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2017-03-21
M133001/01 MSG/STEG

Roof terrace covering with concrete flagstones on pedestals of Buzon and impact sound insulation of Berleburger Schaumstoffwerk

Test of the improvement of impact sound insulation in the ceiling test facility according to EN ISO 10140-1

Test report no. M133001/01

Client:	BSW Berleburger Schaumstoffwerk GmbH Am Hilgenacker 24 57319 Bad Berleburg Germany
Consultant:	M. Eng. Philipp Meistring
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1 Situation and task

On behalf of the Berleburger Schaumstoffwerk GmbH, 57319 Bad Berleburg, Germany, the improvement of the impact sound insulation of a roof terrace covering consisting of concrete flagstones on pedestals of type Buzon DPH-5-PH5 and insulation layer of type Regupol® sound and drain 22, was to be determined in the ceiling test facility on a heavyweight reference floor according to EN ISO 10140-1 [2].

2 References

This test report is based on the following documents:

[1] EN ISO 12999-1: Acoustics - Determination and application of measurement uncertainties in building acoustics - Part 1: Sound insulation. May 2014

[2] EN ISO 10140-1: Acoustics - Laboratory measurement of sound insulation of building elements - Part 1: Application rules for specific products. ISO 10140-1:2016. August 2016.

[3] EN ISO 10140-2: Laboratory measurement of sound insulation of building elements - Part 2: Measurement of airborne sound insulation. September 2010

[4] EN ISO 10140-3: Acoustics - Laboratory measurement of sound insulation of building elements – Part 3: Measurement of impact sound insulation. June 2015 (EN ISO 10140-3: 2010 + A1: 2015)

[5] EN ISO 10140-4: Acoustics - Laboratory measurement of sound insulation of building elements – Part 4: Measurement procedures and requirements. September 2010

[6] EN ISO 10140-5: Acoustics - Laboratory measurement of sound insulation of building elements – Part 5: Requirements for test facilities and equipment. May 2014(EN ISO 10140-5: 2010 + A1: 2014)

[7] EN ISO 717-2: Acoustics - Rating of sound insulation in buildings and of building elements – Part 2: Impact sound insulation. March 2013

[8] DIN 4109-11: Sound insulation in buildings – Part 11: Verification of sound insulation; Quality and suitability testing. May 2010

[9] DIN 4109-4: Sound insulation in buildings - Part 4: Testing of acoustics in buildings. July 2016

[10] EN ISO 3382-2: Acoustics - Measurement of room acoustic parameters – Part 2: Reverberation time in ordinary rooms. September 2009 (EN ISO 3382-2: 2008 + AC: 2009)

[11] EN 29052-1: Acoustics – Determination of dynamic stiffness – Part 1: Materials used under floating floors in dwellings. June 1992

3 Test setup and test objects

The setup of the test objects in the test facility was carried out by the client.

The test object corresponds to category II according to EN ISO 10140-1 [2].

The test setup can be described as follows (from top to bottom):

-	53 mm	Concrete flagstones, size 500 mm x 500 mm x 53 mm; 29.0 kg/piece (116 kg/m²), laid on pedestals (loosely placed, nominal joint dimension 3 mm)
-	162 mm	Air cavity, therein: height-adjustable pedestals made of plastic material, Buzon type DPH-5-PH5 with joint spacer on the top (joint width 3 mm) and 2 mm EPDM compensation shim, pedestals loosely placed on the impact sound insulation layer with the larger contact surface towards the bottom, laying pattern corresponding to the size of the concrete flagstones (approx. 500 mm/ 500 mm).
-	(2 + 15) mm	Impact sound insulation layer Regupol® sound and drain 22 consisting of PU-bonded rubber fibres, slab thickness 15 mm, profiled on the bottom, dynamic stiffness $s'_t \leq$ 22 MN/m³ (manufacturer specification), on the top loosely laid with 2 mm of protective fleece on the uncovered floor
-	140 mm	Reinforced concrete ceiling (heavyweight reference floor according to EN ISO 10140-5, C.2)

The impact sound insulation material was laid full-surface on the uncovered floor, then covered with 42 full-size concrete flagstones. Thus a continuous, rectangular area of width x length = 3.02 m x 3.53 m =10.66 m² was covered by the test setup. Pedestals and concrete flagstones were arranged contact-free towards the flanking walls (connection joint > 5 mm).

