floor and shelf angle floor beams, the rate of increase of deflection is much less rapid.

It follows, therefore, that the maximum rotation at the ends of a simply supported beam is about 9° at the maximum displacement in a fire test. However the end rotation would reduce with increasing moments resisted by the connections. It was thought that in practice connections may be expected to rotate by no more than around 6°, (0.1 radians), maximum under fire conditions. This value was therefore taken to be indicative of the point at which the loads on any particular test assembly should be removed, or reduced.

### 3.1.9 Additional Data

In some cases heating of a test assembly continued beyond the time at which failure was deemed to have occurred and the loads applied to the stub beams were removed. This was an inevitable consequence of testing two different types of assembly simultaneously. The thermal data recorded during these situations

have not been included in the Data Sheets but can be made available on request. In some tests it was possible to reduce the test load to a lower magnitude once failure was imminent thereby giving a measure of the performance of the connection under reduced moment.

### 3.2 Loaded Test Assemblies

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

#### 3.2.1 Assembly No. 1

A non-composite construction consisting of a universal column section of serial size 203 × 203 mm × 52 kg/m × 1985 mm long and two universal beams of serial size 305 × 165 mm × 40 kg/m × 1280 mm long. The stub beams were attached to the column flanges by means of 16 mm thick extended end plate connections using M20 Grade 8.8 bolts. Dimensional data for the end plates are given in Fig. 5(a). Constructional details for the assembly are shown in Fig. 6. 175 mm wide × 60 mm deep × 6 mm thick web stiffeners were welded between the column flanges at positions which corresponded with the lower flanges of the stub beams. A 120 mm thick × 620 mm wide Grade 25 normal weight concrete floor slab was cast over the stub beams. No expansion joints were provided in the concrete but a 20 mm thick fibre-board insert was included adjacent to the column, (see Section 3.1.5.1).

The web of the column extending into the furnace below the concrete floor slab was protected by 'THERMALITE' blockwork cemented into the flange / web cavities. The blockwork rested on an 8 mm thick plate welded to the bottom end of the column. The blocks were cemented into the section cavities on both sides and were finished flush with, or slightly proud of, the flange tips. A nominal 10 mm thick mortar joint was maintained between adjacent blocks and the block / steel interfaces. The blockwork was cut to fit around the web stiffeners. The stub beams were protected by 12 mm thick ceramic fibre blanket which extended to within 40 mm of the end plates on the flanges and 100 mm on the web. The protection was applied in the conventional manner using shot fired pins and washers. The actual connections remained unprotected.

A total of 18 thermocouples were used to monitor the temperature of the steel sections throughout the test with a further six located in selected exposed and unexposed bolts. Six thermocouples were located in the stub beams adjacent to the connections, (25 mm from the ends of the beams), and six remote from the connections, (500 mm from the ends of the beams). The thermocouples in the upper and lower flanges were located at the quarter width positions. Thermocouples were also located in the end plates and in the column extending into the furnace. All the thermocouple positions are indicated in Figs. 7 and 8.

Loads of 6.9 tonnes were applied to each of the beams at a distance of 980 mm from the outside face of the column flange. The loads were maintained for 45 minutes after which time they were reduced to 5.1 tonnes. The loads were removed completely after 49 minutes. Heating of the assembly continued until 120 minutes had elapsed, (tested alongside Assembly No. 7).

Data for this test are summarised in Data Sheet No. 112.

#### 3.2.2 Assembly No. 2

A non-composite construction consisting of the same size universal beam and column sections as given for Assembly No. 1. The stub beams were attached to the column flanges by means of flush end plate connections using M20 Grade 8.8 bolts. Dimensional data for the end plates are given in Fig. 5(b). Details of the assembly are shown in Fig. 9. A 120 mm thick × 620 mm wide Grade 25 normal weight concrete floor slab was cast over the stub beams, (details as for Assembly No. 1).

The web of the column extending into the furnace below the concrete floor slab was protected with 'THERMALITE' blockwork as described for Assembly No. 1. No protection was applied to the beams which remained exposed to the heating conditions of the furnace throughout the test. The thermocouple positions were as described for Assembly No. 1 except that since a flush end plate connection was used only

four bolts were monitored. An additional six thermocouples were included on this test for the purpose of obtaining a vertical thermal profile in the web of one of the beams. The additional thermocouples were located at 10, 30 and 50 mm from both the upper and lower beam flanges and at 25 mm from the end of the beam adjacent to the connection, (see Fig. 10).

Loads of 6.7 tonnes were applied to each of the beams at a distance of 490 mm from the outside face of the column flange. The loads were maintained for a period of 29 minutes and were then removed. Heating of the assembly continued until 122 minutes had elapsed, (tested alongside Assembly No. 4).

Data for this test are summarised in Data Sheet No. 113.

### 3.2.3 Assembly No. 3

This assembly was similar in terms of its construction to Assembly No. 1, i.e. non-composite, extended end plate connections, web stiffeners and normal weight concrete floor slab. The 600 mm of column extending into the furnace below the stub beams was protected, (boxed in), using 50 mm thick 'VICUCLAD' board. The stub beams were protected with ceramic fibre blanket as described for Assembly No. 1. The connections remained unprotected. Construction details for the assembly are shown in Fig. 11. The thermocouple positions were as described for Assembly No. 1.

Loads of 6.7 tonnes were applied to each of the beams at a distance of 490 mm from the outside face of the column flange. The loads were maintained for 97 minutes and then removed. The test was terminated after 98 minutes.

Data for this test are summarised in Data Sheet No. 114.

### 3.2.4 Assembly No. 4

This assembly was similar in terms of its construction to Assembly No. 2, i.e. non-composite, flush end plate connections and normal weight concrete floor slab. There was no blockwork infill between the column flanges on this assembly. The area of the assembly exposed to the heating conditions of the test was protected with spray applied 'MANDOLITE P20'. The coating thickness was nominally 20 mm and had a nominal density of 320 kg/m$^3$. Constructional details for the assembly are shown in Fig. 12. The material had been applied on 10th October 1988 and therefore had an age of 58 days at the time of testing. The moisture content measured on the day of the test was 1.7% w/w.

The thermocouple arrangement was the normal one of 18 in the steelwork plus 4 in selected bolt positions, (flush end plate). Loads of 6.7 tonnes were applied to each of the beams at a distance of 490 mm from the outside face of the column flange. The loads were maintained for a period of 122 minutes at which time they were removed and the test terminated.

Data for this test are summarised in Data Sheet No. 115.

### 3.2.5 Assembly No. 5

A non-composite construction consisting of the same size universal beam and column sections as given for Assembly No. 1. The stub beams were attached to the column flanges by means of double sided web cleat connections using M20 Grade 8.8 bolts. The cleats were formed from lengths of 90 × 90 mm × 8 mm thick rolled steel angle. Constructional data for the cleated connections are given in Figs. 13 and 14. A 120 mm thick × 620 mm wide Grade 25 normal weight concrete floor slab was cast over the stub beams, (details as for Assembly No. 1).

The area of the assembly exposed to the heating conditions of the test was protected with spray applied 'MANDOLITE P20', (details as for Assembly No. 4). The age of the material at the time of testing was 93 days. The moisture content measured on the day of the test was 1.6% w/w. The measured thickness of the protection was as shown in the table below.

| Side | Position | Mean Thickness (mm) |
|---|---|---|
| Left | Beam Web | 19.8 |
| Right | Beam Web | 21.0 |
| Left | Lower Flange | 20.25 |
| Right | Lower Flange | 20.5 |
| | Column Web | 20.5 |

The thermocouple arrangement was the normal one of 18 in the steelwork plus 6 in selected bolt positions, (see Fig. 15). Loads of 3.3 tonnes were applied to each of the beams at a distance of 490 mm from the outside face of the column flange. The loads were maintained for a period of 115 minutes and were then removed. Heating of the assembly continued until 128 minutes had elapsed, (tested alongside Assembly No. 6).

Data for this test are summarised in Data Sheet No. 116.

### 3.2.6 Assembly No. 6

A composite construction consisting of the same size universal beam and column sections as given for Assembly No. 1. The stub beams were attached to the column flanges by means of flush end plate connections, (see Assembly No. 2). Richard Lees 'HOLORIB' steel decking was fixed to the upper beam flanges using 19 mm diameter × 95 mm long shear stud connectors. These were situated at 300 mm centres in a single line over the web of the section. A 120 mm thick × 1000 mm wide light-weight, (LYTAG), Grade 25 concrete floor slab was cast over the decking. An A142 anti-crack mesh was incorporated into the concrete slab. No expansion joints were provided and there were no movement joints adjacent to the column. Details of the construction are shown in Fig. 16.

The area of the assembly exposed to the heating conditions of the test was protected with spray applied 'MANDOLITE P20', (details as for Assembly No. 4). The age of the material at the time of testing was 93 days. The moisture content measured on the day of the test was 1.6% w/w. The measured thickness of the protection was as shown in the table below.

| Side | Position | Mean Thickness (mm) |
|---|---|---|
| Left | Beam Web | 19.6 |
| Right | Beam Web | 19.8 |
| Left | Lower Flange | 20.25 |
| Right | Lower Flange | 21.0 |
| | Column Web | 20.25 |

The thermocouple arrangement was the normal one of 18 in the steelwork plus 4 in selected bolt positions. Loads of 6.7 tonnes were applied to each of the beams at a distance of 980 mm from the outside face of the column flange. The loads were maintained for 100 minutes after which time they were reduced to 5.0 tonnes. The loads were removed completely after 123 minutes. The test was terminated after 128 minutes.

Thermocouples were also placed at various positions within the concrete floor slab, see Appendix 2.

Data for this test are summarised in Data Sheet No. 117.

### 3.2.7 Assembly No. 7

A composite construction consisting of the same size universal beam and column sections as given for Assembly No. 1. The stub beams were attached to the column flanges by means of double sided web cleat connections, (see Assembly No. 5). An additional feature of this assembly was the inclusion of two seating angles situated immediately below the stub beams. Details are given in Figs. 13 and 14. These were welded to the column flanges using continuous 6 mm fillets. Richard Lees 'HOLORIB' steel decking, 19 mm diameter shear connectors, A142 mesh and light-weight concrete were used to form the floor slab, (see Assembly No. 6).

The area of the assembly exposed to the heating conditions of the test was protected with spray applied 'MANDOLITE P20', (details as for Assembly No. 4). The age of the material at the time of testing was 100 days. The moisture content measured on the day of the test was 1.6% w/w.

The thermocouple arrangement was the normal one of 18 in the steelwork plus 6 in selected bolt positions, (see Fig. 15). Loads of 6.6 tonnes were applied to each of the beams at a distance of 490 mm from the outside face of the column flange. The load was maintained for 111 minutes and then removed. Heating of the assembly continued for a further 9 minutes.

Thermocouples were also placed at various positions within the concrete floor slab, see Appendix 2.

Data for this test are summarised in Data Sheet No. 118.

### 3.2.8 Assembly No. 8

A composite shelf angle floor beam construction using the same size universal beam and column sections as given for Assembly No. 1. The stub beams were attached to the column flanges by means of flush end plate connections, (see Assembly No. 2). The shelf angles were formed from lengths of 125 × 75 mm × 12 mm thick rolled steel angle, (Grade 43A). These were attached to the webs of the stub beams using 100 mm long intermittent 6 mm fillet welds along both the top and bottom edges. The 75 mm vertical leg of the angle pointed upwards. Dimensional details relating to the location of the shelf angles are given in Fig. 17.

Richard Lees, 'SUPER HOLORIB' steel decking was fixed to the angles using 19 mm diameter x 95 mm long shear connectors and in-situ light-weight, (LYTAG), Grade 25 concrete was used to form the floor slab. The shear connectors were spaced at 300 mm centres in a single line over the web of the section. The finished floor level was 25 mm above the upper flange of the beams. An A142 mesh was incorporated into the concrete slab. No expansion joints were provided and there were no movement joints adjacent to the column. The overall dimensions of the floor slab were 120 mm thick × 1000 mm wide.

The web of the column extending into the furnace below the concrete floor was protected with 'THERMALITE' blockwork as described for Assembly No. 1. No protection was applied to the lower part of the beams which remained exposed to the heating conditions of the furnace throughout the test.

A total of 30 thermocouples were used to monitor the temperature of the steel sections with a further four located in the exposed and unexposed bolts. All the thermocouple positions are indicated in Figs. 18 and 19.

Loads of 6.6 tonnes were applied to each of the beams at a distance of 490 mm from the outside face of the column flange. The loads were maintained for 70 minutes after which time they were reduced to 3.0 tonnes. The loads were removed completely after 90 minutes. Heating of the assembly continued until 98 minutes had elapsed, (tested alongside Assembly No. 3).

Data for this test are summarised in Data Sheet No. 119.

### 3.2.9 Assembly No. 9

A non-composite beam - beam (minor axis) connection consisting of:

Item 1 - A universal beam section of serial size 305 × 165 mm × 40 kg/m × 1080 mm long which was used as a column.

Item 2 - A universal beam section of serial size 406 × 178 mm × 60 kg/m × 1000 mm long which was welded to the bottom of item 1.

Item 3 - Two universal beam sections of serial size 305 × 165 mm × 40 kg/m × 1380 mm long. Each of these stub beams had a 20 mm thick flush end plate welded to one end.

The end plates were connected by M20 Grade 8.8 bolts which passed through the web of the 406 × 178 mm beam, (item 2). Dimensional data for the end plates are given in Fig. 20. Constructional details for the assembly are shown in Fig. 21.

A 100 mm thick × 600 mm wide Grade 25 normal weight concrete floor slab was cast over the stub beams. The whole of the exposed steelwork was protected by 25 mm thick ceramic fibre blanket, (nominal density 96 kg/m$^3$), which extended to within 40 mm of the end plates on the flanges and 100 mm on the web. The protection was applied in the conventional manner using shot fired steel pins and washers.

A total of 15 thermocouples were used to monitor the temperature of the steel sections throughout the test with a further four located in the bolts. The arrangement of the thermocouples was generally similar to that adopted for the beam to column tests, (Assemblies 1-8). All the thermocouple positions are indicated in Figs. 22 and 23. It should be noted that positions F2 and F3 are on the cross beam and not the test beams.

Loads of 5.7 tonnes were applied to each of the beams at a distance of 590 mm from the outside face of the column web. The loads were maintained for 46 minutes and then removed. The test was terminated after 47 minutes, (tested alongside Assembly No. 10).

Data for this test are summarised in Data Sheet No. 120.

### 3.2.10 Assembly No. 10

A composite beam - beam (minor axis) connection consisting of the same size of universal beam and column sections as given for Assembly No. 9. Fabrication details for the steelwork were identical to Assembly No. 9. The stub beams supported a 1000 mm wide Richard Lees 'RIBDECK 60' steel deck onto which a 120 mm thick Grade 25 normal weight concrete floor slab was cast. An A142 anti-crack mesh was incorporated into the concrete slab. Constructional details are given in Fig. 24.

The whole of the exposed steelwork, with the exception of the small regions immediately adjacent to the connections, was protected with ceramic fibre blanket as described for Assembly No. 9. The thermocouple arrangement was as described for Assembly No. 9. Loads of 6.2 tonnes were applied to each of the beams at a distance of 1080 mm from the outside face of the column web. The loads were maintained for a period of 47 minutes at which time they were removed and the test terminated.

Data for this test are summarised in Data Sheet No. 121.

### 3.2.11 Assembly No. 11

A non-composite beam - beam (minor axis) connection consisting of the same size of universal beam and column sections as given for Assembly No. 9. The stub beams were attached to the web of the 406 × 178 mm beam, (item 2), by means of double sided web cleat connections using M20 Grade 8.8 bolts. The

cleats were formed from lengths of 90 × 90 mm × 8 mm thick rolled steel angle. Constructional data for the cleated connections are given in Figs. 25 and 26.

A 100 mm thick × 600 mm wide Grade 25 normal weight concrete floor slab was cast over the stub beams. The whole of the exposed steelwork, with the exception of the small regions immediately adjacent to the connections was protected with ceramic fibre blanket as described for Assembly No. 9. The thermocouple arrangement was the normal one of 15 in the steelwork, (see Fig. 22), plus 8 in selected bolt positions, (see Fig. 26).

Loads of 2.7 tonnes were applied to each of the beams at a distance of 590 mm from the outside face of the column web. The loads were maintained for a period of 30 minutes at which time they were removed. Heating of the assembly continued until 72 minutes had elapsed, (tested alongside Assembly No. 12).

Data for this test are summarised in Data Sheet No. 122.

### 3.2.12 Assembly No. 12

A non-composite beam - column (minor axis) connection consisting of a 1985 mm long universal column section of serial size 254 × 254 mm × 73 kg/m and two 1380 mm long universal beams of serial size 305 × 165 mm × 40 kg/m. Each of the stub beams had a 20 mm thick flush end plate welded to them and these were connected by M20 Grade 8.8 bolts which passed through the web of the 254 × 254 mm column. Dimensional data for the end plates are given in Fig. 5(b). The arrangement is shown schematically in Fig. 3(b).

A 100 mm thick × 600 mm wide Grade 25 normal weight concrete floor slab was cast over the stub beams. No expansion joints were provided but a 20 mm thick fibre-board insert was included adjacent to the column. The whole of the exposed steelwork, with the exception of the small regions immediately adjacent to the connections was protected with ceramic fibre blanket as described for Assembly No. 9.

A total of 16 thermocouples were used to monitor the temperature of the steel sections throughout the test with a further four located in the bolts. The arrangement of the thermocouples was generally similar to that adopted for the beam to column tests, (Assemblies 1-8). All the thermocouple positions are indicated in Figs. 27 and 28.

Loads of 5.7 tonnes were applied to each of the beams at a distance of 590 mm from the outside face of the column web. The loads were maintained for a period of 69 minutes and then removed. The test was terminated after 72 minutes.

Data for this test are summarised in Data Sheet No. 123.

## 4. INDICATIVE TEST ASSEMBLY

During the course of the foregoing test programme the opportunity arose to include a short, (1 m), length of column section in which the web was encased in blockwork. The thermal data recorded, together with other relevant information are summarised in Data Sheet No. 124.

The test assembly consisted of a universal column section of serial size 356 × 406 mm × 634 kg/m which was partially protected by blockwork cemented into the flange / web cavities. The protection consisted of 'CELCON' aerated, autoclaved concrete blocks, each nominally 440 mm long × 210 mm deep × 150 mm thick, which were cemented into the section cavities and finished flush with, or slightly proud of, the flange tips. A nominal 10 mm thick mortar joint was maintained between adjacent blocks and the block / steel interfaces.

The following properties were quoted by the manufacturer for the 'CELCON' blocks.

- Typical stabilised water content 3%
- Density (at 3% moisture level) 680 kg/m$^3$

| | | |
|---|---|---|
| • | Density (fully dried) | 650 kg/m$^3$ |
| • | Compressive Strength | 4.0 N/mm$^2$ |
| • | Coefficient of expansion | $8 \times 10^{-6}$ mm/°C |

Seven thermocouples were used to monitor the temperature of the steel section throughout the 98 minute heating period of the test. The thermocouples, which were at the mid-height of the section, were positioned as shown in Fig. 29.

The assembly was tested on 25th January 1989 as part of WFRC 44992. It was positioned vertically in the furnace and was raised approximately 300 mm from the furnace floor on a concrete plinth.

## 5. CONCLUSIONS

Data arising from twelve fire resistance tests, involving a range of beam / column and beam / beam connection configurations, have been collated and reported. No standardised test procedures existed for the purpose of determining the moment rotation and load carrying characteristics of different types of connections under fire conditions. However, all the procedures employed the general principles and heating conditions described in BS476:Part 20:1987.

Details of the test assemblies are given together with summaries of the material properties, loading calculations and the thermal data recorded. Similar information is also included for an indicative blocked in column assembly.

Fire resistance periods for all twelve connection assemblies were determined for particular levels of applied loading. It was found that the connection design favourably influenced fire resistance behaviour. It should be noted that this aspect has now been incorporated into structural design procedures for the fire limit state.

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16. 'Structural Use of Steelwork in Building - Code of Practice for Design in Simple and Continuous Construction: Hot Rolled Sections', BS5950:Part 1:1990.

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## TABLE 1
## SUMMARY OF THE MAJOR FEATURES OF THE CONNECTION TEST ASSEMBLIES
## 1ST SERIES - BEAM TO COLUMN MAJOR AXIS TESTS

| Test Assembly No. | Test Order | Test Date | WFRC Test No. | Construction Details | Fire Resistance Rating | Data Sheet No. |
|---|---|---|---|---|---|---|
| 1 | 3 | 18.01.89 | 44175 | Extended end plate connections.<br>Web stiffeners between column flanges.<br>Non-composite normal weight concrete floor slab.<br>Column web protected by Thermalite blockwork infill.<br>Beams protected by 12 mm thick ceramic fibre blanket.<br>Connections unprotected. | 45 min. at 0.4 $M_p$<br>Continued to:<br>49 min. at 0.3 $M_p$ | 112 |
| 2 | 1 | 07.12.88 | 44521 | Flush end plate connections.<br>Non-composite normal weight concrete floor slab.<br>Column web protected by Thermalite blockwork infill<br>Beams and connections both unprotected. | 29 min. at 0.2 $M_p$ | 113 |
| 3 | 4 | 25.01.89 | 44992 | Extended end plate connections.<br>Web stiffeners between column flanges.<br>Non-composite normal weight concrete floor slab.<br>Column protected by 50 mm thick Vicuclad board.<br>Beams protected by 12 mm thick ceramic fibre blanket.<br>Connections unprotected. | 97 min. at 0.2 $M_p$ | 114 |
| 4 | 1 | 07.12.88 | 44521 | Flush end plate connections.<br>Non-composite normal weight concrete floor slab.<br>Beams, column and connections protected by 20 mm thick spray applied Mandolite P20. | 122 min. at 0.2 $M_p$ | 115 |

(Cont ...)

**TABLE 1**
**SUMMARY OF THE MAJOR FEATURES OF THE CONNECTION TEST ASSEMBLIES**
**1ST SERIES - BEAM TO COLUMN MAJOR AXIS TESTS (Continued)**

| Test Assembly No. | Test Order | Test Date | WFRC Test No. | Construction Details | Fire Resistance Rating | Data Sheet No. |
|---|---|---|---|---|---|---|
| 5 | 2 | 11.01.89 | 44519 | Double sided web cleat connections.<br>Non-composite normal weight concrete floor slab.<br>Beams, column and connections protected by 20 mm thick spray applied Mandolite P20. | 115 min. at 0.1 $M_p$ | 116 |
| 6 | 2 | 11.01.89 | 44519 | Flush end plate connections.<br>Composite light-weight concrete floor slab.<br>'Holorib' decking and shear studs.<br>Shear studs 19 mm dia. x 95 mm long at 300 mm centres.<br>A142 mesh in floor slab.<br>Beams, column and connections protected by 20 mm thick spray applied Mandolite P20. | 100 min. at 0.4 $M_p$<br>Continued to:<br>123 min. at 0.3 $M_p$ | 117 |
| 7 | 3 | 18.01.89 | 44175 | Double sided web cleat connections.<br>Seating cleats below test beams.<br>Composite light-weight concrete floor slab.<br>'Holorib' decking and shear studs.<br>Shear studs 19 mm dia. x 95 mm long at 300 mm centres.<br>A142 mesh in floor slab.<br>Beams, column and connections protected by 20 mm thick spray applied Mandolite P20. | 111 min. at 0.2 $M_p$ | 118 |
| 8 | 4 | 25.01.89 | 44992 | Shelf angle floor beam.<br>Flush end plate connections.<br>Composite light-weight concrete floor slab.<br>'Super Holorib' decking and shear studs.<br>Shear studs 19 mm dia. x 95 mm long at 300 mm centres.<br>A142 mesh in floor slab.<br>Column web protected by Thermalite blockwork infill.<br>Beams and connections both unprotected. | 70 min. at 0.2 $M_p$<br>Continued to:<br>90 min. at 0.1 $M_p$ | 119 |

**TABLE 2**
**SUMMARY OF THE MAJOR FEATURES OF THE CONNECTION TEST ASSEMBLIES**
**2ND SERIES - BEAM TO BEAM AND COLUMN MINOR AXIS TESTS**

| Test Assembly No. | Test Order | Test Date | WFRC Test No. | Construction Details | Fire Resistance Rating | Data Sheet No. |
|---|---|---|---|---|---|---|
| 9 | 1 | 27.02.90 | 46733 | Flush end plate connections.<br>Non-composite normal weight concrete floor slab.<br>Steel sections protected by 25 mm thick ceramic fibre blanket.<br>Connections unprotected. | 46 min. at 0.2 $M_p$ | 120 |
| 10 | 1 | 27.02.90 | 46733 | Flush end plate connections.<br>Composite normal weight concrete floor slab.<br>'Ribdeck 60' decking.<br>A142 mesh in floor slab.<br>Steel sections protected by 25 mm thick ceramic fibre blanket.<br>Connections unprotected. | 47 min. at 0.4 $M_p$ | 121 |
| 11 | 2 | 01.03.90 | 46736 | Double sided web cleat connections.<br>Non-composite normal weight concrete floor slab.<br>Steel sections protected by 25 mm thick ceramic fibre blanket.<br>Connections unprotected. | 30 min. at 0.1 $M_p$ | 122 |
| 12 | 2 | 01.03.90 | 46736 | Flush end plate connections.<br>Non-composite normal weight concrete floor slab.<br>Steel sections protected by 25 mm thick ceramic fibre blanket.<br>Connections unprotected. | 69 min. at 0.2 $M_p$ | 123 |

**TABLE 3**
**SCHEDULE OF COMPONENTS SHOWN IN FIG. 1**

| Reference No. | Description |
|---|---|
| 1 | Furnace lining |
| 2 | Loading gantry |
| 3 | Hydraulic rams |
| 4 | 203 × 203 mm × 52 kg/m UC × 1985 mm long |
| 5 | 305 × 165 mm × 40 kg/m UB × 1280 mm long |
| 6 | Connection under test |
| 7 | 620 mm wide × 120 mm thick concrete floor slab |
| 8 | Blockwork perimeter wall |
| 9 | Flexible seal to beam end. (Mineral fibre.) |

## TABLE 4(a-b)
## SUMMARY OF LOADING CONDITIONS

**(a) Test Assemblies 1-8**

| Test Assembly No. | Applied Load (tonnes) | Lever Arm (mm) | Moment * Capacity of Connection Assembly | Test Moment | Fire Resistance Period (min) |
|---|---|---|---|---|---|
| 1 | 6.9<br>5.1 | 980 | 0.6 $M_p$ | 0.4 $M_p$<br>0.3 $M_p$ | 45<br>49 |
| 2 | 6.7 | 490 | 0.3 $M_p$ | 0.2 $M_p$ | 29 |
| 3 | 6.7 | 490 | 0.6 $M_p$ | 0.2 $M_p$ | 97 |
| 4 | 6.7 | 490 | 0.3 $M_p$ | 0.2 $M_p$ | 122 |
| 5 | 3.3 | 490 | 0.1 $M_p$ | 0.1 $M_p$ | 115 |
| 6 | 6.7<br>5.0 | 980 | 0.45 $M_p$ | 0.4 $M_p$<br>0.3 $M_p$ | 100<br>123 |
| 7 | 6.6 | 490 | 0.25 $M_p$ | 0.2 $M_p$ | 111 |
| 8 | 6.6<br>3.3 | 490 | 0.42 $M_p$ | 0.2 $M_p$<br>0.1 $M_p$ | 70<br>90 |

**(b) Test Assemblies 9-12**

| Test Assembly No. | Applied Load (tonnes) | Lever Arm (mm) | Moment * Capacity of Connection Assembly | Test Moment | Fire Resistance Period (min) |
|---|---|---|---|---|---|
| 9 | 5.7 | 590 | 0.3 $M_p$ | 0.2 $M_p$ | 46 |
| 10 | 6.2 | 1080 | 0.45 $M_p$ | 0.4 $M_p$ | 47 |
| 11 | 2.7 | 590 | 0.1 $M_p$ | 0.1 $M_p$ | 30 |
| 12 | 5.7 | 590 | 0.3 $M_p$ | 0.2 $M_p$ | 69 |

Notes:- $M_p$ is the plastic moment capacity of the steel beam = 171.6 kN m
(for a nominal yield stress of 275 N/mm$^2$)

* As given in Refs. 13 and 14

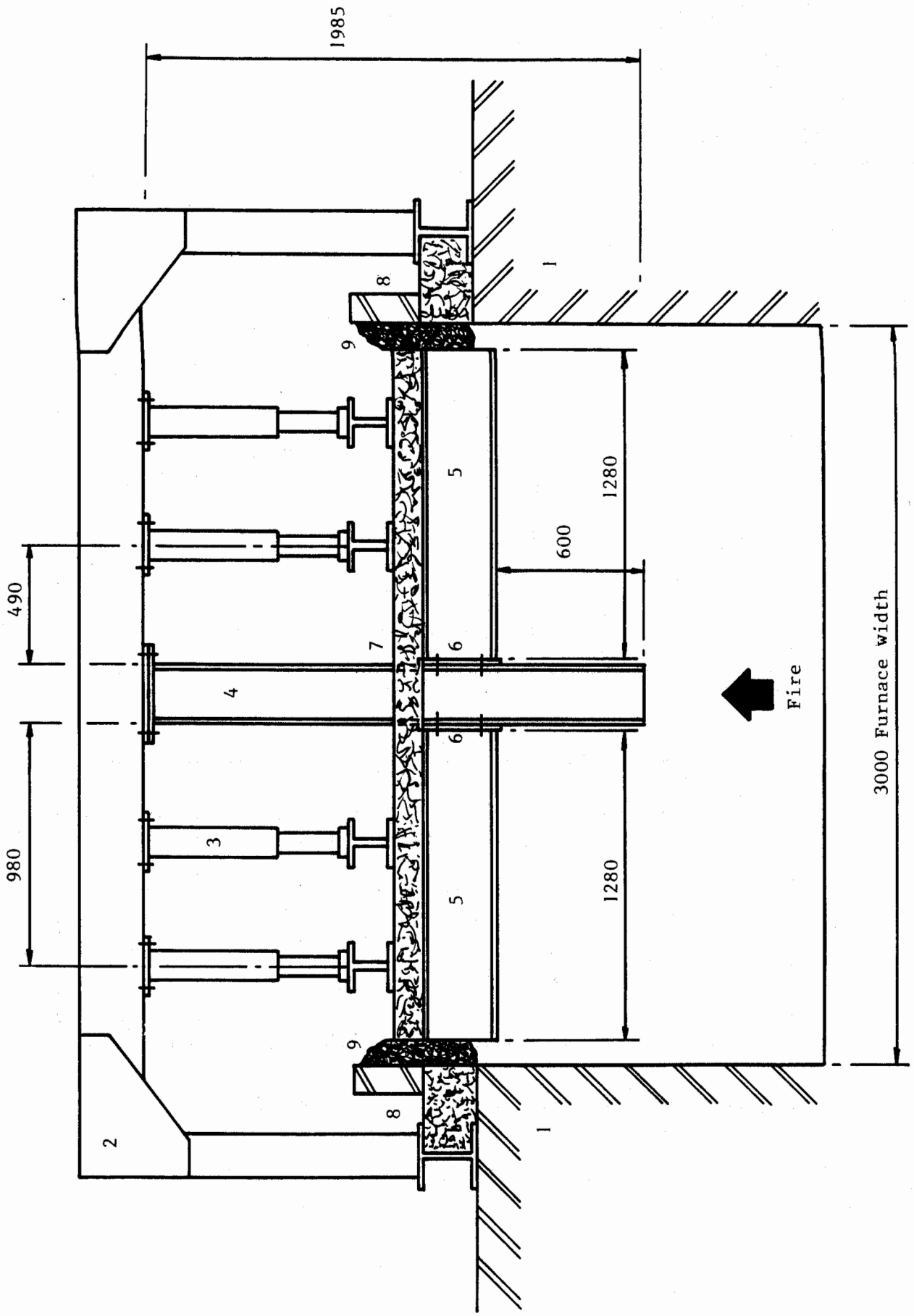



FIG. 1 GENERAL ARRANGEMENT OF COMPONENTS FOR BEAM/COLUMN TESTS (R4/3640)

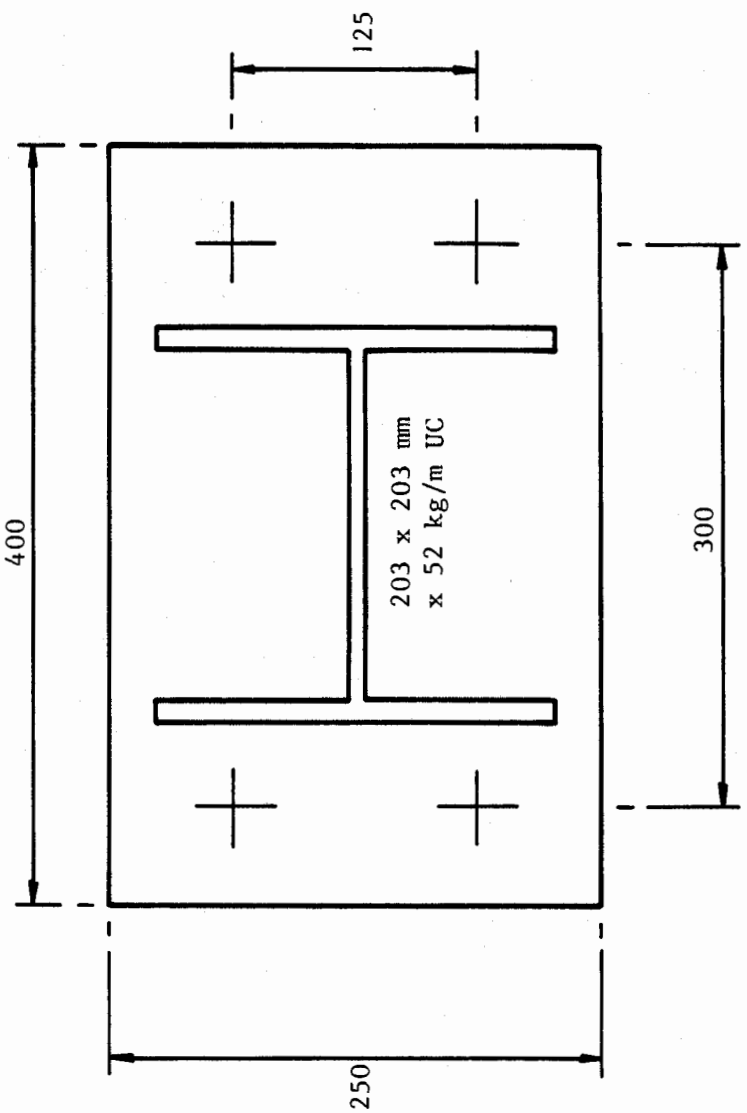
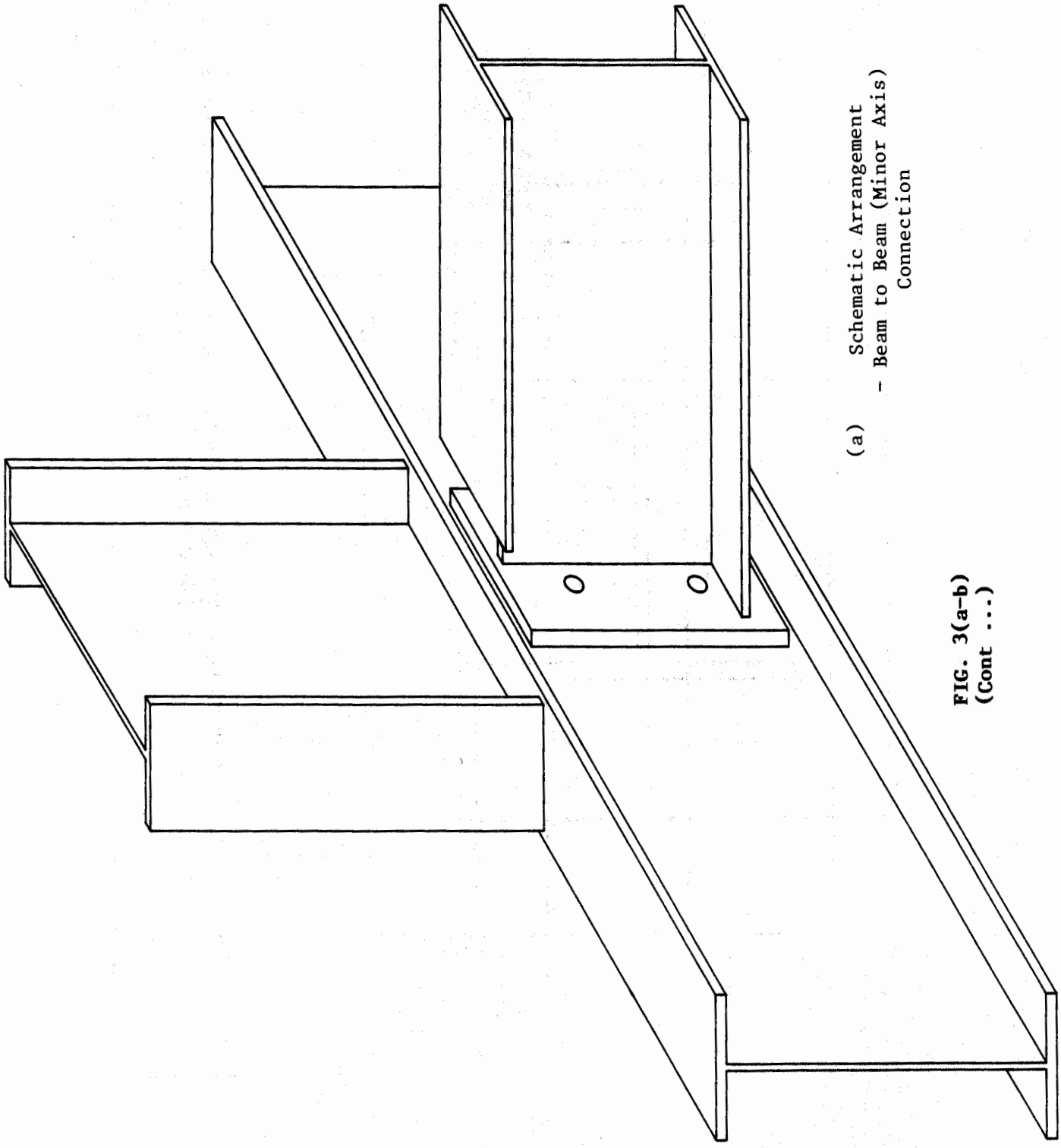
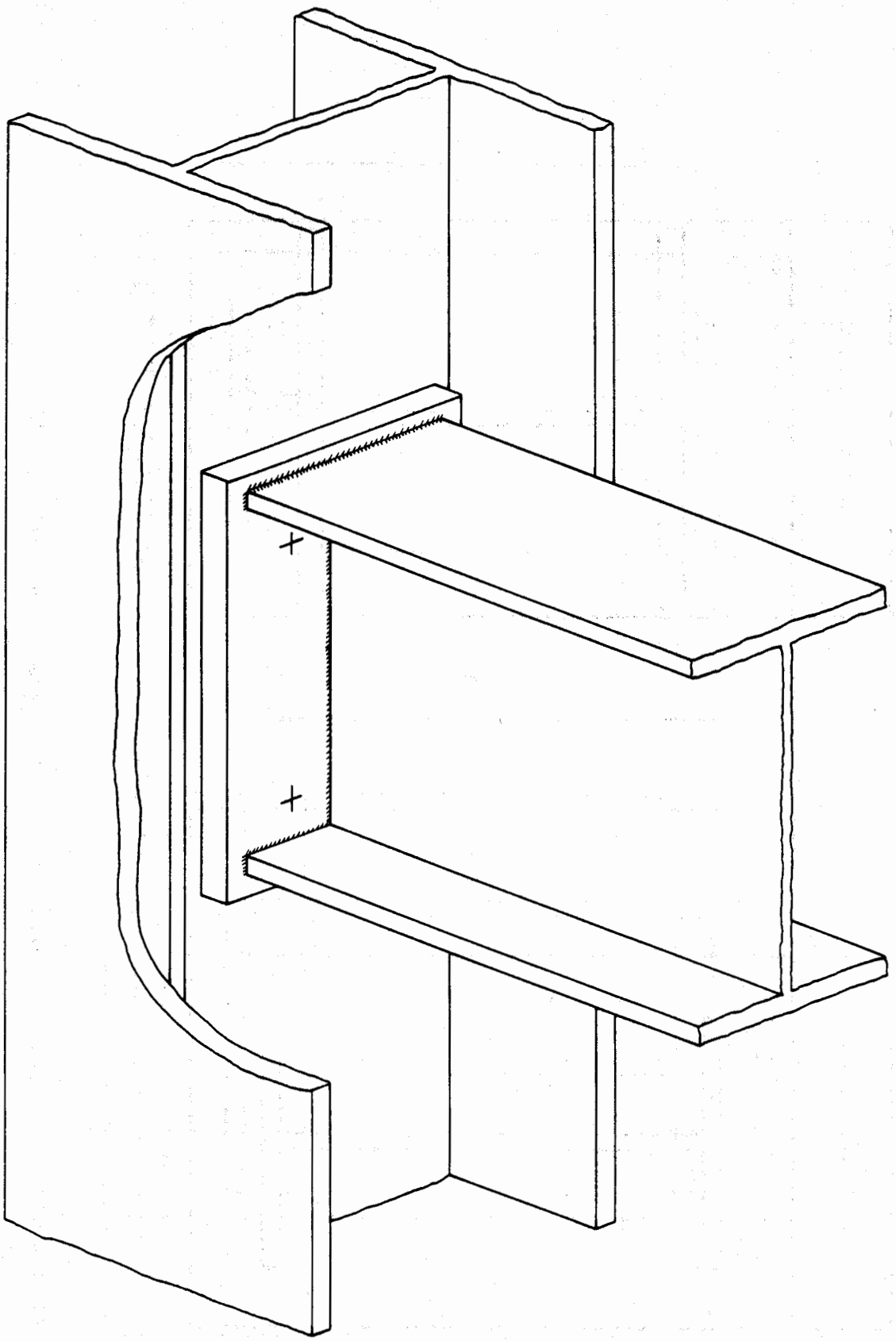



