BS476: Part 21 Fire Resistance Tests

Summary of Data Obtained During a Test on an Arched Metal Deck Floor Beam

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SUMMARY

BS476:PART 21 FIRE RESISTANCE TESTS

SUMMARY OF DATA OBTAINED DURING A TEST ON AN ARCHED METAL DECK FLOOR BEAM

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. 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 fourth report issued as part of that series. It contains a detailed description of the design, instrumentation and construction for a single test assembly, usually referred to as an 'arched metal deck floor beam', together with the data arising from it. The test was carried out at the Warrington Fire Research Centre.

The serial size for the steel section used was 406 x 178 mm x 54 kg/m UB. The steel grade was BS4360:Grade 43A (now BS EN 10025 S275). The section was loaded so as to develop a bending stress of 165 N/mm², (the maximum likely service stress for such a section), in the lower flange. The performance of the test assembly was judged against the load bearing capacity criterion outlined in Section 5 of BS476:Part 21:1987. The fire resistance rating for the assembly was found to be 190 minutes.

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26
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+BS 5950
+BS 449
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Lab Reports

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BS476:PART 21 FIRE RESISTANCE TESTS

SUMMARY OF DATA OBTAINED DURING A TEST ON AN ARCHED METAL DECK FLOOR BEAM

1. INTRODUCTION

Between 1989 and 1993 more than 30 full scale fire resistance tests were carried out on a wide range of structural assemblies. The major features of all the tests were summarised in an earlier Technical Note[1]. Data obtained during the tests are being presented in a series of reports, each of which is concerned with either a different form of construction or a generically similar group of test assemblies. The first report in the series was issued in 1993[2] and included material relating to eight flange plated slim floor beams. The second report[3] gave details relating to five web encased column assemblies. In the most recent report[4] material concerning tests on connections between beams and columns was presented.

This is therefore the fourth report issued as part of that ongoing series. It contains a detailed description of the design, instrumentation and construction for a single test assembly, together with the data arising from it which are included in Appendix 1. The test assembly was a steel and concrete composite floor slab construction which is usually referred to as an 'arched metal deck floor'. The data are presented in a format which is generally consistent with that of the earlier publications. As before, no analysis of the data is included since this has already been incorporated into other publications dealing with design aspects of the form of construction. The numerical sequence of the data sheets has been maintained, the one in this document being numbered 125. As in the previous compendia and reports the thermal data are reduced to summary values at various times throughout the duration of the test. It should be noted, however, that all the thermal data, usually recorded at one minute intervals, can be made available on a PC disk. This may be obtained, on request, from British Steel, Swinden Technology Centre.

The work reported here forms 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. TEST ASSEMBLY WFCR 50427

The test assembly consisted of a 5 metre length of 406 x 179 mm x 54 kg/m universal beam which was encased within Grade 30 lightweight aggregate concrete. The concrete was supported on QUICKSPAN Q51 galvanised mild steel profiled decking having a gauge thickness of 1.2 mm. The decking sheets were positioned so that they rested on the lower flange of the steel section and were inclined upwards at approximately 30° with respect to that flange. The sheets were overlapped and fixed together using steel rivets.

The lightweight concrete contained LYTAG aggregate at a nominal 12 mm sieve size. It was poured in-situ around the beam filling the cavity created by the Q51 decking and the beam. The concrete was cast in accordance with a specification given by BORAL / LYTAG and to BS5110:Parte 1 and 2:1985, 'The Structural Use of Concrete'. The formwork was arranged so as to produce a composite steel/concrete assembly which was 1000 mm wide across the top surface, 150 mm deep at the edges, with a 50 mm thickness of concrete cover to the upper flange of the beam. A layer of A142 steel reinforcing mesh was also incorporated into the concrete slab.
Dimensional details for the OVIKSPAN Q51 decking are given in Fig. 1. A transverse section through the assembly showing the arrangement of the various components is given in Fig. 2. The steel section used in the construction of the test assembly was manufactured by British Steel and supplied to the requirements of BS4360:Grade 43A. Details of its chemical composition and mechanical properties are included in Data Sheet No. 125A in Appendix 1.

