

SBF2016F0013 - Restricted

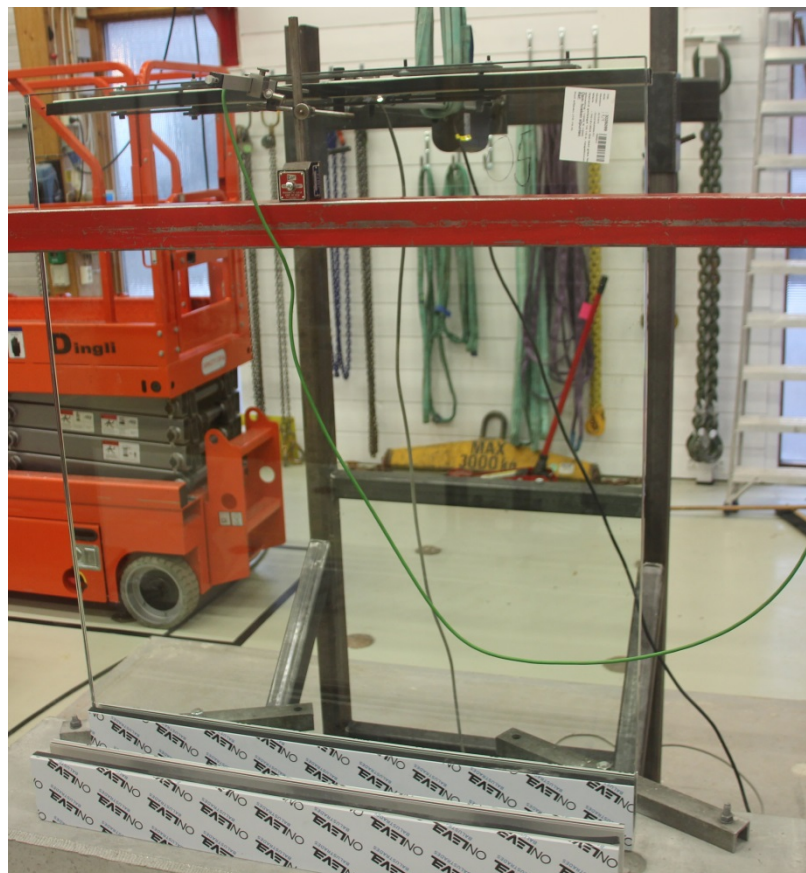
Test report

Glass balustrades OnLevel

Load testing of OnLevel glass balustrades

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17 + appendices

TEST OBJECT

5 glass balustrades various types and sizes

TEST OBJECT RECEIVED

2015-12-02

TEST PROGRAM

NS 3510:2015

TEST LOCATION

Oslo

DATE OF TEST

2015-12-03

ABSTRACT

SINTEF was commissioned to undertake load testing of various types of Onlevel glass balustrade systems.

A total of 5 systems were submitted for loading assessment.

Test specimens were loaded with horizontal line loads approximately 10 mm below the top of glass panels. The deflection was measured for different loads in accordance to NS 3150.

This report presents the results of tests, which were carried out on 2nd and 3th December 2015 at our laboratory in Oslo.

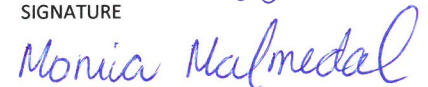
The test results relate only to the items tested

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1 INTRODUCTION

SINTEF was instructed by Onlevel B.V. to carry out load testing of different glass balustrade systems. The load capacity and deflection properties of 5 systems, as received from OnLevel, were tested.

This report presents the results of tests, which were carried out on 2nd and 3th of December, 2015 by Dag Henning Sæther at our laboratory in Oslo, Norway.

This report summarises the test results obtained during the test programme and does not provide interpretation of those results.

The test results relate only to the items tested.

2 METHODOLOGY

2.1 Glass balustrades load requirements according to NS 3510:2015

Barriers for the protection of people should be of adequate strength and stiffness to sustain the applied loads as given in NS 3150:2015 Safety glass in construction works – Requirements for design and classes in various application areas.

Table B.1. – Loads on balustrades and walls of this standard specify minimum horizontal imposed loads for balustrades in the various situations where they would be used:

- *Category A (domestic/residential activities) 1 kN/m*
- *Category B and C1 (offices and work, schools and restaurants etc.) 1 kN/m*
- *Category C2 and C4 and D (churches theater cinemas auditoria hotels gyms etc..) 1,5 kN/m*
- *Category C5 (areas susceptible to over-crowding concert halls, shopping malls etc) 3 kN/m*

According to NS 3510:2015 Table B.2 the deflection of the glass panels under load shall not exceed 50 mm.

Following requirements for minimum fence height in Norway according to NS 3150:2015 clause 6.5 and Regulations on technical requirements for building works, TEK10 § 12-17 and § 12-16 are:

- *0,9 m stairs and ramps,*
- *1,0 m balconies, tribunes passages and similar,*
- *1,2 m for use where difference between two levels (ground) is higher than 10 m.*

2.2 Test systems

The client submitted the glass balustrade systems to the SINTEF Laboratory on December 2, 2015.

The glass balustrade systems were identified as the OnLevel balustrades systems Glass profile TL-60 Aluminium.

Tested glass balustrade systems are with single full view glazing material that is fully captured on only one side. A decorative or protective top rail, or a handrail may or may not be attached to the glass, but does not offer structural support to systems.

The systems specifications and mounting are described in drawings submitted by client. Drawing sample of one individual balustrade system is shown in Appendix B – Drawing 2.

Test specimens configuration is outlined in Table 1.

The width of all test specimens is 1000 mm.

Table 1: Test specimen configuration

Specimen	System Model Translevel TL-60	Mounting type	Glazing	Glazing dimensions	Application area
A	Model 6010	Surface mount	Laminated full tempered glass	10-10-4 (21,52 mm)	Residential
B	Model 6010	Surface mount	Laminated full tempered glass	8-8-4 (16,76 mm)	Residential
C	Model 6011	Side mount	Laminated full tempered glass	10-10-4 (21,52 mm)	Residential
D	Model 6030	Surface mount	Laminated full tempered glass	15-15-4 (32,52 mm)	Public
E	Model 6031	Side mount	Laminated full tempered glass	15-15-4 (32,52 mm)	Public

2.3 Test Procedure

All test specimens are prepared in accordance with the manufacturers specifications and assembled by the representative for OnLevel.

A concrete element was used for mounting the glass balustrades. See Appendix B-Drawing 1 for description of the element.

In each case, horizontal uniformly distributed line load was applied perpendicular to the top of the glass balustrade system using an electric actuator and a load cell with equipment number MO-5388, see Figure 1. The uniform loads were applied gradually, with constant monitoring of the glass panel displacement from an independent position, until required loading had been achieved.

Speed of load application were 20-30 mm/min. The loads were applied in two different heights: 1 m and 1,2 m from the ground level.

The deflection of glass panels was recorded with displacement monitoring equipment, see Figure 2.

For ultimate strength considerations, additional loadings cycles were performed on selected systems until the brakeage was achieved or the loading was discontinued, see tables 2,3,4 and 6.