FIG. 2 DIMENSIONAL DATA FOR COLUMN TOP PLATES (ASSEMBLIES 1-8) (R4/3641)



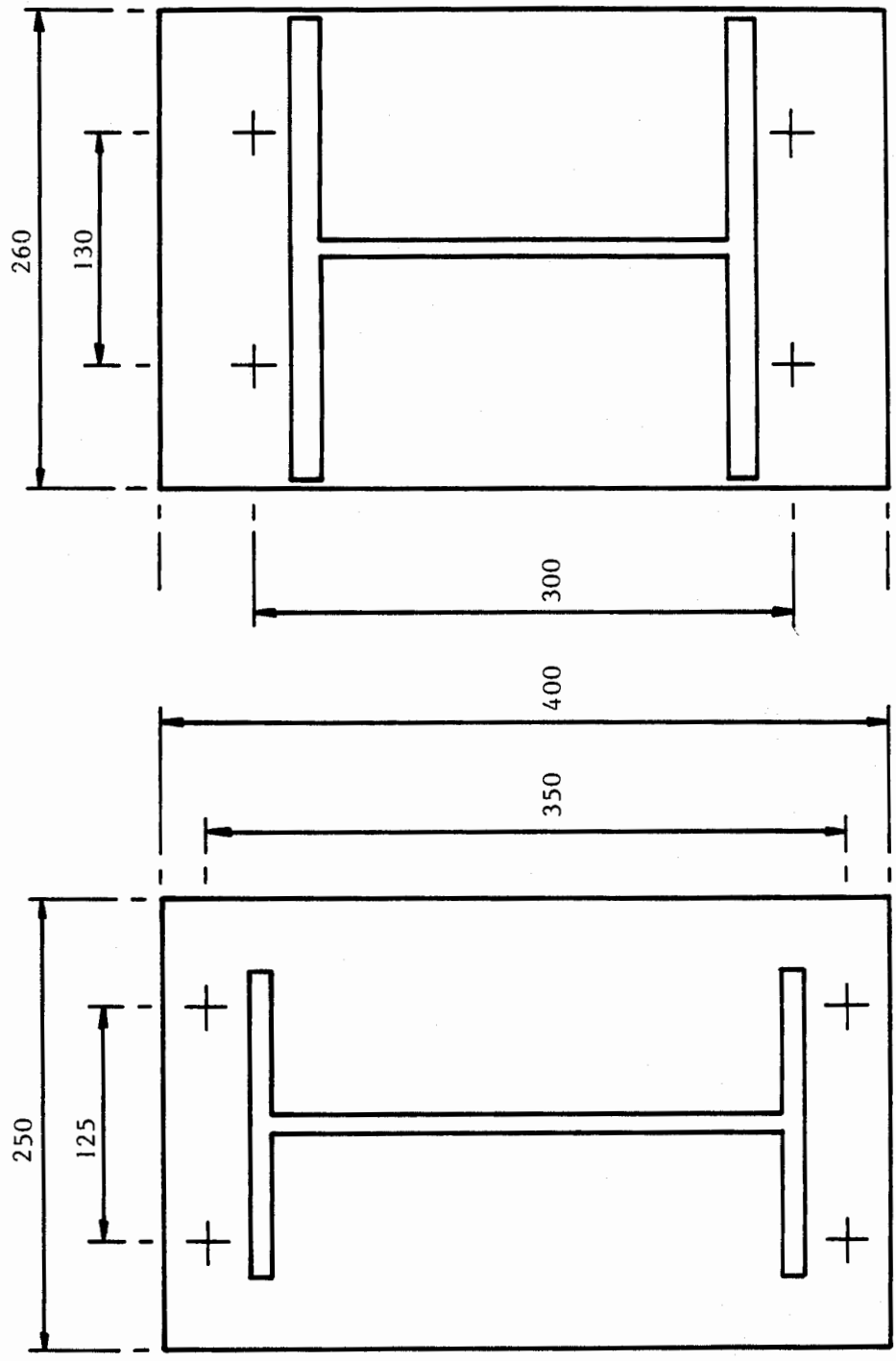
(a) Schematic Arrangement - Beam to Beam (Minor Axis) Connection

**FIG. 3(a-b) (Cont ...)**



(b) Schematic Arrangement - Beam to Column (Minor Axis) Connection (Column Flange Cut Away for Clarity) (R4/3642)

**FIG. 3(a-b)**




(a) Assemblies 9, 10 and 11 (R4/3643) (b) Assembly 12 (R4/3643)

**FIG. 4(a-b) DIMENSIONAL DATA FOR COLUMN TOP PLATES (ASSEMBLIES 9-12)**

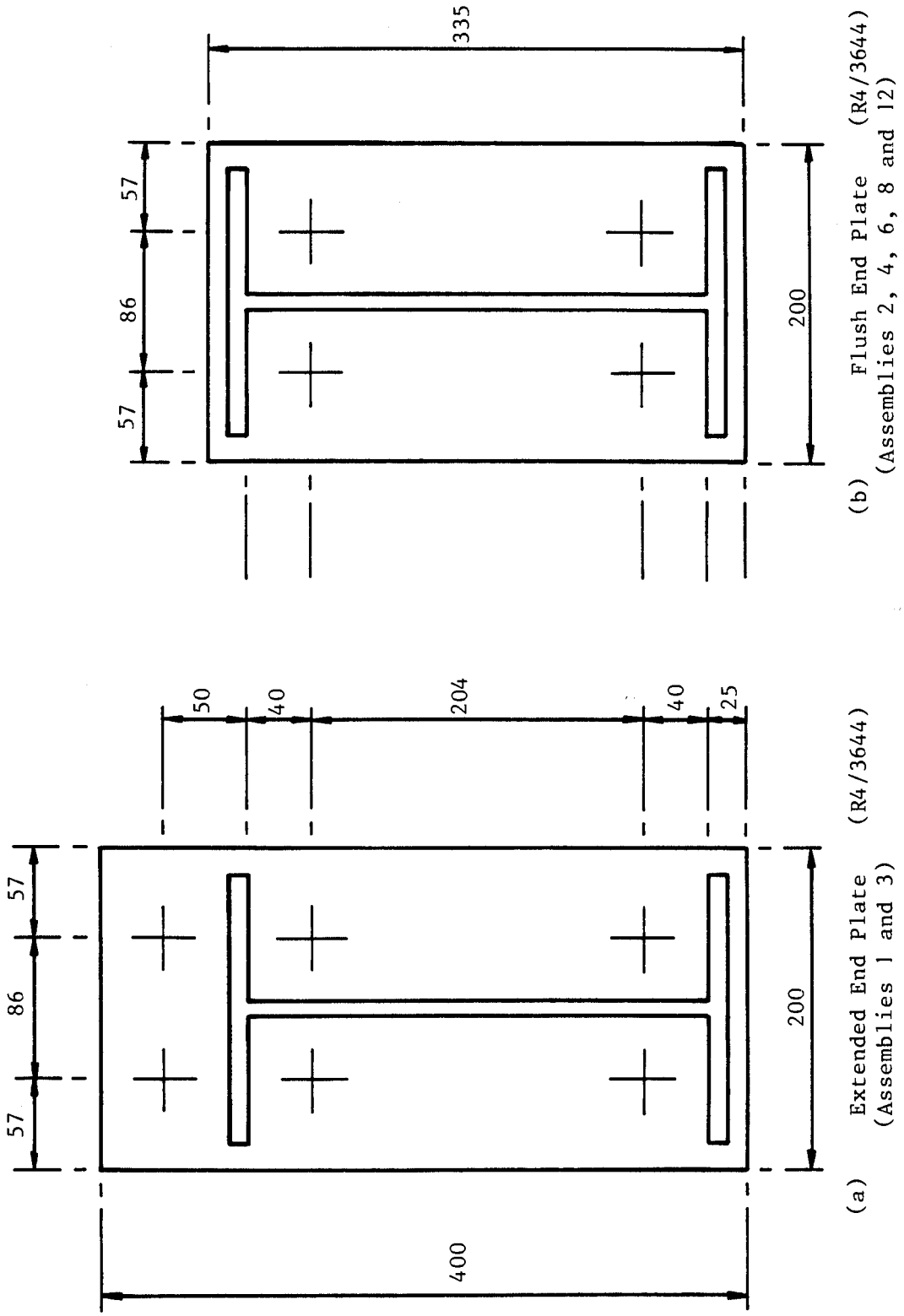



**FIG. 5(a-b) DIMENSIONAL DATA FOR END PLATES**

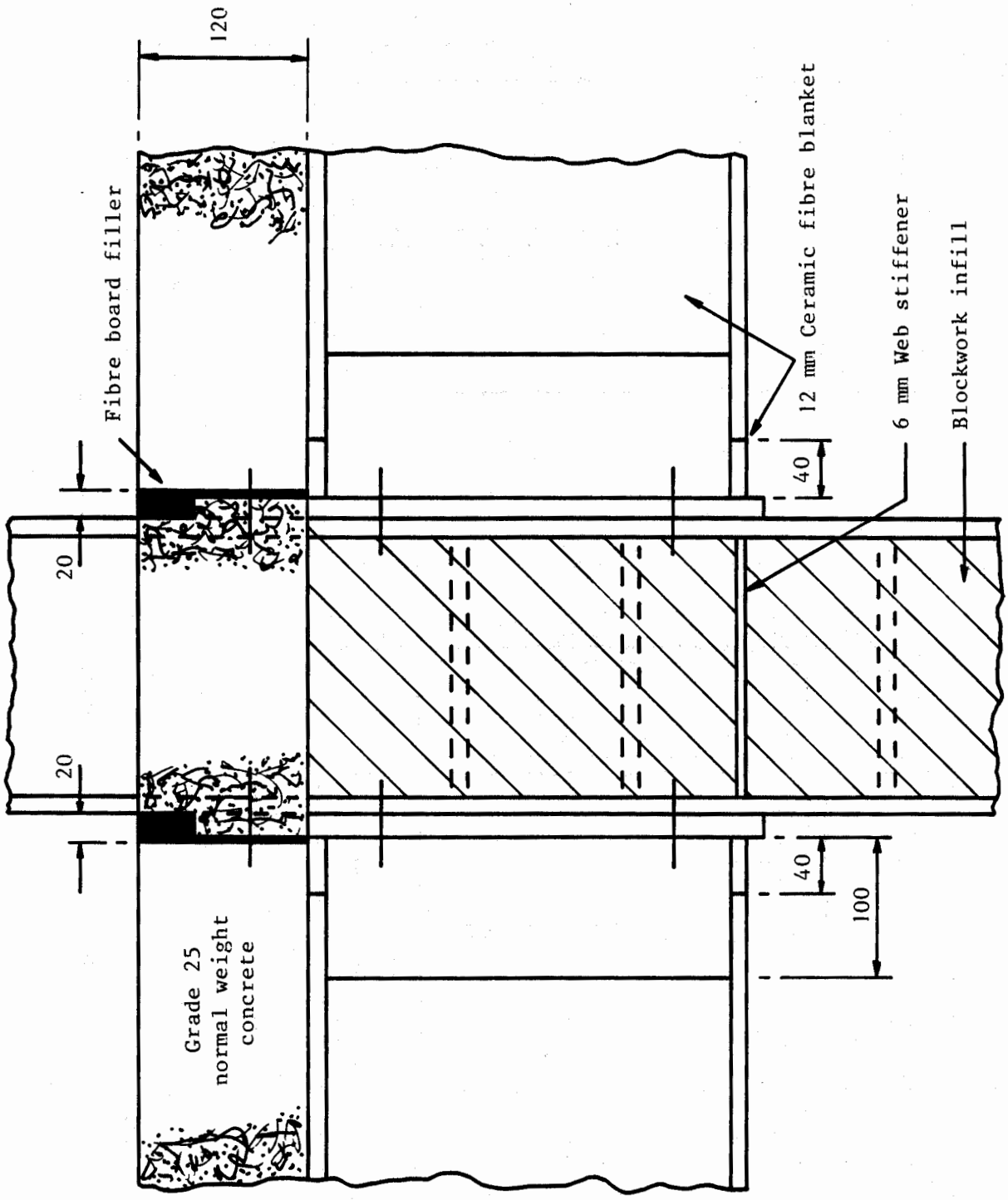



**FIG. 6 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 1 (R4/3645)**

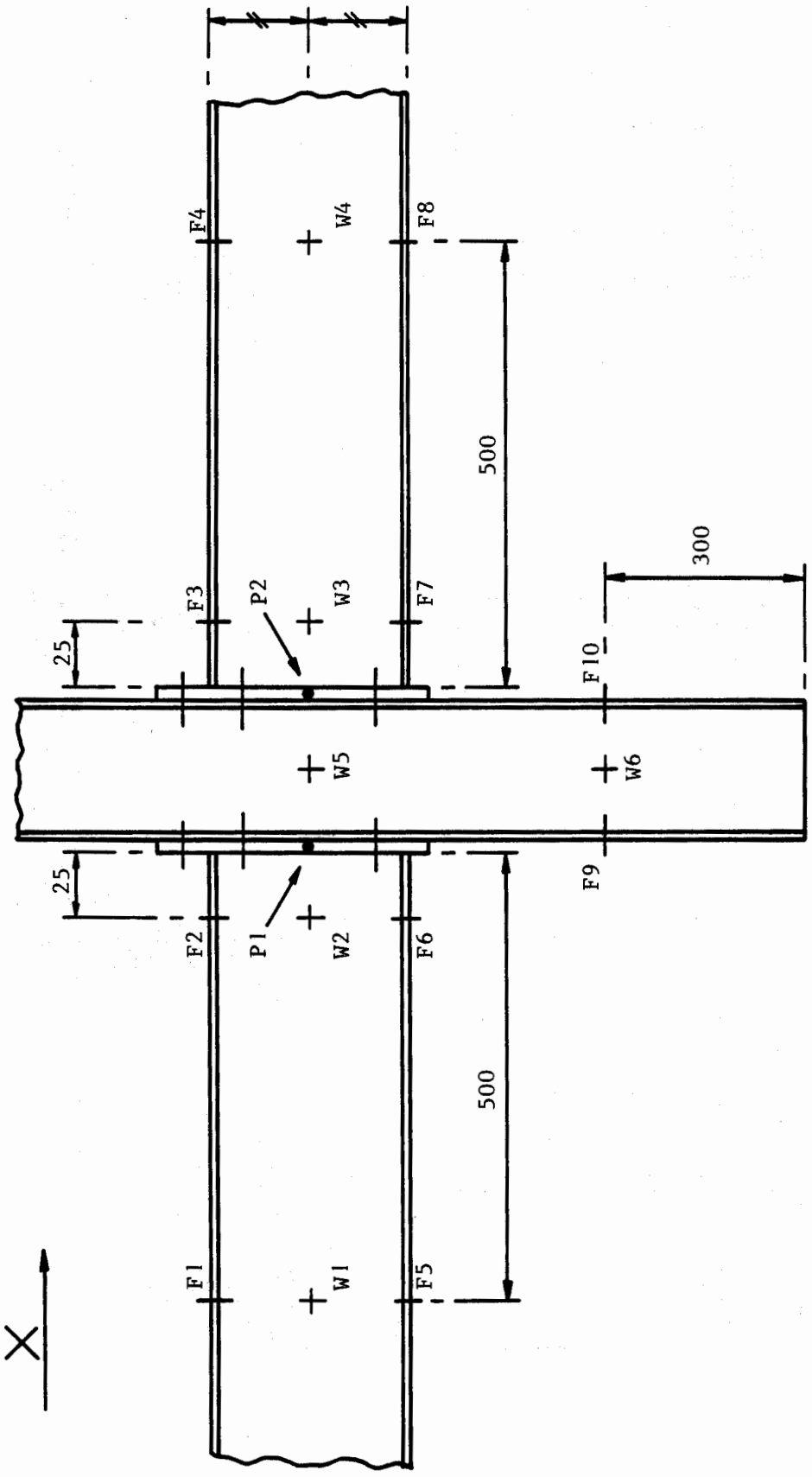
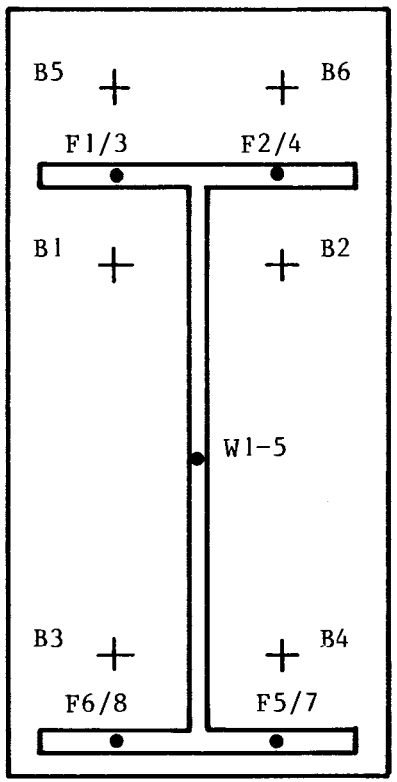
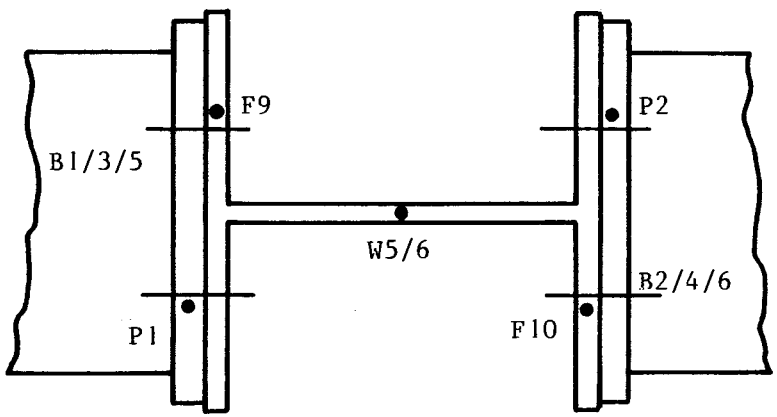



FIG. 7 THERMOCOUPLE POSITIONS - ASSEMBLY NO. 1 (R4/3646)
(LONGITUDINAL ARRANGEMENT)




View in Direction of
Arrow X in Fig. 7




Plan

**FIG. 8** **THERMOCOUPLE POSITIONS - ASSEMBLY NO. 1 (R4/3647)**
**(TRANSVERSE AND PLAN ARRANGEMENTS)**

F9

SL/HED/R/S2442/2/95/C

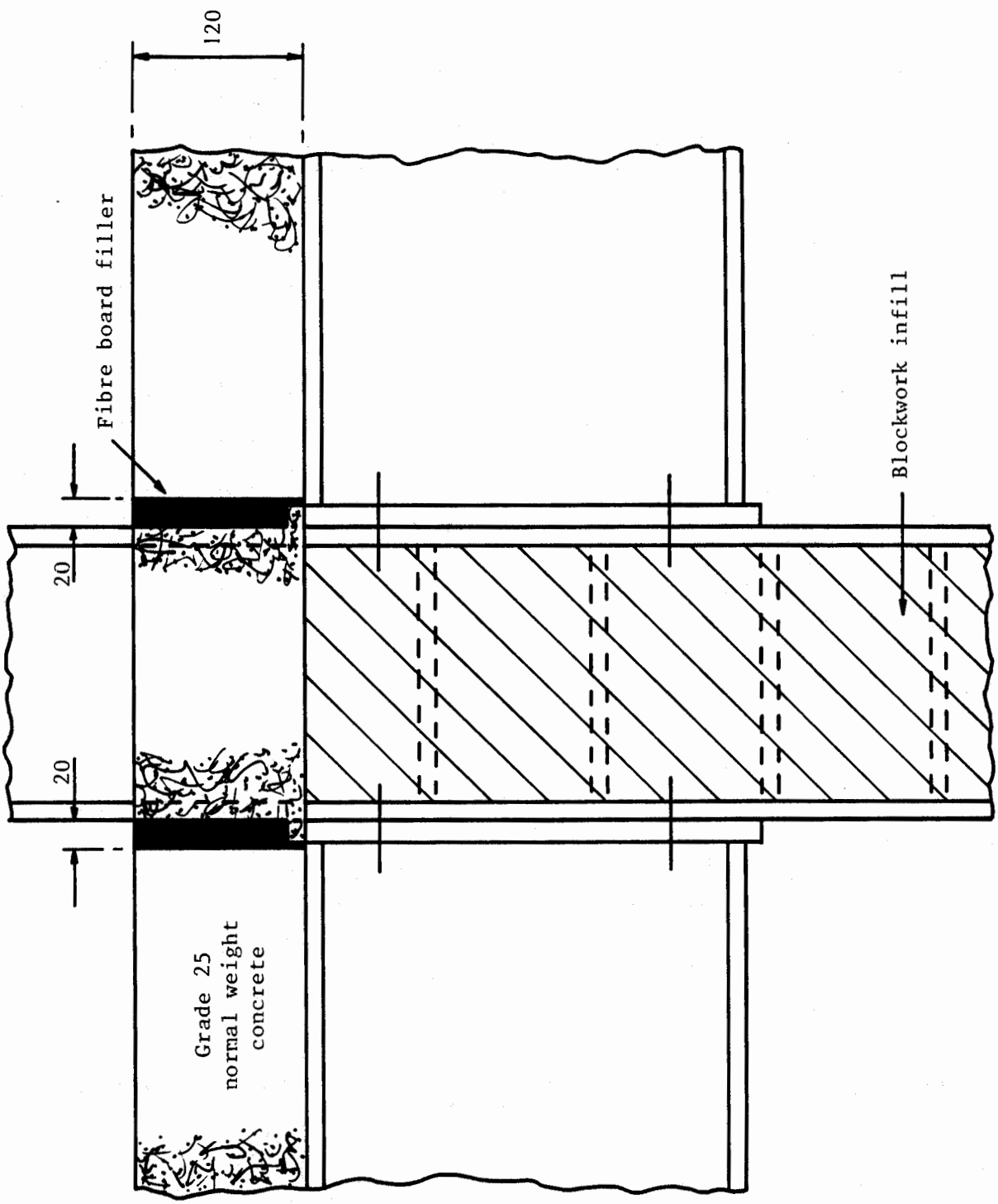



FIG. 9 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 2 (R4/3648)

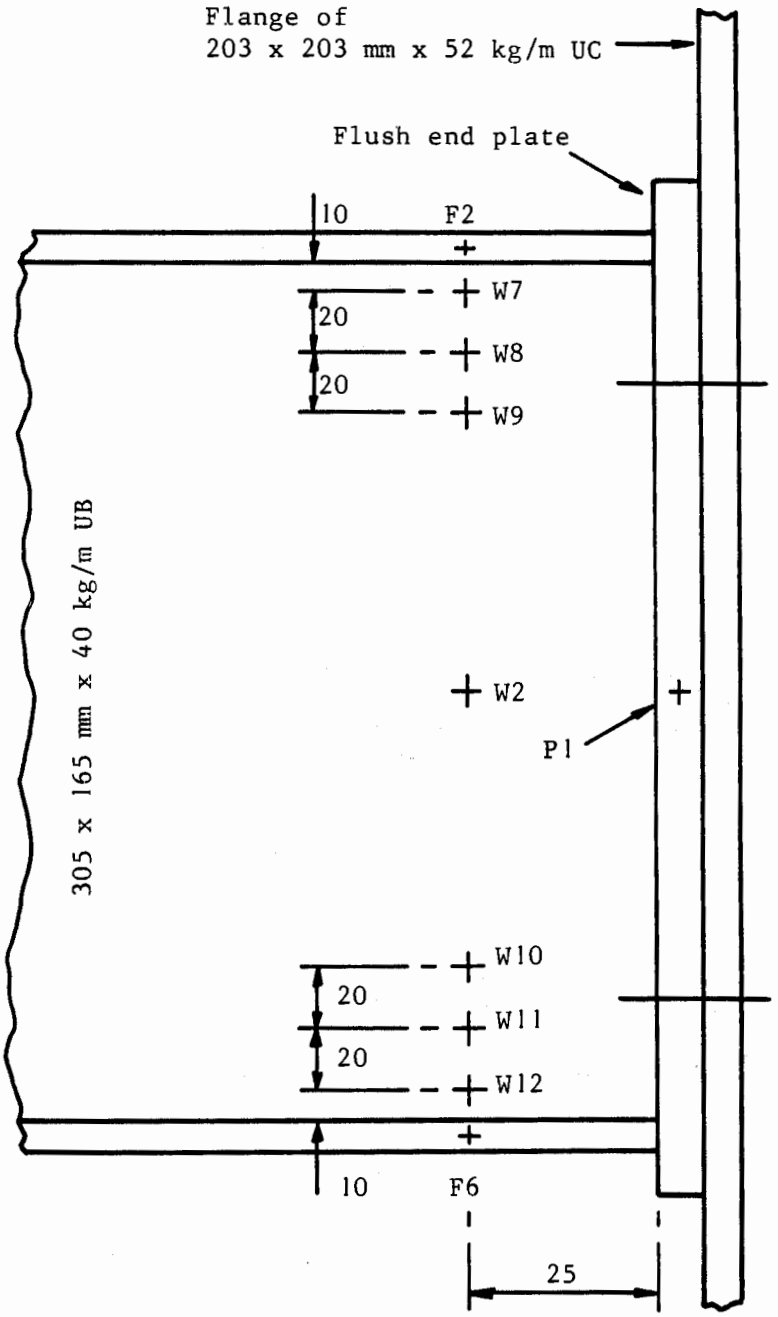



**FIG. 10 ADDITIONAL THERMOCOUPLE POSITIONS IN THE WEB - ASSEMBLY NO. 2** (R4/3649)

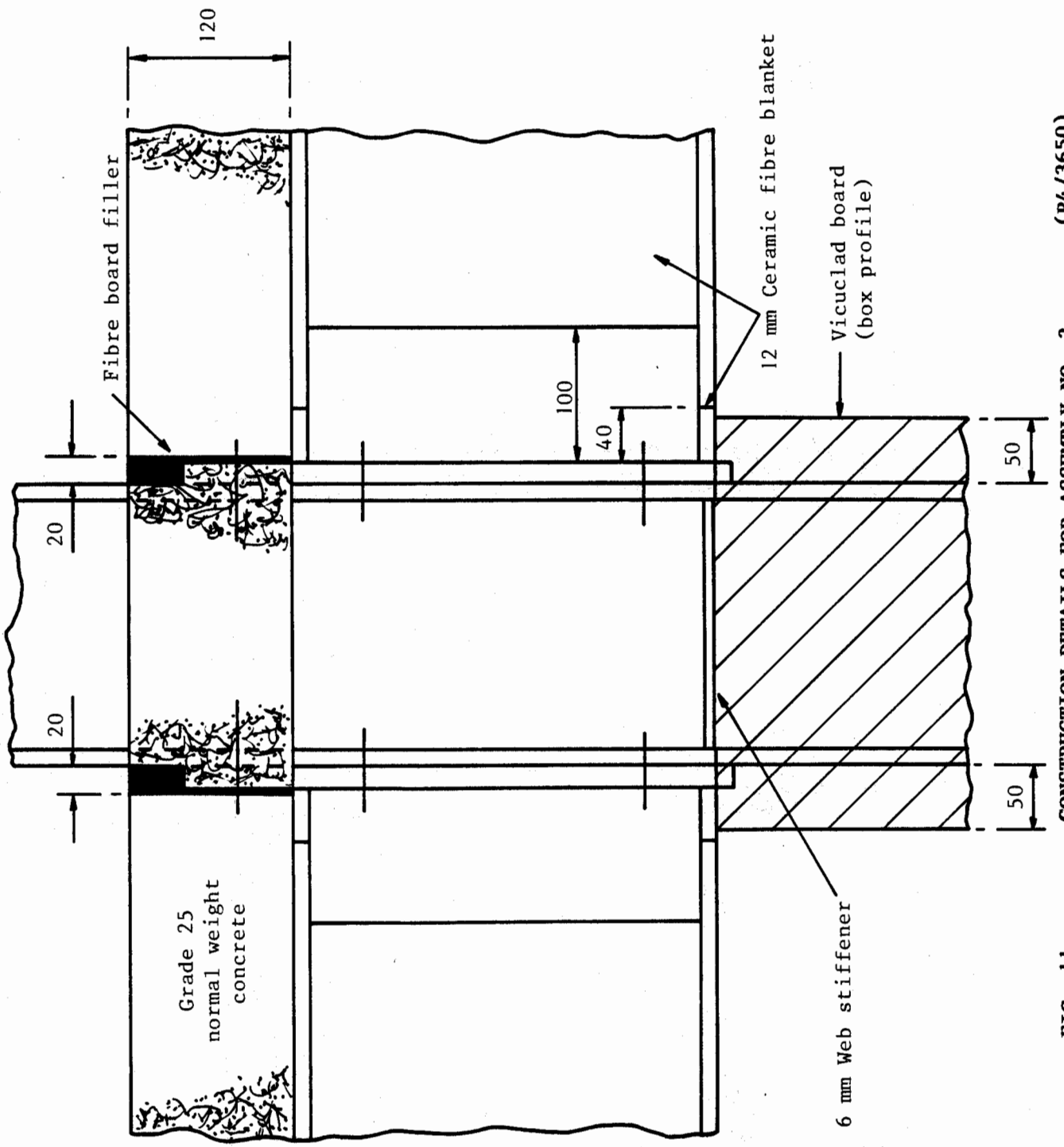



**FIG. 11 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 3 (R4/3650)**

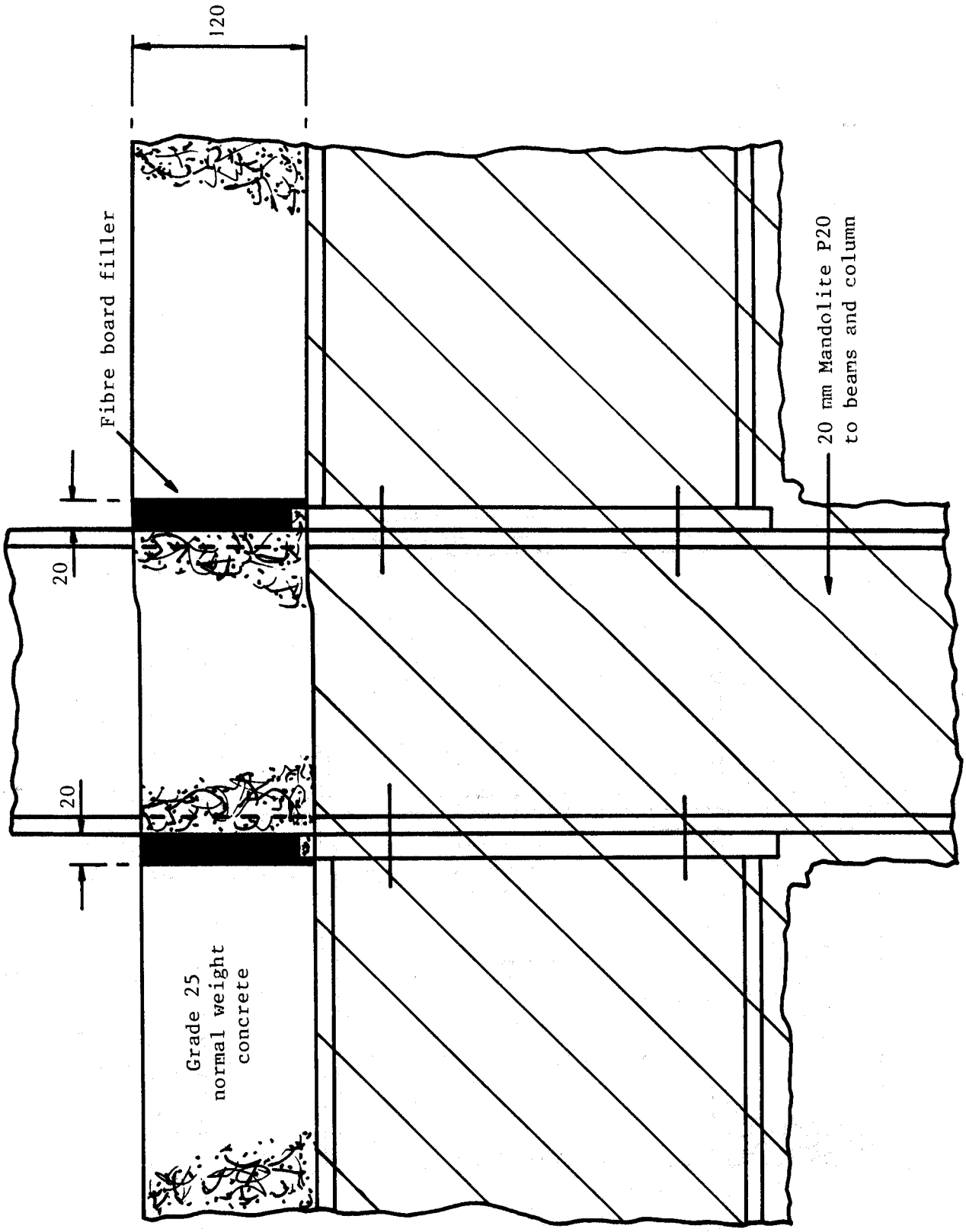



FIG. 12 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 4 (R4/3651)

