New regulations on sound insulation in buildings in Germany

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ABSTRACT

The standards on sound insulation in buildings in Germany have a long tradition starting in 1938. The first standard DIN 4109 "Sound insulation in building" was published in 1959. In July 2016 a new version of DIN 4109 was published. It is a consequence of developments in building materials and construction methods as well as changed expectations on sound insulation in the society during the past years. The standard consists of 4 parts "Requirements" (1), "Verification of compliance with the requirements by calculation" (2), "Building elements catalogue" (3) and "Guidance for testing acoustics in buildings" (4). The presentation highlights the major innovations, such as enhanced requirements, a new calculation procedure to predict the sound pressure level in habitable rooms as well as a catalogue on requirements on the sound reduction index and the standardized impact sound pressure level inside buildings. Additionally to the DIN 4109 "Sound Insulation in Buildings" there are further regulations in Germany defining requirements on enhanced sound insulation in buildings if higher comfort is requested. The requirements according to VDI 4100 are classified in 3 quality levels from smooth enhanced to high enhanced sound insulation in buildings. The characteristic quantities used for defining the requirements are different in DIN 4109 and VDI 4100. In DIN 4109 the building element-related quantities as R'_{w} and $L'_{n,w}$ and in VDI 4100 the reverberation time-related quantities as $D_{nT,w}$ and $L'_{nT,w}$ are used. The relationship between these two categories of quantities is discussed.

1. HISTORY

Soundproofing is of prime importance for buildings as well as for all infrastructural projects. It can have a vital influence on the health and well-being of people. The development on standards on sound insulation in Germany has a long tradition. The first standard DIN 4109 "Sound insulation in buildings" was published in 1959, Table 1. After the issue of DIN 4109:1989 (*DIN 4109,* 1989), a thoroughly revised draft standard was published in 2006 (*DIN 4109,* 2006). It contains modifications in those fields where building materials and construction methods have changed since 1989. Additionally, a change from building element-related quantities as R'_{w} and $L'_{n,w}$ to reverberation time-related quantities as $D_{nT,w}$ and $L'_{nT,w}$ was undertaken. However as a consequence of many objections especially from the industry, the DIN committee decided to keep the building element related quantities. The draft E DIN 4109:2006 was withdrawn.

Table 1: History of the DIN 4109 "Sound insulation in buildings" (Vogel, 2016)

1959	issue of DIN 4109 "Sound insulation in buildings":1959
1989	issue of DIN 4109 "Sound insulation in buildings": 1989
2006	publication of draft E DIN 4109:2006 Part 1 "Requirements" (introduction of reverberation time related quantities as $D_{nT,w}$ and $L'_{nT,w}$)
2011	decision by the DIN committee to keep building element-related quantities as R'_{w} and $L'_{n,w}$
2013	publication of a draft E DIN 4109:2013 with 4 parts
2014	objection process
07/2016	publication of a new issue of DIN 4109 "Sound insulation in buildings" with 4 parts

In 2013 a draft E DIN 4109:2013 with 4 parts was published. Part 1 contains the requirements based on building element-related quantities as R'_{w} and $L'_{n,w}$ (*E DIN 4109*, 2013). This draft contains modifications in the requirements in relation to the issue of 1989 in reaction of changes in building materials and construction methods. Furthermore modifications were made in reaction on court decisions.

2. DIN 4109:2016 SOUND INSULATION IN BUILDINGS

In July 2016 a new issue of DIN 4109 “Sound insulation in buildings” based on the draft E DIN 4109:2013 was published (*DIN 4109*, 2016). The standard consists of four parts:

- Part 1 “Minimum requirements”
- Part 2 “Verification of compliance with the requirements by calculation”
- Part 3 “Data for verification of sound insulation (component catalogue)”
- Part 4 “Testing of acoustics in buildings”

Table 2 shows the most important changes to the requirements by comparison to DIN 4109:1989. The requirements on air borne sound insulation were not modified for dwellings in multi-family buildings, however for partition walls of terraced houses and semi-detached houses. These requirements were increased by 2 dB to 5 dB to R'_w = 59 dB for receiving rooms on the ground floor and R'_w = 62 dB for other receiving rooms. The requirements on structure-born sound insulation have been raised for dwellings in multi-family buildings as well as terraced houses and semi-detached houses by 3 dB to 6 dB, Table 2.