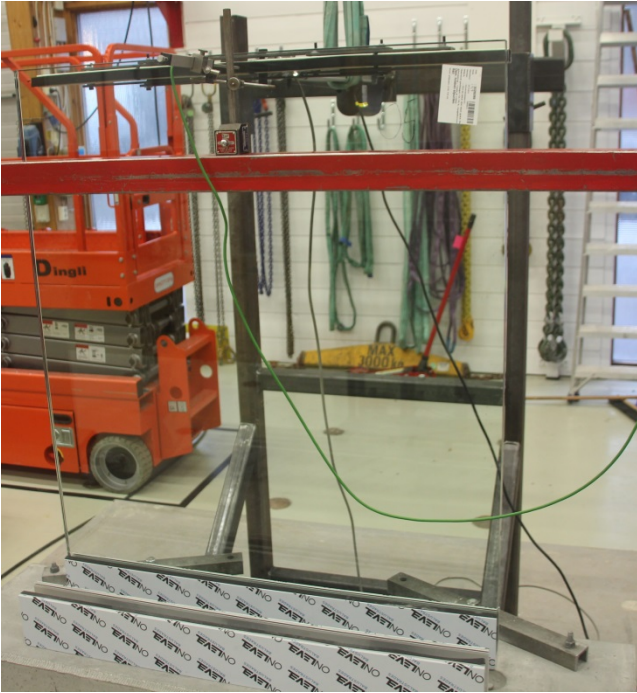


Figure 1 OnLevel glass balustrade system during preparation for testing under the horizontal uniformly distributed line loading

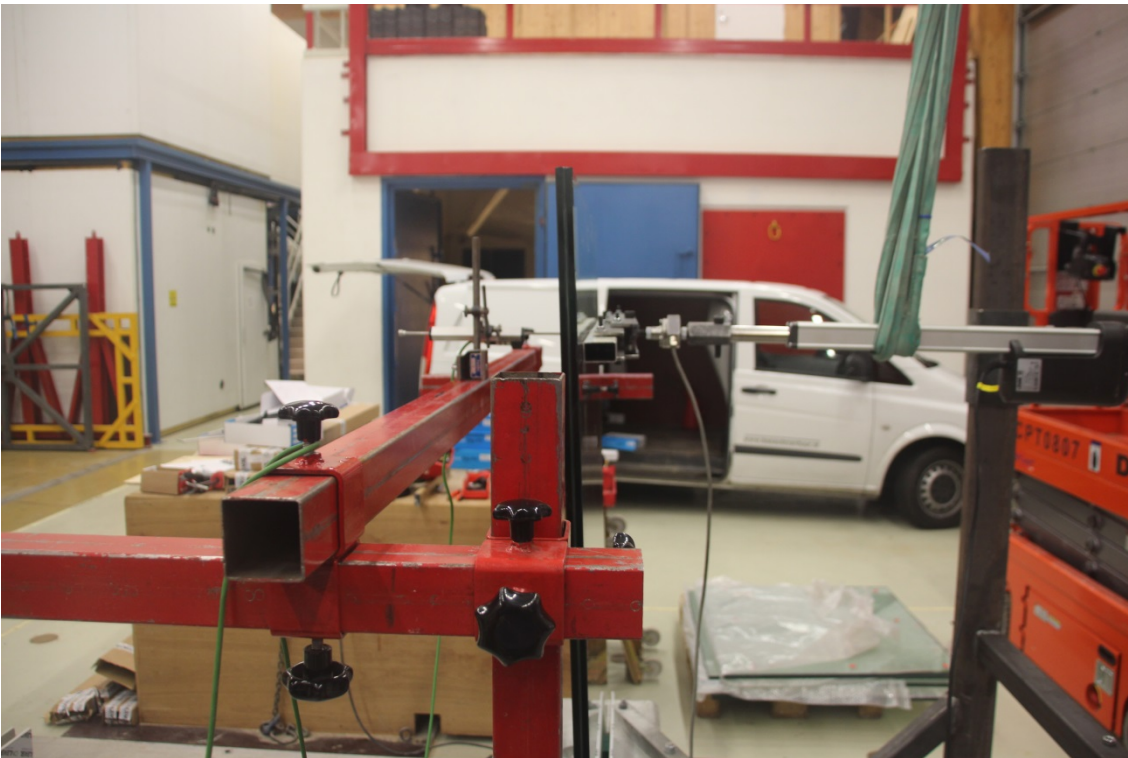


Figure 2 Displacement monitoring equipment (dial test indicator) required to record the maximum displacement of each balustrades component feature under loading.

3 TESTING RESULTS

The results of testing are shown in Tables 2-4.

The load/deflection graphs for all tests are summarized and shown in Appendix B.

Photos showing tested glass balustrades systems are attached in Appendix C.

Table 2: Test results for system A

Test no.	Applied load (kN/m)	Height from surface level to applied load (mm)	Measured deflection (mm) ¹⁾	Number of wedges	Failure/or loading discontinued	Remarks
04	1,5	1000	36	3	Loading discontinued at 4,2kN / No breakage	
05	1,5	1200	59	3	-	
06	1,5	1200	48	4 ²⁾	-	By using 4 wedges and re-testing the system, the measured deflection of glass panel did <u>not</u> exceed 50 mm limit given in NS 3510:2015.

¹⁾ Permitted deflection according to NS 3510:2015 is 50 mm

²⁾ Distance from edge 100mm each side/distance between wedges 266 mm.

Table 3: Test results for system B

Test no.	Applied load (kN/m)	Height from surface level to applied load (mm)	Measured deflection (mm) ¹⁾	Number of wedges	Failure/or loading discontinued	Remarks
08	1,5	1000	42	3	Breakage at 4.8kN, See photo 2 Appendix C	

¹⁾ Permitted deflection according to NS 3510:2015 is 50 mm

Table 4: Test results for system C

Test no.	Applied load (kN/m)	Height from surface level to applied load (mm)	Measured Deflection ¹⁾ (mm)	Number of wedges	Failure/or loading discontinued
10	1,5	1000	41	3	Loading discontinued at 4.8kN / No breakage
11	1,5	1200	64	3	-

¹⁾ Permitted deflection according to NS 3510:2015 is 50 mm

Table 5: Test results for system D

Test no.	Applied load (kN/m)	Height from surface level to applied load (mm)	Measured Deflection ¹⁾ (mm)	Number of wedges	Remarks
01	3	1200	54	3	
03	3	1000	33	3	
07	3	1200	49	4 ²⁾	Re-tested with 4 wedges. The measured deflection of glass panel did <u>not</u> exceed 50 mm limit given in NS 3510:2015

