

Fire Resistance Test in Accordance  
with BS 476: Part 23: 1987, Clause 5, on a  
Suspended Ceiling Assembly Protecting  
Loadbearing 'I' Section Steel Beams

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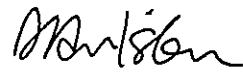

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**Fire Resistance Test in Accordance  
with BS 476: Part 23: 1987, Clause 5, on a  
Suspended Ceiling Assembly Protecting  
Loadbearing 'I' Section Steel Beams**

Test Sponsor

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Report	Name	Signature*
Responsible Officer	D. Hankinson	
Approved	D. Williams	

\* For and on behalf of Warrington Fire Research Centre

Report Issued : 28<sup>th</sup> May 1998

**Fire Resistance Test in Accordance  
with BS 476: Part 23: 1987, Clause 5, on a  
Suspended Ceiling Assembly Protecting  
Loadbearing 'I' Section Steel Beams**

**Summary**

A specimen of a suspended ceiling, protecting loadbearing steel beams, has been subjected to a test in accordance with BS 476: Part 23: 1987, Clause 5, to determine its contribution to the fire resistance performance of loadbearing 'I' section steel beams.

The nominal dimensions of the specimen were 4000 mm long by 3035 mm wide and consisted of an exposed tee suspension system, supporting ceiling tiles referenced 'DanoRex', each of nominal size 594 mm by 594 mm by 6.5 mm thick.

The effective protection offered by the suspended ceiling to the loadbearing steel beams is evaluated by the use of the loadbearing capacity failure criterion specified in BS 476: Part 20: 1987. The result obtained was as follows:

**Effective Protection : 40 minutes**

The test was discontinued after a period of 41 minutes.

**Date of Test : 20<sup>th</sup> March 1998**

**JMP(2378)**

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## 1 Purpose of the Investigation

- 1.1 To determine the effective fire protection provided by a specimen of a suspended ceiling below loadbearing 'I' section steel beams, when tested in accordance with BS 476: Part 23: 1987, Clause 5.

## 2 Introduction

- 2.1 The suspended ceiling was to provide fire protection to loadbearing steel beams therefore the test was conducted in accordance with Clause 5 of BS 476: Part 23: 1987 'Methods for determination of the contribution of components to the fire resistance of a structure. This test report should be read in conjunction with that Standard and with BS 476: Part 20: 1987, 'Methods for determination of the fire resistance of elements of construction (general principles)'.
- 2.2 The specimen was judged on its ability to provide fire protection to hot rolled steel 'I' section beams of serial size 203 mm by 133 mm by 30 kg/m to BSEN10 025: 1993, Grade S275, each having a nominal section factor of  $210\text{m}^{-1}$  (three sided exposure).
- 2.3 Certain aspects of some fire test specifications are open to different interpretations. The Fire Test Study Group has identified a number of such areas and has agreed Resolutions which define common agreement of interpretations between the fire test laboratories which are members of the Group. Where such Resolutions are applicable to this test they have been followed.
- 2.4 The investigation was conducted on the 20<sup>th</sup> March 1998, at the request of Danogips Ceiling Systems, the sponsor of the test.
- 2.5 The test was witnessed by Mr. A. Knibb and Mr. E. B. Ipsen representatives of the sponsor of the test.

## 3 Test Specimen Construction

- 3.1 A comprehensive description of the test construction is given in Annex A. The description is based on a detailed survey of the specimen and information supplied by the sponsor of the test.
- 3.2 The specimen was supplied in component form by the sponsor. Warrington Fire Research Centre was not involved in any selection or sampling procedures of any of the components.
- 3.3 The ceiling assembly was installed by the sponsor within a refractory concrete lined steel support frame on the 19<sup>th</sup> March 1998.

## 4 Instrumentation and Measuring Equipment

- 4.1 The instrumentation was provided in accordance with the requirements of the Standard.
- 4.2 Eight thermocouples evenly distributed over a plane 100 mm from the underside of the suspended ceiling were provided to monitor the temperature of the furnace atmosphere.
- 4.3 Pressure sensors were provided within the furnace to monitor the furnace atmospheric pressure.

- 4.4 Thermocouples were provided to monitor the temperature of the test construction as follows:
- 4.4.1 At sixteen positions, eight uniformly distributed along the length of each 'I' beam, to record the steel temperature, five of the thermocouples were positioned on the inside of the lower flange of each beam, mid-way between the web and the toe of the flange, and three thermocouples were positioned on the web of each beam, at mid-height. (Thermocouples 10 to 17 on beam 'A' and 18 to 25 on beam 'B')
  - 4.4.2 At one position on the unexposed face of each of four ceiling tiles. (Thermocouples 26 to 29)
  - 4.4.3 At four positions at mid-height of the air cavity within the assembly. (Thermocouples 30 to 33)
  - 4.4.4 The locations and reference numbers of the thermocouples of the test construction are shown in Figure 4 of Annex A.

## 5 Test Procedure

- 5.1 The test was conducted in accordance with the procedure specified in Clause 5 of BS 476: Part 23: 1987.
- 5.2 The furnace was controlled so that its mean temperature complied with the requirements of BS 476: Part 20: 1987, Clause 3.1.
- 5.3 The atmospheric pressure within the furnace chamber was controlled to maintain equilibrium relative to the atmospheric pressure of the laboratory at a position 100 mm below the soffit of the ceiling.
- 5.4 A total load of 8.3 tonnes, produced by hydraulic rams, was applied by four point loads to each beam. The rams were positioned at distances of 1/8th, 3/8th, 5/8th and 7/8th of the span of each beam, as shown in Figure 2. This applied load, together with the dead load, was calculated to develop the maximum permissible stress in bending and was kept constant throughout the test. Calculation data for the applied load is given in Annex C.
- 5.5 Throughout the test, the temperatures indicated by the thermocouples provided to monitor the furnace and the specimen were monitored continuously and were recorded at one minute intervals.
- 5.6 Observations were made on the general behaviour of the test specimen during the test.

## 6 Test Data

- 6.1 The following data, which was recorded during the test, is given in Annex B:
  - 6.1.1 Mean furnace temperature, together with a comparison with the temperature/time relationship specified in the Standard.
  - 6.1.2 The central vertical deflections recorded by the linear deflection transducer.
  - 6.1.3 The temperatures recorded by the thermocouples fixed to the test construction at the positions shown in Figures 4.

- 6.2 Calculation of the applied load to BS 449 is given in Annex C.
- 6.3 A summary of the observations made on the general behaviour of the specimen during the test is given in Annex D.
- 6.4 The ambient air temperature in the vicinity of the test construction was 13°C at the start of the test with a variation of +2°C during the test.
- 6.5 The test was discontinued after a period of 41 minutes.

## 7 Evaluation Against the Performance Criterion

- 7.1 The performance of the specimen was judged against the following criterion of BS 476: Part 20: 1987.

7.1.1 **Loadbearing Capacity** - The maximum allowable deflection and the maximum allowable rate of deflection for the beams, as specified by the Standard, are calculated as 210 mm and 9.5 mm per minute respectively. The allowable rate of deflection is not applicable until the deflection exceeds 1/30th of the span (i.e. 140 mm). These criteria were satisfied for a period of 40 minutes after which time Beam A exceeded the maximum rate of deflection.

