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THE RESOURCE CENTRE FOR BUILDING EXCELLENCE

TEST REPORT

FR2392

FIRE RESISTANCE OF A LOADBEARING FLOOR/CEILING

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Quality Endorsed Company

Test Report

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FIRE RESISTANCE OF A LOADBEARING FLOOR/CEILING

1. INTRODUCTION

1.1 Client

Speedfloor Holdings Ltd
Unit 8, No 2 Harris Road
Mt Wellington
Auckland
New Zealand

1.2 Test Specification

The test was conducted in accordance with AS 1530.4-1990 Fire Resistance Tests of Elements of Building Construction, for which the fire resistance of the specimen is the time, expressed in minutes, to failure under one or more of the following criteria:

1.2.1 Structural Adequacy

Failure in relation to structural adequacy shall be deemed to have occurred when collapse occurs, or when the deflection exceeds L/20, or when the rate of deflection exceeds $L^2/9000d$ mm/minute after a deflection of L/30 is exceeded, where "L" is the clear span in mm and "d" is the depth of the structural member in mm.

1.2.2 Integrity

For an element intended to separate spaces and resist the passage of flame from one space to another, failure in relation to integrity shall be deemed to have occurred upon collapse, or the development of cracks, fissures or other openings through which flames or hot gases can pass.

1.2.3 Insulation

Failure in relation to insulation shall be deemed to have occurred when either:

(a) the average temperature of the relevant thermocouples attached to the unexposed face of the test specimen rises by more than 140K above the initial temperature, or

(b) the temperature of any of the relevant thermocouples attached to the unexposed face of the test specimen rises by more than 180K above the initial temperature.

This Laboratory is accredited by International Accreditation New Zealand. The tests reported herein have been performed in accordance with the terms of registration.

IANZ has a mutual recognition agreement with the National Association of Testing Authorities, Australia (NATA) such that both organisations recognise accreditations by IANZ and NATA as being equivalent. Users of test reports recommended to accept test reports in the name of either accrediting body.

2. DESCRIPTION OF THE TEST SPECIMEN

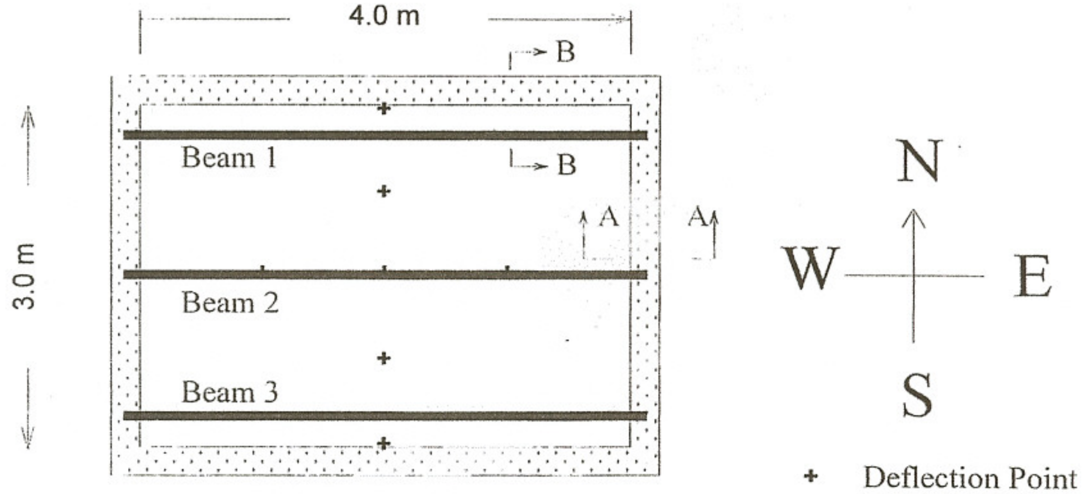
All dimensions given below are nominal unless stated otherwise.

2.1 General

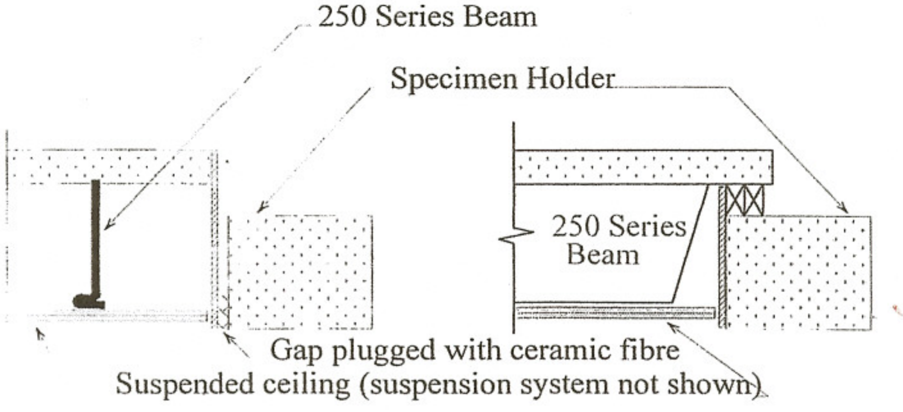
The test specimen consisted of a loadbearing floor/ceiling system constructed from 250 Series Speedfloor Beams, a 75 mm thick concrete floor and a suspended plasterboard ceiling.

The specimen was constructed over a nominal 4 x 3 m concrete lined specimen holder.

2.2 Floor Beams



Floor Framing Members



Section B-B

Section A-A

The Speedfloor 250 Series steel beams spanned the 4 m dimension of the specimen holder and were spaced at 1230 mm centres. Details of the beams are shown in the client supplied drawings reproduced as Figure 4 in this report. The beams were supported at each end on two 70 x 45 mm timber bearers. The clear span of the joists was measured as 4020 mm. The edge joists were only supported at the ends and were therefore free to deflect vertically as shown in Section B-B of the drawing above.

2.3 Suspended Ceiling System

The ceiling was suspended from a Rondo Key-lock system. Samples of all components have been archived at BRANZ. The system is described below using the drawing above to define the compass directions.

A wall angle trim Part No. 140 F.C. Track was screwed at 450 mm nominal centres to the plasterboard simulating a wall lining around the entire perimeter of the specimen holder at the level intended for the furring channel.

Suspension eye bolts were fastened to the underside of the concrete slab using 30 x 6 mm masonry fasteners at 1200 mm centres along the 4 m floor span direction starting 300 mm from the east end. These lines of eye bolts were at 150 mm and 900 mm distance from both the north and south sides of the specimen holder which resulted in a distance between the two innermost eye bolts of 1200 mm. Two additional eye bolts were located close to the Top Cross Rail joiners as described below.

