



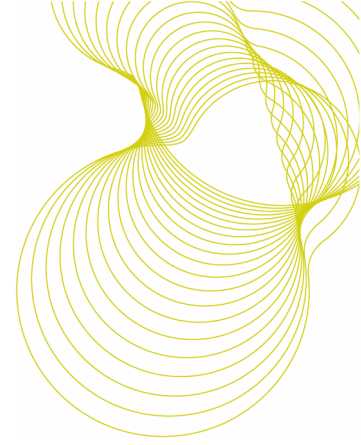
bre

**Load testing of a PVC  
coated handrail system**

Prepared for:  
Mr Rob Cousin  
FibreGrid Limited

25<sup>th</sup> March 2010


Test report number 261-041



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### Tested on behalf of BRE by

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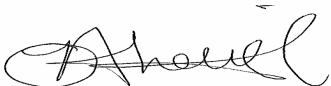
Names Julian Pettifer and Felix Ahatty  
Position Senior Technician and Junior Engineer, Actions, Building Technology Group  
Date 18<sup>th</sup> March 2010  
Signature 

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### Prepared on behalf of BRE by

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Name Felix Ahatty Beng (Hons)  
Position Junior Engineer, Actions, Building Technology Group  
Date 25<sup>th</sup> March 2010  
Signature 

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### Approved on behalf of BRE

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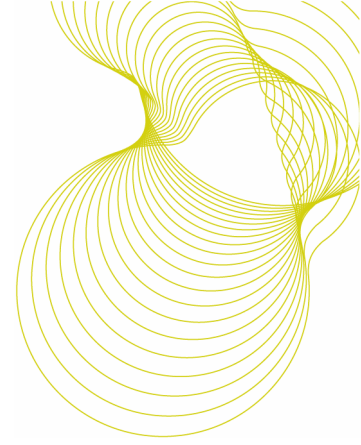
Name Dr. P. Blackmore  
Position Associate Director, Actions, Building Technology Group  
Date 25<sup>th</sup> March 2010  
Signature 

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BRE  
Garston  
WD25 9XX  
T + 44 (0) 1923 664000  
F + 44 (0) 1923 664010  
E [enquiries@bre.co.uk](mailto:enquiries@bre.co.uk)  
[www.bre.co.uk](http://www.bre.co.uk)

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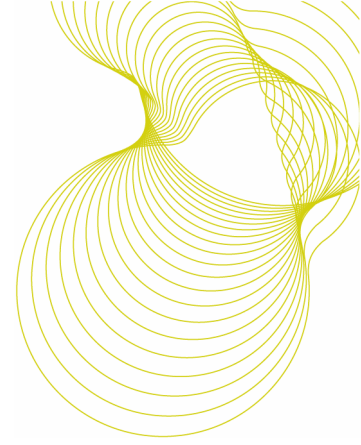
## Executive Summary

This report details load testing undertaken in March 2010 at BRE on a PVC coated handrail system supplied by FibreGrid Limited. The specimen tested was supplied ready assembled by the Client and comprised a hand-rail, knee-rail and two vertical supports along with the associated connecting mouldings and base plates. The specimen was tested to the horizontal loading specifications detailed in the British Standards BS 6180:1999 and BS 6399-1:1996.

A series of uniform horizontal loads were applied to the hand-rail system in the BRE laboratory using a row of three pneumatic loading cylinders. Deflection of the hand-rail was measured at each loading increment using four displacement transducers. Residual displacements were also recorded at some of the load intervals in order to indicate the degree of permanent deformation.

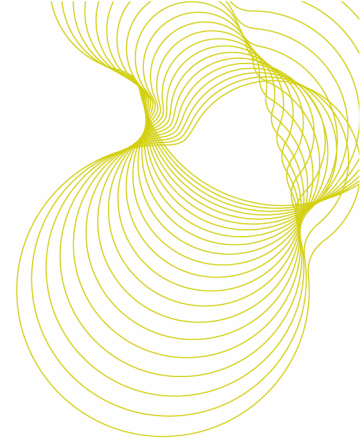
Up to an applied horizontal load of around 0.75kN/m, the measured deflection returned to near-zero values once the load was removed. The maximum displacements of the hand-rail under load were also below the 25mm maximum prescribed in BS 6180:1999 up to this loading level indicating that a person leaning on the barrier in such circumstances would not feel alarmed by the hand-rail movement. No cracking of the joints was observed and the joints stayed intact throughout the test. The hand rail system was visibly bowed after 3.11kN.