¹⁾ Permitted deflection according to NS 3510:2015 is 50 mm

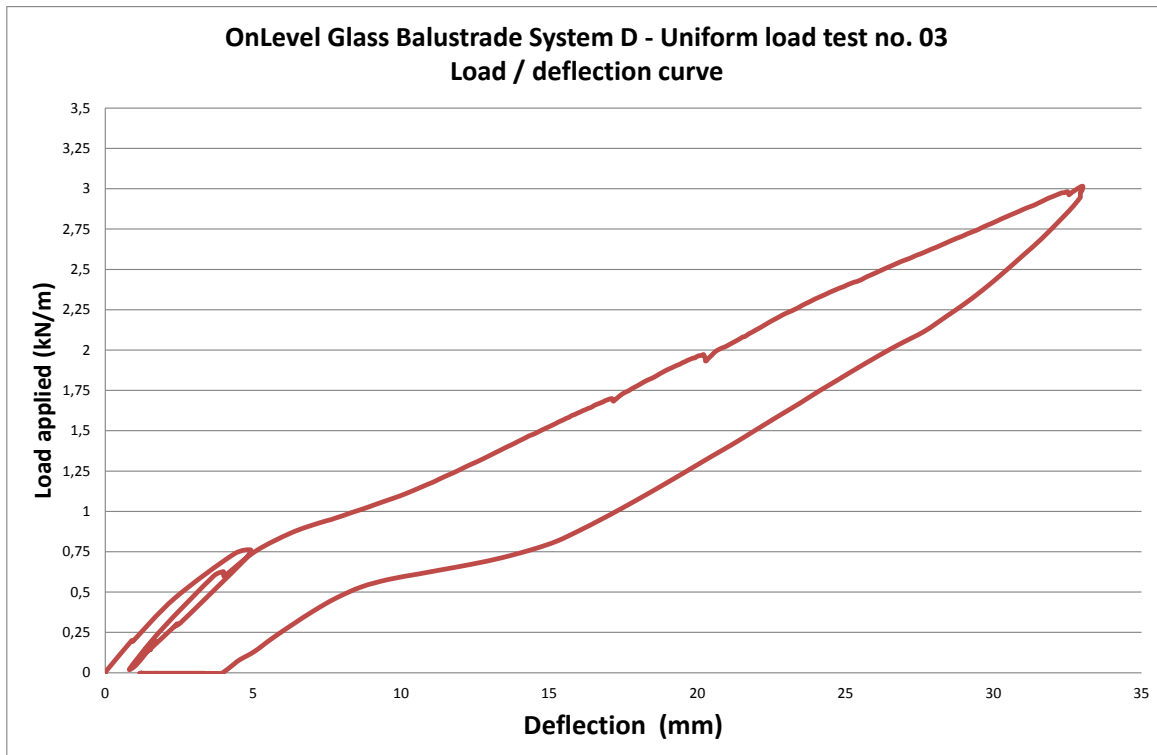
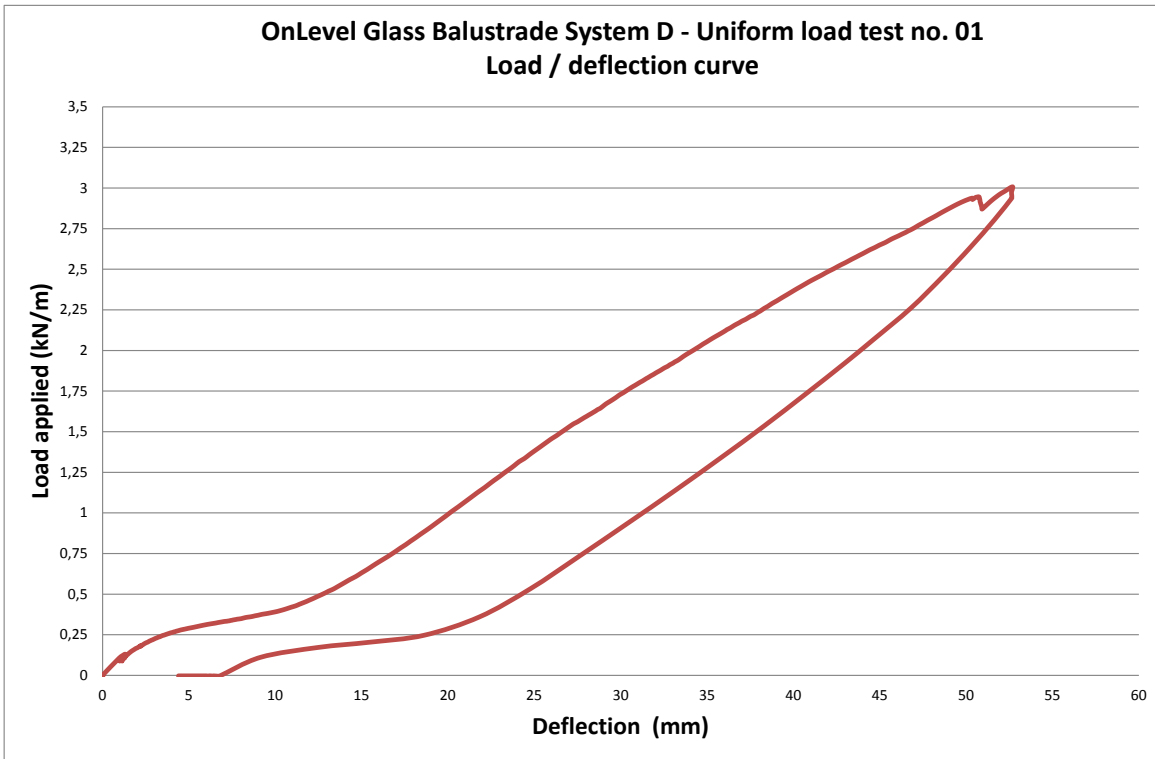
²⁾ Distance from edge 100mm each side/distance between wedges 266 mm.