For the impact sound insulation layer of type Regupol® sound and drain 22, the test institute also determined the dynamic stiffness according to EN 29052-1 [11] without preload. The test was performed on three random samples of the test material (each 200 mm x 200 mm, test including protective fleece covering). The test issued individual values of:

Sample 1: s'_t = 22 MN/m³/
Sample 2: s'_t = 22 MN/m³/
Sample 3: s'_t = 21 MN/m³.

The manufacturer specification regarding the dynamic stiffness of $s'_t \leq$ 22 MN/m³ can thus be confirmed for the test material used.

The test setup was not damaged by the tapping machine.

Appendix B shows photos and Appendix C manufacturer drawings of the test setup.

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4 Test method

The test of the improvement of impact sound insulation was performed according to EN ISO 10140-1 [2].

5 Evaluation

The determination of the single values was carried out according to EN ISO 717-2 [7].

The following definitions apply:

- $L_{n,0,w}$ weighted normalized impact sound pressure level of the reference floor
- $C_{I,0}$ spectrum adaptation term for the impact sound pressure level of the reference floor
- ΔL_w weighted reduction of impact sound pressure level of the floor covering
- $C_{I,\Delta}$ spectrum adaption term or the impact sound pressure level of the floor covering
- ΔL_{lin} reduction of impact sound pressure level of the floor covering based on the unweighted linear impact sound pressure $\Delta L_{lin} = \Delta L_w + C_{I,\Delta}$
- $L_{n,r,w}$ weighted normalized impact sound pressure level of the reference floor with the floor covering under test
- $C_{I,r}$ spectrum adaptation term of the reference floor with the floor covering tested

6 Measurement results

The complete measurement results as well as the spectrum adaption terms are indicated in the test certificate in Appendix A.

For the floor structure tested the following results were obtained:

- Weighted reduction of impact sound pressure level $\Delta L_w(C_{I,\Delta})$ = 37(-11) dB

For the indication of the uncertainty of ΔL_w, an evaluation to one decimal place was added according to EN ISO 717-2 [7] and EN ISO 12999-1 [1]. The evaluation issued the following result:

- Weighted reduction of impact sound pressure level ΔL_w = 37.5 dB ± 1.1 dB (k = 1.00; both sides)

Details for the determination of the indicated uncertainty are given in Appendix D.

7 Remarks

The test results exclusively refer to the conditions given on the day of measurements.

M. Eng. Philipp Meistring
(Project Manager)

Dipl.-Ing. (FH) Dominik Reif
(Quality Assurance)

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Reduction of impact sound pressure level ISO 10140-1

Laboratory measurement of the reduction of transmitted noise by floor coverings on a heavyweight standard floor

Client: BSW Berleburger Schaumstoffwerk GmbH
Am Hilgenacker 24, 57319 Bad Berleburg, Germany

Test specimen: Flagstones on pedestals Buzon DPH-5-PH5 and Regupol® sound and drain 22

