Labor für Stahl- und Leichtmetallbau

[Laboratory for Steel and Light Metal Construction]
HM München [Munich Technical College]

Faculty 02 Structural Engineering / Steel Construction

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Test Report No.: 2007-3094

Subject: - Static load tests

- Pendulum impact tests based on *TRAV*

Constructional element: fully glazed balustrades with HILTI® HIT-HY 70 bedding

Client: HILTI Entwicklungsgesellschaft mbH

Hiltistraße 6

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This test report comprises 7 pages and 7 annexes.

Issued on: 21 Nov. 2007

Project No.: 07-044

1. General

The HILTI company distributes the injectable adhesive mortar HILTI® HIT-HY 70 which has already proven reliable for a multitude of applications in the field of structural glass construction.

To be able to apply the injectable adhesive mortar also as a support option for fully glazed balustrades based on the Technical Regulations for the use of linearly supported glazing (German abbr. *TRAV*), pendulum impact tests for accident proofing and static load tests for testing the durability of the support were carried out.

The HILTI company commissioned the *Labor für Stahl- und Leichtmetallbau* [Laboratory for Steel and Light Metal Construction] of the *Fachhochschule München* [Munich Technical College] to carry out the appropriate tests and record the results in a test report.

2. Description of the tests

Accident proofing

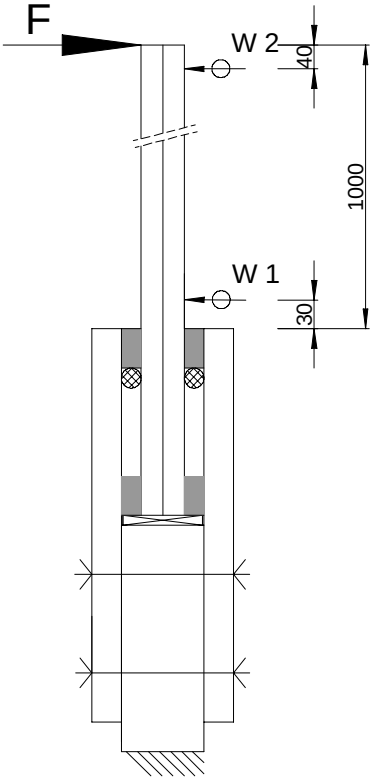
For accident proofing, pendulum impact tests based on *TRAV* (January 2003) are carried out.

The glazing is hit at various impact points by double tyres (weight = 50 kg, tyre pressure 4.0 bar) which are dropped from a height of Δh = 700 (category B). This impact may damage the test panes (cracks up to 76 mm); but the impactor must not go through the pane or tear it from its anchoring. Furthermore, broken glass must not fall down, as it may cause danger in the circulation area. Monolithic exterior panes must not break as a result of the impact tests. If a pane is damaged, it must withstand another impact by the impactor falling from a drop height of Δh = 100 mm with the stated criteria. Furthermore, tests were carried out with drop heights of up to 900 mm as well as with partially damaged laminated glass panes.

The pendulum impact tests were carried out without the planned handrail. This led to a considerably higher deformation of the panes and thus to a higher load on the glazing than in the planned installation situation.

Steady load tests

To test the durability of the glass support with an HILTI® HIT-HY 70 bedding, steady load tests were executed on two railing balustrades. To this end, one point load corresponding to the load on the capping was applied via a pneumatic piston to the top edge of the glass in the centre of the pane. The deformation of the pane happened at the top and base points of the pane. The number of stress cycles *(Lastwechsel-Zahl)* was determined as 10,000 *LW*. The static load tests were carried out without the planned handrail. This led to a considerably higher deformation of the panes and thus to a higher load on the HILTI® HIT-HY 70 bedding than in the planned installation situation. The following sketch shows the test setup and the position of the deformation transducers.



Sketch 1: Test setup: static load test

The test was executed using the facilities of the Laboratory for Steel and Light Metal Construction of Munich Technical College.