## 8 Conclusions

- 8.1 A specimen of a suspended ceiling protecting loadbearing steel beams has been subjected to a test in accordance with BS 476: Part 23: 1987, Clause 5, to determine its contribution to the fire resistance of steel beams.
- 8.2 The specimen satisfied the performance criterion for 'effective protection' to hot rolled steel beams, as specified in Clause 5 of the Standard, for the period stated below:

**Effective Protection:**            40 minutes

- 8.3 The test was discontinued after a period of 41 minutes.

## 9 Limitations

- 9.1 The results relate only to the behaviour of the specimen of the element of construction under the particular conditions of test. They are not intended to be the sole criteria for assessing the potential fire performance of the element in use, nor do they reflect the actual behaviour in fires.
- 9.2 The test results relate only to the specimen tested. Appendix A of BS 476: Part 20: 1987 provides guidance information on the application of fire resistance tests and the interpretation of test data. Application of the results to assemblies of different forms and dimensions incorporating different components should be the subject of a design appraisal.

10 Review

- 10.1 The specification and interpretation of fire test methods are the subject of ongoing development and refinement. Changes in associated legislation may also occur. For these reasons it is recommended that the relevance of test reports over five years old should be considered by the user. The laboratory that issued the report will be able to offer, on behalf of the legal owner, a review of the procedures adopted for a particular test to ensure that they are consistent with current practices, and if required may endorse the test report.

28<sup>th</sup> May 1998

JMP(2378)



**ANNEX A**

**SCHEDULE OF COMPONENTS**

(Refer to Figures 1 to 3)

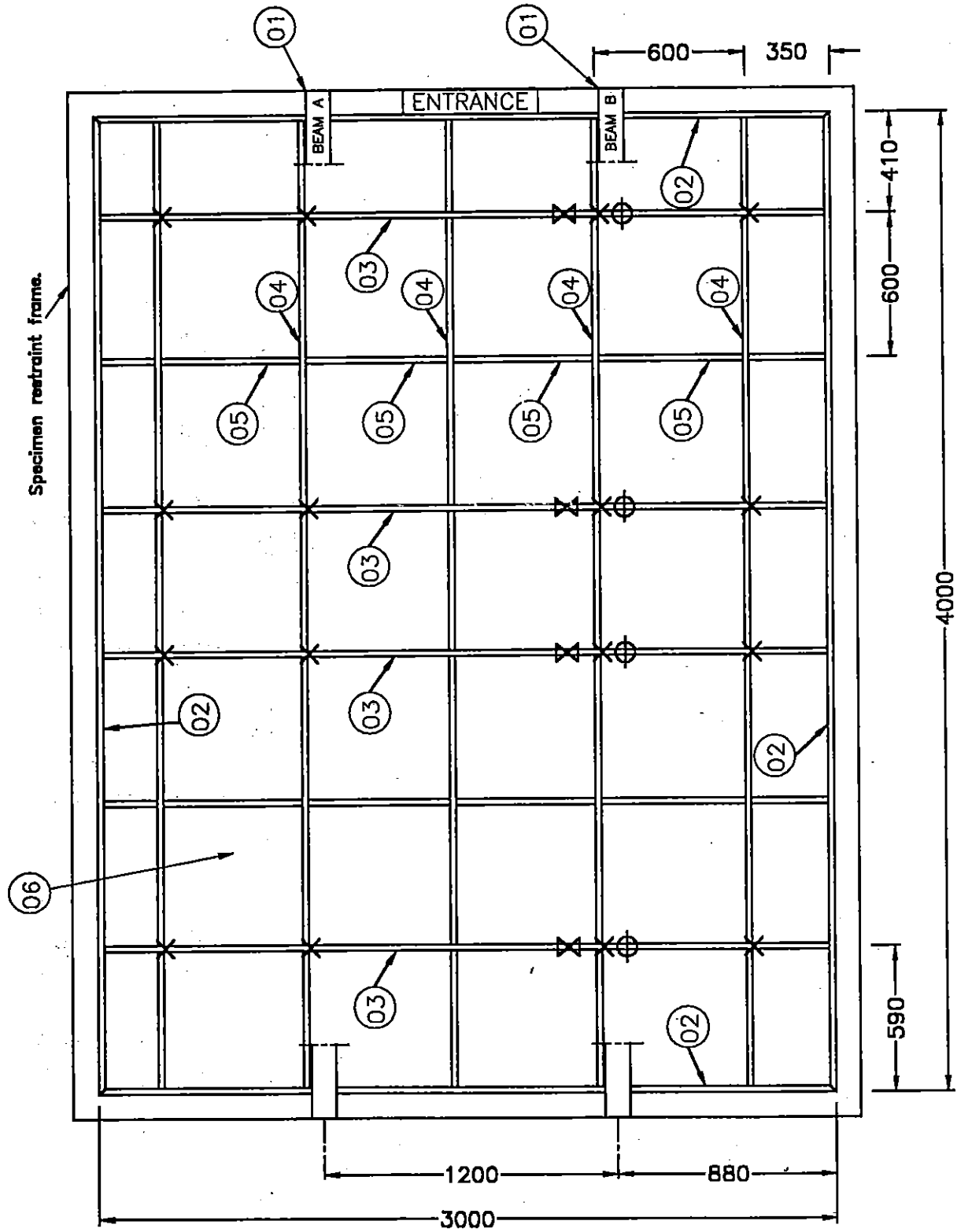
(All values are nominal unless stated otherwise)

(All references are as stated by the sponsor)

<b><u>Item</u></b>	<b><u>Description</u></b>
1.	<b>Steel Beams</b>
Type	: I section beam.
Material	: Mild steel to BS EN10025 : 1993, Grade S275.
Size	
i. overall	: 203 mm x 133 mm.
ii. weight	: 30 kg/m.
iii. span	: 4200 mm
2.	<b>Perimeter Trim</b>
Reference	: 130209.
Material	: Mild steel stove enamelled.
Thickness	: 0.5 mm.
Overall size	: 19 mm wide x 32 mm high.
Expansion allowance	: None.
Fixings	: Steel screws 38 mm x 3.5 mm diameter at 300 mm centres.
3.	<b>Main Tee</b>
Reference	: Prelude TL, 11 40 33A.
Material	: Galvanised mild steel with a painted mild steel capping to the bottom flange.
Thickness	: 0.4 mm with a 0.25 mm capping.
Overall size	: 24 mm wide x 38 mm high.
Grid centres	: See Figure 1.
Expansion allowance	: Single expansion relief per 3035 mm ceiling width.
Fixing method	: Hangers item 7.
4.	<b>Cross Tee</b>
Reference	: Prelude TL, 11 30 33A.
Material	: Galvanised mild steel with a painted mild steel capping to the bottom flange.
Thickness	: 0.4 mm with a 0.25 mm capping.
Overall size	: 24 mm wide x 38 mm high x 1200 mm long.
Grid centres	: See Figure 1.
Expansion allowance	: None.
Fixing method	: Snap fitted into slots along main tees.
5.	<b>Secondary Tee</b>
Reference	: Prelude TL, 11 20 33A.
Material	: Galvanised mild steel with a painted mild steel capping to the bottom flange.
Thickness	: 0.4 mm with a 0.25 mm capping.
Overall size	: 24 mm wide x 38 mm high x 600 mm long.
Grid centres	: See Figure 1.
Expansion allowance	: None.
Fixing method	: Snap fitted into slots along main tees, cross tees and flanges of perimeter trims.