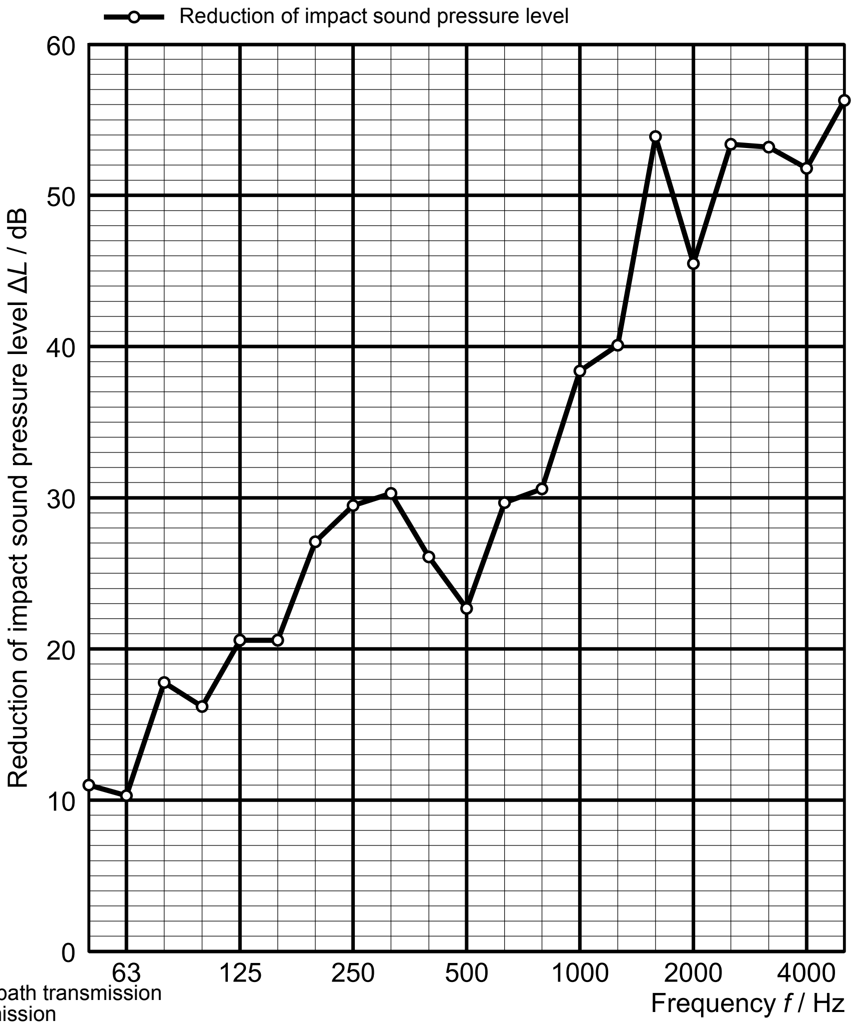
Test setup (from top to bottom):

- 53 mm — concrete flagstones, size 500 mm x 500 mm x 53 mm; 29.0 kg/pc. (116 kg/m²), laid on pedestals (loosely placed, specified joint dimension 3 mm)
- 162 mm — air cavity, therein: pedestals of Buzon, type DPH-5-PH5 with joint spacers on the upper side (3 mm) and 2 mm EPDM shims, pedestals loosely placed on the impact sound insulation layer, laying pattern approx. 500 mm/ 500 mm
- (2 + 15) mm — impact sound insulation layer Regupol® sound and drain 22 made of PU-bonded rubber fibres, on the upper side with protective fleece (2 mm), profiled on the bottom side, dynamic stiffness $s'_t \leq$ 22 MN/m³ (manufacturer specification), loosely laid on the uncovered floor
- 140 mm — reinforced concrete floor (heavyweight reference floor acc. to ISO 10140-5, C.2)

The impact sound insulation layer was laid full-surface on the uncovered floor. The structure above was covered with 42 full-size concrete slabs. Thus a continuous, rectangular area of width x length = 3.02 m x 3.53 m =10.66 m² was occupied by the test setup. Pedestals and concrete flagstones were arranged contact-free from the flanking walls (connection joint > 5 mm).

Date of test: 2017-01-17
Source room: Deckenprüfstand
Vol.: V = 46.60 m³
Receiving room:
Vol.: V = 49.60 m³
θ = 20°C r.h. = 29 %

Frequency [Hz]		ΔL 1/3 octave [dB]	$L_{n,0}$ 1/3 octave [dB]
50		11.0	56.1
63		10.3	53.7
80	▫	17.8	65.1
100	▫	16.2	65.1
125	▫	20.6	67.3
160	▫	20.6	64.8
200	▫	27.1	66.9
250	∘▫	29.5	66.2
315	▫	30.3	66.7
400		26.1	67.4
500		22.7	68.5
630	▫	29.7	68.5
800	▫	30.6	70.3
1000	▫	38.4	71.8
1250	▫	40.1	73.2
1600	▫	53.9	72.4
2000	▫	45.5	73.0
2500	▪	53.4	72.4
3150	▪	53.2	71.4
4000	∘▫	51.8	69.4
5000	•▫	56.3	66.8



▪ minimum value, dominated by indirect path transmission
▫ value corrected for indirect path transmission
• minimum value, dominated by background noise
∘ value corrected for background noise

Rating according to ISO 717-2:

Weighted reduction of impact sound pressure level $\Delta L_w(C_{I,\Delta})$ = 37(-11) dB

These results are based on test made with an artifical source under laboratory conditions (engeneering method) ΔL_{lin} = 26 dB $L_{n,0,w}(C_{I,0})$ = 79(-12) dB $L_{n,r,w}(C_{I,r})$ = 41(0) dB

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Appendix A

Roof terrace covering with concrete flagstones

Figure B.1. Laying of the sound insulation layer Regupol® sound and drain 22 on the uncovered concrete floor.