Suspension hanger rod (5 mm diameter, soft galvanised plain rod Part No. 121) was hooked through the eye of the eye bolts and the other end passed through two holes in a TCR Clip and Joiner (Part No. 2534) suspension clip. This attachment enabled the height of the clip to be simply adjusted.

Top Cross Rails, 38 x 21 x 0.75 mm Part No. 128, were clipped into the TCR clips with lugs on the clips encasing the Top Cross Rail top flange. One Top Cross Rail at 150 mm from the edge of the specimen holder and one at 900 mm from the edge were spliced once along the length using TCR 125/127/128 Section Joiners Part No. 272. The splices were located close to a suspension point and an additional suspension point was placed on the other side. At the east and west ends of the specimen holder the Top Cross Rails sat on top of the F.C. Track and were not attached to the track. There was no expansion gap between the ends of the Top Cross Rails and the plasterboard-lined inside face of the specimen holder.

Seven 28 x 38 x 28 x 0.55 mm BMT furring channels Part No. 129 at 600 mm centres were attached to the Top Cross Rails and spanned the 3 m width of the specimen holder. The attachments clips were TCR 125/127/128 to Furring Channel Part No. 139. The clips slid inside the Top Cross Rails and grooves in lugs encased the top edges of the furring channels. Two near central furring channels were spliced once along their length using Furring Channel Section Joiners 129/308 Part No. 138. At the north and south ends of the specimen holder the furring channels fitted inside of the F.C. Track and the bottom web of the furring channels was fixed to the track with a single rivet. There was a 10-15 mm gap between the ends of the furring channels and the webs of the F.C. Track.

2.4 Ceiling Lining

The specimen was lined on the underside of the furring channels with two layers of nominal 12.5 mm thick Winstone Wallboard Gib® Fyreline gypsum plasterboard. The mean measured properties were as follows:

Thickness	12.5 mm
Moisture Content	1.1%
Mass	9.7 kg/m^2

The Fyreline was generally installed in accordance with the Winstone GBSC 60 Gib® Fire Rated Systems brochure dated July 1997. All sheet butt joints were formed over furring channels. The inner layer of sheets were fixed with 6 g x 25 mm long screws and the outer layer of sheets were fixed with 6 g x 45 mm long screws. Screw spacing was at 200 mm centres along each furring channel except at the ends of the sheet where the spacing was 100 mm. Around the perimeter of the specimen holder the sheets were fastened to the F.C. Track at 200 mm centres. The sheets of the second layer were offset from the first layer by approximately 600 mm in each direction.

The inner layer of plasterboard ceiling was unstopped but the perimeter was sealed with Pyropanel Multiflex sealant. All fastener heads were stopped and joints tape reinforced and stopped in the outer layer. The joint between the edges of the plasterboard ceiling and the plasterboard lining the perimeter of the specimen holder was also reinforced with paper tape and stopped.

2.5 Concrete Slab

Photograph Set 1 shows preparation for placement of the concrete slab. Steel flats were placed through holes in the beam web and plywood sheets laid on top. The 75 mm slab encased the top 38 mm of the beam. The steel flats and plywood sheets were removed before placement of the ceiling.

The 75 mm thick concrete was reinforced with 665 mesh using an overlap of "two-squares" at the single mesh joint. The mesh was laid directly on top of the beams and allowed to sag between. The concrete was delivered to site by Ready-mix truck, placed by barrow, vibrated and screeded. The mesh was walked on during the concrete placing operation as this is done in practice and increases mesh sag. The measured concrete properties were as follows:

Moisture Content:	4.4% (At test from specimen cured in the same conditions as slab)
Density:	2390 kg/m^3
Cylinder Strength:	35.4 MPa (At age at test of 35 days).

2.6 Client Supplied Drawings and Specification

The client provided a drawing No S01 dated July 1997 showing beam details and two undated general sketches. These are held on confidential file at BRANZ. Drawing S01 is reproduced as Figure 4 in this report.

3. TEST PROCEDURE

3.1 General

The test was conducted on 28 October 1997, at the BRANZ laboratories at Judgeford, New Zealand in the presence of a representative of the client.

The frame containing the test specimen was sealed to the 3 m wide x 4 m long furnace, and the temperature and pressure conditions controlled as specified in AS 1530.4-1990.

The ambient temperature at the beginning of the test was 17°C.

3.2 Loading and Restraint

At the request of the client a uniformly distributed load of 3.8 kPa was placed on the specimen. The load was applied using 20 drums partially filled with water and uniformly distributed on the top of the specimen. Each drum had three swivel feet, each with a contact surface consisting of a 100 mm square of particleboard. The load was applied to the specimen not less than 30 minutes before the commencement of the test.

The sides of the specimen had minimum restraint against vertical movement compatible with an adequate seal against the passage of furnace gases.

3.3 Furnace Temperature Measurement

The temperature of the atmosphere within the furnace was measured using twelve chromel-alumel thermocouples distributed evenly on a horizontal plane approximately 100 mm below the exposed face of the specimen.

3.4 Specimen Temperature Measurement

The temperature on the unexposed face of the test specimen was measured using chromel-alumel thermocouples mounted on copper discs and covered with insulating pads, in accordance with clause 2.2.3.2 of the test standard. Five thermocouples were placed on the top surface of the floor, one at the centre point, and one at the centre of each quarter section.

Additional thermocouples were placed internally on ceiling lining, on the suspended ceiling system components, underside of the concrete slab and on the Speedfloor 250 Series steel beams for information purposes.

3.5 Temperature Recording

All the thermocouples described in Sections 3.3 and 3.4 were connected to a computer controlled data logging system which recorded the temperatures at one minute intervals.

3.6 Pressure Measurements

The pressure difference between the furnace and laboratory atmosphere was controlled to be at least 8 Pa at the underside of the specimen. The differential pressure was monitored using a micromanometer connected to a continuously reading recorder.

3.7 Deflection Measurements

The deflection of the specimen was measured using seven linear potentiometers placed on the floor at locations shown on the drawing on Page 4. The potentiometers were connected to the computer controlled data acquisition system which recorded the deflections at one minute intervals.

4. OBSERVATIONS

4.1 Duration

The test was terminated after the specimen had been exposed to the standard fire resistance test for 76 minutes.