Annex A (Continued)

6.       **Tiles**  
          Manufacturer                   :     Danogips.  
          Reference                     :     Danogips DanoRex ceiling tiles. ✓  
          Material                      :     Gypsum plaster based.  
          Density                       :     893 kg/m<sup>3</sup> (measured).  
          Thickness                     :     6.5 mm.  
          Overall size                  :     594 mm x 594 mm.  
          Edge shape                    :     Square.  
          Fixing method                :     Laid onto flanges of perimeter angle and tee supports.
7.       **Hangers**  
          Reference                     :     Quick Adjustable Hangers.  
          Type                          :     Two mild steel wires linked via the adjustable hanger. Wires fixed to beam via clamps and tied to bulb of tees.  
  
          Material                      :     Mild steel.



Key to symbols

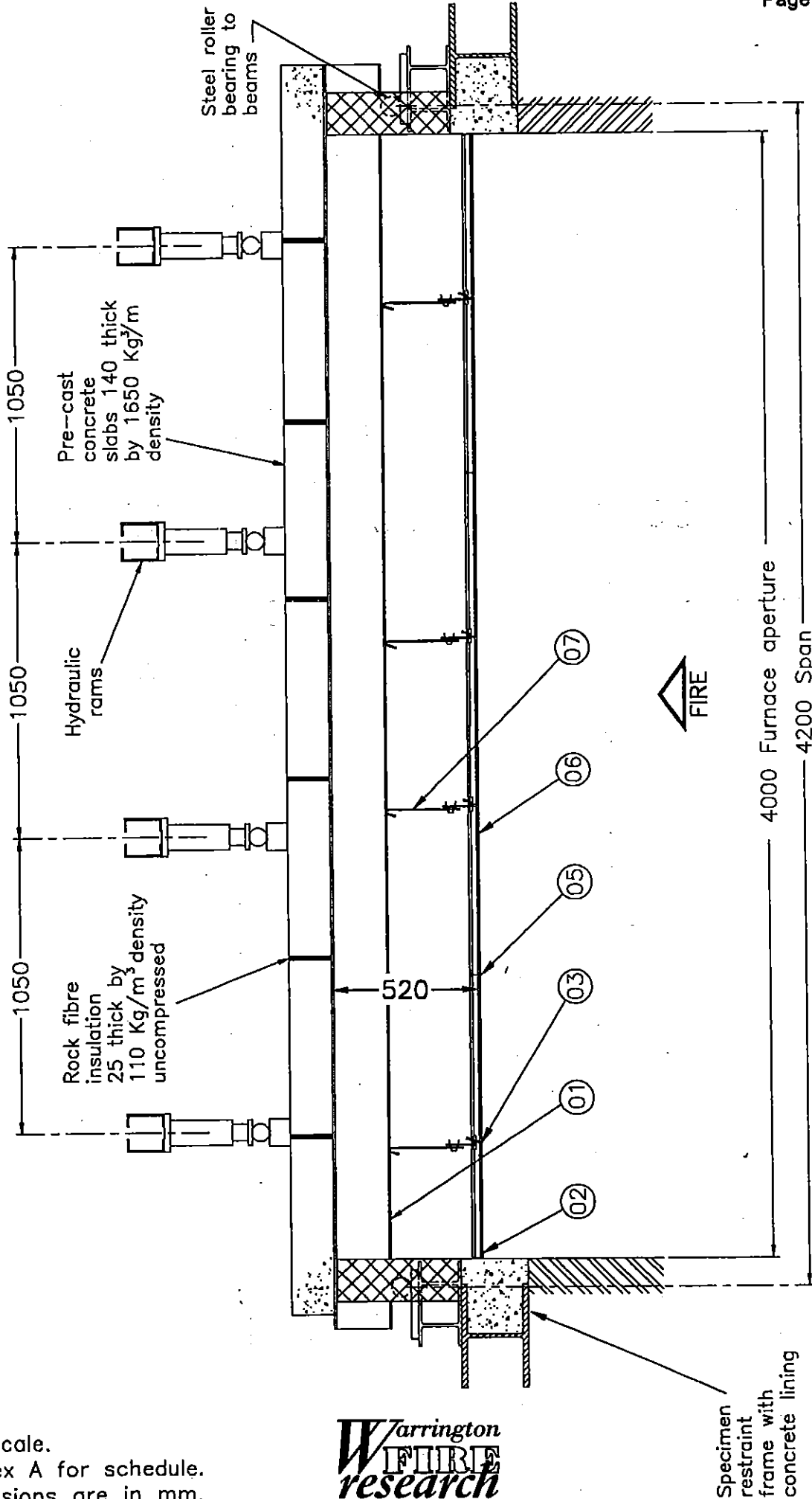
- ⊗ Expansion cut-out
- ⊕ Splice connection
- × Hanger (07)