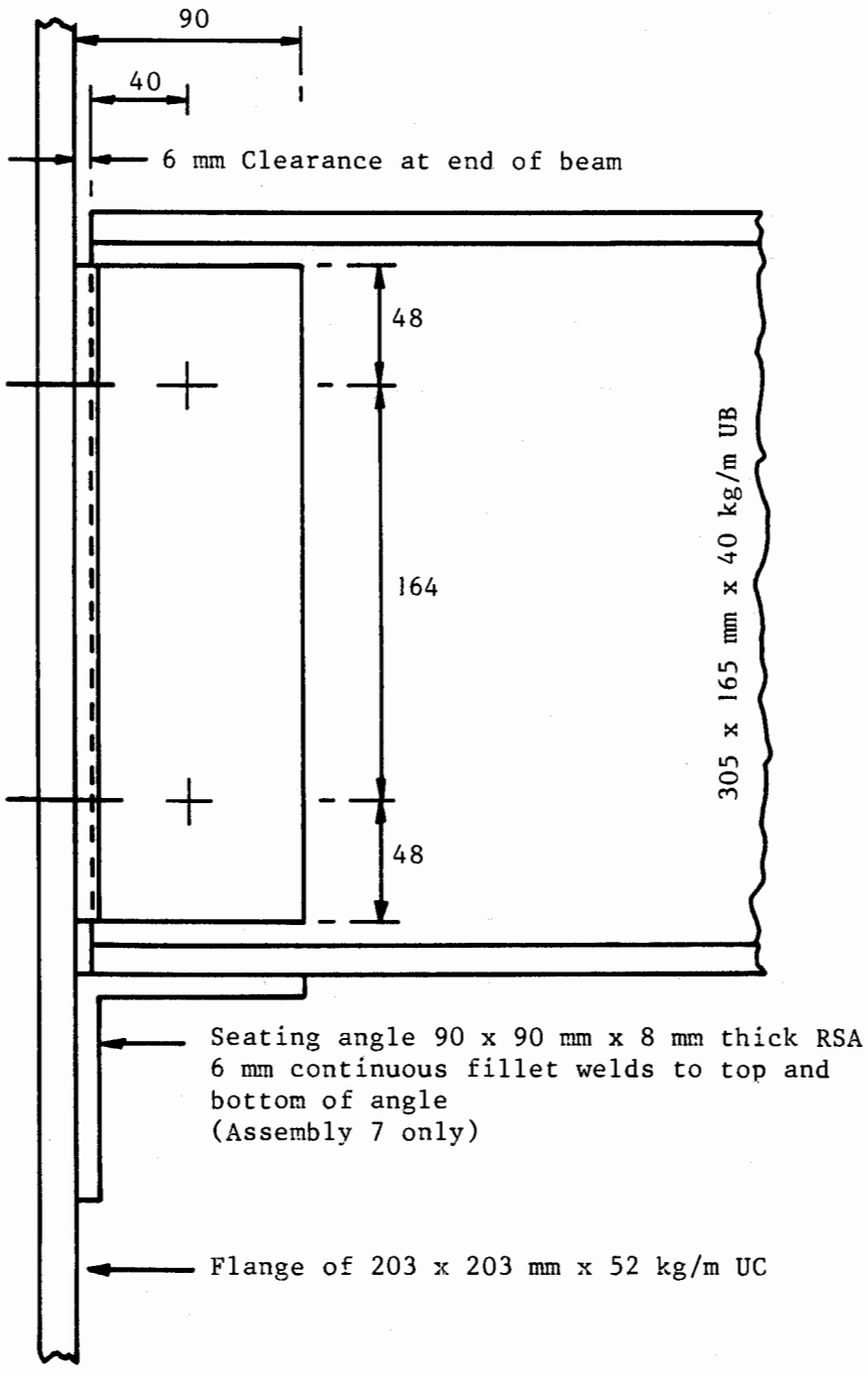



**FIG. 13 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 5 (R4/3652)**

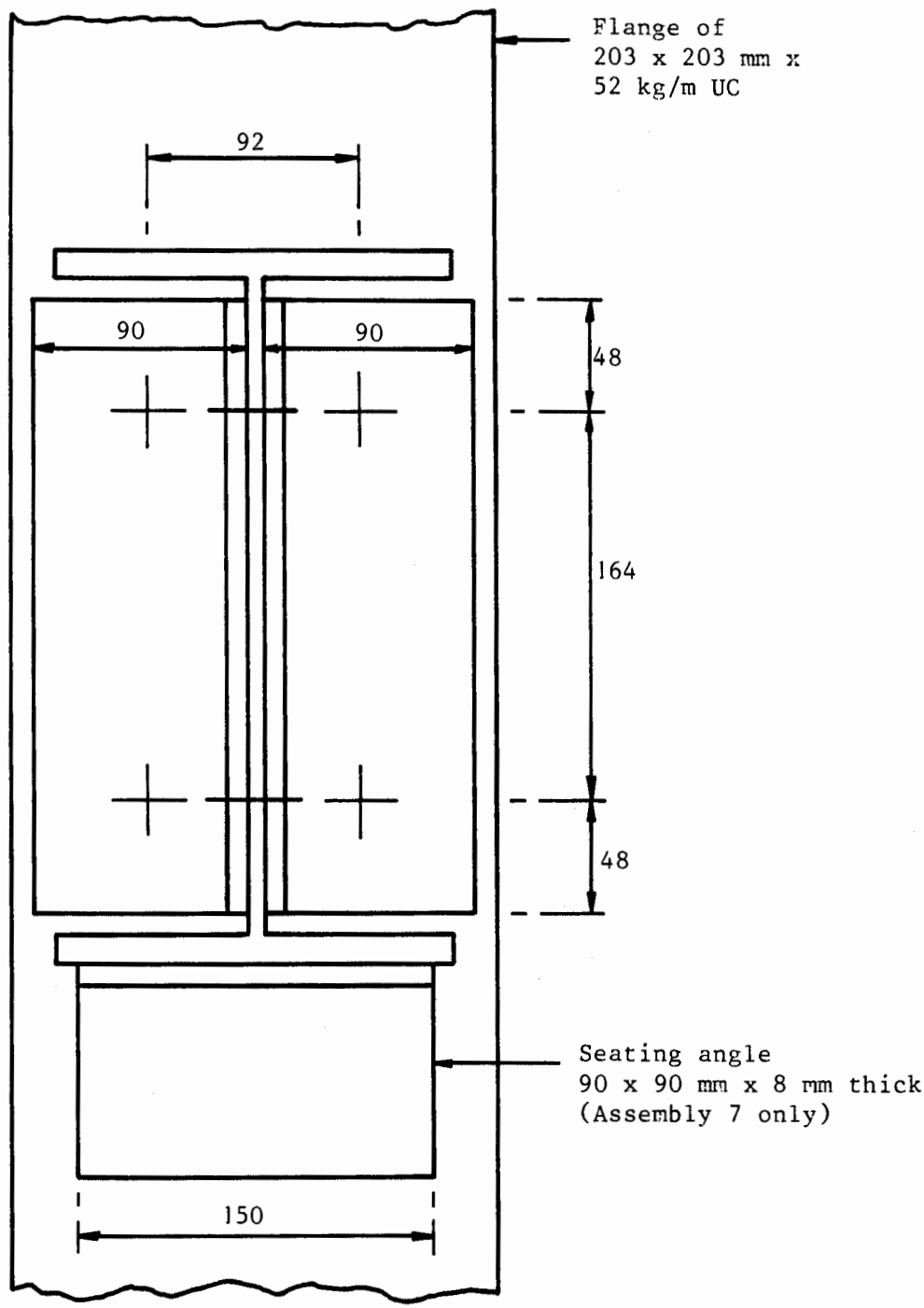



**FIG. 14 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 5 (R4/3653)**

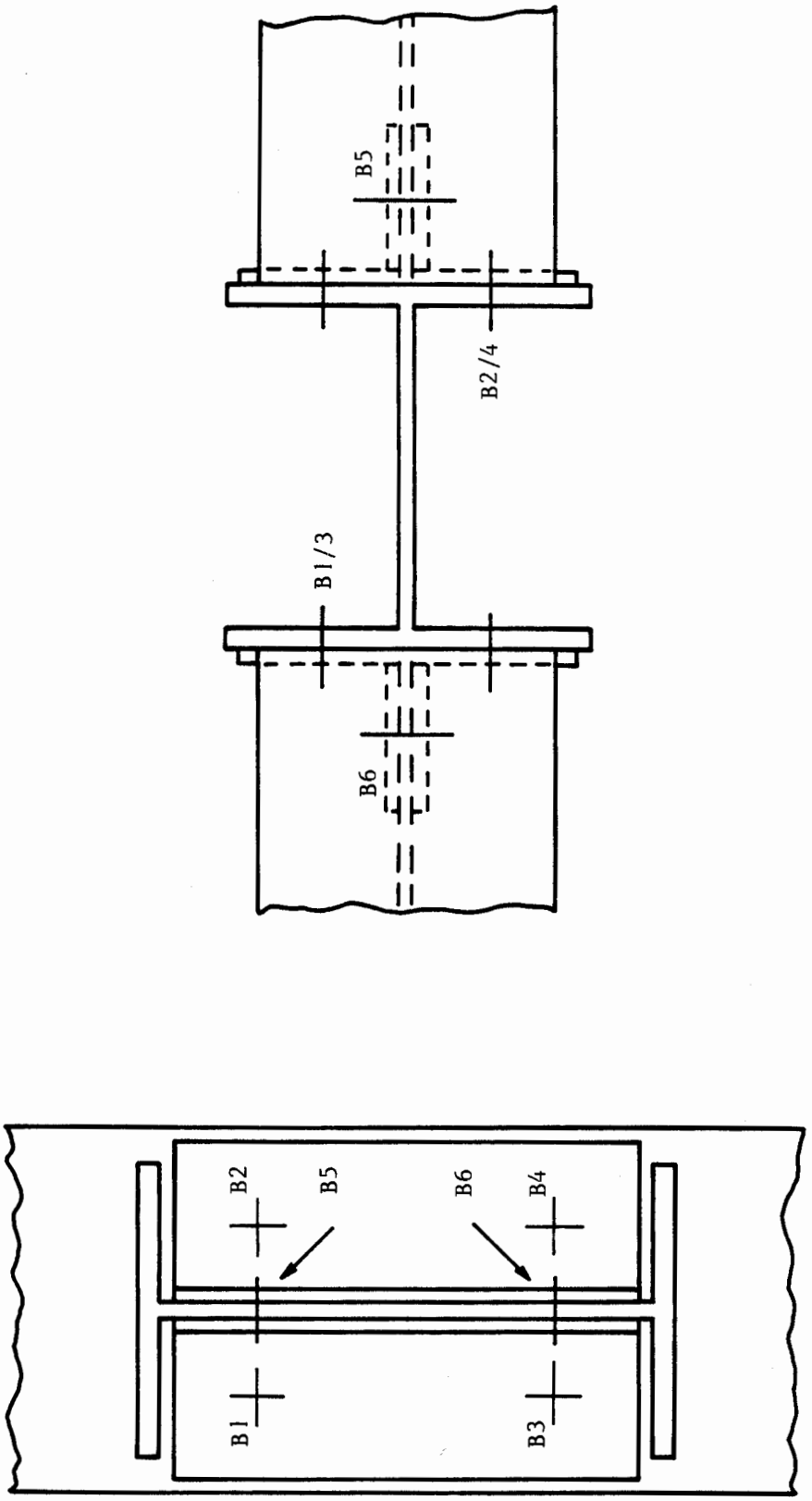



FIG. 15 THERMOCOUPLE POSITIONS IN THE BOLTS - ASSEMBLY NO. 5 (R4/3654)

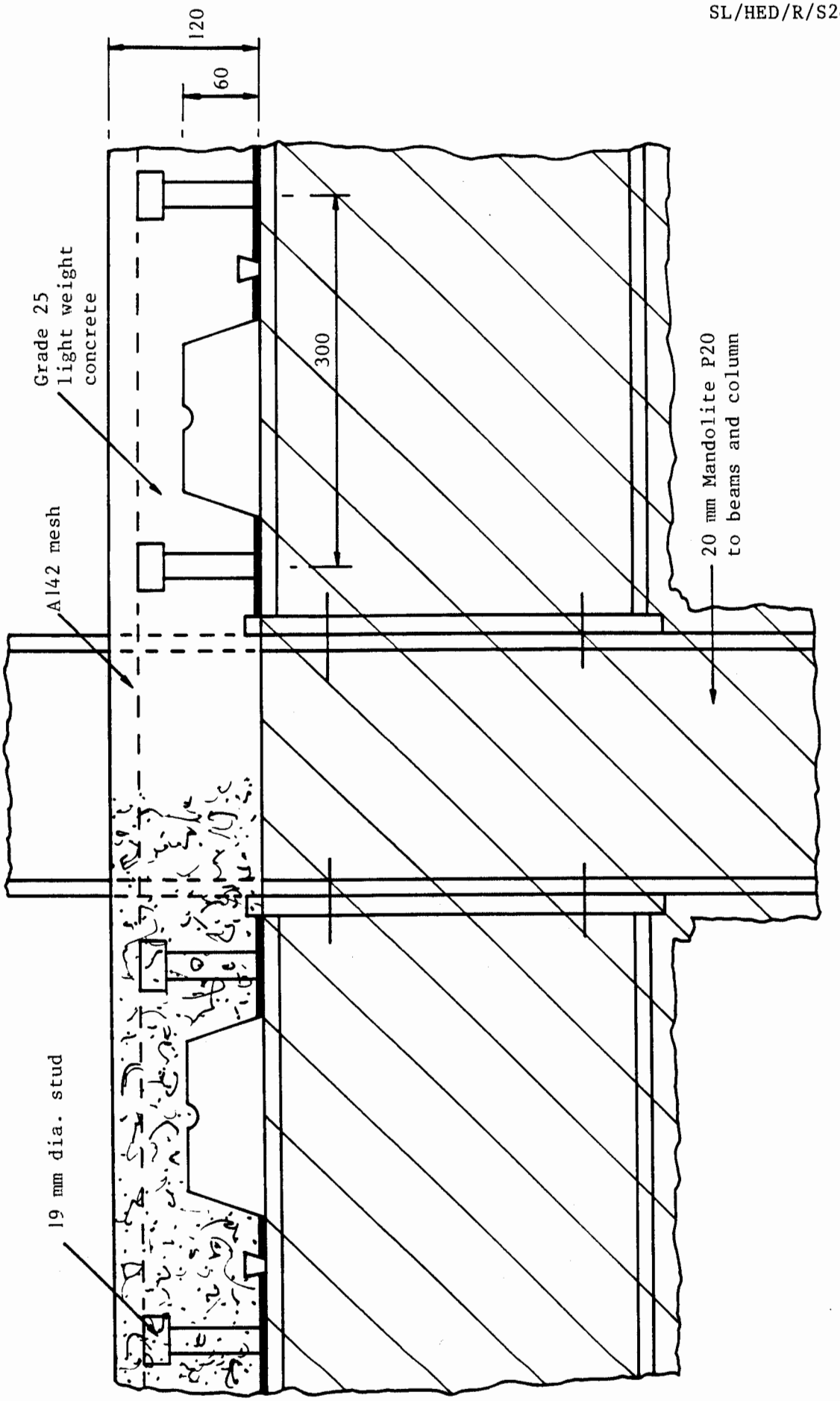
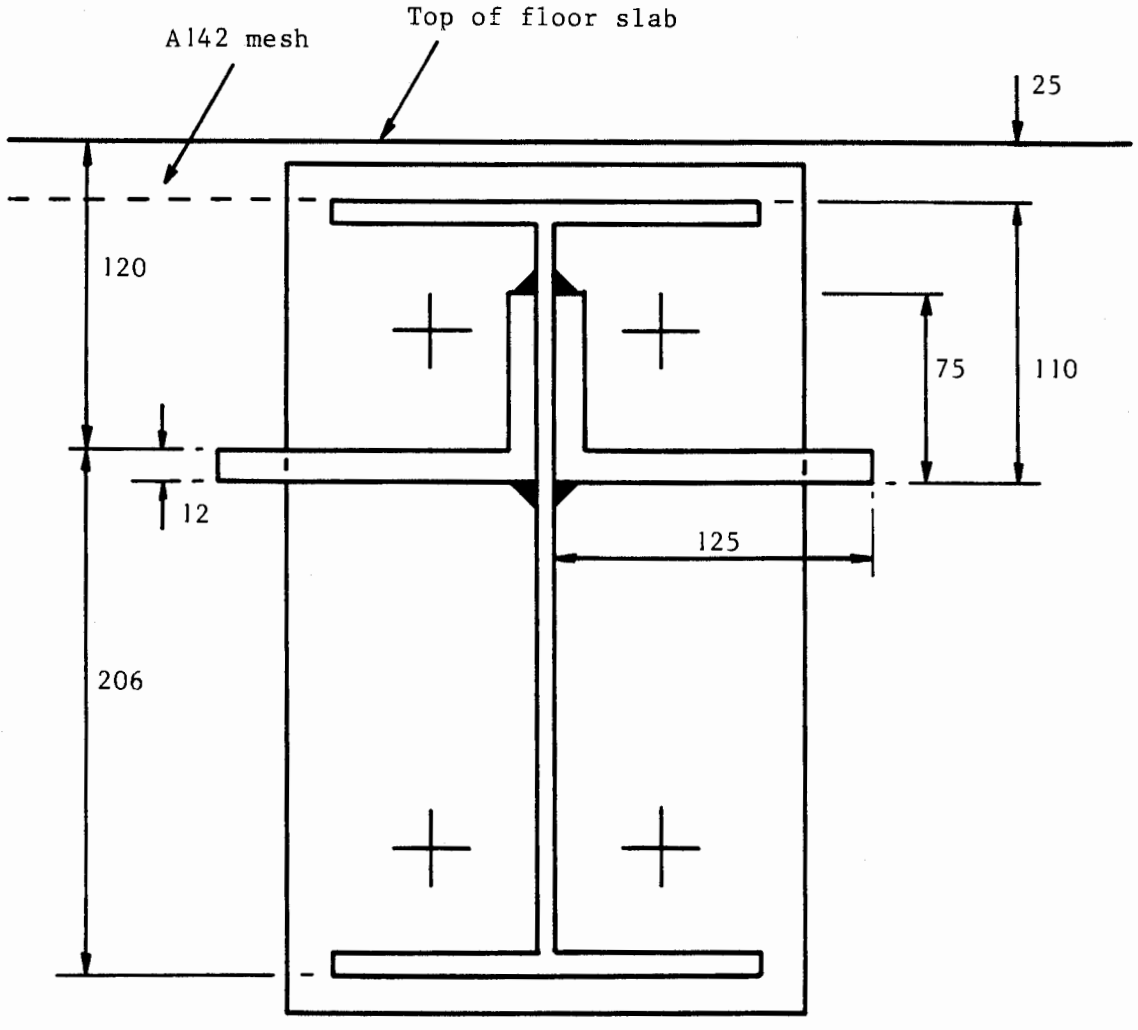



FIG. 16 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 6 (R4/3655)




Flush end plate details shown in Fig. 5(b)

**FIG. 17 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 8 (R4/3656)**

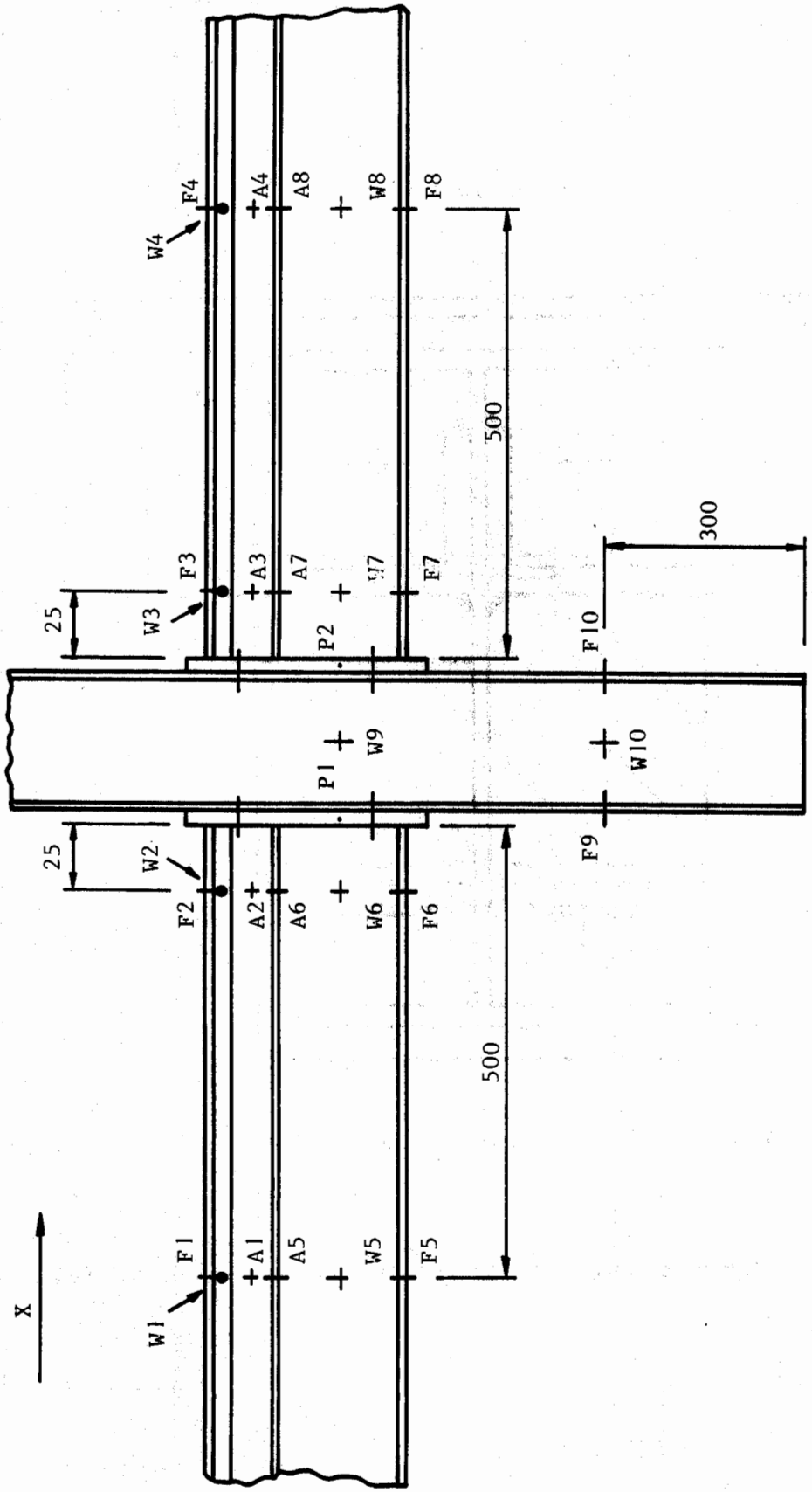
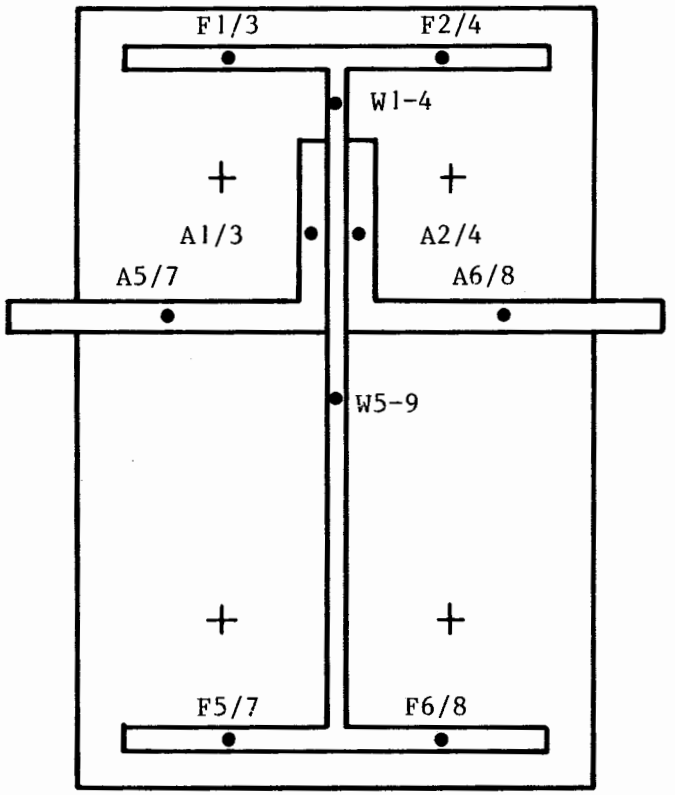
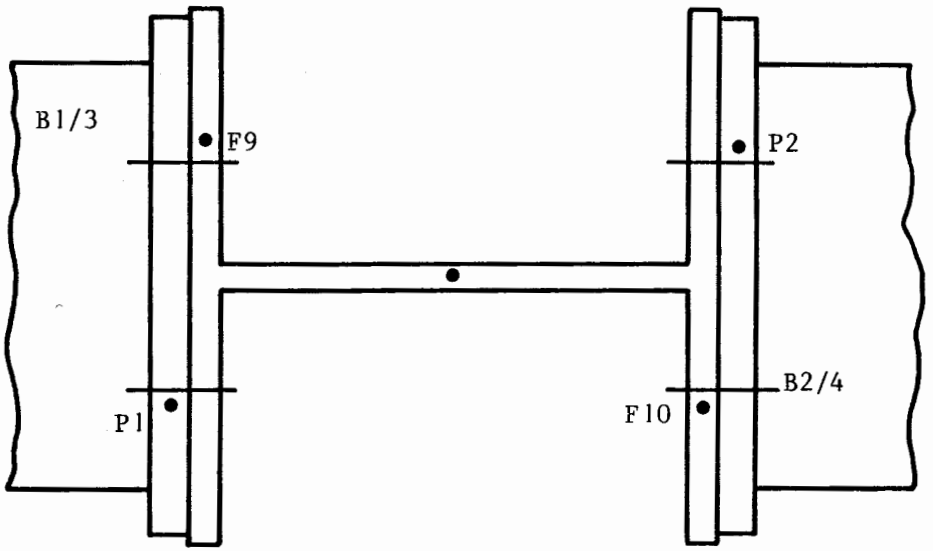



FIG. 18 THERMOCOUPLE POSITIONS - ASSEMBLY NO. 8 (R4/3657)
(LONGITUDINAL ARRANGEMENT)




View in Direction of
Arrow X in Fig. 18




Plan

**FIG. 19** **THERMOCOUPLE POSITIONS - ASSEMBLY NO. 8 (TRANSVERSE AND PLAN ARRANGEMENTS)** **(R4/3658)**

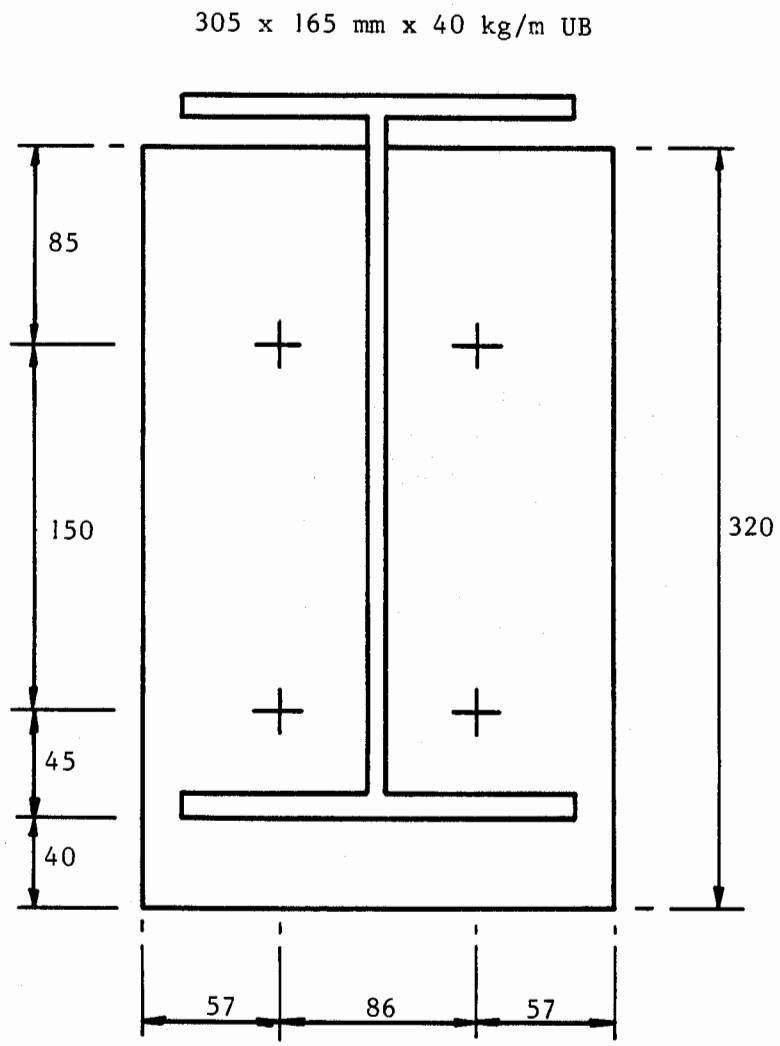



**FIG. 20** **DIMENSIONAL DATA FOR END PLATES - ASSEMBLY NO. 9** **(R4/3659)**

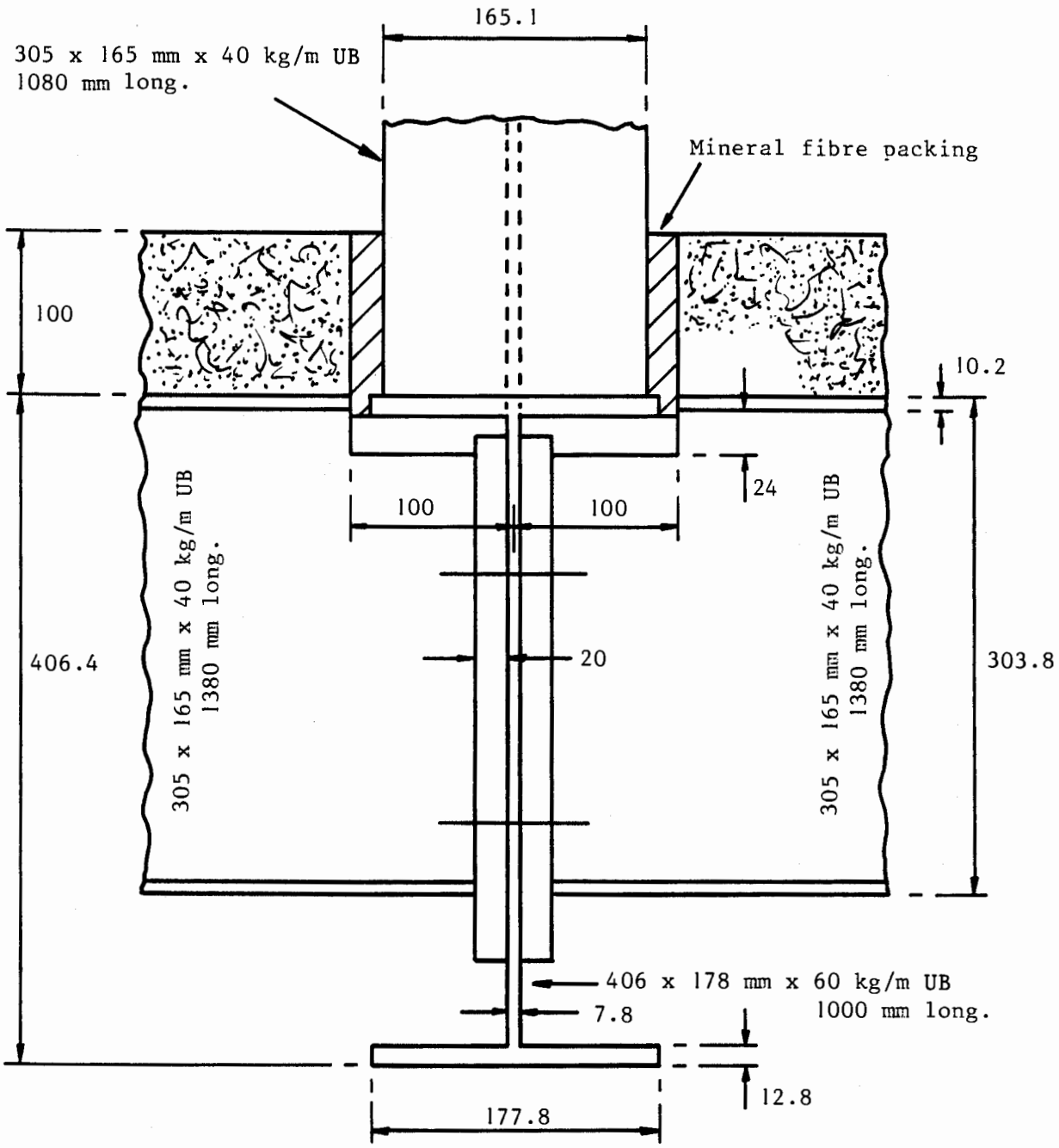



**FIG. 21 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 9 (R4/3660)**

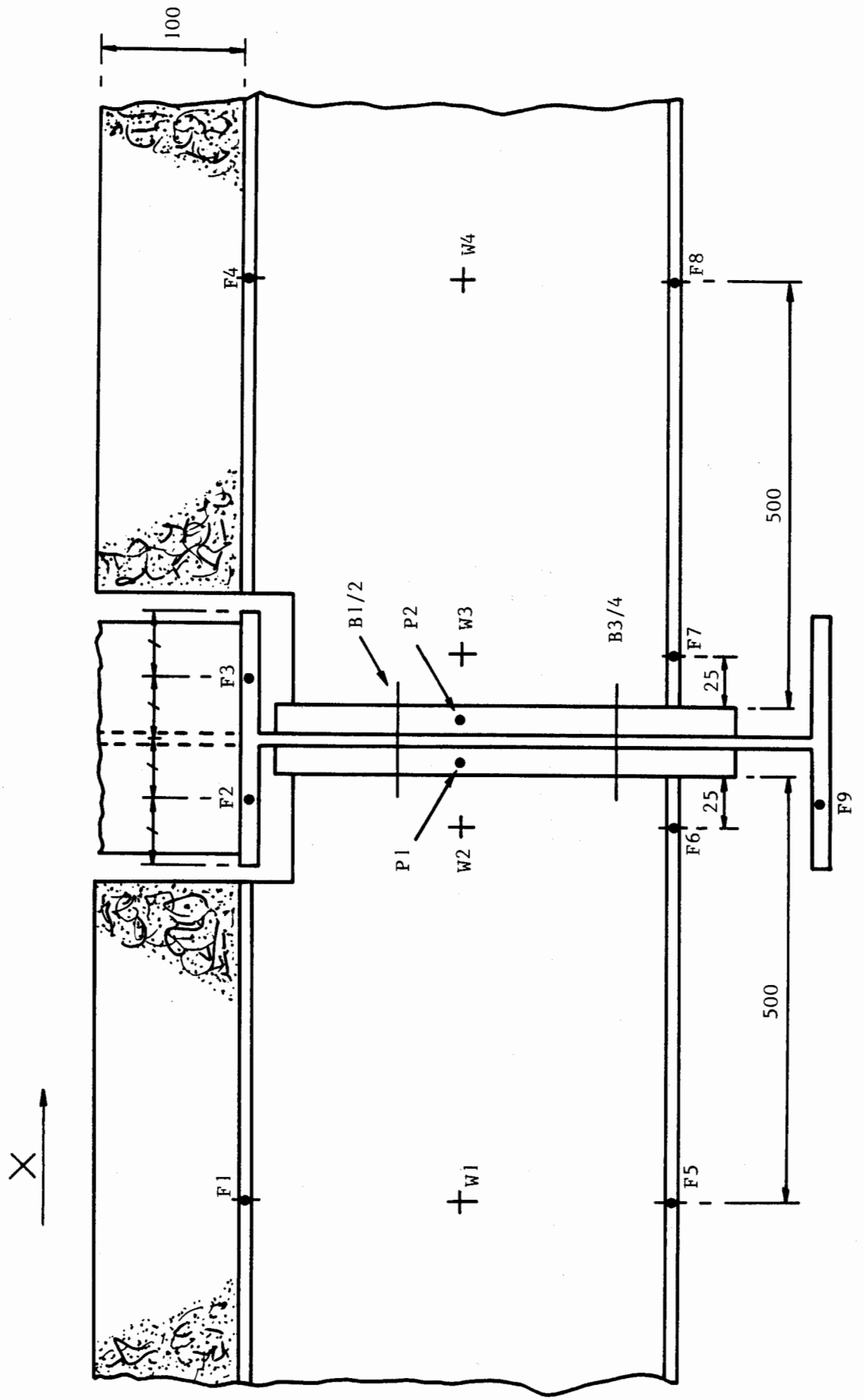
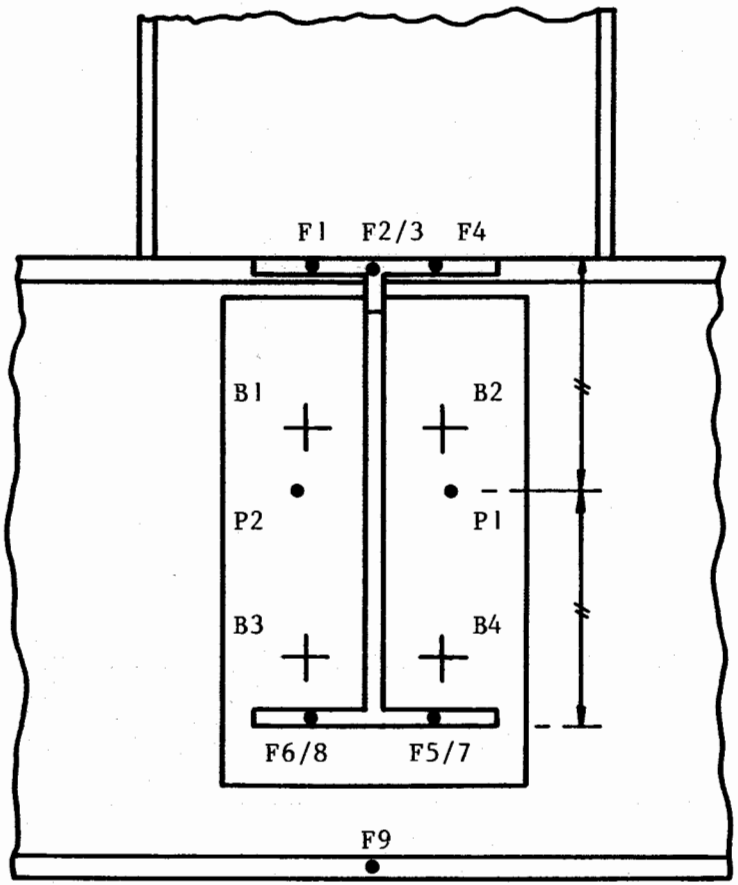
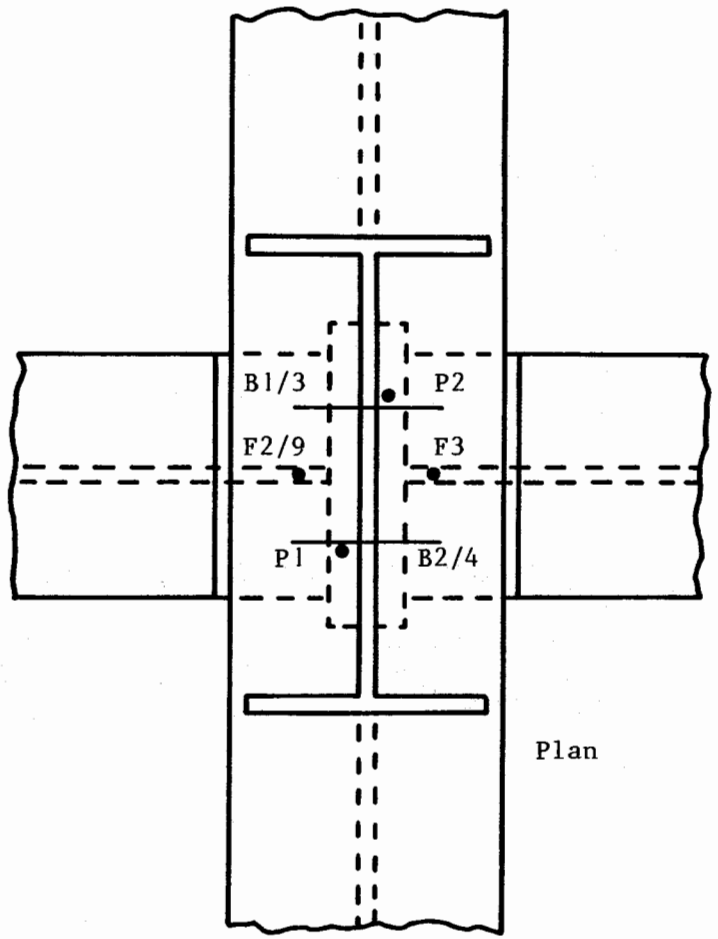