4.2 Severity

The severity of the fire resistance test can be established by comparison of the area under the curve of the mean furnace temperature with the area under the standard curve for the same period. Figure 1 shows the standard curve in relation to the actual mean furnace temperature. The severity of this test for 76 minutes was 99.6%. In accordance with the Standard the furnace temperature accuracy was as follows:

	Variation of area under time-temperature curve %	
	Standard	**Actual**
End of first 10 minutes	±15.0	-2.5
End of first 30 minutes	±10.0	-0.3
After 30 minutes (max)	±5.0	-0.4 to 0.1

	Maximum variation of the furnace temperature (°C)			
	Mean Temperature		**Individual Thermocouples**	
	Standard	Actual	Standard	Actual
After first 10 minutes	±100	-33 to 39	±100	-78 to 65

In summary, the temperatures complied with the test standard. From 50 minutes until test termination falling ceiling lining covered or dislodged some furnace thermocouples and those affected were removed from the above calculations while so influenced.

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4.3 Structural Adequacy

The floor/ceiling did not collapse for the duration of the test. At 70 minutes the rate of deflection reduced and it was considered that from 70 minutes the deflection of the specimen caused some clearances being taken up which resulted in some of the applied drum load being transferred from loading the test specimen to being carried by the support frame. Structural Adequacy is therefore considered to be 70 minutes. The maximum recorded deflection at 70 minutes was 97 mm.

4.4 Integrity

There was no integrity failure for the duration of the test.

4.5 Insulation

4.5.1 Average Specimen Temperature Rise

The average specimen temperature rise as measured by the five standard thermocouples did not exceed the failure criterion of 140K for the duration of the test. The maximum value of the average temperature rise recorded at 76 minutes was 38 K.

4.5.2 Maximum Specimen Temperature Rise

The maximum temperature rise measured by any of the five standard thermocouples did not exceed 180 K for the 76 minutes duration of the test. The maximum temperature rise measured by any of the five thermocouples was 72 K.

Graphs of the average and maximum temperature rises measured by the five thermocouples at the standard locations are included as Figure 2.

4.6 Deflections

The maximum deflection measured during the test was 134 mm and occurred at the mid-span of the floor at the centreline at 76 minutes. At 70 minutes the rate of increase of deflection decreased and it was expected that some of the test loading was effectively removed as discussed in Section 4.3 above and this would have affected the subsequent deflections.

The deflection point positions are shown in the drawing on Page 4 and a graph of the measurements at floor mid-span is shown in Figure 3. A summary of measured deflections at 30, 60, 70 and 76 minutes is given below. At 72 minutes the potentiometer measuring the deflection at mid-span 750 mm north of centreline ran out of travel and the subsequent measurements therefore did not change.

Measured Deflections (mm)

Location	Time (minutes)			
	30	60	70	76
Mid-span 1500 mm north of centreline	2.1	3.8	54	99
Mid-span 750 mm north of centreline	4.5	6.2	77	-
Mid-span at centreline	5.7	7.5	97	134
Mid-span 750 mm south of centreline	4.9	6.3	79	110
Mid-span 1500 mm south of centreline	2.6	3.8	61	94
800 mm east of mid-span and at centreline	1.9	2.6	31	46
800 mm west of mid-span and at centreline	2.2	2.7	31	44

4.7 Specimen Behaviour

4.7.1 Exposed Side

Only the east half of the ceiling could be seen when looking through the viewing ports at the exposed face. The direction of the 4 m span is referred to as the longitudinal direction while the 3 m span direction is referred to as the lateral direction.

Time from start of test (Minutes:Seconds)	Observations
5:26	The paper facing had charred black.
7:08	The joint plaster was fraying and falling at the edges.
8:44	The paper facing was falling
9:02	The joints could be seen through the plaster.
14:02	Only the white paper residue was left on the ceiling.
15:49	The surface plaster at the joints had effectively gone.
27:59	The plasterboard was covered in short fine cracks.
42:25	The joints had opened 3 mm wide between edges. The severity of the plasterboard cracking had increased.
44:10	The visible lateral joints had opened approximately 2 mm.
45:45	The plasterboard along the longitudinal joint had sagged over a span of approximately 200 mm and there was a vertical differential movement of 2-3 mm across the joint.
47:24	The joint noted above had a vertical differential movement across the joint of approximately 30 mm and small pieces had fallen from the edge.
48:34	The longitudinal joint had peeled back approximately 300 mm.
49:07	The sheet on one side of a transverse joint had peeled back approximately 150 mm. The sheet on the side of the longitudinal joint noted above had fallen.

51:52	A longitudinal joint on the inner layer had opened 3-4 mm and there was a vertical differential sag across this joint of 2-3 mm.
56:20	The differential movement at the above ceiling lining longitudinal joint had increased to 10 mm.
57:35	The inner lining was sagging 30 mm at approximately 100 mm from the joint noted above. Another longitudinal joint had opened to be approximately 10 mm wide.
61:00	The inner layer was covered in fine cracks.
61:38	The differential movement across an inner layer longitudinal joint was 30-40 mm.
61:56	The differential movement had increased to 150-200 mm.
62:06	The sheet on one side of the joint noted above had fallen.
63:13	Another sheet had fallen.
76:00	Test terminated.

After the floor was removed from the furnace it was noted that the steel ceiling suspension system was buckled and warped and the centre Speed Floor joist had displaced laterally by approximately 150 mm near the centre span.

4.7.2 Unexposed Side

72:03	The handle clearance on the middle drum had been taken up so that some of this drum weight was taken directly by the support frame.
75:00	The weight of the centre three rows of drums was being partially carried by the support frame.

No charring or flaming was observed on the unexposed face for the duration of the test.

5. SUMMARY

The fire resistance of the loadbearing floor/ceiling system constructed from 250 Series Speedfloor Beams, a 75 mm thick concrete floor and a suspended plasterboard ceiling was as follows:

Structural Adequacy	70 minutes (no failure)
Integrity:	70 minutes (no failure)
Insulation:	70 minutes (no failure)

For the purpose of the Building Regulations in Australia the fire-resistance level (FRL) was 60/60/60.

The test standard requires the following statement to be included "The results of these fire tests may be used to directly assess fire hazard, but it should be recognised that a single test method will not provide a full assessment of fire hazard under all fire conditions."

