TEESSIDE LABORATORIES

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A BS 476: Part 8 Test on an Unprotected 356 x 171 mm x 67 kg/m BS 4360 Grade 43A Beam - Confirmatory Test

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BRITISH STEEL CORPORATION
TEESSIDE LABORATORIES

21st October, 1981

A BS 476:PART 8 TEST ON AN UNPROTECTED 356 x 171 mm x 67 kg/m BS 4360 GRADE 43A BEAM - CONFIRMATORY TEST

SYNOPSIS

The last in a series of BS 476:Part 8 fire tests has been performed to confirm the relationship between P/A value and fire resistance for unprotected, simply supported, fully loaded BS 4360 Grade 43A beams. The test was performed on a 356 x 171 mm x 67 kg/m beam which failed after 29 minutes when the mean steel temperature was 680 ^{o}C.

When this test result is examined along with the data of previous tests it can be shown that beams with P/A values less than 100 m^{-1} would achieve fire resistance periods of 30 minutes. Agreement should be sought with Regulators regarding this critical value so that it can be implemented as a standard design concept.

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BS 476 PART 8 TEST ON AN UNPROTECTED 356 x 171 mm x 67 kg/m BS 4360 GRADE 43A BEAM - CONFIRMATORY TEST

CONTENTS

BS 476 Part 8 Test on an Unprotected 356 x 171 mm x 67 kg/m BS 4360 Grade 43A Beam - Confirmatory Test

1. INTRODUCTION

A BS 476 Part 8 test has been performed on a simply supported, 356 x 171 mm x 67 kg/m (P/A = 142 m^{-1}) Grade 43A beam. This test was carried out to confirm the result of a previous test (1) which showed failure after 27 minutes, and formed part of a larger programme to establish the relationship between P/A value and failure time.

During preliminary discussions with the Fire Research Station it had been tentatively agreed (2) that unprotected steel beams with P/A values less than 110 m^{-1} possess at least 30 minutes fire resistance (3 sided attack with a concrete cover slab) and further test evidence was required to confirm the scatter of results at low P/A values. Limitation of the loading facilities on the test furnace restrict the heaviest beam which can be tested to 356 x 171 mm x 67 kg/m which has a P/A 142 m^{-1}.

Several test results already existed at P/A 169 m^{-1}, (3,4,5) but only one result had been obtained at P/A 142 m^{-1} (1), and hence a further test was required to confirm the trend of the previous data.

The present report describes the results of this test and discusses its significance.

2. STEEL SUPPLY

The beam was obtained from a stockholder and following the fire test samples were taken from an unheated end of the section to check the chemical composition and the room temperature tensile properties.

The product analysis is given along with the composition limits for the BS 4360 Grade 43A specification in Table 1 which shows that the steel possessed carbon and manganese levels of 0.24 and 0.96% respectively and so satisfied the requirements for the specification.

The results from the tensile test specimen sampled in accordance with BS 4360 from both the web and flange positions are given in Table 2. The strength properties of the beam were satisfactory, satisfying BS 4360:Grade 43A requirements.

3. PREPARATION OF TEST BEAM

The beam was prepared for testing using the normal procedure and the concrete cover slab was cast using a low strength grade of concrete and lightweight steel tangs.

Fifteen thermocouples (Pyrotenax, 3 mm dia. chromel/alumel type K with insulated hot junctions) were fitted to the beam in the positions shown in Figure 1. Five thermocouples being fitted to the web, six to the lower flange and four to the upper flange of the steel beam.

Four additional thermocouples were embedded at depths of 30 and 100 mm in the concrete cover slab at the centre line and also at the $\frac{1}{4}$ width position to monitor temperature changes at the positions shown in Figure 2.

The heat input to the furnace was also monitored using a 15 mm dia. copper pipe which had water flowing through it continuously during the test at a known flow rate. The water entry and exit temperatures were continuously recorded.

Six thermocouples were also used to measure the furnace atmosphere temperature. These were located 100 mm away from the test beam and situated along its length in positions shown in Figure 3.

The outputs from the thermocouples were monitored using the BSC Compulog 4, computer controlled, data logging system which was similar to that used in previous tests.

The loading calculations are presented in the Appendix and for this test beam a total load of 30.52 tonnes was required to generate a design stress of 165 N/mm^2. The beam was loaded at four points along its span ($\frac{1}{8}$, $\frac{3}{8}$, $\frac{5}{8}$ and $\frac{7}{8}$ each with a load of 7.6 tonnes).

Deflection measurements were taken at the centre of the beam by the Warrington Research Centre staff using their potentiometric system.

4. RESULTS OF TESTS

Test failure was deemed to have occurred after 29 minutes and the letter from Warrington Research Centre confirming this result is presented in Figure 4. Figure 5 shows the deflection time curve which indicates that the deflection increased relatively slowly for the first 22 minutes and then accelerated rapidly until failure occurred. The results of the temperature measurements are given in Figures 6-12. Figure 6 shows the heating curves for the central bottom flange positions on the test beam. At the end of the test the five temperatures were in the range of 678 to 683°C with a mean of 681°C. The final temperatures recorded were all remarkably similar in view of the scatter observed earlier in the test. The heating curves recorded for the upper flange are given in Figure 7 and apart from one, show very consistent heating rates for the final 15 minutes of test with failure temperatures within the range 460 to 509°C, the mean being 495°C. At the end of the test the web temperatures, as shown in Figure 8 were within the range 666 to 689°C, the mean being 680°C. The mean of the bottom flange and web temperatures at failure was 680°C.

The heating rates given in Figure 9 from the additional thermocouples W5 and F10 located approximately 15 and 5 mm from the furnace wall recorded 242 and 313°C respectively at failure.

The furnace atmosphere heating curves are compared with the international time temperature curve in Figure 10 which shows that the furnace atmosphere temperatures were in excess of the standard curve for the first part of the test, but were below BS 476:Part 8 requirements for the final 15 minutes. A summary of steel temperatures and the furnace atmosphere temperatures at various stages during the test is shown in Data Sheet 17.

The temperature rises which were monitored in the concrete cover slab at the quarter width and centre positions at depths of 30 and 100 mm are shown in Figure 11. The temperature rose steadily in the central position from 18°C to 25 and 100°C at the 30 and 100 mm depths respectively. The temperature also rose steadily in the quarter width position from 18°C to 36 and 101°C at the 30 and 100 mm depths respectively.

Water flowed through the copper pipe at a rate of 161/min ? and by the end of the test, as shown in Figure 12, water which entered the pipe at 15°C was heated to 36°C, ie. equivalent to a heat input rate of 337 k cals/min.

After cooling, the test beam satisfied the reload test, and the strain measurements recorded using the 500 mm fiducial marks are shown in Table 3. The total strain at the centre of the beam at failure was around 3.2%.

5. DISCUSSION

Two previous tests have been performed on simply supported 356 x 171 mm x 67 kg/m beams both using design stresses of 165 N/mm^2. The first was carried out on a BS 4360 Grade 43A member which failed after 27 minutes,(1) the second on a BS 4360 Grade 50 member which failed after 24½ minutes(6). The failure temperatures and steel strength values are compared in the table below:

	FEB 80 (1)	JULY 80 (6)	JULY 81 THIS WORK
Mean Lower Flange °C	647	714	681
Mean Web °C	633	713	680
Mean Upper Flange °C	418	477	495
Mean Lower Flange and Web °C	640	714	680
Yield Stress Web	280	394	291
N/mm^2 Flange	240	392	273
Failure Time (mins)	27	24½	29

More comprehensive temperature data from these tests is presented in Data Sheets No. 4 and No. 8.

The failure times observed show no correlation between steel grade and design stress.

This data confirms the lack of reproducability of the BS 476:Part 8 test, the specimen which should have exhibited the best fire resistance actually gave the poorest result. However, it should be noted that the steel temperatures recorded at failure are in line with those expected for both the Grade 50 specimen, and the marginally higher strength Grade 43A specimen having higher failure temperatures than the specimen tested in February 1980.

The main objective of the present test was to confirm the previous test result on a fully loaded Grade 43A section with P/A value of 142 m^{-1}. However the **result obtained** in the present test **was considered "optimistic"** and some adjustment of the fire resistance period is required for reliable extrapolation to derive the critical P/A value required to achieve 30 minutes fire resistance from simply supported fully loaded members. **The reasons for the optimistic result** have been associated with f**urnace operating characteristics**.

It has been recognised that the fire resistance values can be dependent upon the heating rate of the furnace and the positioning of control thermocouples within the furnace.[6] In the present test some difficulties were encountered with burner performance during the first 15 minutes of heating, as reflected by the heating curves, but these were overcome for the final part of the test. This fault had no major effect but during the final 15 minutes the ITT heating curve could not be followed despite running the furnace at maximum heat input.

The fire resistance period has been "adjusted" by comparing the actual furnace atmosphere temperature at failure with BS 476 Part 8 requirements. Failure occurred when the atmosphere temperature rise was $788^{\circ}C$. At this time (27 minutes) the BS 476 curve specifies a rise of $817^{\circ}C$ ie. a discrepancy of $30^{\circ}C$. However the BS 476 furnace atmosphere curve specifies an atmosphere temperature rise of $789^{\circ}C$ after 24 minutes and hence the member would have survived for at least this period.

A small allowance should also be made for the time lag between furnace atmosphere and steel temperature ie. if the furnace has achieved a temperature of $789^{\circ}C$ in 24 minutes one would expect the mean steel temperature to be below $680^{\circ}C$, ie. the failure temperature recorded. Hence using from this data a fire resistance of 25/26 minutes is reasonable under "idealised" BS 476 conditions. The data from the earlier test[1] can be interpreted in a similar way and a fire resistance value of 25 minutes would be expected.

The previous tests on sections with a P/A value of 169 m^{-1} indicated failure times between 21 and 22 minutes. Hence using the 25/26 min. predicted value for 142 m^{-1} the graph shown in Figure 13 can be constructed which indicates that a P/A value of 110 m^{-1} would be required for 30 minutes fire resistance. This extrapolated critical value is more realistic than using raw BS 476 data as shown in Figure 14 which would predict very optimistic critical values.

In view of the wide differences in heating rates recorded on tests on beams with P/A values of 142 m^{-1} it is of interest to compare clearly the furnace atmosphere and steel heating rates observed in the various tests.

The steel heating rates are controlled by heat transfer from the furnace flames, the main heat transfer process being radiation. Heating curves, furnace atmosphere and mean steel temperatures are compared in Figures 15 and 16. In Figure 17 furnace atmosphere T4 values are plotted. It can be seen that when major differences occur then a "heat transfer" value of $12 \times 10^{11}\ {}^{\circ}A^4$ can be achieved at times which vary from 14 to 30 minutes. One method of examining the influence of atmosphere temperature on heating rate is to compare the T^4 values listed in the table below, from the max and mean furnace atmosphere temperatures when the mean steel temperature reached some arbitrary temperature, say $600^{\circ}C$.