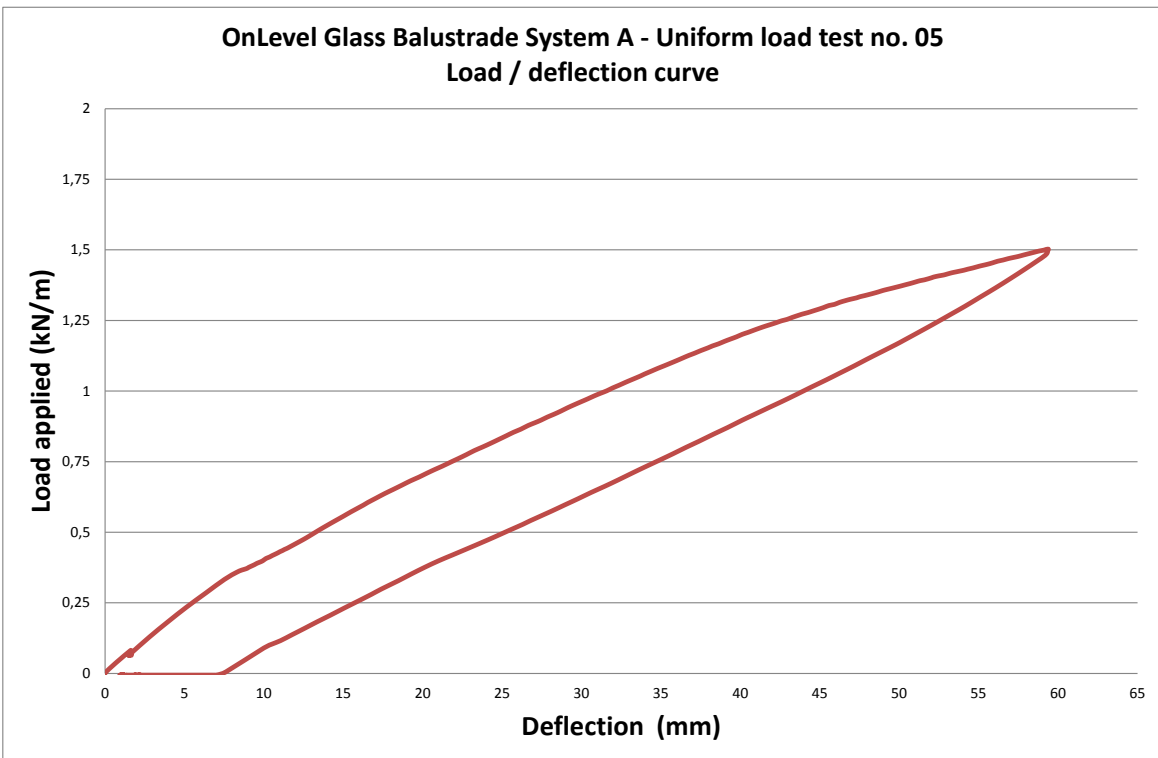
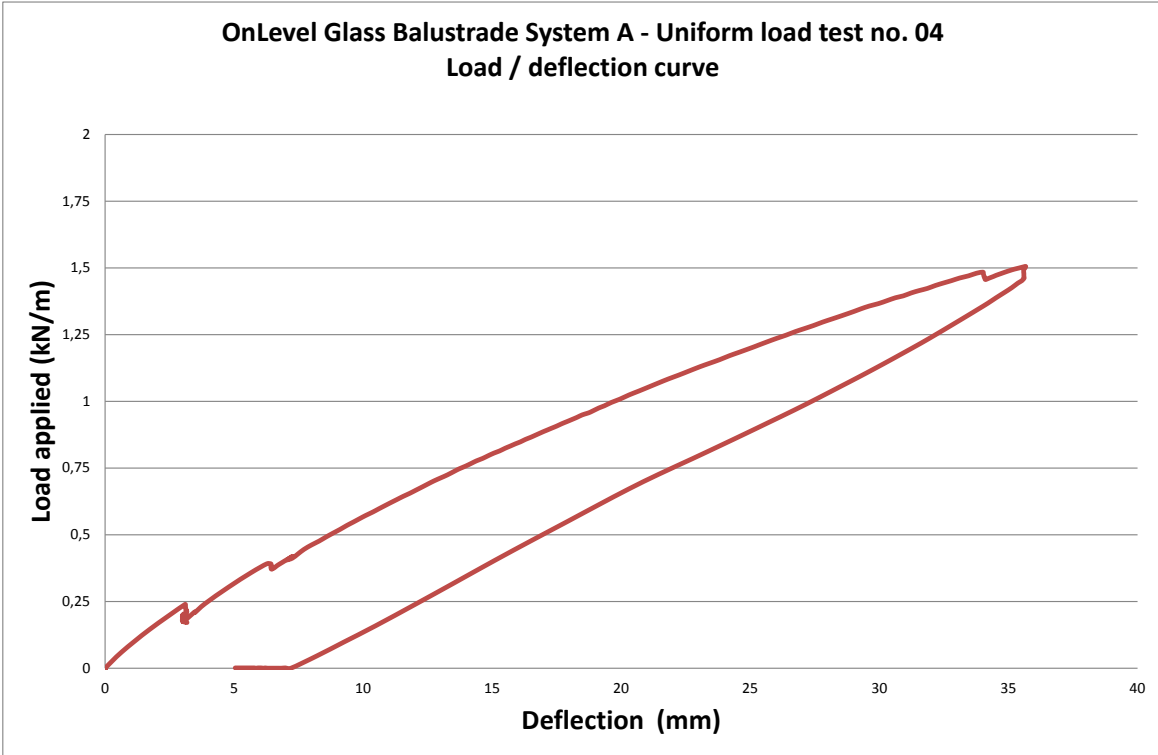
Table 6: Test results for system E