On the basis of the current test results described herein, the deflection on the system did not exceed 25mm until the load reached 0.92kN. As the system tested as tested was 2m wide it can be concluded that the FibreGrid PVC coated hand-rail system complies with the requirements of BS 6399-1:1996 for 0.22kN/m, 0.36kN/m and 0.74kN/m minimum horizontal load requirement applications. The system has been shown to be able to withstand horizontal loads up to approximately 0.75kN/m without deflecting more than 25mm under load or suffering significant residual deformation. This would make it suitable for use in offices, work areas including storage areas and domestic applications, as defined in BS 6399-1:1996.



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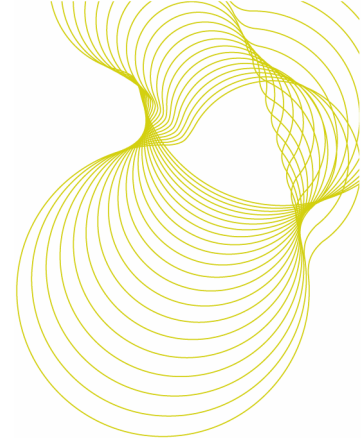


## 1 Introduction

This report details tests undertaken in March 2010 to measure the load capacity of a PVC coated handrail system supplied by FibreGrid Limited. Testing was conducted out at BRE, Bucknalls Lane, Watford, WD25 9XX, UK. The Client for these tests was FibreGrid Limited, Unit 10, 42 Hollands Road, Haverhill, Suffolk, CB9 8SA, UK.

This study is based upon BRE Proposal number 126-699 dated 3<sup>rd</sup> March 2010, which was sent to Mr Rob Cousins of FibreGrid Limited. The proposal was accepted by Mr Cousins in an email and a letter dated 9<sup>th</sup> March 2010.

The test program was carried out as project CV3659 under the BRE's Standard Terms and Conditions for Testing. This report documents the work carried out at BRE and records the findings obtained.



## 2 Test Specimen

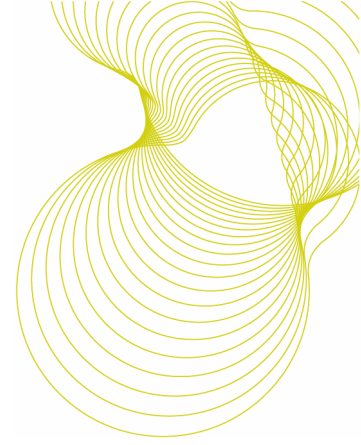
The test specimen comprised a length of PVC coated handrail system of overall length 2m, incorporating a top hand-rail at a height of 1.1m and a knee-rail at approximately half of this height. The specimen was constructed from the components detailed in Table 1 below; this table also gives approximate dimensions of each component and the respective FibreGrid part numbers. The specimen was supplied for test ready assembled using four screws at each connection point.

Photographs of the test specimen prior to testing are shown in Figures 1 to 6 in Section 7 at the rear of this document.

Component	Relevant dimensions (mm)	FibreGrid Part number
PVC coated tubing	900mm long sections, 44mm (approx) outside diameter	TBC
90 degree elbow	45mm diameter	TBC
90 degree T-fitting	60mm diameter on vertical, 45mm diameter on horizontal sections	TBC
Base plate	130mm diameter, 30mm height, fixing holes at 90mm PCD	TBC
Joint screws	PZ3 screws, 4 per joint	TBC

Table 1: Test specimen component list

The specimen was installed onto the concrete floor of the BRE laboratory by BRE laboratory technicians using a total of twelve hex head bolts 8mm x 140mm (four in each base plate).