The concrete was cast during April 1990 and was allowed to cure naturally until four weeks prior to the test. The assembly was then placed in an atmosphere controlled by a de-humidifier until the test date. Samples of the concrete were taken at the time of casting. The density and moisture content, measured on the day of the test, were reported as being:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>1860 kg/m³</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>5.0% w/w</td>
</tr>
</tbody>
</table>

The compressive, (crushing), strength measured 28 days after casting was reported to be 30 N/mm².

3. **Dimensions and Section Properties**

The nominal dimensions and section properties, as specified in BS4:Part 1:1969 for the steel beam used in the construction of the test assembly are included in Data Sheet No. 125A. The actual dimensions of the section are also given, together with the calculated section properties.

4. **Instrumentation**

The test assembly was instrumented such that the temperature attained by the steel section could be recorded throughout the duration of the heating period. For this purpose seventeen 3 mm diameter mineral insulated 'K' type thermocouples (Ni-Cr/Ni-Al), with insulated hot junctions and Inconel 600 sheaths were used. The thermocouples were embedded to the mid-thickness position in the steel section. The thermocouple positions were as shown in Fig. 3. (longitudinal arrangement), and Fig. 4. (transverse arrangement).

Thermocouples of the same type were installed by WTRC for monitoring the temperature of the furnace atmosphere. These were situated at eight positions within the furnace, being evenly distributed on each side of the assembly, level with the soffit of the beam and 190 mm away from it.

Provision was also made for monitoring the vertical deflection of the assembly throughout the test. These measurements were made at the geometric centre of the upper, (concrete), surface using a displacement transducer connected to the WTRC data logging facility. The deflection values recorded are included in Data Sheet No. 125B in Appendix 1.

5. **Assembly**

The test assembly was positioned so as to form part of the roof of the floor furnace at WTRC. It was simply supported on a refractory lined steel loading frame so as to give a total effective span between the roller supports of 4500 mm. The frame was supported on the outer walls of the gas fired furnace so that the length of beam actually exposed to the heating conditions of the test was 4000 mm.
LOADING

A total imposed load of 24.34 tonnes was applied to the steel section by means of four hydraulic rams positioned along the centre line of the web and at points corresponding to $\gamma_1$, $\gamma_2$, $\gamma_3$, and $\gamma_4$ of the supported span. The applied load, together with the self weight of the system, was intended to develop a bending stress of 165 N/mm² in the lower flange of the steel section. This is the maximum allowable bending stress for a BS4360:Grade 43A steel section according to the design rules in BS446:Part 2:1989. The applied load was kept constant for the total test duration of 190 minutes.

The load to be applied to the test assembly was initially calculated on the basis of the nominal dimensions and section properties for the steel member concerned. These calculations were subsequently repeated to take account of the actual dimensions and mechanical properties of the section. Calculations relating to the applied load level are given in Appendix 2. A comparison of the calculation data to BS5950:Part 1:1985 is also included.

FAILURE CRITERIA

The performance of the test assembly was judged against the load bearing capacity criterion outlined in Section 5 of BS476:Part 21:1987. The maximum allowable deflection and the maximum allowable rate of deflection for the test assembly, as specified by the standard, were calculated to be 225 mm, (span / 20), and 5.5 mm/min, (span²/8000 X D), respectively, where $D = 405$ mm, the measured depth of the section. The allowable rate of deflection criterion is not applicable until the deflection exceeds span / 30, i.e. 150 mm. At the termination of the test after 190 minutes the maximum deflection of the assembly was recorded as being only 67 mm.

CONCLUSIONS

1. Data arising from a standard fire resistance test carried out on an arched metal deck floor system have been collected and reported. Details of the test assembly are given, together with a summary of the material properties, structural calculations and the thermal data recorded.

