

assess impact sound right

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1. introduction

To protect against undue harassment from other residential areas will be provided in DIN 4109 [1], among others requirements for sound insulation of partition ceilings. These requirements can be met by today usual separation ceiling structure for faultless execution both in timber and massive construction problems. This is also reflected in quality tests on construction. Nevertheless, the impact sound transmission in surveys among residents of apartment buildings [2], [16] is usually called as the most annoying noise source.

Since the metrological detection of the requirements according to DIN 4109 is performed with a Tapping Machine as an excitation source, first, the match between the result of this measurement (the rated standard impact sound $L'_{n,w}$

respectively. $L_{n,w}$) and question the subjective feeling of the occupant in the conventional excitation by committing the ceiling. In Section 2 is this addressed the correlation between the subjective perception of the resident and rated according to DIN EN ISO 717-2 [3] standard impact sound. Alternative valuation methods that have been developed with the objective of a better match between hammer measurement and subjective feelings are compared in section third from target values are derived for the optimization of components in section. 4 A possible design implementation is proposed under section 5.

Second Correlation of $L_{n,w}$ and subjective perception

The correlation between the subjective perception of the resident and rated according to DIN EN ISO 717-2 [3] standard impact sound has been investigated already in various projects [9] - [16]. The results of these studies show relatively uniform that no useful correlation exists between the two sizes. To illustrate this result in Figure 2 Results of standard hammer mill measurements according to DIN EN ISO 140-6 and DIN EN ISO 10140-2 [4] are compared with the impact sound transmission in committing the ceiling (the measuring arrangement shown in Figure 1). For acoustically correct evaluation of the ceiling has been A-rated from the impact sound transmission when walking and reverberating corrected impact sound $L_{AFmax,n}$

educated. The individual points in Figure 2 left, each of which represents the result of a deck structure, show a very weak correlation. The measurements for this comparison were made as part of a student research project at the University of Rosenheim [6] and a research project of the ift Rosenheim [5]. Additional measurements were in the corporate test Knauf, Iphofen [7] carried out. The measurements thus carried out in three different sized benches and from different measuring teams, thereby uncertainties which are due to the limited dimensions test or the special excitation of a walker, could be reduced. To the suggestion in the commission of the ceiling to make reproducible, the relevant key data have been specified for the walkers. ¹

¹ Walkers male, 75-85 kg, walking on socks with 90-100 step / min. u in a circle. eight

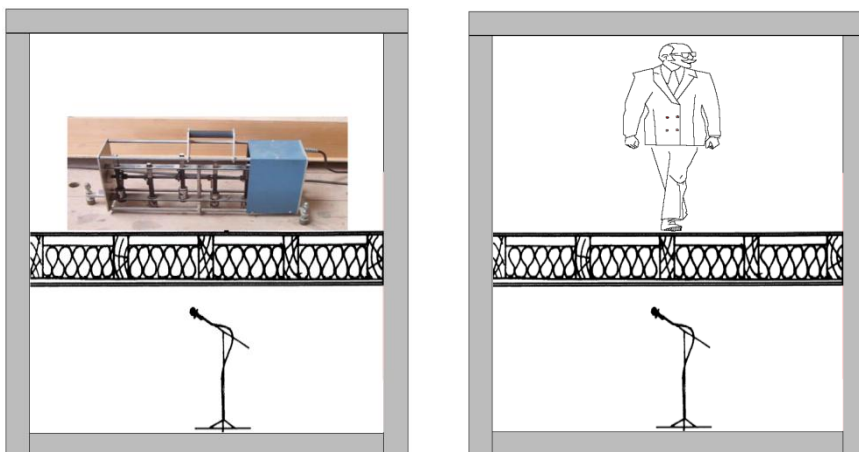


Illustration 1: Measuring the impact sound transmission of a ceiling. Links: impact sound excitation by the tapping machine. Right: excitation by committing the ceiling.