	FEB 80	JULY 80	JULY 81
Mean Temperature (°C)	757 (Warrington)	740 (Warrington)	721 (mean of six BSC
Max Temperature (°C)	783 single BSC value	787 max from single BSC	761 max from six BSC values
T^4 mean (°A)	11.25 x 10"	10.5 x 10"	9.76 x 10"
T^4 max (°A)	12.43 x 10"	12.62 x 10"	11.4 x 10"
Time to 600°C	23 minutes	16 minutes	21.5 minutes

Furnace Atmosphere Temperatures when Mean Steel Temperature Equals 600

Hence whilst the times required to reach a steel temperature of 600°C can vary markedly, there is relatively good agreement between both the maximum and minimum furnace atmosphere temperatures at the time when this steel temperature is achieved (bearing in mind the inertia of the furnace and the specimen)

Hence it can be seen that furnace atmosphere temperature has a major bearing on failure time.

SIGNIFICANCE OF THE CRITICAL P/A VALUE FOR 30 MINUTES FIRE RESISTANCE

The critical value of P/A of 110 m^{-1} required to achieve 30 minutes fire resistance in simply supported fully loaded Grade 43A steel is achieved with most sections with serial sizes and weights larger/heavier than 533 x 210 mm x 122 kg/m. This critical value neglects any influence of restraint or composite action and relates only to simply supported members.[7]

A value of 110 m^{-1} was tentatively agreed with the Fire Research Station for the recent study[2] on fire protection requirements at Birmingham Airport, where a number of the main structural beams had P/A values less than 100 m^{-1} in areas where the fire loading indicated 30 minutes fire resistance was required. Hence although the elements with P/A values less than 100 m^{-1} appear heavy the agreement of this critical value has commercial appeal and could reduce the cost of achieving fire resistance in this structure.

This value could be applied in other projects as sufficient experimental data is available to confirm its validity.

Acceptance of this critical value for fully loaded simply supported beams forms part of a series of critical P/A values for different construction methods where agreement will be sought with Regulators (eg. understressed Grade 50 members, composite construction and restrained members). Test work is proceeding in most of these areas to provide the necessary test evidence.

CONCLUSIONS

The work on establishing the relationship between P/A and fire resistance period for simply supported members has continued. A further BS 476:Part 8 fire test has been completed on a 356 x 171 mm x 67 kg/m (P/A 142 m^{-1}) Grade 43A beam which was tested at maximum design stress. The beam failed after 29 minutes when the mean steel temperature was 680^{o}C.

1. The result has been used along with previous test data to predict the critical P/A value to achieve 30 minutes fire resistance, and a value of 110 m^{-1} is obtained when this result is "adjusted" to account for the slow furnace atmosphere heating rate used in the present test.

2. Regulatory acceptance of critical values of P/A to achieve 30 minutes fire resistance for unprotected members should reduce the cost of steel construction for certain classes of building.

3. Liaison with Regulatory Bodies regarding the interpretation of test data, and implementation of critical P/A values for unprotected steel and short periods of fire resistance should continue as sufficient test data has been obtained to implement this philosophy on a widescale basis.

This would be assisted by general publication of the test data obtained from this part of the work on unprotected steel beams.

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   Teesside Laboratories Report T/RS/1195/14/80/C

4. C.I.Smith and G. Thomson
   Teesside Laboratories Report T/RS/1380/9/81/D

5. C.I.Smith and G. Thomson
   Teesside Laboratories Report T/RS/1380/11/81/D

6. G. Thomson, I.D.Thomas and C.I.Smith
   Teesside Laboratories Report T/RS/1189/17/81/A

7. C.I.Smith and G. Thomson
   Teeside Laboratories Report T/RS/1380/17/81/D

SAMPLE NO	SAMPLE FORM	C	Si	Mn	P	S	Cr	Mo	Ni	V	Ti	Cu	Sn	Nb	Zr	TOT Al	SOL Al	N_2
RS 137	Solid	.24	.032	.96	.022	.039	.013	<.005	.017	<.005	<.005	.019	<.005	<.005	<.005	<.002	<.002	.004
BS4360 Grade 43A Product Requirement		.30 max	.55 max	1.70 max	.06 max	.06 max												

CHEMICAL COMPOSITION OF THE TEST BEAM

TABLE 1

CODE		YIELD STRESS (N/mm^2)	TENSILE STRENGTH (N/mm^2)	%El
RS: 137	Web	291	479	27.0
	Flange	273	476	28.0
BS 4360 Grade 43A Specification Requirements	Web Flange	270 (min) 255 (min)	430/ 540	20.0

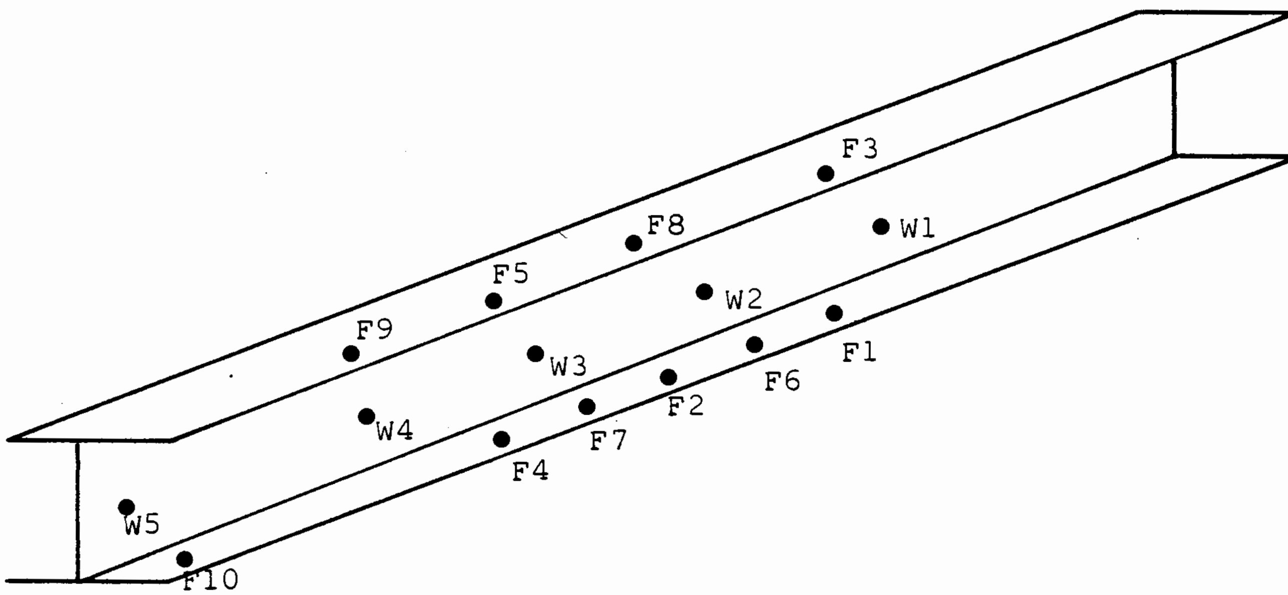
TENSILE TEST DATA FROM THE FIRE TESTED
BS4360 GRADE 43A 356 x 171 mm x 67 kg/m
UNIVERSAL STEEL BEAM

TABLE 2

DISTANCE FROM DOOR END	GAUGE LENGTH BEFORE TEST	GAUGE LENGTH AFTER TEST	CHANGE IN LENGTH	% STRAIN
250				
	500	500	0	0
750				
	500	503	3	0.6
1250				
	499	512	13	2.6
1749				
	500	516	16	3.2
2249				
	500	511	11	2.2
2749				
	500	502	2	0.4
3249				
	500	500	0	0
3749				

MEASUREMENT OF GAUGE LENGTH OF BEAM BEFORE AND AFTER THE FIRE TEST AND STRAIN VALUES IN THE LOWER FLANGE AT THE END OF THE TEST

TABLE 3

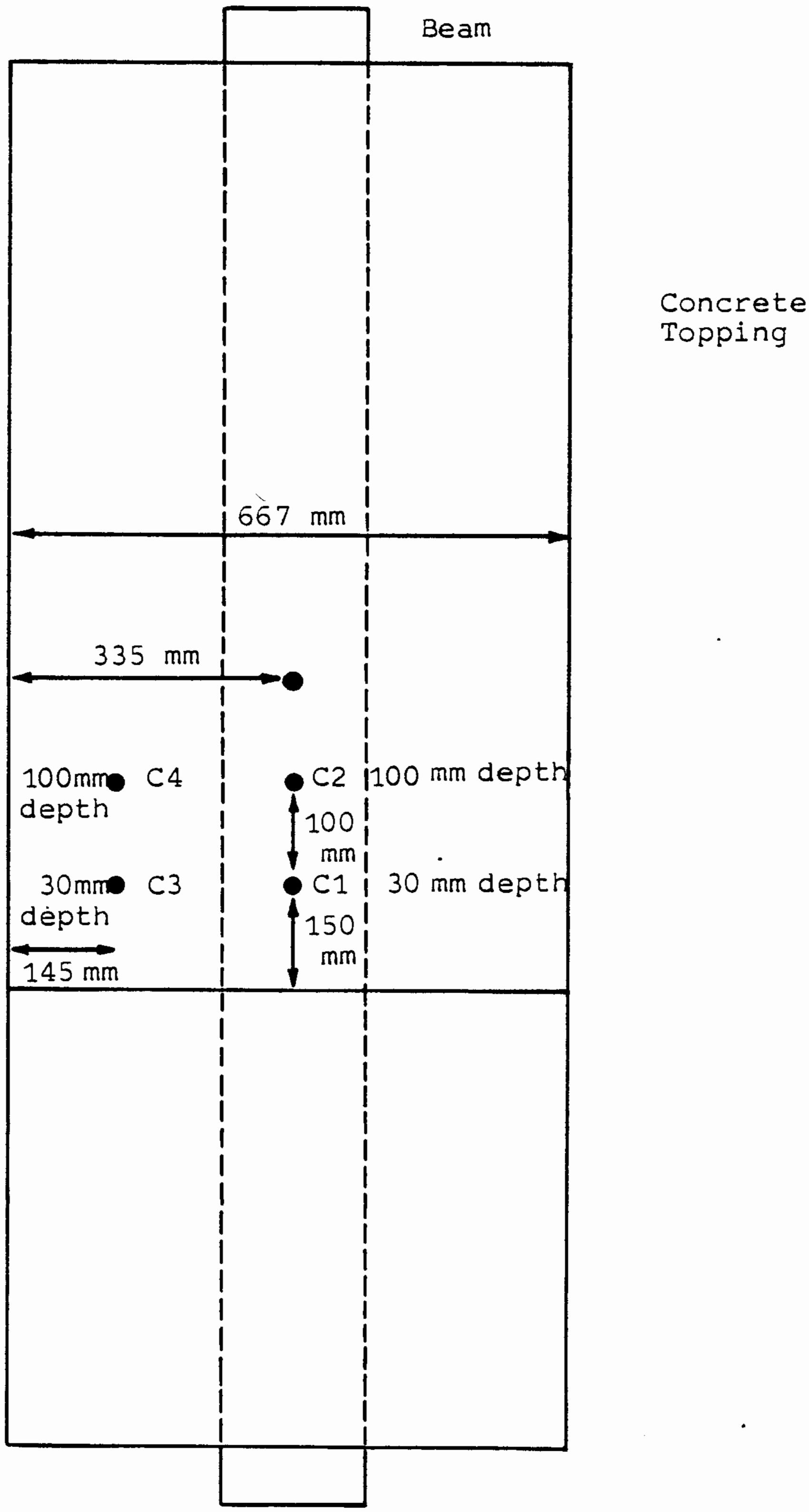


DISTANCE FROM END OF BEAM TO THERMOCOUPLES

W1	3.35 m
F3, F1	3.05 m
W2, F6	2.73 m
F2, F8	2.43 m
W3, F7	2.11 m
F4, F5	1.81 m
W4, F9	1.5 m
End of beam	4.84 m
W5, F10	0.50 m