Table 2: Requirements on DIN 4109:2016 and DIN 4109:1989

type of houses	**construction**	R'_w in dB		$L'_{n,w}$ in dB	
		1989	**2016**	**1989**	**2016**
dwellings	partition walls	53	53	-	-
	floors	54	54	53	50
	stairs	-	-	58	53
terraced/ semi-detached houses	partition wall	57	59/62	-	-
	floors	-	-	48	41/46

3. COMPARISON ON THE CALCULATIONS ACCORDING TO DIN 4109:2016 AND DIN 4109:1989

3.1 DIN 4109:1989

According to DIN 4109:1989, the sound reduction index for solid buildings is determined by the calculation method shown in Figure 1. The calculation consists of 3 steps. In the first step, it is assumed that the separating element has flanks with averaged area-related masses of m’=300kg/m². The sound reduction index for this case is indicated by $R'_{w,R(300)}$. In the second step, a correction on the right area-related masses of the flanks is done. In the third step, a facing formwork if existing is taken into account. According to this calculation there is only a rough correction on the area-related mass of the flanks and no consideration on the kind of joining between the flanks and the separating element (*DIN 4109*, 1989).

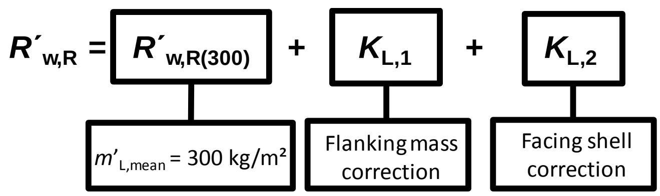

Figure 1: Calculating method according to DIN 4109:1989

3.2 DIN 4109:2016

According to DIN 4109:2016, the calculating method of the sound reduction index based on EN 12354 “Building acoustics – Estimation of acoustic performance of building from the performance of element” (*EN 12354*, 2000). The direct transmission path as well as all 12 flanking transmission paths are treated separately, Figure 2. The values $R_{Dd,w}$, $R_{Ff,w}$, $R_{Df,w}$ and $R_{fD,w}$, the sound reduction index for the direct and flanking transmission paths, can be determined either by DIN 4109:2016 Part 3 "Component catalogue" or from measured data at test rigs (*DIN 4109*, 2016).

$$R'_w = -10\lg\left[10^{-R_{Dd,w}/10} + \sum_{F=f=1}^{n} 10^{-R_{Ff,w}/10} + \sum_{F=f=1}^{n} 10^{-R_{Fd,w}/10} + \sum_{F=f=1}^{n} 10^{-R_{Df,w}/10}\right] dB$$

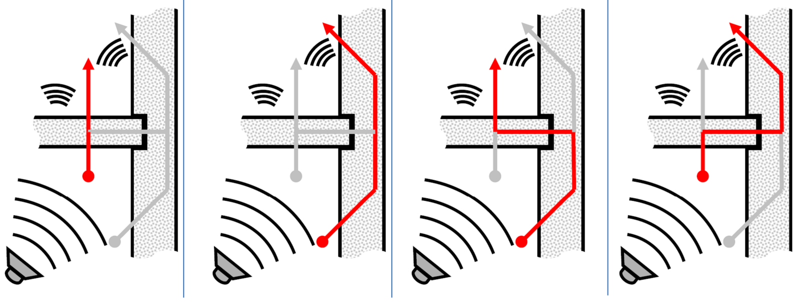

Figure 2: Calculation of the sound reduction index according to DIN 4109:2016 (Meier, 2010)

In the design process uncertainties which might be a result of different executions have to be taken into account by reduction of 2 dB. The amount of 2 dB is a result on a large number of comparative measurements carried out in test rigs (Scholl, 2012), (Vogel, 2015).

4. EFFECTS OF THE NEW CALCULATING PROCESS ON R'_w

To examine the effects of the calculating procedure according to DIN 4109:2016 in comparison to DIN 4109:1989, the sound reduction index of a reference structure shown in Figure 3 was determined. The relevant geometric and material specific data of the structure are given in Table 3.