Figure B.2. Pedestal type Buzon DPH-5-PH5.

Roof terrace covering with concrete flagstones

Figure B.3. Test setup during mounting: concrete flagstones on pedestals.

Figure B.4. Test setup during mounting: support detail of concrete flagstones on a pedestal.

Roof terrace covering with concrete flagstones

Figure B.5. Test setup in the ceilng test facility: ready for testing.

Figure B.6. Test setup in the ceilng test facility: ready for testing.

Roof terrace covering with concrete flagstones

(Manufacturer drawings: schematic designs, dimensions in mm)

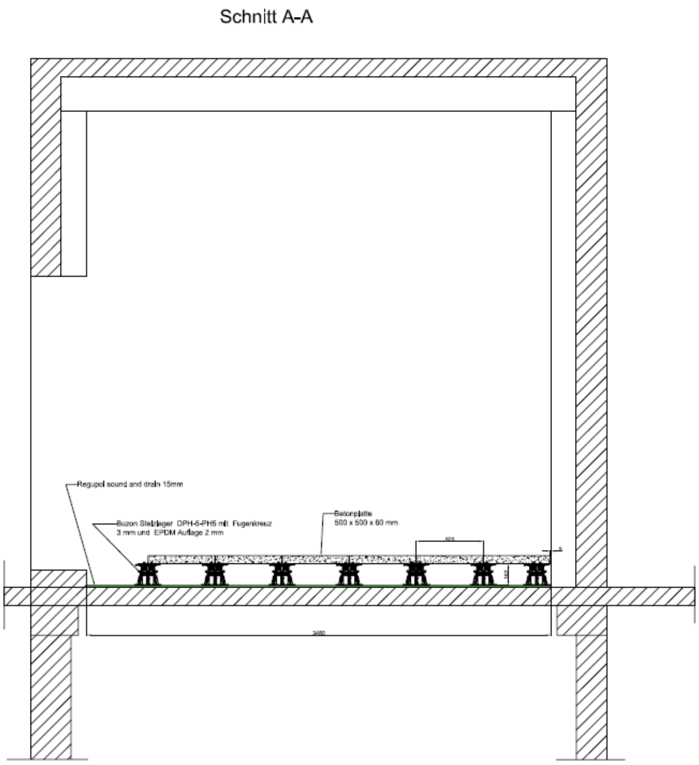

Figure C.1. Test setup in the ceiling test facility: cross section.

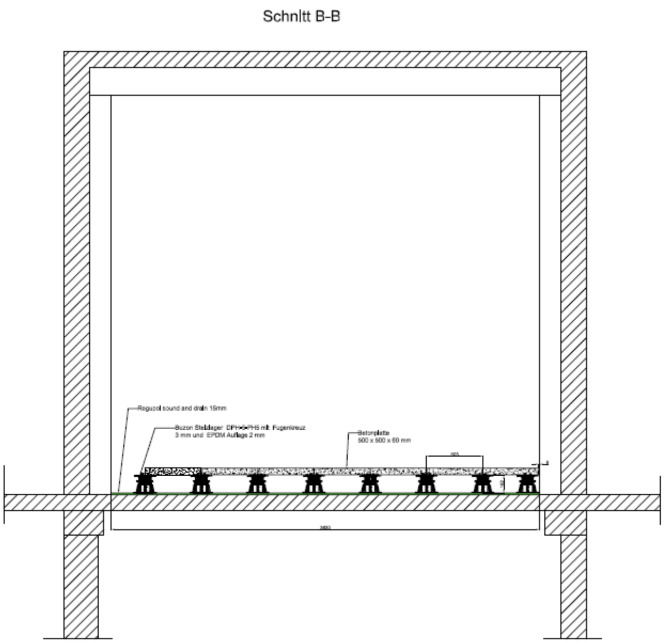

Figure C.2. Test setup in the ceiling test facility: longitudinal section.