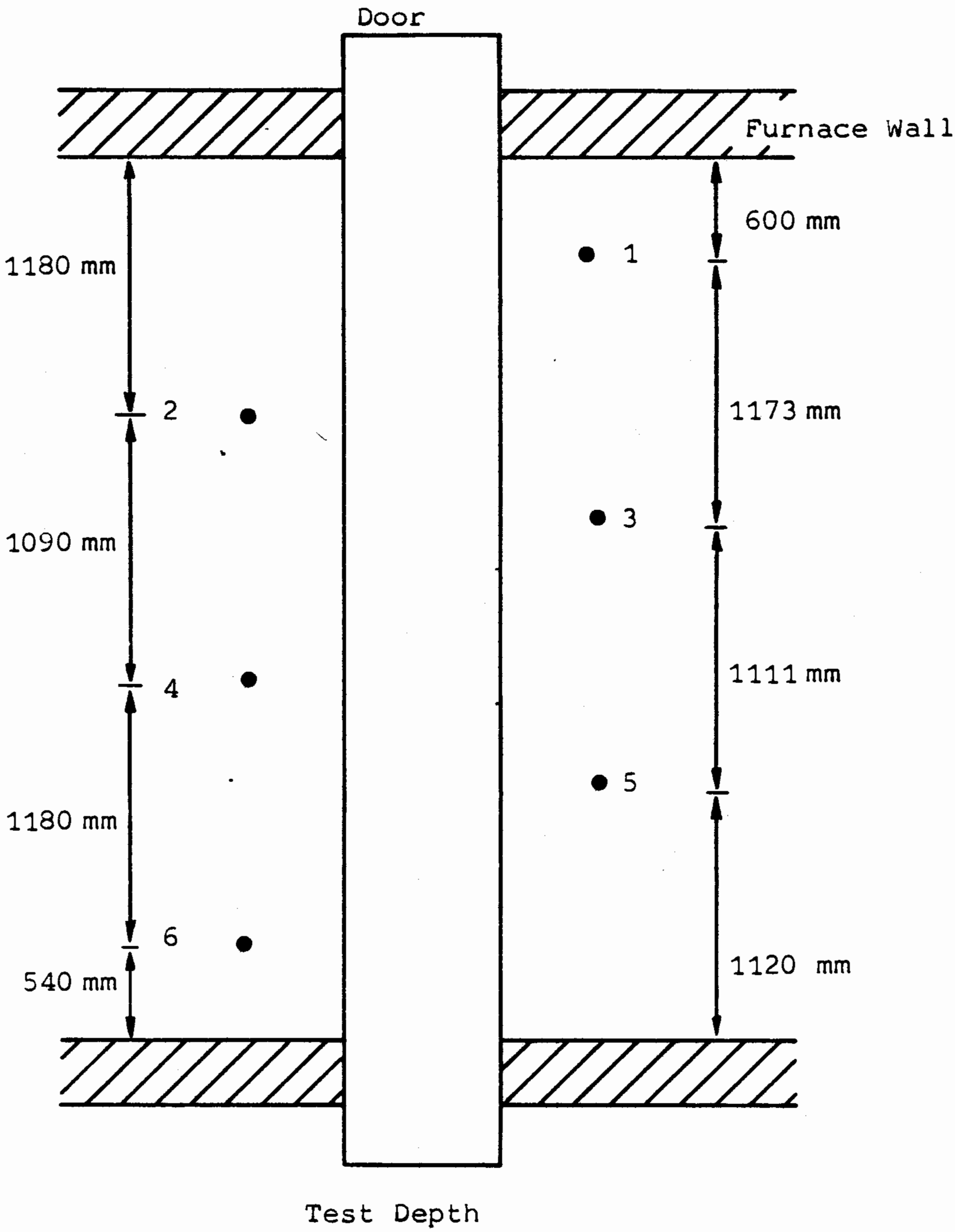
POSITION OF THERMOCOUPLES ON TEST BEAM

FIGURE 1



ARRANGEMENT OF THERMOCOUPLES EMBEDDED IN CONCRETE TOPPING

FIGURE 2



POSITION OF FURNACE ATMOSPHERE THERMOCOUPLES

FIGURE 3

WARRINGTON RESEARCH CENTRE
Fire Research, Testing and Consultancy

Warrington Research
Consultants (Services) Limited
Holmesfield Road
Warrington WA1 2DS
Tel: Warrington (0925) 55116
Telex: 627110 or 628702
CHACOM G WARRES

Dr. I. Smith,
British Steel Corporation,
Teeside Laboratories,
Ladgate Lane,
P.O. Box 74,
Middlesbrough,
Cleveland, TS8 9EG.

W.R.C.S.I. No. 28055
15th July 1981

Dear Sir,

FIRE RESISTANCE TEST RESULTS

We confirm the results of a fire resistance test carried out on your behalf in accordance with B.S. 476: Part 8: 1972 on a loaded and unprotected steel beam Grade 43A of Serial Size 356 mm x 171 mm x 67 kgs/m. The beam was loaded to its maximum permissible design stress (i.e. 165 N/mm^2). The test results were as follows:

Stability : 29 minutes
Re-load Test: Satisfied

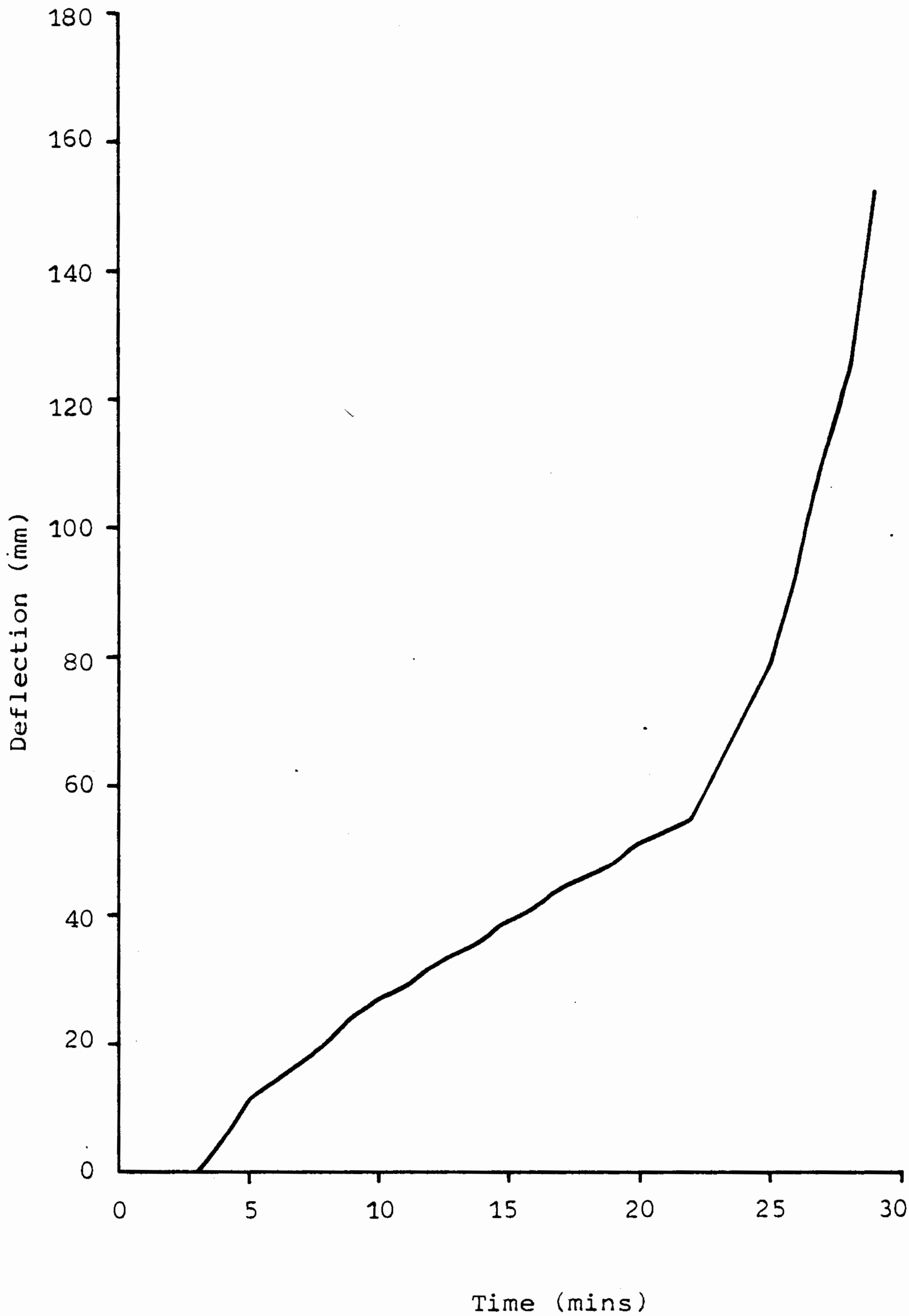
Date of Test: 13th July 1981

Our report will follow in due course.

