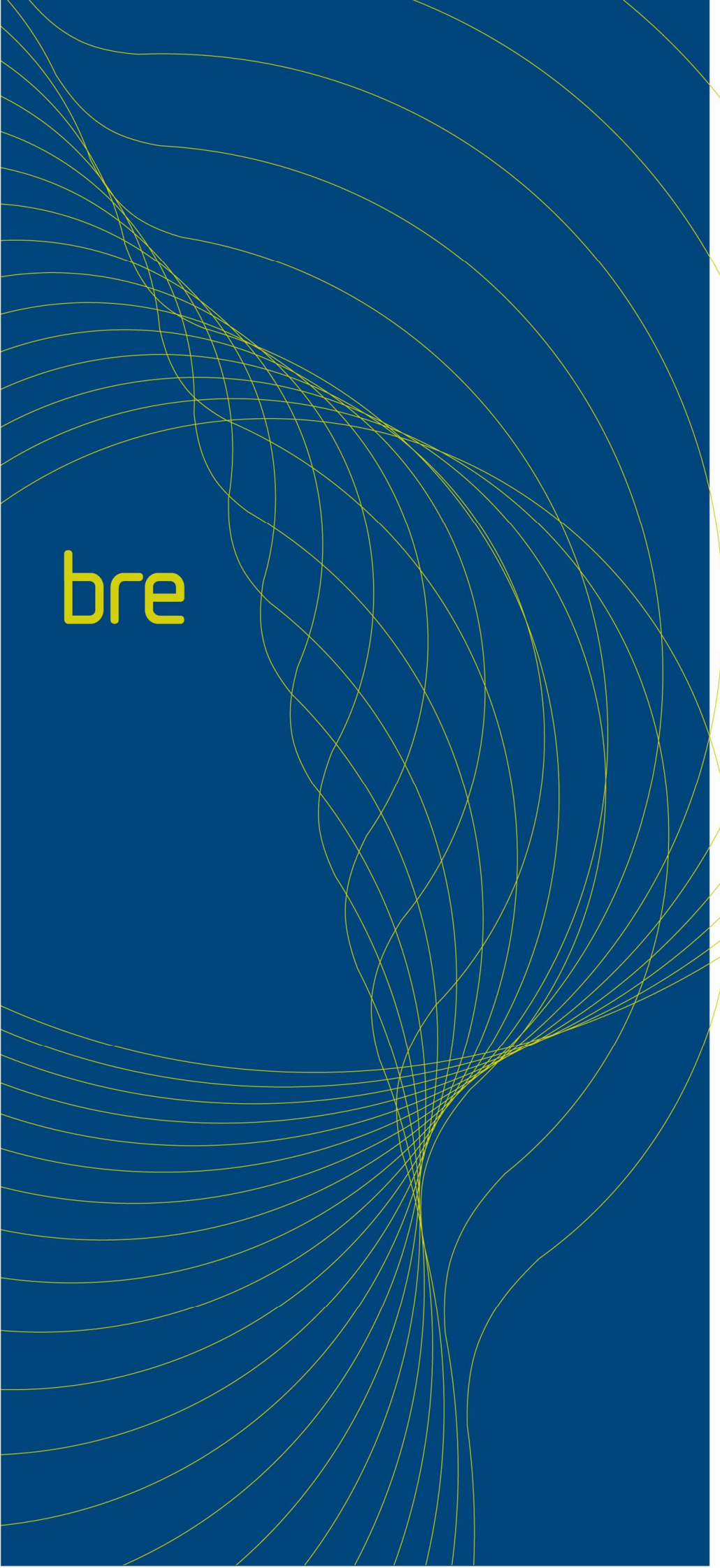

Testing of Thermohouse Roof Panels

Prepared for: Mr Jack O'Driscoll

Thermohouse Limited
Coolcaslagh
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19 February 2009

Client report number 251-448

Prepared by

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Customer:	Thermohouse Limited
Project Title:	Testing of Thermohouse Roof Panels
BRE Report Number:	251448
Project Manager:	Rohan Rupasinghe

(Please mark one box for each question)

	Unsatisfactory	Needs Improvement	Meets Requirements	Exceeds Requirements	Not Applicable
How would you rate the quality of service?	☐	☐	☐	☐	☐
Did we understand and meet all your needs?	☐	☐	☐	☐	☐
Did we deliver on time?	☐	☐	☐	☐	☐
Did we provide value for money?	☐	☐	☐	☐	☐
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How do you rate our technical competency?	☐	☐	☐	☐	☐

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Would you use our services in the future?	☐	☐
Would you recommend our services to other clients?	☐	☐

We would appreciate your comments on how we could improve our service to you

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Email:		Telephone:	
Date:			

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Contents

1 Introduction

Building Research Establishment Ltd (BRE) was commissioned by Thermohouse Ltd to undertake a series of bending tests on Thermohouse insulated roof panels used in their Thermohouse Building System. The roof panels comprised two light gauge steel 'C' profiles encased in polystyrene.

The out-of-plane bending tests carried out in Hall C of BRE's main Structures Lab were aimed to determine the stiffness and strength characteristics of the roof panels in bending, which could be used for product certification.

Four 4m long roof panels provided by Thermohouse Ltd (in December 2008) were used for these tests.

This report briefly describes the tests carried out and presents the results obtained. The results and the photographic data obtained throughout the test programme are presented in a companion CD to this letter report. The numeric data, gathered electronically during the tests, have been copied into Microsoft Excel spread sheets.

2 Test specimen

Four roof panels, each comprising two light gauge steel ‘C’ profiles encased in polystyrene, as shown in Figures 1, were tested.

The dimensions and weight of each test specimen was recorded prior to testing. This information is given in Table 1.