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Roof terrace covering with concrete flagstones

(Manufacturer drawings: schematic designs, dimensions in mm)

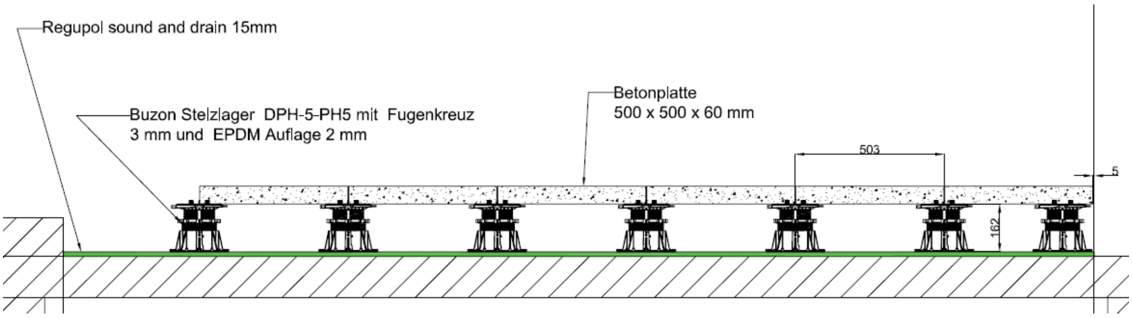

Figure C.3. Test setup in the ceiling test facility: structure details.

Description of the test procedure for the determination of the improvement of impact sound insulation of a floor covering

1 Measurands

The improvement of the impact sound insulation ΔL of a floor covering on a heavyweight reference floor was determined according the following equation:

$$\Delta L = L_{n,0} - L_n$$

With:

$L_{n,0}$ normalized impact sound pressure level of the heavyweight reference floor without floor covering;

L_n normalized impact sound pressure level of the heavyweight reference floor with the floor covering;

The normalized impact sound pressure levels L_n resp. $L_{n,0}$ are determined as follows:

$$L_n = L_i + 10 \log(A/A_0) \text{ dB}$$

With:

L_i average sound pressure level in a one-third octave band in the receiving room, when the tested floor covering is excited by the standard tapping machine (impact sound pressure level) in dB

A equivalent sound absorption area in the receiving room in m^2

A_0 reference absorption area $A_0 = 10\ m^2$

Information concerning the accuracy of the test method is given in EN ISO 12999-1 [1].

For the single-number value ΔL_W a standard uncertainty of 1.1 dB is indicated in EN ISO 12999 [1], Table 7. This value corresponds to the standard uncertainty of reproducibility determined in round-robin tests and describes the standard uncertainty of test results obtained in a test stand for a constructional element under reproducibility conditions. Taking into consideration a coverage factor $k = 1.00$, an expanded uncertainty of $U = 1.1$ dB results for the 2 sided test (confidence level 68 %).

2 Test procedure

2.1 Description of the test facility

The ceiling test facility meets the requirements according section 4 of EN ISO 10140-5 [2].

The heavyweight concrete reference floor was homogenous and had a uniform thickness of 140 mm. The dimensions of the reference floor in the source room were length x width = 3.83 m x 3.48 m = 13.33 m^2.

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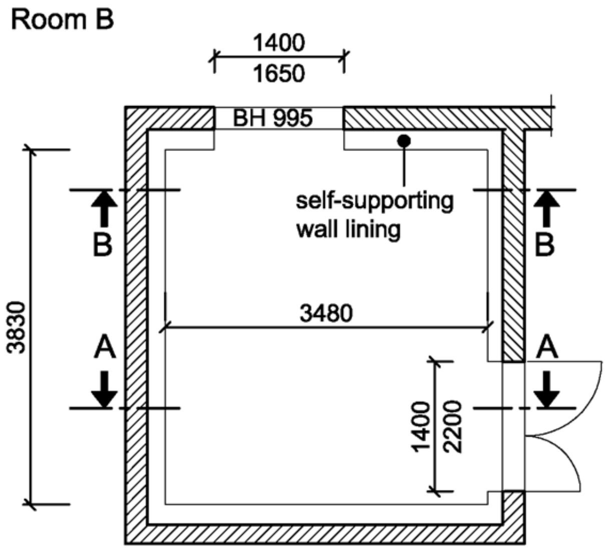
In order to increase the diffusivity of the sound field and to adjust the reverberation time, seven plate resonators and three porous absorbers were placed on the walls of the receiving room. In order to reduce the airborne sound pressure level in the source room, two absorber boxes (dimensioned length x width x height = 0.6 m x 0.6 m x 1.3 m) were arranged on the floor.

