Institut für Baustoffe, Massivbau und Brandschutz
Materialprüfanstalt für das Bauwesen
TU BRAUNSCHWEIG

Test Report

This document is the translated version of Test Report No. 1101/505/18 – dated 06/06/2018. The legally binding text is the aforementioned German Test Report.

Document number:	(1101/505/18) – Bod of 06/06/2018
Client:	medifa hygienic rooms GmbH Heinrich-Hertz-Straße 4 76470 Ötigheim, Germany
Order date:	26/01/2018
Order ref.:	-
Order received:	26/01/2018
Subject of the order:	Testing a wall of 3.50 m x 3.60 m, type MediFa, Bending strength and fall protection pursuant to DIN 4103-1 and with reference to ETAG 003
Test basis:	DIN 4103-1:2015, DIN 18183-1:2018 ETAG 003:2013
Samples received:	Calendar week 20, 2018
Sampling:	By the client
Test material marking:	By MPA Braunschweig
Test date:	Calendar week 20, 2018

Materialprüfanstalt f. d. Bauwesen MPA BS 1 Braunschweig

This test report consists of 17 pages, including the cover sheet, 8 Annexes A, 11 Annexes B, 7 Annex C and 1 Annex D.

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Notified body (0761-CPR) – Approved as a civil engineering testing, inspection and certifying body as well as notified as a civil engineering testing and certifying body.

iBMB MPA TU BRAUNSCHWEIG

Subject

1 Procedure

medifa hygienic rooms GmbH, with headquarters in Ötigheim, Germany commissioned the MPA Braunschweig 26/01/2018 with the test of a lightweight inner shaft wall made of metal profiles (60 x 30 x 2) and a one-sided panelling laminated with a stainless steel sheet panel (t = 19 mm), construction method medifa. To do this, tests were conducted on a wall structure measuring h_{Wall} = 3.00 m high ($h_{Raw\ ceiling}$ = 3.50 m) under consideration of design loads pursuant to DIN 4103-1:2015 and ETAG 003.

The various partial tests were carried out on 15/05/2018 at the MPA Braunschweig. Other relevancies, for example, noise and fire protection properties, are not considered in the calculations of this assessment report.

2 Literature

[1] DIN 4103 Part 1, Internal non-loadbearing partitions, June 2015.

[2] ETAG 003, Guideline for European Technical Approval for internal partition wall kits for use as non-loadbearing walls, Berlin, August 2013.

[3] Struck, Limberger: Die Energieübertragung auf leichte, nichttragende Bauteile, Mitteilungen Ibt 9, 1978. (available in German only)

[4] Research Report 204, Struck, Limberger: Der Glaskugelsack als Prüfkörper für Beanspruchungen durch weichen Stoß – eine erweiterte Modellvorstellung, Berlin, 1994 (available in German only).

3 Test specimen for wall tests

3.1 General

During calendar week 20 in 2018, a flexible wall construction, wall h_{Wall} = 3.20 m ($h_{Raw\ ceiling}$ = 3.50 m) high and w_{Wall} = 3.60 m wide, was installed by the client (Ms. Buhlinger and Mr. Stockmar) in the wall test rig of the MPA Braunschweig .

3.2 Material

The material for the production of the test specimen, consisting of steel sections (60x30x2) and stainless steel sheet laminated gypsum board panels (GKB) $d_{GKB\ panel}$ = 18 mm and screws, were provided by the client.

3.2.1 Panelling material

Designation: laminated gypsum board building panel (GKB) ($d_{Panel,\ GKB}$ = 18 mm), cf. Annex A.4,

Material: Gypsum board building panel (GKB) laminated with t = 0.8 mm thick stainless steel sheet,

Dimensions: 19 mm x 1.20 m x 1.60 m (0.90 m and 0.20 m).

3.2.2 Support sections

Dimensions: 60 mm x 30 mm x 2 mm, cf. Annex A.3,

Material: Steel,

Nominal thickness: t = 2.0 mm, smooth.

3.2.3 Fasteners for panelling material on metal profile

Designation: Self-tapping screw 4.2 mm x 13 mm and 4.8 mm x 19 mm, cf. Annex A.2, Mounting bracket and steel bracket t = 3.0 mm, cf. Annex A.6.

3.2.4 Fasteners for substructure

Designation: Wood screw 8 x 70 mm, cf. Annex A.2.

4 Wall tests

4.1 General

The test specimen was built by the client in calendar week 20 of 2018 in the wall test rig at the MPA Braunschweig.

The wall structure is an inner partition wall with a height of h_{Wall} = 3.20 m ($h_{Raw\ ceiling}$ = 3.50 m) and a width of w_{Wall} = 3.60 m with a stud construction made of four metal sections (60 mm x 30 mm x 2 mm) and with a single-layer panelling on each side, made of laminated gypsum board panels (GKB) $d_{Panel,\ GKB}$, = 18.0 mm, $d_{medifa,\ Panel,\ GKB}$= 19.0 mm (construction method: medifa).

The steel sections (H101-0001-01, 60x30x2) were screwed into metal U-shaped bottom rails (H101-0022 02) t = 2.0 mm thick at a centre distance of e_b = 1.20 m. The U-shaped bottom rails were fastened to the bottom wooden plank (#16/16) of the wall test bench at a distance of e = 50 cm, using hexagon head screws (H422-0730, 8 x 40). The steel sections were screwed on each side using to the U-shaped bottom rail using a self-tapping screw (H422-0240, 3.5 x 13), cf. Annexes A.2 to A.5.

The laminated gypsum board panels (GKB) were mounted onto the steel sections at a distance of approx. 45 cm (H422-02403, 3.5 x 13), using bolted mounting brackets (H102-0007-02), cf. Annex

A.6. At the upper edge, the panels were held in place using a steel ceiling rail (H101-0008 01, t = 3 mm), cf. Annex A.5.

At the top edge, the wall was not fastened directly to the upper wooden plank (# 16/16). The upper transverse U-shaped rail (H101-0001-01, 60x30x2) was mounted using three suspending brackets at an angle of 45° (H101-0001-01, 60x30x2). These three angled suspending brackets were bolted tension and compression-resistant to the upper wooden plank (H422-0730, 8 x 40) and the cross bar of the wall (H422-0220, 4 x 4.8 x 19) at a distance of e = 1.0 m, cf. Annex A.5. Image 1 shows this type of design.

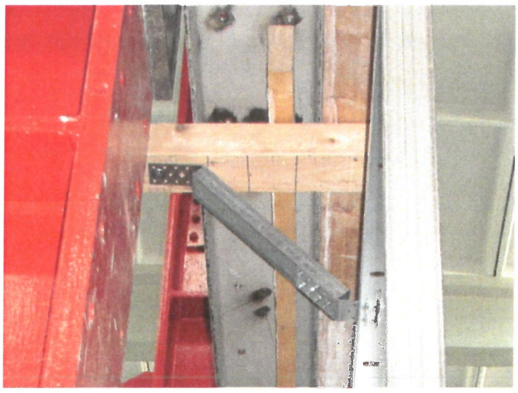

Image 1: Tension and compression-resistant assembly of the wall at the upper edge, using two angles and a steel section attached to the cross strut of the test stand

The vertical steel sections had a length of L = 3.20 m. At this height, angles were used to bolt the cross bar to the vertical sections (hexagon drill screws, H422-0220, 4.8x19), cf. Annex A.4. The panelling had a maximum height of h_{Wall} = 3.00 m. In addition, a horizontal steel ceiling rail (H101-0008 01, t = 3 mm) was mounted at the upper edge in order to finish the panelling. A drill screw (H422-0220, 4.8x19) was used to connect the rail with the vertical sections, cf. Annex A.4. Image 2 illustrates the setup.

Image 2: Front view of the partition wall, the panel height of the wall is h = 3.00 m

The upper edge of the wall structure was not covered with a plank. This is representative for the use of these walls when installing suspended ceiling structures. The same applies to the oblique suspending brackets which were mounted at a distance of e = 1.0 m (H422-0730, 8 x 40, angle 135°, H101-001801), cf. Annexes A.5, A.7 and A.8.

The panelling was installed on one side, using a single layer. The vertical distance of the fasteners was e = 45 cm for the large panels, cf. Annex A.6. The panelling was screwed to the steel sections using mounting brackets (H102-0007 02) and self-tapping screws. The vertical and horizontal joints were sealed using an elastic joint tape.

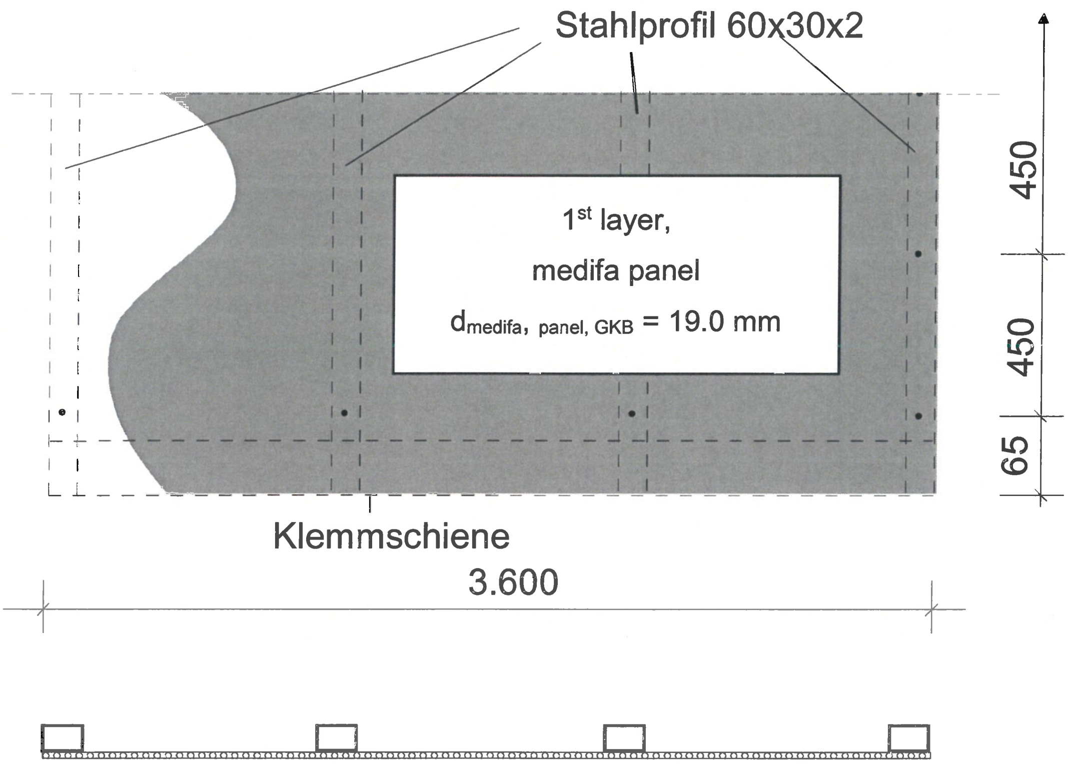

Image 3: Principle drawing and section of the wall structure's setup

4.2 Static test with strut load

On 15/05/2018 a bending load test was carried out. The deformations of the test specimen were recorded by three cable pull receivers (Inv. No. 6751 a, Inv. No. 6751 b and Inv. WS01) on the side facing away from the load, cf. Annex B.3. The displacement transducers were positioned in the middle of the wall at $h_{Displ\ transd}$ = 1.75 m height. A load cell (C 20292, type C2) was used to measure the applied load.