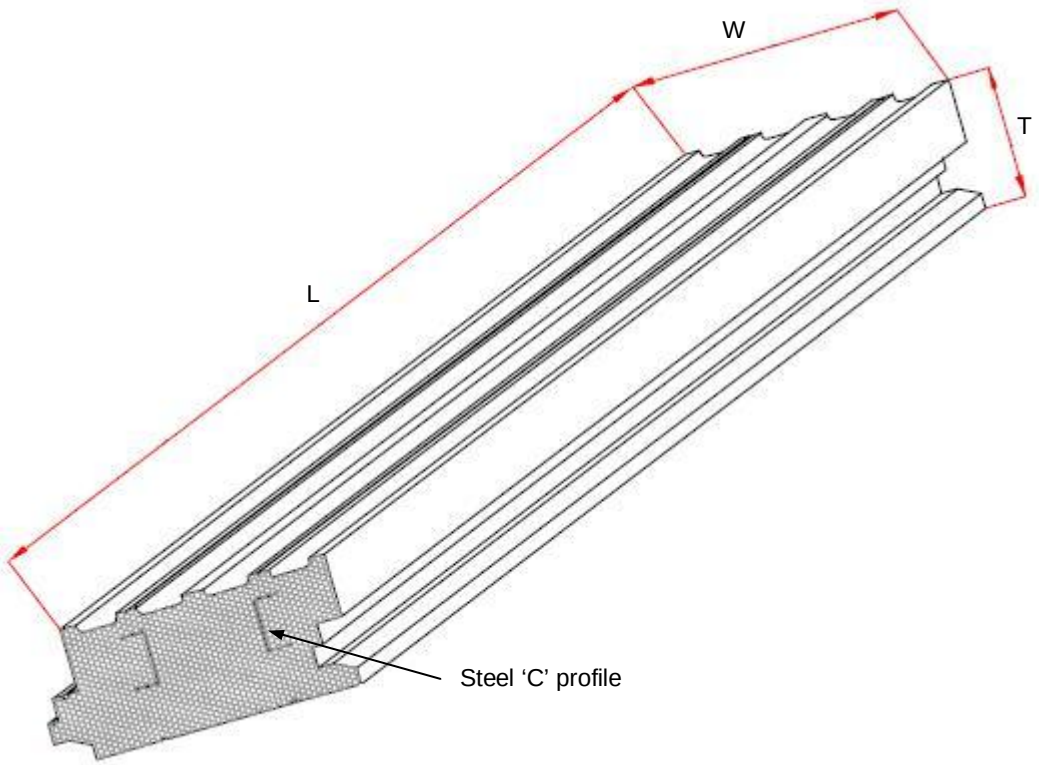


Figure 1. Roof panel specimen.

Panel No.	Average length, L (mm)	Average width, W (mm)	Average thickness, T (mm)	Weight (kg)
1	4019	507	250	26.0
2	4018	507	250	26.5
3	4019	507	250	26.5
4	4017	507	247	27.0

Table 1. Average panel dimensions and weight.

3 Bending tests

Four out-of-plane bending tests were carried out on the roof panels. The roof panels were subjected to three-point bending, with the load applied at the mid-span.

3.1 Test set-up

The test specimens were mounted on rollers giving an effective span of 3.8m. They were loaded centrally in the BRE 250T compression testing machine, via aluminium spreader beams, as shown in the Figure 2.

A load cell was placed at the centre of the spreader beams to measure the load applied to the specimen. The weights of the components of the loading system which rested on the panels in addition to the applied load are given in Table 2.

The deflection of the panel was measured at mid-span and close to the supports of the panels, as indicated in Figures 3 and 4, using displacement transducers with a resolution of 0.01mm.

Component	**Weight (kg)**
Load cell with top and bottom caps	3.05
Aluminium spreader beam (2 nos.)	2.05

Table 2. Weights of the components of the loading system.

Figure 2. Test set-up.

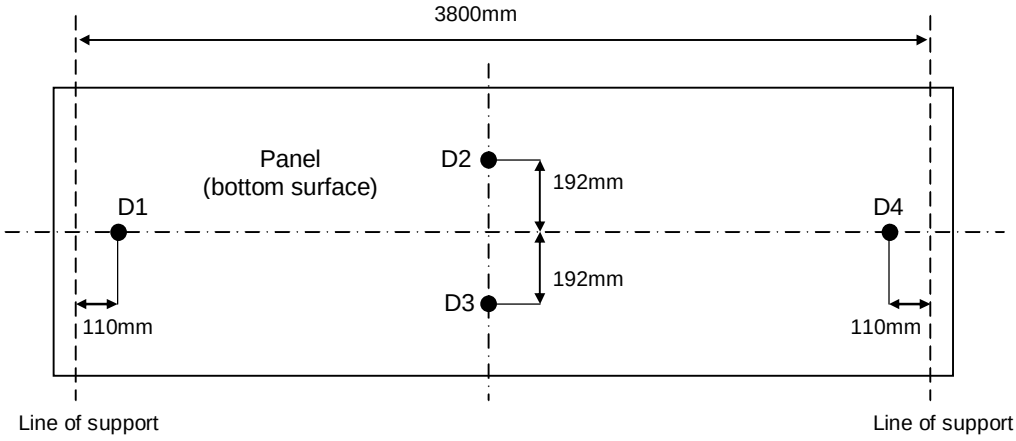


Figure 3. Location of displacement transducers.

Figure 4. Displacement transducers at mid-span and close to the supports.

3.2 Tests

3.2.1 Test 1

Panel number 4 was used for this test. The applied load was increased gradually until the panel failed in flexure. As the load reached about 1.5kN a gap was visible between the steel 'C' profiles and the surrounding polystyrene at the end faces of the panels, which remained without much change throughout the rest of the test. When the load was around 2.4kN a tear in the polystyrene appeared at the top surface of the panel near the aluminium spreader beam as shown in Figure 5. After reaching a maximum load of 3.48kN the load started to drop. With further attempt to apply the load the panel continued to deflect downward, while the actual magnitude of the load decreased, until a sudden tensile snap of the polystyrene occurred at the bottom, across the mid-span of the panel (Figure 6).

The load-deflection curve for this test is given in Figure 7. (Note – to prevent damage to the displacement transducers at mid-span, they were removed once the panel deflection was in excess of 75mm.)

3.2.2 Test 2

Panel number 2 was used for this test. As the applied load was increased the panel was seen to behave in the same manner as Test1. However, the tearing in the polystyrene at the top surface of the panel (near the aluminium spreader beam) was seen to spread along the panel with increasing load, as shown in Figure 8. The load started to drop after reaching 3.61kN and as the downward deflection in the panel increased the tearing in polystyrene at the top of the panel opened up exposing a steel 'C' profile (Figure 8). The loading was stopped as the polystyrene at the bottom, close to the mid-span, snapped in tension as seen in Test 1. The exposed steel 'C' profile, however, was observed to have bent about 400mm away from the mid-span of the panel (Figure 9). (The other steel 'C' profile had bent close to the mid-span of the panel.)

This unsymmetrical bending in the steel 'C' profiles seemed to be the cause for the tearing up of polystyrene seen in Figure 8.

The load-deflection curve for this test is given in Figure 10. (Note – to prevent damage to the displacement transducers at mid-span, they were removed once the panel deflection was in excess of 75mm.)