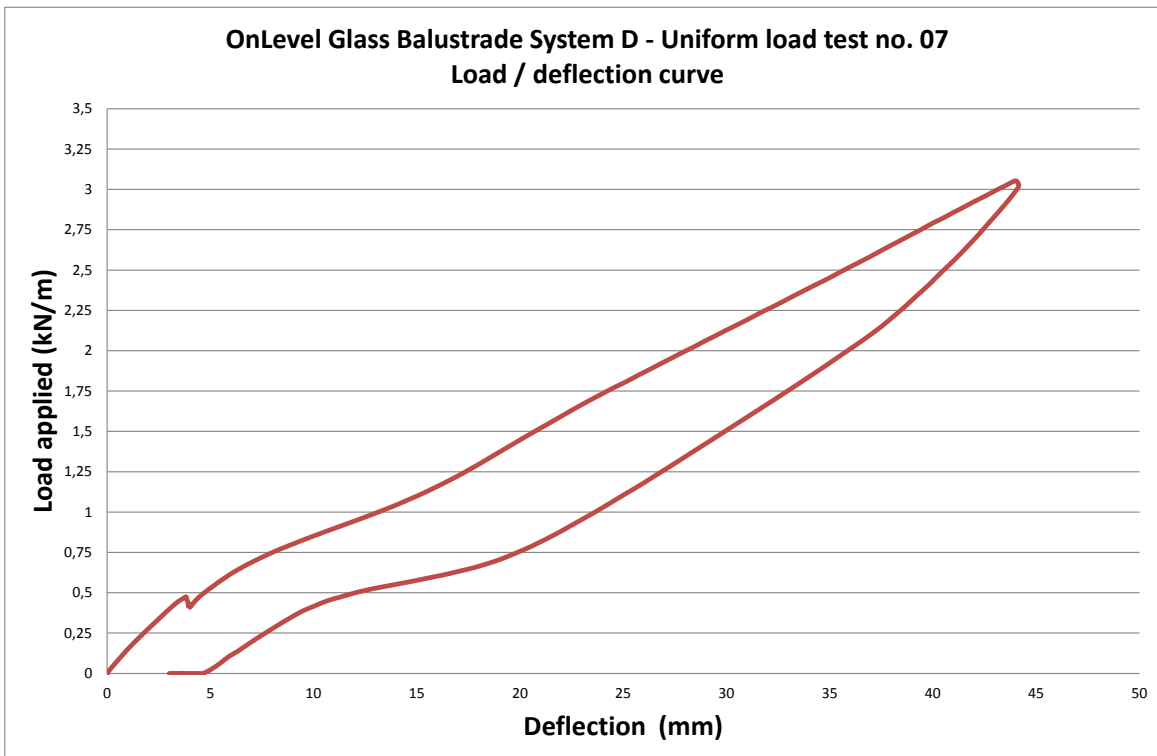
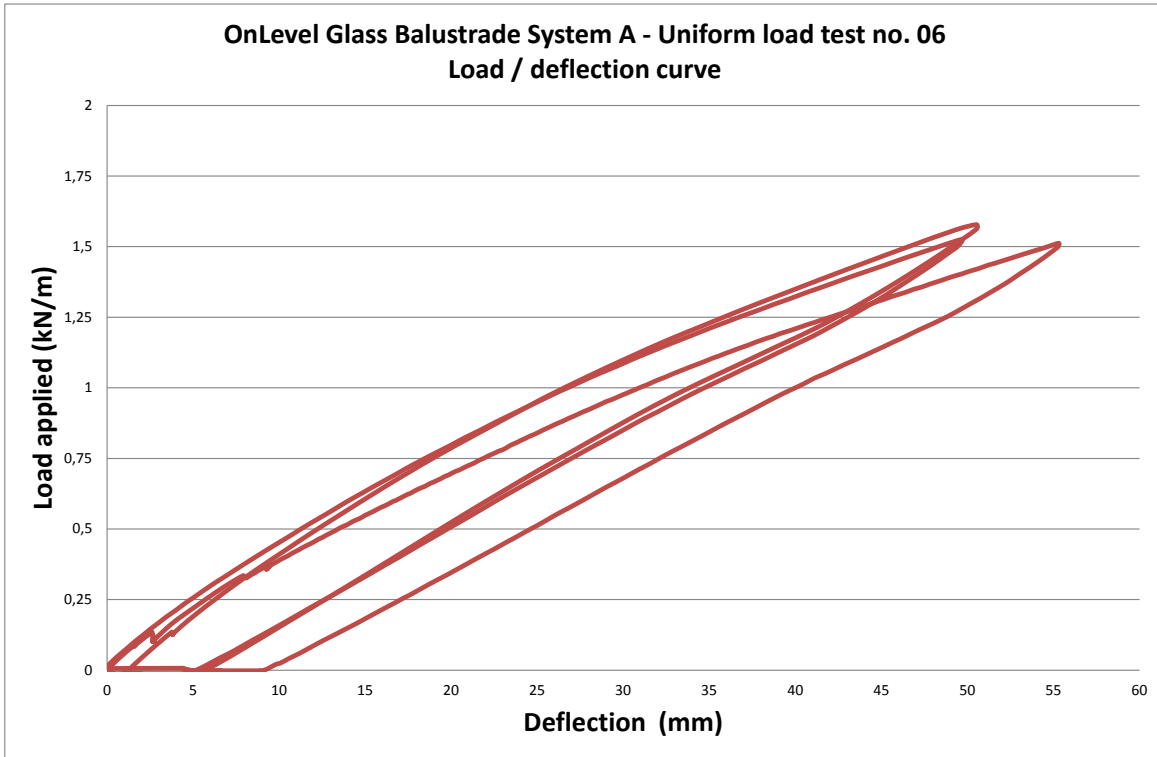
Test no.	Applied load (kN/m)	Height from surface level to applied load (mm)	Measured Deflection ¹⁾ (mm)	Number of wedges	Failure/or loading discontinued	Remarks
13	3	1200	49	4	Loading discontinued at 8 kN / No breakage	By using 4 wedges in sted of 3, the measured deflection of glass panel did <u>not</u> exceed 50 mm limit given in NS 3510:2015

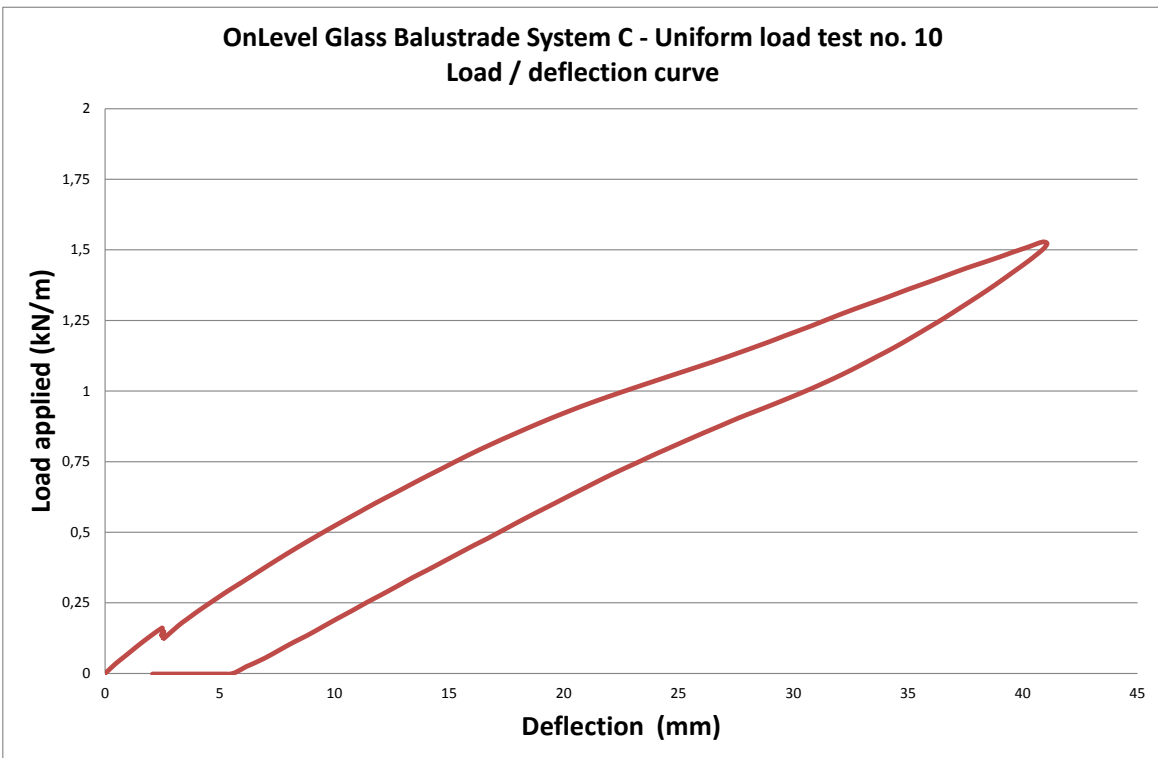
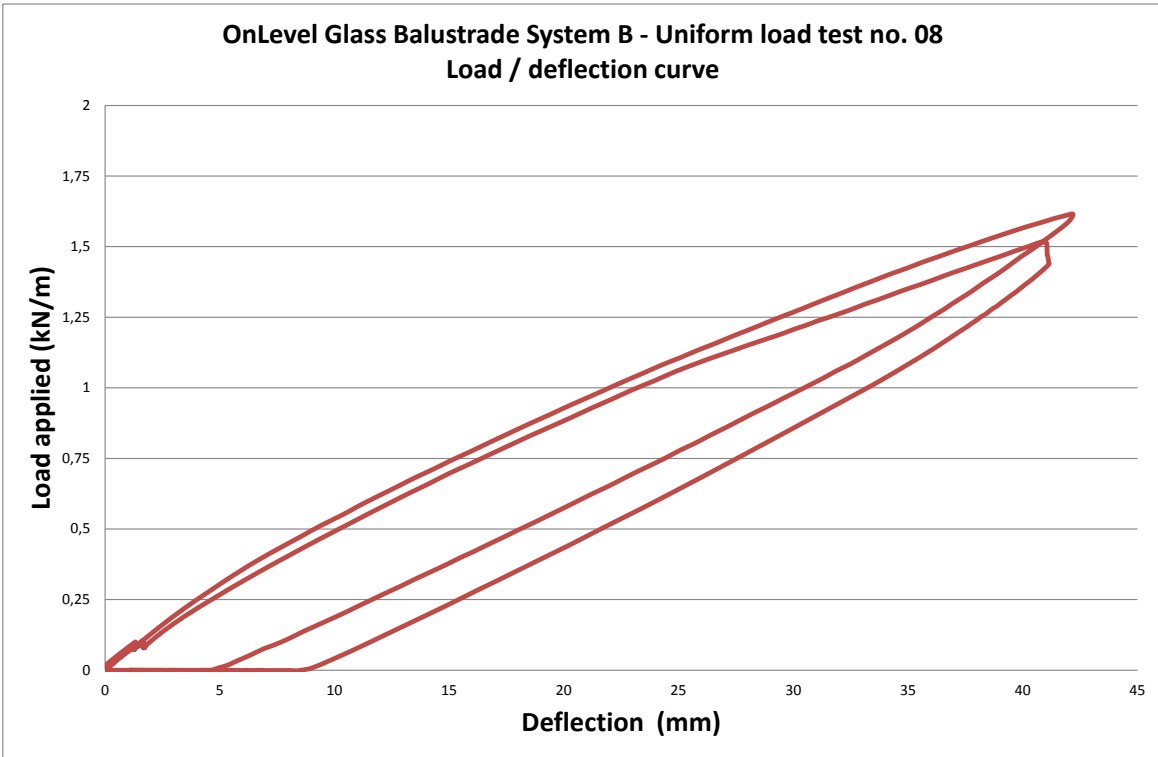
¹⁾ Permitted deflection according to NS 3510:2015 is 50 mm