FIG. 22 THERMOCOUPLE POSITIONS - ASSEMBLY NO. 9 (R4/3661)
(LONGITUDINAL ARRANGEMENT)

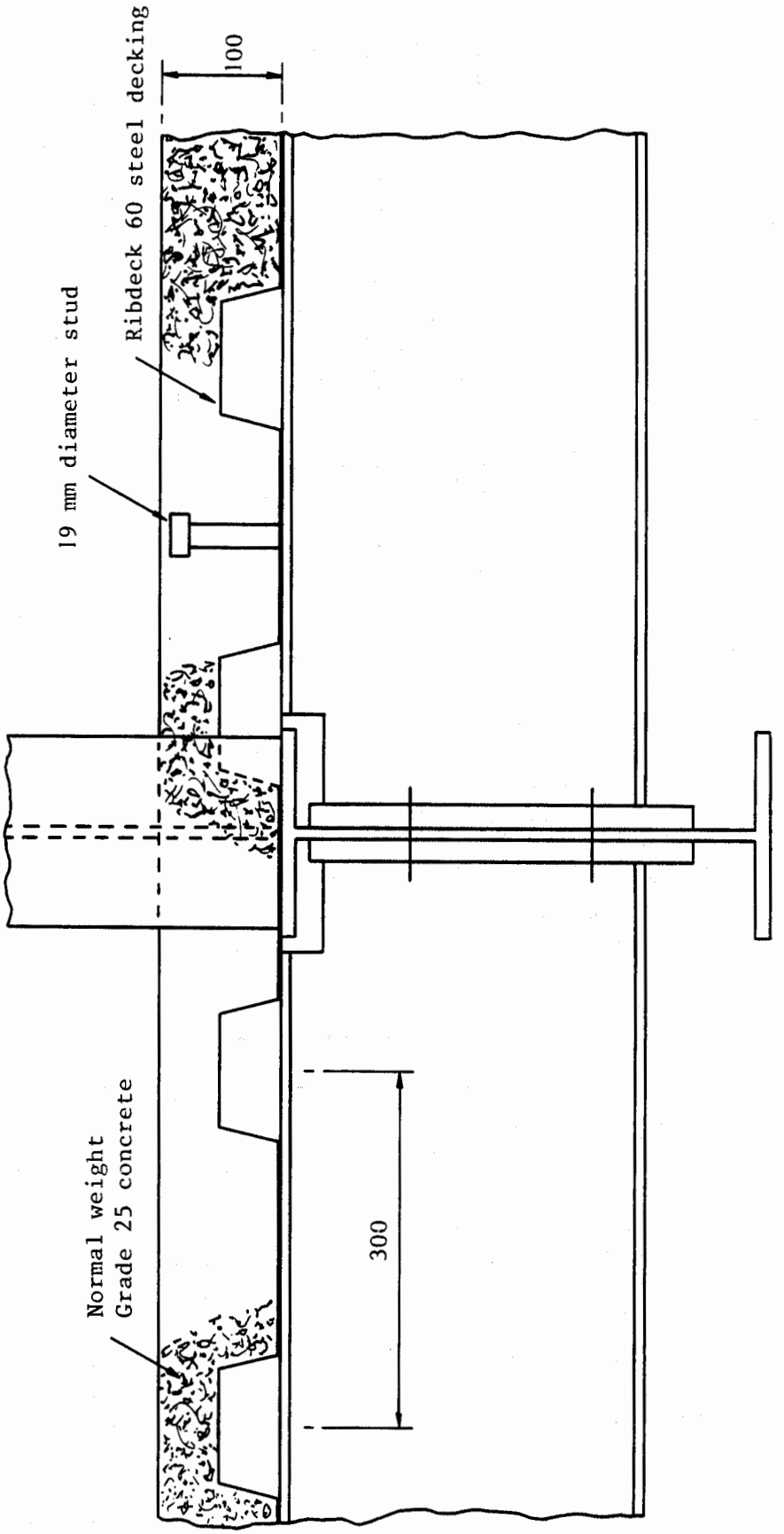



View in Direction of
Arrow X in Fig. 22




Plan

**FIG. 23** **THERMOCOUPLE POSITIONS - ASSEMBLY NO. 9 (R4/3662)**
**(TRANSVERSE AND PLAN ARRANGEMENTS)**




All other dimensions as shown in Fig. 21

**FIG. 24 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 10 (R4/3663)**

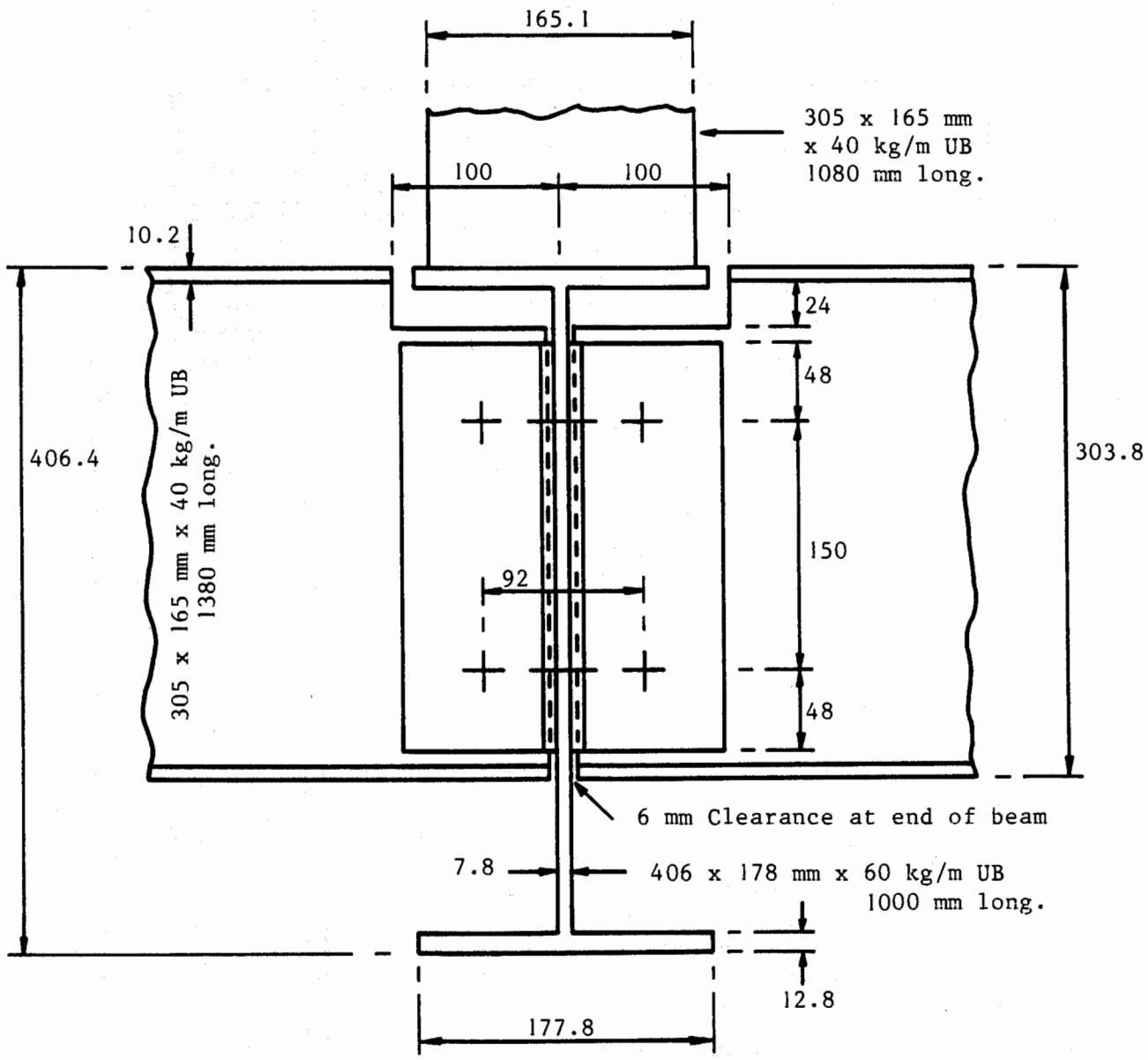



**FIG. 25 CONSTRUCTION DETAILS FOR ASSEMBLY NO. 11 (R4/3664)**

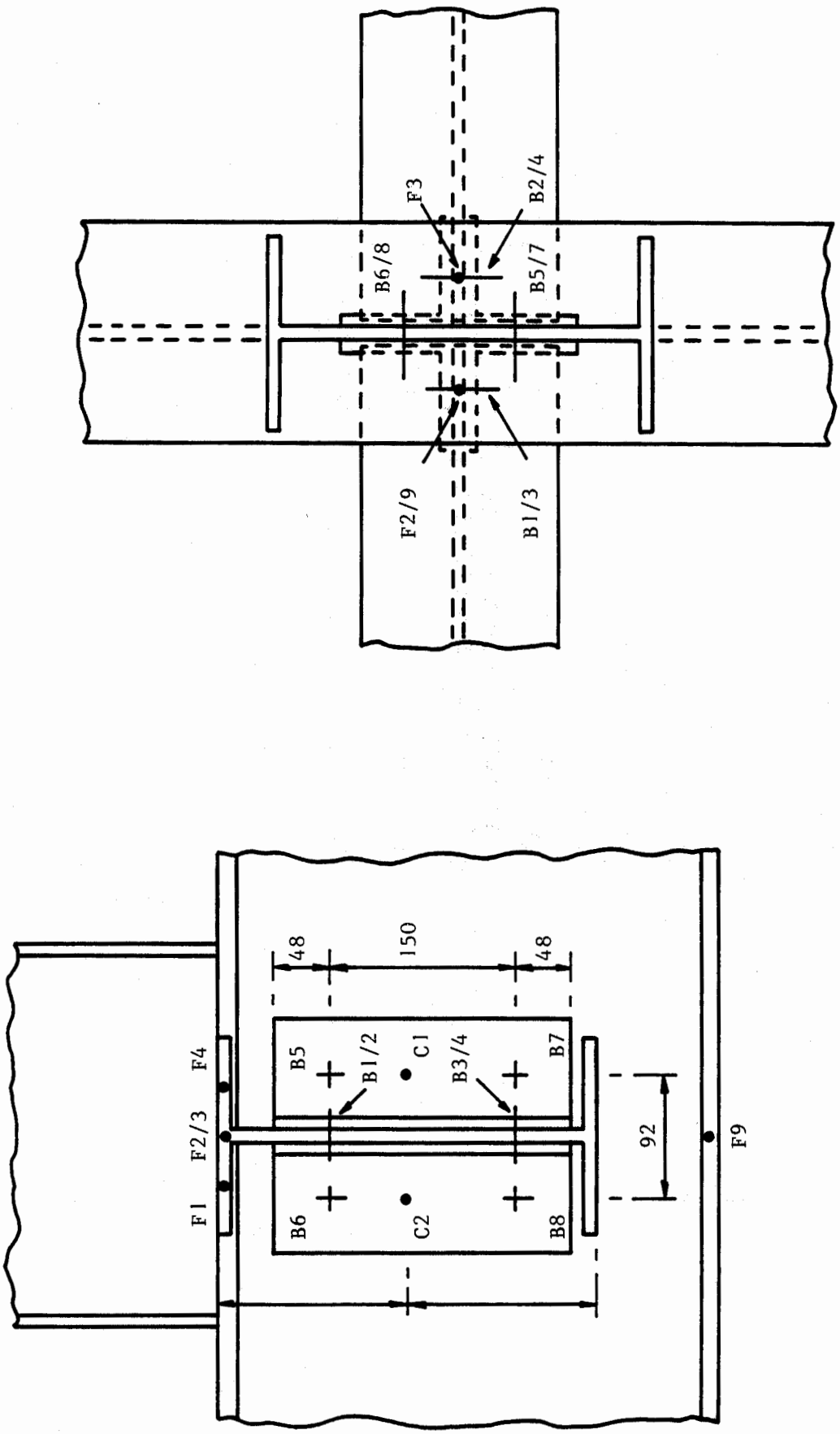



FIG. 26 THERMOCOUPLE POSITIONS IN THE BOLTS - ASSEMBLY NO. 11 (R4/3665)

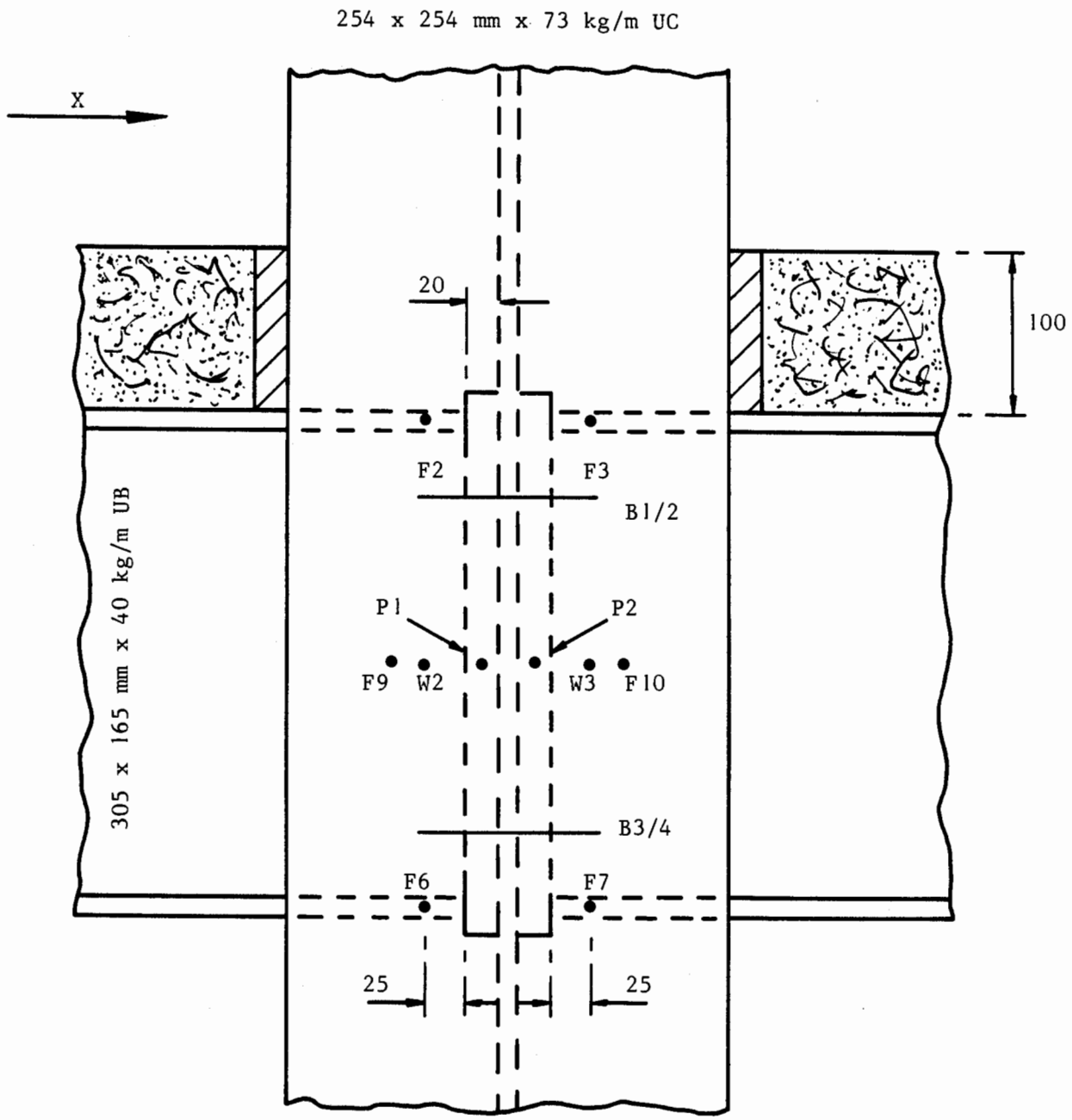
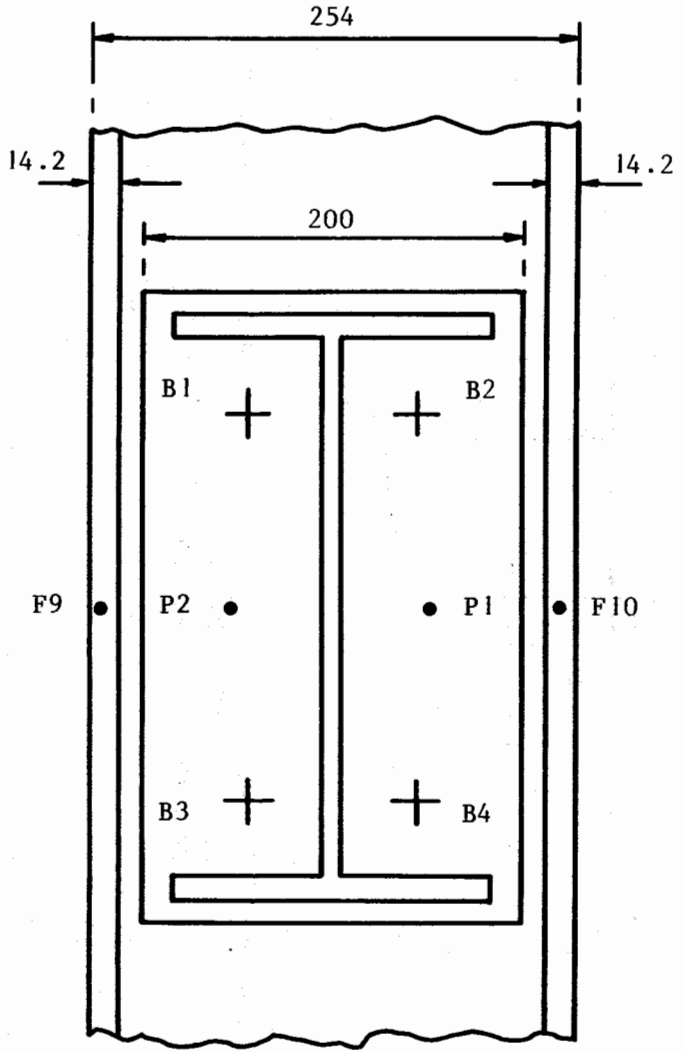
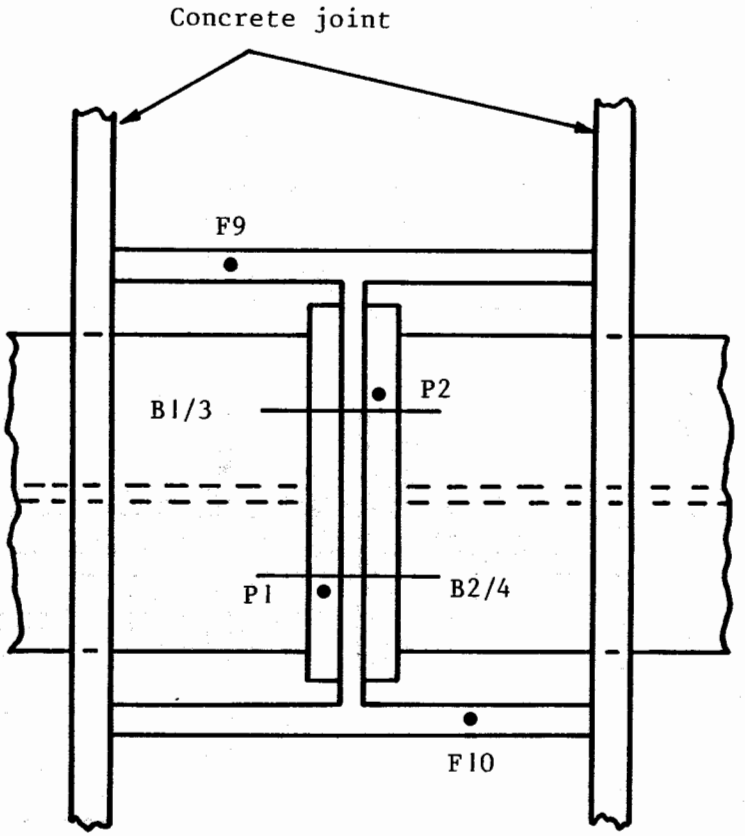



**FIG. 27** **THERMOCOUPLE POSITIONS AROUND THE CONNECTED MEMBERS - ASSEMBLY NO. 12 (LONGITUDINAL ARRANGEMENT)** **(R4/3666)**

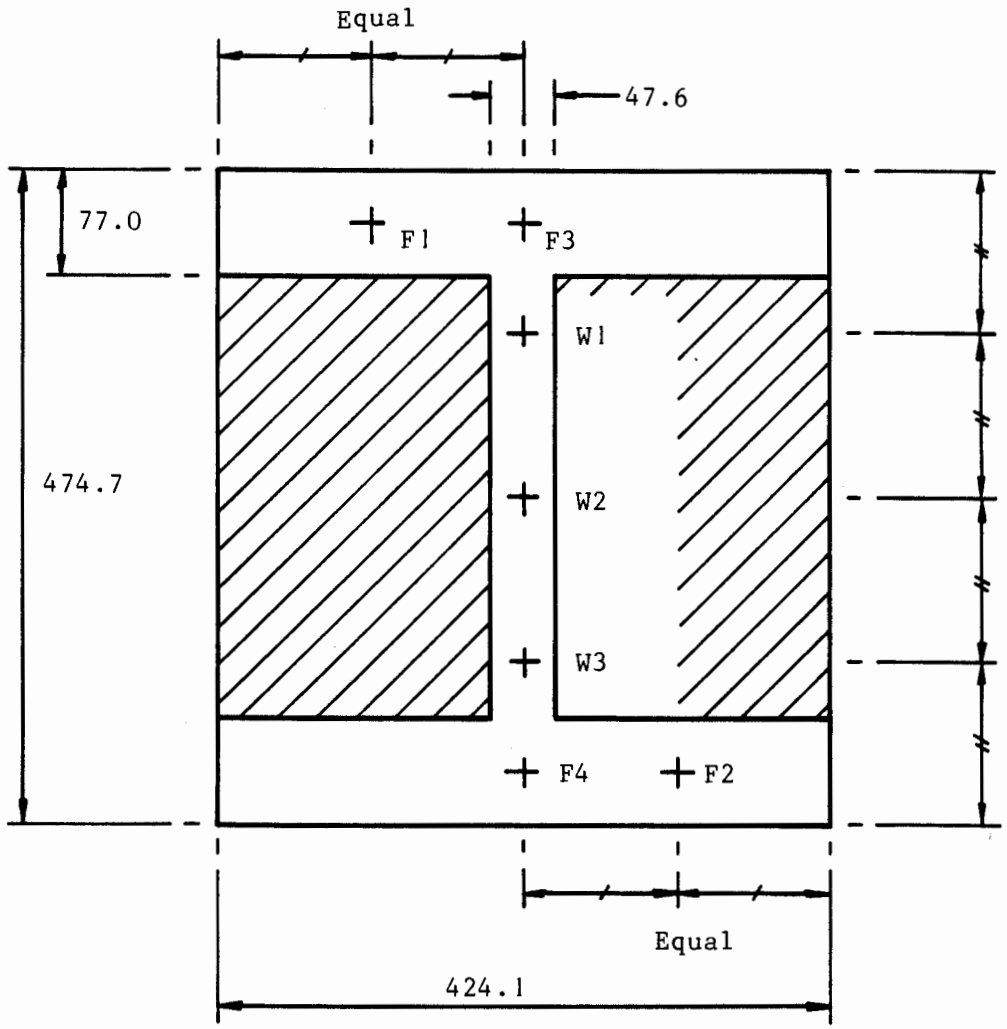



(a) Side Elevation - View in Direction of Arrow X in Fig. 27 (R4/3667)




(b) Plan View (R4/3667)

**FIG. 28(a-b)** **THERMOCOUPLE POSITIONS - ASSEMBLY NO. 12 (TRANSVERSE AND PLAN ARRANGEMENTS)**




Plan View

**FIG. 29** **THERMOCOUPLE POSITIONS IN THE INDICATIVE COLUMN SPECIMEN** **(R4/3668)**

# APPENDIX 1

## DATA SHEET NUMBERS 112-124

DATA SHEET NUMBER **112A**

## BEAM / COLUMN (MAJOR AXIS) CONNECTION

### DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 × 203 Column | Nominal<br>Actual | 52 | 206.2 | 203.9 | 8.0 | 12.5 | 510.4 | 173.6 | 568.1 | 263.7 | 5263 | 1770 |
| 305 × 165 Beam | Nominal<br>Actual | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |

### CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Column | Grade 43A | 0.23 | 0.04 | 0.90 | 0.024 | 0.019 | 0.04 | <0.005 | 0.03 | <0.005 | 0.08 | <0.005 | <0.005 | 0.0048 |
| Beam | Grade 43A | 0.22 | 0.03 | 0.88 | 0.009 | 0.025 | <0.02 | <0.005 | <0.02 | <0.005 | <0.02 | <0.005 | <0.005 | 0.0074 |

### ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| Column - Flange | 288 | 501 | 31 |
| Beam - Flange (Actual) | 309 | 480 | 33 |
| Beam - Flange (Mean) | 295 | 467 | 34 |

### TEST CONDITIONS

### NOTES

| | |
|---|---|
| TEST CENTRE | : Warrington Research |
| TEST DATE | : 18th January 1989 |
| TEST NUMBER | : WFRC 44175 |

**ASSESSMENT**

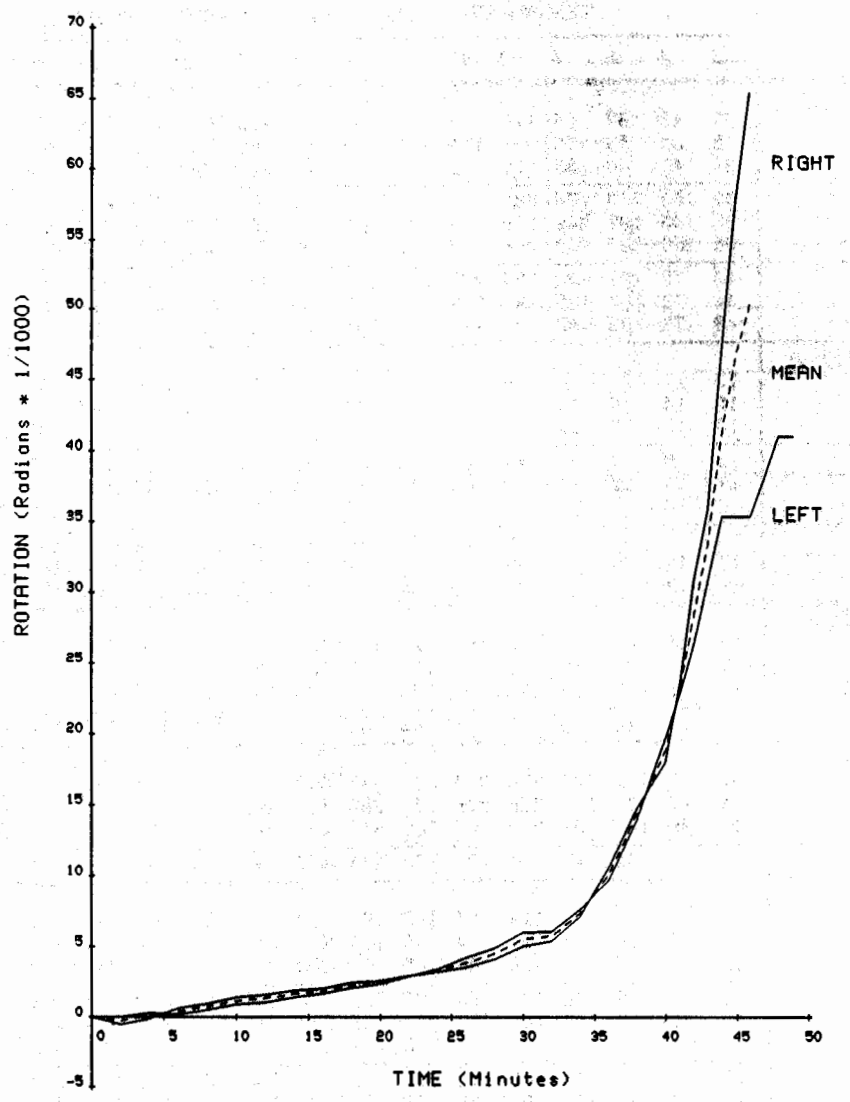
**LOAD BEARING CAPACITY**
45 minutes at 0.4 $M_p$
49 minutes at 0.3 $M_p$

DATA SHEET NUMBER **112B**

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 27 | 30 | 34 | 36 | 40 | 45 | 49 |
| Beam @ 25 mm from End Plate | | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 37 | 48 | 67 | 94 | 126 | 149 | 177 | 203 | 232 | 259 | 287 | 312 | 352 | 377 | 414 | 436 | 474 | 516 | 546 |
| | F3 | 18 | 33 | 53 | 72 | 92 | 110 | 125 | 146 | 168 | 190 | 213 | 236 | 273 | 299 | 333 | 351 | 384 | 425 | 454 |
| | Mean | 28 | 41 | 60 | 83 | 109 | 130 | 151 | 175 | 200 | 225 | 250 | 274 | 313 | 338 | 374 | 394 | 429 | 471 | 500 |
| Web | W2 | 97 | 155 | 216 | 276 | 333 | 379 | 426 | 472 | 517 | 555 | 588 | 615 | 659 | 683 | 715 | 735 | 768 | 793 | 814 |
| | W3 | 93 | 145 | 197 | 249 | 299 | 334 | 378 | 421 | 462 | 501 | 530 | 561 | 607 | 630 | 668 | 693 | 721 | 746 | 766 |
| | Mean | 95 | 150 | 207 | 263 | 316 | 357 | 402 | 447 | 490 | 528 | 559 | 588 | 633 | 657 | 692 | 714 | 745 | 770 | 790 |
| Lower Flange | F6 | 42 | 73 | 107 | 144 | 187 | 228 | 270 | 311 | 353 | 393 | 433 | 467 | 525 | 562 | 615 | 642 | 685 | 718 | 737 |
| | F7 | 44 | 72 | 104 | 139 | 181 | 217 | 258 | 297 | 339 | 379 | 418 | 456 | 513 | 556 | 610 | 636 | 676 | 711 | 725 |
| | Mean | 43 | 73 | 106 | 142 | 184 | 223 | 264 | 304 | 346 | 386 | 426 | 462 | 519 | 559 | 613 | 639 | 681 | 715 | 731 |
| Beam @ 500 mm from End Plate | | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 13 | 17 | 20 | 24 | 29 | 35 | 41 | 48 | 55 | 62 | 69 | 76 | 87 | 97 | 109 | 115 | 126 | 145 | 161 |
| | F4 | 12 | 14 | 16 | 19 | 23 | 27 | 32 | 38 | 43 | 47 | 52 | 58 | 67 | 73 | 83 | 88 | 97 | 107 | 115 |
| | Mean | 13 | 16 | 18 | 22 | 26 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 77 | 85 | 96 | 102 | 112 | 126 | 138 |
| Web | W1 | 13 | 16 | 23 | 32 | 45 | 60 | 73 | 84 | 98 | 115 | 131 | 148 | 175 | 197 | 229 | 246 | 278 | 317 | 347 |
| | W4 | 11 | 15 | 22 | 32 | 45 | 59 | 71 | 81 | 94 | 109 | 124 | 140 | 167 | 187 | 219 | 236 | 267 | 307 | 335 |
| | Mean | 12 | 16 | 23 | 32 | 45 | 60 | 72 | 83 | 96 | 112 | 128 | 144 | 171 | 192 | 224 | 241 | 273 | 312 | 341 |
| Lower Flange | F5 | 10 | 12 | 17 | 24 | 35 | 47 | 61 | 74 | 87 | 103 | 120 | 138 | 169 | 195 | 233 | 254 | 295 | 344 | 383 |
| | F8 | 12 | 14 | 20 | 28 | 38 | 51 | 64 | 77 | 85 | 100 | 115 | 132 | 162 | 186 | 224 | 244 | 283 | 333 | 370 |
| | Mean | 11 | 13 | 19 | 26 | 37 | 49 | 63 | 76 | 86 | 102 | 118 | 135 | 166 | 191 | 229 | 249 | 289 | 339 | 377 |
| Column / End Plate Connection | | | | | | | | | | | | | | | | | | | | |
| Plate / Flange | P1 | 16 | 26 | 40 | 57 | 83 | 107 | 127 | 152 | 181 | 212 | 244 | 276 | 330 | 371 | 428 | 459 | 515 | 574 | 616 |
| | P2 | 17 | 26 | 37 | 52 | 72 | 102 | 117 | 137 | 159 | 183 | 208 | 235 | 280 | 318 | 372 | 402 | 461 | 530 | 573 |
| | Mean | 17 | 26 | 39 | 55 | 78 | 105 | 122 | 145 | 170 | 198 | 226 | 256 | 305 | 345 | 400 | 431 | 488 | 552 | 595 |
| Web | W5 | 13 | 14 | 16 | 20 | 26 | 35 | 45 | 56 | 69 | 84 | 102 | 112 | 134 | 152 | 179 | 195 | 226 | 269 | 303 |
| Column @ 300 mm from Base | | | | | | | | | | | | | | | | | | | | |
| Flanges | F9 | 51 | 97 | 151 | 207 | 276 | 333 | 391 | 448 | 502 | 552 | 595 | 633 | 687 | 721 | 756 | 781 | 823 | 858 | 881 |
| | F10 | 44 | 82 | 131 | 174 | 228 | 278 | 329 | 380 | 436 | 490 | 543 | 590 | 655 | 700 | 742 | 763 | 802 | 838 | 863 |
| | Mean | 48 | 90 | 141 | 191 | 252 | 306 | 360 | 414 | 469 | 521 | 569 | 612 | 671 | 711 | 749 | 772 | 813 | 848 | 872 |
| Web | W6 | 15 | 20 | 31 | 47 | 74 | 100 | 120 | 144 | 167 | 190 | 213 | 236 | 274 | 303 | 347 | 369 | 405 | 448 | 480 |
| Exposed Bolts | | | | | | | | | | | | | | | | | | | | |
| Upper | B1 | 27 | 43 | 63 | 87 | 114 | 135 | 166 | 192 | 220 | 248 | 273 | 299 | 340 | 370 | 411 | 434 | 475 | 520 | 552 |
| | B2 | 29 | 46 | 69 | 94 | 121 | 144 | 170 | 194 | 219 | 246 | 272 | 297 | 340 | 371 | 416 | 439 | 480 | 524 | 555 |
| | Mean | 28 | 45 | 66 | 91 | 118 | 140 | 168 | 193 | 220 | 247 | 273 | 298 | 340 | 371 | 414 | 437 | 478 | 522 | 554 |
| Lower | B3 | 30 | 48 | 72 | 100 | 133 | 163 | 195 | 228 | 263 | 298 | 334 | 368 | 423 | 463 | 517 | 544 | 592 | 643 | 677 |
| | B4 | 29 | 49 | 77 | 109 | 145 | 177 | 211 | 245 | 280 | 315 | 348 | 382 | 435 | 476 | 531 | 559 | 607 | 656 | 689 |
| | Mean | 30 | 49 | 75 | 105 | 139 | 170 | 203 | 237 | 272 | 307 | 341 | 375 | 429 | 470 | 524 | 552 | 600 | 650 | 683 |
| Unexposed Bolts | B5 | 16 | 22 | 34 | 46 | 60 | 74 | 91 | 105 | 124 | 144 | 161 | 176 | 205 | 230 | 262 | 280 | 313 | 354 | 387 |
| | B6 | 16 | 22 | 37 | 51 | 65 | 79 | 98 | 110 | 127 | 147 | 166 | 184 | 211 | 232 | 264 | 281 | 314 | 354 | 386 |
| | Mean | 16 | 22 | 36 | 49 | 63 | 77 | 95 | 108 | 126 | 146 | 164 | 180 | 208 | 231 | 263 | 281 | 314 | 354 | 387 |
| Mean Furnace Gas | | 475 | 537 | 614 | 678 | 701 | 717 | 745 | 763 | 784 | 791 | 799 | 813 | 843 | 858 | 880 | 899 | 909 | 916 | 932 |
| Standard Curve | | 445 | 544 | 603 | 645 | 678 | 705 | 728 | 748 | 766 | 781 | 796 | 809 | 826 | 842 | 860 | 869 | 885 | 902 | 915 |
| Rotation (Radians x $10^{-3}$) | | | | | | | | | | | | | | | | | | | | |
| Transducers | T1 | 0 | 0.3 | 0.2 | 0.5 | 0.9 | 1.1 | 1.4 | 1.7 | 2.1 | 2.3 | 2.9 | 3.4 | * | 6.0 | 7.7 | 9.8 | 19.7 | 35.4 | 41.1 |
| | T2 | -0.5 | -0.1 | 0.6 | 1.0 | 1.4 | 1.6 | 1.9 | 2.1 | 2.4 | 2.6 | 3.0 | 3.2 | * | 5.0 | 7.1 | 10.6 | 18.0 | 57.8 | * |
| | Mean | -0.3 | 0.1 | 0.4 | 0.8 | 1.2 | 1.4 | 1.7 | 1.9 | 2.3 | 2.5 | 3.0 | 3.3 | * | 5.5 | 7.4 | 10.2 | 18.9 | 46.6 | * |