### 3 Test Methods

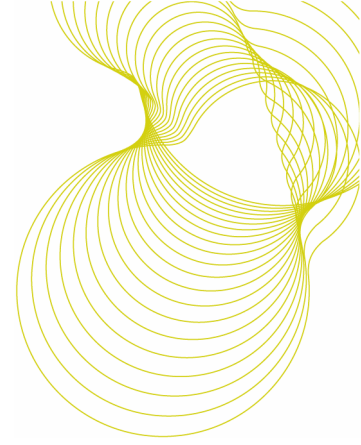
#### 3.1 Relevant British Standards

The document *BS 6180:1999 'Barriers in and about buildings – Code of Practice'*<sup>(1)</sup> gives recommendations for the design and construction of barriers provided in and around buildings and places of assembly. In particular, Clause 6.3 details the minimum horizontal imposed loads which the barrier should withstand and Clause 6.4.1 specifies maximum deflections under these loads.

Reference is made to Clause 10 of *BS 6399-1:1996 'Loading for buildings – Part 1: Code of practice for dead and imposed loads'*<sup>(2)</sup> which tabulates the minimum horizontal imposed loads for barriers according to the type of occupancy of the building or structure. Three types of horizontal loading are specified: a uniformly distributed line load, a uniformly distributed load applied to the infill and a point load applied to the infill. Of these, only the first type of loading is applicable, as the FibreGrid Limited product to be tested does not feature an infill. The stated loads range from 0.22kN/m for light access stairs in offices up to 3.0kN/m in areas susceptible to overcrowding (for example, in theatres and bars) and are summarised in the table below. Please refer to *BS6399-1:1996* Clause 10 for full load data for specific types of occupancy and usage.

Minimum horizontal load (kN/m)	Example of types of occupancy and specific uses
0.22	Offices: Light access stairs and gangways not more than 600mm wide
0.36	Domestic: All areas serving exclusively one single family dwelling Offices: Light pedestrian traffic routes
0.74	Offices: Areas not susceptible to overcrowding Domestic: All other domestic and residential not covered above Areas without obstacles: Stairs, landings, corridors and ramps External balconies
1.50	Areas where people congregate: Restaurants and bars Retail: All areas Vehicular: Pedestrian areas in car parks
3.00	Areas susceptible to overcrowding: Theatres, bars, shopping malls, etc.

Table 2: Summary of the minimum horizontal imposed uniformly distributed loads and examples of specific uses given in BS6399-1:1996



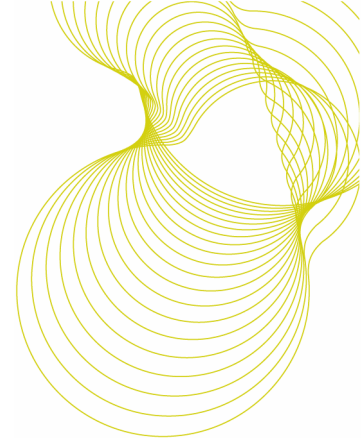
### 3.2 Test procedure

The 2m long (approx.) section of the PVC coated handrail system was installed onto the concrete floor of the BRE laboratory by BRE Technicians, as shown in Figure 7. A uniform horizontal load was then applied to the hand-rail as prescribed in BS 6180:1999 using a series of three pneumatic rams connected in parallel. Air pressure (and thus applied loading) was controlled via a precision regulator and the applied load measured using a calibrated Novatech F256 type loadcell on the central ram. The pneumatic cylinders acted on the hand-rail via a rubber-faced loading beam which was independently suspended from the laboratory's overhead crane. The loading beam ensured that the applied load was evenly distributed across the hand-rail and its rubber face absorbed any irregularities in the barriers profile (i.e. between corner joints or protruding screw heads).

The deflection of the hand-rail was measured at the ends and centre of the hand-rail, and also at the centre of the knee-rail using calibrated ASM type WS10 displacement gauges which were mounted on an independent support frame. The residual deformations at certain load increments were also noted after removal of the applied load in order to gauge permanent deflection of the system.