The load was applied to the wall at $h_{Strut\ load}$ = 0.90 m, cf. Annex B.4. The maximum load was limited to $F_{Test} \approx 5.4$ kN. After reaching the maximum load of $F_{Test} \approx 5.4$ kN, the load was not increased any further. The load was introduced for a short period of time, after which the load applied to the test specimen was removed again. The test load of $F_{Test} \approx 5.4$ kN corresponds to the load pursuant to DIN 4103-1.

4.2.1 Testobservations

A bending test with a linear load was conducted on the wall specimen (test name Roosy) pursuant to DIN 4103-1. The observations on the wall test were recorded during the experiment and photographed.

Table 1: Pressing forces, deformation and observations

Test	Pressure [kN]	Displacement [mm]	Observations
Roosy	1.8	6.1	Load, installation area 1, no damage.
	3.6	12.0	Load, installation area 2, no damage.
	5.57	19.2	Load, load according to standard, no damage.

4.3 Pendulum impact tests

Following the static pressure test, pendulum impact tests were also carried out on the same test specimen to demonstrate the soft impact on the panelling, cf. Annex B.5.

4.3.1 General

Pursuant to DIN 4103-1, sufficient resistance of the wall reacting to an impact load caused by a human body (soft impact) striking the wall must be demonstrated. Compliance with the following requirements is mandatory [1]:

a) the partition wall must not be torn apart from its attachments,
b) wall fragments that can cause serious physical injury must not fall to the ground,
c) the entire thickness of the partition wall must not be penetrated.

4.3.2 Wall tests using a soft impact

Following the partial test with the strut load, pendulum impact tests were subsequently carried out on the same partition wall in order to demonstrate the soft impact. The impact was carried out at a wall height of h = 1.50 m (with reference to ETAG 003).

During the first pendulum impact test, the drop height of the impactor (impactor's mass = 50 kg) used to test the partition wall – a single-ply was used on each side – was $h_{pendulum,1} = 0.24$ m. The impacting pendulum energy in this experiment was $E_{Test,1} = 500 \times 0.24 = 120$ Nm.

Image 4: Test setup of the partition wall for the pendulum impact test, h = 1.50 m

Image 4 shows the test setup After the experiment, the wall structure was subject to a close visual inspection for damage. The test was repeated twice according to ETAG 003 using a pendulum energy of E_{Test} = 120 Nm.
The pendulum height of the impactor (impact mass = 50 kg) at the next pendulum impact test was $h_{Pendulum,\ 2}$ = 40 cm. The acting pendulum energy in this experiment was $E_{Text,\ 2}$ = 500 x 0.40 = 200 Nm.
After the experiment, the wall structure was examined closely for damage. Subsequently, another pendulum impact test $h_{Pendulum,\ 3}$ = 1.15 m was carried out. The acting pendulum energy in this experiment was $E_{Text,\ 3}$ = 575 Nm. The implementation of the pendulum impact tests with details of the impact points as well as the close visual examination after the test are summarized in Table 2 below.

Table 2: Points of impact, drop heights and results for the pendulum impact tests

Wall	Point of impact	Drop height [mm]	Result
Roosy	1, h = 1.50 m, mullion no. 2	3 x 240	No damage to the panelling and the metal sub-structure
	1, h = 1.50 m, mullion no. 2	1 x 400	No damage to the panelling and the metal sub-structure
	2, h = 1.50 m, centre of panelling in area 1	3 x 240	No damage to the panelling and the metal sub-structure
	2, h = 1.50 m, centre of panelling in area 1	1 x 400	In the upper panelling in area 1 on the left-hand side, 2 out of 5 mounting brackets are loosened.

After each pendulum impact test, the wall was subject to a close visual inspection on the front and back. Any damage is listed in the 'Result' column.

The pendulum impact heights in Table 2 are taken from ETAG 003 for use class II.

The upper panelling in the first area was replaced. Further pendulum impact tests were carried out pursuant to DIN 4103-1. The detailed calculation of the pendulum impact energies pursuant to DIN 4103-1 is shown in Annexes C.6 and C.7. The implementation of the pendulum impact tests with details of the impact points as well as the close visual examination after the test are summarized in Table 3 below.

Table 3: Points of impact, drop heights and results for the pendulum impact tests

Wall	Point of impact	Drop height [mm]	Result
Roosy	3, h = 1.60 m, mullion no. 2	1 x 1,150	No damage to the panelling and the metal sub-structure Permanent deformation in the metal mullion Δw = 3 mm.
	4, h = 1.15 m, centre of panelling in area 1, installation panel	1 x 700	Breakage of the gypsum board panel (GKB) in the installation panel. Gypsum plasterboard pieces did not fall to the ground since the gypsum plasterboard is glued to the stainless steel panelling. Permanent deformation in the panelling Δw = 15 mm, cf. Annex B.10.

After each pendulum impact test, the wall was subject to a close visual inspection on the front and back. Any damage is listed in the 'Result' column.

5 Evaluation of the wall tests with strut load

5.1 General

When applying a horizontal strut load of $F_{Test} \sim 5.57$ kN (load range for installation area 1 and 2 of DIN 4103-1:1984 [1]), the load was not increased any further.

$$F_{Test} \sim 5.40 \text{ kN} = F_{Test}/\,b = 5.57/3.60 = 1.55 \text{ kN/m, with } b_{Wall} = 3.60 \text{ m.}$$

At this load height, the load was briefly stopped and then the pressure onto the wall was relieved again.

Installation area 1 (DIN 4103-1) p_1 = 0.50 kN/m.

Installation area 1: Areas with small gatherings of people, e.g. apartments, hotel, office and hospital rooms; partition walls without fall-arresting function.

Installation area 2 (DIN 4103-1) p_2 = 1.00 kN/m.

Installation area 2: Areas with large gatherings of people, e.g. larger meeting rooms, classrooms, lecture halls, exhibition and sales rooms, partition walls with fall-arresting function.

5.2 Evaluation method of the wall tests with strut load

The load-deformation curve, cf. Diagram 1, was evaluated here for test 001 in the linear-elastic range. Diagram 1 and Annex C.2 show the load-deformation diagram for the wall during the bending test.

Diagram 1 shows schematically the procedure for the evaluation method (cf. Diagram 1 and Table 2, a secant between points P1 and P2). In the elastic region of the load-deflection curve between the points P1 and P2 (cf. Diagram 1, blue line) the secant stiffness was calculated. The evaluation was in tabulated (cf. Table 2).

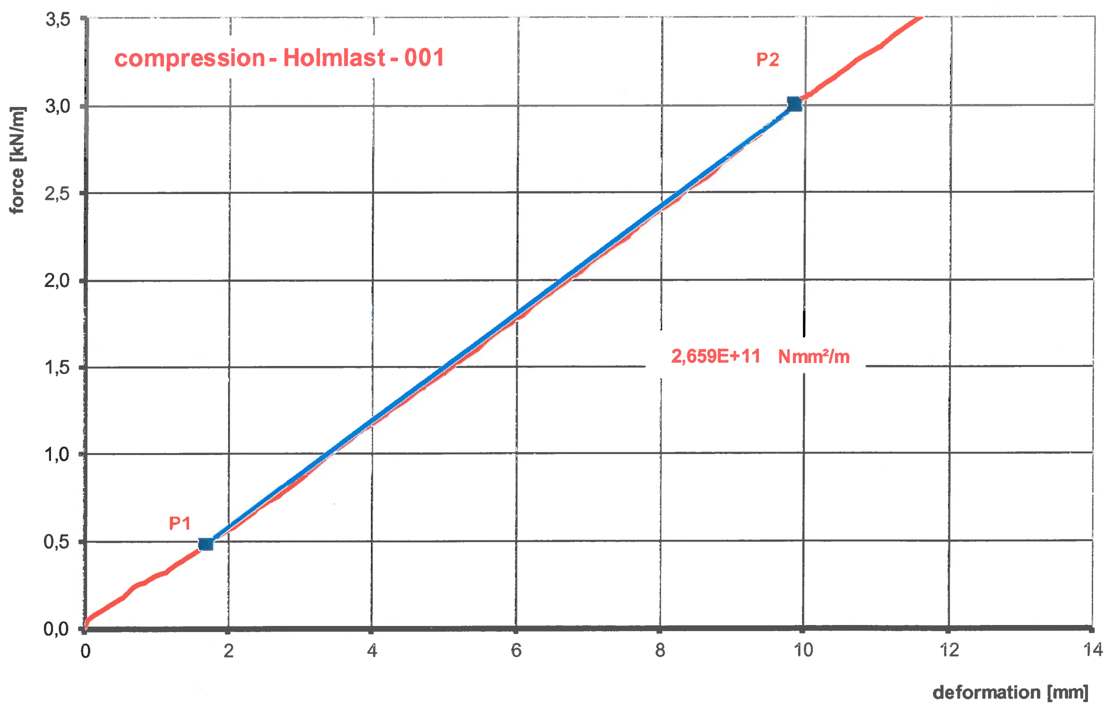

Diagram 1: Graphical representation of the evaluation for the wall Roosy 001

During the test, cf. Diagram 2, the horizontal load was increased to reach the load F_{Test} ~ 5.57 kN. This load was introduced for a short period of time, after which the load applied to the wall was removed again.