3.2.3 Test 3

Panel number 1 was used for this test. The panel was seen to behave in a similar manner to Test 1 as the applied load was increased. The load reached a maximum of 3.38kN before it started to drop. The load was then removed gradually without attempting to deflect panel downwards any further.

The load-deflection curve for this test is given in Figure 11.

3.2.4 Test 4

Panel number 3 was used for this test. Upon client's request this test included a cyclic loading regime. During loading the applied load was relaxed back to zero three times upon reaching 1.0kN, 2.0kN and 3.0kN, in three consecutive loading cycles, before increasing the load until the panel failed in flexure. At the end of each loading cycle an average residual downward deflection of 1.0mm, 1.7mm and 4.4mm, respectively, were seen at the mid-span of the panel. The panel marked a maximum load of 3.45kN and with further attempt to load the panel a sudden tensile snap of the polystyrene occurred at the bottom, close to the mid-span, as seen in Test 1.

The load-deflection curve for this test is given in Figure 12. (Note – to prevent damage to the displacement transducers at mid-span, they were removed once the panel deflection was in excess of 75mm.)

Figure 5. Tearing of polystyrene at the top surface of the panel near aluminium spreader beams (Test 1).

Figure 6. Tensile snap of the polystyrene at the bottom, across the mid-span (Test 1).

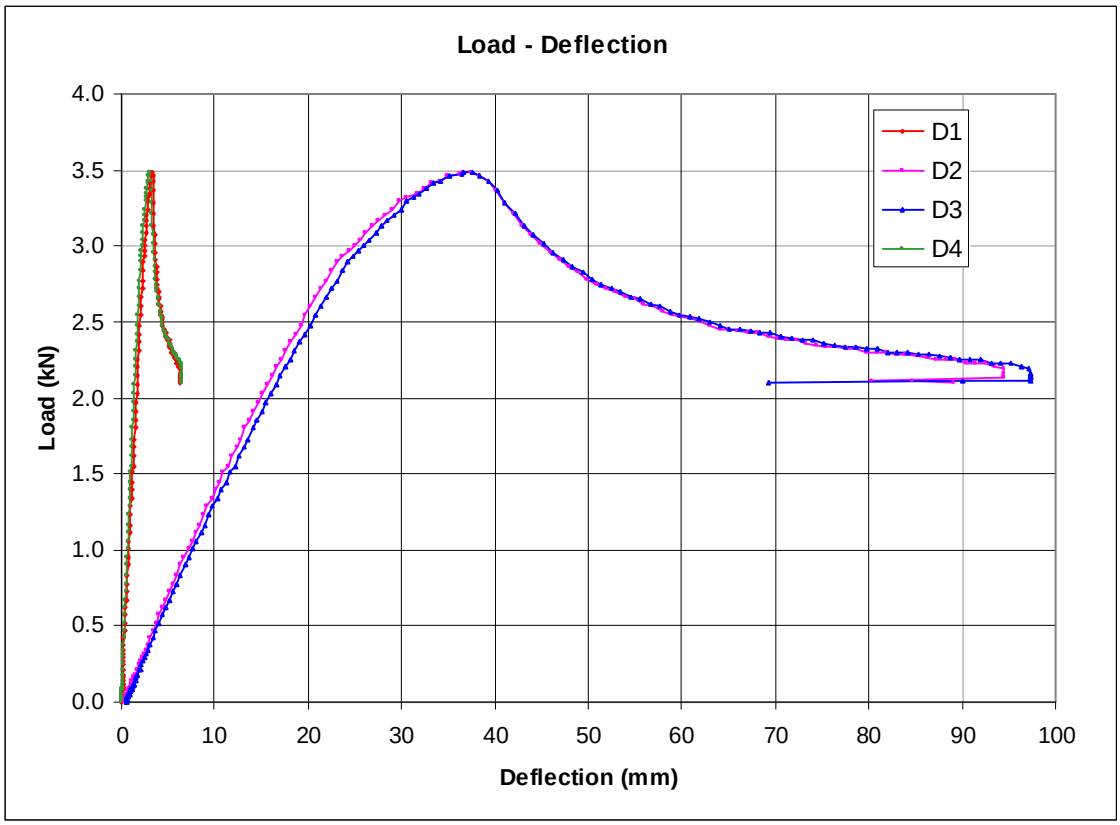


Figure 7. Load-deflection curve for Test 1. (Note – to prevent damage to the displacement transducers at mid-span, they were removed once the panel deflection was in excess of 75mm.)

Figure 8. Tearing of polystyrene at the top surface spread along the panel and opened up exposing a steel 'C' profile with increasing deflection (Test 2).

Figure 9. The exposed steel 'C' profile was observed to have bent about 400mm away from the mid-span (Test 2).