6. ATTACHMENTS

Figure 1 Furnace Temperature

Figure 2 Temperature Rise on Unexposed Face

Figure 3 Floor Deflections at Floor Midspan

Figure 4 Client Supplied Drawing S01

Photograph Set 1: Construction of Speedfloor Floor
Photograph Set 2: Construction of Suspended Ceiling System
Photograph Set 3: Test and Post-test Photographs

S J Thurston
Fire Testing Manager

M E Godkin
Fire Testing Engineer
FOR THE ASSOCIATION

Figure 1 Furnace Temperature

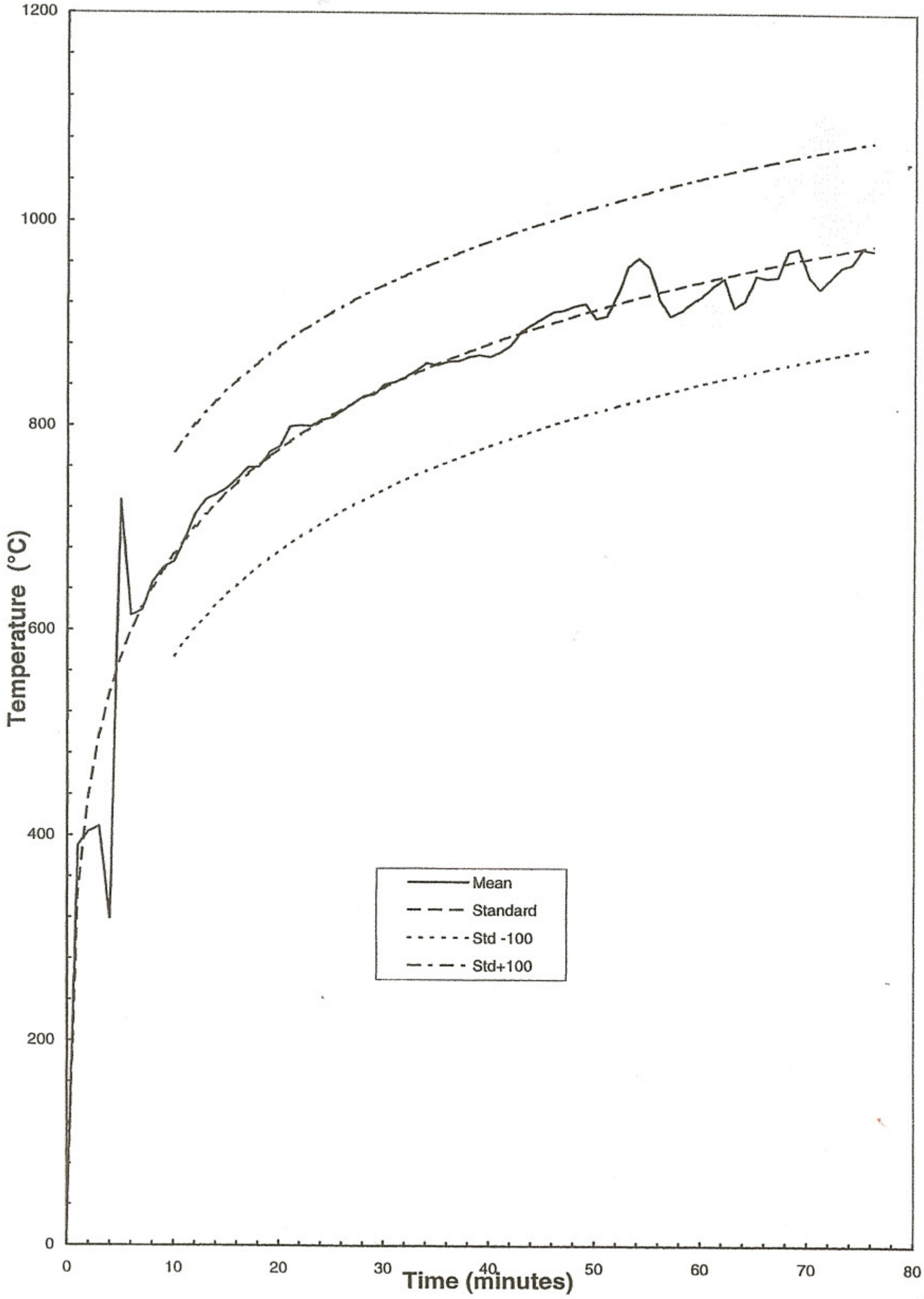

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Figure 2 Temperature Rise on Unexposed Face