DATA SHEET NUMBER **112C**

## BEAM / COLUMN (MAJOR AXIS) CONNECTION



DATA SHEET NUMBER **113A**

## BEAM / COLUMN (MAJOR AXIS) CONNECTION

### DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 × 203 Column | Nominal<br>Actual | 52 | 206.2 | 203.9 | 8.0 | 12.5 | 510.4 | 173.6 | 568.1 | 263.7 | 5263 | 1770 |
| 305 × 165 Beam | Nominal<br>Actual | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |

### CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Column | Grade 43A | 0.23 | 0.04 | 0.90 | 0.024 | 0.019 | 0.04 | <0.005 | 0.03 | <0.005 | 0.08 | <0.005 | <0.005 | 0.0048 |
| Beam | Grade 43A | 0.23 | 0.03 | 0.87 | 0.008 | 0.026 | <0.02 | <0.005 | <0.02 | <0.005 | <0.02 | <0.005 | <0.005 | 0.0075 |

### ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| Column - Flange | 288 | 501 | 31 |
| Beam - Flange (Actual) | * | * | * |
| Beam - Flange (Mean) | 295 | 467 | 34 |

### TEST CONDITIONS

### NOTES

| | |
|---|---|
| TEST CENTRE | : Warrington Research |
| TEST DATE | : 7th December 1988 |
| TEST NUMBER | : WFRC 44521 |

**ASSESSMENT**

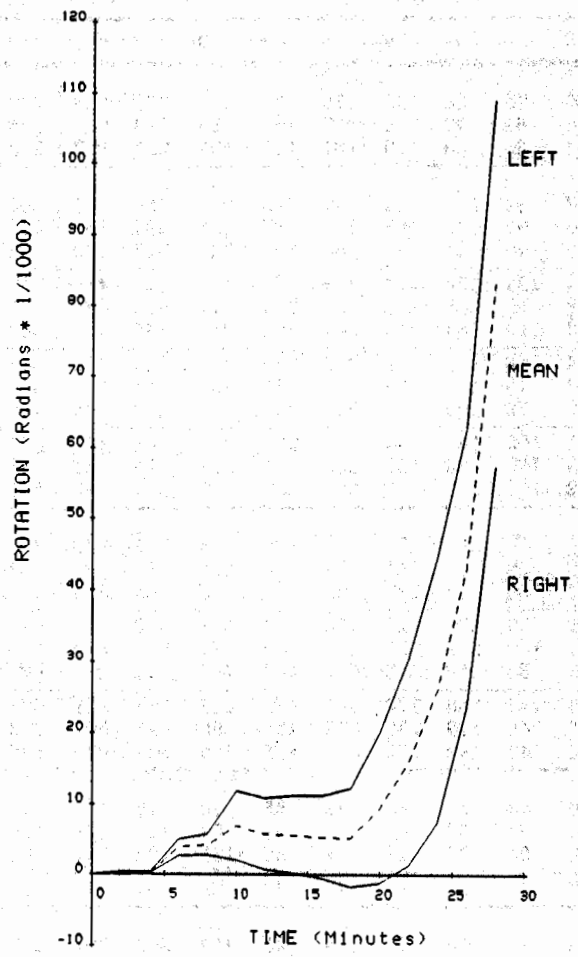
**LOAD BEARING CAPACITY**
**29 minutes at 0.2 $M_p$**

DATA SHEET NUMBER **113B**

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 6 | 8 | 9 | 10 | 12 | 15 | 18 | 21 | 24 | 27 | 28 | 29 |
| Beam @ 25 mm from End Plate | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 60 | 75 | 94 | 135 | 175 | 190 | 207 | 250 | 328 | 400 | 457 | 502 | 531 | 540 | 552 |
| | F3 | 48 | 61 | 77 | 120 | 158 | 167 | 185 | 219 | 285 | 345 | 398 | 444 | 475 | 483 | 487 |
| | Mean | 54 | 68 | 86 | 128 | 167 | 179 | 196 | 235 | 307 | 373 | 428 | 473 | 503 | 512 | 520 |
| Web | | | | | | | | | | | | | | | | |
| 10 mm from UF | W7 | 67 | 88 | 114 | 154 | 197 | 215 | 233 | 268 | 333 | 396 | 449 | 497 | 537 | 551 | 560 |
| 30 mm from UF | W8 | 72 | 95 | 123 | 169 | 216 | 237 | 256 | 293 | 361 | 427 | 482 | 529 | 567 | 579 | 588 |
| 50 mm from UF | W9 | 85 | 110 | 141 | 191 | 240 | 262 | 283 | 319 | 389 | 454 | 509 | 552 | 589 | 602 | 611 |
| Mid Height | W2 | 97 | 123 | 158 | 214 | 269 | 298 | 320 | 374 | 459 | 527 | 578 | 613 | 641 | 653 | 662 |
| | W3 | 89 | 115 | 148 | 205 | 261 | 286 | 311 | 355 | 427 | 491 | 544 | 585 | 613 | 622 | 630 |
| | Mean | 93 | 119 | 153 | 210 | 265 | 292 | 316 | 365 | 443 | 509 | 561 | 599 | 627 | 638 | 646 |
| 50 mm from LF | W10 | 64 | 86 | 115 | 169 | 222 | 250 | 279 | 329 | 402 | 467 | 521 | 565 | 598 | 610 | 622 |
| 30 mm from LF | W11 | 59 | 78 | 104 | 155 | 207 | 236 | 265 | 314 | 387 | 451 | 505 | 551 | 584 | 599 | 610 |
| 10 mm from LF | W12 | 60 | 79 | 105 | 157 | 212 | 241 | 270 | 320 | 394 | 459 | 513 | 559 | 595 | 608 | 619 |
| Lower Flange | F6 | 81 | 105 | 138 | 194 | 252 | 283 | 310 | 366 | 453 | 525 | 585 | 633 | 671 | 683 | 694 |
| | F7 | 83 | 106 | 138 | 198 | 262 | 291 | 324 | 375 | 451 | 516 | 569 | 613 | 648 | 659 | 670 |
| | Mean | 82 | 106 | 138 | 196 | 257 | 287 | 317 | 371 | 452 | 521 | 577 | 623 | 660 | 671 | 682 |
| Beam @ 500 mm from End Plate | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 57 | 73 | 91 | 127 | 166 | 188 | 209 | 254 | 332 | 408 | 476 | 534 | 581 | 596 | 611 |
| | F4 | 46 | 58 | 73 | 118 | 159 | 180 | 201 | 236 | 298 | 363 | 424 | 481 | 528 | 545 | 559 |
| | Mean | 52 | 66 | 82 | 123 | 163 | 184 | 205 | 245 | 315 | 386 | 450 | 508 | 555 | 571 | 585 |
| Web | W1 | 129 | 173 | 226 | 321 | 412 | 453 | 488 | 552 | 631 | 686 | 724 | 743 | 768 | 779 | 789 |
| | W4 | 117 | 160 | 211 | 309 | 401 | 443 | 479 | 529 | 590 | 640 | 681 | 712 | 734 | 738 | 742 |
| | Mean | 123 | 167 | 219 | 315 | 407 | 448 | 484 | 541 | 611 | 663 | 703 | 728 | 751 | 759 | 766 |
| Lower Flange | F5 | 104 | 143 | 190 | 274 | 361 | 405 | 444 | 517 | 611 | 678 | 722 | 743 | 770 | 780 | 790 |
| | F8 | 102 | 140 | 189 | 283 | 378 | 424 | 465 | 525 | 598 | 652 | 692 | 725 | 738 | 747 | 757 |
| | Mean | 103 | 142 | 190 | 279 | 370 | 415 | 455 | 521 | 605 | 665 | 707 | 734 | 754 | 764 | 774 |
| Column / End Plate Connection | | | | | | | | | | | | | | | | |
| Plate / Flange | P1 | 20 | 24 | 32 | 48 | 72 | 85 | 99 | 125 | 165 | 212 | 267 | 330 | 383 | 400 | 417 |
| | P2 | 20 | 24 | 32 | 47 | 71 | 85 | 103 | 123 | 156 | 198 | 245 | 300 | 357 | 376 | 394 |
| | Mean | 20 | 24 | 32 | 48 | 72 | 85 | 101 | 124 | 161 | 205 | 256 | 315 | 370 | 388 | 406 |
| Web | W5 | 12 | 12 | 13 | 14 | 19 | 23 | 28 | 37 | 52 | 74 | 101 | 120 | 141 | 150 | 158 |
| Column @ 300 mm from Base | | | | | | | | | | | | | | | | |
| Flanges | F9 | 56 | 74 | 100 | 149 | 199 | 227 | 253 | 305 | 392 | 475 | 547 | 608 | 658 | 673 | 687 |
| | F10 | 58 | 80 | 112 | 177 | 245 | 278 | 310 | 372 | 458 | 531 | 587 | 639 | 680 | 691 | 702 |
| | Mean | 57 | 77 | 106 | 163 | 222 | 253 | 282 | 339 | 425 | 503 | 567 | 624 | 669 | 682 | 695 |
| Web | W6 | 14 | 15 | 20 | 30 | 47 | 59 | 72 | 103 | 132 | 163 | 195 | 228 | 260 | 272 | 285 |
| Exposed Bolts | | | | | | | | | | | | | | | | |
| Upper | B1 | 37 | 46 | 57 | 86 | 118 | 133 | 148 | 180 | 232 | 281 | 327 | 362 | 403 | 417 | 430 |
| | B2 | 34 | 42 | 53 | 76 | 103 | 117 | 129 | 158 | 204 | 249 | 292 | 332 | 370 | 383 | 395 |
| | Mean | 36 | 44 | 55 | 81 | 111 | 125 | 139 | 169 | 218 | 265 | 310 | 347 | 387 | 400 | 413 |
| Lower | B3 | 40 | 48 | 59 | 87 | 120 | 135 | 151 | 185 | 238 | 293 | 346 | 399 | 448 | 465 | 481 |
| | B4 | 32 | 41 | 52 | 80 | 117 | 138 | 156 | 192 | 245 | 300 | 352 | 398 | 441 | 456 | 470 |
| | Mean | 36 | 45 | 56 | 84 | 119 | 137 | 154 | 189 | 242 | 297 | 349 | 399 | 445 | 461 | 476 |
| Mean Furnace Gas | | 481 | 518 | 584 | 617 | 664 | 685 | 695 | 707 | 731 | 769 | 784 | 805 | 824 | 831 | 834 |
| Standard Curve | | 445 | 502 | 544 | 603 | 645 | 663 | 678 | 705 | 739 | 766 | 789 | 809 | 826 | 832 | 837 |
| Rotation (Radians × $10^{-3}$) | | | | | | | | | | | | | | | | |
| Transducers | T1 | 0.3 | * | 0.3 | 5.1 | 5.8 | * | 11.9 | 10.8 | * | 12.2 | * | 44.7 | * | 109.3 | * |
| | T2 | 0.3 | * | 0.2 | 2.7 | 2.8 | * | 2.0 | 0.7 | * | -1.7 | * | 7.5 | * | 57.5 | * |
| | Mean | 0.3 | * | 0.3 | 3.9 | 4.3 | * | 7.0 | 5.8 | * | 5.25 | * | 26.1 | * | 83.4 | * |

DATA SHEET NUMBER **113C**

## BEAM/COLUMN (MAJOR AXIS) CONNECTION



DATA SHEET NUMBER **114A**

## BEAM / COLUMN (MAJOR AXIS) CONNECTION

### DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 × 203 Column | Nominal Actual | 52 | 206.2 | 203.9 | 8.0 | 12.5 | 510.4 | 173.6 | 568.1 | 263.7 | 5263 | 1770 |
| 305 × 165 Beam | Nominal Actual | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |

### CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Column | Grade 43A | 0.23 | 0.04 | 0.90 | 0.024 | 0.019 | 0.04 | <0.005 | 0.03 | <0.005 | 0.08 | <0.005 | <0.005 | 0.0048 |
| Beam | Grade 43A | 0.23 | 0.03 | 0.85 | 0.008 | 0.024 | <0.02 | <0.005 | <0.02 | <0.005 | <0.02 | <0.005 | <0.005 | 0.0072 |

### ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| Column - Flange | 288 | 501 | 31 |
| Beam - Flange (Actual) | 291 | 457 | 33 |
| Beam - Flange (Mean) | 295 | 467 | 34 |

### TEST CONDITIONS

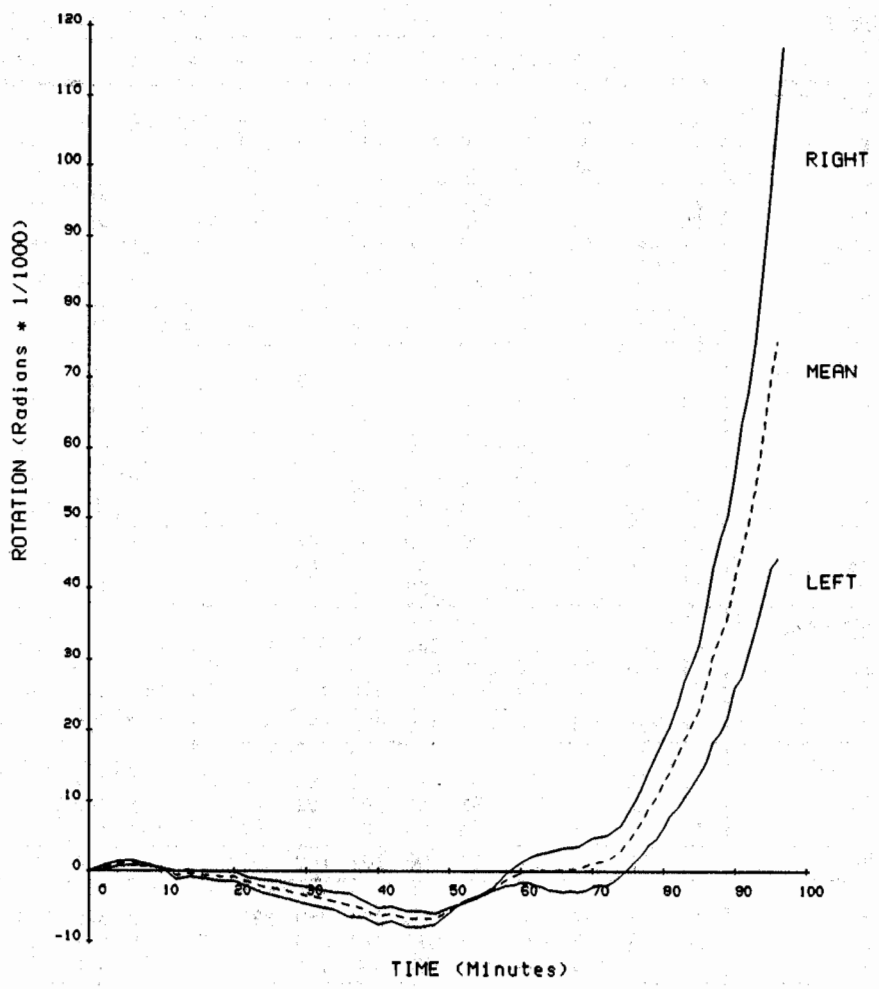
### NOTES

| | | |
|---|---|---|
| TEST CENTRE : Warrington Research<br>TEST DATE : 25th January 1989<br>TEST NUMBER : WFRC 44992 | ASSESSMENT<br>LOAD BEARING CAPACITY<br>97 minutes at 0.2 $M_p$ | DATA SHEET NUMBER **114B** |

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 35 | 40 | 50 | 60 | 70 | 80 | 90 | 97 |
| Beam @ 25 mm from End Plate | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 18 | 31 | 49 | 72 | 97 | 116 | 140 | 167 | 189 | 210 | 236 | 266 | 327 | 377 | 430 | 478 | 521 | 551 |
| | F3 | 15 | 30 | 49 | 73 | 99 | 120 | 142 | 164 | 186 | 209 | 245 | 280 | 345 | 397 | 448 | 498 | 548 | 589 |
| | Mean | 17 | 31 | 49 | 73 | 98 | 118 | 141 | 166 | 188 | 210 | 241 | 273 | 336 | 387 | 439 | 488 | 535 | 570 |
| Web | W2 | 21 | 47 | 79 | 119 | 170 | 211 | 256 | 298 | 336 | 374 | 430 | 480 | 563 | 617 | 669 | 724 | 781 | 820 |
| | W3 | 20 | 47 | 81 | 125 | 175 | 217 | 261 | 303 | 343 | 381 | 439 | 492 | 580 | 635 | 684 | 739 | 795 | 834 |
| | Mean | 21 | 47 | 80 | 122 | 173 | 214 | 259 | 301 | 340 | 378 | 435 | 486 | 572 | 626 | 677 | 732 | 788 | 827 |
| Lower Flange | F6 | 18 | 37 | 60 | 87 | 125 | 160 | 198 | 235 | 269 | 304 | 358 | 410 | 501 | 571 | 635 | 693 | 741 | 777 |
| | F7 | 18 | 34 | 57 | 85 | 121 | 155 | 192 | 228 | 262 | 296 | 349 | 401 | 493 | 564 | 626 | 685 | 733 | 769 |
| | Mean | 18 | 36 | 59 | 86 | 123 | 158 | 195 | 232 | 266 | 300 | 354 | 406 | 497 | 568 | 631 | 689 | 737 | 773 |
| Beam @ 500 mm from End Plate | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 12 | 13 | 15 | 17 | 21 | 24 | 30 | 36 | 41 | 46 | 55 | 66 | 83 | 98 | 117 | 137 | 159 | 178 |
| | F4 | 13 | 13 | 14 | 16 | 19 | 22 | 27 | 32 | 37 | 42 | 51 | 60 | 80 | 94 | 109 | 127 | 146 | 162 |
| | Mean | 13 | 13 | 15 | 17 | 20 | 23 | 29 | 34 | 39. | 44 | 53 | 63 | 82 | 96 | 113 | 132 | 153 | 170 |
| Web | W1 | 8 | 10 | 15 | 21 | 32 | 41 | 54 | 66 | 76 | 85 | 111 | 140 | 193 | 238 | 282 | 333 | 384 | 420 |
| | W4 | 11 | 13 | 19 | 25 | 35 | 46 | 60 | 73 | 81 | 90 | 115 | 141 | 193 | 238 | 285 | 336 | 387 | 423 |
| | Mean | 10 | 12 | 17 | 23 | 34 | 44 | 57 | 70 | 79 | 88 | 113 | 141 | 193 | 238 | 284 | 335 | 386 | 422 |
| Lower Flange | F5 | 12 | 14 | 16 | 21 | 29 | 39 | 51 | 65 | 78 | 89 | 116 | 148 | 211 | 272 | 334 | 399 | 463 | 507 |
| | F8 | 8 | 8 | 13 | 18 | 27 | 37 | 51 | 65 | 77 | 92 | 119 | 149 | 211 | 272 | 333 | 399 | 464 | 508 |
| | Mean | 10 | 11 | 15 | 20 | 28 | 38 | 51 | 65 | 78 | 91 | 118 | 149 | 211 | 272 | 334 | 399 | 464 | 508 |
| Column / End Plate Connection | | | | | | | | | | | | | | | | | | | |
| Plate / Flange | P1 | 55 | 107 | 166 | 231 | 299 | 350 | 400 | 445 | 485 | 522 | 580 | 631 | 708 | 747 | 820 | 884 | 931 | 960 |
| | P2 | 59 | 115 | 173 | 235 | 300 | 352 | 404 | 449 | 491 | 528 | 587 | 639 | 719 | 760 | 830 | 891 | 938 | 966 |
| | Mean | 57 | 111 | 170 | 233 | 300 | 351 | 402 | 447 | 488 | 525 | 584 | 635 | 714 | 754 | 825 | 888 | 935 | 963 |
| Web | W5 | 117 | 206 | 299 | 390 | 463 | 509 | 550 | 587 | 620 | 650 | 694 | 732 | 781 | 814 | 878 | 923 | 962 | 984 |
| Column @ 300 mm from Base | | | | | | | | | | | | | | | | | | | |
| Flanges | F9 | 11 | 11 | 14 | 27 | 57 | 92 | 98 | 98 | 104 | 114 | 141 | 177 | 258 | 344 | 423 | 497 | 564 | 605 |
| | F10 | 9 | 10 | 12 | 22 | 51 | 88 | 99 | 99 | 103 | 110 | 133 | 165 | 248 | 337 | 420 | 498 | 566 | 610 |
| | Mean | 10 | 11 | 13 | 25 | 54 | 90 | 99 | 99 | 104 | 112 | 137 | 171 | 253 | 341 | 422 | 498 | 565 | 608 |
| Web | W6 | 12 | 13 | 18 | 32 | 70 | 99 | 102 | 102 | 108 | 118 | 141 | 175 | 259 | 349 | 432 | 508 | 574 | 616 |
| Exposed Bolts | | | | | | | | | | | | | | | | | | | |
| Upper | B1 | 49 | 90 | 136 | 184 | 234 | 276 | 320 | 359 | 395 | 428 | 482 | 530 | 608 | 660 | 717 | 772 | 834 | 875 |
| | B2 | 50 | 88 | 142 | 196 | 246 | 282 | 319 | 356 | 391 | 425 | 475 | 521 | 595 | 642 | 704 | 754 | 813 | 850 |
| | Mean | 50 | 89 | 139 | 190 | 240 | 279 | 320 | 358 | 393 | 427 | 479 | 526 | 602 | 651 | 711 | 763 | 824 | 863 |
| Lower | B3 | 40 | 75 | 120 | 173 | 229 | 277 | 330 | 378 | 421 | 463 | 523 | 577 | 663 | 713 | 768 | 838 | 897 | 930 |
| | B4 | 38 | 72 | 123 | 181 | 238 | 281 | 326 | 370 | 413 | 453 | 513 | 567 | 652 | 701 | 753 | 820 | 882 | 915 |
| | Mean | 39 | 74 | 122 | 177 | 234 | 279 | 328 | 374 | 417 | 458 | 518 | 572 | 658 | 707 | 761 | 829 | 890 | 923 |
| Unexposed Bolts | B5 | 16 | 31 | 49 | 71 | 99 | 108 | 128 | 146 | 169 | 193 | 232 | 267 | 333 | 394 | 445 | 502 | 565 | 630 |
| | B6 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | Mean | 16 | 31 | 49 | 71 | 99 | 108 | 128 | 146 | 169 | 193 | 232 | 267 | 333 | 394 | 445 | 502 | 565 | 630 |
| Mean Furnace Gas | | 504 | 601 | 663 | 699 | 726 | 741 | 757 | 773 | 786 | 802 | 824 | 847 | 851 | 895 | 945 | 977 | 1006 | 1023 |
| Standard Curve | | 502 | 603 | 663 | 705 | 739 | 766 | 789 | 809 | 826 | 842 | 865 | 885 | 918 | 945 | 968 | 988 | 1006 | 1017 |
| Rotation (Radians × $10^{-3}$) | | | | | | | | | | | | | | | | | | | |
| Transducers | T1 | * | 0.8 | * | 0.0 | * | -0.1 | * | -1.3 | * | -2.3 | * | -5.3 | -5.3 | -1.6 | -2.3 | 6.1 | 26.1 | * |
| | T2 | * | 1.6 | * | -1.2 | * | -1.4 | * | -3.2 | * | -4.8 | * | -7.5 | -6.0 | 1.2 | 4.8 | 18.7 | 56.3 | 117 |
| | Mean | * | 1.2 | * | -0.6 | * | -0.8 | * | -2.3 | * | -3.6 | * | -6.4 | -5.7 | -0.2 | 1.3 | 12.4 | 41.2 | * |

DATA SHEET NUMBER **114C**

## BEAM / COLUMN (MAJOR AXIS) CONNECTION



DATA SHEET NUMBER **115A**

**BEAM / COLUMN (MAJOR AXIS) CONNECTION**

DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 × 203 Column | Nominal | 52 | 206.2 | 203.9 | 8.0 | 12.5 | 510.4 | 173.6 | 568.1 | 263.7 | 5263 | 1770 |
| | Actual | | | | | | | | | | | |
| 305 × 165 Beam | Nominal | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |
| | Actual | | | | | | | | | | | |

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Column | Grade 43A | 0.23 | 0.04 | 0.90 | 0.024 | 0.019 | 0.04 | <0.005 | 0.03 | <0.005 | 0.08 | <0.005 | <0.005 | 0.0048 |
| Beam | Grade 43A | 0.23 | 0.03 | 0.87 | 0.008 | 0.026 | <0.02 | <0.005 | <0.02 | <0.005 | <0.02 | <0.005 | <0.005 | 0.0075 |

ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| Column - Flange | 288 | 501 | 31 |
| Beam - Flange (Actual) | * | * | * |
| Beam - Flange (Mean) | 295 | 467 | 34 |

TEST CONDITIONS

NOTES

TEST CENTRE : Warrington Research
TEST DATE : 7th December 1988
TEST NUMBER : WFRC 44521

ASSESSMENT

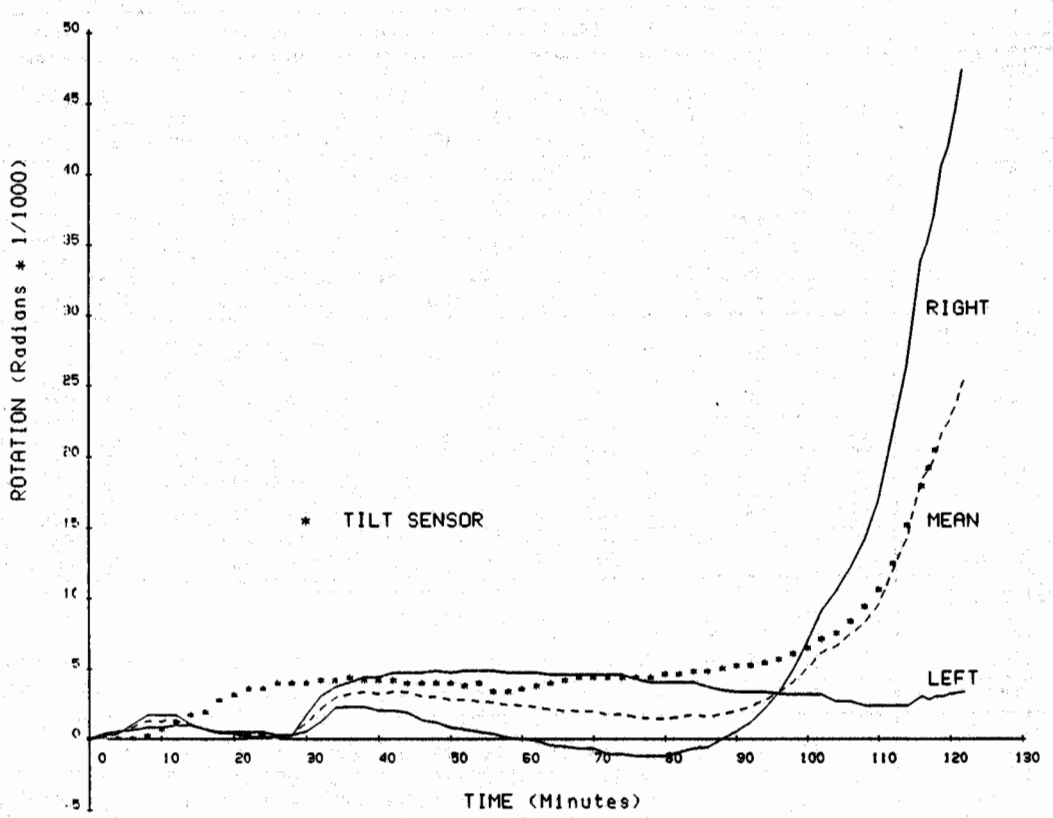
LOAD BEARING CAPACITY
122 minutes at 0.2 $M_p$

DATA SHEET NUMBER **115B**

| 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 | 122 |
| Beam @ 25 mm from End Plate | | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 14 | 20 | 30 | 40 | 52 | 67 | 83 | 93 | 99 | 100 | 117 | 156 | 210 | 266 | 313 | 354 | 392 | 432 | 479 |
| | F3 | 17 | 25 | 35 | 47 | 61 | 77 | 91 | 104 | 107 | 109 | 149 | 192 | 247 | 300 | 346 | 387 | 430 | 472 | 519 |
| | Mean | 16 | 23 | 33 | 44 | 57 | 72 | 87 | 99 | 103 | 105 | 133 | 174 | 229 | 283 | 330 | 371 | 411 | 452 | 499 |
| Web | W2 | 14 | 20 | 35 | 52 | 71 | 94 | 103 | 105 | 104 | 105 | 142 | 212 | 282 | 349 | 409 | 464 | 512 | 554 | 602 |
| | W3 | 13 | 18 | 33 | 50 | 77 | 99 | 103 | 103 | 103 | 105 | 145 | 217 | 287 | 355 | 414 | 469 | 517 | 561 | 608 |
| | Mean | 14 | 19 | 34 | 51 | 74 | 97 | 103 | 104 | 104 | 105 | 144 | 215 | 285 | 352 | 412 | 467 | 515 | 558 | 605 |
| Lower Flange | F6 | 17 | 28 | 45 | 62 | 80 | 99 | 105 | 110 | 119 | 132 | 195 | 267 | 343 | 417 | 483 | 542 | 593 | 637 | 685 |
| | F7 | 17 | 31 | 49 | 66 | 84 | 98 | 107 | 119 | 133 | 151 | 218 | 294 | 371 | 445 | 509 | 566 | 616 | 662 | 710 |
| | Mean | 17 | 30 | 47 | 64 | 82 | 99 | 106 | 115 | 126 | 142 | 207 | 281 | 357 | 431 | 496 | 554 | 605 | 650 | 698 |
| Beam @ 500 mm from End Plate | | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 15 | 24 | 34 | 43 | 53 | 64 | 76 | 88 | 96 | 102 | 118 | 148 | 184 | 221 | 257 | 291 | 324 | 355 | 391 |
| | F4 | 16 | 27 | 37 | 47 | 60 | 76 | 90 | 99 | 106 | 111 | 135 | 167 | 209 | 252 | 292 | 329 | 363 | 396 | 434 |
| | Mean | 16 | 26 | 36 | 45 | 57 | 70 | 83 | 94 | 101 | 107 | 127 | 158 | 197 | 237 | 275 | 310 | 344 | 376 | 413 |
| Web | W1 | 16 | 37 | 69 | 92 | 103 | 107 | 110 | 117 | 137 | 163 | 257 | 340 | 415 | 484 | 544 | 596 | 639 | 678 | 718 |
| | W4 | 18 | 43 | 73 | 95 | 103 | 109 | 119 | 146 | 178 | 210 | 304 | 386 | 458 | 525 | 582 | 631 | 673 | 711 | 742 |
| | Mean | 17 | 40 | 71 | 94 | 103 | 108 | 115 | 132 | 158 | 187 | 281 | 363 | 437 | 505 | 563 | 614 | 656 | 695 | 730 |
| Lower Flange | F5 | 17 | 35 | 58 | 78 | 97 | 104 | 104 | 115 | 133 | 155 | 236 | 331 | 427 | 510 | 580 | 639 | 688 | 728 | 755 |
| | F8 | 18 | 40 | 67 | 89 | 102 | 106 | 119 | 145 | 172 | 200 | 296 | 394 | 484 | 564 | 630 | 685 | 729 | 753 | 796 |
| | Mean | 18 | 38 | 63 | 84 | 100 | 105 | 112 | 130 | 153 | 178 | 266 | 363 | 456 | 537 | 605 | 662 | 709 | 741 | 776 |
| Column / End Plate Connection | | | | | | | | | | | | | | | | | | | | |
| Plate / Flange | P1 | 18 | 30 | 48 | 66 | 85 | 102 | 115 | 127 | 141 | * | * | * | * | * | * | * | * | * | * |
| | P2 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | Mean | 18 | 30 | 48 | 66 | 85 | 102 | 115 | 127 | 141 | * | * | * | * | * | * | * | * | * | * |
| Web | W5 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Column @ 300 mm from Base | | | | | | | | | | | | | | | | | | | | |
| Flanges | F9 | 16 | 37 | 61 | 83 | 100 | 108 | 128 | 154 | 177 | 205 | 293 | 381 | * | * | * | * | * | * | * |
| | F10 | 17 | 39 | 63 | 85 | 102 | 111 | 134 | 161 | 185 | 210 | 304 | 395 | 477 | 550 | 611 | 664 | 709 | 740 | 771 |
| | Mean | 17 | 38 | 62 | 84 | 101 | 110 | 131 | 158 | 181 | 208 | 299 | 388 | 477 | 550 | 611 | 664 | 709 | 740 | 771 |
| Web | W6 | 16 | 34 | 61 | 85 | 102 | 108 | 114 | 136 | 162 | 192 | 294 | 388 | 472 | 546 | 608 | 661 | 705 | 741 | 773 |
| Exposed Bolts | | | | | | | | | | | | | | | | | | | | |
| Upper | B1 | 17 | 26 | 38 | 49 | 64 | 80 | 94 | 106 | 113 | * | 156 | 198 | 249 | 304 | 356 | 403 | 447 | 491 | * |
| | B2 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | Mean | 17 | 26 | 38 | 49 | 64 | 80 | 94 | 106 | 113 | * | 156 | 198 | 249 | 304 | 356 | 403 | 447 | 491 | * |
| Lower | B3 | 19 | 24 | 37 | 53 | 70 | 91 | 106 | * | * | * | 188 | 254 | 321 | 387 | 448 | 507 | 561 | 613 | * |
| | B4 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | Mean | 19 | 24 | 37 | 53 | 70 | 91 | 106 | * | * | * | 188 | 254 | 321 | 387 | 448 | 507 | 561 | 613 | * |
| Mean Furnace Gas | | 518 | 617 | 685 | 707 | 731 | 769 | 784 | 805 | 824 | 848 | 890 | 934 | 970 | 996 | 1007 | 1025 | 1040 | 1061 | 1082 |
| Standard Curve | | 502 | 603 | 663 | 705 | 739 | 766 | 789 | 809 | 826 | 842 | 885 | 918 | 945 | 968 | 988 | 1006 | 1022 | 1036 | 1052 |
| Rotation (Radians x $10^{-3}$) | | | | | | | | | | | | | | | | | | | | |
| Transducers | T1 | * | 1.0 | * | 1.7 | * | 0.3 | * | 0.1 | * | 1.7 | 4.4 | 4.7 | 4.7 | 4.6 | 4.1 | 3.4 | 3.2 | 2.4 | 3.4 |
| | T2 | * | 0.6 | * | 0.9 | * | 0.5 | * | 0.5 | * | 0.5 | 2.0 | 0.8 | 0.0 | -0.7 | -1.2 | 0.5 | 7.0 | 16.9 | 47.4 |
| | Mean | * | 0.8 | * | 1.3 | * | 0.4 | * | 0.3 | * | 1.1 | 3.2 | 2.8 | 2.4 | 2.0 | 1.5 | 2.0 | 5.1 | 9.7 | 25.4 |
| Tilt Sensor | | * | 0 | * | 1.0 | * | 2.7 | * | 3.6 | * | 4.0 | 4.2 | 4.0 | 3.6 | 4.4 | 4.6 | 5.2 | 6.5 | 10.7 | * |

DATA SHEET NUMBER **115C**

**BEAM / COLUMN (MAJOR AXIS) CONNECTION**



DATA SHEET NUMBER **116A**

**BEAM / COLUMN (MAJOR AXIS) CONNECTION**

DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 × 203 Column | Nominal<br>Actual | 52 | 206.2 | 203.9 | 8.0 | 12.5 | 510.4 | 173.6 | 568.1 | 263.7 | 5263 | 1770 |
| 305 × 165 Beam | Nominal<br>Actual | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Column | Grade 43A | 0.23 | 0.04 | 0.90 | 0.024 | 0.019 | 0.04 | <0.005 | 0.03 | <0.005 | 0.08 | <0.005 | <0.005 | 0.0048 |
| Beam | Grade 43A | 0.23 | 0.03 | 0.89 | 0.008 | 0.026 | <0.02 | <0.005 | <0.02 | <0.005 | <0.02 | <0.005 | <0.005 | 0.0076 |

ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| Column - Flange | 288 | 501 | 31 |
| Beam - Flange (Actual) | * | * | * |
| Beam - Flange (Mean) | 295 | 467 | 34 |

TEST CONDITIONS

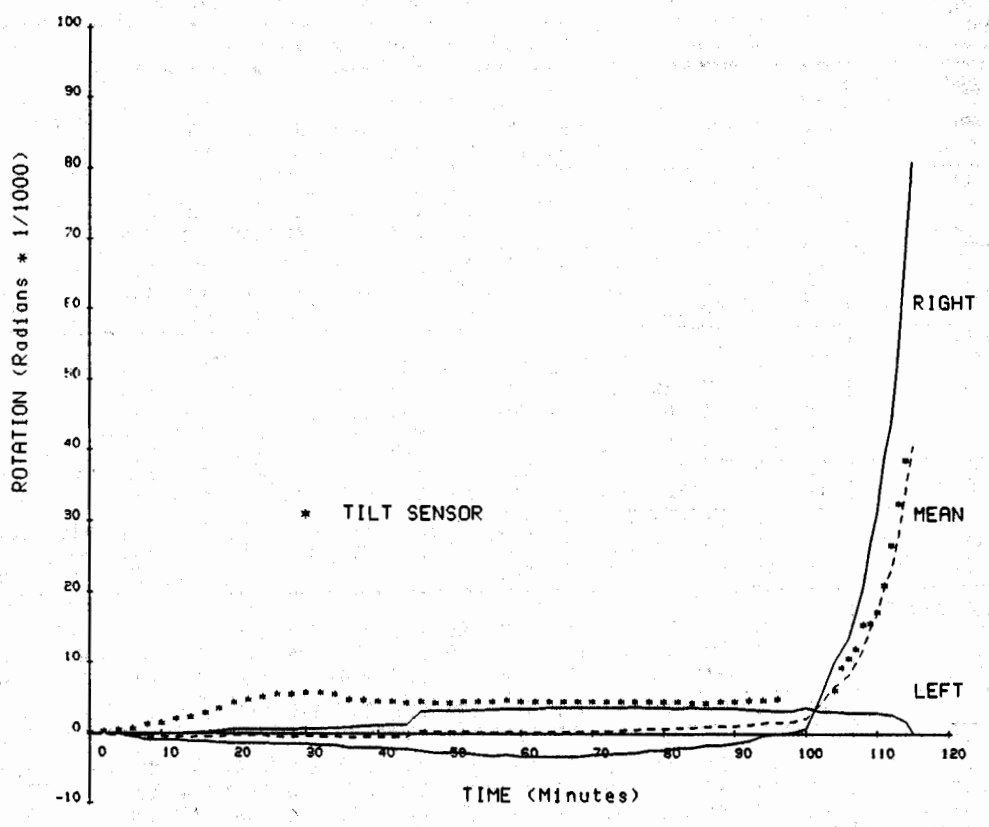
NOTES

| | | |
|---|---|---|
| TEST CENTRE : Warrington Research<br>TEST DATE : 11th January 1989<br>TEST NUMBER : WFRC 44519 | ASSESSMENT<br>LOAD BEARING CAPACITY<br>115 minutes at 0.1 $M_p$ | DATA SHEET NUMBER **116B** |

