Flanking sound reduction of suspended ceilings

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Introduction

Recently, at the Fraunhofer Institute of building physics (IBP), measurements of a suspended ceiling made of closed gypsum boards were accomplished in cooperation with the German industry group for gypsum boards. The values for construction examples given in the current valid version of the table 26, appendix 1 to the German standard DIN 4109, Schallschutz im Hochbau, "Ausführungsbeispiele und Rechenverfahren"[1] are based on old measurements. However, in the meantime building materials have been modified. Acoustically important features like the mass per unit area, the thickness or the elastic modulus of currently available gypsum boards (gb) have been changed. Additionally, the smaller flow resistance (r) caused by reduced mass of the insulation material, used at the present, has to be taken into account.

Measurement method

According to DIN EN 20140-9: 1993, the measurements of the flanking sound reduction were carried out in a labatory at the Fraunhofer Institute of building physics (s. fig. 1) The labatory has an in height adjustable concrete floor. This allows different measurements of the cavity height without structural modification. According to DIN EN 20140-9, the measurement were carried out in both measurement directions, the normalized sound level difference $D_{n,c}$ which means the same as the flanking sound reduction index, results from the arithmetic means.

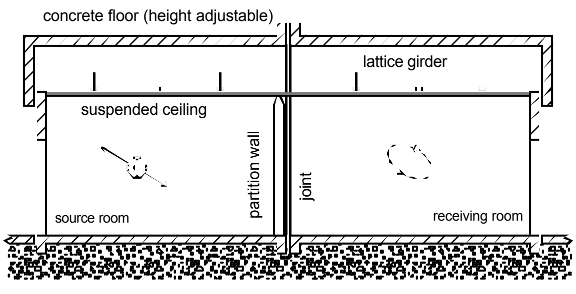

Fig. 1: test stand for suspended ceilings, height adjustable.

Parameters of interest

The normalized flanking sound reduction $D_{n,c}$, of suspended ceilings is influenced by the following parameters:

Sound reduction of the construction of the suspended ceiling

- characteristics of the ceiling board (thickness, number of layers, mass per unit area, flexural stiffness, loss factor)
- density
- absorptive lining above the ceiling (in the cavity)
- fastening of the ceiling boards

Sound propagation within the cavity

- characteristics of the absorptive lining (thickness, sound absorption coefficient, setting...)
- absorptive barrier/ panel barrier
- characteristics of the cavity (height, installations)

Structure-borne sound transmission:

- characteristics of the ceiling surface (thickness, number of layers, mass per unit area, flexural stiffness, loss factor)
- arrangements (e.g. elements, elastic joints)
- absorptive lining in the cavity
- fastening of the ceiling boards

Measurements

The systems under investigation are given in table 26, appendix 1 to DIN 4109. Different types of connections to the partition, using continuous boards, separated boards, separated boards and suspension were investigated. The latter were also investigated for the case when a panel barrier or an absorptive barrier was fitted into the cavity above the partition (s. fig. 2).

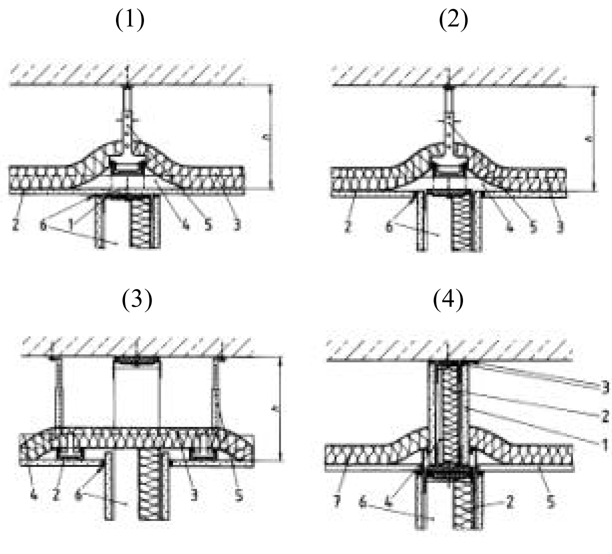

Fig. 2: examined variants of the connection to the partition wall, built with continuous surface (1), separated surface and continuous basement construction (2), separated surface and basement (3) and with panel barrier in the cavity (4).

For the suspended ceilings gypsum boards with thickness 12.5 mm, mass per unit area 8.5 kg/m², elastic modulus 2.7 mPa were applied. The gypsum boards were used in one and two layer configurations. For the absorptive lining mineral wool with the following properties: thickness 40 mm (r=10,5 kPa s/m²) and 80 mm (r=8,4 kPa s/m²) was used.