Yours faithfully,

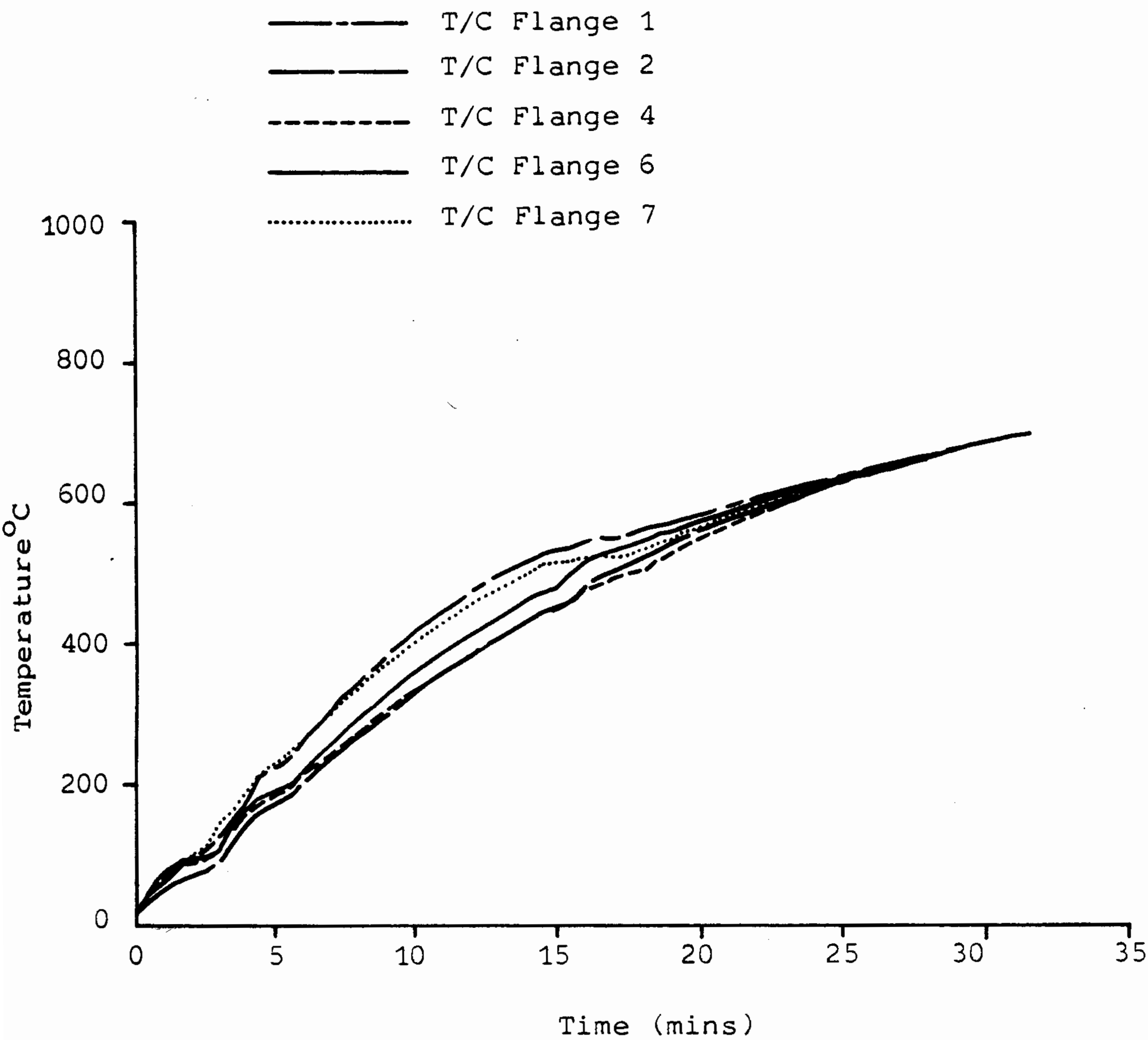
(A.H. BONE)
Technical Manager - Structural Fire Protection
Warrington Research Centre