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 6 | 12 | 18 | 24 | 28 | 30 | 36 | 40 | 46 | 50 | 56 | 60 | 70 | 80 | 90 | 100 | 110 | 115 |
| Beam @ 25 mm from End | | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 10 | 27 | 54 | 83 | 106 | 118 | 125 | 143 | 156 | 185 | 206 | 240 | 262 | 313 | 357 | 398 | 436 | 474 | 491 |
| | F3 | 9 | 16 | 43 | 76 | 97 | 99 | 100 | 110 | 130 | 160 | 182 | 216 | 239 | 290 | 337 | 381 | 421 | 473 | 505 |
| | Mean | 10 | 22 | 49 | 80 | 102 | 109 | 113 | 127 | 143 | 173 | 194 | 228 | 251 | 302 | 347 | 390 | 429 | 474 | 498 |
| Web | W2 | 11 | 17 | 50 | 86 | 102 | 105 | 109 | 142 | 172 | 217 | 245 | 287 | 314 | 379 | 439 | 493 | 542 | 586 | 606 |
| | W3 | 10 | 15 | 48 | 84 | 100 | 102 | 102 | 123 | 157 | 212 | 245 | 292 | 323 | 393 | 457 | 515 | 566 | 612 | 633 |
| | Mean | 11 | 16 | 49 | 85 | 101 | 104 | 106 | 133 | 165 | 215 | 245 | 290 | 319 | 386 | 448 | 504 | 554 | 599 | 620 |
| Lower Flange | F6 | 10 | 31 | 73 | 106 | 132 | 158 | 173 | 222 | 256 | 310 | 345 | 396 | 428 | 500 | 563 | 621 | 672 | 719 | 737 |
| | F7 | 10 | 21 | 65 | 97 | 110 | 133 | 146 | 194 | 227 | 280 | 316 | 369 | 403 | 481 | 549 | 609 | 662 | 706 | 724 |
| | Mean | 10 | 26 | 69 | 102 | 121 | 146 | 160 | 208 | 242 | 295 | 331 | 383 | 416 | 491 | 556 | 615 | 667 | 713 | 731 |
| Beam @ 500 mm from End | | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 9 | 26 | 45 | 65 | 87 | 96 | 100 | 120 | 140 | 166 | 181 | 204 | 220 | 258 | 294 | 330 | 362 | 393 | 407 |
| | F4 | 9 | 17 | 37 | 59 | 80 | 91 | 94 | 101 | 108 | 128 | 142 | 164 | 180 | 220 | 259 | 296 | 331 | 362 | 377 |
| | Mean | 9 | 22 | 41 | 62 | 84 | 94 | 97 | 111 | 124 | 147 | 162 | 184 | 200 | 239 | 277 | 313 | 347 | 378 | 392 |
| Web | W1 | 11 | 38 | 96 | 112 | 153 | 194 | 216 | 277 | 315 | 367 | 399 | 443 | 472 | 534 | 587 | 634 | 675 | 707 | 720 |
| | W4 | 10 | 45 | 94 | 134 | 166 | 202 | 221 | 281 | 319 | 372 | 405 | 451 | 480 | 543 | 598 | 646 | 687 | 722 | 737 |
| | Mean | 11 | 42 | 95 | 123 | 160 | 198 | 219 | 279 | 317 | 370 | 402 | 447 | 476 | 539 | 593 | 640 | 681 | 715 | 729 |
| Lower Flange | F5 | 11 | 35 | 87 | 108 | 153 | 191 | 210 | 272 | 314 | 377 | 416 | 470 | 504 | 578 | 639 | 691 | 733 | 755 | 770 |
| | F8 | 10 | 32 | 83 | 104 | 139 | 177 | 195 | 251 | 292 | 352 | 390 | 444 | 479 | 556 | 620 | 674 | 721 | 746 | 760 |
| | Mean | 11 | 34 | 85 | 106 | 146 | 184 | 203 | 262 | 303 | 365 | 403 | 457 | 492 | 567 | 630 | 683 | 727 | 751 | 765 |
| Column / Web Cleat Connection | | | | | | | | | | | | | | | | | | | | |
| Cleat / Flange | C1 | 12 | 30 | 64 | 97 | 127 | 147 | 157 | 190 | 215 | 252 | 277 | 316 | 342 | 404 | 461 | 516 | 564 | 608 | 628 |
| | C2 | 14 | 33 | 70 | 105 | 137 | 161 | 173 | 212 | 239 | 279 | 306 | 347 | 375 | 440 | 501 | 559 | 608 | 653 | 674 |
| | Mean | 13 | 32 | 67 | 101 | 132 | 154 | 165 | 201 | 227 | 266 | 292 | 332 | 359 | 422 | 481 | 538 | 586 | 631 | 651 |
| Web | W5 | 10 | 34 | 80 | 100 | 136 | 166 | 180 | 223 | 251 | 293 | 320 | 361 | 389 | 452 | 512 | 567 | 618 | 661 | 681 |
| Column @ 300 mm from Base | | | | | | | | | | | | | | | | | | | | |
| Flanges | F9 | 10 | 38 | 94 | 124 | 180 | 221 | 243 | 310 | 353 | 416 | 453 | 507 | 540 | 612 | 672 | 723 | 755 | 785 | 803 |
| | F10 | 11 | 34 | 87 | 106 | 152 | 195 | 218 | 287 | 333 | 397 | 436 | 490 | 524 | 598 | 659 | 710 | 745 | 772 | 791 |
| | Mean | 11 | 36 | 91 | 115 | 166 | 208 | 231 | 299 | 343 | 407 | 445 | 499 | 532 | 605 | 666 | 717 | 750 | 779 | 797 |
| Web | W6 | 13 | 33 | 86 | 104 | 140 | 190 | 215 | 286 | 332 | 397 | 435 | 490 | 523 | 596 | 655 | 706 | 743 | 769 | 786 |
| Exposed Bolts | | | | | | | | | | | | | | | | | | | | |
| Upper | B1 | 12 | 26 | 58 | 87 | 108 | 118 | 127 | 155 | 175 | 208 | 231 | 267 | 292 | 351 | 407 | 461 | 511 | 555 | 575 |
| | B2 | 11 | 26 | 63 | 95 | 115 | 133 | 142 | 175 | 197 | 233 | 258 | 298 | 324 | 386 | 445 | 504 | 557 | 607 | 634 |
| | Mean | 12 | 26 | 61 | 91 | 112 | 126 | 135 | 165 | 186 | 221 | 245 | 283 | 308 | 369 | 426 | 483 | 534 | 581 | 605 |
| Lower | B3 | 13 | 22 | 57 | 93 | 112 | 122 | 133 | 174 | 204 | 252 | 284 | 330 | 362 | 433 | 498 | 556 | 607 | 650 | 670 |
| | B4 | 12 | 26 | 64 | 97 | 121 | 138 | 149 | 193 | 224 | 273 | 305 | 354 | 385 | 457 | 523 | 582 | 633 | 675 | 694 |
| | Mean | 13 | 24 | 61 | 95 | 117 | 130 | 141 | 184 | 214 | 263 | 295 | 342 | 374 | 445 | 511 | 569 | 620 | 663 | 682 |
| Web Cleat | B5 | 10 | 19 | 47 | 80 | 101 | 108 | 111 | 131 | 152 | 192 | 218 | 258 | 285 | 347 | 404 | 457 | 506 | 551 | 575 |
| | B6 | 10 | 15 | 43 | 82 | 100 | 103 | 108 | 135 | 162 | 211 | 242 | 291 | 323 | 396 | 462 | 521 | 573 | 618 | 639 |
| Mean Furnace Gas | | 471 | 609 | 723 | 777 | 818 | 842 | 855 | 881 | 904 | 926 | 941 | 964 | 970 | 998 | 1017 | 1045 | 1043 | 1059 | 1061 |
| Standard Curve | | 445 | 603 | 705 | 766 | 809 | 832 | 842 | 869 | 885 | 906 | 918 | 935 | 945 | 968 | 988 | 1006 | 1022 | 1036 | 1043 |
| Rotation (Radians x $10^{-3}$) | | | | | | | | | | | | | | | | | | | | |
| Transducers | T1 | -0.2 | -0.4 | 0.0 | 0.3 | 0.6 | 0.6 | 0.7 | 0.9 | 1.2 | 3.1 | 3.2 | 3.4 | 3.5 | 3.7 | 3.7 | 3.6 | 3.7 | 2.9 | 0.0 |
| | T2 | 0.0 | -0.5 | -0.9 | -1.3 | -1.4 | -1.5 | -1.5 | -2.0 | -2.0 | -2.5 | -2.7 | -3.2 | -3.3 | -3.0 | -2.4 | -1.4 | 0.7 | 31.1 | 81.1 |
| | Mean | -0.1 | -0.5 | -0.5 | -0.5 | -0.4 | -0.5 | -0.4 | -0.6 | -0.4 | 0.3 | 0.3 | 0.1 | 0.1 | 0.4 | 0.7 | 1.1 | 2.2 | 17.0 | 40.6 |
| Tilt Sensor | | 0.2 | 0.6 | 2.0 | 3.5 | 5.1 | 5.5 | 5.7 | 4.7 | 4.5 | 4.5 | 4.3 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | * | 17.3 | * |

DATA SHEET NUMBER **116C**

## BEAM / COLUMN (MAJOR AXIS) CONNECTION



DATA SHEET NUMBER **117A**

## BEAM / COLUMN (MAJOR AXIS) CONNECTION

### DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 × 203 Column | Nominal<br>Actual | 52 | 206.2 | 203.9 | 8.0 | 12.5 | 510.4 | 173.6 | 568.1 | 263.7 | 5263 | 1770 |
| 305 × 165 Beam | Nominal<br>Actual | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |

### CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Column | Grade 43A | 0.23 | 0.04 | 0.90 | 0.024 | 0.019 | 0.04 | <0.005 | 0.03 | <0.005 | 0.08 | <0.005 | <0.005 | 0.0048 |
| Beam | Grade 43A | 0.23 | 0.03 | 0.87 | 0.008 | 0.026 | <0.02 | <0.005 | <0.02 | <0.005 | <0.02 | <0.005 | <0.005 | 0.0075 |

### ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| Column - Flange | 288 | 501 | 31 |
| Beam - Flange (Actual) | * | * | * |
| Beam - Flange (Mean) | 295 | 467 | 34 |

### TEST CONDITIONS

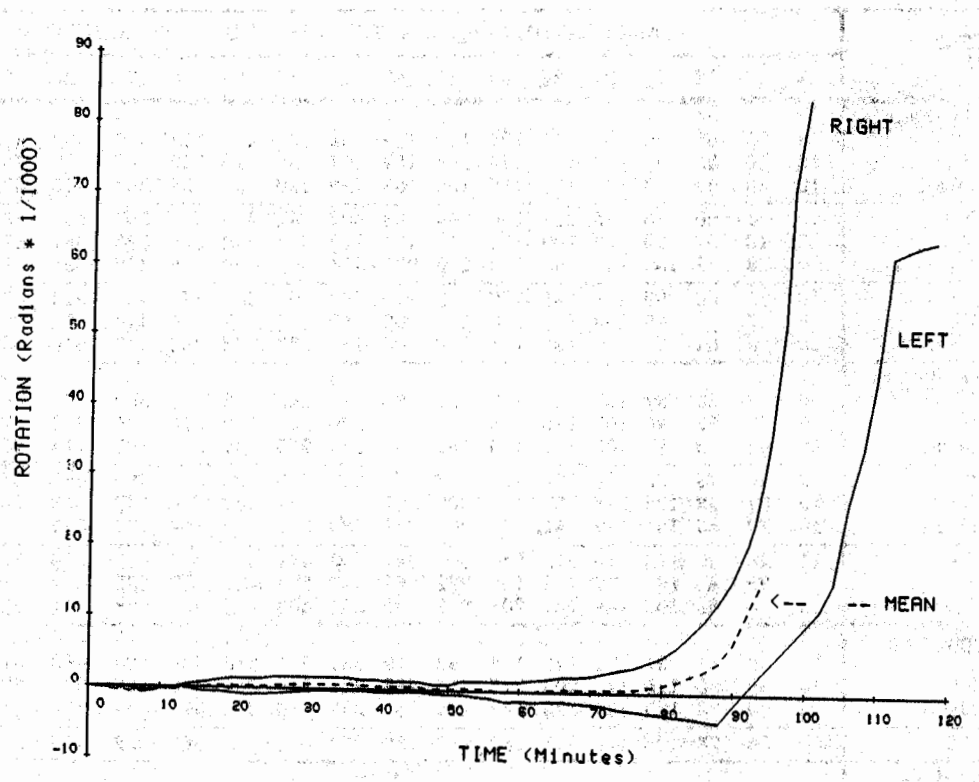
### NOTES

| | | |
|---|---|---|
| TEST CENTRE : Warrington Research<br>TEST DATE : 11th January 1989<br>TEST NUMBER : WFRC 44519 | ASSESSMENT<br>LOAD BEARING CAPACITY<br>100 minutes at 0.4 $M_p$<br>123 minutes at 0.3 $M_p$ | DATA SHEET NUMBER **117B** |

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 6 | 12 | 18 | 24 | 28 | 30 | 36 | 40 | 46 | 50 | 56 | 60 | 70 | 80 | 90 | 100 | 110 | 123 |
| Beam @ 25 mm from End Plate | | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 9 | 20 | 52 | 79 | 100 | 104 | 107 | 129 | 149 | 183 | 207 | 246 | 273 | 340 | 400 | 456 | 512 | 577 | 654 |
| | F3 | 10 | 20 | 53 | 87 | 107 | 116 | 122 | 148 | 169 | 207 | 233 | 274 | 302 | 368 | 429 | 488 | 551 | 621 | 697 |
| | Mean | 10 | 20 | 53 | 83 | 104 | 110 | 115 | 139 | 159 | 195 | 220 | 260 | 288 | 354 | 415 | 472 | 532 | 599 | 676 |
| Web | W2 | 10 | 41 | 100 | 115 | 165 | 213 | 236 | 304 | 348 | 407 | 444 | 495 | 527 | 597 | 655 | 704 | 745 | 774 | 821 |
| | W3 | 8 | 15 | 58 | 99 | 100 | 100 | 104 | 141 | 174 | 222 | 253 | 298 | 328 | 398 | 461 | 519 | 568 | 621 | 688 |
| | Mean | 9 | 28 | 79 | 107 | 133 | 157 | 170 | 223 | 261 | 315 | 349 | 397 | 428 | 498 | 558 | 612 | 657 | 698 | 755 |
| Lower Flange | F6 | 10 | 24 | 63 | 99 | 109 | 125 | 136 | 179 | 210 | 258 | 290 | 338 | 371 | 445 | 512 | 570 | 622 | 666 | 713 |
| | F7 | 9 | 22 | 65 | 99 | 103 | 116 | 126 | 172 | 203 | 252 | 284 | 333 | 365 | 440 | 508 | 567 | 620 | 667 | 717 |
| | Mean | 10 | 23 | 64 | 99 | 106 | 121 | 131 | 176 | 207 | 255 | 287 | 336 | 368 | 443 | 510 | 569 | 621 | 667 | 715 |
| Beam @ 500 mm from End Plate | | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 9 | 20 | 63 | 97 | 102 | 113 | 122 | 157 | 184 | 222 | 246 | 282 | 306 | 359 | 408 | 454 | 498 | 535 | 579 |
| | F4 | 10 | 23 | 62 | 96 | 107 | 120 | 128 | 164 | 189 | 229 | 254 | 292 | 318 | 375 | 427 | 476 | 521 | 562 | 608 |
| | Mean | 10 | 22 | 63 | 97 | 105 | 117 | 125 | 161 | 187 | 226 | 250 | 287 | 312 | 367 | 418 | 465 | 510 | 549 | 594 |
| Web | W1 | 9 | 20 | 73 | 98 | 98 | 100 | 105 | 140 | 173 | 222 | 253 | 300 | 331 | 398 | 460 | 517 | 566 | 612 | 669 |
| | W4 | 10 | 37 | 93 | 104 | 141 | 181 | 202 | 262 | 301 | 358 | 393 | 444 | 476 | 548 | 608 | 662 | 708 | 745 | 797 |
| | Mean | 10 | 29 | 83 | 101 | 120 | 141 | 154 | 201 | 237 | 290 | 323 | 372 | 404 | 473 | 534 | 590 | 637 | 679 | 733 |
| Lower Flange | F5 | 11 | 46 | 93 | 115 | 179 | 219 | 240 | 302 | 342 | 403 | 441 | 494 | 527 | 600 | 660 | 712 | 754 | 784 | 830 |
| | F8 | 9 | 29 | 83 | 101 | 110 | 143 | 162 | 222 | 262 | 325 | 364 | 421 | 457 | 535 | 602 | 659 | 707 | 738 | 775 |
| | Mean | 10 | 38 | 88 | 108 | 145 | 181 | 201 | 262 | 302 | 364 | 403 | 458 | 492 | 568 | 631 | 686 | 731 | 761 | 803 |
| Column / End Plate Connection | | | | | | | | | | | | | | | | | | | | |
| Plate / Flange | P1 | 11 | 30 | 61 | 91 | 121 | 142 | 152 | 193 | 219 | 257 | 281 | 318 | 344 | 403 | 460 | 515 | 557 | 608 | 674 |
| | P2 | 14 | 49 | 85 | 115 | 177 | 203 | 217 | 255 | 282 | 321 | 345 | 381 | 404 | 465 | 521 | 573 | 618 | 670 | 735 |
| | Mean | 13 | 40 | 73 | 103 | 149 | 173 | 185 | 224 | 251 | 289 | 313 | 350 | 374 | 434 | 491 | 544 | 588 | 639 | 705 |
| Web | W5 | 10 | 34 | 74 | 100 | 119 | 148 | 163 | 209 | 237 | 279 | 305 | 343 | 369 | 429 | 486 | 541 | 587 | 633 | 692 |
| Column @ 300 mm from Base | | | | | | | | | | | | | | | | | | | | |
| Flanges | F9 | 11 | 40 | 91 | 111 | 170 | 216 | 239 | 309 | 352 | 414 | 452 | 504 | 537 | 608 | 666 | 716 | 747 | 777 | 832 |
| | F10 | 10 | 32 | 87 | 102 | 145 | 185 | 207 | 272 | 316 | 380 | 418 | 472 | 507 | 580 | 642 | 694 | 735 | 756 | 807 |
| | Mean | 11 | 36 | 89 | 107 | 158 | 201 | 223 | 291 | 334 | 397 | 435 | 488 | 522 | 594 | 654 | 705 | 741 | 767 | 820 |
| Web | W6 | 10 | 34 | 88 | 104 | 149 | 197 | 221 | 291 | 336 | 399 | 437 | 491 | 524 | 597 | 656 | 707 | 743 | 771 | 819 |
| Exposed Bolts | | | | | | | | | | | | | | | | | | | | |
| Upper | B1 | 10 | 20 | 50 | 82 | 105 | 115 | 121 | 142 | 160 | 192 | 215 | 252 | 277 | 339 | 398 | 453 | 508 | 579 | 672 |
| | B2 | 10 | 19 | 48 | 80 | 100 | 110 | 117 | 145 | 164 | 199 | 223 | 260 | 287 | 348 | 407 | 462 | 523 | 624 | 718 |
| | Mean | 10 | 20 | 49 | 81 | 103 | 113 | 119 | 144 | 162 | 196 | 219 | 256 | 282 | 344 | 403 | 458 | 516 | 602 | 695 |
| Lower | B3 | 10 | 21 | 56 | 94 | 100 | 116 | 128 | 167 | 198 | 244 | 274 | 319 | 349 | 419 | 486 | 548 | 600 | 646 | 701 |
| | B4 | 10 | 20 | 52 | 88 | 106 | 116 | 125 | 159 | 187 | 232 | 261 | 306 | 336 | 408 | 476 | 542 | 593 | 636 | 700 |
| | Mean | 10 | 21 | 54 | 91 | 103 | 116 | 127 | 163 | 193 | 238 | 268 | 313 | 343 | 414 | 481 | 545 | 597 | 641 | 701 |
| Mean Furnace Gas | | 471 | 609 | 723 | 777 | 818 | 842 | 855 | 881 | 904 | 926 | 941 | 964 | 970 | 998 | 1017 | 1045 | 1043 | 1059 | 1073 |
| Standard Curve | | 445 | 603 | 705 | 766 | 809 | 832 | 842 | 869 | 885 | 906 | 918 | 935 | 945 | 968 | 988 | 1006 | 1022 | 1036 | 1053 |
| Rotation (Radians x $10^{-3}$) | | | | | | | | | | | | | | | | | | | | |
| Transducers | T1 | -0.3 | -0.7 | -0.4 | -0.6 | -0.8 | -0.6 | -0.4 | -0.2 | -0.4 | -0.3 | -0.6 | -1.0 | -1.4 | -1.7 | -2.9 | -1.7 | * | 45.3 | * |
| | T2 | 0.0 | -0.3 | 0.0 | 1.0 | 1.3 | 1.6 | 1.6 | 1.6 | 1.3 | 1.2 | 0.8 | 1.3 | 1.3 | 2.3 | 5.2 | 16.3 | 84.5 | * | * |
| | Mean | -0.2 | -0.5 | -0.2 | 0.2 | 0.3 | 0.5 | 0.6 | 0.7 | 0.5 | 0.5 | 0.1 | 0.2 | -0.1 | 0.3 | 1.2 | 7.3 | * | * | * |

DATA SHEET NUMBER **117C**

**BEAM / COLUMN (MAJOR AXIS) CONNECTION**



DATA SHEET NUMBER **118A**

## BEAM / COLUMN (MAJOR AXIS) CONNECTION

### DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 × 203 Column | Nominal<br>Actual | 52 | 206.2 | 203.9 | 8.0 | 12.5 | 510.4 | 173.6 | 568.1 | 263.7 | 5263 | 1770 |
| 305 × 165 Beam | Nominal<br>Actual | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |

### CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Column | Grade 43A | 0.23 | 0.04 | 0.90 | 0.024 | 0.019 | 0.04 | <0.005 | 0.03 | <0.005 | 0.08 | <0.005 | <0.005 | 0.0048 |
| Beam | Grade 43A | 0.22 | 0.03 | 0.88 | 0.008 | 0.027 | <0.02 | <0.005 | <0.02 | <0.005 | <0.02 | <0.005 | <0.005 | 0.0074 |

### ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| Column - Flange | 288 | 501 | 31 |
| Beam - Flange (Actual) | 298 | 468 | 34 |
| Beam - Flange (Mean) | 295 | 467 | 34 |

### TEST CONDITIONS

### NOTES

| | |
|---|---|
| TEST CENTRE | : Warrington Research |
| TEST DATE | : 18th January 1989 |
| TEST NUMBER | : WFRC 44175 |

**ASSESSMENT**

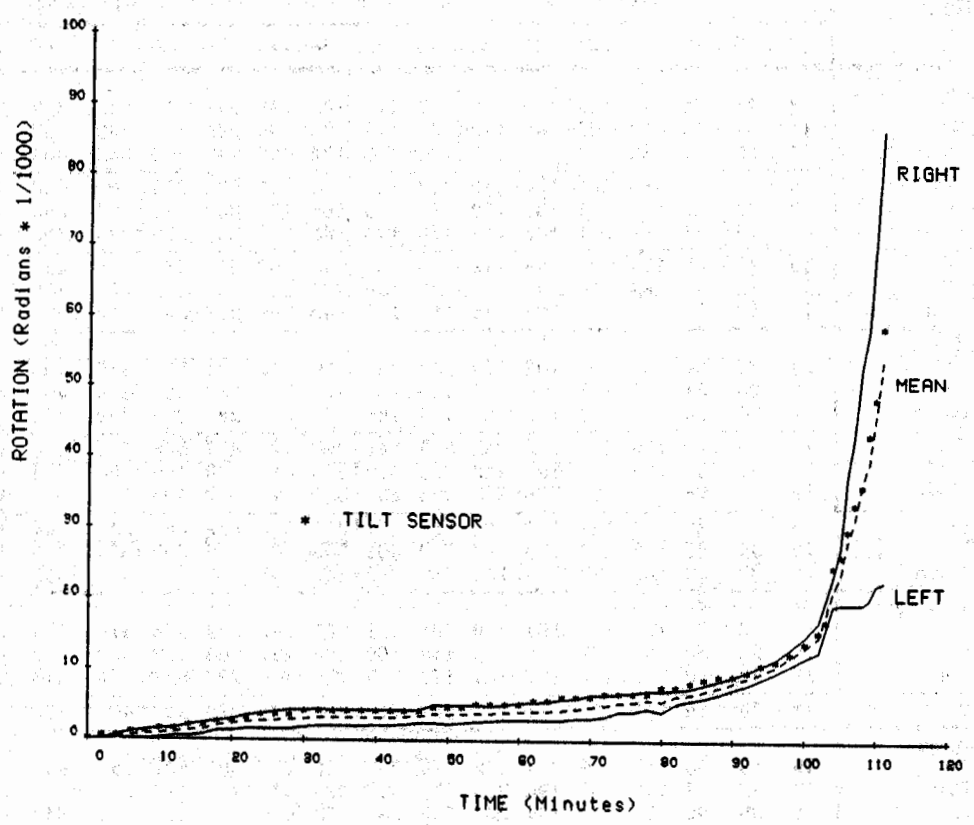
LOAD BEARING CAPACITY
111 minutes at 0.2 $M_p$

DATA SHEET NUMBER **118B**

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 6 | 12 | 18 | 24 | 27 | 30 | 36 | 40 | 46 | 50 | 56 | 60 | 70 | 80 | 90 | 100 | 111 |
| Beam @ 25 mm from End | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 14 | 27 | 60 | 90 | 103 | 106 | 107 | 122 | 142 | 180 | 208 | 248 | 275 | 343 | 407 | 464 | 514 | 572 |
| | F3 | 14 | 24 | 54 | 82 | 103 | 107 | 112 | 130 | 148 | 183 | 206 | 245 | 272 | 340 | 402 | 454 | 503 | 576 |
| | Mean | 14 | 26 | 57 | 86 | 103 | 107 | 110 | 126 | 145 | 182 | 207 | 247 | 274 | 342 | 405 | 459 | 509 | 574 |
| Web | W2 | 14 | 19 | 47 | 85 | 101 | 104 | 110 | 138 | 163 | 204 | 231 | 272 | 299 | 365 | 426 | 482 | 533 | 582 |
| | W3 | 13 | 16 | 40 | 83 | 101 | 101 | 102 | 113 | 129 | 166 | 193 | 233 | 260 | 324 | 385 | 440 | 491 | 540 |
| | Mean | 14 | 18 | 44 | 84 | 101 | 103 | 106 | 126 | 146 | 185 | 212 | 253 | 280 | 345 | 406 | 461 | 512 | 561 |
| Lower Flange | F6 | 15 | 20 | 52 | 100 | 102 | 108 | 119 | 159 | 192 | 236 | 266 | 312 | 342 | 415 | 483 | 540 | 592 | 641 |
| | F7 | 13 | 18 | 48 | 84 | 100 | 101 | 106 | 145 | 179 | 224 | 255 | 302 | 332 | 405 | 470 | 526 | 577 | 627 |
| | Mean | 14 | 19 | 50 | 92 | 101 | 105 | 113 | 152 | 186 | 230 | 261 | 307 | 337 | 410 | 477 | 533 | 585 | 634 |
| Beam @ 500 mm from End | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 14 | 22 | 54 | 97 | 101 | 102 | 113 | 153 | 180 | 219 | 244 | 281 | 304 | 358 | 407 | 450 | 491 | 529 |
| | F4 | 13 | 25 | 54 | 89 | 105 | 120 | 134 | 166 | 189 | 225 | 249 | 283 | 306 | 359 | 408 | 453 | 493 | 536 |
| | Mean | 14 | 24 | 54 | 93 | 103 | 111 | 124 | 160 | 185 | 222 | 247 | 282 | 305 | 359 | 408 | 452 | 492 | 533 |
| Web | W1 | 15 | 46 | 102 | 116 | 179 | 215 | 242 | 303 | 341 | 396 | 429 | 477 | 506 | 572 | 628 | 675 | 715 | 742 |
| | W4 | 14 | 40 | 94 | 109 | 162 | 197 | 223 | 283 | 322 | 378 | 412 | 460 | 490 | 556 | 613 | 661 | 703 | 735 |
| | Mean | 15 | 43 | 98 | 113 | 171 | 206 | 233 | 293 | 332 | 387 | 421 | 469 | 498 | 564 | 621 | 668 | 709 | 739 |
| Lower Flange | F5 | 15 | 31 | 80 | 103 | 127 | 155 | 181 | 239 | 277 | 335 | 374 | 429 | 464 | 541 | 604 | 657 | 703 | 737 |
| | F8 | 15 | 34 | 85 | 106 | 137 | 170 | 197 | 259 | 301 | 363 | 402 | 456 | 490 | 564 | 626 | 678 | 722 | 749 |
| | Mean | 15 | 33 | 83 | 105 | 132 | 163 | 189 | 249 | 289 | 349 | 388 | 443 | 477 | 553 | 615 | 668 | 713 | 743 |
| Column / Web Cleat Connection | | | | | | | | | | | | | | | | | | | |
| Cleat / Flange | C1 | 17 | 33 | 71 | 105 | 136 | 154 | 169 | 205 | 231 | 267 | 292 | 329 | 354 | 416 | 475 | 528 | 578 | 628 |
| | C2 | 14 | 23 | 52 | 86 | 102 | 110 | 119 | 148 | 169 | 203 | 227 | 264 | 289 | 352 | 412 | 468 | 519 | 569 |
| | Mean | 16 | 28 | 62 | 96 | 119 | 132 | 144 | 177 | 200 | 235 | 260 | 297 | 322 | 384 | 444 | 498 | 549 | 599 |
| Web | W5 | 13 | 30 | 76 | 101 | 104 | 123 | 141 | 187 | 217 | 256 | 281 | 319 | 343 | 405 | 463 | 517 | 566 | 614 |
| Column @ 300 mm from Base | | | | | | | | | | | | | | | | | | | |
| Flanges | F9 | 16 | 43 | 95 | 118 | 179 | 214 | 242 | 310 | 353 | 413 | 450 | 501 | 532 | 599 | 657 | 704 | 742 | 771 |
| | F10 | 13 | 32 | 84 | 106 | 160 | 194 | 223 | 290 | 333 | 393 | 430 | 481 | 513 | 581 | 638 | 686 | 726 | 757 |
| | Mean | 15 | 38 | 90 | 112 | 170 | 204 | 233 | 300 | 343 | 403 | 440 | 491 | 523 | 590 | 648 | 695 | 734 | 764 |
| Web | W6 | 14 | 36 | 90 | 104 | 145 | 188 | 222 | 297 | 341 | 404 | 441 | 492 | 523 | 591 | 648 | 695 | 734 | 762 |
| Exposed Bolts | | | | | | | | | | | | | | | | | | | |
| Upper | B1 | 15 | 23 | 50 | 82 | 107 | 111 | 114 | 130 | 145 | 171 | 192 | 224 | 247 | 307 | 363 | 414 | 462 | 522 |
| | B2 | 16 | 29 | 64 | 97 | 117 | 129 | 142 | 176 | 199 | 232 | 254 | 289 | 313 | 371 | 426 | 477 | 525 | 574 |
| | Mean | 16 | 26 | 57 | 90 | 112 | 120 | 128 | 153 | 172 | 202 | 223 | 257 | 280 | 339 | 395 | 446 | 494 | 548 |
| Lower | B3 | 16 | 21 | 50 | 85 | 109 | 112 | 119 | 148 | 172 | 211 | 237 | 278 | 306 | 372 | 435 | 494 | 551 | 604 |
| | B4 | 17 | 31 | 67 | 104 | 123 | 137 | 153 | 194 | 222 | 264 | 292 | 333 | 360 | 426 | 488 | 543 | 592 | 642 |
| | Mean | 17 | 26 | 59 | 95 | 116 | 125 | 136 | 171 | 197 | 238 | 265 | 306 | 333 | 399 | 462 | 519 | 572 | 623 |
| Web Cleat | B5 | 15 | 17 | 40 | 76 | 105 | 106 | 105 | 113 | 126 | 159 | 190 | 233 | 264 | 338 | 406 | 468 | 526 | 577 |
| | B6 | 15 | 19 | 45 | 80 | 102 | 104 | 106 | 124 | 143 | 177 | 204 | 243 | 270 | 336 | 398 | 453 | 503 | 554 |
| | Mean | 15 | 18 | 43 | 78 | 104 | 105 | 106 | 119 | 135 | 168 | 197 | 238 | 267 | 337 | 402 | 461 | 515 | 566 |
| Mean Furnace Gas | | 475 | 614 | 717 | 784 | 813 | 843 | 858 | 899 | 909 | 918 | 939 | 951 | 958 | 982 | 1001 | 1016 | 1036 | 1049 |
| Standard Curve | | 445 | 603 | 705 | 766 | 809 | 826 | 842 | 869 | 885 | 906 | 918 | 935 | 945 | 968 | 988 | 1006 | 1022 | 1037 |
| Rotation (Radians x $10^{-3}$) | | | | | | | | | | | | | | | | | | | |
| Transducers | T1 | 0.0 | 0.0 | 0.5 | 1.3 | 1.6 | * | 1.8 | 2.0 | 2.1 | 2.5 | 2.3 | 2.8 | 2.9 | 3.2 | 4.2 | 7.5 | 11.8 | 22.7 |
| | T2 | 0.0 | 1.0 | 1.7 | 2.7 | 3.7 | * | 4.3 | 4.3 | 4.3 | 4.3 | 5.0 | 4.9 | 5.3 | 6.6 | 7.2 | 9.3 | 14.8 | 86.7 |
| | Mean | 0.0 | 0.5 | 1.1 | 2.0 | 2.7 | * | 3.1 | 3.2 | 3.2 | 3.4 | 3.7 | 3.9 | 4.1 | 4.9 | 5.7 | 8.4 | 13.3 | 54.7 |
| Tilt Sensor | | 0.5 | 1.0 | 1.5 | 2.6 | 3.6 | * | 4.1 | 4.1 | 4.1 | 4.1 | 4.6 | 5.2 | 5.2 | 6.2 | 7.7 | 9.3 | 13.9 | 58.9 |

DATA SHEET NUMBER **118C**

**BEAM / COLUMN (MAJOR AXIS) CONNECTION**



DATA SHEET NUMBER **119A**

# SHELF ANGLE FLOOR BEAM / COLUMN (MAJOR AXIS) CONNECTION

## DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 × 203 Column | Nominal<br>Actual | 52 | 206.2 | 203.9 | 8.0 | 12.5 | 510.4 | 173.6 | 568.1 | 263.7 | 5263 | 1770 |
| 305 × 165 Beam | Nominal<br>Actual | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |
| 125 × 75 Angle | Nominal<br>Actual | 17.8 | 125 | 75 | 12 | 12 | 43.2 | 16.9 | 77.36 | 31.42 | 354 | 95.5 |

## CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Column | Grade 43A | 0.23 | 0.04 | 0.90 | 0.024 | 0.019 | 0.04 | <0.005 | 0.03 | <0.005 | 0.08 | <0.005 | <0.005 | 0.0048 |
| Beam | Grade 43A | 0.24 | 0.03 | 0.87 | 0.008 | 0.026 | <0.02 | <0.005 | <0.02 | <0.005 | <0.02 | <0.005 | <0.005 | 0.0077 |
| Angle | Grade 43A | 0.15 | 0.02 | 1.35 | 0.010 | 0.019 | 0.02 | <0.005 | 0.02 | <0.001 | 0.03 | <0.005 | <0.005 | 0.0056 |

## ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| Column - Flange | 288 | 501 | 31 |
| Beam - Flange (Actual) | 286 | 467 | 36 |
| Beam - Flange (Mean) | 295 | 467 | 34 |
| Angle | 277 | 473 | 34 |

## TEST CONDITIONS

## NOTES

| | |
|---|---|
| TEST CENTRE | : Warrington Research |
| TEST DATE | : 25th January 1989 |
| TEST NUMBER | : WFRC 44992 |