3. Description of glass structure, pane dimensions and support

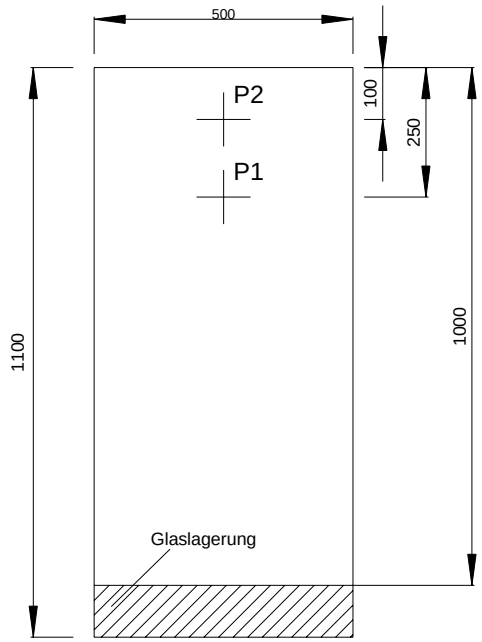
Pendulum impact tests were carried out on three test pieces in all.

Glass structure and dimensions:

Tempered safety glass (TSG)	10.00 mm
Polyvinylbutyral interlayer (PVB interlayer)	1.52 mm
Tempered safety glass (TSG)	10.00 mm
Total glass thickness approx.	**21.5** mm

A pane format with the dimension w x h = 500 x 1100 mm was tested.

The impact points can be seen in the following sketch:



Sketch 2: Impact points and dimensions

Pane support:

The pane support can be seen in the drawing of annex 1. The panes were tested without the handrail installed.

The dimensions of the panes were checked by an employee of the *Labor für Stahl- und Leichtmetallbau* of Munich Technical College prior to the test. It was established that the plan specifications were complied with.

4. Test results

4.1 Pendulum impact tests

In the following section, the exact execution of the test of the individual test panes is described and its results are summarised.

Test piece 1:

Table 1: Results of impact actions on test piece 1

Drop point	Impact	Height of drop [mm]	Comment
P1	Impact 1	700	no break
P1	Impact 2	900	no break
Impact on the back sheet of laminated safety glass			
P1	Impact 3	700	no changes
P1	Impact 4	900	no changes

Impact actions 1 and 2 did not lead to any break of the pane. The test piece also withstood the other impact actions without any further breaks in spite of one sheet of the laminated safety glass being damaged. The pane remained fixed in its support. No broken glass fell down from the glazing. The HILTI® HIT-HY 70 bedding was not damaged.

Test piece 2:

Table 2: Results of impact actions on test piece 2

Drop point	Impact	Height of drop [mm]	Comment
P2	Impact 1	700	front laminated safety glass sheet broke
P2	Impact 2	100	no changes

The first impact on the laminated safety glass by the pendulum destroyed the respective sheet. The test piece withstood the other impact actions from a height of drop of Δh = 100 mm without any further breaks. The pane remained fixed in its support. No broken glass fell down from the glazing. The HILTI® HIT-HY 70 bedding was not damaged.

Test piece 3:

Table 3: Results of impact actions on test piece 3

Drop point	Impact	Height of drop [mm]	Comment
P1	Impact 1	700	no break
P1	Impact 2	900	no break
P2	Impact 3	900	front laminated safety glass sheet broke
P1	Impact 4	100	no changes

Impact actions 1 and 2 did not lead to any break of the pane. The impact on P2 by the pendulum destroyed the respective sheet of the laminated safety glass pane. The test piece withstood the other impact actions from a height of drop of Δh = 100 mm without any further breaks. The pane remained fixed in its support. No broken glass fell down from the glazing. The HILTI® HIT-HY 70 bedding was not damaged.