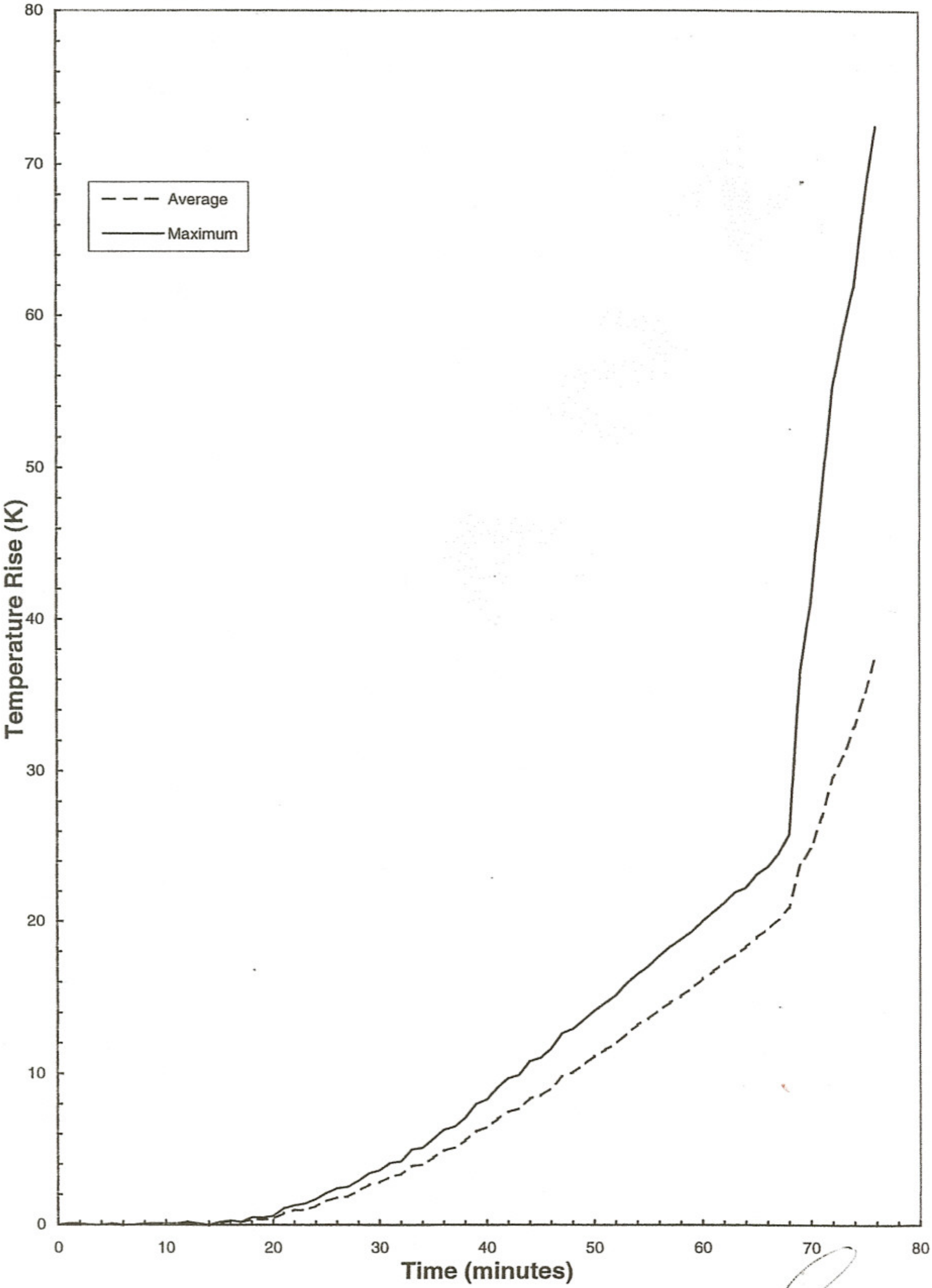


Figure 3 Floor Deflections at Floor Midspan

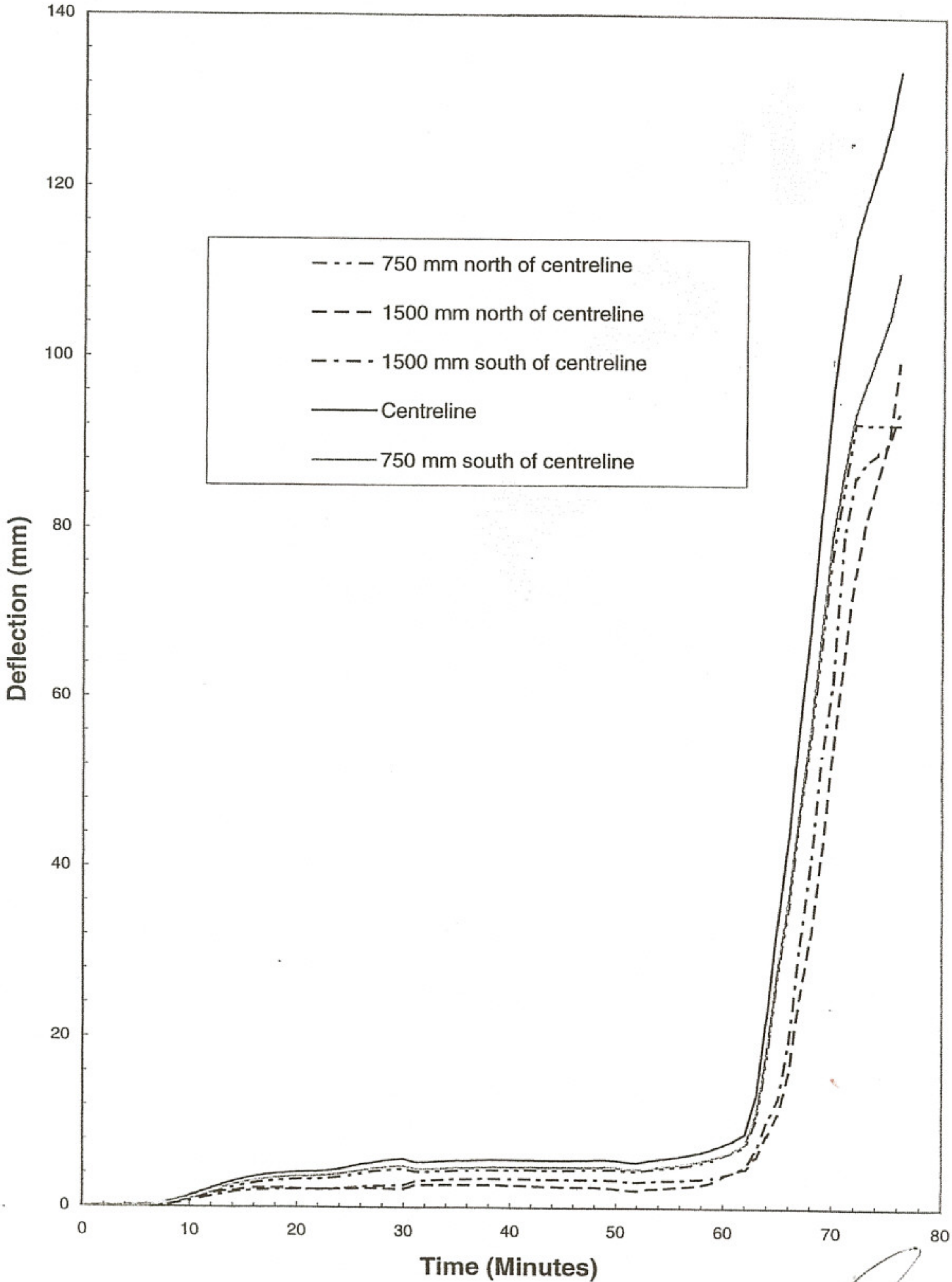