Figures D.1. and D.2. show drawings of the test facility.



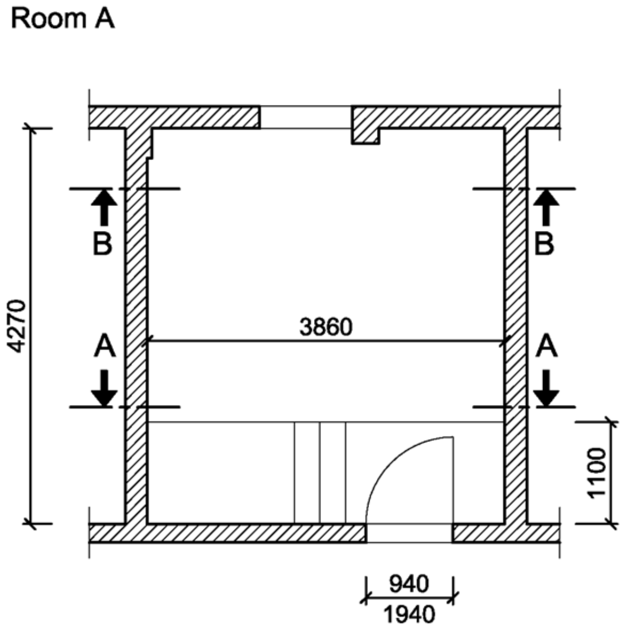


Figure D.1. Floor plans of the source and receiving rooms of the ceiling test facility.

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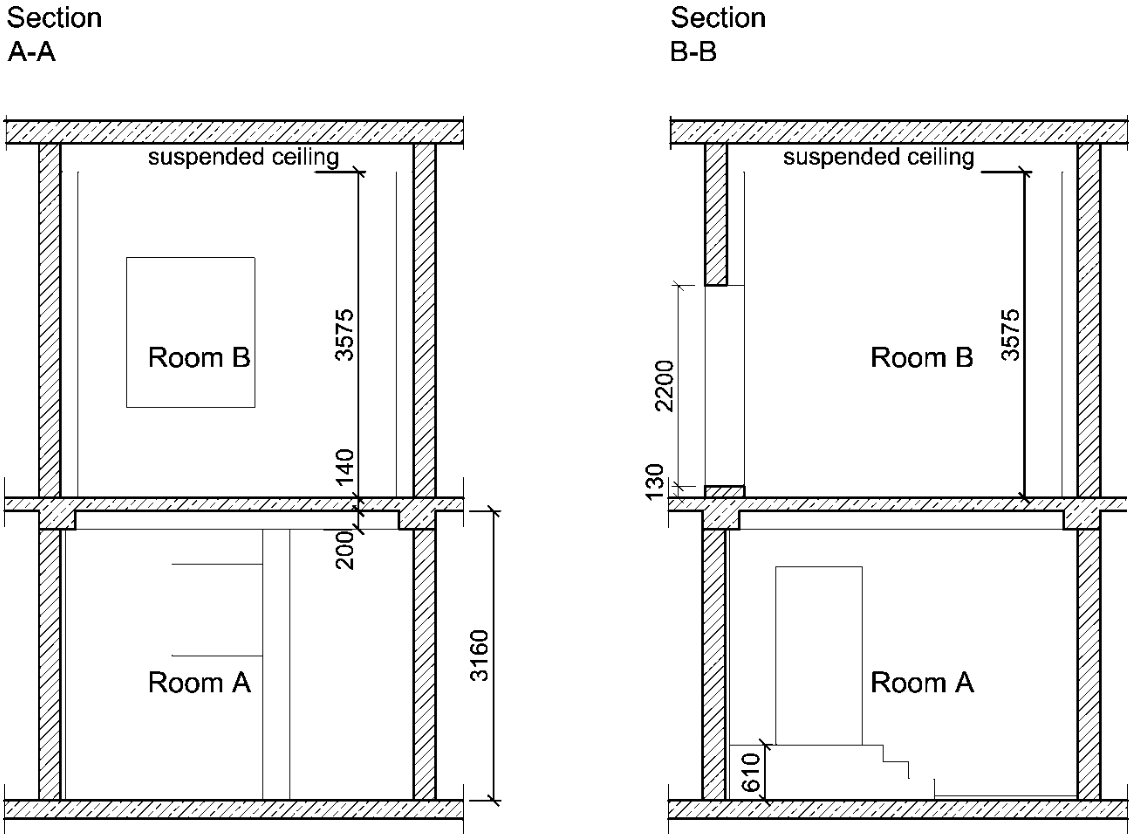

Figure D.2. Sections of the ceiling test facility (dimensions in mm).