4.1 Steady load tests

Steady load tests were carried out on a total of two test pieces. Both panes were subject to a load on the capping of 1.0 kN/m. After completion of the tests, the deformations that occurred were evaluated and compared in the following table.

Table 4: Results Steady load test

Test piece	W1		W2	
	10 LW	10.000 LW	10 LW	10.000 LW
1	0,75	0,77	15,63	17,34
2	0,65	0,71	12,38	14,46

The results show that in the clamping area of the glass only a slight deformation increase occurred (max. 0.6 mm). Due to the lever arm, the deformation acted more intensely at the top edge of the panes (max. 2.08 mm).
The graphic evaluation of the tests can be found in the annexes 2 to 4.

5. Summary

The HILTI company plans to build fully glazed balustrades supported in a HILTI® HIT-HY 70 bedding. For accident proofing, pendulum impact tests were carried out based on the Technical Regulations for the use of linearly supported glazing (German abbr. *TRAV*) and static load tests were carried out to check the durability of the glass clamping.
The results of the tests are reproduced in section 4 of this report. The essential results are summarised in the following sections.

Pendulum impact tests (accident proofing)

Pendulum impact tests were carried out on three test pieces in all up to a drop height of Δh = 900 mm.

The test pieces tested fulfilled the requirements with respect to accident proofing for category B based on *TRAV*.

Static load test (durability)

The dynamic load on the glazing with a load on the capping of q = 1.0 kN/m during 10,000 stress cycles only caused a slight deformation increase which was detected in the clamping area of the glazing.

From the test authority's point of view, this support consequently has the required load-bearing capacity for the target service life.

The manufacturer's information must be observed when processing the HILTI HIT-HY 70 bedding.

Please find the photographic documentation of the tests in annexes 6 and 7.

For the management — Responsible officer

Prof. Ö. Bucak, D. Eng. — A. Lorenz, B. Eng. (Tech. Coll.)

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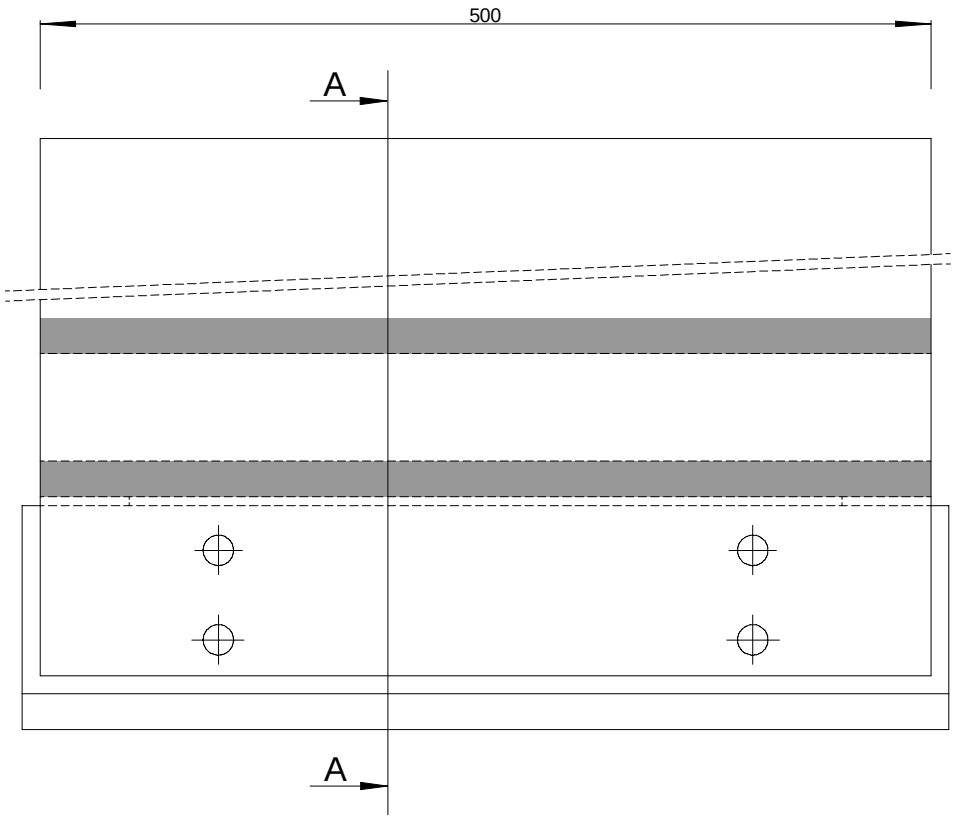
LABOR FÜR STAHL- U. LEICHTMETALLBAU
Fachhochschule München (02)