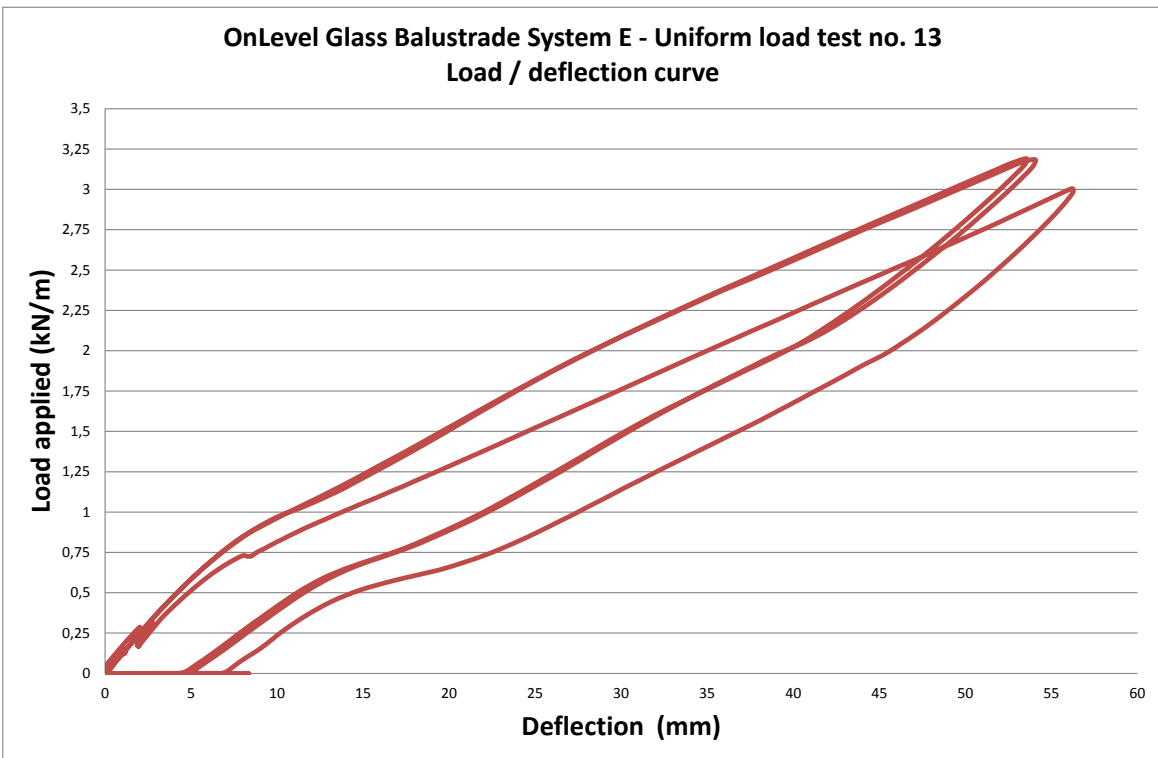
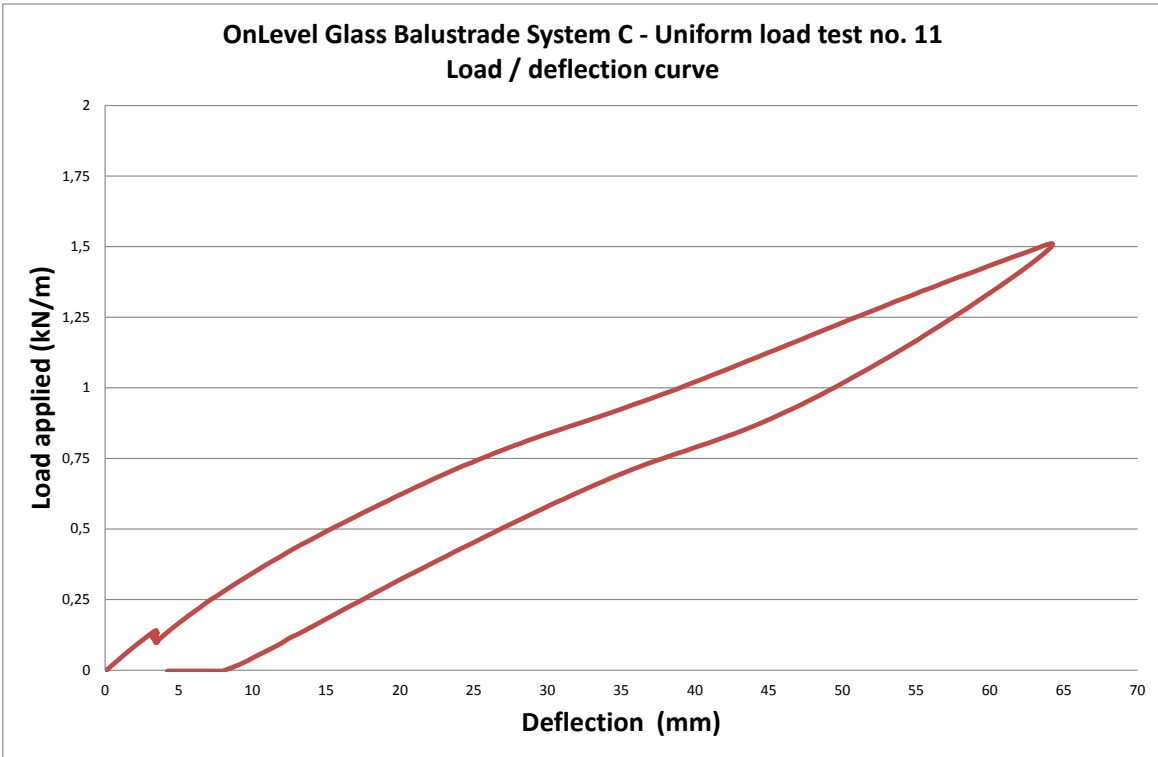
Appendix A: Load / deflection curves