2. The performance of the test assembly was judged against the load bearing capacity criterion outlined in Section 5 of BS 476:Part 21:1987. The fire resistance rating for the assembly was found to be 190 minutes which was the time at which the test was terminated. The measured central vertical displacement of the assembly at this time was only 67 mm.

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Manager
Heavy Engineering & Design Department

D.J. Price
Research Manager
General Steel Products
REFERENCES


DIMENSIONAL DETAILS FOR THE QUICKSPAN GS1 PROFILED STEEL DECKING

FIG. 1
FIG. 2

Schematic Arrangement of Components
Test No. WFRG-5042 (Transverse Section)
(Based on Nominal Dimensions)

Load

1000

400 x 178 x 54 UB

Grade 30 Lightweight Lying Concrete

A142 Mesh 200 x 200 x 6

Chilean Gr1 12 mm Gauge

403

50

178

150

(All dimensions in mm)
FIG. 4  THERMOCOUPLE POSITIONS IN THE STEELWORK - TRANSVERSE ARRANGEMENT IN DIRECTION OF ARROW 'X' IN FIG. 3

(G1066B02)
APPENDIX 1

DATA SHEET NO. 125
### ARCHED METAL DECK FLOOR BEAM

**DIMENSIONS AND PROPERTIES**

<table>
<thead>
<tr>
<th>Section</th>
<th>Mass per Metre (kg)</th>
<th>Depth of Section (mm)</th>
<th>Width of Section (mm)</th>
<th>Thickness (mm)</th>
<th>Elastic Modulus Axial (x) (GPa)</th>
<th>Elastic Modulus Axial (y) (GPa)</th>
<th>Moment of Inertia Axial (x) (cm⁴)</th>
<th>Moment of Inertia Axial (y) (cm⁴)</th>
</tr>
</thead>
<tbody>
<tr>
<td>406 x 178 Beam</td>
<td>54</td>
<td>402.5</td>
<td>177.5</td>
<td>7.5</td>
<td>10.3</td>
<td>925.3</td>
<td>177.5</td>
<td>18.885</td>
</tr>
<tr>
<td>54.4</td>
<td>405</td>
<td>177</td>
<td>8.08</td>
<td>10.57</td>
<td>922.8</td>
<td>110.6</td>
<td>1053</td>
<td>177.5</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Section</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>V</th>
<th>Cu</th>
<th>Nb</th>
<th>Al</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Grade 43A</td>
<td>0.11</td>
<td>0.31</td>
<td>1.30</td>
<td>0.02</td>
<td>0.02</td>
<td>&lt;0.02</td>
<td>&lt;0.005</td>
<td>0.03</td>
<td>&lt;0.005</td>
<td>0.0048</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ROOM TEMPERATURE TENSILE PROPERTIES**

<table>
<thead>
<tr>
<th>Position</th>
<th>LYS (N/mm²)</th>
<th>UTS (N/mm²)</th>
<th>Elongation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flange</td>
<td>330</td>
<td>484</td>
<td>36</td>
</tr>
</tbody>
</table>

**NOTES**

(a) Initial ambient temperature = 24°C.
(b) Based on an initial ambient temperature of 20°C.