**ASSESSMENT**

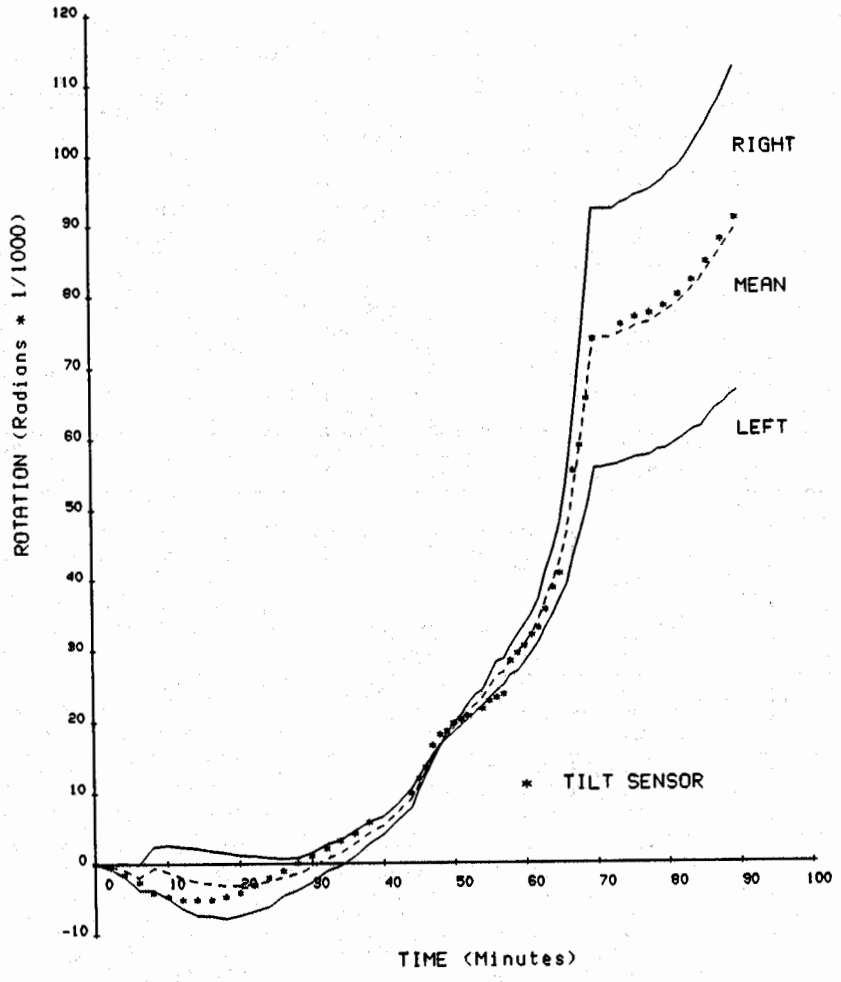
**LOAD BEARING CAPACITY**
70 minutes at 0.2 $M_p$
90 minutes at 0.1 $M_p$

DATA SHEET NUMBER **119B**

| 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 |
| Beam @ 25 mm from End Plate | | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 12 | 13 | 17 | 24 | 34 | 43 | 56 | 69 | 82 | 91 | 108 | 126 | 146 | 165 | 184 | 202 | 240 | 283 | 327 |
| | F3 | 11 | 15 | 23 | 43 | 71 | 88 | 100 | 102 | 102 | 110 | 129 | 150 | 171 | 191 | 209 | 229 | 268 | 310 | 351 |
| | Mean | 12 | 14 | 20 | 34 | 53 | 66 | 78 | 86 | 92 | 101 | 119 | 138 | 159 | 178 | 197 | 216 | 254 | 297 | 339 |
| Unexposed Web | W2 | 13 | 18 | 28 | 41 | 58 | 73 | 89 | 106 | 119 | 132 | 160 | 187 | 214 | 238 | 261 | 284 | 328 | 375 | 421 |
| | W3 | 15 | 22 | 36 | 58 | 78 | 95 | 104 | 114 | 134 | 151 | 178 | 203 | 228 | 253 | 275 | 294 | 339 | 383 | 429 |
| | Mean | 14 | 20 | 32 | 50 | 68 | 84 | 97 | 110 | 127 | 142 | 169 | 195 | 221 | 246 | 268 | 289 | 334 | 379 | 425 |
| Unexposed Angle | A2 | 20 | 34 | 55 | 83 | 107 | 131 | 158 | 187 | 215 | 241 | 282 | 323 | 362 | 395 | 422 | 445 | 501 | 555 | 604 |
| | A3 | 20 | 39 | 92 | 102 | 104 | 125 | 160 | 193 | 224 | 252 | 291 | 326 | 358 | 389 | 414 | 436 | 488 | 544 | 592 |
| | Mean | 20 | 37 | 74 | 93 | 106 | 128 | 159 | 190 | 220 | 247 | 287 | 325 | 360 | 392 | 418 | 441 | 495 | 550 | 598 |
| Exposed Angle | A6 | 38 | 66 | 113 | 155 | 201 | 232 | 267 | 301 | 333 | 367 | 419 | 466 | 513 | 549 | 574 | 602 | 670 | 733 | 790 |
| | A7 | 52 | 98 | 138 | 170 | 225 | 272 | 315 | 354 | 389 | 421 | 470 | 513 | 551 | 577 | 595 | 618 | 684 | 742 | 798 |
| | Mean | 45 | 82 | 126 | 163 | 213 | 252 | 291 | 328 | 361 | 394 | 445 | 490 | 532 | 563 | 585 | 610 | 677 | 738 | 794 |
| Exposed Web | W6 | 102 | 176 | 255 | 329 | 397 | 431 | 468 | 505 | 538 | 570 | 616 | 652 | 689 | 712 | 725 | 748 | 822 | 878 | 921 |
| | W7 | 91 | 172 | 249 | 320 | 389 | 429 | 469 | 504 | 533 | 561 | 604 | 644 | 681 | 700 | 716 | 738 | 813 | 869 | 912 |
| | Mean | 97 | 174 | 252 | 325 | 393 | 430 | 469 | 505 | 536 | 566 | 610 | 648 | 685 | 706 | 721 | 743 | 818 | 874 | 917 |
| Lower Flange | F6 | 113 | 210 | 316 | 413 | 493 | 540 | 582 | 618 | 651 | 678 | 718 | 751 | 782 | 799 | 808 | 828 | 891 | 941 | 978 |
| | F7 | 99 | 205 | 317 | 417 | 491 | 533 | 573 | 606 | 637 | 665 | 707 | 740 | 771 | 790 | 799 | 818 | 887 | 933 | 968 |
| | Mean | 106 | 208 | 317 | 415 | 492 | 537 | 578 | 612 | 644 | 672 | 713 | 746 | 777 | 795 | 804 | 823 | 889 | 937 | 973 |
| Beam @ 500 mm from End Plate | | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 13 | 14 | 15 | 20 | 25 | 32 | 42 | 52 | 64 | 76 | 90 | 101 | 108 | 116 | 125 | 134 | 153 | 179 | 209 |
| | F4 | 11 | 12 | 14 | 19 | 25 | 31 | 40 | 50 | 60 | 71 | 85 | 96 | 107 | 117 | 128 | 136 | 156 | 181 | 208 |
| | Mean | 12 | 13 | 15 | 20 | 25 | 32 | 41 | 51 | 62 | 74 | 88 | 99 | 108 | 117 | 127 | 135 | 155 | 180 | 209 |
| Unexposed Web | W1 | 15 | 22 | 34 | 51 | 70 | 87 | 104 | 123 | 141 | 157 | 183 | 207 | 231 | 250 | 268 | 284 | 319 | 356 | 391 |
| | W4 | 12 | 19 | 29 | 43 | 61 | 76 | 96 | 107 | 117 | 137 | 162 | 183 | 206 | 225 | 241 | 257 | 289 | 325 | 361 |
| | Mean | 14 | 21 | 32 | 47 | 66 | 82 | 100 | 115 | 129 | 147 | 173 | 195 | 219 | 238 | 255 | 271 | 304 | 341 | 376 |
| Unexposed Angle | A1 | 21 | 42 | 69 | 103 | 117 | 168 | 201 | 233 | 265 | 292 | 335 | 375 | 411 | 442 | 467 | 488 | 543 | 593 | 639 |
| | A4 | 18 | 38 | 65 | 98 | 122 | 162 | 190 | 220 | 251 | 277 | 319 | 359 | 392 | 423 | 447 | 466 | 520 | 573 | 620 |
| | Mean | 20 | 40 | 67 | 101 | 120 | 165 | 196 | 227 | 258 | 285 | 327 | 367 | 402 | 433 | 457 | 477 | 532 | 583 | 630 |
| Exposed Angle | A5 | 50 | 85 | 154 | 218 | 282 | 332 | 379 | 424 | 464 | 501 | 557 | 604 | 651 | 680 | 697 | 721 | 791 | 862 | 913 |
| | A8 | 55 | 106 | 164 | 223 | 292 | 334 | 380 | 421 | 460 | 495 | 545 | 592 | 631 | 656 | 672 | 693 | 762 | 829 | 887 |
| | Mean | 53 | 96 | 159 | 221 | 287 | 333 | 380 | 423 | 462 | 498 | 551 | 598 | 641 | 668 | 685 | 707 | 777 | 846 | 900 |
| Exposed Web | W5 | 148 | 281 | 415 | 523 | 599 | 632 | 658 | 686 | 710 | 732 | 756 | 787 | 816 | 822 | 825 | 848 | 913 | 953 | 987 |
| | W8 | 139 | 258 | 374 | 475 | 549 | 589 | 624 | 653 | 679 | 701 | 733 | 761 | 792 | 795 | 799 | 819 | 894 | 936 | 971 |
| | Mean | 144 | 270 | 395 | 499 | 574 | 611 | 641 | 670 | 695 | 717 | 745 | 774 | 804 | 809 | 812 | 834 | 904 | 945 | 979 |
| Lower Flange | F5 | 141 | 285 | 433 | 557 | 635 | 673 | 699 | 722 | 740 | 751 | 777 | 806 | 834 | 846 | 848 | 871 | 930 | 967 | 998 |
| | F8 | 135 | 268 | 416 | 531 | 607 | 642 | 671 | 694 | 714 | 732 | 751 | 784 | 812 | 817 | 818 | 838 | 905 | 944 | 976 |
| | Mean | 138 | 277 | 425 | 544 | 621 | 658 | 685 | 708 | 727 | 742 | 764 | 795 | 823 | 832 | 833 | 855 | 918 | 956 | 987 |
| Column / End Plate Connection | | | | | | | | | | | | | | | | | | | | |
| Plate / Flange | P1 | 18 | 32 | 64 | 110 | 138 | 168 | 205 | 245 | 285 | 323 | 378 | 436 | 486 | 533 | 565 | 592 | 655 | 713 | 769 |
| | P2 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | Mean | 18 | 32 | 64 | 110 | 138 | 168 | 205 | 245 | 285 | 323 | 378 | 436 | 486 | 533 | 565 | 592 | 655 | 713 | 769 |
| Web | W9 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Column @ 300 mm from Base | | | | | | | | | | | | | | | | | | | | |
| Flanges | F9 | 67 | 142 | 239 | 334 | 419 | 473 | 526 | 571 | 608 | 643 | 691 | 725 | 762 | 787 | 799 | 817 | 893 | 939 | 974 |
| | F10 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | Mean | 67 | 142 | 239 | 334 | 419 | 473 | 526 | 571 | 608 | 643 | 691 | 725 | 762 | 787 | 799 | 817 | 893 | 939 | 944 |
| Web | W10 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Unexposed Bolts | B1 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | B2 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | Mean | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Exposed Bolts | B3 | 37 | 64 | 115 | 173 | 232 | 280 | 322 | 363 | 400 | 436 | 492 | 546 | 597 | 626 | 652 | 687 | 747 | 811 | 876 |
| | B4 | 36 | 65 | 117 | 172 | 227 | 268 | 316 | 363 | 406 | 447 | 508 | 560 | 604 | 638 | 660 | 683 | 743 | 810 | 872 |
| | Mean | 37 | 65 | 116 | 173 | 230 | 274 | 319 | 363 | 403 | 442 | 500 | 553 | 601 | 632 | 656 | 685 | 745 | 811 | 874 |
| Mean Furnace Gas | | 504 | 601 | 663 | 699 | 726 | 741 | 757 | 773 | 786 | 802 | 824 | 847 | 867 | 851 | 859 | 895 | 945 | 977 | 1006 |
| Standard Curve | | 502 | 603 | 663 | 705 | 739 | 766 | 789 | 809 | 826 | 842 | 865 | 885 | 902 | 918 | 932 | 945 | 968 | 988 | 1006 |
| Rotation (Radians x 10-3) | | | | | | | | | | | | | | | | | | | | |
| Transducers | T1 | * | -0.1 | * | 2.3 | * | 1.6 | * | 0.9 | * | 1.6 | * | 6.5 | * | 18.5 | * | 28.3 | 55.8 | 58.5 | 66.7 |
| | T2 | * | -3.7 | * | -6.3 | * | -7.8 | * | -6.0 | * | -2.6 | * | 4.1 | 10.5 | 19.8 | 26.3 | 33.6 | 92.4 | 96.4 | 112 |
| | Mean | * | -1.9 | * | -2.0 | * | -3.1 | * | -2.6 | * | -0.5 | * | 5.3 | * | 19.2 | * | 31.0 | 74.1 | 77.5 | 89.4 |
| Tilt Sensor | | * | -2.6 | * | -5.2 | * | -4.6 | * | -2.1 | * | 1.0 | * | * | 11.9 | 19.6 | 22.7 | 30.5 | 73.9 | 78.5 | 90.9 |

DATA SHEET NUMBER **119C**

## SHELF ANGLE FLOOR BEAM / COLUMN (MAJOR AXIS) CONNECTION



DATA SHEET NUMBER **120A**

**BEAM / BEAM (MINOR AXIS) CONNECTION**

DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 ($cm^4$) |
| 406 × 178 Beam | Nominal<br>Actual | 60 | 406.4 | 177.8 | 7.8 | 12.8 | 1058 | 134.8 | 1194 | 208.3 | 21508 | 1199 |
| 305 × 165 Beam/Column | Nominal<br>Actual | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 406 UB<br>305 UB | Grade 43A<br>Grade 43A | 0.17 | 0.23 | 0.64 | 0.015 | 0.017 | 0.03 | 0.005 | 0.04 | <0.005 | 0.03 | <0.005 | 0.035 | 0.0065 |

ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| | | | |

TEST CONDITIONS

NOTES

| | |
|---|---|
| TEST CENTRE | : Warrington Research |
| TEST DATE | : 27th February 1990 |
| TEST NUMBER | : WFRC 46733 |

**ASSESSMENT**

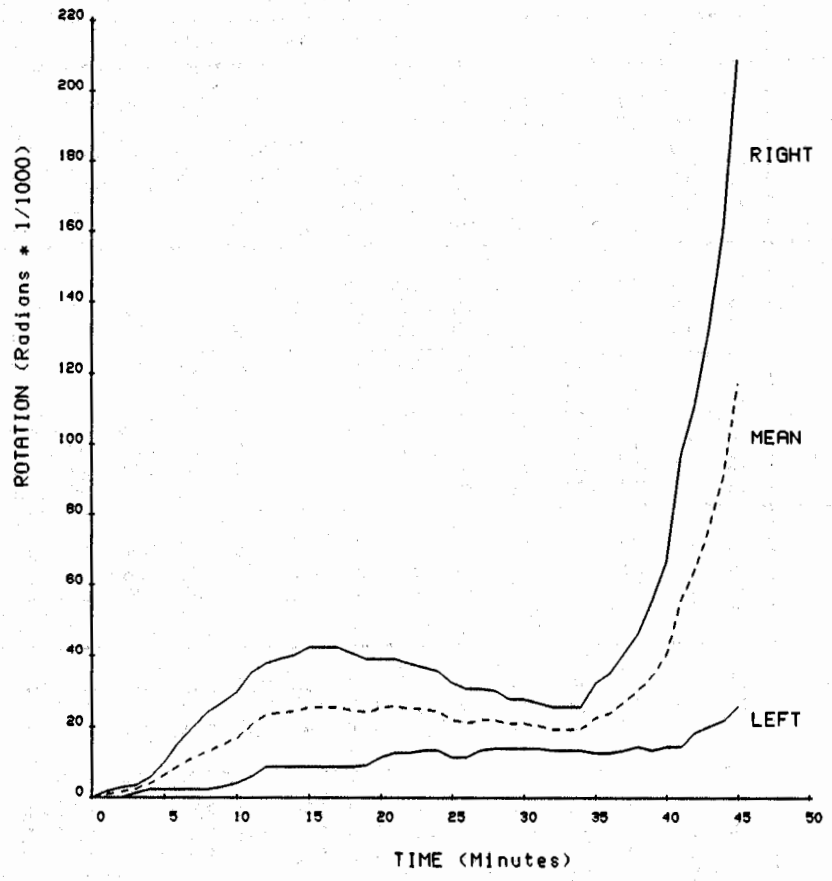
**LOAD BEARING CAPACITY**
46 minutes at 0.2 $M_p$

DATA SHEET NUMBER **120B**

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 6 | 8 | 9 | 10 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 35 | 40 | 45 | 46 |
| Beam @ 25 mm from End Plate | | | | | | | | | | | | | | | | | | | |
| Web | W2 | 30 | 35 | 41 | 59 | 81 | 92 | 105 | 128 | 169 | 211 | 256 | 302 | 348 | 392 | 462 | 528 | 587 | 598 |
| | W3 | 19 | 23 | 29 | 43 | 61 | 71 | 86 | 110 | 152 | 195 | 241 | 287 | 333 | 379 | 450 | 516 | 575 | 585 |
| | Mean | 25 | 29 | 35 | 51 | 71 | 82 | 96 | 119 | 161 | 203 | 249 | 295 | 341 | 386 | 456 | 522 | 581 | 592 |
| Lower Flange | F6 | 15 | 19 | 23 | 35 | 50 | 59 | 69 | 88 | 126 | 169 | 214 | 259 | 305 | 352 | 424 | 492 | 554 | 567 |
| | F7 | 17 | 22 | 29 | 48 | 70 | 83 | 99 | 125 | 167 | 215 | 266 | 313 | 363 | 411 | 483 | 549 | 607 | 618 |
| | Mean | 16 | 21 | 26 | 42 | 60 | 71 | 84 | 107 | 147 | 192 | 240 | 286 | 334 | 382 | 454 | 521 | 581 | 593 |
| Beam @ 500 mm from End Plate | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 13 | 13 | 13 | 15 | 17 | 18 | 19 | 22 | 27 | 34 | 41 | 47 | 54 | 62 | 75 | 87 | 102 | 104 |
| | F4 | 12 | 12 | 12 | 14 | 16 | 18 | 19 | 22 | 29 | 37 | 48 | 58 | 70 | 84 | 101 | 110 | 116 | 118 |
| | Mean | 13 | 13 | 13 | 15 | 17 | 18 | 19 | 22 | 28 | 36 | 45 | 53 | 62 | 73 | 88 | 99 | 109 | 111 |
| Web | W1 | 12 | 12 | 14 | 18 | 25 | 29 | 35 | 46 | 64 | 80 | 98 | 119 | 140 | 162 | 198 | 236 | 273 | 282 |
| | W4 | 12 | 13 | 14 | 18 | 23 | 27 | 31 | 40 | 55 | 71 | 85 | 103 | 124 | 145 | 179 | 215 | 250 | 258 |
| | Mean | 12 | 13 | 14 | 18 | 24 | 28 | 33 | 43 | 60 | 76 | 92 | 111 | 132 | 154 | 189 | 226 | 262 | 270 |
| Lower Flange | F5 | 14 | 15 | 17 | 20 | 25 | 28 | 32 | 40 | 58 | 75 | 94 | 113 | 135 | 160 | 202 | 246 | 293 | 302 |
| | F8 | 13 | 14 | 16 | 20 | 26 | 28 | 31 | 39 | 53 | 69 | 85 | 102 | 122 | 145 | 171 | 212 | 256 | 265 |
| | Mean | 14 | 15 | 17 | 20 | 26 | 28 | 32 | 40 | 56 | 72 | 90 | 108 | 129 | 153 | 187 | 229 | 275 | 284 |
| Cross Beam | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 14 | 17 | 22 | 32 | 45 | 52 | 59 | 72 | 93 | 118 | 152 | 184 | 215 | 248 | 297 | 343 | 389 | 413 |
| | F3 | 20 | 25 | 31 | 45 | 59 | 66 | 74 | 90 | 118 | 144 | 178 | 208 | 240 | 271 | 316 | 365 | 427 | 445 |
| | Mean | 17 | 21 | 27 | 39 | 52 | 59 | 67 | 81 | 106 | 131 | 165 | 196 | 228 | 260 | 307 | 354 | 408 | 429 |
| Lower Flange | F9 | 55 | 83 | 117 | 197 | 280 | 325 | 376 | 450 | 546 | 619 | 671 | 711 | 740 | 769 | 818 | 855 | 890 | 895 |
| Cross Beam / End Plate Connection | | | | | | | | | | | | | | | | | | | |
| Plate / Web | P1 | 22 | 29 | 38 | 58 | 83 | 97 | 115 | 144 | 195 | 248 | 301 | 354 | 406 | 460 | 539 | 608 | 666 | 679 |
| | P2 | 21 | 29 | 38 | 58 | 83 | 98 | 117 | 147 | 198 | 252 | 307 | 361 | 414 | 466 | 543 | 610 | 669 | 680 |
| | Mean | 22 | 29 | 38 | 58 | 83 | 98 | 116 | 146 | 197 | 250 | 304 | 358 | 410 | 463 | 541 | 609 | 668 | 680 |
| Exposed Bolts | | | | | | | | | | | | | | | | | | | |
| Upper | B1 | 23 | 30 | 38 | 56 | 79 | 93 | 114 | 140 | 188 | 238 | 290 | 339 | 388 | 438 | 512 | 577 | 632 | 643 |
| | B2 | 24 | 34 | 43 | 65 | 93 | 109 | 128 | 160 | 211 | 264 | 319 | 371 | 422 | 473 | 547 | 611 | 665 | 676 |
| | Mean | 24 | 32 | 41 | 61 | 86 | 101 | 121 | 150 | 200 | 251 | 305 | 355 | 405 | 456 | 530 | 594 | 649 | 660 |
| Lower | B3 | 22 | 29 | 37 | 52 | 76 | 92 | 112 | 145 | 198 | 253 | 309 | 361 | 414 | 466 | 540 | 606 | 658 | 667 |
| | B4 | 23 | 30 | 38 | 57 | 85 | 103 | 124 | 156 | 210 | 267 | 325 | 380 | 434 | 487 | 563 | 624 | 678 | 689 |
| | Mean | 23 | 30 | 38 | 55 | 81 | 98 | 118 | 151 | 204 | 260 | 317 | 371 | 424 | 477 | 552 | 615 | 668 | 678 |
| Mean Furnace Gas | | 448 | 496 | 542 | 605 | 643 | 671 | 685 | 716 | 738 | 769 | 793 | 810 | 833 | 844 | 878 | 896 | 913 | 919 |
| Standard Curve | | 445 | 502 | 544 | 603 | 645 | 663 | 678 | 705 | 739 | 766 | 789 | 809 | 826 | 842 | 865 | 885 | 902 | 906 |
| Rotation (Radians x $10^{-3}$) | | | | | | | | | | | | | | | | | | | |
| Transducers | T1 | 0 | 1.2 | 2.3 | 2.3 | 2.3 | 2.9 | 4.0 | 8.7 | 8.7 | 8.7 | 12.7 | 13.3 | 13.3 | 13.9 | 12.7 | 14.4 | 26.0 | * |
| | T2 | 2.8 | 3.3 | 5.6 | 15.6 | 24.0 | 26.8 | 29.6 | 37.9 | 42.4 | 40.7 | 39.1 | 35.7 | 30.7 | 27.9 | 32.4 | 66.9 | 209 | * |
| | Mean | 1.4 | 2.3 | 4.0 | 9.0 | 13.2 | 14.9 | 16.8 | 23.3 | 25.6 | 24.7 | 25.9 | 24.5 | 22.0 | 20.9 | 22.6 | 40.7 | 118 | * |

DATA SHEET NUMBER **120C**

## BEAM / BEAM (MINOR AXIS) CONNECTION



DATA SHEET NUMBER **121A**

## BEAM / BEAM (MINOR AXIS) CONNECTION

DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 ($cm^4$) |
| 406 × 178 Beam | Nominal<br>Actual | 60 | 406.4 | 177.8 | 7.8 | 12.8 | 1058 | 134.8 | 1194 | 208.3 | 21508 | 1199 |
| 305 × 165 Beam/Column | Nominal<br>Actual | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 406 UB<br>305 UB | Grade 43A<br>Grade 43A | 0.17 | 0.23 | 0.64 | 0.015 | 0.017 | 0.03 | 0.005 | 0.04 | <0.005 | 0.03 | <0.005 | 0.035 | 0.0065 |

ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| | | | |

TEST CONDITIONS

NOTES

| | |
|---|---|
| TEST CENTRE | : Warrington Research |
| TEST DATE | : 27th February 1990 |
| TEST NUMBER | : WFRC 46733 |

**ASSESSMENT**

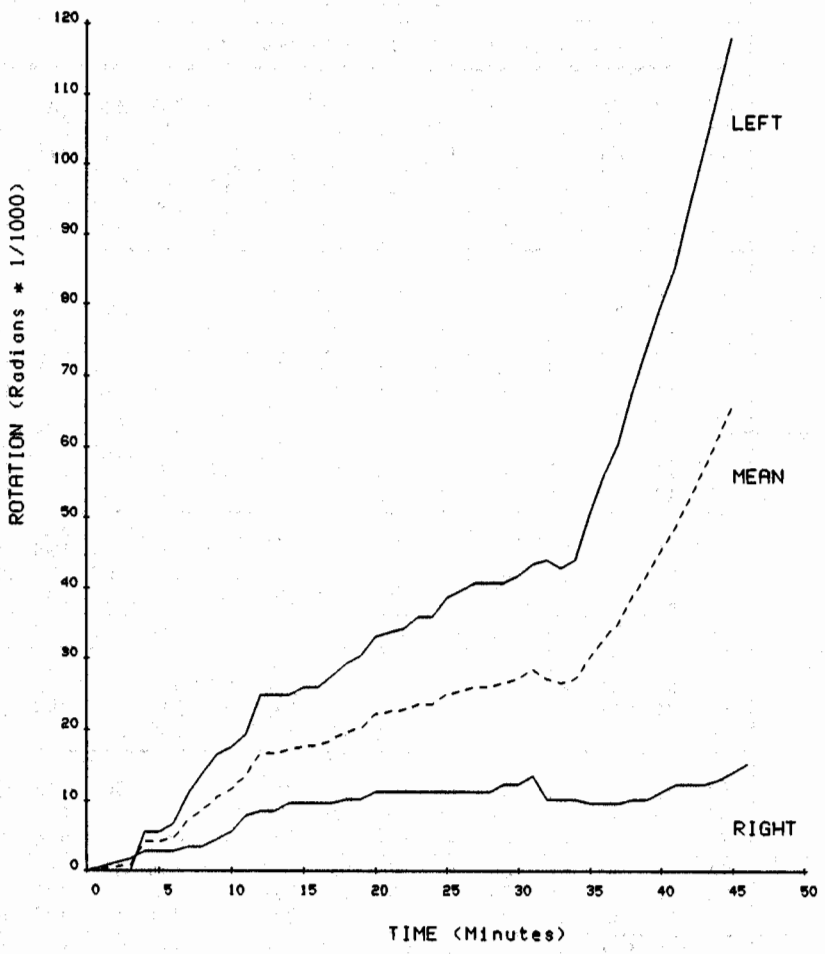
**LOAD BEARING CAPACITY**
**47 minutes at 0.4 $M_p$**

DATA SHEET NUMBER **121B**

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 6 | 8 | 9 | 10 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 35 | 40 | 45 | 47 |
| Beam @ 25 mm from End Plate | | | | | | | | | | | | | | | | | | | |
| Web | W2 | 18 | 22 | 28 | 42 | 59 | 68 | 80 | 105 | 149 | 195 | 242 | 288 | 334 | 381 | 451 | 517 | 575 | 596 |
| | W3 | 16 | 20 | 24 | 37 | 52 | 60 | 71 | 91 | 130 | 172 | 216 | 261 | 307 | 354 | 424 | 491 | 551 | 573 |
| | Mean | 17 | 21 | 26 | 40 | 56 | 64 | 76 | 98 | 140 | 184 | 229 | 275 | 321 | 368 | 438 | 504 | 563 | 585 |
| Lower Flange | F6 | 17 | 21 | 26 | 40 | 58 | 69 | 82 | 106 | 156 | 207 | 259 | 310 | 360 | 410 | 482 | 549 | 607 | 628 |
| | F7 | 14 | 16 | 19 | 29 | 42 | 49 | 59 | 77 | 115 | 161 | 207 | 255 | 302 | 351 | 423 | 492 | 554 | 576 |
| | Mean | 16 | 19 | 23 | 35 | 50 | 59 | 71 | 92 | 136 | 184 | 233 | 283 | 331 | 381 | 453 | 521 | 581 | 602 |
| Beam @ 500 mm from End Plate | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 10 | 10 | 10 | 11 | 13 | 15 | 17 | 22 | 30 | 42 | 54 | 65 | 77 | 88 | 111 | 137 | 165 | 176 |
| | F4 | 11 | 11 | 11 | 13 | 16 | 18 | 21 | 26 | 37 | 49 | 61 | 73 | 85 | 99 | 123 | 154 | 187 | 199 |
| | Mean | 11 | 11 | 11 | 12 | 15 | 17 | 19 | 24 | 34 | 46 | 58 | 69 | 81 | 94 | 117 | 146 | 176 | 188 |
| Web | W1 | 13 | 13 | 15 | 18 | 23 | 26 | 31 | 39 | 56 | 73 | 90 | 109 | 131 | 154 | 191 | 231 | 272 | 289 |
| | W4 | 13 | 14 | 16 | 20 | 26 | 29 | 34 | 42 | 58 | 75 | 93 | 113 | 135 | 158 | 195 | 234 | 274 | 291 |
| | Mean | 13 | 14 | 16 | 19 | 25 | 28 | 33 | 41 | 57 | 74 | 92 | 111 | 133 | 156 | 193 | 233 | 273 | 290 |
| Lower Flange | F5 | 11 | 12 | 12 | 14 | 17 | 19 | 22 | 30 | 46 | 63 | 75 | 91 | 113 | 138 | 179 | 222 | 268 | 286 |
| | F8 | 11 | 11 | 12 | 13 | 15 | 16 | 19 | 24 | 35 | 50 | 67 | 83 | 103 | 127 | 166 | 207 | 251 | 269 |
| | Mean | 11 | 12 | 12 | 14 | 16 | 18 | 21 | 27 | 41 | 57 | 71 | 87 | 108 | 133 | 173 | 215 | 260 | 278 |
| Cross Beam | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 23 | 26 | 29 | 39 | 50 | 56 | 62 | 74 | 95 | 120 | 145 | 171 | 198 | 227 | 276 | 328 | 375 | 396 |
| | F3 | 18 | 21 | 25 | 33 | 42 | 47 | 54 | 66 | 87 | 113 | 135 | 168 | 200 | 231 | 278 | 324 | 368 | 385 |
| | Mean | 21 | 24 | 27 | 36 | 46 | 52 | 58 | 70 | 91 | 117 | 140 | 170 | 199 | 229 | 277 | 326 | 372 | 391 |
| Lower Flange | F9 | 69 | 96 | 126 | 198 | 290 | 336 | 387 | 462 | 559 | 632 | 681 | 720 | 747 | 777 | 823 | 858 | 889 | 901 |
| Cross Beam / End Plate Connection | | | | | | | | | | | | | | | | | | | |
| Plate / Web | P1 | 27 | 34 | 42 | 62 | 87 | 102 | 119 | 151 | 206 | 263 | 317 | 373 | 426 | 478 | 550 | 614 | 668 | 689 |
| | P2 | 21 | 27 | 34 | 50 | 69 | 81 | 96 | 123 | 172 | 225 | 279 | 334 | 388 | 441 | 519 | 586 | 644 | 664 |
| | Mean | 24 | 31 | 38 | 56 | 78 | 92 | 108 | 137 | 189 | 244 | 298 | 354 | 407 | 460 | 535 | 600 | 656 | 677 |
| Exposed Bolts | | | | | | | | | | | | | | | | | | | |
| Upper | B1 | 24 | 32 | 41 | 63 | 91 | 108 | 127 | 159 | 210 | 264 | 317 | 368 | 419 | 469 | 543 | 607 | 660 | 680 |
| | B2 | 23 | 30 | 37 | 54 | 77 | 90 | 106 | 136 | 188 | 242 | 294 | 346 | 398 | 450 | 522 | 586 | 639 | 659 |
| | Mean | 24 | 31 | 39 | 59 | 84 | 99 | 117 | 148 | 199 | 253 | 306 | 357 | 409 | 460 | 533 | 597 | 650 | 670 |
| Lower | B3 | 24 | 32 | 40 | 61 | 89 | 107 | 128 | 163 | 220 | 277 | 335 | 390 | 443 | 495 | 568 | 628 | 680 | 698 |
| | B4 | 23 | 29 | 37 | 54 | 76 | 90 | 107 | 140 | 197 | 255 | 313 | 370 | 425 | 478 | 552 | 616 | 670 | 690 |
| | Mean | 24 | 31 | 39 | 58 | 83 | 99 | 118 | 152 | 209 | 266 | 324 | 380 | 434 | 487 | 560 | 622 | 675 | 694 |
| Mean Furnace Gas | | 448 | 496 | 542 | 605 | 643 | 671 | 685 | 716 | 738 | 769 | 793 | 810 | 833 | 844 | 878 | 896 | 913 | 926 |
| Standard Curve | | 445 | 502 | 544 | 603 | 645 | 663 | 678 | 705 | 739 | 766 | 789 | 809 | 826 | 842 | 865 | 885 | 902 | 909 |
| Rotation (Radians x $10^{-3}$) | | | | | | | | | | | | | | | | | | | |
| Transducers | T1 | 0 | 0 | 5.5 | 6.6 | 13.8 | 16.6 | 17.7 | 24.8 | 25.9 | 29.3 | 33.7 | 35.9 | 40.8 | 41.9 | 50.8 | 79.9 | 118 | * |
| | T2 | 1.1 | 1.7 | 2.8 | 2.8 | 3.4 | 4.5 | 5.6 | 8.5 | 9.6 | 10.2 | 11.3 | 11.3 | 11.3 | 12.4 | 9.6 | 11.3 | 14.1 | * |
| | Mean | 0.6 | 0.9 | 4.2 | 4.7 | 8.6 | 10.6 | 11.7 | 16.7 | 17.8 | 19.8 | 22.5 | 23.6 | 26.1 | 27.2 | 30.2 | 45.6 | 66.1 | * |

DATA SHEET NUMBER **121C**

## BEAM / BEAM (MINOR AXIS) CONNECTION



DATA SHEET NUMBER **122A**

# BEAM / BEAM (MINOR AXIS) CONNECTION

## DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 ($cm^4$) |
| 406 × 178 Beam | Nominal | 60 | 406.4 | 177.8 | 7.8 | 12.8 | 1058 | 134.8 | 1194 | 208.3 | 21508 | 1199 |
| | Actual | | | | | | | | | | | |
| 305 × 165 Beam/Column | Nominal | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |
| | Actual | | | | | | | | | | | |

## CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 406 UB<br>305 UB | Grade 43A<br>Grade 43A | 0.17 | 0.23 | 0.64 | 0.015 | 0.017 | 0.03 | 0.005 | 0.04 | <0.005 | 0.03 | <0.005 | 0.035 | 0.0065 |

## ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| | | | |

## TEST CONDITIONS

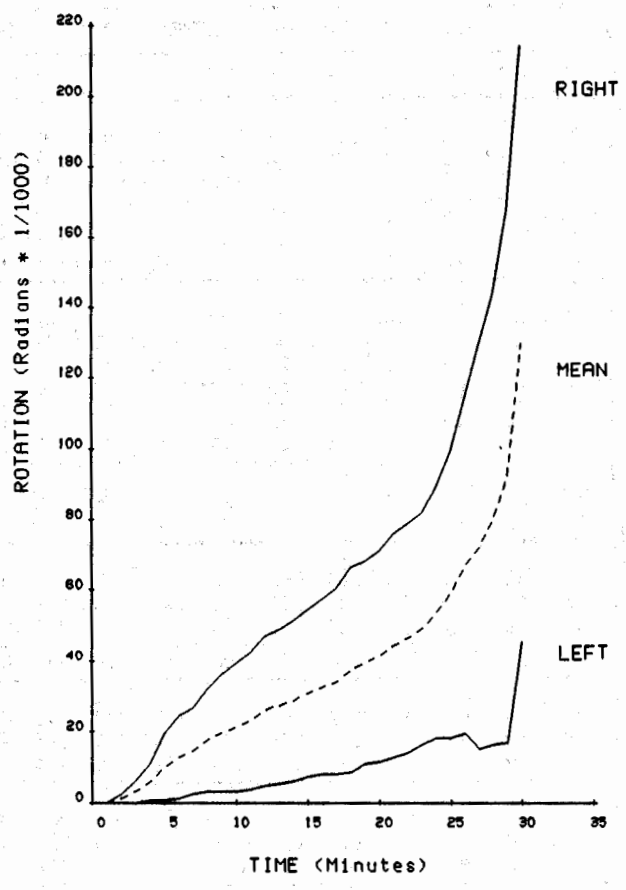
## NOTES

| | | |
|---|---|---|
| TEST CENTRE : Warrington Research<br>TEST DATE : 1st March 1990<br>TEST NUMBER : WFRC 46736 | ASSESSMENT<br>LOAD BEARING CAPACITY<br>30 minutes at 0.1 $M_p$ | DATA SHEET NUMBER **122B** |