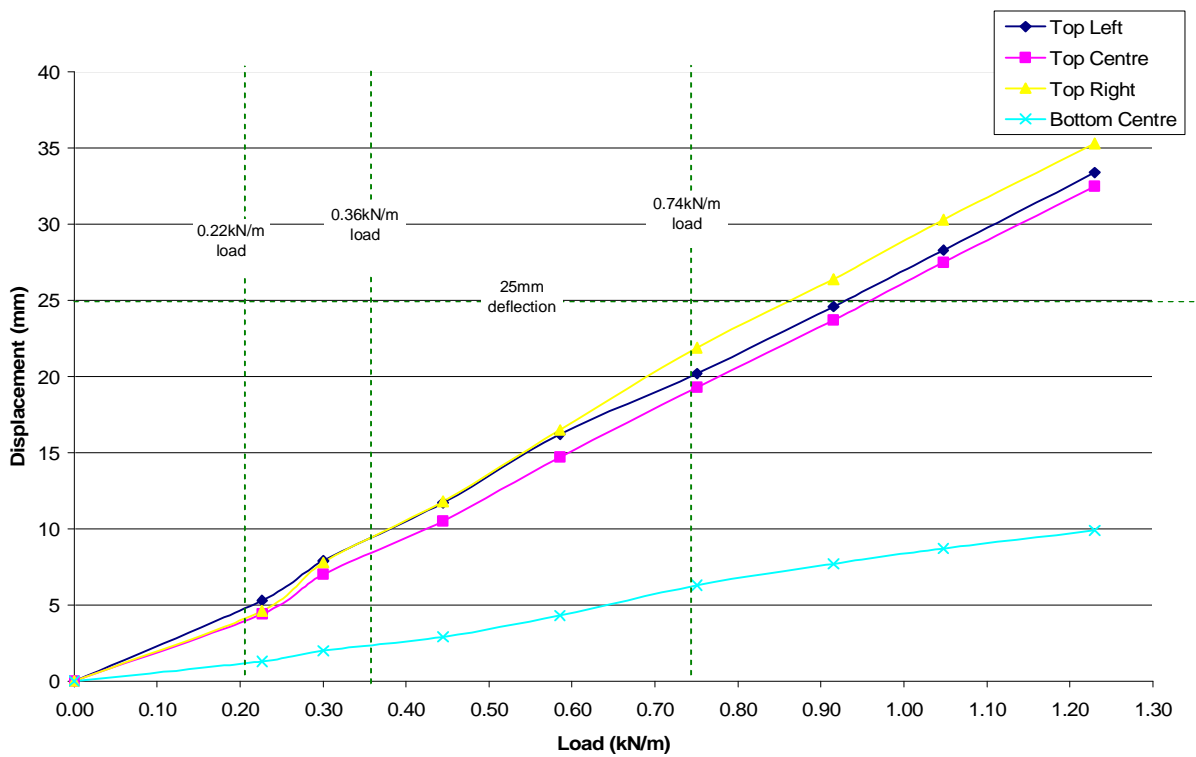
Only a single test specimen was available for test and hence it was not possible to determine the characteristic failure load for the hand-rail system (this would have required at least three repeat tests in order to obtain statistically significant data).

Photographs taken during the tests are shown in Section 7 of this report.