GENERAL ARRANGEMENT OF CEILING

Do not scale  
All dimensions are in mm  
See annex A for schedule



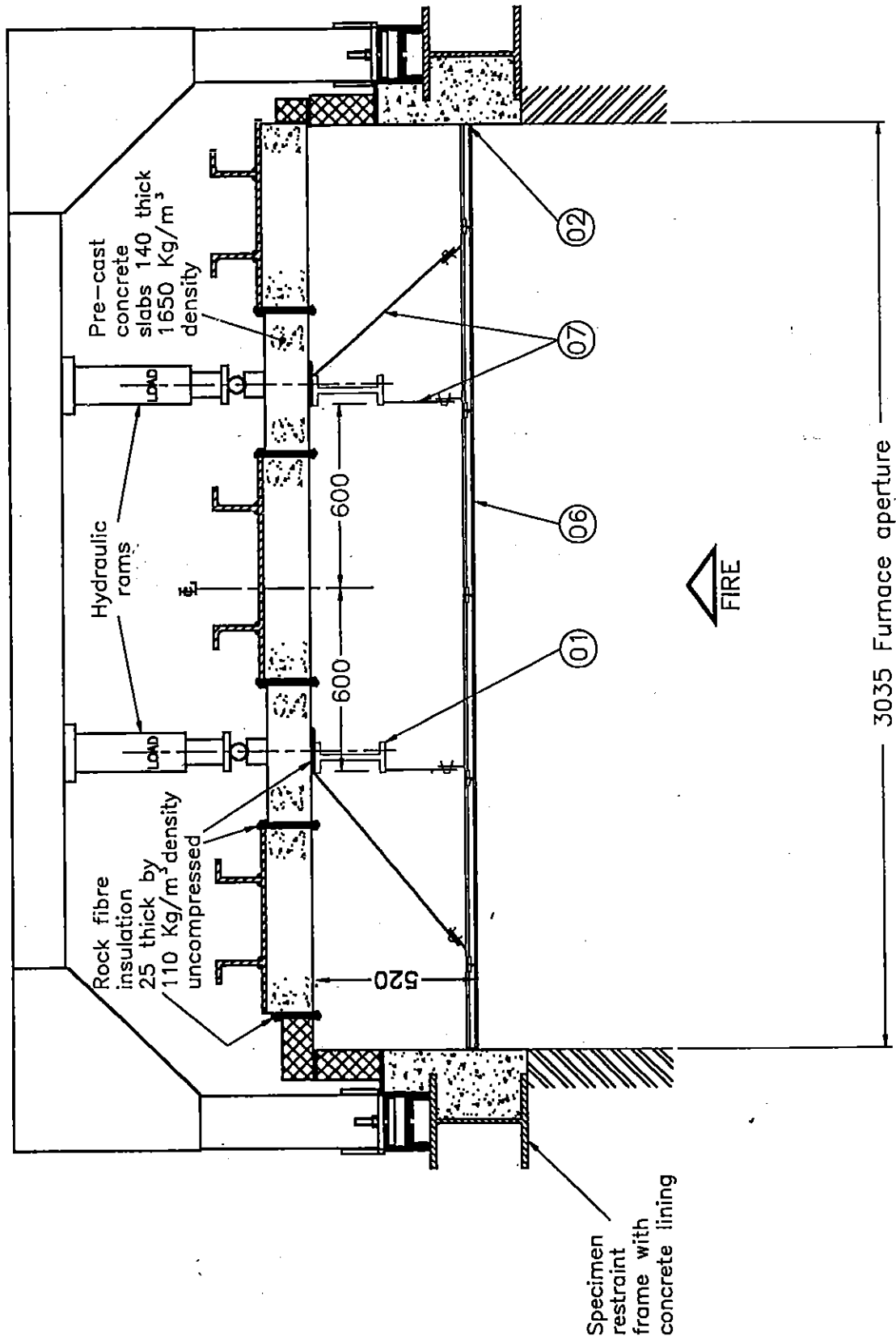
FIGURE 1



LONGITUDINAL SECTION

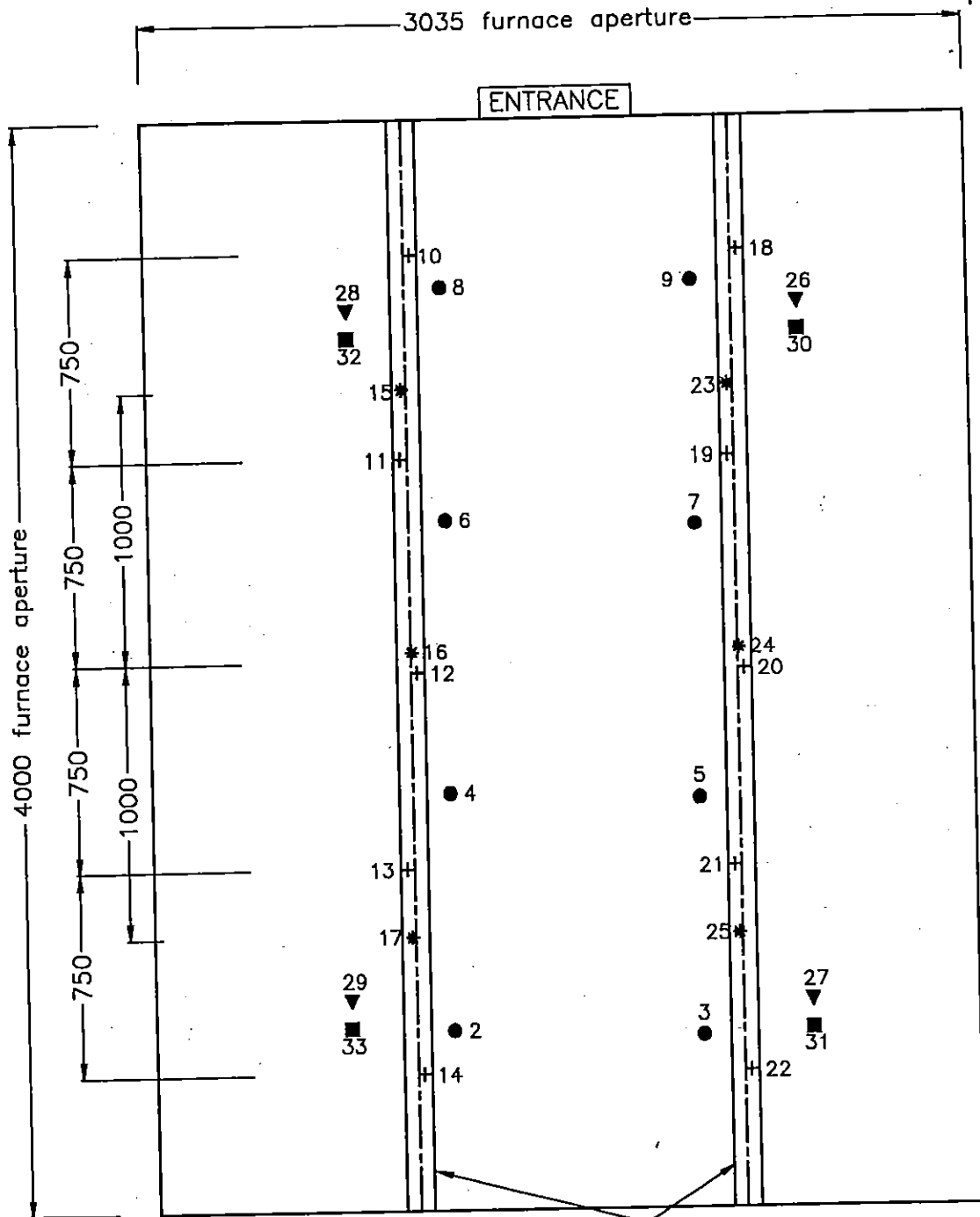
Do not scale.  
See annex A for schedule.  
All dimensions are in mm.

Specimen  
restraint  
frame with  
concrete lining



Do not scale

See annex A for schedule.  
All dimensions are in mm.



Key to thermocouple positions

- Air at mid-cavity height
- ▼ Upper face of ceiling membrane
- Furnace 100mm below ceiling
- + Lower flange of steel beam
- \* Mid web of steel beam

Numbers adjacent to thermocouples are WFRG logging numbers

PLAN OF THERMOCOUPLE POSITIONS

All dimensions are in mm



FIGURE 4

ANNEX B

DATA RECORDED DURING THE TEST

TABLE 1

ACTUAL AND SPECIFIED FURNACE TEMPERATURES WITH  
PERCENTAGE TOLERANCES

: :Time: : :Mins:	: STANDARD: FURNACE TEMP. : Deg C	: ACTUAL FURNACE TEMP. : Deg C	: AREA UNDER STANDARD CURVE : Deg C.min	: AREA UNDER ACTUAL CURVE : Deg C.min	: PERCENT DIFF.	: PERCENT TOLERANCE: : + or -
: 0:	20	18	:	:	:	:
: 1:	349	347	:	:	:	:
: 2:	445	459	:	:	:	:
: 3:	502	509	:	:	:	:
: 4:	544	534	:	:	:	:
: 5:	576	645	:	:	:	:
: 6:	603	550	:	:	:	:
: 7:	626	594	:	:	:	:
: 8:	645	641	:	:	:	:
: 9:	663	675	:	:	:	:
: 10:	678	685	5302	5307	.086	15
: 12:	705	709	:	:	:	:
: 14:	728	724	:	:	:	:
: 16:	748	733	:	:	:	:
: 18:	766	756	:	:	:	:
: 20:	781	771	:	:	:	:
: 22:	796	783	:	:	:	:
: 24:	809	801	:	:	:	:
: 26:	820	824	:	:	:	:
: 28:	831	835	:	:	:	:
: 30:	842	842	15493	15397	-1	10
: 35:	865	862	:	:	:	:
: 40:	885	883	:	:	:	:
: 41:	888	893	9529	9475	-1	5

Annex B (Continued)