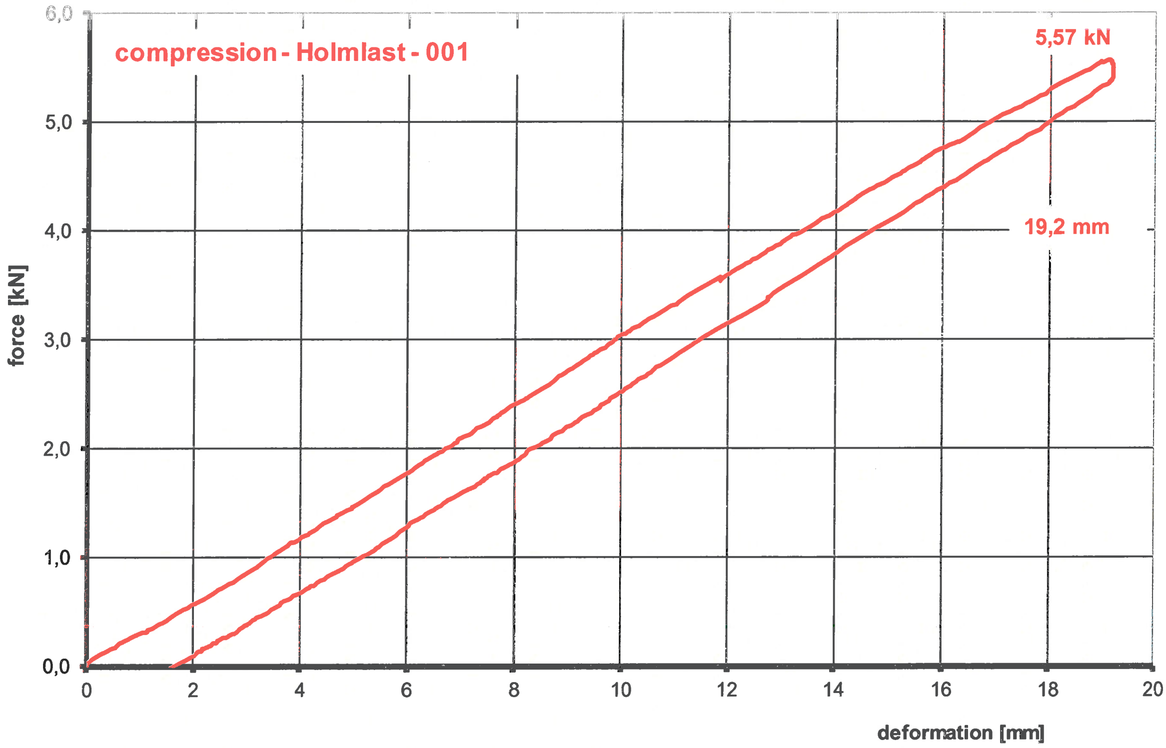

Diagram 2: Graphical representation of the evaluation for the wall Roosy 001

The strut load F_{max} achieved in the experiment was F_{max} = 5.57 kN. The associated deformation was w_{max} = 19.2 mm, cf. Annexes C.2 and C.3.

The evaluation is provided in a table, cf. Table 4, where the maximum test load reached is indicated by the letter F.

Table 4: Bending stiffnesses for the wall Roosy 001, stud distance 1,200 mm

Biegesteifigkeit des Probekörpertyps Roosy													
Lichte Höhe 3.500 mm, Probekörperbreite 3.600 mm (Einfachständerwand, Profile (60/30/2), einseitige einlagige Beplankung d = 19 mm, Pfostenabstand 1.200 mm)													
	$F_{Versuch}$	max. $F_{Versuch}$	max. F_U / γ	max. $\delta_{Versuch}$		ΔF_{elast}	$\Delta\delta_{elast.}$		Breite B	Stützweite H	eb (Pfosten-abstand)		$EI_{y\ elast.\ Versuch}$
	[kN]	[kN]	[kN]	[mm]		[kN]	[mm]		[m]	[m]	[m]		[Nmm²]
Roosy	5,57	5,57	3,71	19,2		2,51	8,17		3,60	3,5	1,20		**2,659E+11**

The system dimensions, the width W and the height H (span l) of the construction are given, as well as the distance between the metal stud frames e_b to each other.

In the evaluation, $\Delta F_{elast.\ test}$ refers to the test load between the points P1 and P2. They correspond to the load for the installation areas 1 and 2 of DIN 4103-1 in the elastic range of the load-deformation curve (cf. Diagram 1). The associated deformation between the points P1 and P2 (cf. Diagram 1) is referred to as $\Delta\delta_{elast.\ test}$, see also to Annex C.2 and C.3.

5.3 Calculated bending stiffness resulting from the partial tests

The bending stiffness $EI_{y\ elast.\ test}$ in the elastic range of the load-deformation curve (cf. Table 4) is calculated in the evaluation of the test results (equation 1) as secant rigidity (blue straight line in Diagram 1) from the points P1 (the load level is 0.50 kN) and P2 (the load level is 3.0 kN).

$$EI_{y,elast.Versuch} = ef.EI = \frac{1}{48} \cdot \Delta F \cdot h^3 / \Delta\partial \qquad \text{(Equation 1)}$$

With:

h Wall height,

ΔF $\Delta F_{elast.\ test}$ Load difference between points P1 and P2,

Δδ $\Delta\delta_{elast.\ test}$ to load difference $\Delta F_{elast.\ test}$ corresponding deformation difference.

Table 5 lists the measured load and calculated rigidity for the wall for the test.

Table 5: Pressing force, calculated effective rigidity for the flexible wall construction with single-layer panelling

Test	Load [kN]	ef. EI from test [Nmm²]	Special feature
001	5.57	2.659 E^{+11}	Test in the elastic region of the load-deformation curve. Test up to the load pursuant to DIN 4103-1.

6 Verification pursuant to DIN 4103

6.1 Verifications in the limit state of serviceability

6.1.1 General

The verifications are carried out pursuant to DIN 18183-1, Table 1, taking into account the static loads and considering three deformation limits. The safety level of the respective construction is determined at the discretion of the client and based on the deformation classes resulting from the deformation limits (with h = wall height):

Deformation class 1:	max. permissible deflection h / 200,
Deformation class 2:	max. permissible deflection h / 350,
Deformation class 3:	max. permissible deflection h / 500,

The evaluation of the deformations at different wall heights and load levels is done by comparing the corresponding effective rigidity ef. EI with the permissible deflections δ_{perm}.

6.1.2 Evaluation based on the deformations

The flexural rigidity of the tested structure was determined according to Equation 1. For the wall structure to be verified, the effective flexural rigidity ef. EI was calculated taking into account the permissible deflection δ_{perm} as a result of load from line load pursuant to DIN 18183 according to Equation 2.

$$ef.\,EI_{y,elast.} = ef.\,EI = \frac{1}{48}\frac{F \cdot h^3}{\delta_{zul}}$$ (Equation 2)

With:

δ_{perm} $\leq$ h / 200,

or $\leq$ h / 350,

or $\leq$ h / 500 pursuant to DIN 18183.

By using Equation 3, the associated deformation δ_{appl} was calculated for the strut load from the installation area 1 and 2:

$$\delta_{vorh} = \frac{1}{48}\frac{F \cdot h^3}{ef.\,EI_{y,elast.}}$$ (Equation 3)

Table 6: Calculated deformations using the calculated effective flexural rigidity from the wall tests

Biegesteifigkeit des Probekörpertyps Roosy													
Lichte Höhe 3 500 mm, Probekörperbreite 3 600 mm (Einfachständerwand, Profile (60/30/2), einseitige einlagige Beplankung d = 19 mm, Pfostenabstand 1 200 mm)													
	F_U	$\delta_{U\,[Mittelwert]}$	B (Probekörperbreite)	l (Stüzweite)	eb (Pfostenabstand)	$M_{y,elast\ Versuch}$	$M_{yelast\ rechn.}$	Ausnutzung	$EI_{y\ elast.\ Versuch}$	$\delta_{Rechnung}$	δ l/ 200	δ l/ 350	δ l/ 500
	[kN]	[mm]	[m]	[m]	[m]	[kNm]	[kNm]	[%]	[Nmm²/m]	[mm]	[mm]	[mm]	[mm]
Roosy 001	5,57	19,2	3,60	3,50	1,20	--	0,669	--	2,659E+11	13,2	17,5	10,0	7,0

6.1.3 Evaluation of the soft impact

The verification of the safety against soft impact is provided here on the basis of the results of the pendulum impact tests. The impact is carried out at the most unfavourable point acting between the sections.

The verification of the soft impact was performed according to Equation 4 for the 3.50 m high flexible wall construction.

$$E_R \geq \nu \cdot \alpha' / \alpha'' \cdot E_{Basis} \qquad \text{(Equation 4)}$$

With:

ν = 1.25,

E_{Basis} = 100 Nm,

mt Total mass of the partition wall in kg. In order to keep it simple, only the panelling is considered,

λ mass factor, $\lambda = 0.5$ in accordance with Table 2 DIN 4103,

m resonant mass, $m = \lambda \cdot m_t$,

α' impact transfer factor, accordance with Table 1, DIN 4103-1,

α'' from [8] according to Image 4

For the 3.50 m high one-layer partition wall construction, a required impact energy $E_{Impact} = E_{Test} \approx 545$ Nm was calculated, cf. Annex C.6. During the test, impact energies of up to an $E_{Impact} = E_{Test} = 575$ Nm were recorded for the wall structure.

The detailed calculation of the impact energy E_{Impact} of the flexible wall construction is shown in Annexes C.6 and C.7.

6.1.4 Evaluation of the soft impact with reference to ETAG 003

The verification of the safety against soft impact is based here on the results of the pendulum impact tests with reference to the ETAG 003. The impact energies of the respective use class for functional failure due to soft-body impact and structural damage testing are also used by soft-body impact, ETAG 003, Table 6 and 11. The impact is carried out at the most unfavourable point acting between the sections and also on the section at a height of h = 1.50 m. The category for the building surface according to Table 1 is A. The use category according to Table 2 is II. According to Table 6, a pendulum height of 3 x Δh = 24 cm and according to Table 11 of 1 x Δh = 40 cm is tested,

Proof is deemed to have been provided if:

- a functional failure of the wall does not occur,
- the maximum permanent deflection after 3 impacts is less than or equal to 5 mm,
- the increase in deflection stabilizes during the test,
- the pendulum body does not penetrate the wall or the wall collapses and
- no other dangerous failure occurs in and on the wall.

With reference to ETAG 003, pendulum impact tests were carried out for the use class A.II. The requirements for the verification of soft body impact on lightweight partition walls pursuant to ETAG 003 were met.

6.2 Verifications in the limit state of loadbearing capacity (Verification of breaking load pursuant to DIN 4103-1)

Pursuant to DIN 4103-1, the breaking load must be γ = 1.50 times greater than the working load. Pursuant to DIN 4103-1:1984, the following stresses in installation area 1 and 2 are required to verify the bending resistance:

$F_{\text{Installation Area 2:}}$	$F_{IA\,2}$ = 1.00 kN,
Safety factor (DIN 4103-1)	γ_F = 1.5 [-],
Width	w_{Wall} = 3.60 m,

$$F_u = \gamma_F \cdot F_{EB\,2} \cdot w_{Wall} = 1.5 \cdot 1.00 \cdot 3.60 = 5.40 \text{ kN}.$$

F (Test Roosy 001)	F_{Test} = 5.57 kN > 5.40 kN.

7 Summary

medifa hygienic rooms GmbH with headquarters in Ötigheim, Germany commissioned the MPA Braunschweig with the test of a lightweight inner shaft wall made of metal profiles (60 x 30 x 2) and a one-sided panelling with stainless steel sheet laminated panels (t = 19 mm), construction method medifa.

To do this, tests were carried out on a wall structure measuring h_{Wall} = 3.20 m ($h_{Raw\ ceiling}$ = 3.50 m) under consideration of the design loads pursuant to DIN 4103-1:1984 and ETAG 003.

The tests were carried out by employees of MPA Braunschweig in the test hall of the MPA Braunschweig during calendar week 20, 2018.