FIGURE 4



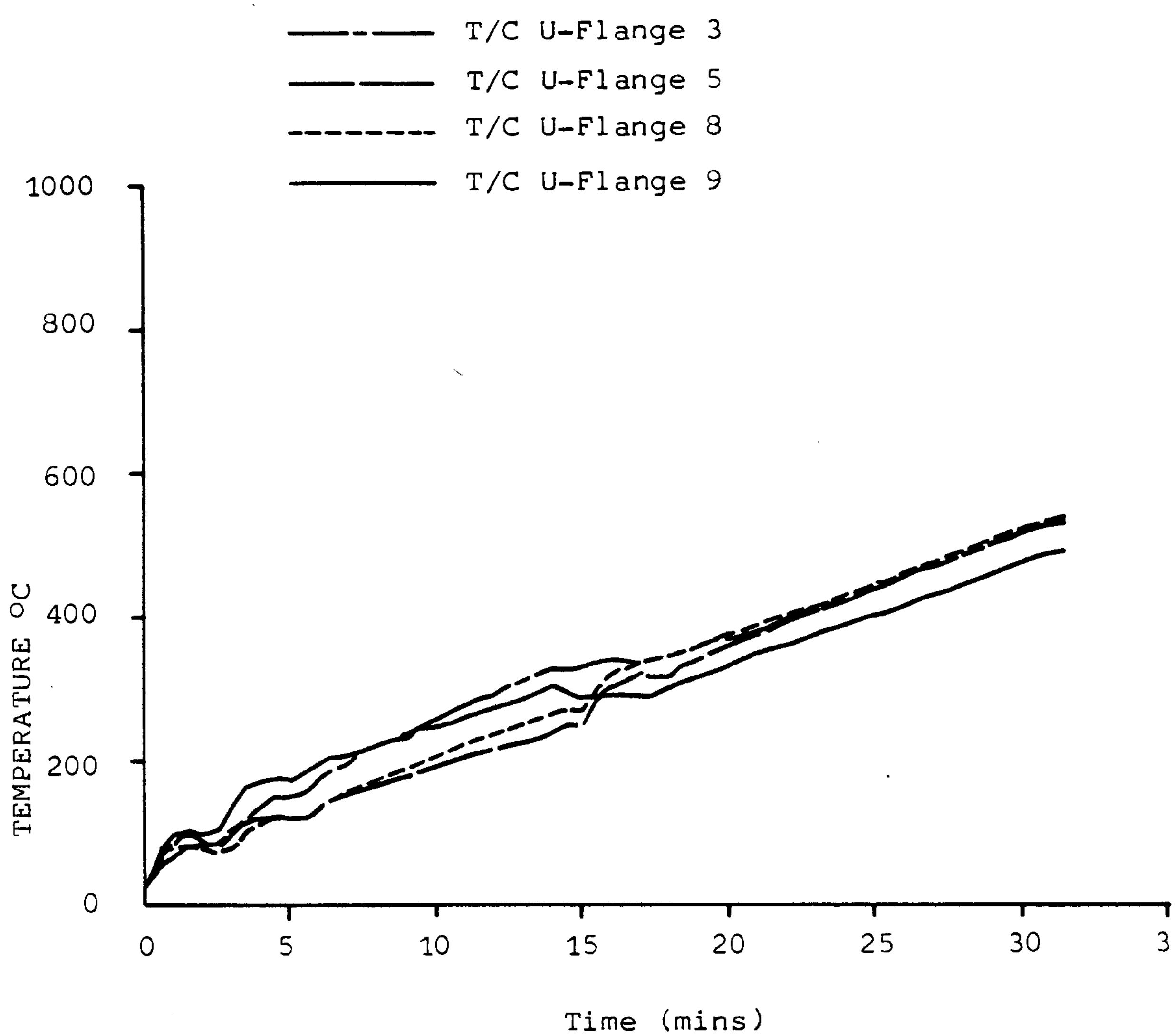
PLOT OF DEFLECTION AT THE CENTRE OF THE BEAM AS A FUNCTION OF TIME

FIGURE 5



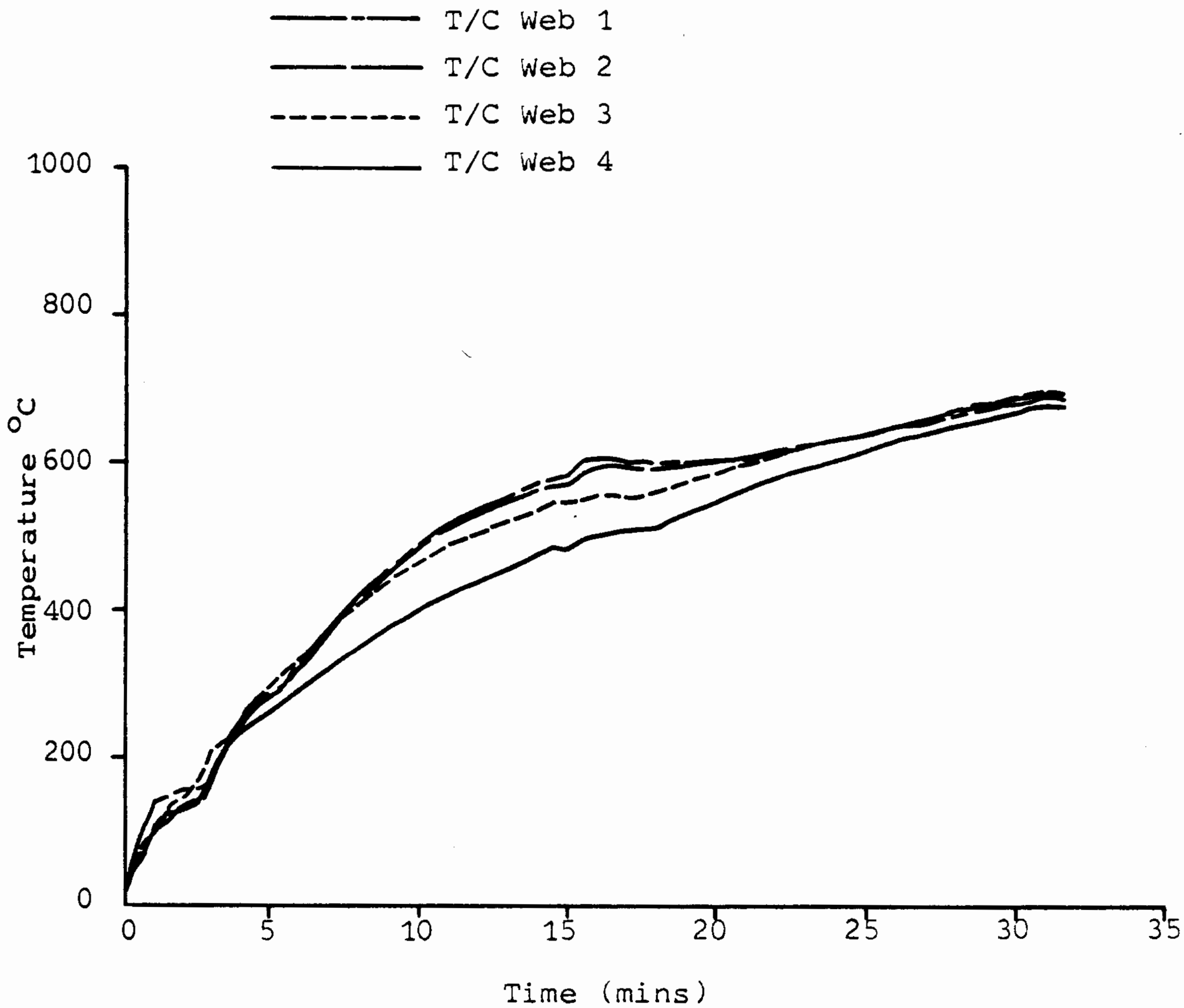
LOWER FLANGE TEMPERATURE RECORDED ON TEST BEAM

FIGURE 6



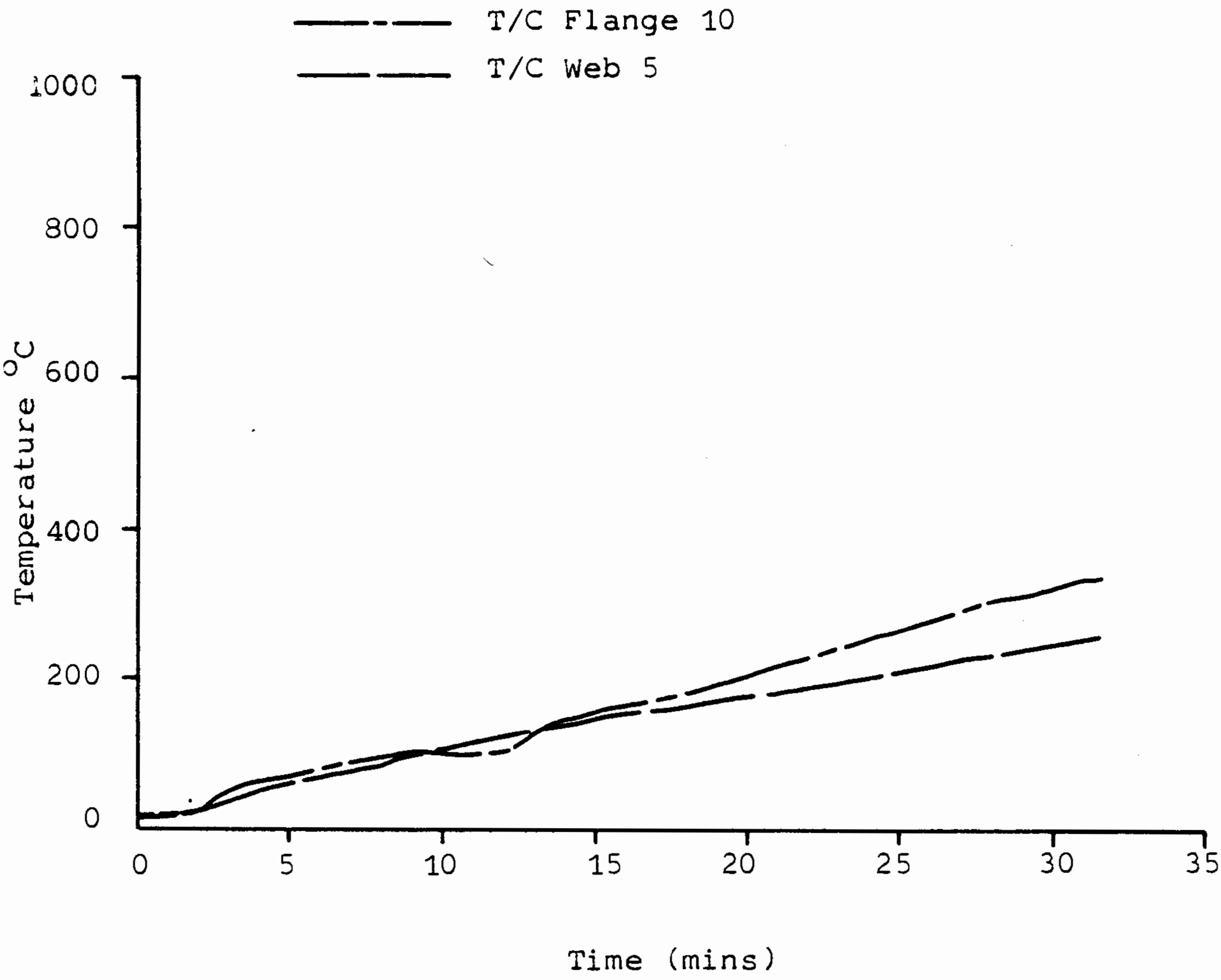
UPPER FLANGE TEMPERATURE RECORDED ON TEST BEAM

FIGURE 7



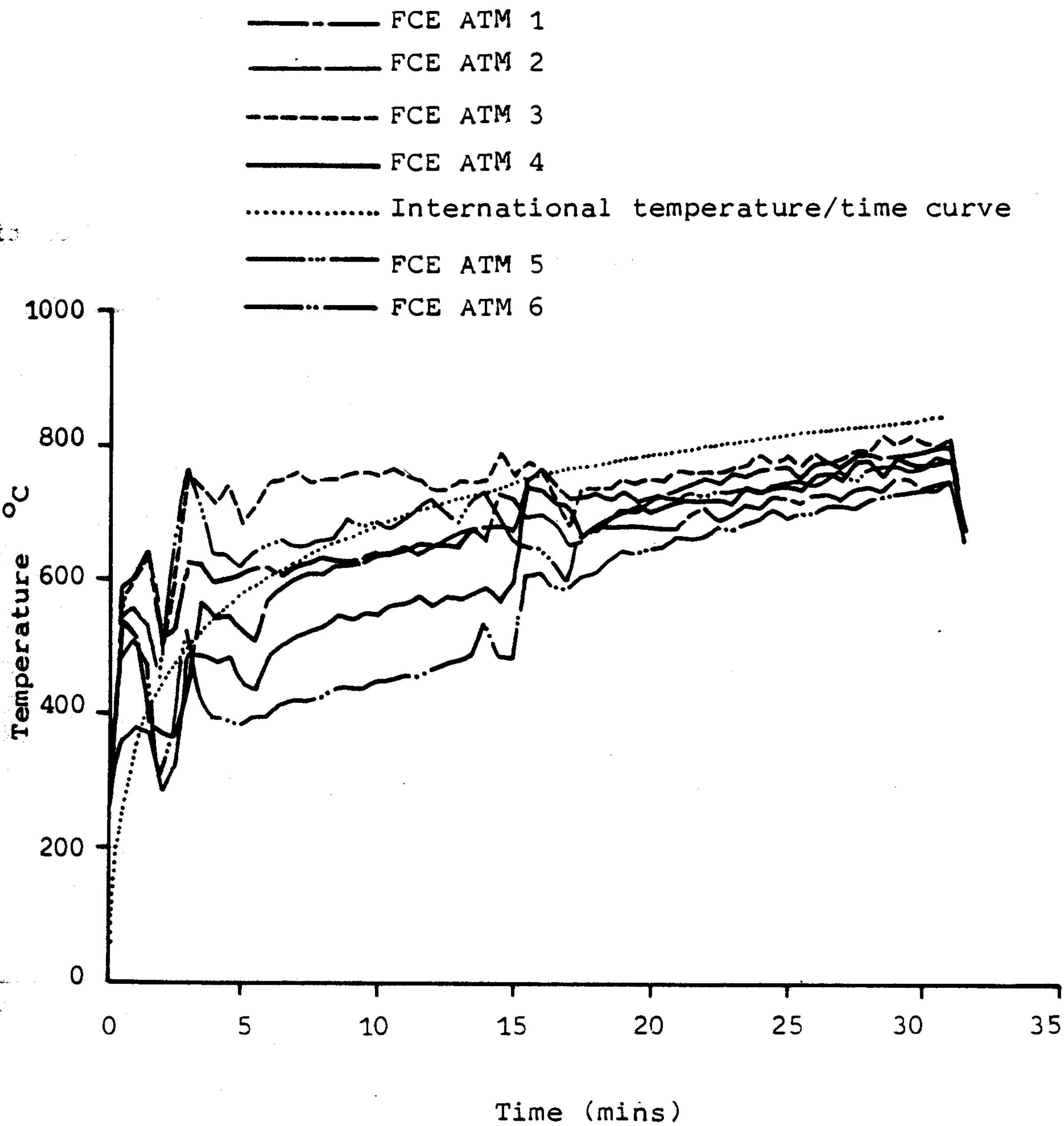
WEB TEMPERATURE RECORDED ON TEST BEAM

FIGURE 8



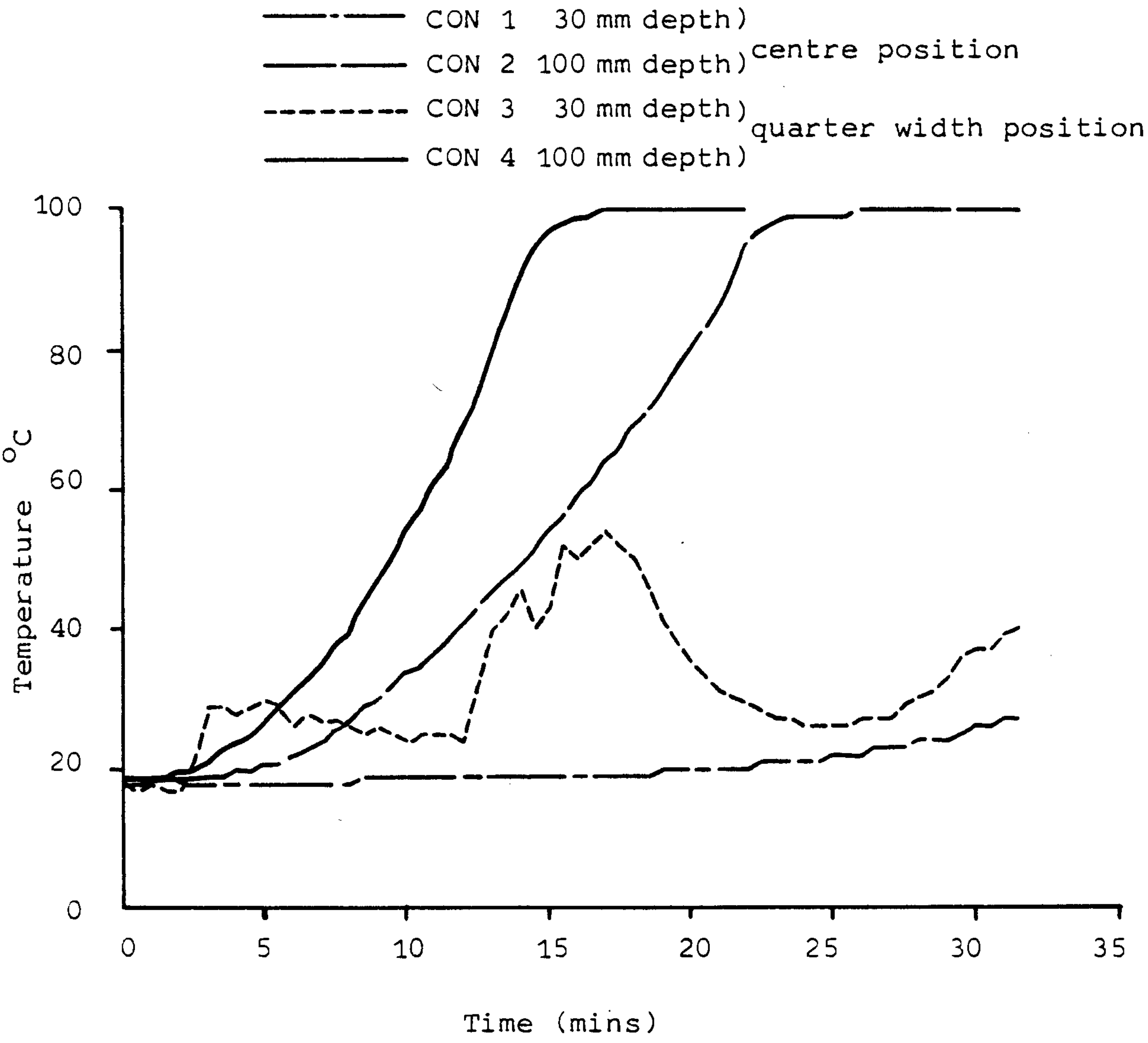
TEMPERATURES RECORDED FROM THE ADDITIONAL LOWER FLANGE AND WEB THERMOCOUPLES LOCATED 5 AND 15MM FROM THE WALL OF THE FURNACE