TABLE 2

INDIVIDUAL AND MEAN TEMPERATURES RECORDED ON BEAM A

:Time:	T/C 10:	T/C 11:	T/C 12:	T/C 13:	T/C 14:	T/C 15:	T/C 16:	T/C 17:	MEAN
:Mins:	Deg C:	Deg C:	Deg C:	Deg C:	Deg C:	Deg C:	Deg C:	Deg C:	TEMP.:
:	:	:	:	:	:	:	:	:	Deg C:
: 0:	13	15	16	20	15	17	15	17	16
: 1:	18	15	16	20	18	17	15	18	17
: 2:	18	16	17	21	19	17	15	18	18
: 3:	20	18	19	24	21	19	18	21	20
: 4:	26	23	26	31	27	26	28	29	27
: 5:	34	32	36	43	36	37	42	41	37
: 6:	56	52	52	54	48	62	35	51	51
: 7:	62	63	62	57	52	70	60	52	61
: 8:	68	67	67	61	58	80	66	56	67
: 9:	74	71	77	66	62	84	71	60	72
: 10:	81	78	81	71	66	91	75	65	77
: 11:	94	81	84	74	71	92	78	69	82
: 12:	92	85	86	79	76	94	82	74	85
: 13:	94	93	91	85	82	97	92	80	90
: 14:	98	97	98	91	86	106	106	91	97
: 15:	97	102	100	98	90	113	121	104	103
: 16:	100	108	112	103	93	124	137	117	111
: 17:	115	124	133	106	104	131	152	128	123
: 18:	134	140	153	108	123	145	167	141	139
: 19:	151	158	173	129	139	158	181	153	156
: 20:	168	175	192	154	155	172	197	165	173
: 21:	184	192	209	176	171	185	212	177	190
: 22:	199	208	227	194	186	198	226	189	205
: 23:	213	223	245	211	200	210	241	203	220
: 24:	227	240	260	229	214	224	254	216	235
: 25:	241	256	276	245	229	237	268	229	250
: 26:	259	283	295	262	244	260	286	245	270
: 27:	293	345	324	282	262	310	318	268	305
: 28:	328	400	352	304	281	358	349	290	339
: 29:	358	448	380	325	300	396	378	312	369
: 30:	388	488	406	348	327	428	404	335	398
: 31:	413	523	431	375	377	454	429	368	429
: 32:	435	552	453	402	419	476	451	400	455
: 33:	452	572	474	427	462	490	468	440	478
: 34:	467	590	492	452	506	505	484	*	499
: 35:	482	607	511	479	544	520	502	:	521
: 36:	499	625	530	508	582	539	522	:	544
: 37:	518	644	552	543	612	560	546	:	568
: 38:	559	663	575	574	638	592	570	:	596
: 39:	606	682	600	608	656	626	596	:	625
: 40:	645	701	625	635	670	657	622	:	651
: 41:	674	720	653	659	684	682	647	:	674

\* Thermocouple Malfunction



Annex B (Continued)

TABLE 3

INDIVIDUAL AND MEAN TEMPERATURES RECORDED ON BEAM B

:Time:	T/C 18:	T/C 19:	T/C 20:	T/C 21:	T/C 22:	T/C 23:	T/C 24:	T/C 25:	MEAN :
:Mins:	Deg C:	Deg C:	Deg C:	Deg C:	Deg C:	Deg C:	Deg C:	Deg C:	TEMP.:
:	:	:	:	:	:	:	:	:	Deg C:
: 0:	16 :	16 :	15 :	14 :	16 :	15 :	13 :	11 :	14 :
: 1:	16 :	16 :	15 :	14 :	14 :	15 :	13 :	11 :	14 :
: 2:	17 :	16 :	15 :	14 :	15 :	15 :	14 :	11 :	15 :
: 3:	19 :	19 :	17 :	17 :	16 :	17 :	15 :	14 :	17 :
: 4:	24 :	25 :	24 :	24 :	22 :	24 :	24 :	22 :	24 :
: 5:	33 :	35 :	33 :	36 :	32 :	35 :	38 :	34 :	35 :
: 6:	40 :	52 :	51 :	47 :	40 :	47 :	50 :	45 :	47 :
: 7:	44 :	58 :	58 :	50 :	44 :	49 :	53 :	46 :	50 :
: 8:	50 :	62 :	62 :	55 :	49 :	57 :	59 :	49 :	55 :
: 9:	59 :	69 :	66 :	60 :	55 :	64 :	63 :	54 :	61 :
: 10:	65 :	72 :	71 :	64 :	60 :	66 :	67 :	58 :	65 :
: 11:	71 :	76 :	76 :	69 :	65 :	68 :	72 :	62 :	70 :
: 12:	78 :	81 :	80 :	74 :	70 :	75 :	74 :	67 :	75 :
: 13:	83 :	86 :	86 :	80 :	76 :	81 :	81 :	72 :	81 :
: 14:	87 :	90 :	88 :	84 :	81 :	92 :	95 :	83 :	88 :
: 15:	94 :	94 :	94 :	89 :	85 :	105 :	114 :	96 :	96 :
: 16:	97 :	102 :	99 :	94 :	91 :	119 :	131 :	108 :	105 :
: 17:	111 :	126 :	121 :	107 :	96 :	132 :	146 :	121 :	120 :
: 18:	124 :	144 :	144 :	135 :	102 :	144 :	162 :	133 :	136 :
: 19:	142 :	163 :	162 :	155 :	125 :	156 :	178 :	147 :	153 :
: 20:	156 :	180 :	181 :	173 :	147 :	169 :	192 :	159 :	170 :
: 21:	170 :	198 :	199 :	193 :	165 :	183 :	207 :	174 :	186 :
: 22:	186 :	215 :	222 :	222 :	185 :	198 :	226 :	192 :	206 :
: 23:	203 :	231 :	245 :	250 :	207 :	213 :	247 :	214 :	226 :
: 24:	218 :	249 :	266 :	278 :	227 :	229 :	265 :	233 :	246 :
: 25:	234 :	265 :	287 :	305 :	248 :	244 :	285 :	254 :	265 :
: 26:	249 :	284 :	308 :	332 :	267 :	260 :	304 :	273 :	285 :
: 27:	267 :	307 :	328 :	358 :	285 :	280 :	324 :	292 :	305 :
: 28:	285 :	331 :	348 :	384 :	303 :	301 :	344 :	311 :	326 :
: 29:	303 :	353 :	369 :	408 :	320 :	322 :	365 :	331 :	346 :
: 30:	321 :	374 :	389 :	430 :	338 :	341 :	384 :	350 :	366 :
: 31:	338 :	391 :	407 :	451 :	357 :	358 :	404 :	372 :	385 :
: 32:	355 :	407 :	425 :	474 :	384 :	375 :	423 :	402 :	406 :
: 33:	372 :	425 :	445 :	510 :	438 :	393 :	446 :	459 :	436 :
: 34:	388 :	440 :	464 :	539 :	488 :	410 :	468 :	504 :	463 :
: 35:	403 :	456 :	482 :	566 :	532 :	426 :	490 :	544 :	487 :
: 36:	417 :	472 :	499 :	589 :	568 :	443 :	509 :	576 :	509 :
: 37:	432 :	488 :	515 :	610 :	597 :	459 :	527 :	602 :	529 :
: 38:	465 :	516 :	532 :	627 :	620 :	498 :	544 :	621 :	553 :
: 39:	521 :	550 :	550 :	639 :	639 :	546 :	565 :	634 :	580 :
: 40:	571 :	593 :	568 :	654 :	662 :	589 :	587 :	651 :	609 :
: 41:	611 :	628 :	586 :	672 :	682 :	624 :	610 :	670 :	635 :