## 4 Test data

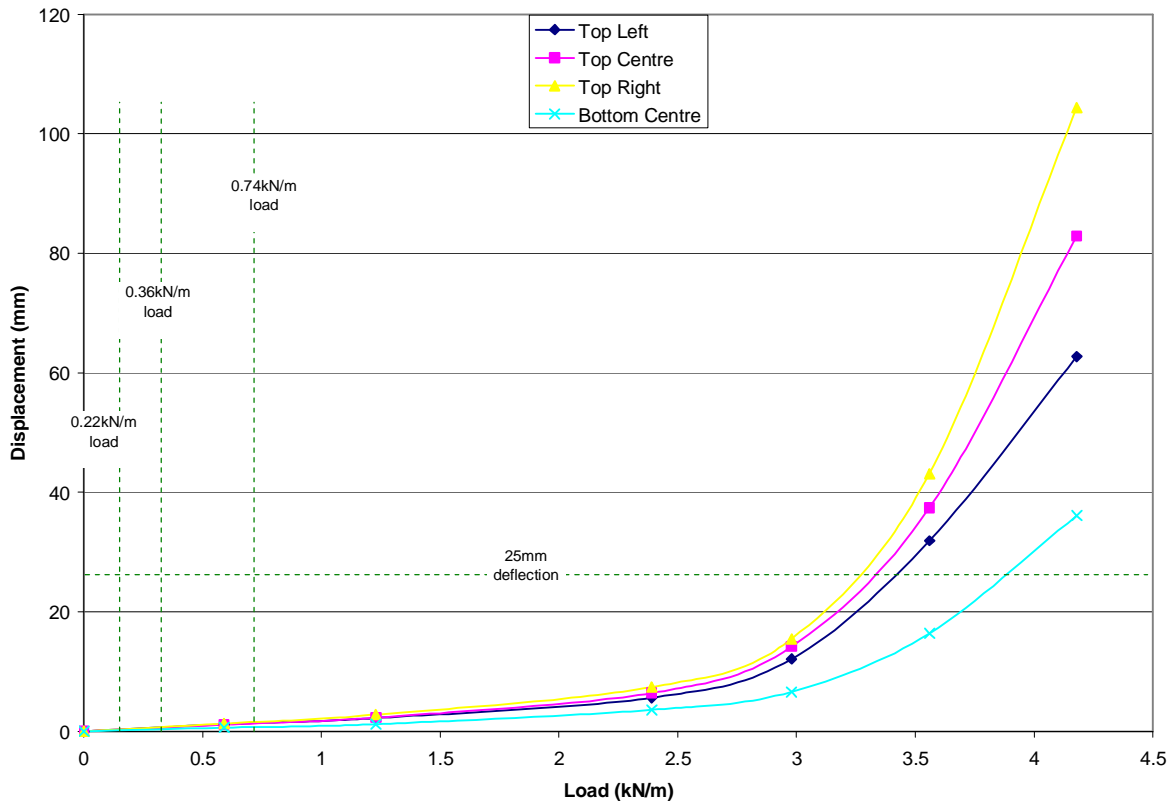
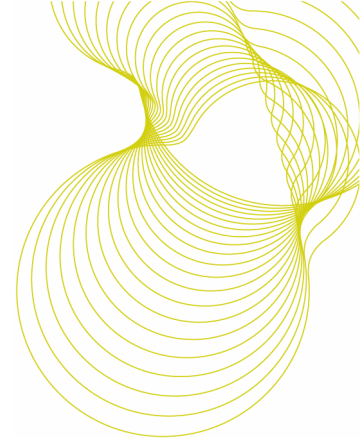
### 4.1 Horizontal uniform load



Plot 1: Deflections of hand-rail measured under uniform horizontal load

Load (kN/m)	Deflection of hand-rail under load
0.22	Less than 10mm (approx. 4mm)
0.36	Less than 15mm (approx. 7mm)
0.74	Less than 25mm (approx. 22mm)

Table 3: Deflections under load for 1m PVC coated barrier system

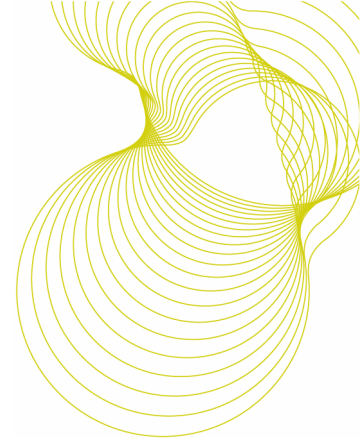


Plot 2: Residual deformation of hand-rail after removal of uniform horizontal load

Note for information purposes the specimen was further loaded after exceeding 25mm deflection to see the permanent damage that could be done to the system under extreme load. Results are presented in Annex A.

Load (kN/m)	Residual deformation measured at hand-rail
0.22	Less than 5mm
0.36	Less than 5mm
0.74	Less than 5mm

Table 4: Residual deformations after removed of horizontal loading

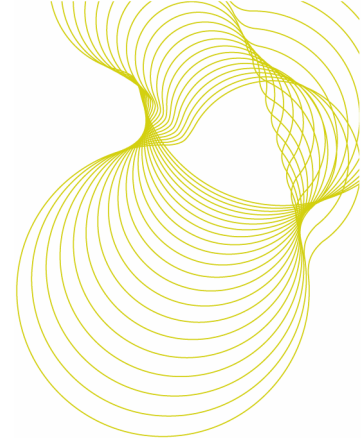


## 4.2 Mode of failure

Under the applied horizontal loading, there was no visible deformation on the hand rail system until loading reached 3.56kN/m when the system was inclined at a measured angle of 88.4°.