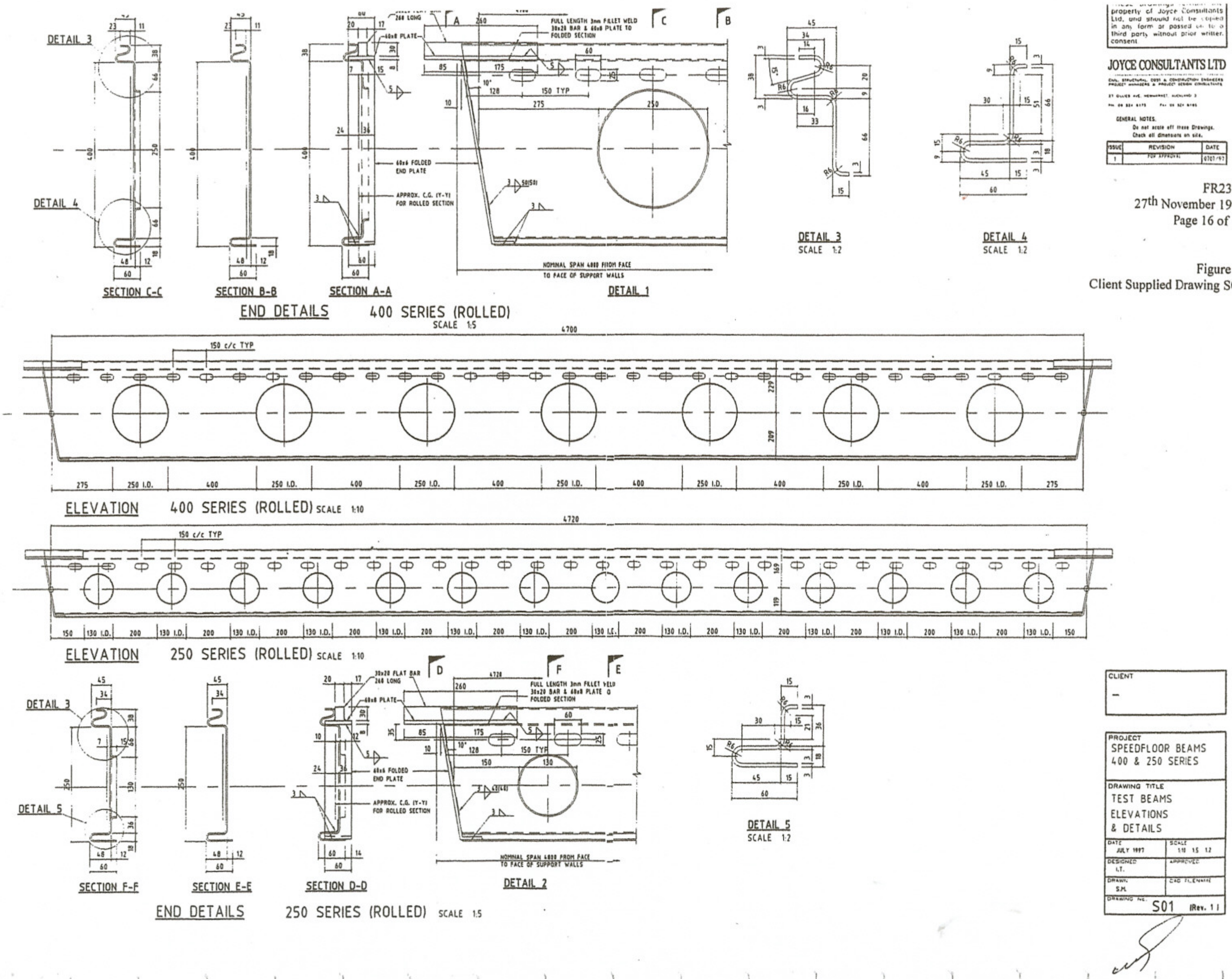
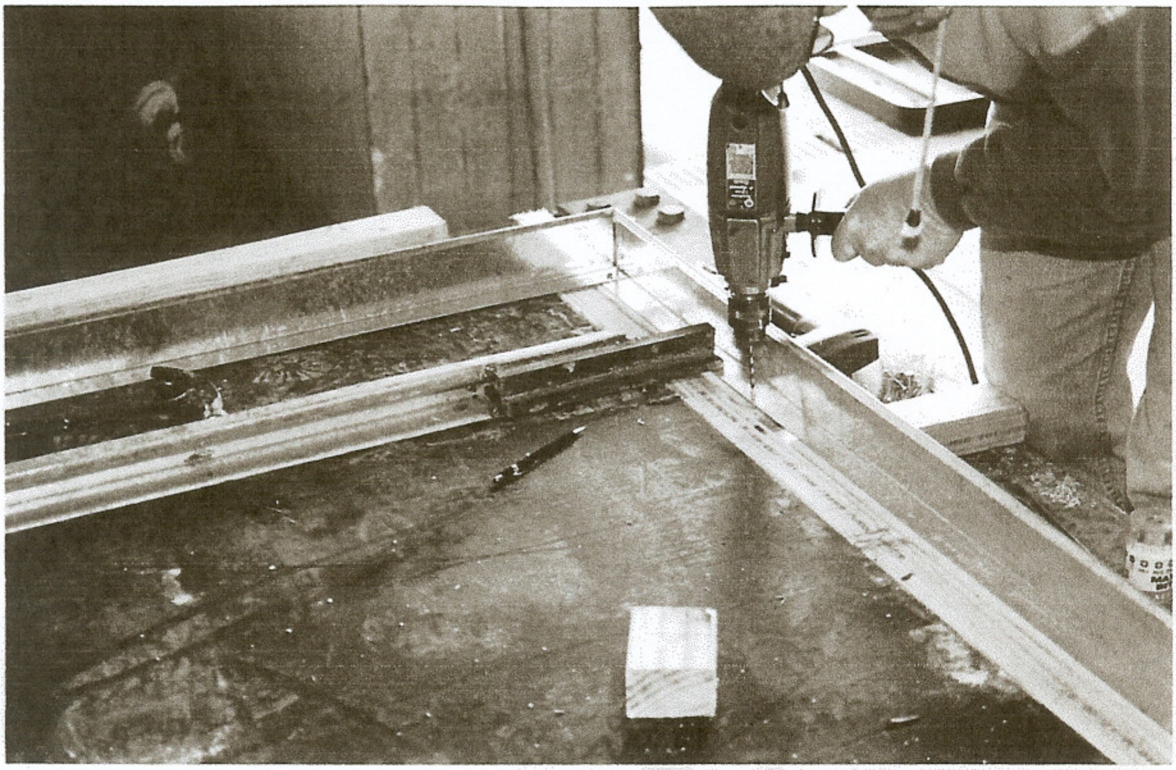
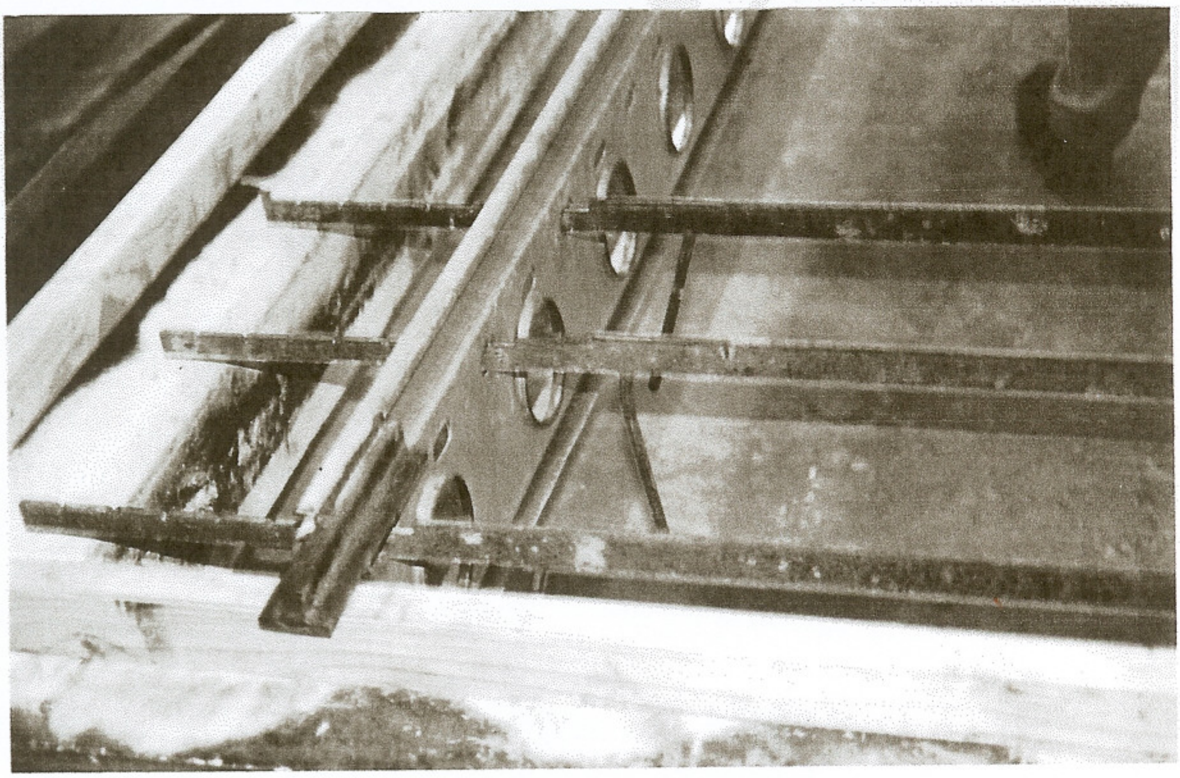