Annex B (Continued)

TABLE 4

INDIVIDUAL AND MEAN TEMPERATURES RECORDED ON THE UNEXPOSED SURFACE OF THE CEILING TILES

Time:	T/C 26	T/C 27	T/C 28	T/C 29	MEAN
Mins:	Deg C	Deg C	Deg C	Deg C	TEMP.
					Deg C
0:	14	14	15	14	14
1:	23	26	23	28	25
2:	50	44	43	48	46
3:	67	79	74	79	75
4:	73	72	72	75	73
5:	84	75	75	76	78
6:	86	78	78	79	80
7:	85	78	79	76	79
8:	86	84	84	77	83
9:	90	90	91	81	88
10:	94	95	96	85	92
11:	105	103	101	90	100
12:	136	124	124	101	121
13:	198	171	178	124	168
14:	268	236	244	164	228
15:	324	290	300	208	281
16:	363	332	342	239	319
17:	385	362	368	258	343
18:	397	382	385	270	359
19:	404	396	396	282	370
20:	410	404	405	294	378
21:	416	410	412	306	386
22:	428	428	418	314	397
23:	442	444	425	322	408
24:	450	454	431	330	416
25:	458	464	438	339	425
26:	464	472	449	348	433
27:	472	473	487	382	453
28:	481	478	510	402	468
29:	489	485	525	414	478
30:	498	492	539	429	490
31:	506	506	557	457	507
32:	513	521	566	480	520
33:	520	570	559	533	546
34:	528	610	559	572	567
35:	538	651	561	598	587
36:	548	678	575	619	605
37:	559	693	590	628	617
38:	574	701	623	630	632
39:	799	701	652	626	694
40:	822	704	678	637	710
41:	832	780	685	647	736

Annex B (Continued)

TABLE 5

INDIVIDUAL AND MEAN TEMPERATURES RECORDED  
WITHIN THE AIR CAVITY

: Time :	T/C 30 :	T/C 31 :	T/C 32 :	T/C 33 :	MEAN :
: Mins :	Deg C :	Deg C :	Deg C :	Deg C :	TEMP. :
:	:	:	:	:	Deg C :
: 0:	14 :	14 :	14 :	14 :	14 :
: 1:	16 :	15 :	16 :	18 :	16 :
: 2:	21 :	21 :	21 :	23 :	22 :
: 3:	36 :	35 :	35 :	36 :	36 :
: 4:	55 :	58 :	53 :	54 :	55 :
: 5:	72 :	75 :	69 :	69 :	71 :
: 6:	72 :	73 :	76 :	75 :	74 :
: 7:	74 :	75 :	76 :	74 :	75 :
: 8:	84 :	86 :	84 :	80 :	83 :
: 9:	98 :	99 :	96 :	91 :	96 :
: 10:	100 :	104 :	99 :	93 :	99 :
: 11:	110 :	116 :	104 :	105 :	109 :
: 12:	139 :	150 :	126 :	129 :	136 :
: 13:	174 :	185 :	158 :	156 :	169 :
: 14:	193 :	199 :	180 :	178 :	188 :
: 15:	207 :	216 :	198 :	196 :	204 :
: 16:	222 :	228 :	216 :	211 :	219 :
: 17:	234 :	237 :	228 :	222 :	230 :
: 18:	245 :	253 :	242 :	232 :	243 :
: 19:	257 :	266 :	252 :	246 :	255 :
: 20:	262 :	275 :	260 :	253 :	262 :
: 21:	273 :	290 :	270 :	265 :	275 :
: 22:	312 :	346 :	274 :	269 :	300 :
: 23:	329 :	369 :	283 :	274 :	314 :
: 24:	335 :	377 :	293 :	283 :	322 :
: 25:	351 :	393 :	301 :	292 :	334 :
: 26:	355 :	384 :	372 :	328 :	360 :
: 27:	369 :	380 :	478 :	382 :	402 :
: 28:	380 :	394 :	502 :	398 :	419 :
: 29:	390 :	404 :	498 :	407 :	425 :
: 30:	399 :	417 :	510 :	434 :	440 :
: 31:	408 :	454 :	553 :	476 :	473 :
: 32:	428 :	579 :	522 :	480 :	502 :
: 33:	448 :	672 :	499 :	574 :	548 :
: 34:	461 :	711 :	504 :	577 :	563 :
: 35:	470 :	716 :	556 :	579 :	580 :
: 36:	477 :	714 :	569 :	625 :	596 :
: 37:	482 :	713 :	591 :	631 :	604 :
: 38:	586 :	697 :	638 :	623 :	636 :
: 39:	700 :	714 :	656 :	635 :	676 :
: 40:	708 :	751 :	663 :	637 :	690 :
: 41:	706 :	769 :	654 :	646 :	694 :

Annex B (Continued)

TABLE 6

CENTRAL VERTICAL DEFLECTION AND RATE OF DEFLECTION OF BEAM A

: Time :	CENTRAL VERTICAL DEFLECTION :	RATE OF DEFLECTION :
: Mins :	OF SPECIMEN :	DEFLECTION :
:	mm :	mm/min :
: 0 :	0 :	0 :
: 1 :	0 :	0 :
: 2 :	0 :	0 :
: 3 :	0 :	0 :
: 4 :	0 :	0 :
: 5 :	0 :	0 :
: 6 :	1 :	1 :
: 7 :	1 :	0 :
: 8 :	1 :	0 :
: 9 :	1 :	0 :
: 10 :	1 :	0 :
: 11 :	1 :	0 :
: 12 :	1 :	0 :
: 13 :	1 :	0 :
: 14 :	1 :	0 :
: 15 :	1 :	0 :
: 16 :	2 :	1 :
: 17 :	3 :	1 :
: 18 :	4 :	1 :
: 19 :	5 :	1 :
: 20 :	6 :	1 :
: 21 :	7 :	1 :
: 22 :	8 :	1 :
: 23 :	9 :	1 :
: 24 :	10 :	1 :
: 25 :	11 :	1 :
: 26 :	12 :	1 :
: 27 :	15 :	3 :
: 28 :	17 :	2 :
: 29 :	20 :	3 :
: 30 :	22 :	2 :
: 31 :	24 :	2 :
: 32 :	25 :	1 :
: 33 :	27 :	2 :
: 34 :	29 :	2 :
: 35 :	31 :	2 :
: 36 :	34 :	3 :
: 37 :	39 :	5 :
: 38 :	50 :	11 :
: 39 :	71 :	21 :
: 40 :	112 :	41 :

Annex B (Continued)

TABLE 7

CENTRAL VERTICAL DEFLECTION AND RATE OF DEFLECTION OF BEAM B

Time:	CENTRAL VERTICAL DEFLECTION OF SPECIMEN	RATE OF DEFLECTION
Mins:	mm	mm/min
0:	0	0
1:	0	0
2:	0	0
3:	0	0
4:	0	0
5:	1	1
6:	1	0
7:	1	0
8:	1	0
9:	1	0
10:	1	0
11:	1	0
12:	1	0
13:	2	1
14:	2	0
15:	2	0
16:	2	0
17:	3	1
18:	4	1
19:	5	1
20:	7	2
21:	8	1
22:	9	1
23:	11	2
24:	12	1
25:	13	1
26:	15	2
27:	16	1
28:	17	1
29:	18	1
30:	19	1
31:	20	1
32:	21	1
33:	23	2
34:	24	1
35:	26	2
36:	27	1
37:	29	2
38:	32	3
39:	37	5
40:	43	6