During the test, the 1.5-fold strut load for installation area 2 could be sustained pursuant to DIN 4103-1.

$$F_{(Test\ Roosy\ 001)} = 5.57\ kN > 5.40\ kN.$$

The capacity of the bending limit load for installation areas 1 and 2 was verified under experimental conditions for the h_{Wall} = 3.50 m high shaft wall with steel sections pursuant to DIN 4103-1:2015, Section 5.2.3.

The requirements for the verification of the soft impact on lightweight partition walls pursuant to DIN 4103-1:2015 were fulfilled. The structural integrity against soft impact loads for the h_{Wall} = 3.50 m high wall structure can therefore be considered to be fulfilled.

In addition, with reference to ETAG 003, pendulum impact tests were carried out for use class A.II.

The requirements for the verification of soft body impact on lightweight partition walls pursuant to ETAG 003 were also fulfilled. The structural integrity against soft impact loads for the h_{Wall} = 3.50 m high wall structure can therefore be considered to be fulfilled.

The proof of the bending limit load capacity for the installation areas 1 and 2 and the requirements for the proof of the soft impact on light partition walls could be fulfilled by the shaft wall construction in the experiment. A partition wall construction of the construction method medifa with a double-sided panelling was not tested. Experience has shown that a partition wall structure has a somewhat stiffer material or deformation behaviour and, in our opinion, also fulfils the requirements for verification of the soft impact and bending limit load capacity for installation area 1 and 2.

The sound and fire properties of the partition walls must be verified separately.

Braunschweig, 06/06/2018

Head of Testing Laboratory

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1
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Construction

shaft wall

Construction method

medifa

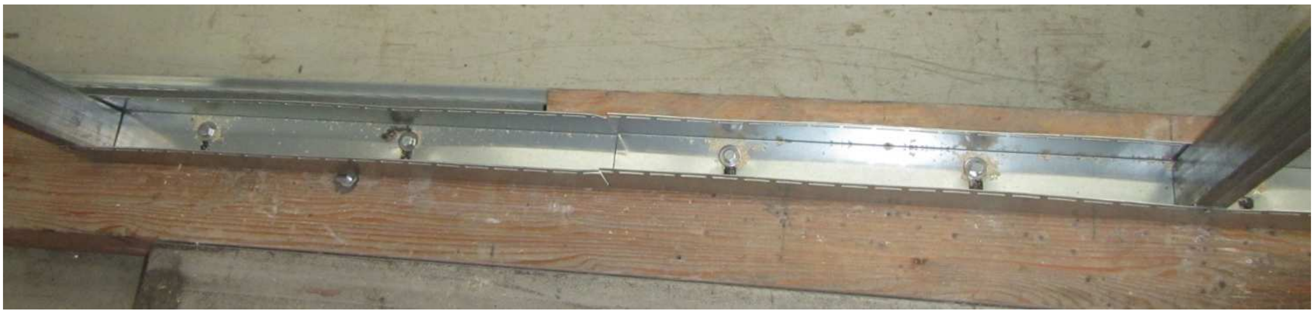

Image A.2.1: Assembly of the U-shaped bottom rail, H101-0022-02 onto the floorboard (#16/16) by the client at test stand of the MPA Braunschweig

Image A.2.2: Assembly of the U-shaped bottom rail onto the floorboard (#16/16) by the client at test stand of the MPA Braunschweig Spacing of the screws e ≈ 50 cm. Threaded connection with hexagon head screw 8 x 40, H422-0730

Image A.2.3: Side of threaded connection for support and U-shaped bottom rail with countersunk drill screw 4.2 x 13, H422-0240

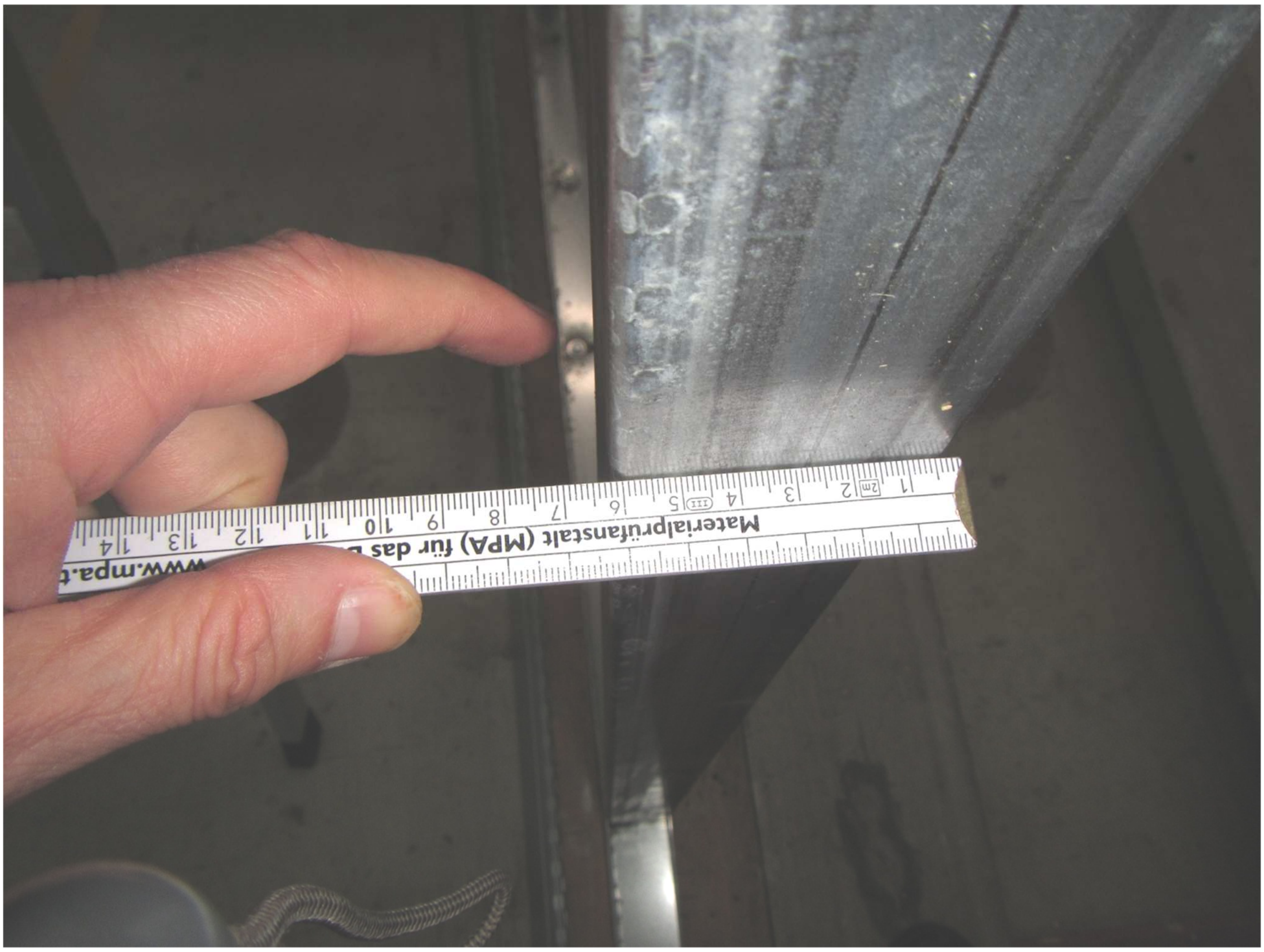

Image A.3.1: Support section 60 x 30 x 2, H101-0001-01

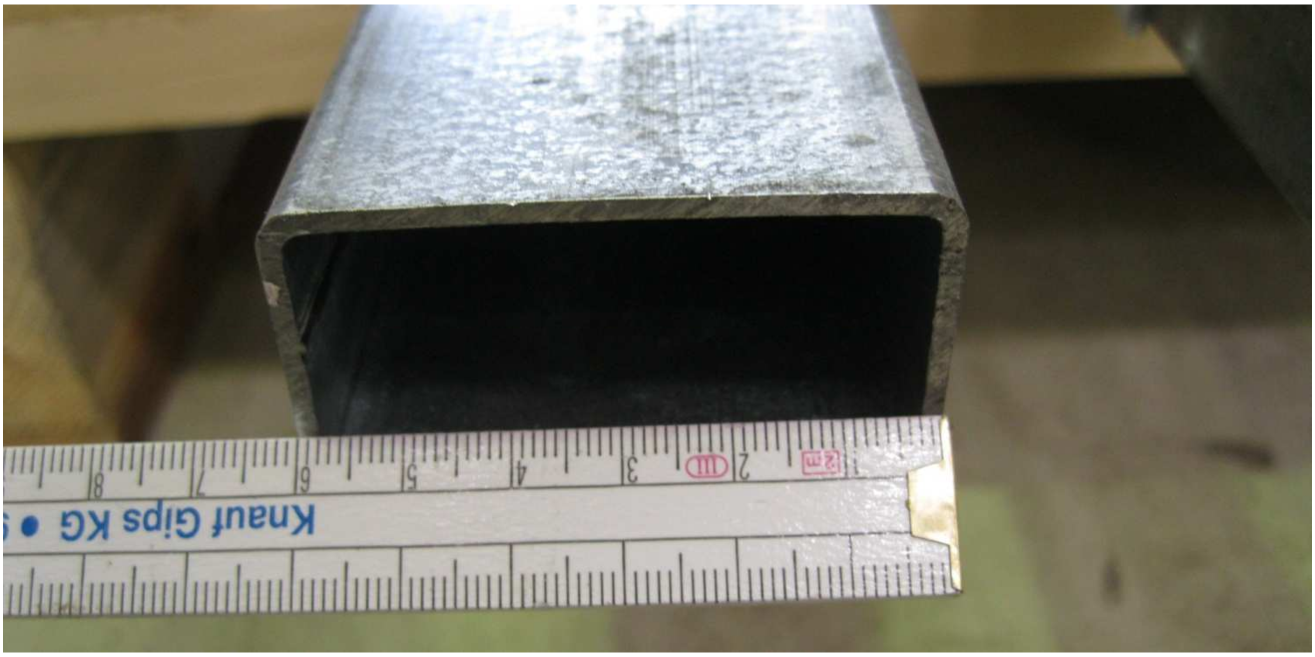

Image A.3.2: Cross section of wall support section 60 x 30 x 2, H101-0001-01

Image A.4.1: Setup of the support section 60 x 30 x 2 in the grid e = 1.20 m

Image A.4.2: The same U-rail is mounted at the top. The support sections are screwed to the U-rail with hexagon drill screws 4.8 x 19, H422-0220

Image A.5.1: The upper bracing, angle section 135°, t_{Angle} = 2.0 mm, H101-0018-01 and strut (60 x 30 x 2) were bolted using self-tapping screws for each side 6 x 4.8 x 19, H422-0220

Image A.5.2: The gypsum board panels are guided in a ceiling rail, H101-0008 01. The ceiling rail is fastened to the section with hexagonal drill screw, H422-0220

Image A.6.1: The mounting brackets, H102-0007-02, are used to attach the panelling with the support sections, using a drill screw 3.5 x 13, H422-0240

Image A.6.2: The mounting brackets are spaced at about e = 45 cm

Image A.7: The front of the wall is already assembled. Wall element above, 1,193 mm x 1,755 mm, installation element 1,193 mm x 200 mm and wall element below 1,193 mm x 950 mm

Image A.8: The edge the wall’s back remains uncovered. A rail is bolted to the top of the panelling. Here, a suspended ceiling can be attached. At half of the wall’s height, a wooden beam is installed. The displacement transducers are mounted during the test to this wooden beam.