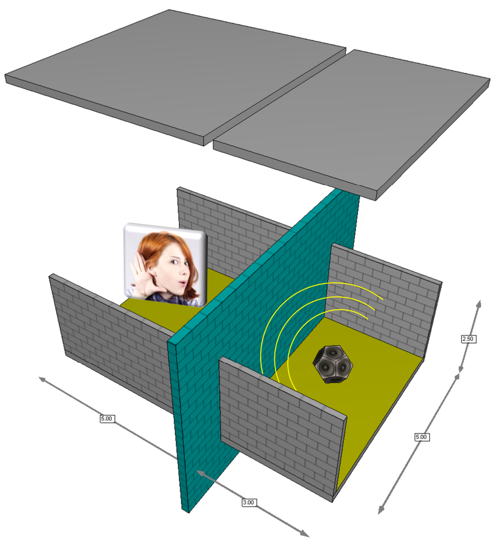

Figure 3: Reference structure

The influence of the sound reduction index on different kinds of joints between the flanks and the separating element was investigated by assuming the conditions shown in Figure 4-7. The calculation according to the old standard DIN 4108:1989 results in a sound reduction index of $R'_{w,R}$ = 55 dB for all cases of joining because the calculation method isn't sensitive on the kind of joints.

Table 3: Geometric and material specific data of the reference structure

	material	**area-related mass** in kg/m²	**thickness** in cm
partition wall with plaster	sand-lime bricks 1.8 kg/m³	482	24
flanking walls with plaster	sand-lime bricks 1.2 kg/m³	188	11,5
ceiling and floor	reinforced concrete with floating screed	377	16