Figure 4.
Client Supplied Drawing S01







Construction of Speedfloor Floor

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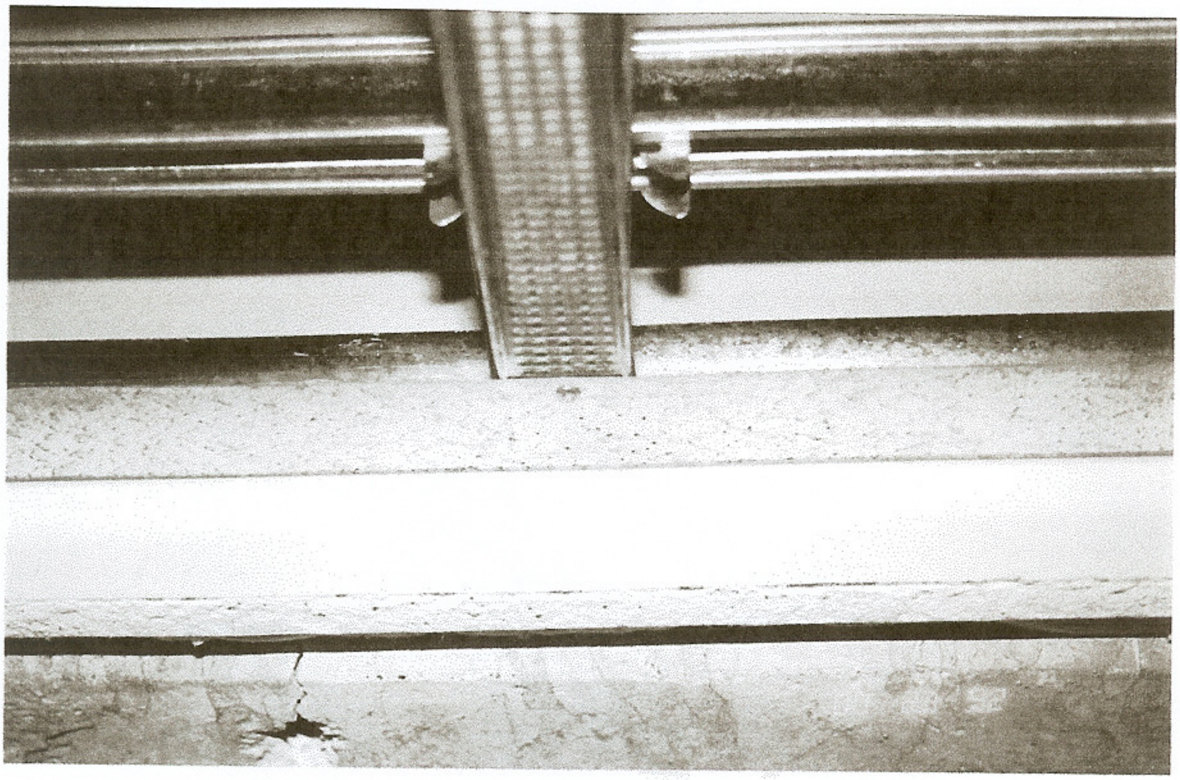