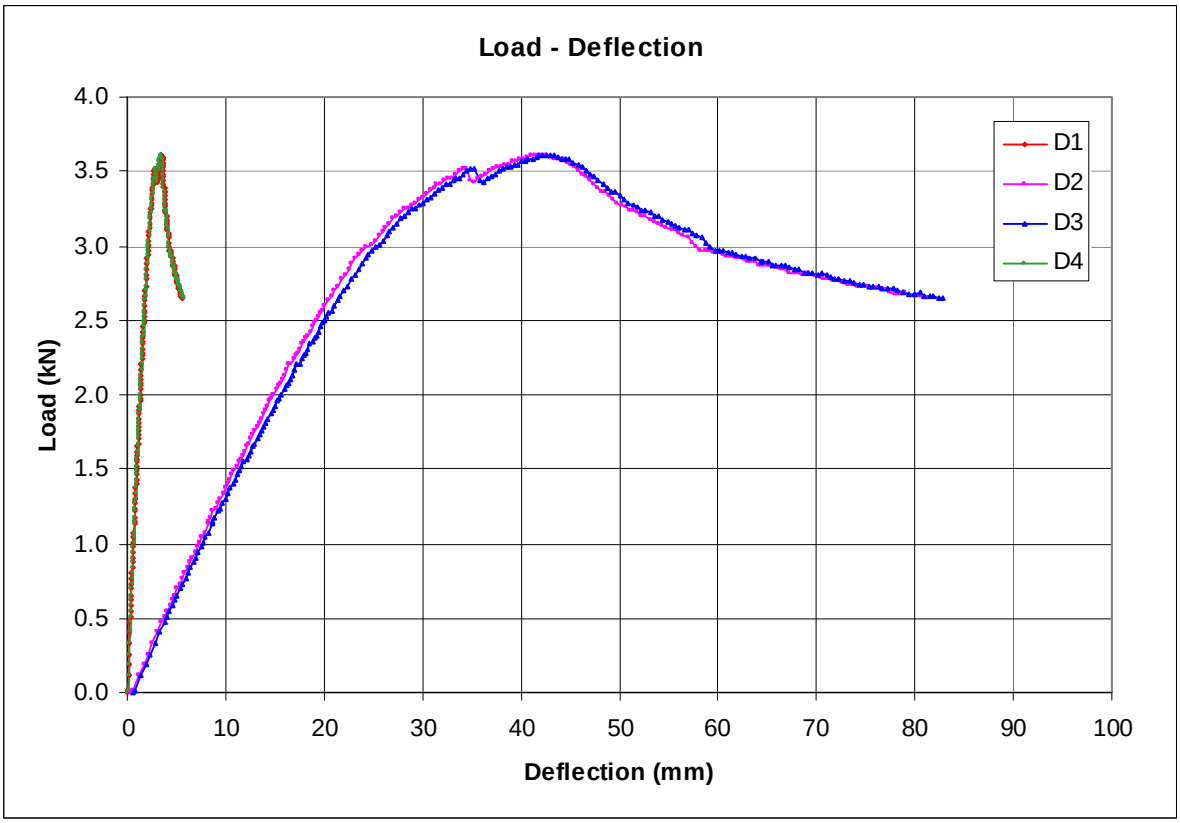


Figure 10. Load-deflection curve for Test 2. (Note – to prevent damage to the displacement transducers at mid-span, they were removed once the panel deflection was in excess of 75mm.)

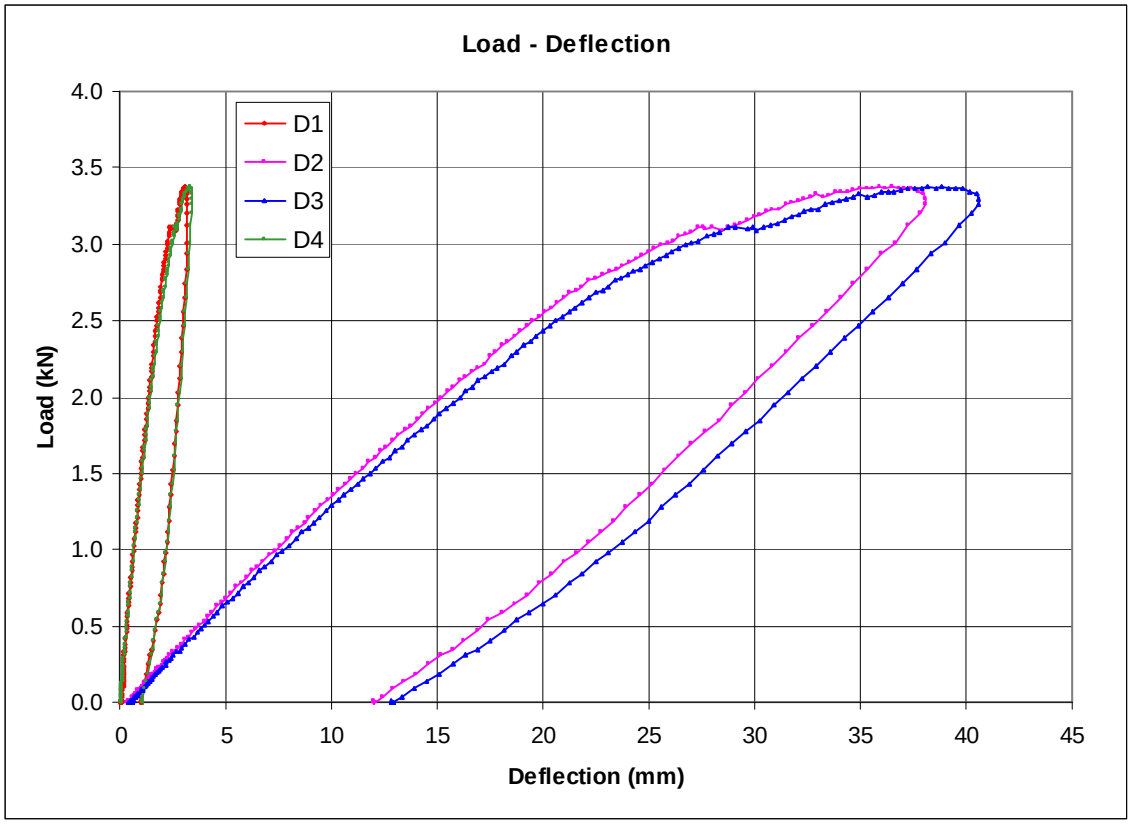


Figure 11. Load-deflection curve for Test 3.