Prof. Ö. Bucak, D. Eng.

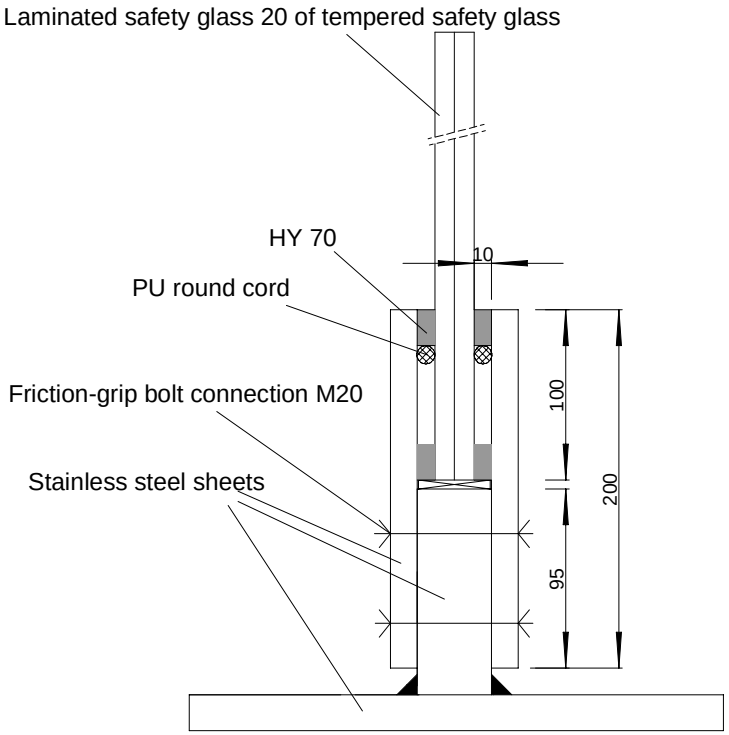
Responsible officer