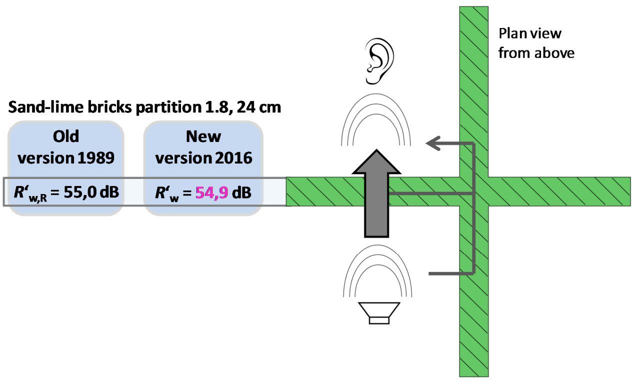

Figure 4: Rigid joint

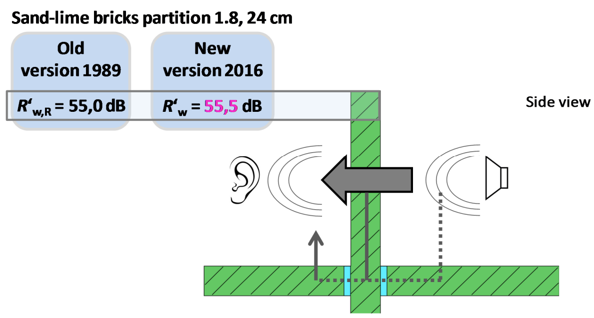

Figure 5: Decoupled ceiling and floor

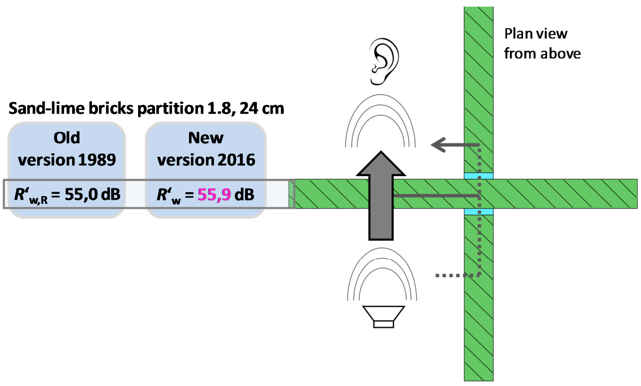

Figure 6: Decoupled flanking walls

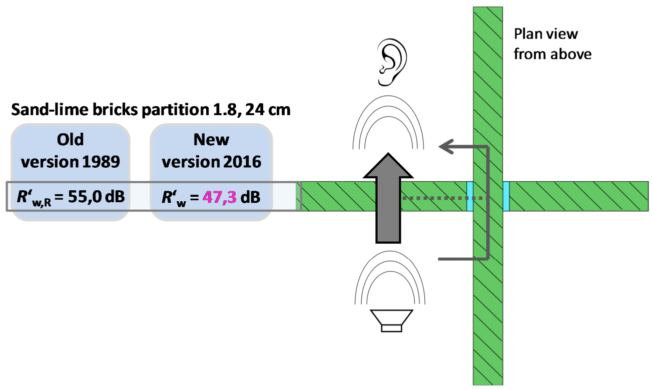

Figure 7: Continuous flanking walls

However the new standard DIN 4109:2016 is much more detailed. The different couplings result in different values for the sound reduction index, Figure 4-7 (Kornadt, 2015:43). Comparing the results three categories can be identified:

- **No effect**

  There are no significant differences between the methods of calculation according to DIN 4109:1989 and 2016 for the rigid coupling, Figure 4.

- **Increase of R'$_w$**

  The decoupling of continuous floors and the partition wall results in a slightly higher sound reduction index by calculating according to the new standard method of calculation for heavy partitioning components, Figure 5, 6.

- **Reduce of R'$_w$**

  In the case of a continuous flanking wall combined with a decoupling of the joints between the separating element and the flanks, an extremely high sound transmission via the flanks occurs. This leads to a distinct reduction in the sound insulation, Figure 7.

Figure 8 concludes the results for 6 different kinds of joints between the separating wall and the flanks. Additionally to the cases discussed in Figure 4-7 with a separating wall made of sand-lime bricks of a thickness of 30cm, wall thicknesses of 24cm and 17,5cm were also investigated and presented in Figure 8. The three cases mentioned above can be clearly identified. For continuous flanking walls combined with a decoupling of the joints between the separating element and the flanks the weighted sound reduction index is nearly identical for all investigated wall thicknesses. The sound transmission via the flanks dominates. Even a separating wall made of 30cm sand-lime bricks with a high reduction index for the sound transmission through the direct path cannot compensate the effect on a high flanking transmission (Kornadt, 2015:110). The influence of the formation of joints results in a difference of the weighted sound reduction index of 10 dB. However the 1989 standard does not reveal this effect with its simple calculation method. According to DIN 4109:1989, a figure of R'_w = 55 dB is obtained in all cases.