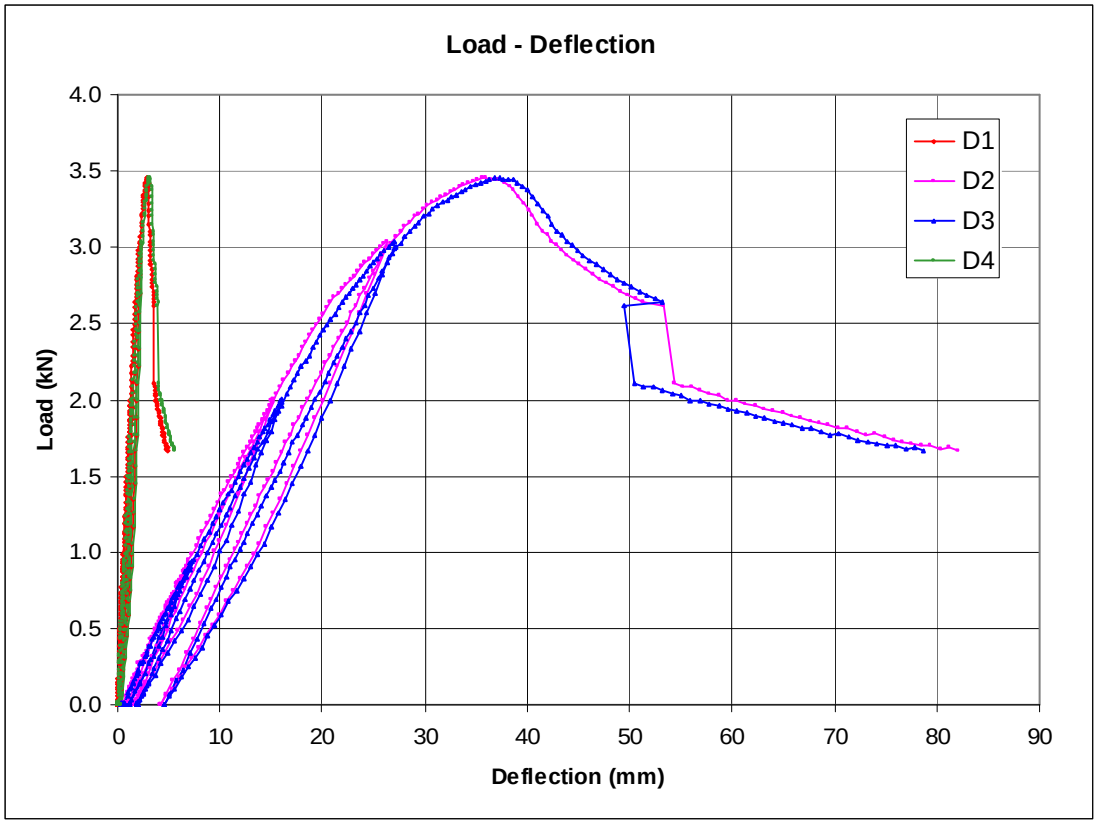


Figure 12. Load-deflection curve for Test 4. (Note – to prevent damage to the displacement transducers at mid-span, they were removed once the panel deflection was in excess of 75mm.)

3.3 Results

The panels were seen to behave almost linearly up to about 2.5kN. The maximum loads attained by the panels and the corresponding average mid-span deflections are summarised in Table 3.

The removal of the polystyrene surrounding the steel 'C' profiles at the end of the Tests 1, 2 and 3 revealed buckling in the compression flange (see Figure 13). No signs of torsional rotation of the steel 'C' profiles were noticed in these inspections.

While the compression in polystyrene at the supports was difficult to measure, it was observed to be in the sub-millimetre range (see Figure 14).

Test	Panel No.	Maximum load attained (kN)	Average mid-span deflection at maximum load (mm)
1	4	3.48	37.5
2	2	3.61	42.2
3	1	3.38	37.7
4	3	3.45	37.6

Table 2. Summary of bending test results.

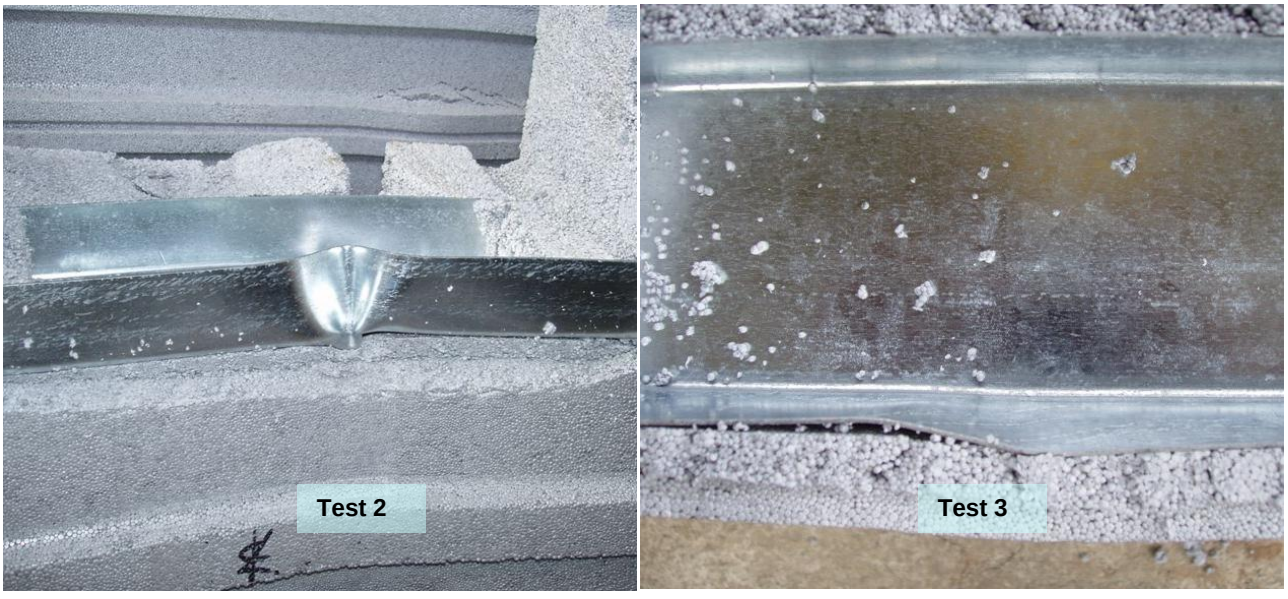
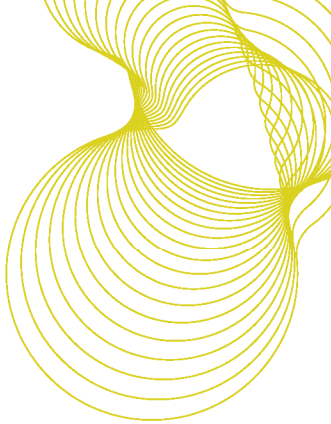


Figure 13. Buckling in the compression flange of steel 'C' profiles.

Figure 14. Compression in polystyrene at the supports was observed to be very small.

4 Conclusion

- All the roof panels (Tests 1 to 4) showed a consistent maximum bending strength, in three-point out-of-plane bending, with a relatively low variation. The average maximum load sustained in bending was 3.48kN.
- All roof panels also displayed a similar failure pattern. The failure in the panels was characterised by the buckling of the compression flange of steel ‘C’ profiles.
- The maximum bending load achieved in Tests 4, where the panel was unloaded several times before failure, was similar to that obtained in the Tests 1 to 3 (where no cyclic loading was carried out).