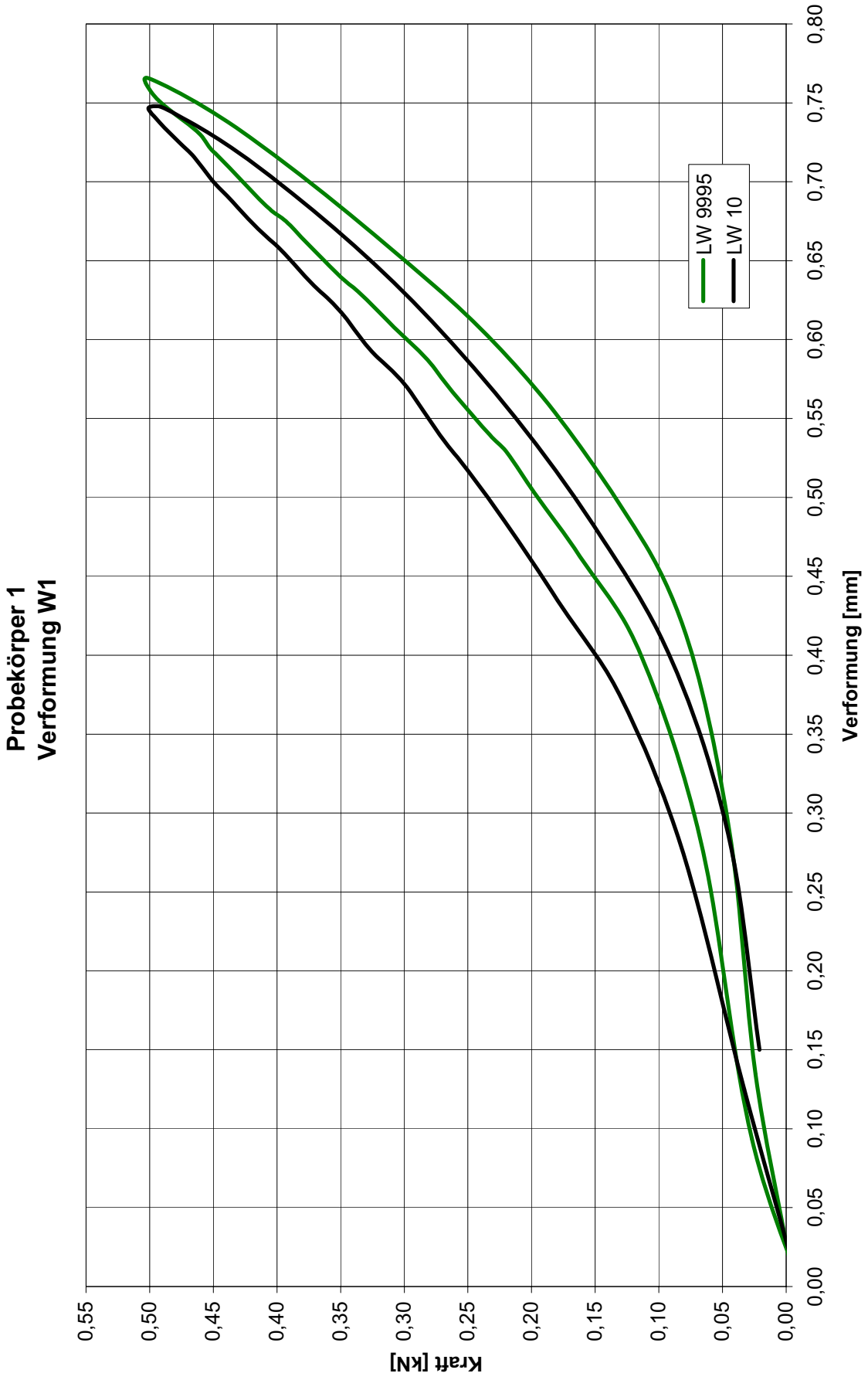
A. Lorenz, B. Eng. (Tech. Coll.)