2.2 Determination of the impact sound pressure level

The impact sound was generated by a standard tapping machine.

The measurement of the averaged sound pressure level was executed by continuously moved microphones in both the source and the receiving room. The sweep radius of the microphones was 1.0 m. The plane of the traverse of the microphones was inclined by approx. 10° to the horizontal. The microphone traverses were distributed equally in the permitted room volume.

The standard tapping machine was placed at an angle of 45° to the anisotropic floor construction at five different positions, distributed irregularly on the tested floor of the source room. The distance between the standard tapping machine and the edges of the floor was at least 0.5 m.

The rms-averages of the sound pressure level at the different microphone positions and positions of the standard tapping machine, each in the source and the receiving room, were determined.

The following minimum distances of the microphone positions were considered:

- 0.7 m between each microphone position and room boundaries
- 1.0 m between each microphone position and test specimen

Measurement of the sound pressure level was effected in one third-octave bands.

A dependence of the impact sound pressure level on the time of excitation by the standard tapping machine could not be determined.

2.3 Determination of the airborne sound pressure level difference

A pink noise signal was used as a test sound. The sound pressure level difference between adjacent one-third-octave-bands in the source room was < 6 dB.

A dodecahedron was used in terms of sound source. The excitation was effected at two loudspeaker positions in the source room. The sound source was arranged in such a way that the sound field generated was as diffuse as possible. For this purpose, the excitation was effected in the upper corner positions. The distance between the sound source positions and the floor was at least 2 m, so that the part of the direct sound of the sound source onto the test specimen was negligible compared to the diffuse sound.

The measurement of the averaged sound pressure level was executed by continuously moved microphones in both the source and the receiving room. The sweep radius of the microphones was 1.0 m. The plane of the traverse of the microphones was inclined by approx. 10° to the horizontal. The microphone traverses were equally distributed in the permitted room volume.

For each of the two sound source positions two microphone traverses were registered. The averaging time of 60 seconds corresponded to the duration of two traverses of the moved microphones.

After correction of background noise for all sound source positions, the rms-average of the sound pressure at the different microphone positions were determined, each in the source and the receiving room. The sound pressure level difference D_i of a sound source position was determined from the rms-averaged sound pressure levels. The sound pressure level difference D is calculated as follows:

$$D = -10 \log\left(\frac{1}{n}\sum_{i=1}^{n} 10^{-0,1 D_i}\right) \text{dB}$$

The following minimum distances of the microphone positions were considered:

- 0.7 m between each microphone position and room boundaries
- 1.0 m between each microphone position and sound source
- 1.0 m between each microphone position and test object

Measurement of the sound pressure level was effected in one third-octave bands.

The measurement results were determined for one measuring direction.

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2.4 Correction of the airborne noise transmission in the determination of the impact sound pressure level

For the determination of the influence of the sound power level radiated into the source room by the standard tapping machine and the structures excited by it, on the impact sound level in the receiving room, the corrected impact sound pressure level was calculated according to DIN 4109-11 [8] as follows:

$$L = 10 \log(10^{0.1\,L_E} - 10^{0.1\,(L_{HW} - D)})\ \mathrm{dB}$$

With:

L corrected impact sound pressure level in dB;

L_E impact sound pressure level in the receiving room (including the disturbing impact sound level) in dB;

L_{HW} sound pressure level in the source room during operation of the standard tapping machine in dB;

D sound pressure level difference between source and receiving room according to section 2.3 in dB.

According to EN ISO 10140-3 [4], the airborne sound part transmitted from the source room to the receiving room must be by at least 10 dB lower than the level of the transmitted impact sound pressure level. If this condition could not be complied with, a level correction ΔL of the impact sound level L_E was carried out for the determination of the corrected impact sound level L, whereby the level correction was limited to maximum ΔL_{max} = 1.3 dB, i. e. $L \geq L_E - \Delta L_{max}$ dB.