The maximum displacements of the hand-rail under load were below the 25mm maximum prescribed in BS 6180:1999 for a load of 0.74kN/m. This indicates that a person leaning on the barrier in such circumstances would not feel alarmed by the hand-rail movement. The point of failure was however when deflection exceeded 25mm and this happened at a load of about 0.9kN/m.

The base plates remained intact during the test and the spigot on the base plate was visibly deformed at the end of the test as can be seen in Figure 10. After failure, a small degree of loosening of the other connections in the hand-rail system was noted, although this was not considered to be significant.

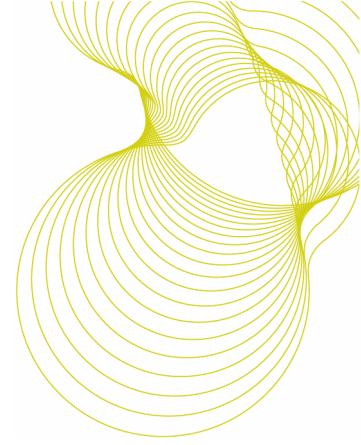


## 5 Discussion and conclusions

A two metre section of PVC coated handrail system supplied by FibreGrid Limited was tested at BRE to the loading criteria detailed in BS6180:1999 and BS6399-1:1996. On the basis of these test results, the PVC coated hand-rail system tested complies with the requirements of BS 6399-1:1996 for 0.22kN/m, 0.36kN/m and 0.74kN/m minimum horizontal load requirement applications. The system has been shown to be able to withstand horizontal loads up to approximately 0.9kN/m without deflecting more than 25mm under load or suffering significant residual deformation. This would make it suitable for use in offices, work areas including storage areas and domestic applications, as detailed in Table 2 of this report (reproduced from BS 6399-1:1996).

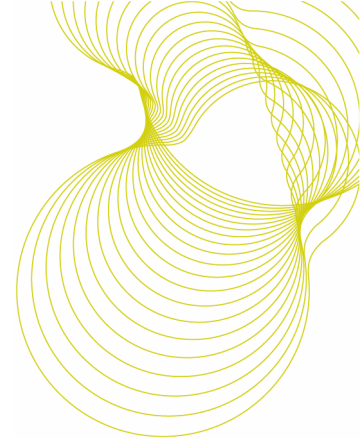
However, it should be noted that it is standard practice to conduct at least three repeats of such loading tests in order to determine statistically significant results

The full load versus deflection data from these tests is provided in Annex A of this document to allow the manufacturer or users to determine whether these characteristics are appropriate for a given application.



## 6 References

- (1) BS 6180:1999. Barriers in and about buildings – Code of practice. British Standards Institution, London.
- (2) BS 6399-1:1996. Loading for buildings – Part 1: Code of practice for dead and imposed loads. British Standards Institution, London.