Annex 1


500
A
A

A-A


Laminated safety glass 20 of tempered safety glass
HY 70
10
PU round cord
Friction-grip bolt connection M20
Stainless steel sheets
100
200
95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0,20
0,15
0,10
0,05
0,00
Verformung [mm]
0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
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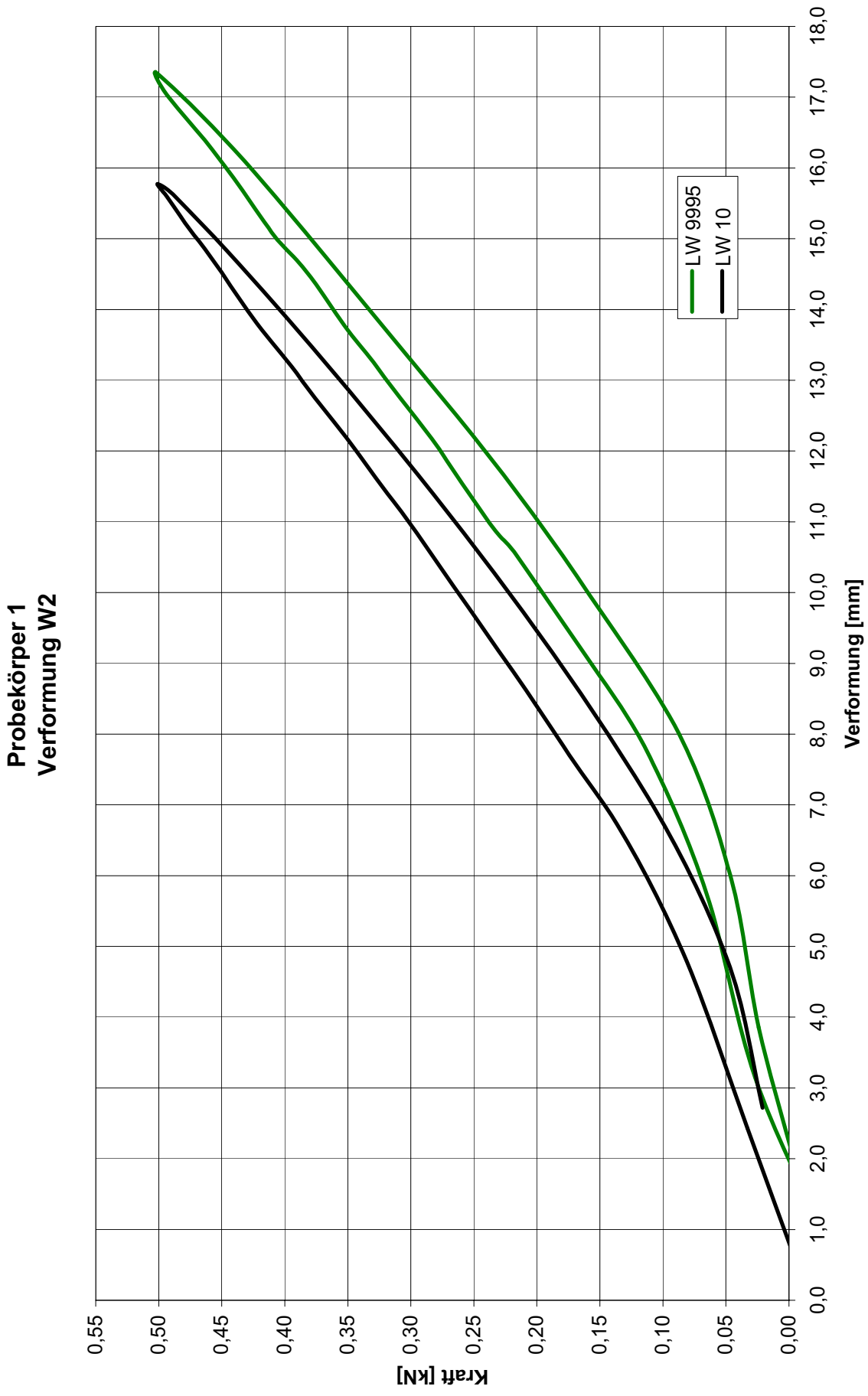
0,60
0,65
0,70
0,75
0,80
LW 9995
LW 10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0,15
0,10
0,05
0,00
Verformung [mm]