FIGURE 9



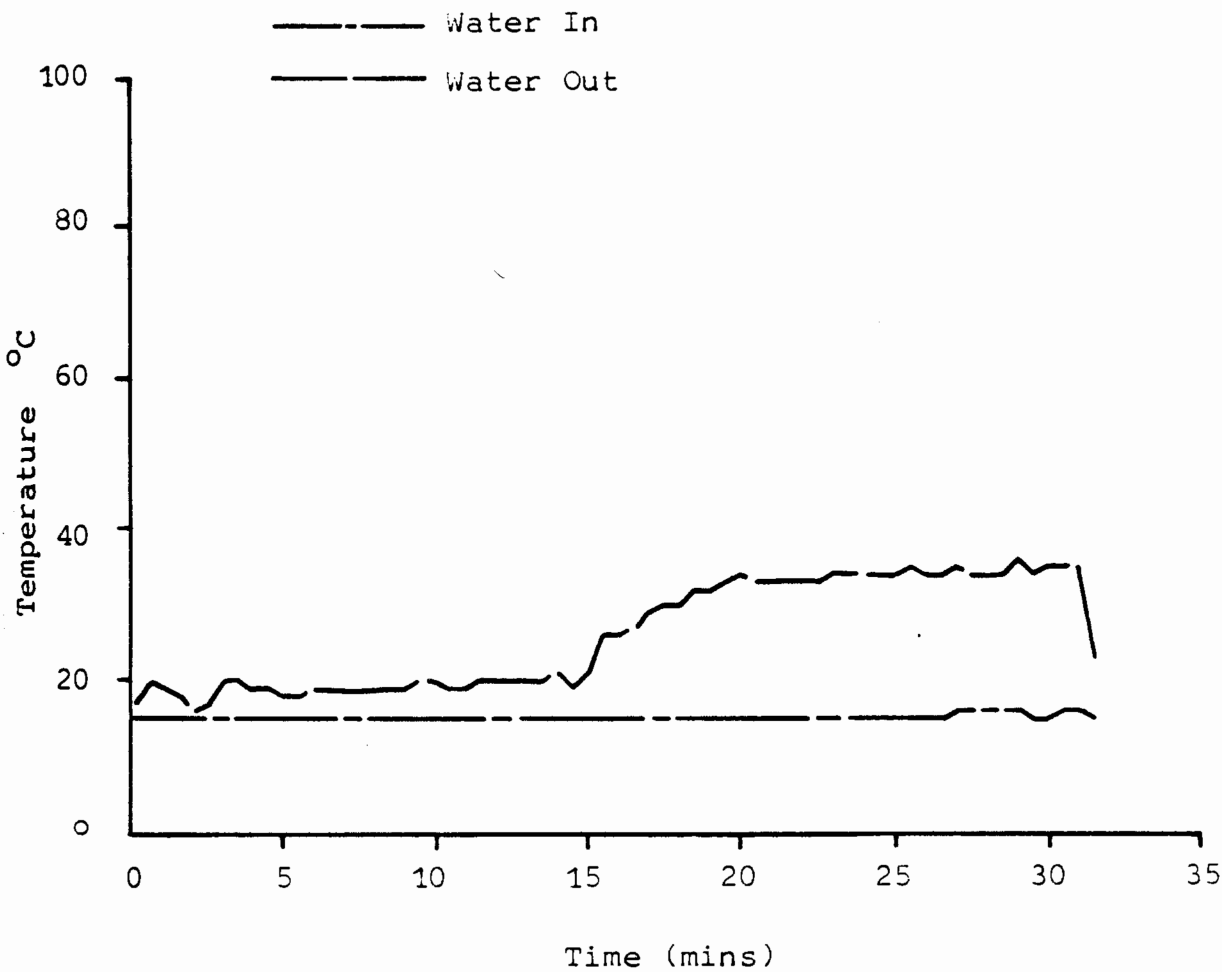
FURNACE ATMOSPHERE TEMPERATURES RECORDED DURING TEST

FIGURE 10



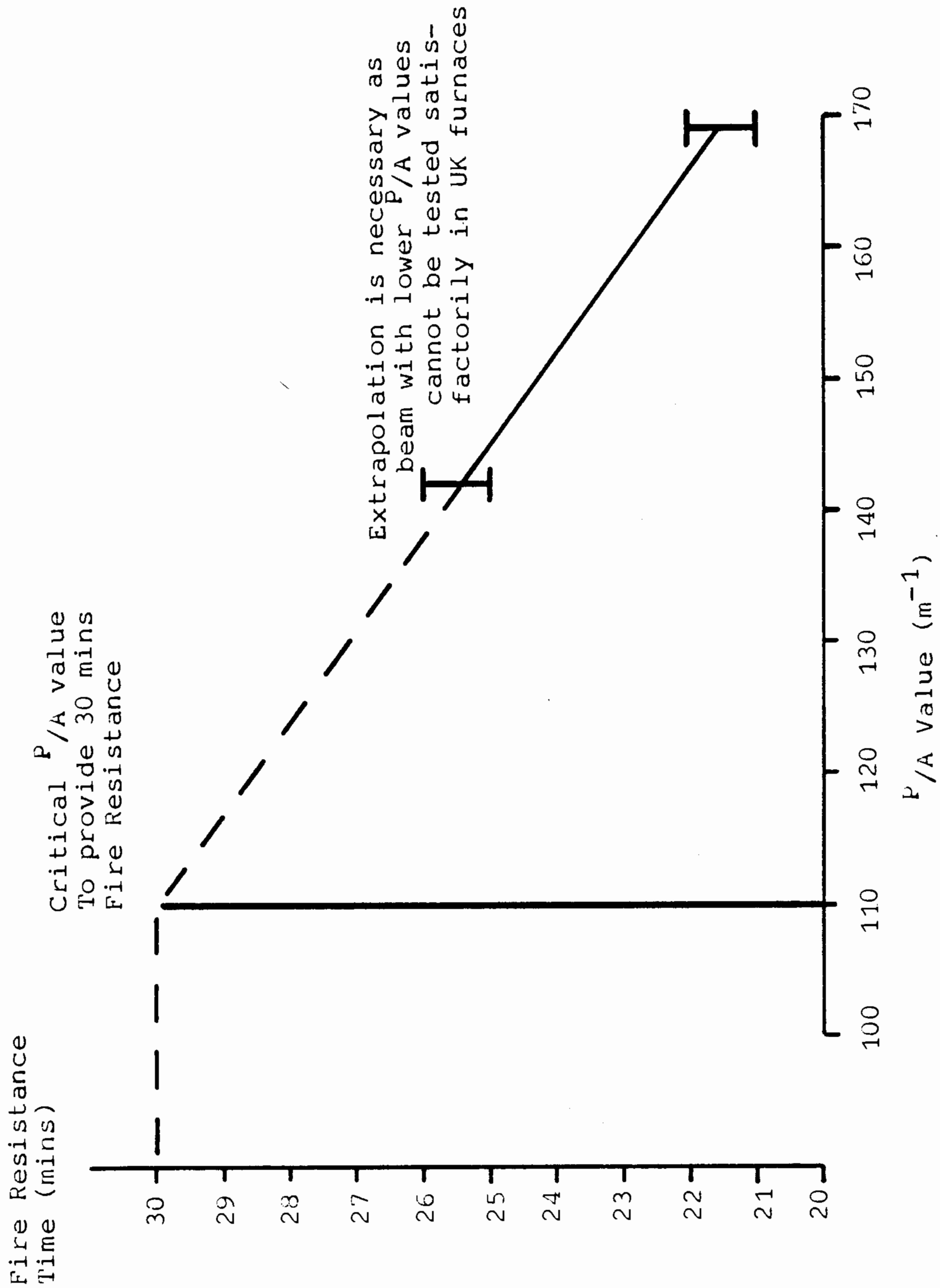
TEMPERATURE RISE RECORDED IN THE CONCRETE COVER-SLAB AT THE CENTRAL AND QUARTER WIDTH POSITIONS DURING THE TEST