---

SLHED/R/S2442/3/96/C
<table>
<thead>
<tr>
<th>THERMOCOUPLE LOCATION</th>
<th>TEMPERATURE Dev. C AFTER VARIOUS TIMES (MINUTES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Upper Flange</td>
<td></td>
</tr>
<tr>
<td>F3</td>
<td>19</td>
</tr>
<tr>
<td>F5</td>
<td>19</td>
</tr>
<tr>
<td>F8</td>
<td>19</td>
</tr>
<tr>
<td>F9</td>
<td>20</td>
</tr>
<tr>
<td>Mean</td>
<td>19</td>
</tr>
<tr>
<td>Upper Web</td>
<td></td>
</tr>
<tr>
<td>W6</td>
<td>20</td>
</tr>
<tr>
<td>Mean</td>
<td>20</td>
</tr>
<tr>
<td>Centre Web</td>
<td></td>
</tr>
<tr>
<td>W1</td>
<td>20</td>
</tr>
<tr>
<td>W2</td>
<td>20</td>
</tr>
<tr>
<td>W3</td>
<td>20</td>
</tr>
<tr>
<td>W4</td>
<td>20</td>
</tr>
<tr>
<td>Mean</td>
<td>20</td>
</tr>
<tr>
<td>Lower Web</td>
<td></td>
</tr>
<tr>
<td>W5</td>
<td>21</td>
</tr>
<tr>
<td>W7</td>
<td>21</td>
</tr>
<tr>
<td>Mean</td>
<td>21</td>
</tr>
<tr>
<td>Lower Flange</td>
<td></td>
</tr>
<tr>
<td>F1</td>
<td>134</td>
</tr>
<tr>
<td>F2</td>
<td>100</td>
</tr>
<tr>
<td>F3</td>
<td>122</td>
</tr>
<tr>
<td>F4</td>
<td>95</td>
</tr>
<tr>
<td>F5</td>
<td>148</td>
</tr>
<tr>
<td>Mean</td>
<td>121</td>
</tr>
<tr>
<td>Mean Furnace Gas (a)</td>
<td>468</td>
</tr>
<tr>
<td>Standard Curve (b)</td>
<td>502</td>
</tr>
<tr>
<td>Deflection (mm)</td>
<td>-</td>
</tr>
</tbody>
</table>
APPENDIX 2

LOAD CALCULATION SUMMARY SHEETS

A2.1 TEST NO. WFRC 50427 ON 7 AUG 1990
A2.2 CALCULATIONS BASED ON BS449:PART 2:1969
A2.3 CALCULATIONS BASED ON BS5950:PART 1:1985
A2.4 COMPARISON OF LOADINGS
A2.1 TEST NO. WFRC 50427 ON 7 AUG 1990

A2.1.1 Geometry

Figure 2 gives the relevant details

A2.1.2 Material Properties

(a) Steel

Universal Beam - 406 x 178 mm x 54 kg/m
Steel Grade - BS4360 Grade +3A

(b) Summary of Nominal and Actual Dimensions and Properties

<table>
<thead>
<tr>
<th></th>
<th>Nominal</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of Section h (mm)</td>
<td>402.6</td>
<td>405</td>
</tr>
<tr>
<td>Breadth of Section b (mm)</td>
<td>177.6</td>
<td>177</td>
</tr>
<tr>
<td>Thickness of Flange t (mm)</td>
<td>10.9</td>
<td>10.57</td>
</tr>
<tr>
<td>Thickness of Web z (mm)</td>
<td>7.6</td>
<td>8.08</td>
</tr>
<tr>
<td>Area of Section A (mm²)</td>
<td>6 840</td>
<td>6 933</td>
</tr>
<tr>
<td>Mass m (kg/m)</td>
<td>54</td>
<td>54.42</td>
</tr>
<tr>
<td>Weight m (N/m)</td>
<td>530</td>
<td>534</td>
</tr>
<tr>
<td>Distance of Neutral Axis from Base of Beam y (mm)</td>
<td>201.3</td>
<td>202.5</td>
</tr>
<tr>
<td>Effective Span of Beam L (mm)</td>
<td>4 500</td>
<td>4 500</td>
</tr>
<tr>
<td>Moment of Inertia (z-x) i (cm⁴)</td>
<td>10 626</td>
<td>10 866</td>
</tr>
<tr>
<td>Elastic Modulus (z-x) E (10⁶ N/mm²)</td>
<td>963.3</td>
<td>922.8</td>
</tr>
<tr>
<td>Plastic Modulus (x-x) S (cm³)</td>
<td>1 048</td>
<td>1 053</td>
</tr>
<tr>
<td>Modulus of Elasticity E (10⁶ N/mm²)</td>
<td>205</td>
<td>205</td>
</tr>
</tbody>
</table>

(c) Concrete

The maximum moisture content of the concrete, measured on the day of the test, was found to be 6.0%. The characteristic strength of the concrete was accepted as being 30 N/mm² based on the results from the 28 day cube strength tests. The density was reported to be 1860 kg/m³ which is approximately 77.5% of typical normal weight concrete density of 2400 kg/m³.