Measurement results

Below, fig. 3 presents four typical results of the present investigation. The results are obtained for a cavity height of 400 mm. Using these results, the influence of the different parameters are revealed clearly.

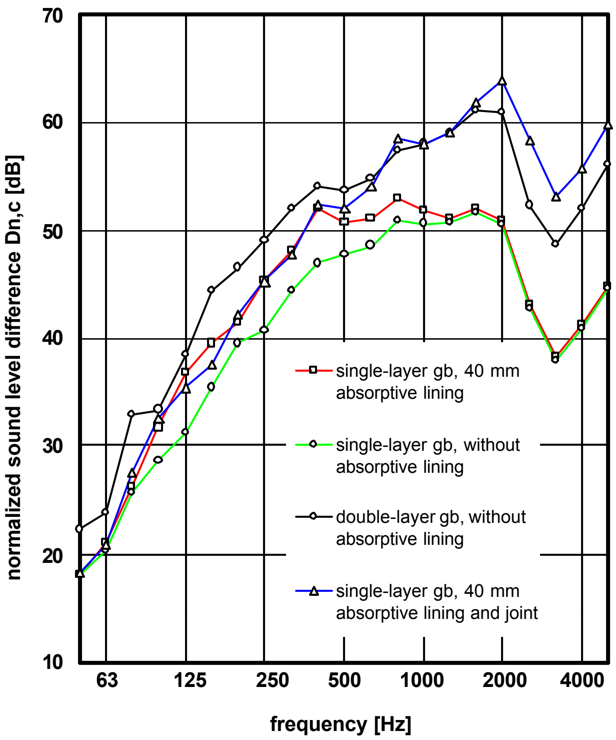

Fig. 3: spectrums of different variants of closed suspended ceilings, cavity height 400 mm.

If the results are compared with the measurement with one continuous layer and without absorptive lining, due to the double board configuration, the doubled mass per unit area leads to an improvement of the flanking sound reduction of approx. 6 dB. The influence of the absorptive lining results as negligible. By separateing the board an improvement up to 6 dB can be achieved. The influence of the cavity height is not taken into account in fig. 3. This parameter is also negligible. In order to achieve a sound reduction of more than 55 dB, a separation of the boards above the partition is necessary. The improvement due to the single number value is between 2 dB and 5 dB.

Comparison of the new results with DIN 4109

The following table 1 contains the values for constructions measured at a cavity height from 400 mm and the values given in table 26 if available. The values from table 26 of appendix 1 are given in brackets. The comparison with the DIN 4109 shows, that the values for constructions without absorptive lining in the cavity given in table 26 should be corrected to higher values.

joint	number of layers	absorptive lining in the cavity		
		without	40 (50) mm	80 (100) mm
no	1	46 (40)	47 (51)	48 (--)
no	2	53 (43-50)	54 (--)	54 (--)
yes	1	48 (--)	52 (--)	54 (57)
yes	2	55 (--)	57 (55-56)	57 (59)

table 1: comparison between the measurement results from the test series 2003 and the DIN 4109, appendix 1 (values from DIN 4109 in brackets).

The new suggested values for the normalized sound level difference are about 3 to 10 dB higher than those given in the standard. Otherwise, the improvement of constructions with absorptive lining is small. The normalized sound level difference of continuous constructions with 80 mm absorptive lining was measured from 2 dB to 4 dB much less than given in the standard.

Results

The calculation values for the flanking sound reduction determined in table 26 do not correspond with the actually measured values. First, this is caused by the fact, that since these values have been introduced the measurement standard for measuring the normalized flanking sound reduction respectively the normalized sound level difference was changed. The valid DIN EN 20140-9 demands highly sound absorptive boundaries of the cavity. This was not demanded in the former DIN 52210, part 2, paragraph 7. This highly absorptive sound damping in the cavity influences the measurement considerably. It leads to a smaller influence of the absorptive lining. The influence of the structure borne sound transmission and the mass per unit area is proved to be larger as considered up to now. Whilst the investigations started with the idea to examine the influence on the sound reduction by changing the material properties, it turned out that the changes in the flanking sound reduction is mainly caused by modified measurement method.

Forecast

In order to revise the DIN 4109, suggestions for new calculation values for closed suspended ceilings in table 26 of appendix 1 are given. Following investigations should also verify the calculating values for absorptive suspended ceilings. Changes in the values due to the changed measurement method are expected.

Literature

[1] Beiblatt 1 zu DIN 4109, Schallschutz im Hochbau, Ausführungsbeispiele und Rechenverfahren: 1998 (sound insulation in building constructions, examples for execution and calculation method).

[2] DIN EN 20 140, part 9, Labatory measuremnet of room-to-room airborne sound insulation of a suspended ceiling with a plenum above it; German version: 1993