Appendix A – Calibration certificates

LVDT for displacement D1

Title: RDP Electronics LVDT

Type: LDC1000A

Ser No: 1520

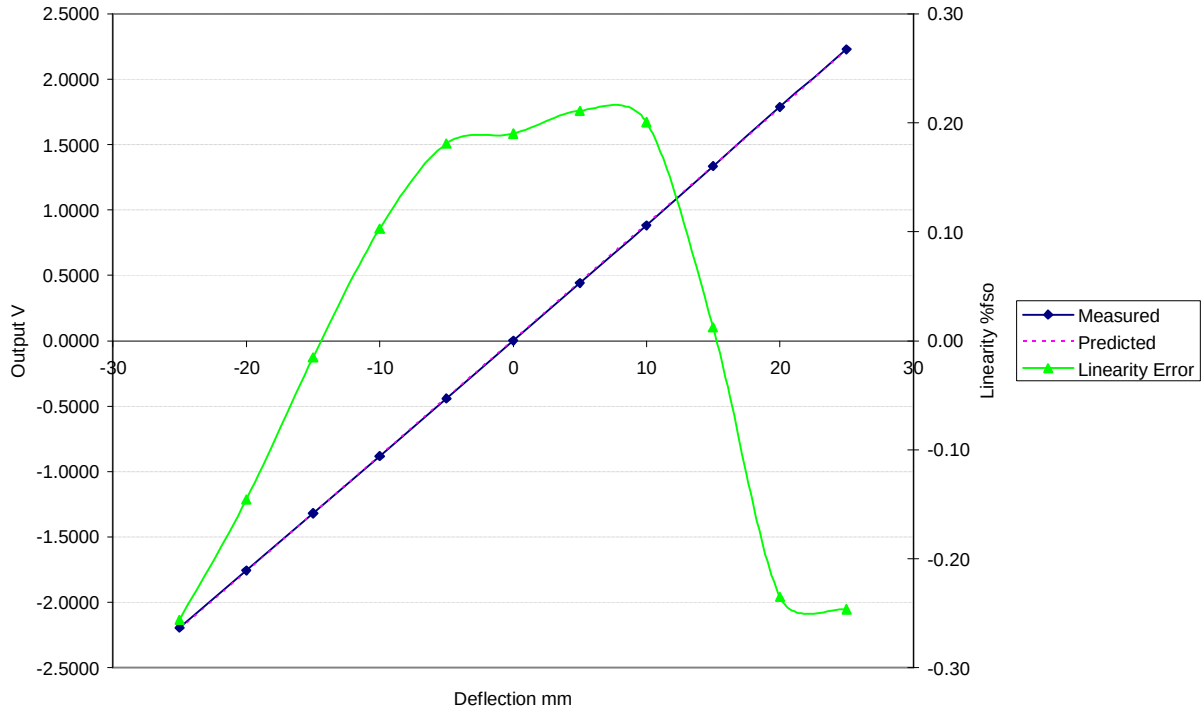
Location: B14/B01

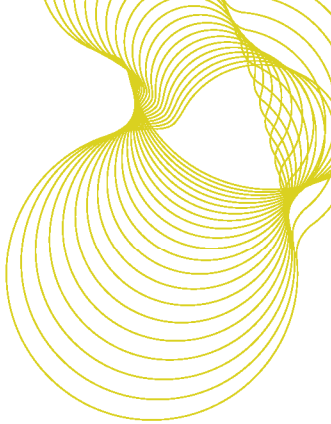
Date of Test: January 29, 2009

Calibration Equipment:
Thurlby Thandar 1906 DMM S/N 117357
Thurlby Thandar PL320 Bench PSU S/N
Mitutoyo Micrometer Head BRE IN 3895

Displacement mm	Measured Output V				Calculated Output V	error %fso
-25	-2.1930	-2.1941	-2.1947	-2.1939	-2.2053	-0.26
-20	-1.7553	-1.7561	-1.7565	-1.7560	-1.7624	-0.15
-15	-1.3192	-1.3176	-1.3198	-1.3189	-1.3195	-0.02
-10	-0.8818	-0.8798	-0.8821	-0.8812	-0.8767	0.10
-5	-0.4420	-0.4408	-0.4427	-0.4418	-0.4338	0.18
0	0.0003	0.0010	0.0006	0.0006	0.0091	0.19
5	0.4423	0.4426	0.4428	0.4426	0.4519	0.21
10	0.8827	0.8877	0.8873	0.8859	0.8948	0.20
15	1.3359	1.3379	1.3375	1.3371	1.3377	0.01
20	1.7896	1.7915	1.7917	1.7909	1.7805	-0.24
25	2.2280	2.2372	2.2377	2.2343	2.2234	-0.25
m	0.08857333			fso	4.4287	
c	0.00905455			mean		0.00