A2.2 CALCULATIONS BASED ON BS449:PART 2:1969

A2.2.1 Calculations Using Nominal Dimensions and Properties

Maximum allowable bending stress, Table 2, (for steel with a minimum yield stress of 275 N/mm²):

\[ f_{max} = 165 \text{ N/mm}^2 \]

Percentage of allowable bending stress required during the test is 100%.
Therefore, bending stress required is 165 N/mm²

\[
t = 165 \text{ N/mm}^2
\]

The required bending moment is given by \((ft)/y\).

\[
f \frac{t}{y} = \frac{wL^2}{8}
\]

Therefore, \(w\), the load per metre run, \((\text{in N/m})\), is given by:

\[
w = \frac{8ft}{yL^2}
\]

\[
= \frac{8 \times 165 \times 18,668 \times 10^7}{201.3 \times 4500 \times 4500} \text{ N/m}
\]

\[
= 60,315 \text{ N/m}
\]

For the Light-Weight Concrete Slab.

Based on the dimensional data given in Fig. 2 the area of cross section is 0.3035 m².

Density of concrete is 1660 kg/m³.

Therefore the concrete load per metre run is given by:

\[
w_{con} = 0.3035 \times 1860 \text{ kg/m}
\]

\[
= 564.51 \text{ kg/m}
\]

\[
= 5536 \text{ N/m}
\]

Total Self Weight of Beam and Concrete Slab, (Dead Load).

\[
w_t = 550 + 5536 \text{ N/m}
\]

\[
= 6086 \text{ N/m}
\]

Total load to produce required bending stress

\[
w_z = 60,315 - 6086 \text{ N/m}
\]

\[
= 54,247 \text{ N/m}
\]

Therefore total imposed load

\[
W = 54,247 \times 4.5 \text{ N}
\]

\[
= 244,112 \text{ N}
\]

\[
= 244.11 \text{ kN}
\]

A2/5
Using four point loads at \( y_1, y_2, y_3 \) and \( y_4 \) of the supported span, equivalent to \( W/4 \).

**Point Loads Required are:**

\[
P = \frac{244.11}{4} \text{ kN} \quad \text{(i.e. 24 864 / 4 kg)}
\]
\[
P = 61.03 \text{ kN} \quad \text{(i.e. 6221 kg)}
\]
\[
6.22 \text{ tonnes}
\]

The total load actually applied was 24.34 tonnes.

### A2.2.2 Retrospective Calculations Using Actual Dimensions and Properties

The required bending moment is given by \( f_1(y) \)

\[
f_1(y) = \frac{wL^2}{y}
\]

Therefore, \( w \), the load per metre run, (in N/m), is given by

\[
w = \frac{8 f_1(y) L^2}{202.5 \times 4500 \times 4500} \text{ N/m} \quad \ldots (A2/1)
\]

Since the load actually applied was 24.34 tonnes

\[
W = 24340 \text{ kg}
\]
\[
W = 238775 \text{ N}
\]

and therefore the total load generating the bending stress is

\[
w_s = \frac{238775}{4.5} \text{ N/m}
\]
\[
w_s = 53061.2 \text{ N/m}
\]

But the total self-weight of the Beam and Concrete Slab is given by

\[
w_1 = 534 + 5538 \text{ N/m}
\]
\[
w_1 = 6072 \text{ N/m}
\]

Therefore the load available to generate a bending moment is

\[
w = 53061.2 + 6072 \text{ N/m}
\]
\[
w = 59133.2 \text{ N/m}
\]

A2/4
Substituting $w$ in the earlier expression (A2/1) we have:

$$59 \text{ 133.}2 = \frac{8 \times 18 \text{ 686} \times 10^7}{202.5 \times 4500 \times 4500} \text{ N/mm}^2$$

$$\therefore f = \frac{59 \text{ 133.}2 \times 202.5 \times 4500 \times 4500}{8 \times 18 \text{ 686} \times 10^7} = 162.2 \text{ N/mm}^2$$

The retrospective calculation, based on actual dimensions and properties, suggests that the steel section was loaded to 98.3% of the maximum allowable bending stress (BS449 Design Rules).