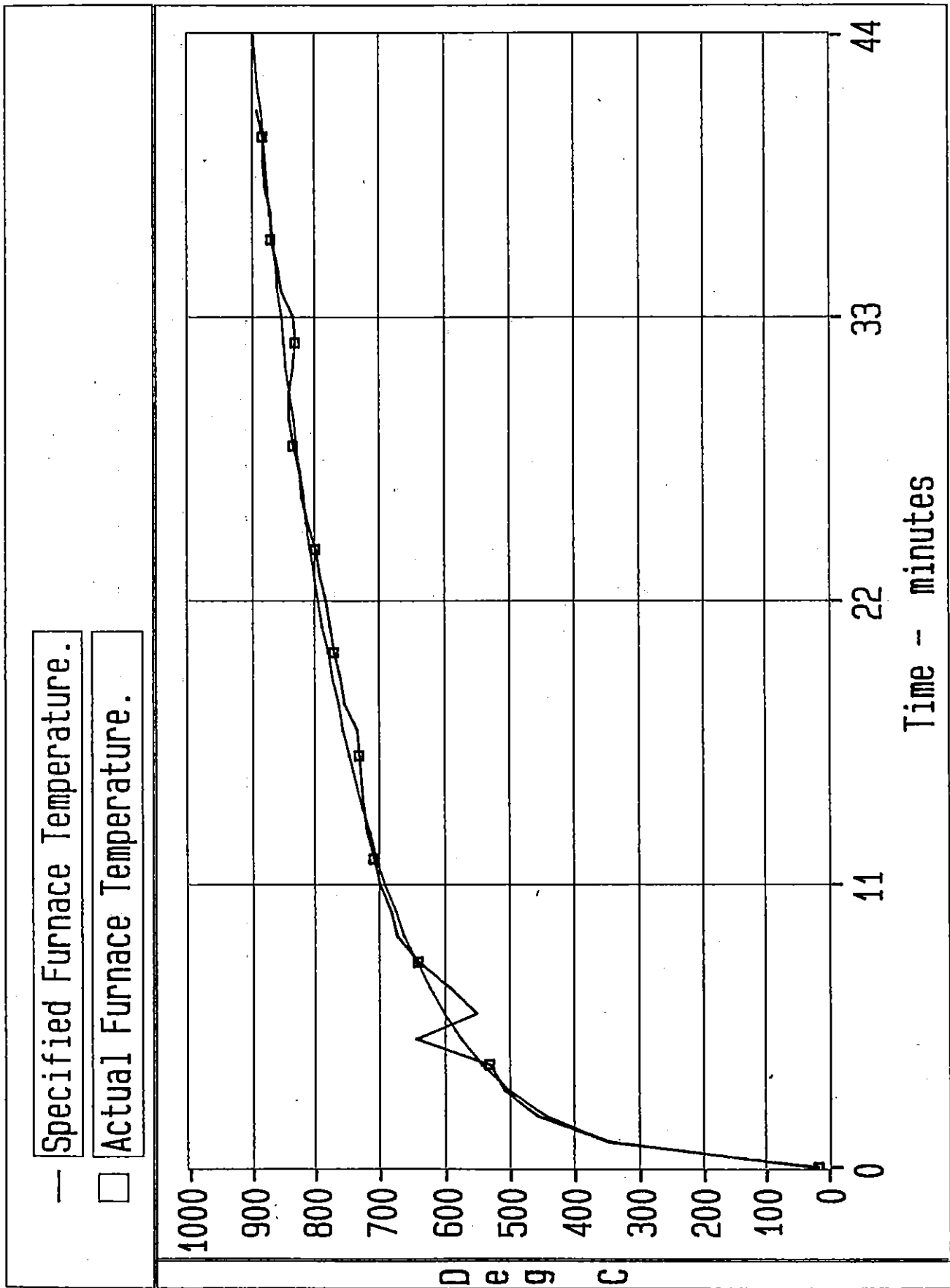


FIGURE 5

— Central Vertical Deflection Of Beam A.