Bending and pendulum impact tests on the shaft wall construction method medifa

Image B.2.1: Test Roosy 001, strut load at 90 cm height, bending test in the elastic support area of the steel sections

Image B.2.2: Strut load at a 90 cm height over a l = 4.0 m long double T-section. Before the test, the double T-section must be secured in the crane due to its own weight

Image B.3.1: Displacement transducer No. 1 to No. 3 on the wall's rear

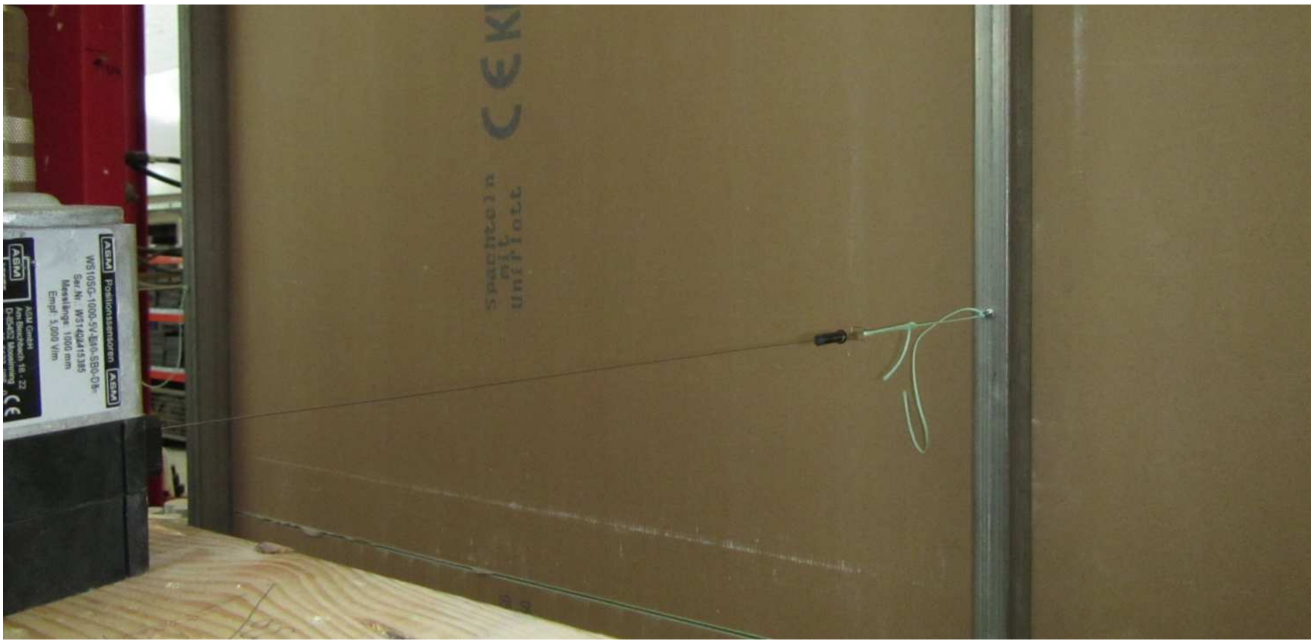

Image B.3.2: Photograph of the horizontal deformations using cable transducers. The green "measuring cable" was bolted directly onto the sections

Image B.4: End, bending test Roosy 001, the load is about 5.0 kN. The horizontal deformation is about w = 30 mm

Image B.5.1: Partial test, pendulum impact test, pendulum impact test directly on mullion no. 2, on the left side of the wall. Impact height, according to ETAG 003, h = 1.50 m. Pendulum drop height 3 x h = 24 cm, impact energy 3 x E = 120 Nm

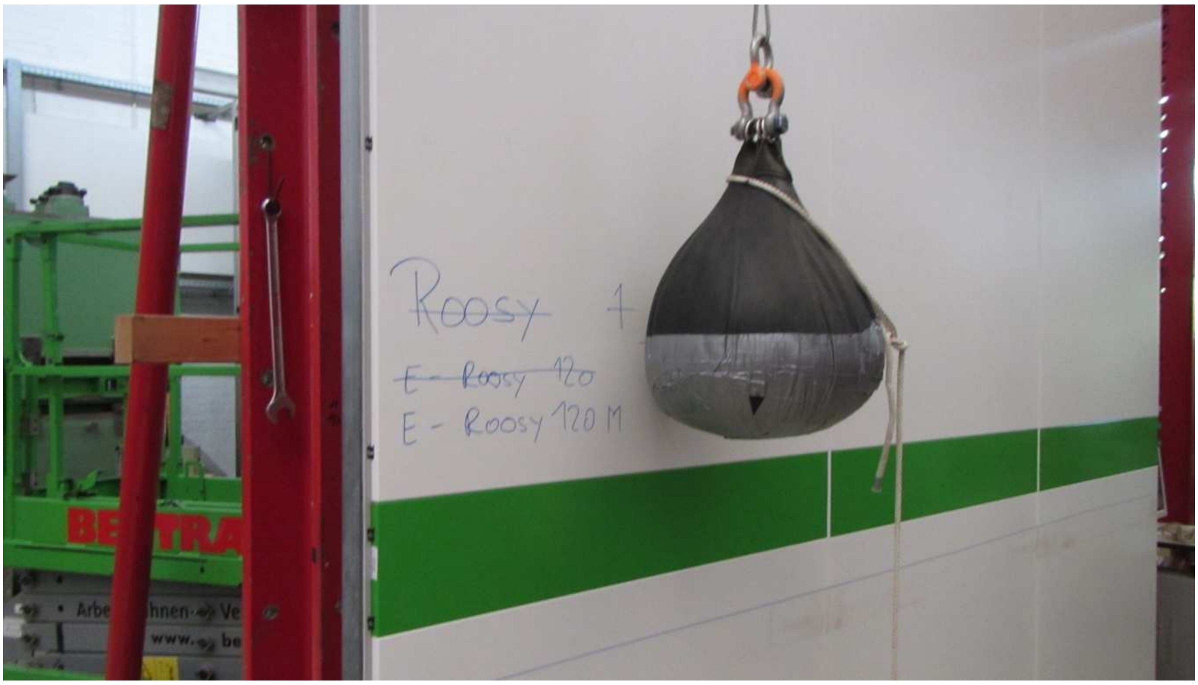

Image B.5.2: Partial test, pendulum impact test, pendulum impact test directly onto the panelling between mullion no. 1 and no. 2, on the left-hand side of the wall. Impact height, according to ETAG 003, h = 1.50 m. Pendulum drop height 3 x h = 24 cm, impact energy 3 x E = 120 Nm and pendulum drop height 1 x h = 40 cm, impact energy 1 x E = 200 Nm

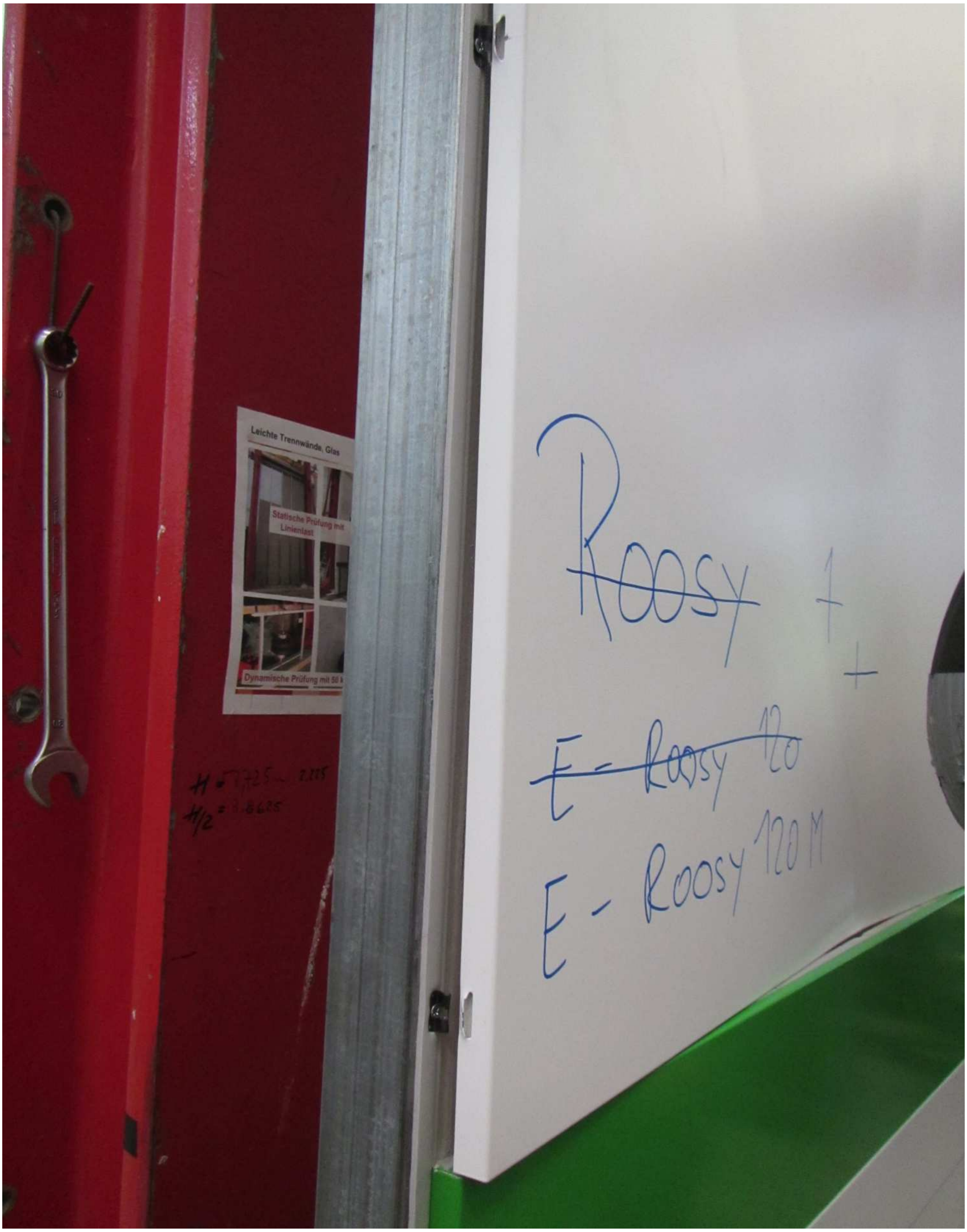

Image B.6: Partial test, pendulum impact test, pendulum impact test directly onto the panelling between mullion no. 1 and no. 2, on the left-hand side of the wall. Impact height, according to ETAG 003, h = 1.50 m. Pendulum drop height 1 x h = 40 cm, impact energy 1 x E = 200 Nm Two mounting brackets on the left edge of the panelling have come off