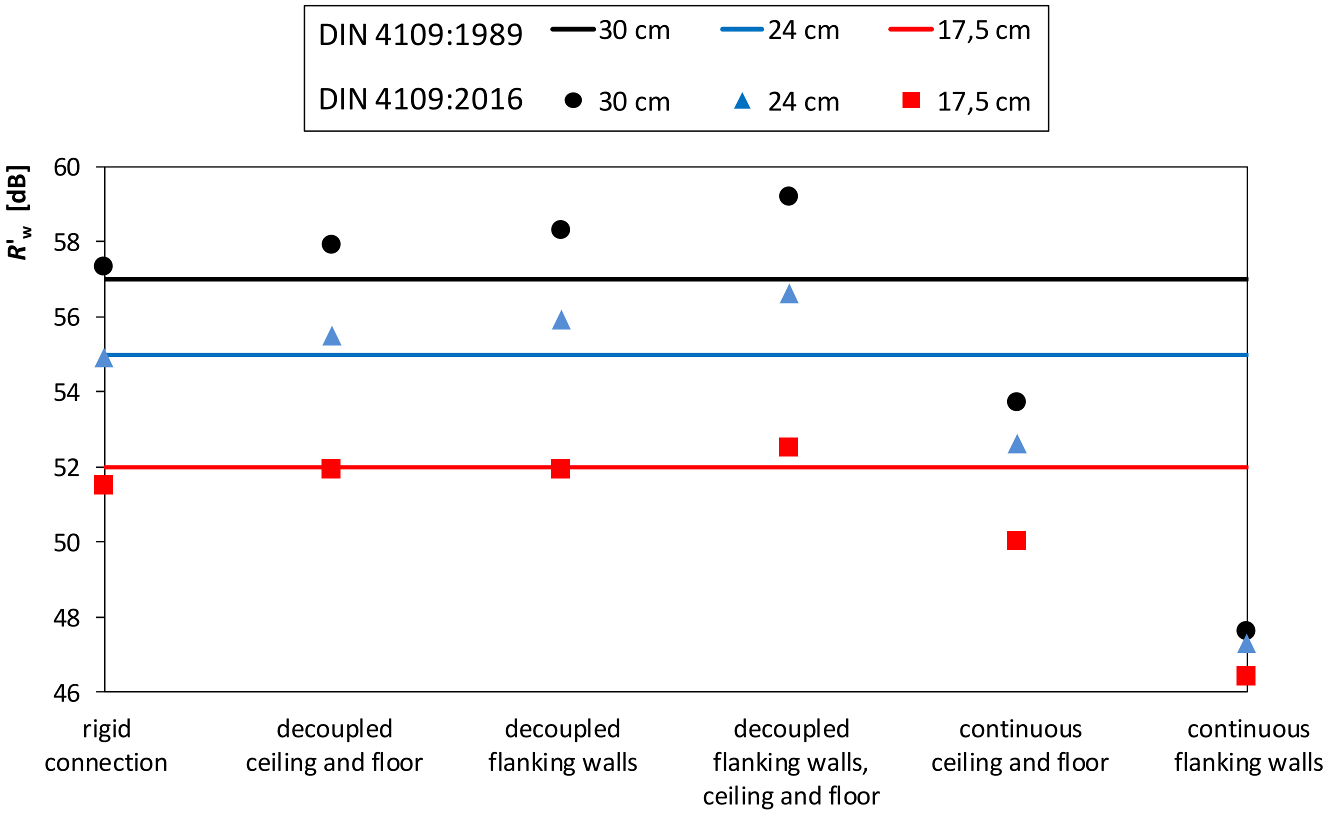

Figure 8: Weighted sound reduction index according to DIN 4109:1989 and DIN 4109:1989

To summarize, it can be stated that the balancing calculation method according to EN 12354 enables a very realistic soundproofing prognosis. Continuous components can considerably worsen the soundproofing. Disengaged components can distinctly improve this. This effect of decoupling was not taken into account in DIN 4109:1989, and led to considerable uncertainty amongst designers, executing companies and users. The method of calculation of

DIN 4109:2016 now provides considerably improved design security for all structures (Kornadt, 2015;110), (Vogel, 2016).

5. INCREASED SOUND INSULATION

DIN 4109:2016 indicates minimum requirements. However in many cases increased sound insulation is required. In Germany, guidelines for increased sound insulation are given in VDI 4100 "Sound insulation between rooms in buildings - Dwellings - Assessment and proposals for enhanced sound insulation between rooms" published by the association of German engineers (*VDI 4100*, 2012) and further recommendations. VDI 4100 defines four classes of sound insulation for the planning and evaluation of enhanced sound insulation for multi-family buildings, terrace and semi-detached houses. With the classes of sound insulation between rooms easy to handle decision-making tools are given to the user.

In VDI 4100 the characteristic quantities used for defining the requirements are reverberation time-related quantities as $D_{nT,w}$ and $L'_{nT,w}$. This can occur irritations as in DIN 4109 the characteristic quantities used for defining the requirements are building element-related quantities as R'_w and $L'_{n,w}$. For cuboid-formed receiving rooms with a volume according to Eq. (1) the mathematical relationship between the weighted sound reduction index R'_w and the weighted standard sound level difference $D_{nT,w}$ is given by the Eq. (2).

$$V = S \cdot l \tag{1}$$

where *S*: surface of the separating element
l: dimension of the room perpendicular to S

$$D_{\mathrm{nT,w}} = R'_{\mathrm{w}} - 10 \cdot \lg \frac{3{,}1\,\mathrm{m}}{l} \quad \text{in dB} \tag{2}$$

The sound energy that is transferred to a receiving room through a separating element and the flaks is determined by the building element-related quantity, R'_w. However, the sound pressure level in the receiving room depends not only on the introduced sound energy but also on the volume of the receiving room, in which the energy is distributed. As larger the volume of the receiving room as lower the sound pressure level in the receiving room. As a consequence of this, the weighted standard sound level difference $D_{nT,w}$ - indicating the soundproofing - increases by enlarging the size of the receiving room, Figure 9. For l = 3.1 m, R'_w and $D_{nT,w}$ are identical.