Supply V 10





LVDT for displacement D2

Title: RDP Electronics LVDT

Type: LDC3000A

Ser No: 748

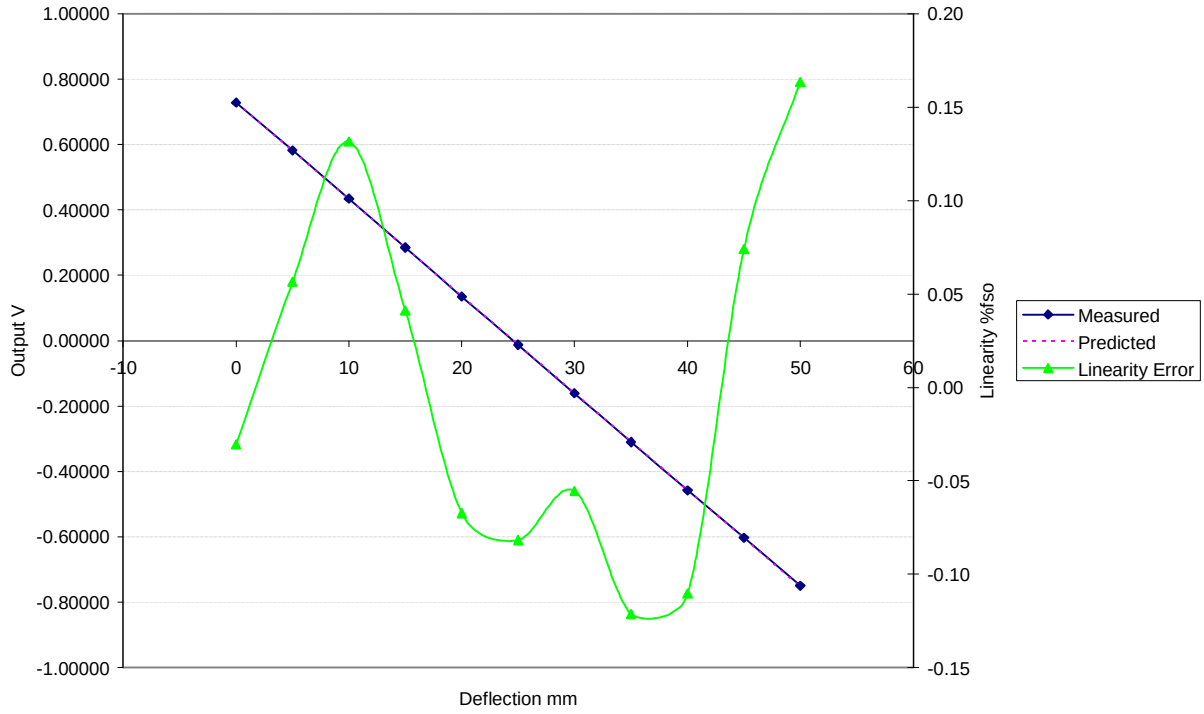
Location: B14/B01 Operater: D Brooke

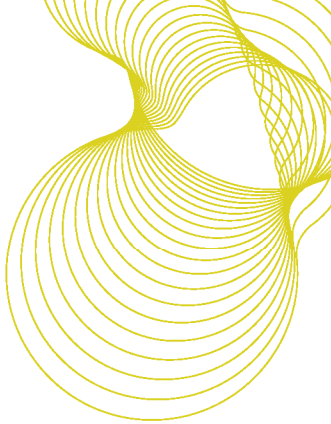
Date of Test: January 29, 2009

Calibration Equipment:
Thurlby Thandar 1906 DMM S/N 117357
Thurlby Thandar PL320 Bench PSU S/N
Mitutoyo Micrometer Head BRE IN 3895

Displacement mm	Measured Output V			Average	Calculated Output V	error %fso
0	0.72850	0.72871	0.72854	0.72858	0.7290	-0.03
5	0.58182	0.58156	0.58168	0.58169	0.5808	0.06
10	0.43463	0.43467	0.43454	0.43461	0.4327	0.13
15	0.28525	0.28511	0.28491	0.28509	0.2845	0.04
20	0.13564	0.13492	0.13533	0.13530	0.1363	-0.07
25	-0.01269	-0.01358	-0.01303	-0.01310	-0.0119	-0.08
30	-0.16042	-0.16138	-0.16089	-0.16090	-0.1601	-0.06
35	-0.30975	-0.31049	-0.30993	-0.31006	-0.3083	-0.12
40	-0.45742	-0.45863	-0.45819	-0.45808	-0.4564	-0.11
45	-0.60282	-0.60416	-0.60362	-0.60353	-0.6046	0.07
50	-0.74929	-0.75099	-0.75089	-0.75039	-0.7528	0.16
m	-0.0296369			fso	-1.4818	
c	0.72903364			mean		0.00

Supply V 10





LVDT for displacement D3

Title: RDP Electronics LVDT

Type: LDC3000A

Ser No: 747

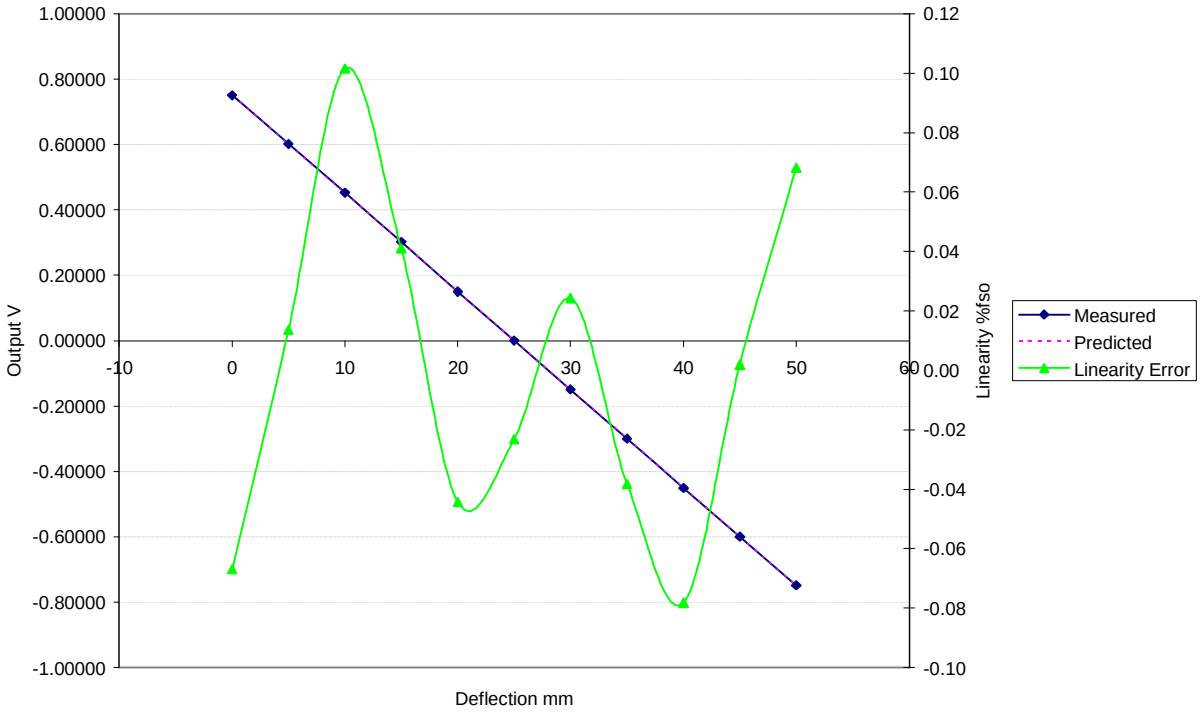
Location: B14/B01 Operater: D Brooke

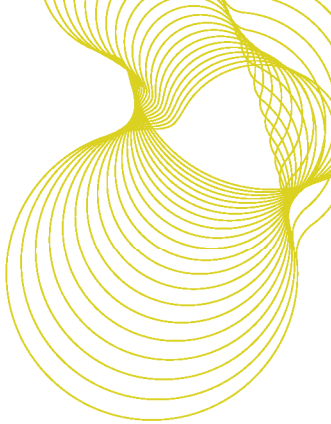
Date of Test: January 29, 2009

Calibration Equipment:
Thurlby Thandar 1906 DMM S/N 117357
Thurlby Thandar PL320 Bench PSU S/N
Mitutoyo Micrometer Head BRE IN 3895