Image B.7: Partial test, pendulum impact test, pendulum impact test directly onto the panelling between mullion no. 1 and no. 2, on the left-hand side of the wall. Impact height, according to ETAG 003, h = 1.50 m. Pendulum drop height 1 x h = 40 cm, impact energy 1 x E = 200 Nm. The gypsum board panelling is broken in the middle

Image B.8: Partial test, pendulum impact test, pendulum impact test directly on mullion no. 2, on the left-hand side of the wall. Impact height, according to DIN 4103-1, h = 1.60 m. Pendulum drop height 1 x h = 1.15 cm, impact energy1 x E = 575 Nm

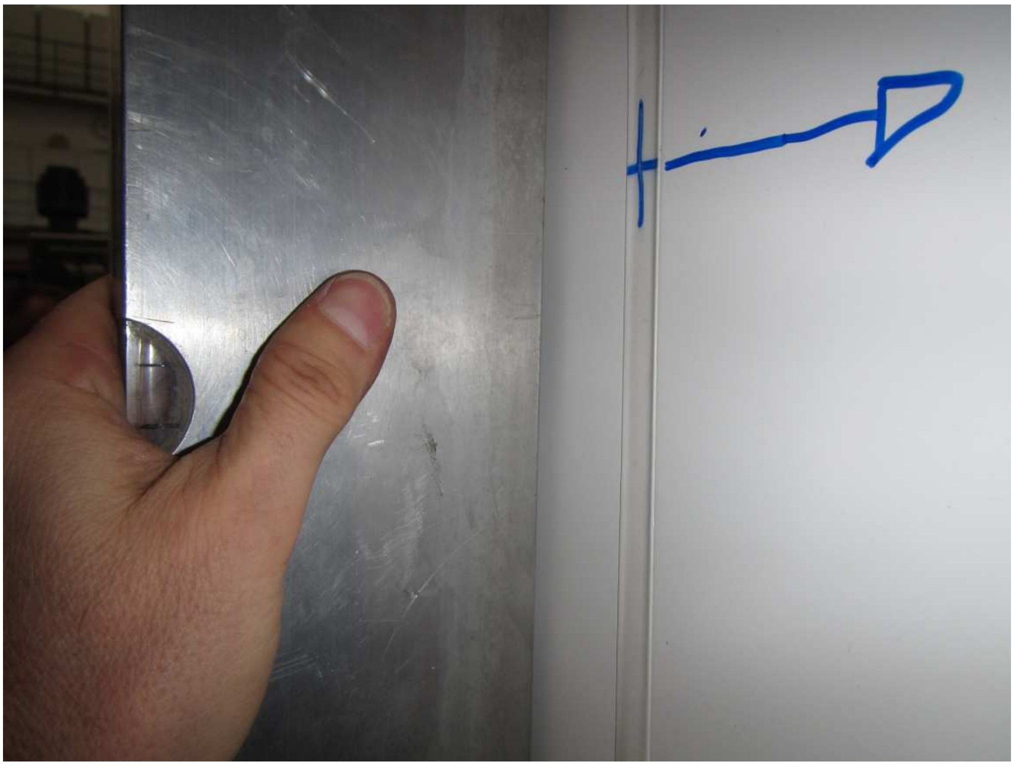

Image B.9.1: Partial test, pendulum impact test, pendulum impact test directly on mullion no. 2, on the left-hand side of the wall. Impact height, according to DIN 4103-1, h = 1.15 m. Pendulum drop height 1 x h = 1.15 cm, impact energy 1 x E = 575 Nm Deformation check using a straight edge Δw = 3 mm.

Image B.9.2: Partial test, pendulum impact test, pendulum impact test directly onto the panelling (installation panel) between mullion no. 1 and no. 2, on the left-hand side of the wall. Impact height, according to DIN 4103-1, h = 1.15 m. Pendulum drop height 1 x h = 70 cm, impact energy 1 x E = 350 Nm

Image B.10.1: Partial test, pendulum impact test, pendulum impact test directly onto the panelling (installation panel) between mullion no. 1 and no. 2, on the left-hand side of the wall. Impact height, according to DIN 4103-1, h = 1.15 m. Pendulum drop height 1 x h = 70 cm, impact energy 1 x E = 350 Nm

Image B.10.2: Partial test, pendulum impact test, pendulum impact test directly onto the panelling (installation panel) between mullion no. 1 and no. 2, on the left-hand side of the wall. Impact height, according to DIN 4103-1, h = 1.15 m. Pendulum drop height 1 x h = 70 cm, impact energy 1 x E = 350 Nm Deformation check using a straight edge Δw = 15 mm.

Image B.11: Partial test, pendulum impact test, pendulum impact test directly onto the panelling (installation panel) between mullion no. 1 and no. 2, on the left-hand side of the wall. Impact height, according to DIN 4103-1, h = 1.15 m. Pendulum drop height 1 x h = 70 cm, impact energy 1 x E = 350 Nm Deformation check using a straight edge Δw = 15 mm. Breakage of the gypsum board panelling in the installation panel on the wall's back

Evaluation tests

shaft wall

construction method

medifa

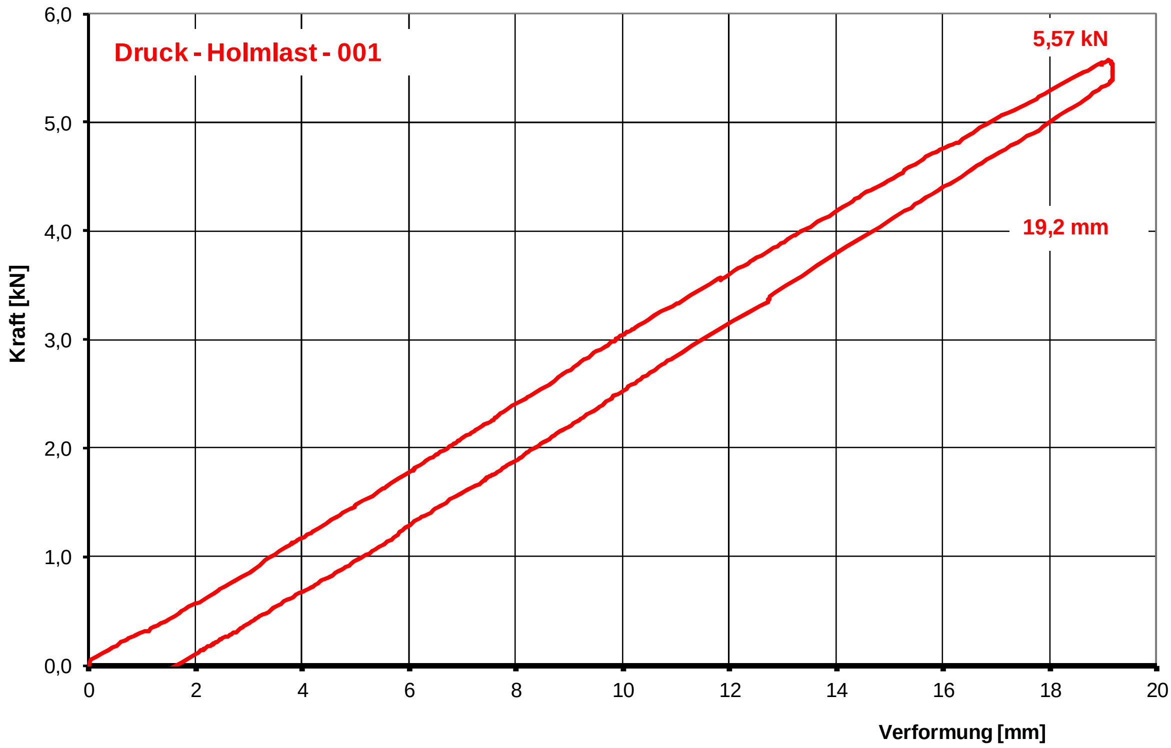

Image C.2: Force-displacement diagram applicable to Test 001

Table C.2.1: Evaluation (short) of Test 001

Biegesteifigkeit des Probekörpertyps Roosy													
Lichte Höhe 3.500 mm, Probekörperbreite 3.600 mm (Einfachständerwand, Profile (60/30/2), einseitige einlagige Beplankung d = 19 mm, Pfostenabstand 1.200 mm)													
	$F_{Versuch}$	max. $F_{Versuch}$	max. F_U / γ	max. $\delta_{Versuch}$		ΔF_{elast}	$\Delta\delta_{elast.}$		Breite B	Stützweite H	eb (Pfosten-abstand)		$EI_{y\ elast.\ Versuch}$
	[kN]	[kN]	[kN]	[mm]		[kN]	[mm]		[m]	[m]	[m]		[Nmm^2]
Roosy	5,57	5,57	3,71	19,2		2,51	8,17		3,60	3,5	1,20		**2,659E+11**

Table C.2.2: Evaluation (long) of Test 001

Biegesteifigkeit des Probekörpertyps Roosy																		
Lichte Höhe 3.500 mm, Probekörperbreite 3.600 mm (Einfachständerwand, Profile (60/30/2), einseitige einlagige Beplankung d = 19 mm, Pfostenabstand 1.200 mm)																		
	F_U	$\delta_{U\ [Mittelwert]}$	B (Probekör-perbreite)	l (Stüz-weite)	eb (Pfosten-abstand)	$M_{y,elast\ Versuch}$			$M_{yelast\ rechn.}$	Aus-nutzung		$EI_{y\ elast.\ Versuch}$	$\delta_{Rechnung}$		δ l/ 200	δ l/ 350	δ l/ 500
	[kN]	[mm]	[m]	[m]	[m]		[kNm]		[kNm]	[%]		[Nmm^2/m]	[mm]		[mm]	[mm]	[mm]
Roosy 001	5,57	19,2	3,60	3,50	1,20		--		0,669	--		2,659E+11	13,2		17,5	10,0	7,0