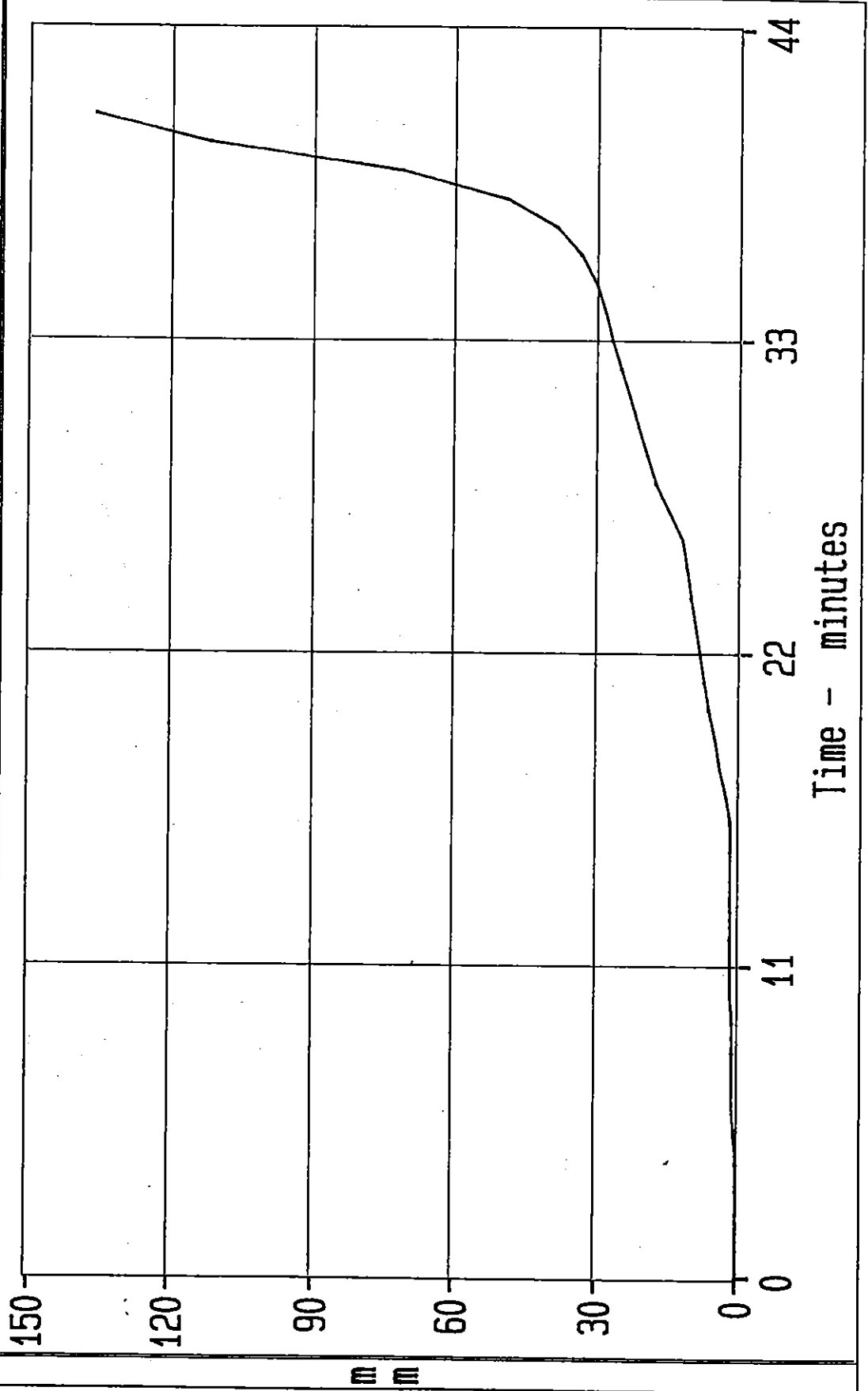
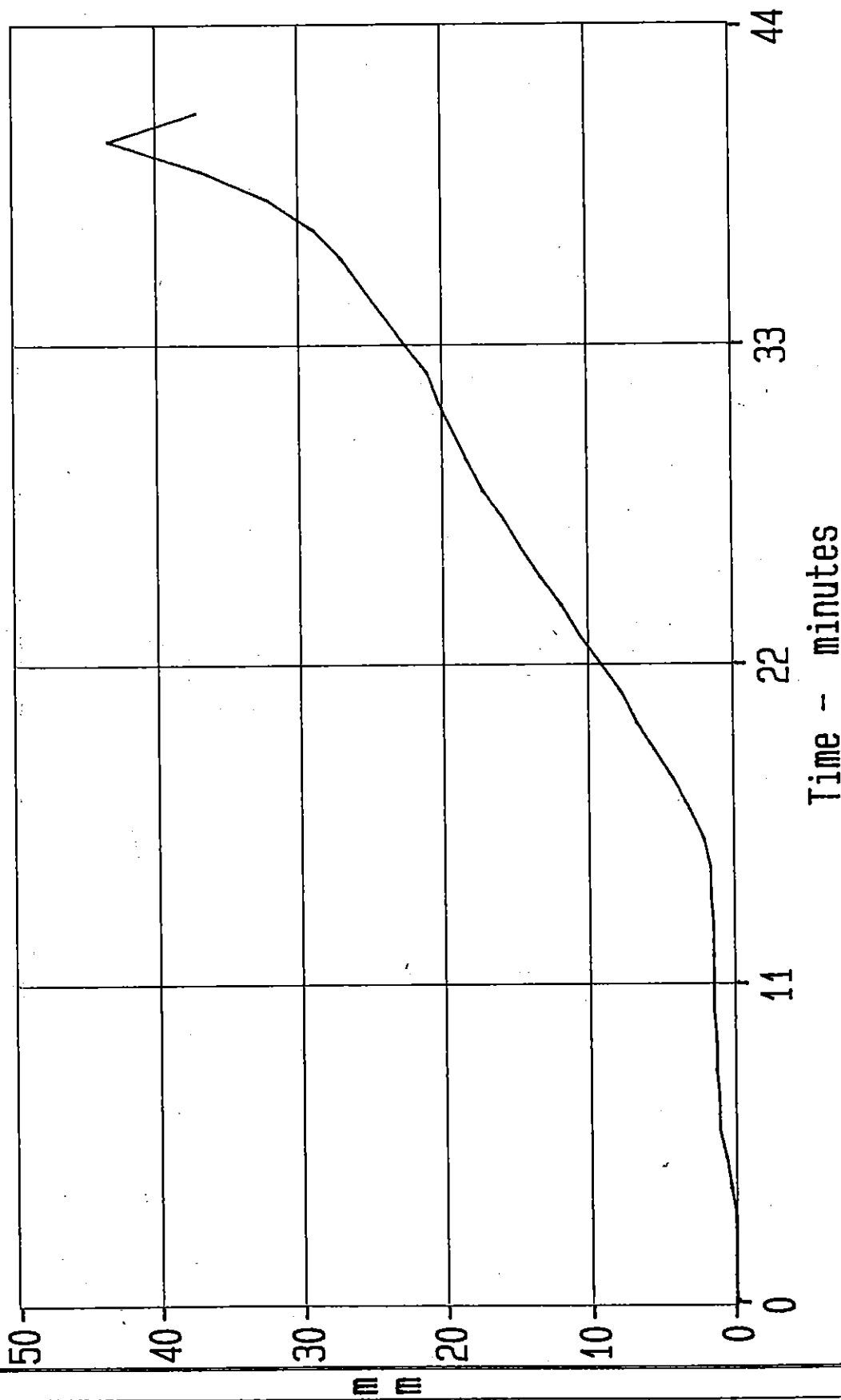


FIGURE 6

— Central Vertical Deflection Of Beam B.





ANNEX C

**CALCULATION LOAD AS SPECIFIED IN BS 449: PART 2: 1969**

**LOAD CALCULATIONS**

Actual properties of universal beam:

Depth of section (D)	: 207 mm
Breadth of section (B)	: 135 mm
Thickness of flange (T)	: 9.4 mm
Thickness of web (t)	: 6.6 mm
Mass per metre	: 292.0 N/m
Moment of inertia (I)	: $2.84595 \times 10^7 \text{ mm}^4$
Distance of neutral axis to base of beam (y)	: 103.5 mm
Effective span of the beam (L)	: 4200 mm

Maximum allowable bending stress to BS 449: Part 2: 1969, Table 2  
f = 165 N/mm<sup>2</sup>

Percentage of allowable bending stress required during the test  
f1 = 100%

Required bending moment =  $f1/y = wL^2/8 \text{ N mm}$

Therefore where  $w = 8f1/yL^2$   
w = load per metre run in N/m  
=  $8 \times 165 \times 2.84595 \times 10^7 / 103.5 \times 4200 \times 4200$   
= 20576.04 N/m

Concrete topping slab  
Depth = 135 mm  
Width = 400 mm  
Mass per metre = 874.1 N/m

Total self-weight of beam and topping = 1166.062 N/m

Required imposed load to produce required bending stress  
= 20576.04 - 1166.06 N/m  
= 19409.98 N/m

Therefore total imposed load = 8310.1 kg

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

Point Loads required = 2077.521 kg

Load Calculated by

Load Checked by



D. HANKINSON  
Technical Officer  
Structural Fire Protection

D. WILLIAMS  
Technical Officer  
For and on behalf of  
WARRINGTON FIRE RESEARCH CENTRE

ANNEX D

OBSERVATIONS MADE DURING THE TEST

The following observations were made during the test by Warrington Fire Research Centre

E - Observations from exposed side  
U - Observations from unexposed side

Time			
mins	secs		
00	00		The test commences.
03	00	E	The facings of the tiles are starting to char and fall away.
05	30	E	The furnace chamber is a mass of red flame as the surface of the tiles ignites.
		U	There is a large smoke release from the furnace.
08	12	E	Gaps of up to approximately 20 mm have opened up between the edges of several tiles and the tee sections, as the tiles start to bow.
15	50	E	The underside of the ceiling is radiating a dull red colour.
19	20	E	One of the tiles beneath beam B has sagged significantly and is no longer supported by the tee section along one of its edges.
20	54	E	The tile mentioned at 19 minutes 20 seconds has fallen from the ceiling assembly.
26	00	E	Another tile at the approximate centre of the specimen has fallen from the assembly.
34	00	E	Further tile has fallen from the ceiling.
38	00	E	Several more tiles have fallen from the ceiling.
40	38		Beam A exceeds the maximum rate of deflection allowable by the standard. Failure of the specimens loadbearing capacity is deemed to occur.
41	00		The test is discontinued.