FIGURE 11



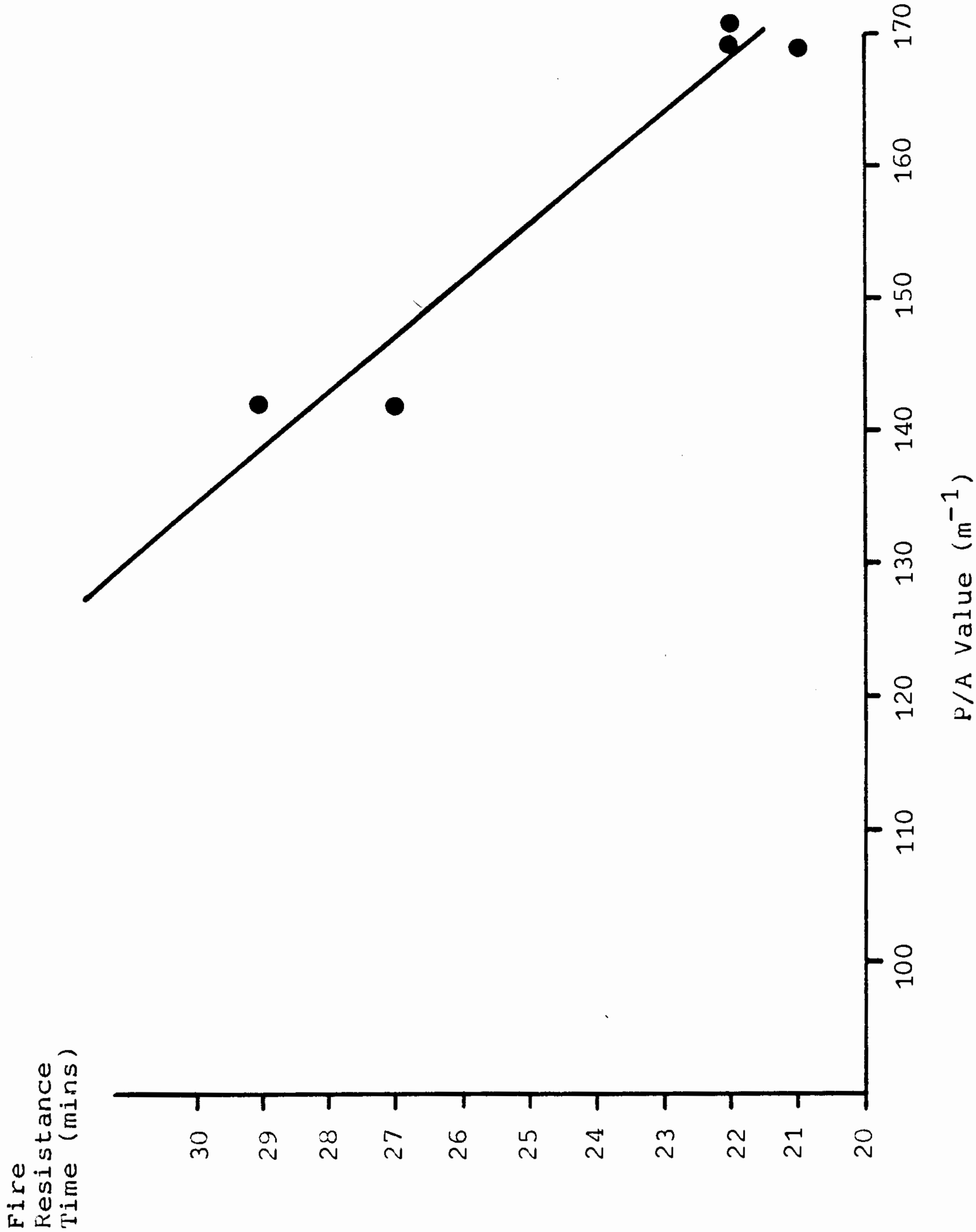
WATER TEMPERATURE RISE RECORDED USING COPPER CALORIMETER DURING TEST

FIGURE 12



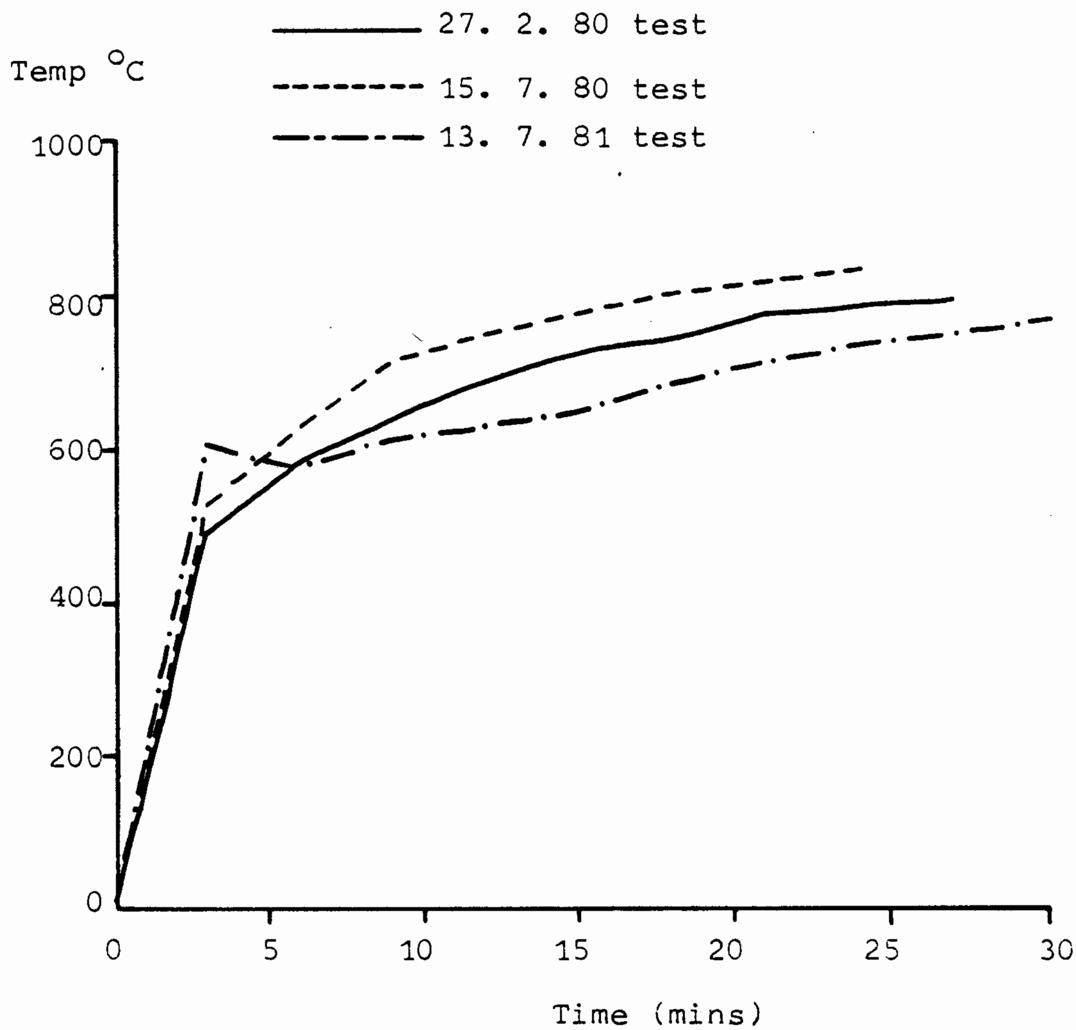
THE RELATIONSHIP BETWEEN $^{P}/A$ AND FIRE RESISTANCE FOR UNPROTECTED STEEL BEAMS. GRADE 43A DATA ADJUSTED TO PRECISELY SATISFY BS476: PART 8 HEATING RATE

FIGURE 13



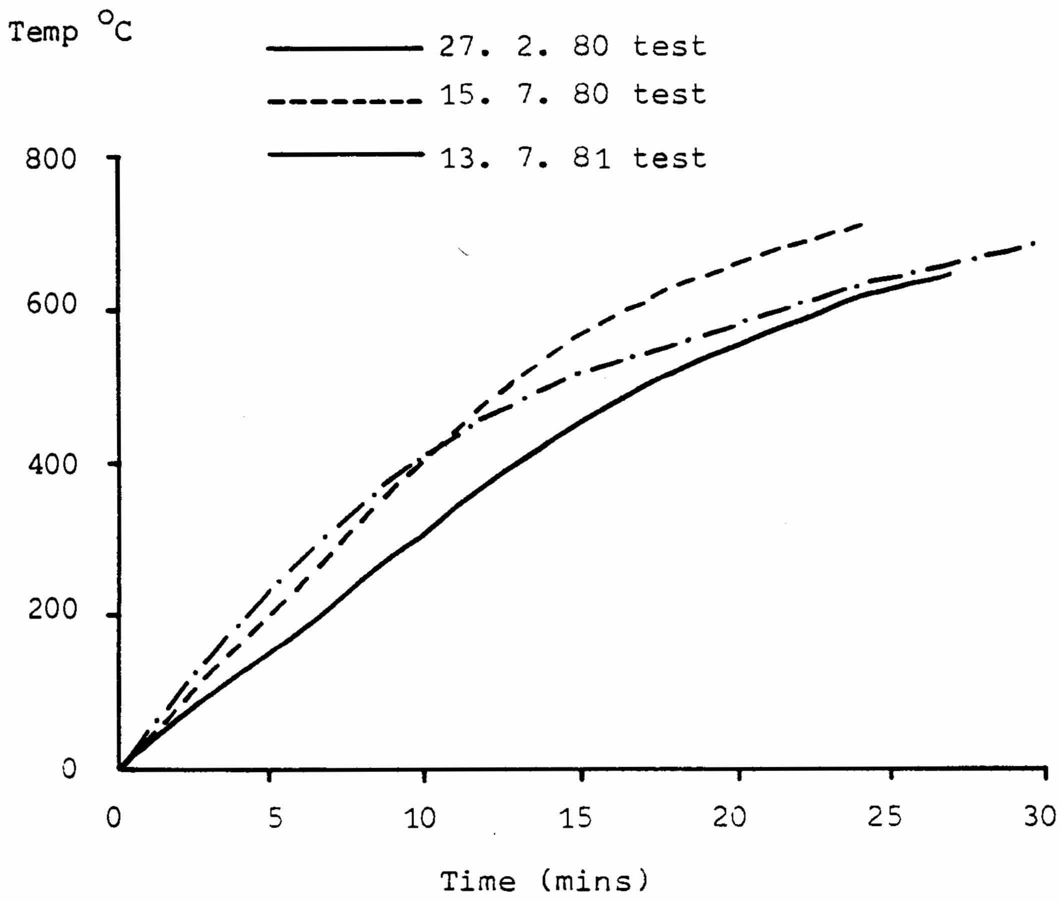
THE INFLUENCE OF $^{P}/A$ VALUE ON FIRE RESISTANCE PERIOD OF SIMPLY SUPPORTED FULLY LOADED GRADE 43A BEAMS

FIGURE 14



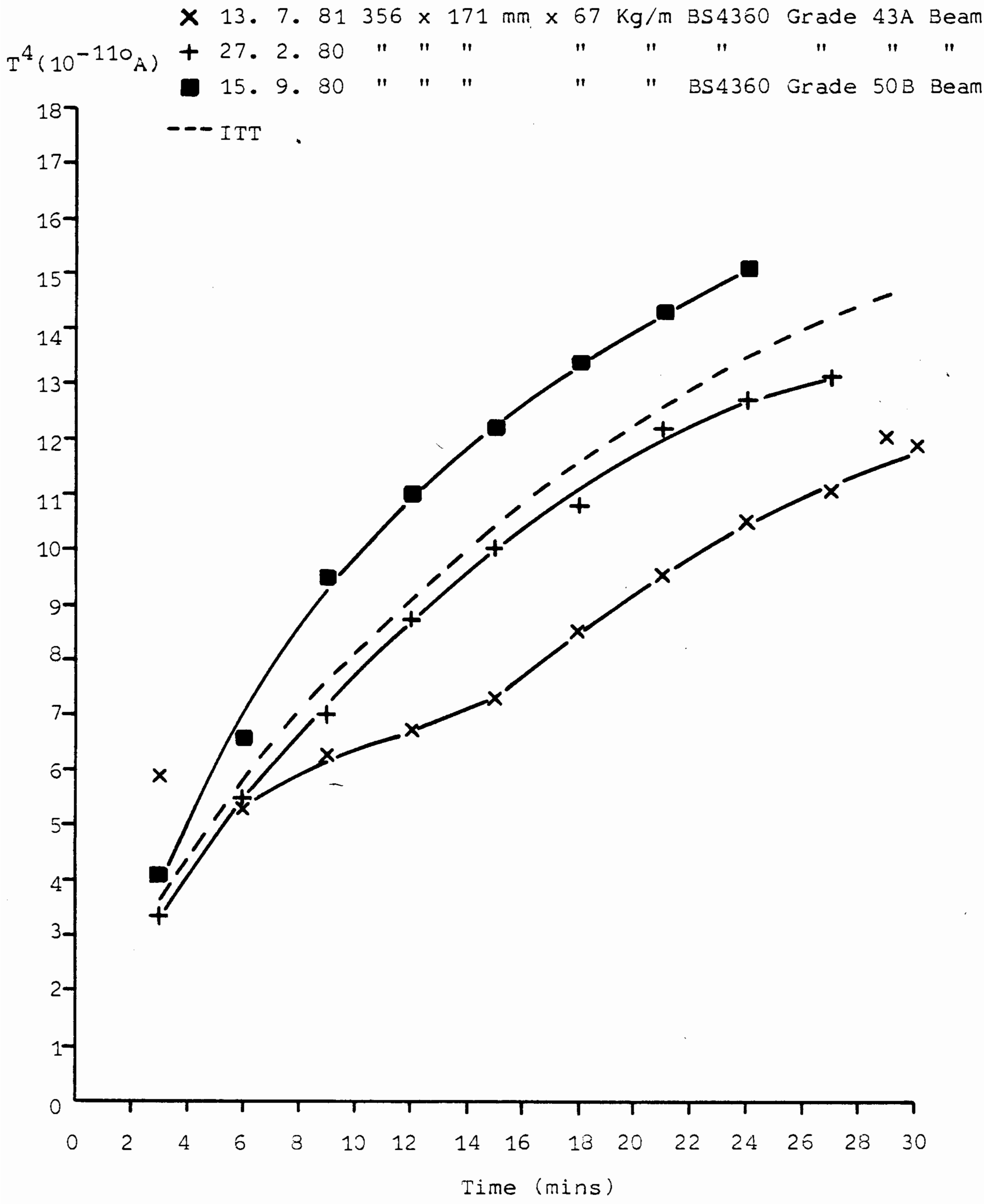
COMPARISON OF FURNACE ATMOSPHERE HEATING RATES OBTAINED FROM EARLIER TESTS ON 356 x 171 MM x 67 Kg/M BEAMS