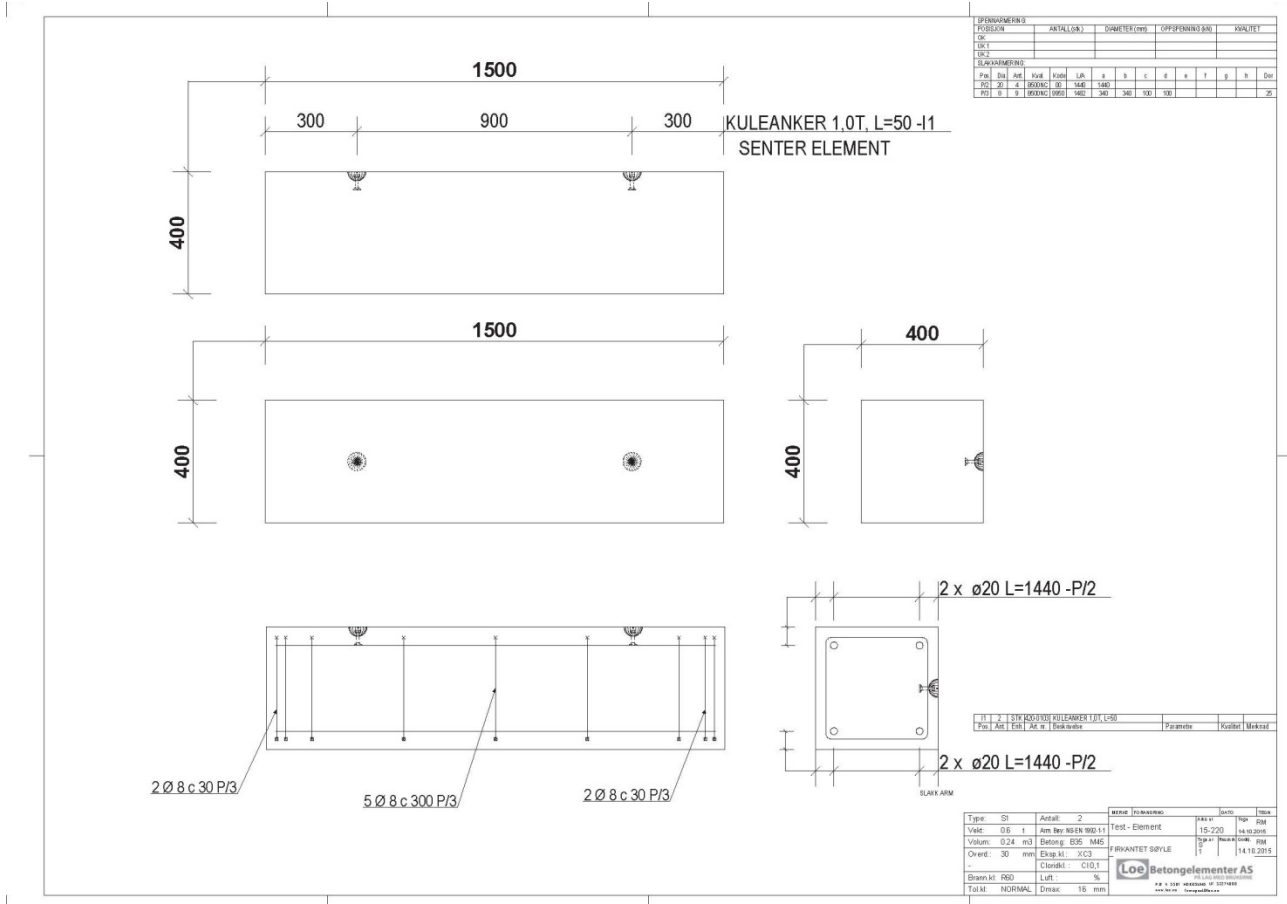




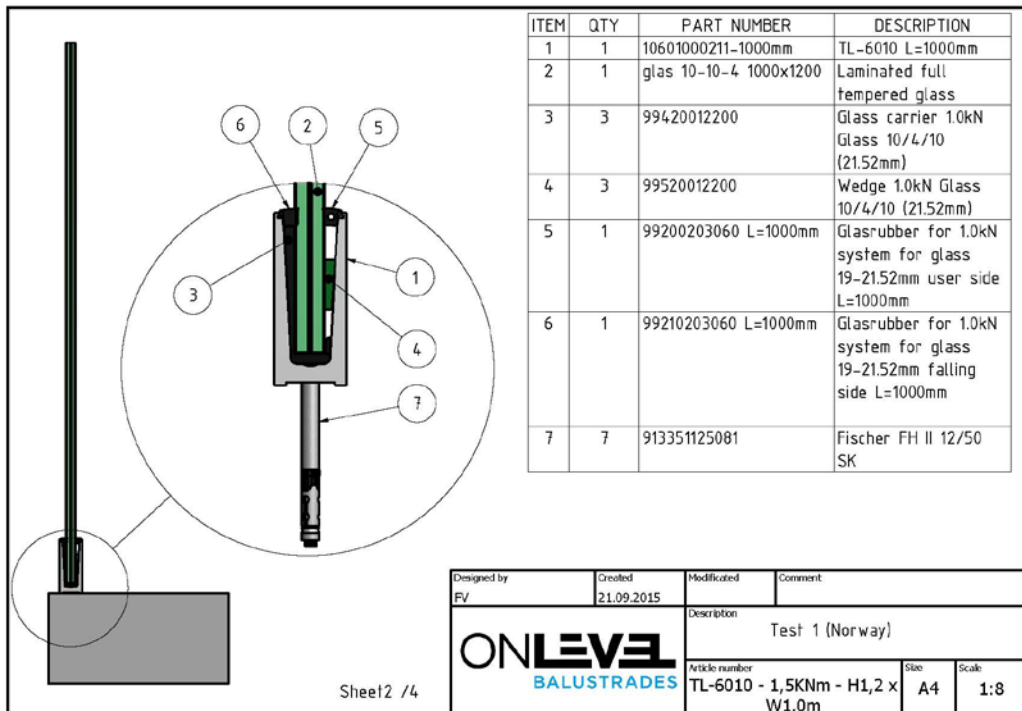
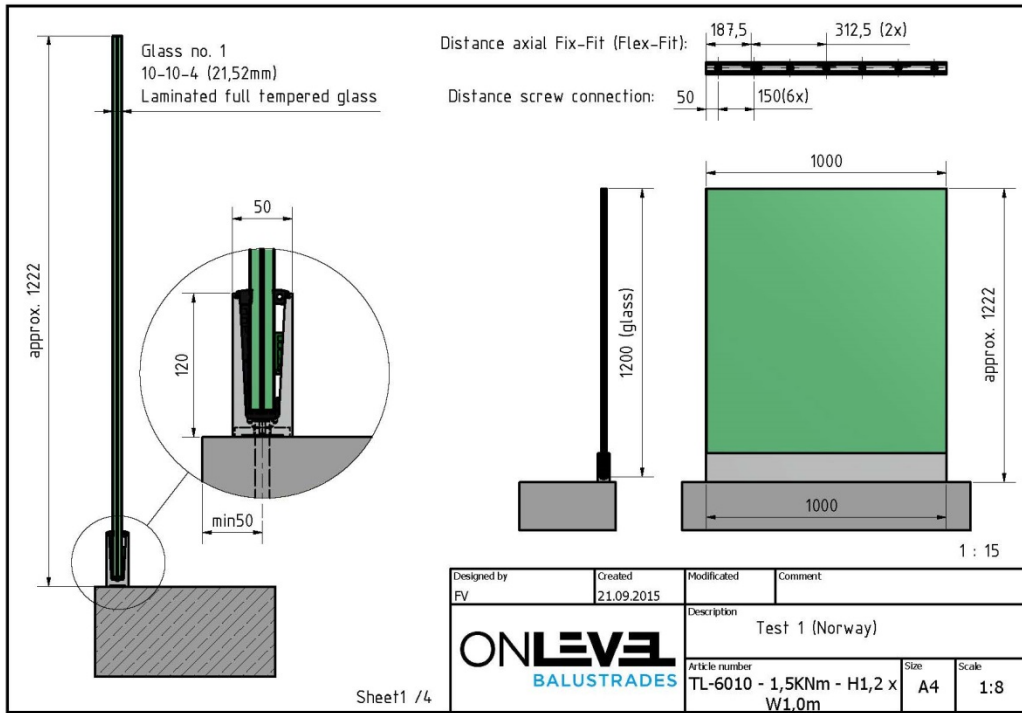