## 7 Figures



Figure 1: Test specimen installed onto the laboratory floor prior to testing

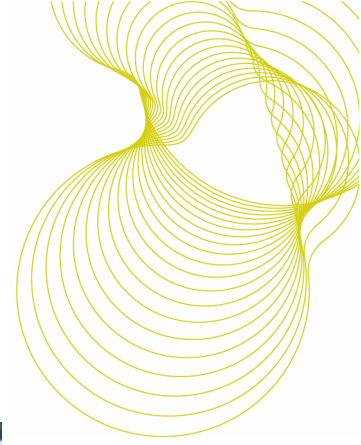


Figure 2: Close-up of top corner connection prior to testing



Figure 3: Close-up of top corner connection prior to testing

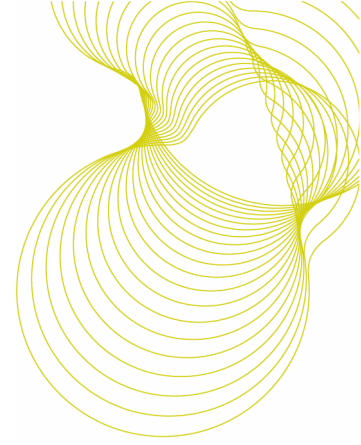


Figure 4: Close-up of knee-rail connection prior to testing



Figure 5: Close-up of knee-rail connection prior to testing

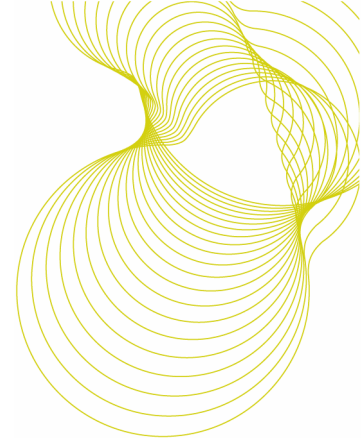


Figure 6: Bolted connection to laboratory floor prior to testing

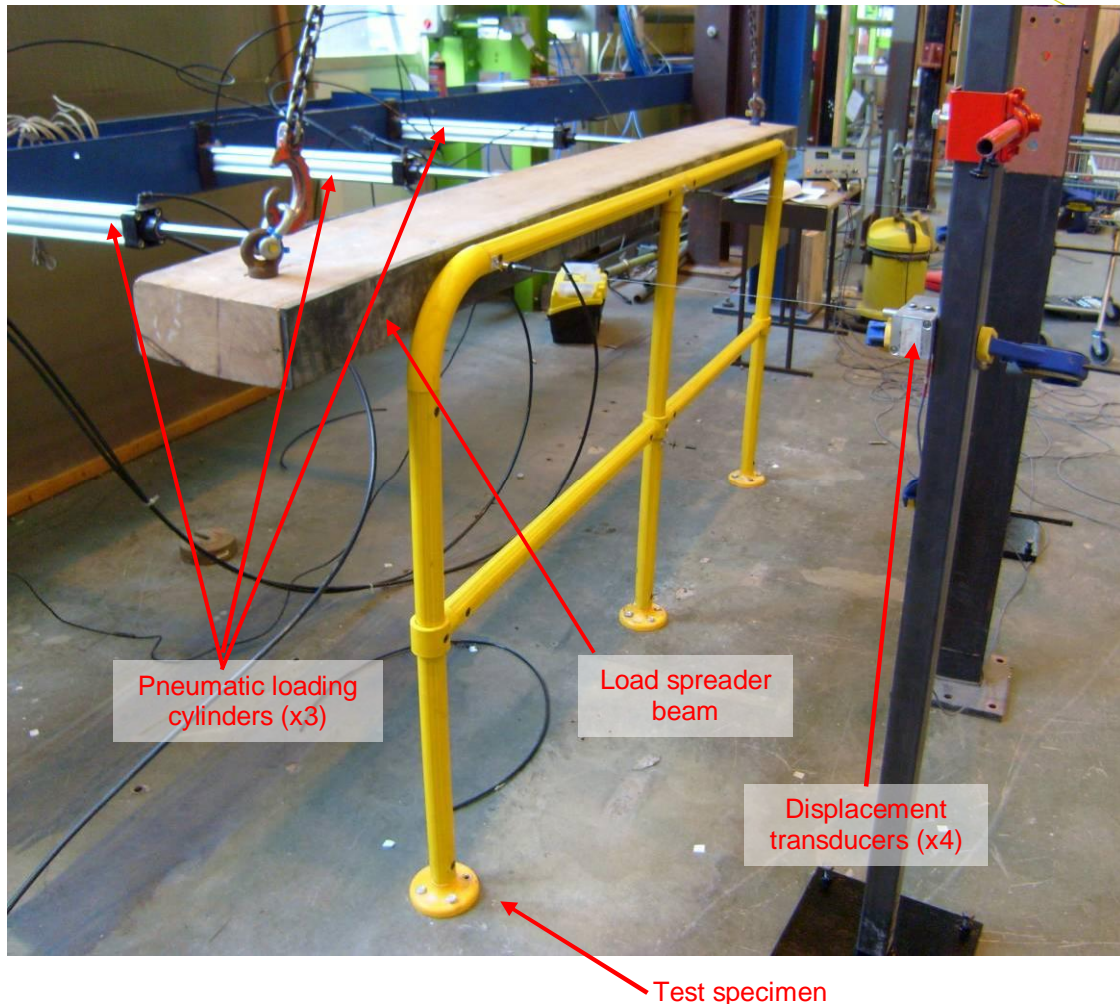
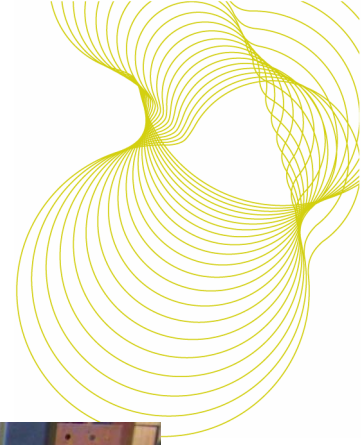