FIGURE 15



COMPARISON OF MEAN STEEL TEMPERATURES WITH THOSE OBTAINED FROM PREVIOUS TESTS ON 356 x 171 MM x 67 Kg/M BEAMS

FIGURE 16



PLOT OF FURNACE ATMOSPHERE T^4 VALUES AS FUNCTION OF TIME

FIGURE 17

APPENDIX

LOAD CALCULATIONS

Actual properties of the Universal Beam

Depth of section	(D)	:	367 mm
Breadth of section	(B)	:	172 mm
Thickness of flange	(T)	:	15.5 mm
Thickness of web	(t)	:	9.47 mm
Mass per metre	(m)	:	657.649 N/m
Moment of inertia	(I)	:	1.94737E+08 mm^4
Distance of neutral axis to the base of beam	(y)	:	183.5 mm

Effective span of the beam (L) : 4500 mm

Maximum allowable bending stress to B.S.449: Part 2: 1969, Table 2
f = 165 N/mm^2

Percentage of allowable bending stress required during the test
f1 = 165 N/mm^2

Required bending moment = f1I/y = wL^2/8 N/mm

Therefore w = 8f1I/yL^2
where w = load per metre run in N/m

w = 8 * 165 * 1.94737E+08 / 183.5 * 4500 * 4500
w = 69177.1 N/m

Concrete topping slab

Depth	=	135 mm
Width	=	660 mm
Mass per metre	=	1957.92 N/m

Total self weight of beam & topping = 2615.57 N/m

Required imposed load to produce required bending stress = 69177.1 - 2615.57 N/m
= 66561.5 N/m

Therefore total imposed load = 30532.8 Kg

Using four point loads at 1/8, 3/8, 5/8 and 7/8 span equivalent to wL/4.

Point loads required = 7633.2 Kg

Test Reference Nos

WRC No. 28055

BSC Test No: 32

Test Date: 13.7.81

Section Size	P/A Value		web	flange
356 x 171 mm x 67 kg/m	$142\ m^{-1}$	Yield Stress (N/mm^2)	263	286
Grade	Design Stress:	Tensile Strength (N/mm^2)	432	497
BS 4360 Grade 43A	$165\ N/mm^2$	% Elongation (200 mm GL)	27	28

Composition	%C	%Si	%Mn	%P	%S	%Cr	%Mo	%Ni	%V	%Ti	%Cr	%Sn	%Nb	%Zr	%Sol Al	%Tot Al
Rs 137	.24	.032	.96	.022	.038	.013	<.005	.017	<.005	<.005	.019	<.005	<.005	<.005	<.002	<.002

FAILURE TIME: 29 MIN

THERMOCOUPLE LOCATION	TEMPERATURE (°C) AFTER VARIOUS TIMES (MIN)										
	3	6	9	12	15	18	21	24	27	29	30
Lower Flange 1	128	266	385	477	537	566	600	633	662	683	692
Lower Flange 2	93	205	303	390	458	529	582	625	660	681	691
Lower Flange 4	113	214	308	391	454	511	572	620	657	680	689
Lower Flange 6	110	223	330	419	484	551	594	630	661	682	691
Lower Flange 7	144	262	372	459	517	537	582	621	656	678	688
Mean Lower Flange	118	234	340	427	90	539	586	626	659	681	690
Web 1	175	334	461	541	588	603	614	639	659	679	687
Web 2	172	331	459	535	574	598	615	641	666	625	693
Web 3	213	339	444	509	551	567	604	637	668	689	698
Web 4	182	295	380	443	487	518	569	611	645	666	675
Mean Web	185	325	436	507	550	571	600	628	659	680	688
Mean Lower Flange & Web	148	274	382	463	517	553	592	632	659	680	689
Upper Flange 3	107	176	240	293	330	349	383	424	473	504	519
Upper Flange 5	100	138	181	218	250	317	377	422	469	509	525
Upper Flange 8	81	137	190	239	271	347	391	432	477	509	522
Upper Flange 9	140	196	235	275	287	303	349	389	433	460	476
Mean Upper Flange	107	162	211	256	284	329	375	417	463	495	510
Web 5	38	71	99	124	148	166	184	204	226	242	249
Flange 10	51	81	102	104	156	183	220	255	291	313	324
Atmosphere 1	629	620	629	652	723	683	679	710	723	754	739
Atmosphere 2	442	574	625	652	675	731	735	765	769	788	795
Atmosphere 3	758	744	761	736	758	739	765	790	782	805	805
Atmosphere 4	438	486	543	562	599	682	718	734	752	783	774
Atmosphere 5	767	654	693	723	666	677	726	737	770	781	777
Atmosphere 6	527	398	443	468	488	615	670	698	719	737	744
Ave Atmosphere	602	579	616	632	651	688	715	739	752	775	772
ISO Curve R.T. 20°C	502	603	663	705	738	766	769	808	820	826	837
Deflection (mm)	0	14	24	32	39	46	53	71	110	152	—

/21

TEST REFERENCE NO. 25875

WRC NO.

BSC TEST REFERENCE NO. 11

T/RS/1189/21/81/A

CARRIED OUT 27/2/80

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Section Size 356 x 171 x 67 Kg/m	P/A Value 142 m^{-1}		WEB	FLANGE
		Yield Stress (N/mm^2)	280	240
		Tensile Strength (N/mm^2)	463	443
Grade 43A	Design Stress 165 N/mm^2			

Composition	%C	%Si	%Mn	%P	%S	%Cr	%Mo	%Ni	%V	%Ti	%Cu	%Sn	%Nb	%Zr	% Sol. Al.	% Tot. Al.
RS 891	.23	.03	.74	.01	.023	.005	<.005	.026	<.005	<.005	0.019	.002	<.005	-	-	-

Failure Time 27 Mins.

THERMOCOUPLE LOCATION	TEMPERATURE (°C) AFTER VARIOUS TIMES (mins)								
	3	6	9	12	15	18	21	24	27
Lower Flange 1	81	156	248	340	425	496	553	602	637
Lower Flange 2	76	157	256	352	438	510	569	618	653
Lower Flange 4	77	157	252	343	432	509	569	618	652
Lower Flange 6	72	147	235	327	418	494	553	604	639
Lower Flange 7	79	157	257	355	445	517	575	623	655
Centre Web 1	114	205	295	384	460	520	567	604	630
Centre Web 2	122	214	319	417	494	549	595	633	658
Centre Web 3	127	228	337	429	502	556	600	636	663
Centre Web 4	128	216	312	397	470	527	574	611	640
Mean Lower Flange and Centre Web °C	97	182	279	374	454	520	571	617	647
¼ Web (5) °C	130	211	297	371	437	492	535	576	607
¼ Web (6) °C	118	201	292	371	438	492	539	578	612
Upper Flange (3) °C	76	91	137	173	214	259	303	354	399
Upper Flange (5) °C	77	90	137	179	226	277	328	380	436
Upper Flange Av. °C	77	91	137	176	220	268	316	367	418
Furnace Atmosphere °C	493	587	642	694	727	747	779	788	798
I.T.T. Standard °C Room Temperature 14 °C	497	597	657	699	733	760	783	803	820
Deflection mm	3	6	12	20	26	32	40	64	150

SUMMARY OF FIRE TEST DATA FROM 27/2/80

356 x 171 mm x 67 Kg/m P/A 143 m^{-1} GRADE 43A STRESS 165 N/mm^2

DATA SHEET NO. 4

T/RS/1189/21/81/A

TEST REFERENCE NO 26069

WRC NO.

BSC TEST REFERENCE NO. 17

CARRIED OUT

15/7/80

Section Size	P/A Value		WEB	FL
356 x 171mm x 67 kg/m	142 m^{-1}	Yield Stress (N/mm^2)	395	3
		Tensile Strength (N/mm^2)	498	4
Grade	Design Stress			
50B	165 N/mm^2			

Composition	%C	%Si	%Mn	%P	%S	%Cr	%Mo	%Ni	%V	%Ti	%Cu	%Sn	%Nb	%Zr	% Sol. Al.	% Tot Al.
Code RS 976	.17	.020	1.42	.012	.050	.016	<.005	.014	.072	<.005	.008	.005	<.005	<.005		

Failure Time 24½ Mins.

THERMOCOUPLE LOCATION	TEMPERATURE (°C) AFTER VARIOUS TIMES (mins)								
	3	6	9	12	15	18	21	24	24½
Lower Flange 1	110	211	324	436	531	606	658	698	702
Lower Flange 2	120	221	342	458	553	624	673	711	717
Lower Flange 4	97	199	325	449	548	619	668	705	711
Lower Flange 6	132	244	363	468	558	526	675	712	718
Lower Flange 7	106	220	353	469	564	632	680	716	721
Centre Web 1	124	246	377	483	563	623	665	696	701
Centre Web 2	142	273	410	517	596	652	690	721	724
Centre Web 3	151	290	436	542	612	657	692	721	725
Centre Web 4	136	258	392	501	578	630	666	698	703
Mean Lower Flange and Centre Web °C	124	240	369	480	567	630	674	709	714
¼ Web (5) °C	143	265	390	491	559	608	644	677	684
¾ Web (6) °C	129	253	372	468	542	601	643	676	682
Upper Flange (3) °C	76	120	167	218	275	334	387	438	447
Upper Flange (5) °C	79	129	188	255	318	380	437	496	507
Upper Flange Av. °C	78	125	178	237	297	357	412	467	477
Furnace Atmosphere °C	527	330	715	752	778	804	820	836	835
I.T.T. Standard °C Room Temperature °C	506	606	666	708	742	759	792	812	815
Deflection mm	3	10	20	28	38	50	71	101	152

SUMMARY OF FIRE TEST DATA FROM 15/7/80

356 x 171 mm x 67 Kg/m P/A 142 m^{-1} GRADE 50B STRESS 165 N/mm^2

DATA SHEET NO. 8

364 x 171 x 73 kg/m
— model of test 3

Time	LF	1/4	1/2	3/4	TF
0	24	24	24	24	24
3	81.3	95.0	97.5	92.2	52.4
6	174.2	201.0	207.8	188.8	101.8
9	276.0	311.1	319.9	286.5	158.0
12	375.8	414.8	423.4	378.4	215.2
15	467.8	506.9	514.1	461.3	270.7
18	548.3	584.5	589.9	533.4	323.0
21	615.4	646.8	650.3	594.0	371.0
24	668.7	693.9	695.9	643.2	414.1