The results corrected due to indirect paths of airborne noise transmission are marked in the test certificate as follows:

- $\Delta L \geq \Delta L_{max}$: “minimum value determined by indirect path of transmission“
- 0.5 dB < $\Delta L < \Delta L_{max}$: “corrected value with indirect path of transmission“
- other: no marking

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2.5 Correction for background noise

In case the averaged sound pressure level in the receiving room during excitation with the standard tapping machine was less than 15 dB higher than the average sound pressure level of the background noise, the averaged sound pressure level in the receiving room was corrected according to the following equation:

$$L = 10\ \log(10^{0.1\,L_{sb}} - 10^{0.1\,L_b})\ \text{dB}$$

With:

L corrected sound pressure level in the receiving room in dB;

L_{sb} sound pressure level in the receiving room (including background noise level) in dB;

L_b sound pressure level of background noise in the receiving room in dB.

The level correction ΔL of the sound pressure level in the receiving room L_{sb} for calculation of the corrected sound pressure level in the receiving room L was limited to a maximum of ΔL_{max} = 1.3 dB, i. e. $L \geq L_{sb} - \Delta L_{max}$ dB according to EN ISO 10140-4 [5].

The test results which are corrected due to the background noise are indicated in the test certificates as follows:

- $\Delta L \geq \Delta L_{max}$: “minimum value determined by background noise“
- 0,14 dB < $\Delta L < \Delta L_{max}$: “corrected value with background noise“
- other: no marking

2.6 Determination of the equivalent sound absorption area

The equivalent sound absorption area was calculated on the basis of the reverberation time measured according to EN ISO 3382-2 [10] using the Sabine’s formula:

$$A = 0.16 \times V/T\ \ \text{m}^2$$

With:

A equivalent sound absorption area in m^2;

V volume of the receiving room in m^3;

T reverberation time in the receiving room in s.

For the determination of the reverberation time the interrupted noise method was used. After excitation of the receiving room using a Pink-Noise signal as test signal, the decay curve was registered. A dodecahedron was used as sound source. In order to produce a steady-state sound pressure level in the receiving room, the excitation time was fixed to 2 s. The differences of resulting sound pressure levels of adjacent one-third-octave-bands in the source room was less than 6 dB.

The determination of the reverberation time was performed for each single decay curve. The evaluation of decay curves was made by linear averaging. The evaluation of the reverberation time was carried out beginning 5 dB below the initial sound pressure level. The evaluation range comprised 20 dB. The level difference between the sound pressure level during excitation with the sound source and the level of the background noise was in each one-third-octave-band at least 35 dB. For each loudspeaker-microphone-combination two decay curves were determined and the reverberation times averaged arithmetically.

In total, the reverberation time was determined for two loudspeaker positions at three fixed microphone positions. The reverberation times averaged of two decay curves of each of the six microphone-loudspeaker-combinations were also averaged arithmetically.

2.7 List of test equipment

For the measurements and evaluations the test equipment indicated in the list below was used:

Table D.1. Test equipment.

Designation	Manufacturer	Type	Serial-No.	Calibration valid until
Building acoustics measurement system, test facility	Norsonic	121	26341	2017-12
Amplifier	APart	Champ One	10050104	
Dodecahedron	Müller-BBM	DOD360A	372832	2018-08
Dodecahedron	Müller-BBM	DOD360A	372833	2018-08
Dodecahedron	Müller-BBM	DOD250B	333714	2017-04
Dodecahedron	Müller-BBM	DOD250B	333715	2017-04
Microphone swivel facility	Norsonic	212	12986	
Microphone swivel facility	Norsonic	212	12991	
Pre-amplifier microphone with free-field microphone	Norsonic Norsonic	1201 1220	26145 25160	2017-12
Pre-amplifier microphone with free-field microphone	Norsonic Norsonic	1201 1220	30588 26071	2017-12
Pistonphone	Brüel & Kjaer	4228	1651956	2018-12
Standard tapping machine	Norsonic	211	12961	2019-08
Software for measurement and evaluation	Müller-BBM	Bau4	Version 1.10	

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