Appendix B: Test specimens and mounting jig description

Drawing 1 The concrete element and the mounting jig specifications



Drawing 2 Test specimen A description



Appendix C: Photos

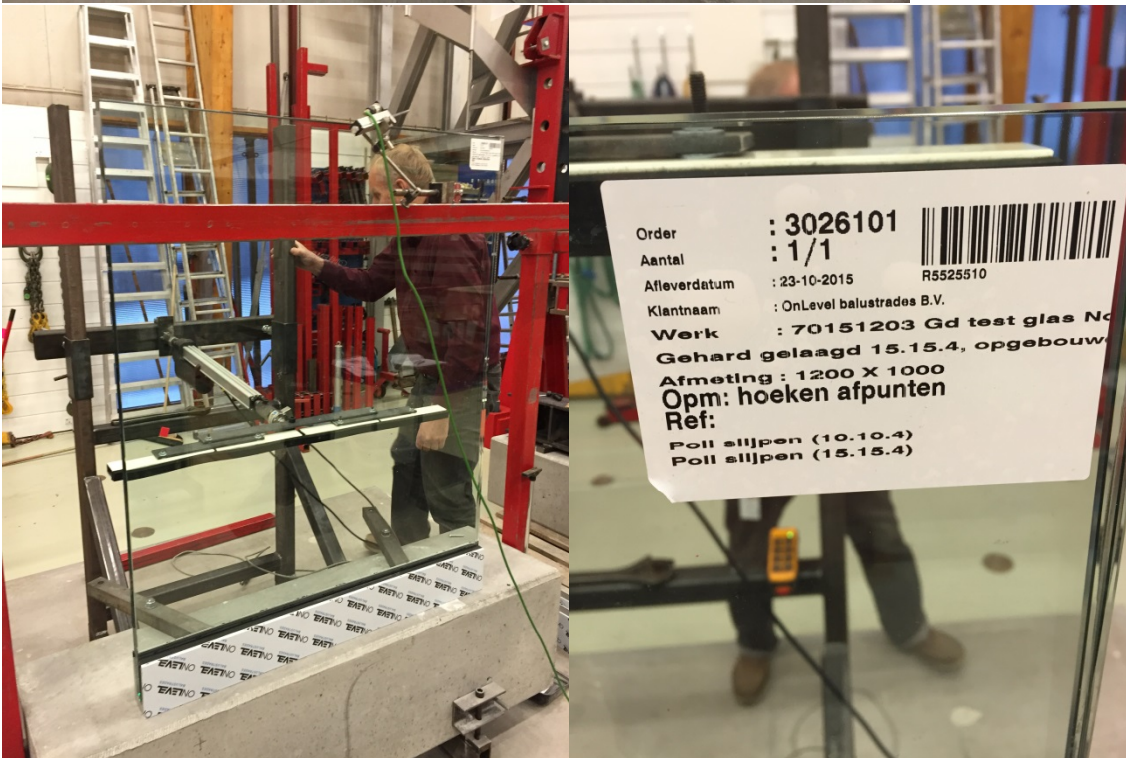


Photo 1 Onlevel mounting and testing system A as described in table 1 and appendix B

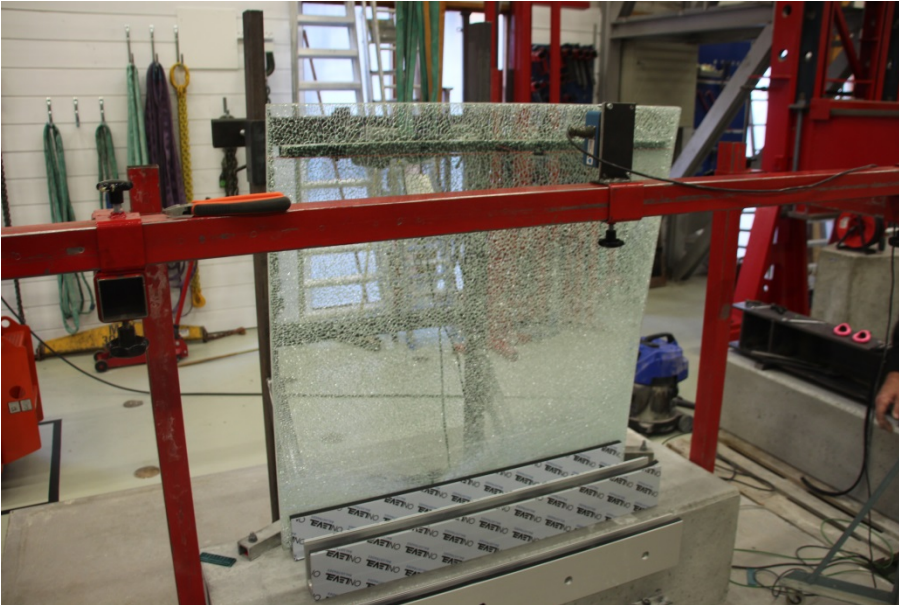


Photo 2 System B (as described in Table 1) – Breakage – applied load 4.8 kN/m



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