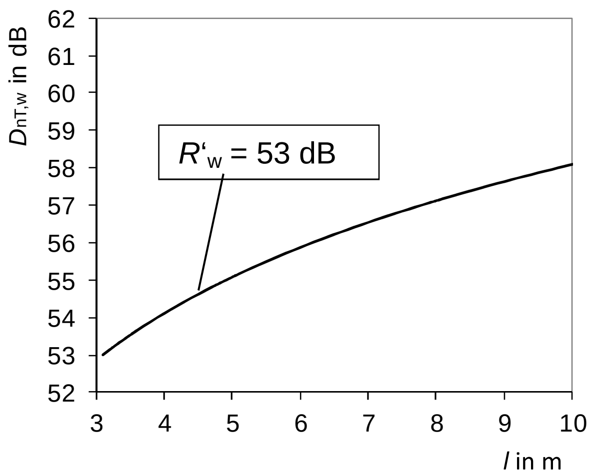

Figure 9: Relationship between R'_w and $D_{nT,w}$

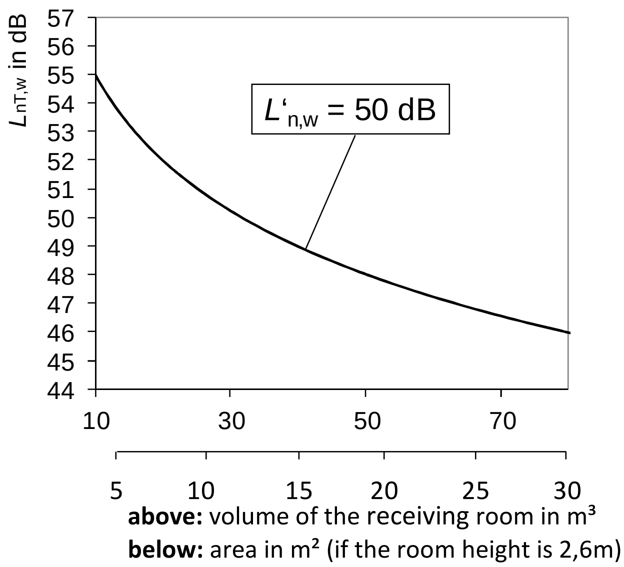

Figure 10: Relationship between $L'_{n,w}$ and $L'_{nT,w}$

A similar relationship is valid for protection against impact sound for the quantities $L'_{n,w}$ and $L'_{nT,w}$, Eq. 3 and Figure 10 (Kornadt, 2015:43).

$$L'_{\mathrm{nT,w}} = L'_{\mathrm{n,w}} - 10 \cdot \lg \frac{V}{\mathrm{m}^3} + 15\ \mathrm{dB} \tag{3}$$

6. CONCLUSIONS

In Germany, a new version of the standard DIN 4109 “Sound insulation in building” was published in July 2016. The requirements according to the new standard in comparison to the former DIN 4109:1989 are enhanced for terraced and semi-detached houses and for multi-family buildings for impact sound insulation. In DIN 4109:2016 the flanking transmission to calculate the sound reduction index is considered in detail according to EN 12354 “Estimation of acoustic performance of buildings from the performance of products”. This new calculation method results in a difference of the weighted sound reduction index up to 10 dB by comparison DIN 4109:1989 and DIN 4109:2016. Enhanced sound insulation are defined e.g. in VDI 4100 “Sound insulation between rooms in buildings - Dwellings - Assessment and proposals for enhanced sound insulation between rooms”. However in VDI 4100 reverberation time-related quantities are used as the characteristic quantities to define the requirements, whereas in DIN 4109 building element-related quantities are used. For given building element-related quantities, R'_w and $L'_{n,w}$, the soundproofing set by the reverberation time-related quantities, $D_{nT,w}$ and $L'_{nT,w}$, increases by enlarging the volume of the receiving room. In order to have more transparency for planners, architects, implementing companies, owners, users and others the aim should be to have the same characteristic quantities for minimum and enhanced requirements on the sound protection.

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