A2.3 CALCULATIONS BASED ON BS5950:PART 1:1985

A2.3.1 Initial Calculations Using Nominal Dimensions and Properties

(a) Moment Capacity of beam for a plastic or compact section, with assumed low shear load,

$$M_s = p_s S \quad \text{but} \leq 1.2 p_s Z$$

$$= 275 \times 1048 \times 10^3 \text{ kN m}$$

$$= 288.2 \text{ kN m}$$

Check whether $p_s S \leq 1.2 p_s Z$

$$1.2 p_s Z = 1.2 \times 275 \times 925.3 \times 10^3 \text{ kN m}$$

$$= 306.3 \text{ kN m}$$

So $p_s S$ is less than $1.2 p_s Z$

(b) From A2.2.1, Self Weight of beam and Concrete Slab, (dead load), is 6068 N/m

So $w_i = 6.068 \text{ kN/m}$

Moment produced by dead load is given by

$$\text{Moment}_i = \frac{(w_i L^2)}{8} \text{ kN m}$$

$$= \frac{6.068 \times 4.5 \times 4.5}{8} \text{ kN m}$$

$$= 15.360 \text{ kN m}$$

From A2.2.1, Total Imposed Load is 244 112 N.

So $W = 244.112 \text{ kN}$
Assuming a uniformly distributed load, the moment produced by the imposed load is given by

\[
\text{Moment}_2 = \frac{(WL)}{8} \text{ kN m}
\]

\[
= \frac{244.112 \times 4.5}{8} \text{ kN m}
\]

\[
= 137.313 \text{ kN m}
\]

Total Moment Applied, (dead + imposed loads)

\[
M_t = 15.36 + 137.313 \text{ kN m}
\]

\[
= 152.673 \text{ kN m}
\]

Since \(M_t\) also equals the applied moment at the fire limit state, \(M_s\), then the load ratio is

\[
LR = \frac{M_t}{M_s}
\]

\[
= 152.673 / 288.2
\]

\[
= 0.530
\]

(c) Check Shear Force, \((F_s)\), does not exceed shear capacity, \((P_v)\)

Maximum Shear Force at the ends

\[
F_v = \frac{WL}{2}
\]

\[
= \frac{(60.315 \times 4.5)}{2} \text{ kN}
\]

\[
= 135.71 \text{ kN}
\]

Shear Capacity

\[
P_v = 0.6 P_f A_s
\]

where \(A_s\) is the shear area.

For an I section \(A_s = h \times s\)

\[
\therefore P_v = 0.6 \times 275 \times 402.6 \times 7.6 \times 10^3 \text{ kN}
\]

\[
= 504.86 \text{ kN}
\]

Therefore since \(F_v < P_v\) the low shear load calculation, (a), is acceptable.
A2.3.2 Calculations Using Actual Dimensions and Properties

(a) Moment Capacity of Beam for a plastic or compact section, with assumed low shear load.

\[ M_s = p_s S \text{ but } \leq 1.2 p_s Z \]
\[ = 335 \times 1053 \times 10^9 \text{ kN m} \]
\[ = 352.76 \text{ kN m} \]

Check whether \( p_s S \leq 1.2 p_s Z \)

\[ 1.2 p_s Z = 1.2 \times 335 \times 922.8 \times 10^9 \text{ kN m} \]
\[ = 370.97 \text{ kN m} \]

So \( p_s S \) is less than \( 1.2 p_s Z \).

(b) From A2.2.2, Self Weight of beam and concrete slab, (dead load), is 6072 N/m.