Displacement mm	Measured Output V			Average	Calculated Output V	error %fso
0	0.75069	0.74955	0.74983	0.75002	0.7510	-0.07
5	0.60175	0.60082	0.6011	0.60122	0.6010	0.01
10	0.45294	0.45228	0.45238	0.45253	0.4510	0.10
15	0.30215	0.30139	0.30131	0.30162	0.3010	0.04
20	0.15042	0.1503	0.15027	0.15033	0.1510	-0.04
25	0.00072	0.00075	0.00045	0.00064	0.0010	-0.02
30	-0.14868	-0.14871	-0.14858	-0.14866	-0.1490	0.02
35	-0.29971	-0.29955	-0.29955	-0.29960	-0.2990	-0.04
40	-0.45060	-0.4496	-0.45046	-0.45021	-0.4490	-0.08
45	-0.59910	-0.59889	-0.59906	-0.59902	-0.5990	0.00
50	-0.74826	-0.74829	-0.74754	-0.74803	-0.7491	0.07
m	-0.0300016			fso	-1.5001	
c	0.75102652			mean		0.00

Supply V 10





LVDT for displacement D4

Title: RDP Electronics LVDT

Type: LDC1000A

Ser No: 1521

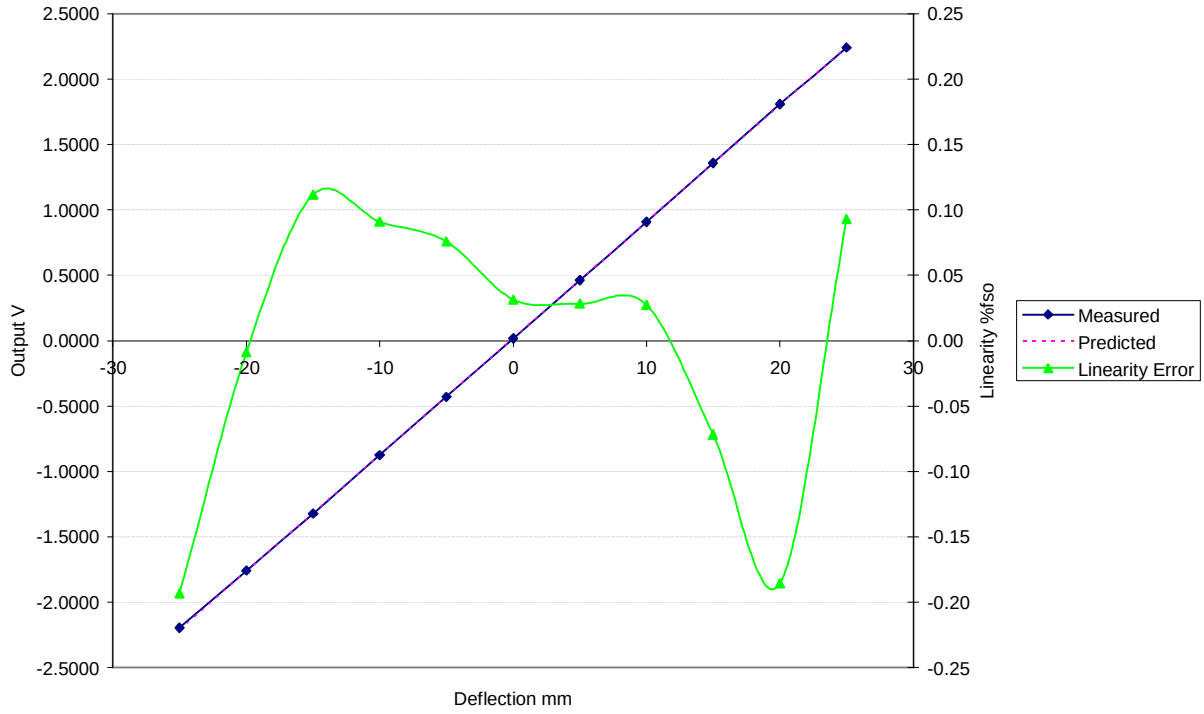
Location: B14/B01

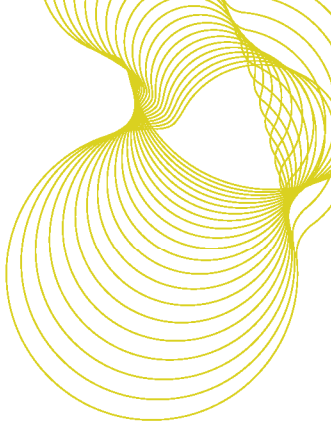
Date of Test: January 29, 2009

Calibration Equipment:
Thurlby Thandar 1906 DMM S/N 117357
Thurlby Thandar PL320 Bench PSU S/N
Mitutoyo Micrometer Head BRE IN 3895

Displacement mm	Measured Output V				Calculated Output V	error %fso
-25	-2.1943	-2.2035	-2.2036	-2.2005	-2.2091	-0.19
-20	-1.7580	-1.7659	-1.7654	-1.7631	-1.7635	-0.01
-15	-1.3219	-1.3243	-1.3224	-1.3229	-1.3179	0.11
-10	-0.8757	-0.8778	-0.8756	-0.8764	-0.8723	0.09
-5	-0.4298	-0.4307	-0.4298	-0.4301	-0.4267	0.08
0	0.0178	0.0170	0.0176	0.0175	0.0189	0.03
5	0.4630	0.4630	0.4636	0.4632	0.4645	0.03
10	0.9084	0.9087	0.9094	0.9088	0.9101	0.03
15	1.3588	1.3590	1.3587	1.3588	1.3556	-0.07
20	1.8097	1.8092	1.8096	1.8095	1.8012	-0.19
25	2.2427	2.2430	2.2423	2.2427	2.2468	0.09
m	0.08911794			fso	4.4559	
c	0.01887273			mean		0.00

Supply V 10





Load cell

Title: Novatech Load Cell and BRE Readout

Type: 100kN

Ser No:

Location: B14/C

Date of Test: January 27, 2009

Calibration Equipment:
Denison 500kN Press S/N 29725

Load Applied kN	Indicated Output kN			Mean	Calculated Output kN	error %fso
0	0.0	0.0	0.0	0.00	0.036	0.15
2.5	2.5	2.5	2.5	2.50	2.522	0.09
5	5.0	5.0	5.0	5.00	5.007	0.03
7.5	7.5	7.5	7.5	7.50	7.493	-0.03
10	10.0	10.0	10.0	10.00	9.978	-0.09
12.5	12.4	12.5	12.5	12.47	12.464	-0.01
15	15.0	15.0	15.0	15.00	14.949	-0.20
17.5	17.5	17.5	17.5	17.50	17.435	-0.26
20	19.9	20.0	20.0	19.97	19.920	-0.19
22.5	22.2	22.4	22.4	22.33	22.405	0.29
25	24.7	24.9	24.9	24.83	24.891	0.23
m	0.994		fso		24.855	
c	0.036		mean			0.00