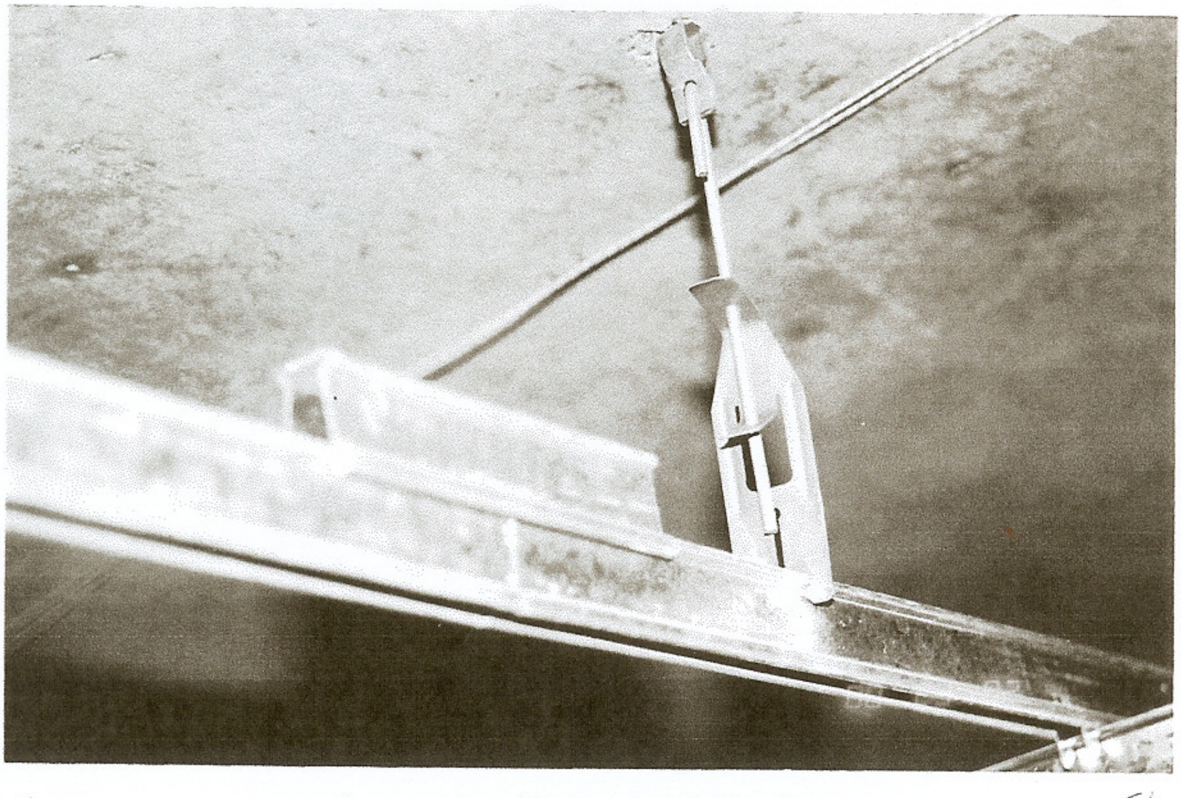

Construction of Suspended Ceiling System

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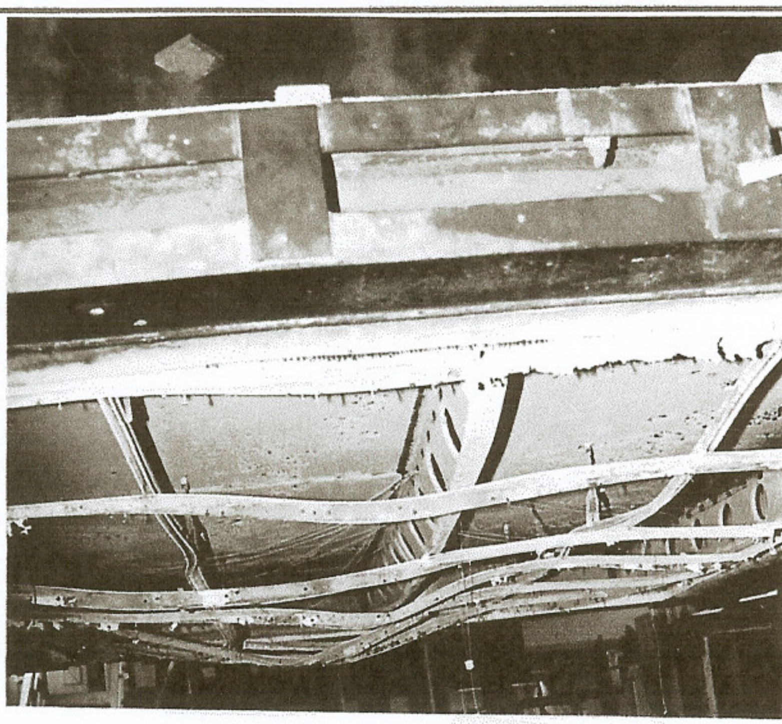
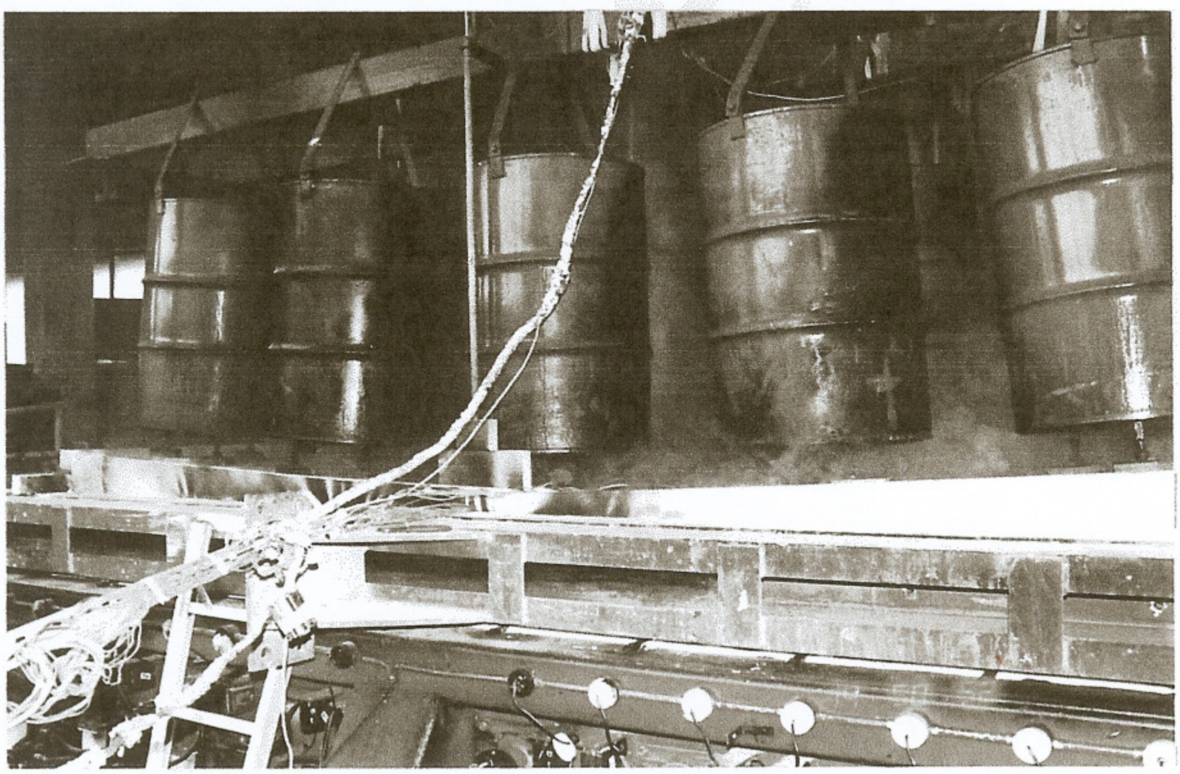


(a) Post-test Photograph of Buckled Steelwork



(b) Loaded Floor Near Test Completion

Test and Post-test Photographs.

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MISSION

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for the development of the
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