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 6 | 8 | 9 | 10 | 12 | 15 | 18 | 21 | 24 | 27 | 28 | 29 | 30 |
| Beam @ 25 mm from End | | | | | | | | | | | | | | | | | |
| Web | W2 | 32 | 43 | 56 | 82 | 111 | 128 | 145 | 182 | 235 | 295 | 351 | 409 | 461 | 479 | 496 | 512 |
| | W3 | 32 | 42 | 53 | 74 | 100 | 118 | 134 | 169 | 220 | 276 | 333 | 390 | 443 | 460 | 477 | 494 |
| | Mean | 32 | 43 | 55 | 78 | 106 | 123 | 140 | 176 | 228 | 286 | 342 | 400 | 452 | 470 | 487 | 503 |
| Lower Flange | F6 | 14 | 15 | 18 | 29 | 42 | 49 | 57 | 72 | 98 | 134 | 174 | 218 | 265 | 281 | 297 | 312 |
| | F7 | 15 | 17 | 20 | 32 | 45 | 52 | 58 | 73 | 99 | 138 | 178 | 225 | 272 | 288 | 304 | 320 |
| | Mean | 15 | 16 | 19 | 31 | 44 | 51 | 58 | 73 | 99 | 136 | 176 | 222 | 269 | 285 | 301 | 316 |
| Beam @ 500 mm from End | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 13 | 13 | 14 | 16 | 19 | 21 | 22 | 27 | 34 | 42 | 50 | 57 | 64 | 67 | 69 | 73 |
| | F4 | 12 | 13 | 15 | 18 | 23 | 26 | 31 | 39 | 51 | 63 | 75 | 87 | 96 | 98 | 100 | 101 |
| | Mean | 13 | 13 | 15 | 17 | 21 | 24 | 27 | 33 | 43 | 53 | 63 | 72 | 80 | 83 | 85 | 87 |
| Web | W1 | 13 | 15 | 17 | 24 | 32 | 36 | 41 | 52 | 67 | 83 | 103 | 124 | 145 | 152 | 159 | 166 |
| | W4 | 14 | 16 | 18 | 27 | 36 | 42 | 48 | 62 | 79 | 101 | 124 | 148 | 172 | 180 | 188 | 196 |
| | Mean | 14 | 16 | 18 | 26 | 34 | 39 | 45 | 57 | 73 | 92 | 114 | 136 | 159 | 166 | 174 | 181 |
| Lower Flange | F5 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | F8 | 12 | 12 | 13 | 17 | 24 | 28 | 32 | 44 | 61 | 78 | 97 | 122 | 148 | 157 | 166 | 175 |
| | Mean | 12 | 12 | 13 | 17 | 24 | 28 | 32 | 44 | 61 | 78 | 97 | 122 | 148 | 157 | 166 | 175 |
| Cross Beam | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 20 | 32 | 76 | 124 | 145 | 158 | 173 | 201 | 237 | 280 | 316 | 358 | 396 | 408 | 419 | 431 |
| | F3 | 49 | 60 | 74 | 99 | 126 | 145 | 157 | 188 | 229 | 271 | 318 | 360 | 397 | 410 | 426 | 442 |
| | Mean | 35 | 46 | 75 | 112 | 136 | 152 | 165 | 195 | 233 | 276 | 317 | 359 | 397 | 409 | 423 | 437 |
| Lower Flange | F9 | 79 | 126 | 167 | 244 | 320 | 364 | 406 | 487 | 574 | 648 | 699 | 737 | 760 | 770 | 780 | 790 |
| Cross Beam / Web Cleat Connection | | | | | | | | | | | | | | | | | |
| Cleat / Web | C1 | 33 | 48 | 63 | 97 | 132 | 152 | 172 | 217 | 278 | 344 | 406 | 465 | 517 | 534 | 550 | 565 |
| | C2 | 36 | 49 | 62 | 95 | 130 | 153 | 174 | 218 | 280 | 344 | 407 | 466 | 518 | 534 | 550 | 565 |
| | Mean | 35 | 49 | 63 | 96 | 131 | 153 | 173 | 218 | 279 | 344 | 407 | 466 | 518 | 534 | 550 | 565 |
| Bolts (Cleats / Test Beams) | | | | | | | | | | | | | | | | | |
| Upper | B1 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | B2 | 30 | 45 | 62 | 97 | 132 | 151 | 171 | 213 | 270 | 331 | 388 | 444 | 493 | 509 | 524 | 540 |
| | Mean | 30 | 45 | 62 | 97 | 132 | 151 | 171 | 213 | 270 | 331 | 388 | 444 | 493 | 509 | 524 | 540 |
| Lower | B3 | 29 | 40 | 50 | 79 | 110 | 128 | 148 | 190 | 250 | 315 | 376 | 435 | 487 | 503 | 519 | 534 |
| | B4 | 33 | 46 | 59 | 90 | 125 | 145 | 166 | 212 | 275 | 342 | 404 | 463 | 514 | 531 | 546 | 562 |
| | Mean | 31 | 43 | 55 | 85 | 118 | 137 | 157 | 201 | 263 | 329 | 390 | 449 | 501 | 517 | 533 | 548 |
| Bolts (Cleats / Cross Beam) | | | | | | | | | | | | | | | | | |
| Upper | B5 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | B6 | 29 | 40 | 50 | 74 | 102 | 119 | 136 | 172 | 222 | 277 | 333 | 385 | 436 | 453 | 469 | 486 |
| | Mean | 29 | 40 | 50 | 74 | 102 | 119 | 136 | 172 | 222 | 277 | 333 | 385 | 436 | 453 | 469 | 486 |
| Lower | B7 | 26 | 35 | 44 | 65 | 89 | 104 | 120 | 156 | 206 | 264 | 320 | 376 | 426 | 444 | 460 | 476 |
| | B8 | 32 | 42 | 51 | 71 | 93 | 110 | 126 | 160 | 209 | 263 | 321 | 379 | 432 | 449 | 467 | 484 |
| | Mean | 29 | 39 | 48 | 68 | 91 | 107 | 123 | 158 | 208 | 264 | 321 | 378 | 429 | 447 | 464 | 480 |
| Mean Furnace Gas | | 529 | 562 | 581 | 603 | 639 | 666 | 688 | 719 | 739 | 763 | 804 | 815 | 829 | 831 | 846 | 852 |
| Standard Curve | | 445 | 502 | 544 | 603 | 645 | 663 | 678 | 705 | 739 | 766 | 789 | 809 | 826 | 832 | 837 | 842 |
| Rotation (Radians x $10^{-3}$) | | | | | | | | | | | | | | | | | |
| Transducers | T1 | 0 | 0 | 0.6 | 1.2 | 3.0 | 3.0 | 3.0 | 4.8 | 7.3 | 8.5 | 12.7 | 18.1 | 15.1 | 16.3 | 16.9 | 45.3 |
| | T2 | 2.4 | 6.0 | 10.9 | 24.2 | 32.0 | 36.3 | 39.3 | 47.1 | 54.4 | 66.4 | 76.1 | 89.3 | 129 | 144 | 168 | 214 |
| | Mean | 1.2 | 3.0 | 5.8 | 12.7 | 17.5 | 19.7 | 21.2 | 26.0 | 30.9 | 37.5 | 44.4 | 53.7 | 72.1 | 80.2 | 92.5 | 129.7 |

DATA SHEET NUMBER **122C**

## BEAM / BEAM (MINOR AXIS) CONNECTION



DATA SHEET NUMBER **123A**

**BEAM / COLUMN (MINOR AXIS) CONNECTION**

DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 × 254 Column | Nominal | 73 | 254.0 | 254.0 | 8.6 | 14.2 | 894.5 | 305.0 | 988.6 | 462.4 | 11360 | 3873 |
| | Actual | | | | | | | | | | | |
| 305 × 165 Beam | Nominal | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 561.2 | 92.4 | 624.5 | 141.5 | 8523 | 763 |
| | Actual | | | | | | | | | | | |

CHEMICAL COMPOSITION (PRODUCT ANALYSIS - Wt. %)

| Section | Steel Quality | C | Si | Mn | P | S | Cr | Mo | Ni | V | Cu | Nb | Al | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Column | Grade 43A | 0.13 | 0.22 | 0.59 | 0.037 | 0.028 | 0.12 | 0.028 | 0.16 | <0.005 | 0.61 | <0.005 | 0.012 | 0.012 |
| Beam | Grade 43A | 0.17 | 0.23 | 0.64 | 0.015 | 0.017 | 0.03 | 0.005 | 0.04 | <0.005 | 0.03 | <0.005 | 0.035 | 0.0065 |

ROOM TEMPERATURE TENSILE PROPERTIES

| Position | LYS ($N/mm^2$) | UTS ($N/mm^2$) | Elongation (%) |
|---|---|---|---|
| | | | |

TEST CONDITIONS

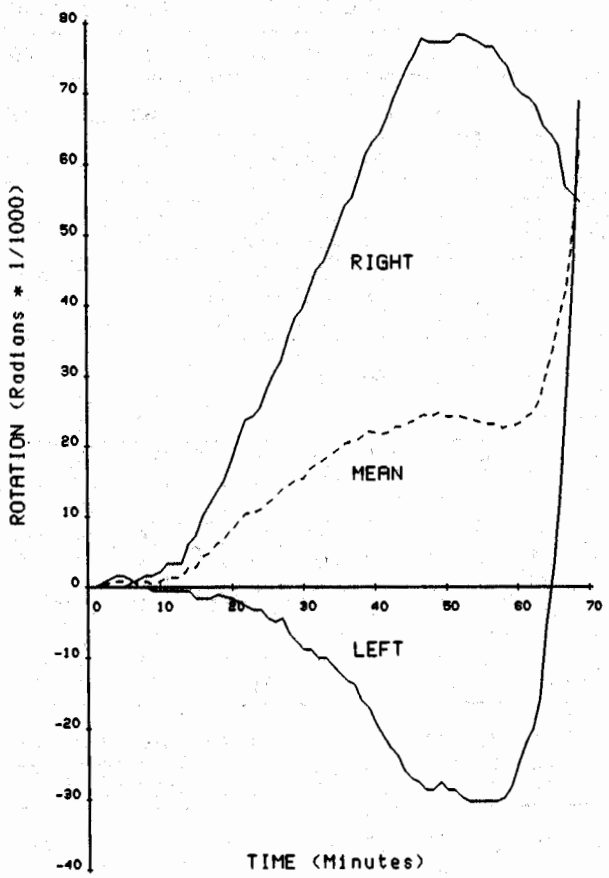
NOTES

| | | |
|---|---|---|
| TEST CENTRE : Warrington Research<br>TEST DATE : 1st March 1990<br>TEST NUMBER : WFRC 46736 | ASSESSMENT<br>LOAD BEARING CAPACITY<br>69 minutes at 0.2 $M_p$ | DATA SHEET NUMBER **123B** |

| 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 | 65 | 69 |
| Beam @ 25 mm from End Plate | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F2 | 28 | 43 | 58 | 73 | 86 | 107 | 127 | 149 | 171 | 194 | 231 | 267 | 300 | 334 | 368 | 400 | 431 | 455 |
| | F3 | 14 | 22 | 32 | 45 | 59 | 74 | 91 | 112 | 133 | 154 | 186 | 201 | 217 | 249 | 287 | 323 | 356 | 380 |
| | Mean | 21 | 33 | 45 | 59 | 73 | 91 | 109 | 131 | 152 | 174 | 209 | 234 | 259 | 292 | 328 | 362 | 394 | 418 |
| Web | W2 | 20 | 38 | 55 | 76 | 101 | 131 | 162 | 197 | 232 | 268 | 330 | 390 | 446 | 498 | 546 | 590 | 632 | 663 |
| | W3 | 20 | 33 | 55 | 83 | 106 | 133 | 162 | 193 | 223 | 254 | 307 | 359 | 406 | 451 | 495 | 539 | 583 | 615 |
| | Mean | 20 | 36 | 55 | 80 | 104 | 132 | 162 | 195 | 228 | 261 | 319 | 375 | 426 | 475 | 521 | 565 | 608 | 639 |
| Lower Flange | F6 | 23 | 43 | 63 | 91 | 121 | 156 | 194 | 234 | 272 | 311 | 375 | 436 | 494 | 547 | 596 | 640 | 680 | 708 |
| | F7 | 16 | 30 | 47 | 65 | 87 | 115 | 146 | 180 | 215 | 252 | 316 | 378 | 439 | 496 | 548 | 596 | 639 | 671 |
| | Mean | 20 | 37 | 55 | 78 | 104 | 136 | 170 | 207 | 244 | 282 | 346 | 407 | 467 | 522 | 572 | 618 | 660 | 690 |
| Beam @ 500 mm from End Plate | | | | | | | | | | | | | | | | | | | |
| Upper Flange | F1 | 12 | 16 | 19 | 26 | 33 | 40 | 48 | 57 | 65 | 73 | 87 | 100 | 109 | 118 | 131 | 150 | 169 | 183 |
| | F4 | 12 | 15 | 19 | 26 | 33 | 41 | 50 | 57 | 64 | 71 | 85 | 100 | 109 | 112 | 122 | 141 | 167 | 187 |
| | Mean | 12 | 16 | 19 | 26 | 33 | 41 | 49 | 57 | 65 | 72 | 86 | 100 | 109 | 115 | 127 | 146 | 168 | 185 |
| Web | W1 | 16 | 28 | 44 | 65 | 83 | 103 | 125 | 150 | 173 | 197 | 237 | 278 | 318 | 358 | 396 | 435 | 473 | 503 |
| | W4 | 15 | 25 | 37 | 55 | 71 | 90 | 113 | 137 | 161 | 184 | 222 | 260 | 297 | 334 | 370 | 407 | 446 | 476 |
| | Mean | 16 | 27 | 41 | 60 | 77 | 97 | 119 | 144 | 167 | 191 | 230 | 269 | 308 | 346 | 383 | 421 | 460 | 490 |
| Lower Flange | F5 | 13 | 18 | 28 | 44 | 61 | 79 | 98 | 124 | 149 | 175 | 222 | 270 | 319 | 369 | 418 | 466 | 513 | 549 |
| | F8 | 13 | 20 | 31 | 49 | 70 | 93 | 114 | 138 | 163 | 189 | 233 | 279 | 326 | 373 | 419 | 465 | 510 | 544 |
| | Mean | 13 | 19 | 30 | 47 | 66 | 86 | 106 | 131 | 156 | 182 | 228 | 275 | 323 | 371 | 419 | 466 | 512 | 547 |
| Column / End Plate Connection | | | | | | | | | | | | | | | | | | | |
| Plate / Web | P1 | 72 | 95 | 130 | 158 | 186 | 224 | 271 | 313 | 357 | 402 | 468 | 530 | 583 | 632 | 673 | 711 | 745 | 763 |
| | P2 | 33 | 51 | 74 | 110 | 144 | 183 | 226 | 273 | 319 | 367 | 442 | 509 | 566 | 618 | 662 | 701 | 736 | 753 |
| | Mean | 53 | 73 | 102 | 134 | 165 | 204 | 249 | 293 | 338 | 385 | 455 | 520 | 575 | 625 | 668 | 706 | 741 | 758 |
| Column | | | | | | | | | | | | | | | | | | | |
| Flanges | F9 | 100 | 176 | 255 | 341 | 410 | 479 | 541 | 589 | 626 | 660 | 706 | 738 | 767 | 798 | 823 | 848 | 871 | 888 |
| | F10 | 121 | 175 | 243 | 314 | 382 | 450 | 513 | 566 | 606 | 643 | 692 | 731 | 758 | 790 | 818 | 843 | 868 | 884 |
| | Mean | 111 | 176 | 249 | 328 | 396 | 465 | 527 | 578 | 616 | 652 | 699 | 735 | 763 | 794 | 821 | 846 | 870 | 886 |
| Exposed Bolts | | | | | | | | | | | | | | | | | | | |
| Upper | B1 | 30 | 48 | 70 | 99 | 129 | 162 | 197 | 232 | 267 | 303 | 362 | 416 | 465 | 509 | 552 | 591 | 627 | 655 |
| | B2 | 37 | 55 | 75 | 104 | 133 | 167 | * | * | * | * | * | * | * | * | * | * | * | * |
| | Mean | 34 | 52 | 73 | 102 | 131 | 165 | 197 | 232 | 267 | 303 | 362 | 416 | 465 | 509 | 552 | 591 | 627 | 655 |
| Lower | B3 | 26 | 46 | 71 | 109 | 147 | 192 | 239 | 289 | 338 | 388 | 467 | 537 | 600 | 652 | 697 | 734 | 760 | 784 |
| | B4 | 33 | 51 | 72 | 107 | 144 | 187 | 231 | 280 | 329 | 378 | 455 | 525 | 586 | 638 | 682 | 721 | 750 | 768 |
| | Mean | 30 | 49 | 72 | 108 | 146 | 190 | 235 | 285 | 334 | 383 | 461 | 531 | 593 | 645 | 690 | 728 | 755 | 776 |
| Mean Furnace Gas | | 562 | 603 | 666 | 719 | 739 | 763 | 804 | 815 | 829 | 852 | 868 | 892 | 906 | 915 | 934 | 959 | 971 | 979 |
| Standard Curve | | 502 | 603 | 663 | 705 | 739 | 766 | 789 | 809 | 826 | 842 | 865 | 885 | 902 | 918 | 932 | 945 | 957 | 966 |
| Rotation (Radians x $10^{-3}$) | | | | | | | | | | | | | | | | | | | |
| Transducers | T1 | 1.1 | 1.1 | -0.6 | -0.6 | -1.7 | -1.1 | -2.2 | -3.3 | -4.4 | -8.8 | -12.1 | -19.3 | -27.0 | -28.7 | -30.4 | -24.8 | 2.8 | 68.9 |
| | T2 | 0.0 | 0.6 | 1.7 | 3.4 | 7.3 | 13.5 | 20.9 | 25.4 | 32.2 | 39.5 | 51.3 | 63.1 | 73.8 | 77.2 | 77.2 | 71.0 | 64.3 | 54.7 |
| | Mean | 0.6 | 0.9 | 0.6 | 1.4 | 2.8 | 6.2 | 9.4 | 11.1 | 13.9 | 15.4 | 19.6 | 21.9 | 23.4 | 24.3 | 23.4 | 23.1 | 33.6 | 61.8 |

DATA SHEET NUMBER **123C**

## BEAM / COLUMN (MINOR AXIS) CONNECTION



DATA SHEET NUMBER **124**

INDICATIVE COLUMN WITH BLOCKED-IN WEB

FURNACE TYPE: FLOOR FURNACE
POSITION IN FURNACE: FREE STANDING ON PLINTH

TEST CENTRE : Warrington Research
TEST DATE : 25th January 1989
TEST NUMBER : WFRC 44992

DIMENSIONS AND PROPERTIES

| Section Serial Size and Type (mm) | Dimensions and Properties | Mass per Metre (kg) | Depth of Section (mm) | Width of Section (mm) | 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 ($cm^4$) |
| 356 × 406 Column | Nominal | 634 | 474.7 | 424.1 | 47.6 | 77.0 | 11592 | 4632 | 14247 | 7114 | 275140 | 98211 |
| | Actual | | | | | | | | | | | |

THERMAL DATA

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6 | 12 | 18 | 24 | 27 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 98 |
| Flanges | F1 | 32 | 88 | 157 | 226 | 260 | 294 | 349 | 404 | 457 | 506 | 550 | 588 | 624 | 659 | 690 | 717 | 740 | 762 | 813 |
| | F2 | 36 | 106 | 183 | 247 | 281 | 316 | 376 | 439 | 499 | 553 | 596 | 631 | 669 | 701 | 729 | 751 | 780 | 808 | 856 |
| | Mean | 34 | 97 | 170 | 237 | 271 | 305 | 363 | 422 | 478 | 530 | 573 | 610 | 647 | 680 | 710 | 734 | 760 | 785 | 835 |
| Flange / Web Junction | F3 | 24 | 64 | 119 | 174 | 202 | 230 | 275 | 322 | 370 | 415 | 458 | 496 | 531 | 567 | 601 | 631 | 656 | 680 | 715 |
| | F4 | 27 | 69 | 126 | 175 | 201 | 228 | 276 | 327 | 378 | 423 | 463 | 499 | 536 | 572 | 603 | 629 | 652 | 672 | 705 |
| | Mean | 26 | 67 | 123 | 175 | 202 | 229 | 276 | 325 | 374 | 419 | 461 | 498 | 534 | 570 | 602 | 630 | 654 | 676 | 710 |
| Web | W1 | 14 | 23 | 42 | 73 | 90 | 109 | 137 | 168 | 200 | 231 | 262 | 292 | 322 | 350 | 378 | 404 | 430 | 454 | 491 |
| | W3 | 14 | 24 | 47 | 82 | 99 | 110 | 140 | 171 | 204 | 234 | 265 | 295 | 325 | 355 | 382 | 410 | 435 | 458 | 495 |
| | Mean | 14 | 24 | 45 | 78 | 95 | 110 | 139 | 170 | 202 | 233 | 264 | 294 | 324 | 353 | 380 | 407 | 433 | 456 | 493 |
| Web | W2 | 10 | 13 | 25 | 48 | 62 | 77 | 103 | 133 | 161 | 189 | 217 | 246 | 274 | 301 | 327 | 354 | 379 | 404 | 443 |
| Mean Furnace Gas | | 601 | 699 | 741 | 773 | 786 | 802 | 824 | 847 | 867 | 851 | 859 | 895 | 925 | 945 | 961 | 977 | 992 | 1006 | 1027 |
| Standard Curve | | 603 | 705 | 766 | 809 | 826 | 842 | 865 | 885 | 902 | 918 | 932 | 945 | 957 | 968 | 979 | 988 | 997 | 1006 | 1019 |

NOTES

# APPENDIX 2

## THERMAL DATA ASSOCIATED WITH THE CONCRETE FLOOR SLABS

As noted in Section 3.1.4.1 thermocouples were installed at various positions within two of the concrete floor slabs in order to monitor the temperatures of the concrete, shear connectors, metal decking and mesh reinforcement. The assemblies involved were Nos. 6 and 7. Unfortunately this particular aspect of the data recording exercise was not entirely successful and consequently it did not yield as much information as was hoped for. An unusually high number of thermocouple failures were experienced, especially on Assembly No. 6. At the time, these were attributed to problems caused by either the presence of free water in the concrete, causing the thermocouples to short circuit, or mechanical damage to the wiring resulting from flexing of the floor slabs.

For these reasons the data associated with the concrete floor slabs are being presented separately.

### A2.1 ASSEMBLY NO. 6

Thermocouples were installed at 18 positions as indicated in Fig. A2.1. These may be summarised as:

- Six in the concrete at a trough position in the metal decking to give a vertical thermal profile at 20 mm increments, (T Series).
- Three in the concrete at a crest position in the metal decking to give a vertical thermal profile at 20 mm increments, (R Series).
- One in the concrete at the edge of the metal decking, (Coded RE).
- Four on shear connectors, (Coded S).
- Four on the reinforcing mesh, (Coded RF).

Of the 18 thermocouples installed only 8 are considered to have generated reliable data and these are presented in Data Sheet No. 117D.

### A2.2 ASSEMBLY NO. 7

Thermocouples were installed at the same 18 positions as described for Assembly No. 6. Only 11 are considered to have generated reliable data and these are presented in Data Sheet No. 118D.

TEST CENTRE : Warrington Research
TEST DATE : 11th January 1989
TEST NUMBER : WFRC 44519

DATA SHEET NUMBER **117D**

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 6 | 12 | 18 | 24 | 28 | 30 | 36 | 40 | 46 | 50 | 56 | 60 | 70 | 80 | 90 | 100 | 110 | 123 |
| Concrete | | | | | | | | | | | | | | | | | | | | |
| T Series | T | 77 | 183 | 352 | 484 | 581 | 645 | 670 | 730 | 759 | 809 | 840 | * | * | * | * | * | * | * | * |
| | T20 | 21 | 77 | 116 | 178 | 246 | 297 | 320 | 389 | 427 | 483 | 516 | 560 | 587 | 652 | * | * | * | * | * |
| | T40 | 12 | 32 | 107 | 117 | 124 | 147 | 170 | 233 | 272 | 323 | 353 | 389 | 411 | 466 | 521 | 572 | 640 | 690 | 742 |
| | T60 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | T80 | 10 | 10 | 103 | 103 | 103 | 103 | 103 | 104 | 108 | 110 | 112 | 125 | 138 | 171 | 211 | 249 | 296 | 331 | 390 |
| | T100 | 10 | 14 | 79 | 109 | 115 | 119 | 119 | 119 | 120 | 123 | 125 | 128 | 130 | 145 | 186 | 229 | 273 | 319 | 378 |
| R Series | R | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | R20 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | R40 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Deck Edge | RE | * | 62 | 106 | 139 | 185 | 220 | 237 | 292 | 329 | 385 | 421 | 476 | 510 | 589 | 658 | 716 | 758 | 796 | 840 |
| Shear Connectors | S1 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | S1A | 10 | 11 | 22 | 94 | 101 | 102 | 101 | 102 | 113 | 133 | 144 | 162 | 173 | 201 | 230 | 262 | 296 | 329 | 379 |
| | S2 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | S2A | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Reinforcement | RF1 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | RF1A | 10 | 20 | 25 | 36 | 52 | 60 | 62 | 73 | 82 | 92 | 99 | 110 | 117 | 118 | 120 | 122 | 128 | 140 | 166 |
| | RF2 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | RF2A | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |

TEST CENTRE : Warrington Research
TEST DATE : 18th January 1989
TEST NUMBER : WFRC 44175

DATA SHEET NUMBER **118D**

| THERMOCOUPLE LOCATION | | TEMPERATURE Deg. C AFTER VARIOUS TIMES (MINUTES) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 6 | 12 | 18 | 24 | 27 | 30 | 36 | 40 | 46 | 50 | 56 | 60 | 70 | 80 | 90 | 100 | 111 |
| Concrete | | | | | | | | | | | | | | | | | | | |
| T Series | T | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | T20 | 17 | 90 | 105 | 103 | 147 | 200 | 239 | 317 | 365 | 426 | 461 | 508 | 537 | 598 | 652 | 703 | 753 | 838 |
| | T40 | 14 | 34 | 105 | 104 | 106 | 110 | 120 | 171 | 203 | 252 | 284 | 330 | 357 | 418 | 475 | 532 | 590 | 777 |
| | T60 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | T80 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | T100 | 14 | 15 | 103 | 105 | 106 | 106 | 106 | 106 | 106 | 106 | 105 | 105 | 110 | 131 | 164 | 205 | 264 | 438 |
| R Series | R | 16 | 58 | 86 | 95 | 101 | 106 | 123 | 166 | 185 | 209 | 221 | 242 | 255 | 292 | 328 | 367 | 414 | 512 |
| | R20 | 13 | 17 | 35 | 51 | 85 | 94 | 94 | 93 | 93 | 94 | 99 | 103 | 103 | 123 | 147 | 179 | 218 | 275 |
| | R40 | 14 | 14 | 23 | 34 | 58 | 71 | 77 | 85 | 88 | 90 | 92 | 95 | 96 | 101 | 106 | 116 | 144 | 184 |
| Deck Edge | RE | * | * | 102 | 111 | 122 | 129 | 141 | 175 | 192 | 215 | 229 | 251 | 264 | 299 | 333 | 367 | 399 | 481 |
| Shear Connectors | S1 | 14 | 15 | 38 | 103 | 103 | 103 | 103 | 104 | 107 | 118 | 125 | 138 | 147 | 174 | 206 | 238 | 273 | 314 |
| | S1A | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | S2 | 14 | 15 | * | 49 | 76 | 85 | 92 | 105 | 106 | 107 | 121 | 136 | 155 | 187 | 221 | 254 | 286 | 318 |
| | S2A | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Reinforcement | RF1 | 13 | 13 | 13 | 23 | 46 | 59 | 67 | 79 | 83 | 88 | 91 | 94 | 96 | 98 | 102 | 104 | 105 | 110 |
| | RF1A | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | RF2 | 14 | 14 | 37 | 69 | 85 | 90 | 93 | 98 | 102 | 105 | 104 | 105 | 105 | 117 | 148 | 180 | 215 | 263 |
| | RF2A | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |

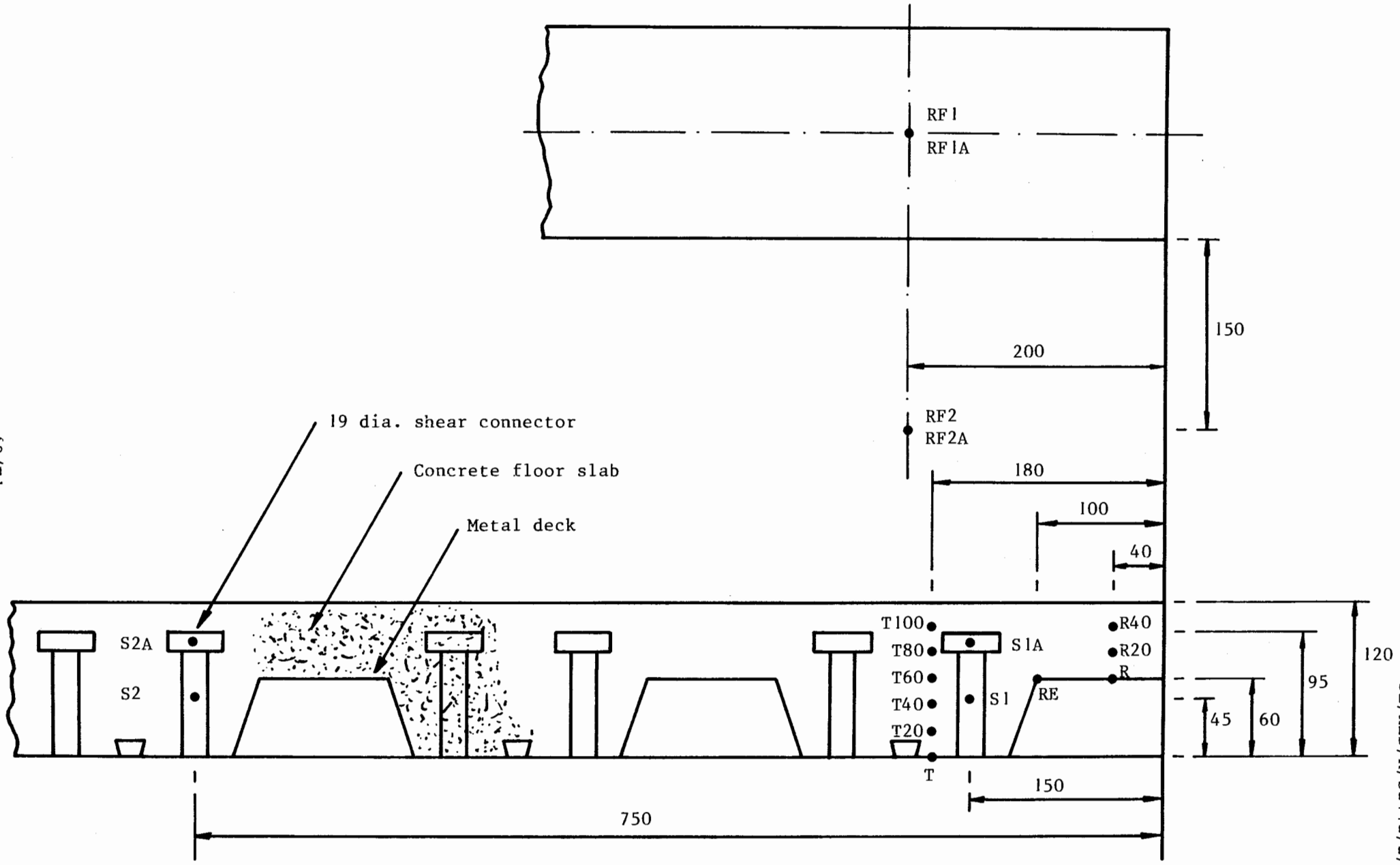



FIG. A2.1 CONCRETE, SHEAR STUD AND REINFORCEMENT THERMOCOUPLE POSITIONS (R4/3668A)

# APPENDIX 3

## SUMMARY OF LOADS ON JACKS (TEST ASSEMBLIES 1-8)

### A3.1 NON-COMPOSITE BEAM ASSEMBLIES

Floor slab width = 620 mm
Floor slab depth = 120 mm

Density of normal weight concrete assumed to be 2400 kg/m$^3$.

Self weight of floor slab = $0.12 \times 0.62 \times 2400$ kg/m
= 178.56 kg/m

Self weight of steel beam = 40 kg/m

Total self weight of system = 178.56 + 40 kg/m
= 218.56 kg/m
= 2.143 kN/m

Beam length = 1280 mm

Moment due to self weight = $2.143 \times (1.28)^2 / 2$ kN m
= 1.756 kN m

### A3.1.1 Assembly No. 1

Applied moment required = $0.4\ M_p$

where $M_p$ is the plastic moment capacity of the steel beam = 171.6 kN m (assuming specified grade of steel).

Test moment = $0.4 \times 171.6$ kN m
= 68.64 kN m

$P \times \ell a$ = 68.64 - 1.756 kN m
= 66.884 kN m

Lever arm, $\ell a$, = 980 mm

$\therefore$ P = 66.884 / 0.98 kN
= 68.249 kN
= 6.96 tonnes

After 45 minutes the load was reduced to 0.3 $M_p$.

Test moment = $0.3 \times 171.6$ kN m
= 51.48 kN m

$P \times \ell a$ = 51.48 - 1.756 kN m
= 49.724 kN m

The lever arm remained at 980 mm.

$\therefore$ P = 49.724 / 0.98 kN
= 50.739 kN
= 5.17 tonnes

Notes

Initial Loading

Test load applied was 6.9 tonnes
Lever arm was 980 mm
Actual test moment = 0.397 $M_p$

Reduced Loading

Test load applied was 5.1 tonnes
Lever arm was 980 mm
Actual test moment = 0.296 $M_p$

**A3.1.2 Assembly No. 2**

Applied moment required = 0.2 $M_p$

Test moment = 0.2 × 171.6 kN m
= 34.32 kN m

P × $\ell$a = 34.32 - 1.756 kN m
= 32.564 kN m

Lever arm, $\ell$a, = 490 mm

$\therefore$ P = 32.564 / 0.49 kN
= 66.457 kN
= 6.78 tonnes

Note

Test load applied was 6.7 tonnes
Lever arm was 490 mm
Actual test moment = 0.198 $M_p$

**A3.1.3 Assembly No. 3**

Moments and jack force calculations as for Assembly No. 2.

Test load applied was 6.7 tonnes
Lever arm was 490 mm
Actual test moment = 0.198 $M_p$

**A3.1.4 Assembly No. 4**

Moments and jack force calculations as for Assembly No. 2.

Test load applied was 6.7 tonnes
Lever arm was 490 mm
Actual test moment = 0.198 $M_p$

### A3.1.5 Assembly No. 5

Applied moment required = $0.1\ M_p$

Test moment = $0.1 \times 171.6$ kN m
= 17.16 kN m

$P \times \ell a$ = 17.16 - 1.756 kN m
= 15.404 kN m

Lever arm, $\ell a$, = 490 mm

$\therefore$ P = 15.404 / 0.49 kN
= 31.437 kN
= 3.21 tonnes

Notes

Test load applied was 3.3 tonnes
Lever arm was 490 mm
Actual test moment = $0.103\ M_p$

## A3.2 COMPOSITE BEAM ASSEMBLIES

Floor slab width = 1000 mm
Average floor slab thickness = 120 - 30 mm
= 90 mm

Density of light-weight concrete assumed to be 1200 kg/m$^3$.

Self weight of floor slab = $0.09 \times 1.0 \times 1200$ kg/m
= 108.0 kg/m

Self weight of steel beam = 40 kg/m

Self weight (steel + concrete) = 108.0 + 40 kg/m
= 148.0 kg/m
= 1.451 kN/m

Allow 0.14 kN/m for weight of steel decking.

Total self weight of system = 1.591 kN/m

Moment due to self weight = $1.591 \times (1.28)^2 / 2$ kN m
= 1.303 kN m

### A3.2.1 Assembly No. 6

Applied moment required = $0.4\ M_p$

Test moment = $0.4 \times 171.6$ kN m
= 68.64 kN m

$P \times \ell a$ = 68.64 - 1.303 kN m
= 67.337 kN m

Lever arm, $\ell a$, = 980 mm

$\therefore$ P = 67.337 / 0.98 kN
= 68.711 kN
= 7.0 tonnes

After 100 minutes the load was reduced to 0.3 $M_p$.

Test moment = 0.3 × 171.6 kN m
= 51.48 kN m

P × $\ell a$ = 51.48 - 1.303 kN m
= 50.177 kN m

The lever arm remained at 980 mm.

$\therefore$ P = 50.177 / 0.98 kN
= 51.201 kN
= 5.22 tonnes

Notes

Initial Loading

Test load applied was 6.7 tonnes
Lever arm was 980 mm
Actual test moment = 0.383 $M_p$

Reduced Loading

Test load applied was 5.0 tonnes
Lever arm was 980 mm
Actual test moment = 0.288 $M_p$

**A3.2.2 Assembly No. 7**

Applied moment required = 0.2 $M_p$

Test moment = 0.2 × 171.6 kN m
= 34.32 kN m

P × $\ell a$ = 34.32 - 1.303 kN m
= 33.017 kN m

Lever arm, $\ell a$, = 490 mm

$\therefore$ P = 33.017 / 0.49 kN
= 67.382 kN
= 6.87 tonnes

Note

Test load applied was 6.6 tonnes
Lever arm was 490 mm
Actual test moment = 0.192 $M_p$

### A3.2.3 Assembly No. 8

Moments and jack force calculations as for Assembly No. 7.

After 70 minutes the load was reduced to 0.1 $M_p$.

Test moment = 0.1 × 171.6 kN m
= 17.16 kN m

$P \times \ell a$ = 17.16 - 1.303 kN m
= 15.857 kN m

The lever arm remained at 490 mm.

$\therefore$ P = 15.857 / 0.49 kN
= 32.361 kN
= 3.3 tonnes

Notes

Initial Loading

Test load applied was 6.6 tonnes
Lever arm was 490 mm
Actual test moment = 0.192 $M_p$

Reduced Loading

Test load applied was 3.0 tonnes
Lever arm was 490 mm
Actual test moment = 0.092 $M_p$

# APPENDIX 4

## PC DISK VERSION OF DATA

As mentioned in the Introduction to this report the data recorded during each of the twelve fire tests on connected assemblies 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 112.DAT to 124.DAT inclusive. This numbering system is consistent with that introduced in reference 1. Thus, for example, data from test number WFRC 46733 can be found in data files 120.DAT and 121.DAT, (since two assemblies were tested simultaneously). For each individual assembly 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.120, which relates to data in file 120.DAT, is shown in Fig. A4.1.

It may be seen by reference to the data presented in Appendix 1 that there have been occasions when no temperature or deflection 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', Report SL/HED/R/S2298/1/92/C, British Steel Technical, Swinden Laboratories, 1992.

# TABLE A4.1
# README FILE ASSOCIATED WITH DATA FILE 120.DAT

Data file 120.DAT contains data recorded during the ad-hoc fire resistance test number WFRC 46733 / ASSEMBLY No. 9 which is described in report number SL/HED/R/S2442/2/95/C - "SUMMARY OF DATA OBTAINED DURING TESTS ON BOLTED BEAM / COLUMN AND BEAM / BEAM CONNECTIONS" and should be read in conjunction with that document.

There are 29 items of data which, together with their mean values, are grouped in sets as shown below.

| SET NUMBER | ITEMS IN COLUMNS |
|---|---|
| SET001.DAT | TIME, W2, W3, MEAN(2+3), F6, F7, MEAN(6+7) |
| SET002.DAT | TIME, F1, F4, MEAN(1+4), W1, W4, MEAN(1+4), F5, F8, MEAN(5+8) |
| SET003.DAT | TIME, F2, F3, MEAN(2+3), F9, P1, P2, MEAN(1+2) |
| SET004.DAT | TIME, B1, B2, MEAN(1+2), B3, B4, MEAN(3+4) |
| SET005.DAT | TIME, ISO, ATM1, ATM2, ATM3, ATM4, ATM5, ATM6, MEAN ATM |
| SET006.DAT | TIME, T1, T2, MEAN(1+2) |