Figure 7: Specimen under horizontal load test

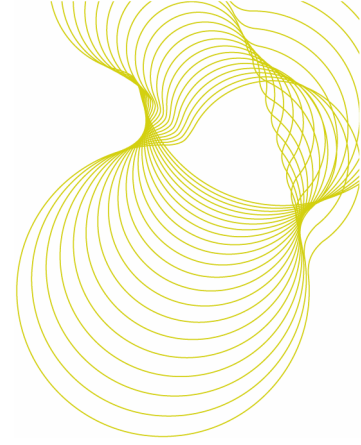


Figure 8: Close-up of base plate under load



Figure 9: Barrier with load removed showing residual deformation

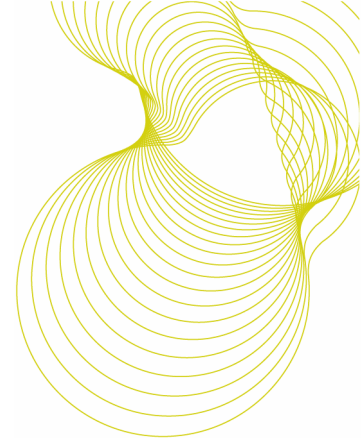
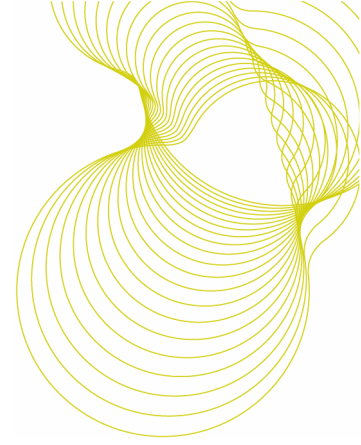


Figure 10: Close-up of base plate after test termination



## Annex A – Experimental data

Total applied load (kN)	Top left displacement (mm)	Top centre displacement (mm)	Top right displacement (mm)	Bottom centre displacement (mm)
0.00	0	0	0	0
0.23	5.3	4.4	4.6	1.3
0.30	7.9	7	7.8	2
0.44	11.7	10.5	11.8	2.9
0.59	16.2	14.7	16.5	4.3
0.75	20.2	19.3	21.9	6.3
0.92	24.6	23.7	26.4	7.7
1.05	28.3	27.5	30.3	8.7
1.23	33.4	32.5	35.3	9.9
1.34	36.8	35.8	38.4	11.1

Table A1: Experimental measurements of displacement under a uniform horizontal load

Total applied load (kN)	Top left displacement (mm)	Top centre displacement (mm)	Top right displacement (mm)	Bottom centre displacement (mm)
0	0	0	0	0
0.59	1.2	1.1	1.3	0.59
1.23	2.2	2.3	2.8	1.23
2.39	5.6	6.4	7.4	2.39
2.98	12.1	14.2	15.5	2.98
3.56	31.9	37.4	43.1	3.56
4.18	62.7	82.9	104.4	4.18

Table A2: Experimental measurements of residual deformation after removal of horizontal load