So \( w_1 = 6.072 \text{ kN/m} \)

Moment produced by dead load is given by

\[ \text{Moment}_1 = \frac{(w_1 L^2)}{8} \text{ kN m} \]
\[ = \frac{6.072 \times 4.5 \times 4.5}{8} \text{ kN m} \]
\[ = 15.37 \text{ kN m} \]

From A2.2.2 Total imposed load is 238 775 N.

So \( W = 238.775 \text{ kN} \)

Assuming a uniformly distributed load, the moment produced by the imposed load is given by

\[ \text{Moment}_2 = \frac{(WL)}{8} \text{ kN m} \]
\[ = \frac{238.775 \times 4.5}{8} \text{ kN m} \]
\[ = 134.311 \text{ kN m} \]

Total Moment Applied, (dead + imposed loads)

\[ M_s = 15.37 + 134.311 \text{ kN m} \]
\[ = 149.681 \text{ kN m} \]

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and therefore the load ratio given by

\[ LR = \frac{M_p}{M_o} \]

\[ = \frac{149.681}{352.76} \]

\[ = 0.424 \]

A2.4 COMPARISON OF LOADINGS

A2.4.1 BS449:Part 2:1969

Based on nominal dimensions and section properties it was calculated that in order to develop the maximum permissible bending stress of 165 N/mm² in the lower flange of the steel section an imposed load of 24.88 tonnes was required. However, in the test the load actually applied was 24.34 tonnes. Retrospective calculations using this load in conjunction with the actual section properties data indicates that the bending stress in the lower flange was slightly lower than intended at 162.2 N/mm², or 98.3% of the maximum permitted value.

A2.4.2 BS5500:Part 1:1985

Based on nominal values and the application of the previously calculated imposed loading of 24.88 tonnes the load ratio for the test assembly was found to be 0.53. When the lower actual loading value was used in conjunction with the actual section properties data the load ratio value reduced to 0.42. The single most effective factor in bringing about such a reduction is the design strength which at 335 N/mm² is much higher than the nominal value of 275 N/mm².
APPENDIX 3

PC DISK VERSION OF DATA

As mentioned in the Introduction to this report the data recorded during the test are available on a PC disk. 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 disk 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 DDS, 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 file is identified by reference to the DATA SHEET NUMBER sequence, i.e. 125.DAT. This numbering system is consistent with that introduced in Reference 1. The thermal data recorded during the fire test have been divided into 'SETS' which reflect the positions of the thermocouples in the steel section. Mean temperature values are included in the 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 the data file, README.125 which relates to data in file 125.DAT is shown in Table A3.1.

REFERENCE


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Table A3.1
README FILE ASSOCIATED WITH DATA FILE 125.DAT

Data file 125.DAT contains data recorded during the standard fire resistance test number WFRC 50427 which is described in report number SL/HED/R/S2442/3/95/C - 'Summary of Data Obtained During a Test on an Arched Metal Deck Floor Beam' and should be read in conjunction with that document.

There are 28 items of data which, together with their mean values, are grouped in sets as shown below.

<table>
<thead>
<tr>
<th>Set Number</th>
<th>Items in Columns</th>
</tr>
</thead>
<tbody>
<tr>
<td>SET001.DAT</td>
<td>TIME, F3, F5, F8, F9, MEAN</td>
</tr>
<tr>
<td>SET002.DAT</td>
<td>TIME, W6, W8, MEAN</td>
</tr>
<tr>
<td>SET003.DAT</td>
<td>TIME, W1, W2, W3, W4, MEAN</td>
</tr>
<tr>
<td>SET004.DAT</td>
<td>TIME, W5, W7, MEAN</td>
</tr>
<tr>
<td>SET005.DAT</td>
<td>TIME, F1, F2, F4, F6, F7, MEAN</td>
</tr>
<tr>
<td>SET006.DAT</td>
<td>TIME, ISO, AT1, AT2, AT3, AT4, AT5, AT6, AT7, AT8, MEAN ATM</td>
</tr>
<tr>
<td>SET007.DAT</td>
<td>TIME, DEFLECTION</td>
</tr>
</tbody>
</table>

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