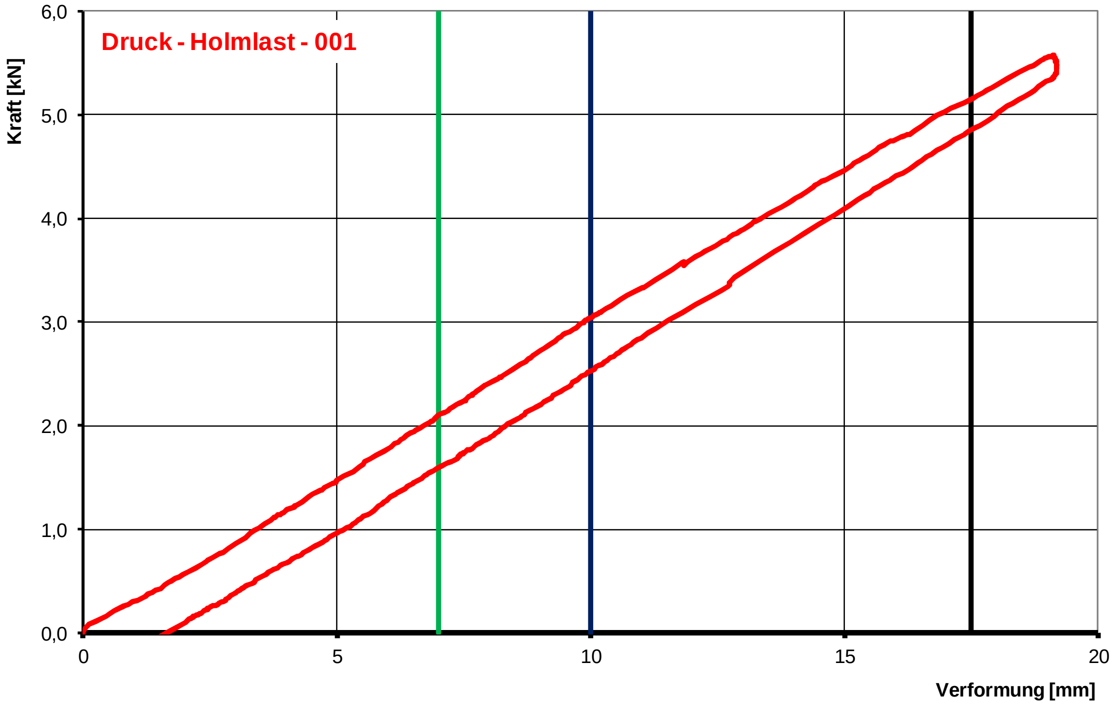

Image C.3.1: Force-displacement diagram applicable to Test 001. In addition, the deformation limits H/200 (black line), H/350 (blue line) and H/500 (green line) are also entered

Image C.3.2: Force-displacement diagram applicable to Test 001. In addition, the forces for installation area 1 (green line), installation area 2 (blue line) and load capacity (black line) are also entered.

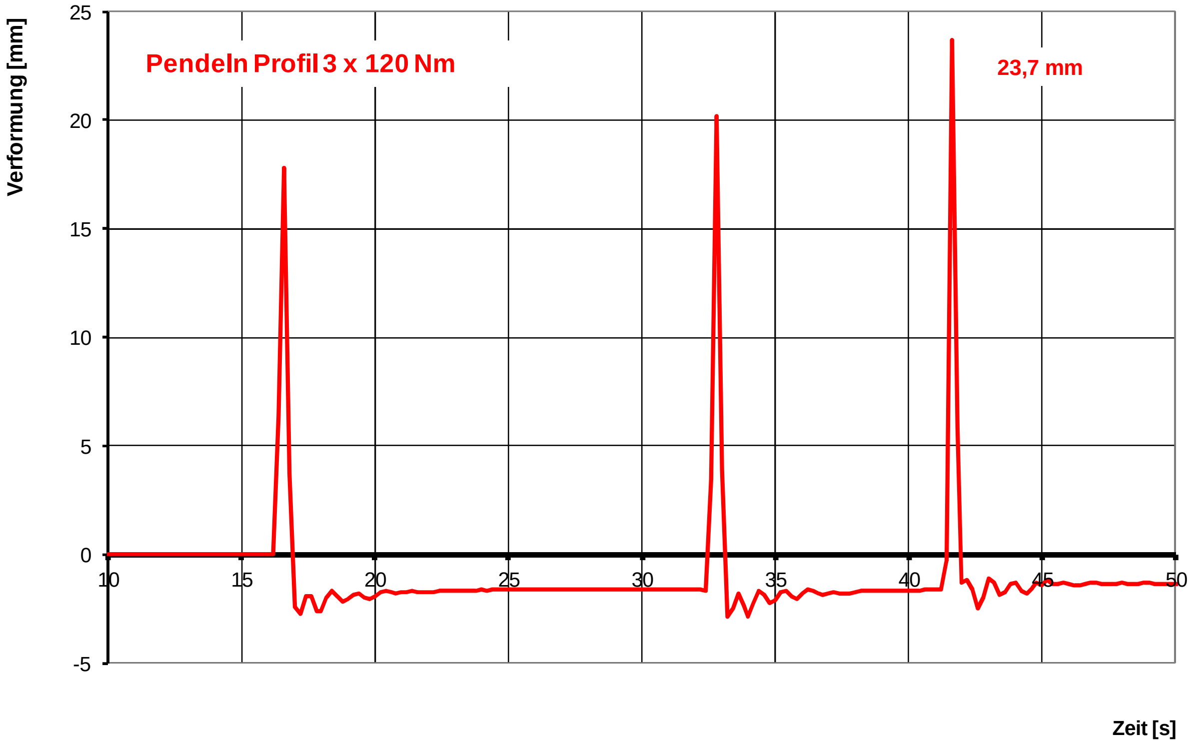

Image C.4.1: Distance-time diagram, pendulum impact test in centre of wall (section), h = 1.50 m. Three pendulum impact tests with 120 Nm, pendulum drop height Δh = 24 cm

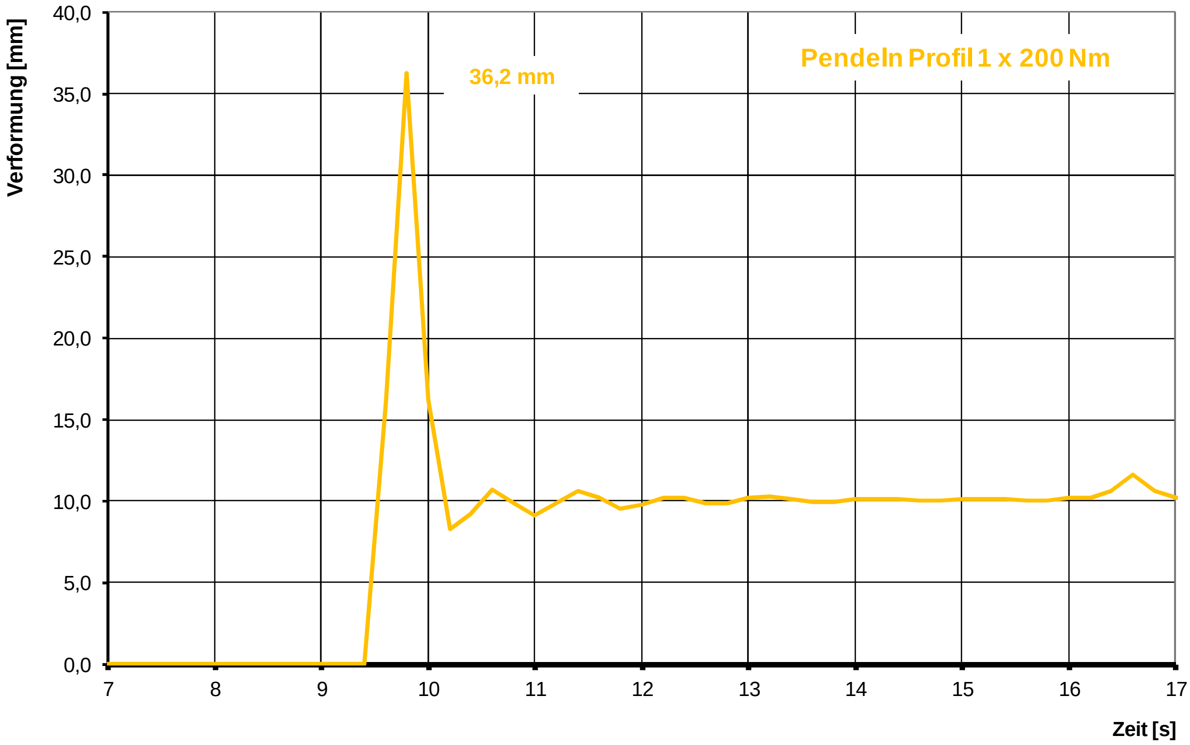

Image C.4.2: Distance-time diagram, pendulum impact test in centre of wall (section), h = 1.50 m. One pendulum impact tests with 200 Nm, pendulum drop height Δh = 40 cm

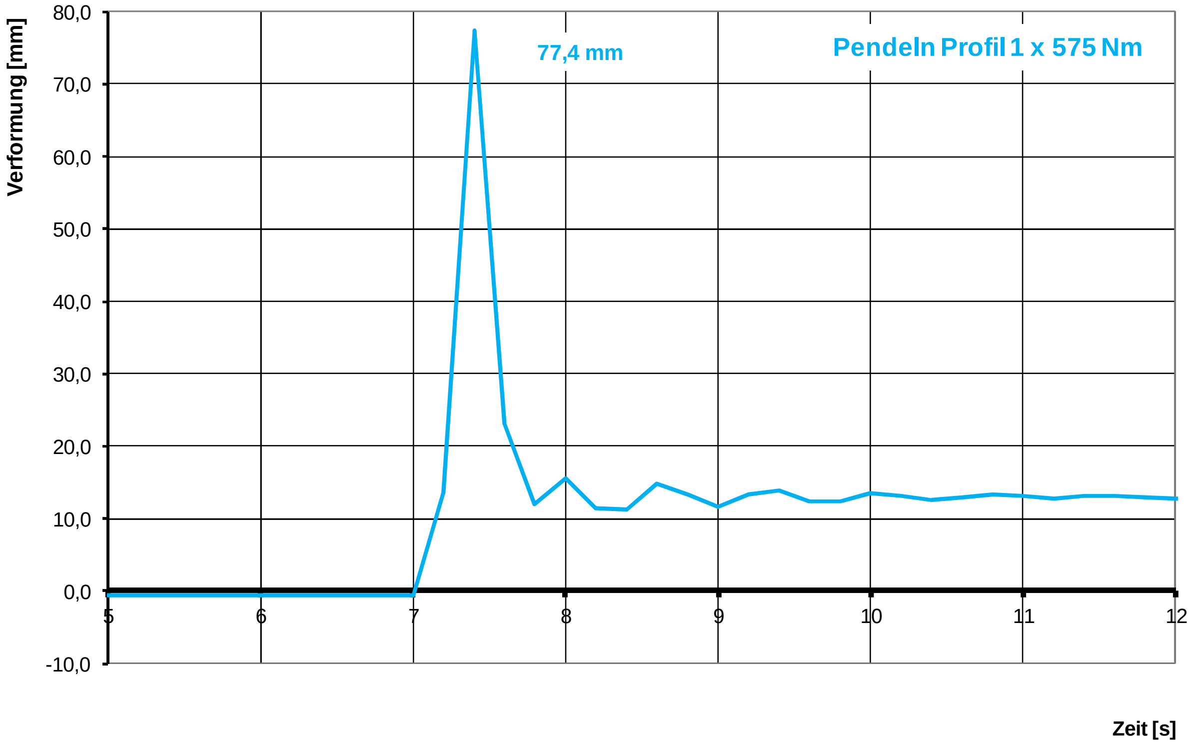

Image C.5.1: Distance-time diagram, pendulum impact test in centre of wall (section), h = 1.60 m. One pendulum impact test with 575 Nm, pendulum drop height Δh = 1.15 cm