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3,0
4,0
5,0
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7,0
8,0
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12,0
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14,0
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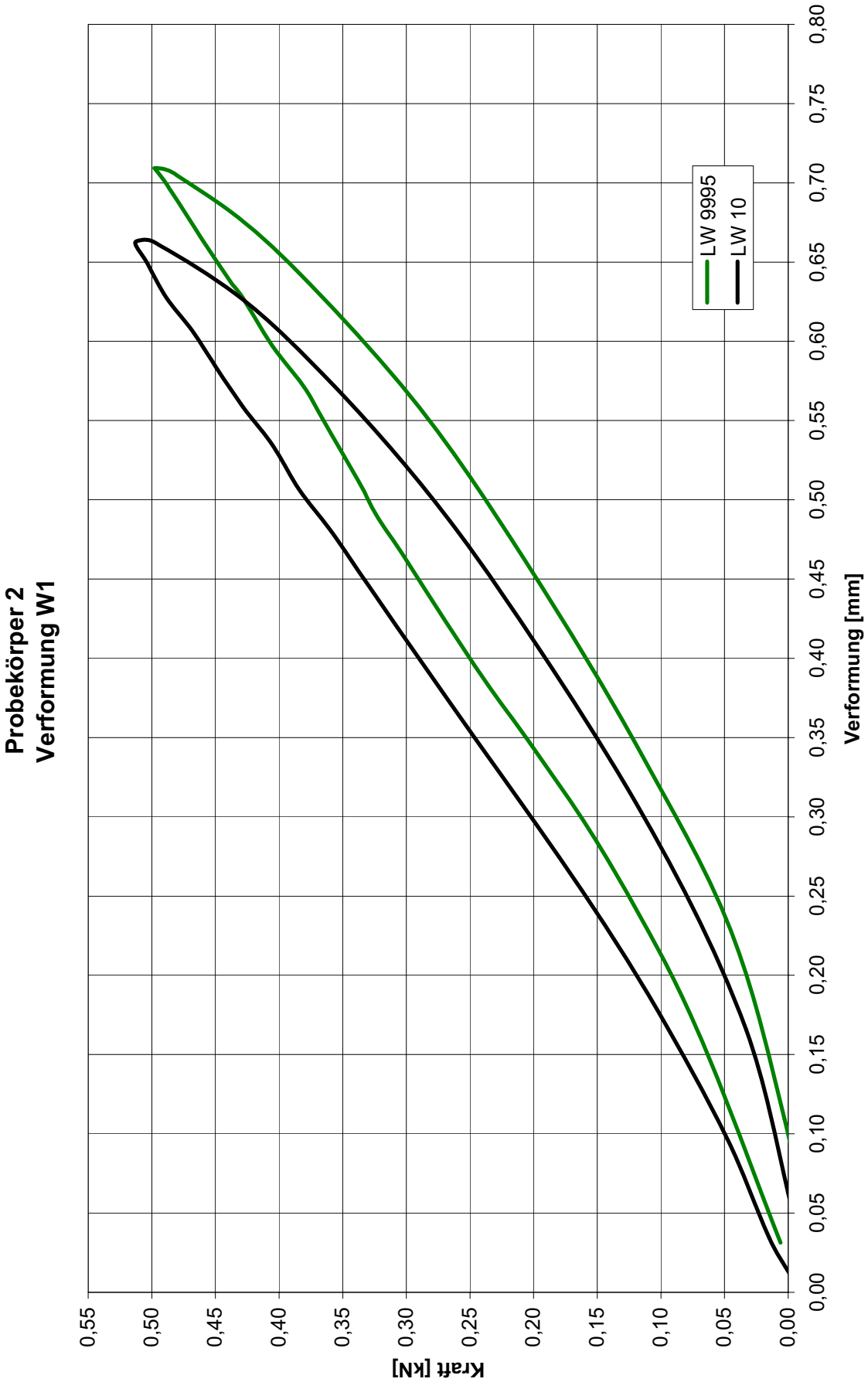
16,0
17,0
18,0
LW 9995
LW 10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0,00
Verformung [mm]
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0,50
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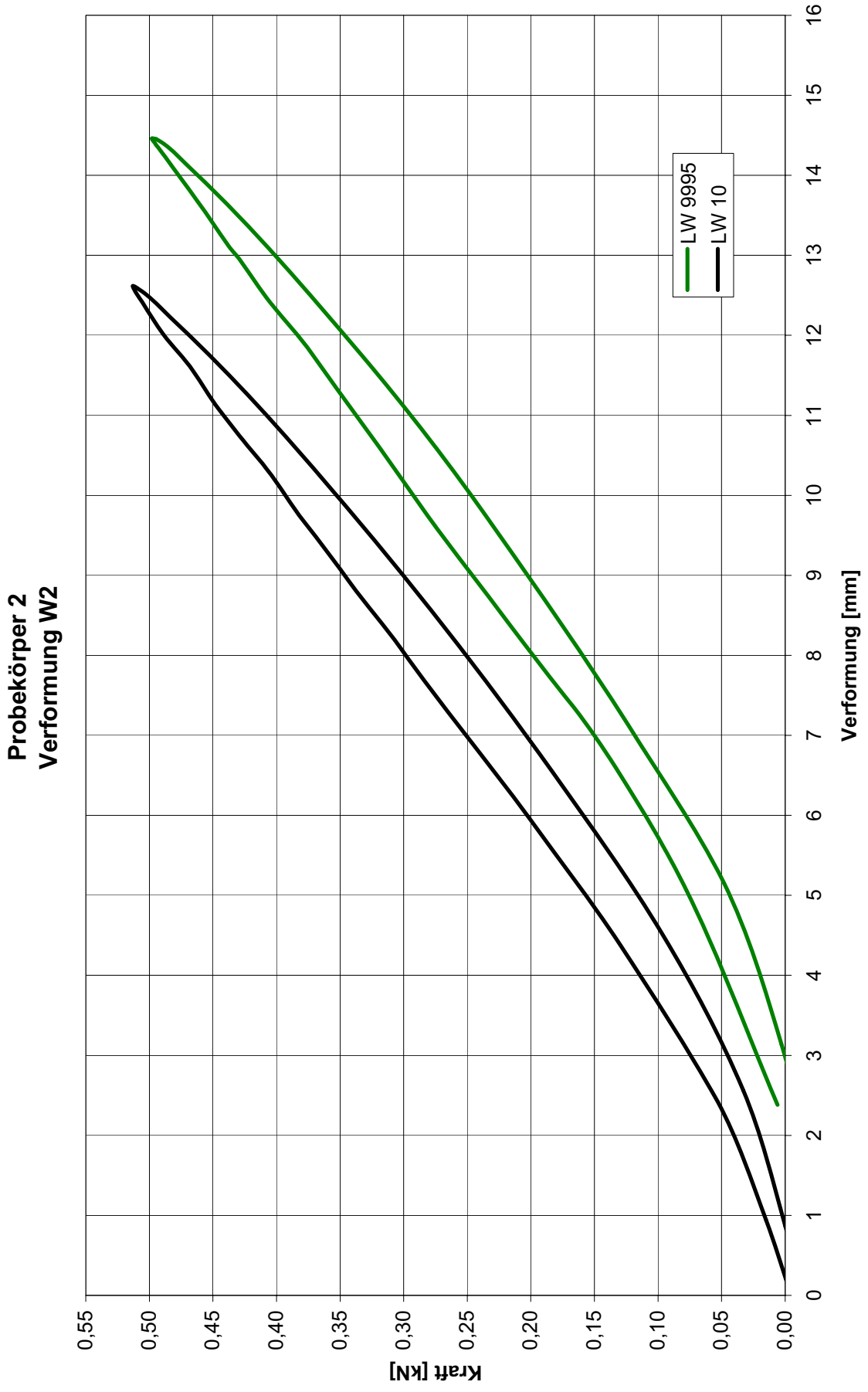
0,75
0,80
LW 9995
LW 10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0,35
0,30
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0,20
0,15
0,10
0,05
0,00
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Verformung [mm]
LW 9995
LW 10

Test piece 1
Impact on P1 from a height of drop of Δh = 900 m
→ no damage

Test piece 1 after executing all impact actions

Test piece 3
Impact on P1 to test the residual load-bearing capacity; height of drop Δh = 100 m
→ no further damage

Test setup for the static load test of the glass support