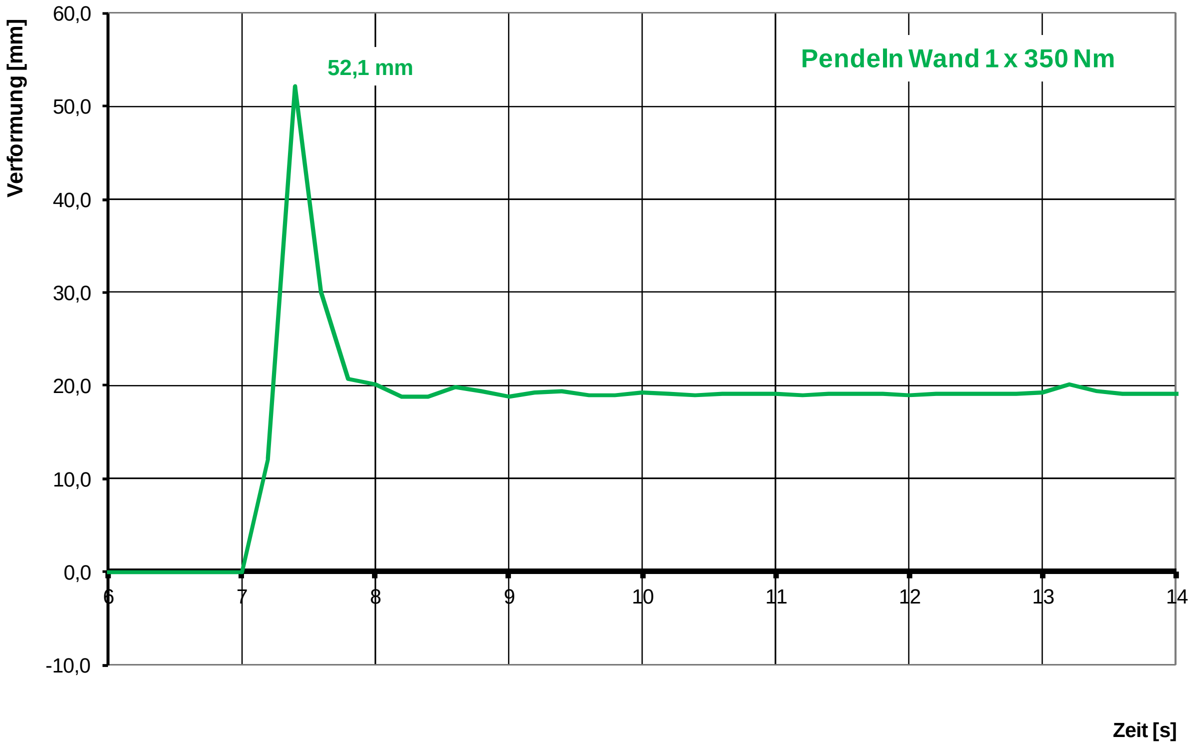

Image C.5.2: Distance-time diagram, pendulum impact test in centre of wall (panel), h = 1.15 m. One pendulum impact test with 350 Nm, pendulum drop height Δh = 0.70 cm

Table C.6: Calculation of the required pendulum impact height for a pendulum impact directly onto the mullion, at a height of h = 1.60 m. Selected Δh = 1.15 m > 1.11 m for the pendulum drop height

DIN 4103-1 **Verification of the soft impact**

Impact on stand (Input fields)

Input data		**Input**		
Pendulum	Mass	m_1 [kg]	50	
Pendulum	Type		Bag filled with glass balls	
Wall type			*Roosy*	
Height of wall (incl. panelling)		H [m]	3,5	
Width of wall (incl. panelling)		W [m]	3,6	
Thickness of panelling		D [m]	0,019	
Number of layers side 1		[-]	1	
Number of layers side 2		[-]	0	
Apparent density of panelling		ρ [kg/m³]	1200	
Mass of panelling		[kg]	100	
Spacing of sections		[m]	1,2	
Mass of sections/m		mp [kg/m³]		(negligible)
Mass of partition wall		m_t [kg]	100	Control: (manual calculation optional)
Support type			*2*	(2-sided, board cut-out etc. in accordance with DIN 4103

Resulting values	**Calculated**		
Lambda		0,5	(dep. on type of support, see table 2 of DIN 4103-1)
Res. mass	m [kg]	50	
alfa'	α ' [-]	1,0000	
alfa "	α " [-]	0,2750	

Verification through pendulum impact tests

Calculation of energy: $E_{Impact} \geq \gamma * \nu * \alpha' / \alpha'' * E_{Basis}$

E_{Impact} >/= 545 Nm

with:

E_{Basis}	E_{Basis} [Nm]	100	
Partial safety factor	γ [-]	1,2	between 1.1 and 1.2
Safety factor	ν [-]	1,25	(defined, for tests)

Calculation of pendulum drop height: $h = E_{Impact} / (m_1 * g)$

h = 1,11 m 545 Nm

with:

Acceleration due to gravity	g [m/sec²]	9,81

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Table C.7: Calculation of the required pendulum impact height for a pendulum impact onto the single-layer panel between the mullions (installation panel) Selected Δh = 0.70 m > 0.67 m for the pendulum drop height

DIN 4103-1 **Verification of the soft impact**

Impact on panelling

Input data		**Input**		
Pendulum	Mass	m_1 [kg]	50	
Pendulum	Type		Bag filled with glass balls	
Wall type			*Roosy*	
Height of wall (incl. panelling)		H [m]	1,8	--> red. for squ. board cut-out
Width of wall (inc. panelling)		W [m]	1,2	--> as spacing of sections
Thickness of panelling		D [m]	0,019	
Number of layers side 1		[-]	1	
Number of layers side 2		[-]	0	
Apparent density of panelling		ρ [kg/m³]	1200	
Mass of panelling		[kg]	49,248	
Spacing of sections		[m]	1,2	
Mass of sections/m		mp [kg/m³]		(negligible)
Mass of partition wall		m_t [kg]	49,248	Control: (manual calculation optional)
Support type			*2*	(2-sided, board cut-out etc. in accordance with DIN 410

Resulting values	**Calculated**		
Lambda		0,2	(dep. on type of support, see table 2 of DIN 4103-1)
Res. mass	m [kg]	9,8496	
alfa'	α ' [-]	1,0000	
alfa ''	α '' [-]	0,4595	

Verification through pendulum impact tests

Calculation of energy: E_{Impact} >/= $\gamma * \nu * \alpha' / \alpha'' * E_{Basis}$

E_{Impact} >/= 326 Nm

with:

E_{Basis}	E_{Basis} [Nm]	100	
Partial safety factor	γ [-]	1,2	between 1.1 and 1.2
Safety factor	ν [-]	1,25	(defined, for tests)

Calculation of pendulum drop height: h = $E_{Impact} / (m_1 * g)$

h = 0,67 m 326 Nm

with:

Acceleration due to gravity g [m/sec²] 9,81

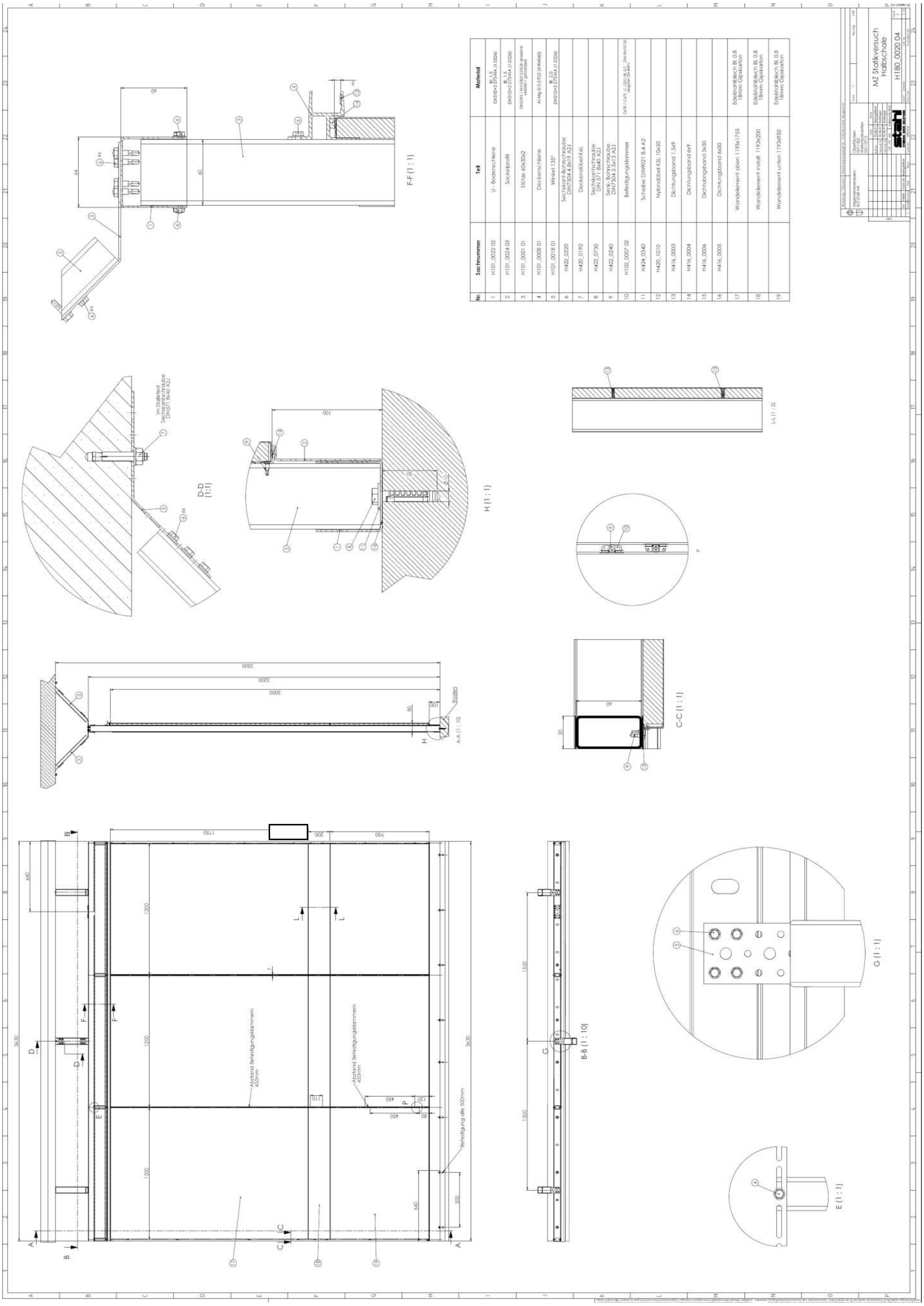

Image D.1: Planning documents MediFa, MZ static and pendulum test, plan H180 - 0020 04.