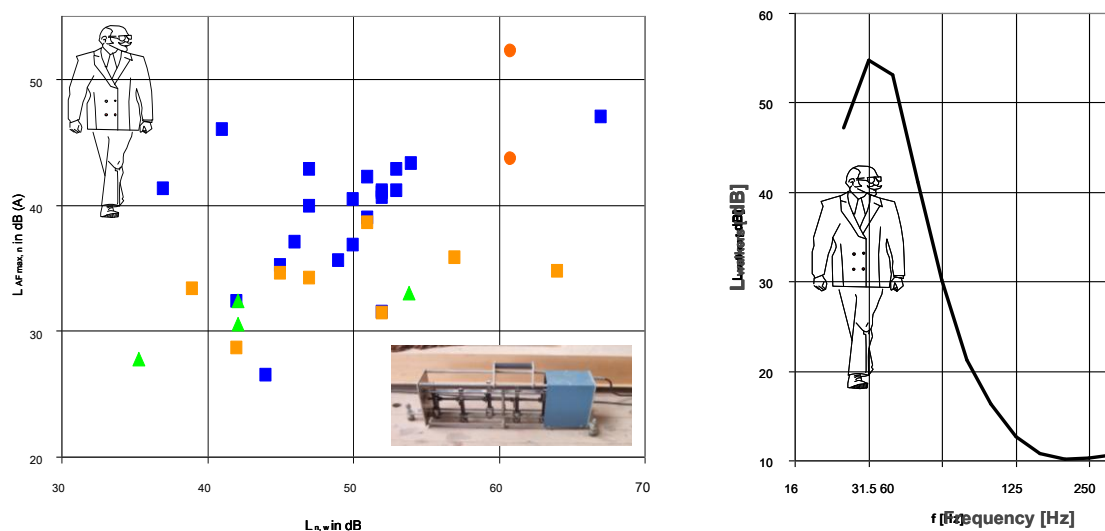


Figure 2: Correlation of $L_{n,w}$ and subjective feeling. Links: link between the evaluated standard impact sound level $L_{n,w}$ and the A-weighted impact sound level $L_{AFmax,n}$ when walking by wooden ceilings. Blue squares: Measurements at ift Rosenheim [5], orange circles: measurements at the HS Rosenheim [6], green triangles: measurements in the ceiling test stand by Knauf, Iphofen [7]. Right: Frequency-dependent representation of the impact sound transmission when walking on a blanket.

The cause of the weak correlation is shown in Figure 2 - shown to the right on the basis of frequency-dependent representation of a typical impact sound transmission when walking on a wooden ceiling. From the levels can be clearly seen that almost the entire transmission takes place below 100 Hz when walking on the ceiling. In contrast, in the evaluation of the standard impact sound according to DIN EN ISO 717-2 excluding the frequency range 100 to 3150 Hz for the single value ($L_{n,w}$) used. the $L_{n,w}$ can not therefore assess relevant to the subjective perception range below 100 Hz. A better correlation is thus accessible only by a changed evaluation of the standard impact sound.

Third Alternative assessment procedures

To address the problem of low correlation between real goer and the rated standard impact sound, was in DIN EN ISO a spectrum adaptation term C 717-2, introduced, which can also be applied for the extended downward frequency range up to 50 Hz ($C_{1, 50-2500}$). By additionally taking into account the spectrum adaptation value ($L_{n,w} + C_{1, 50-2500}$) the correlation is significantly improved, as Figure 5 shows (section 3).

In addition to this standardized method further alternative assessment procedures have been presented in the literature [17], [18], [19] whose value curves are shown in Figure 3.

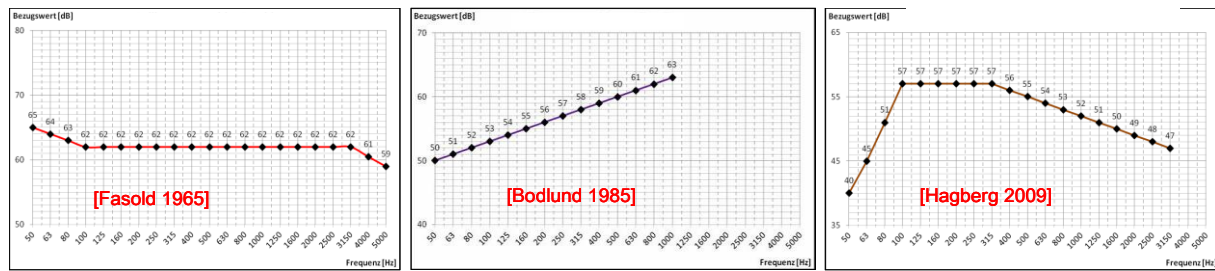


Figure 3: Alternative evaluation curves [17], [18], [19].

In order to compare the evaluation procedures, in first was the correlation between the $L_{n,w} + C_{l,50-2500}$ and the results of alternative valuation methods investigated [8]. This subject were 356 standard tests are used to wood ceilings from the database of the ift Rosenheim. As Figure 3 shows, for the two recent review process according to Bodlund [18] and Hagberg [19], the correlation is surprisingly good. It is therefore 717-2 expect no substantial difference to the standard procedure according to DIN EN ISO.

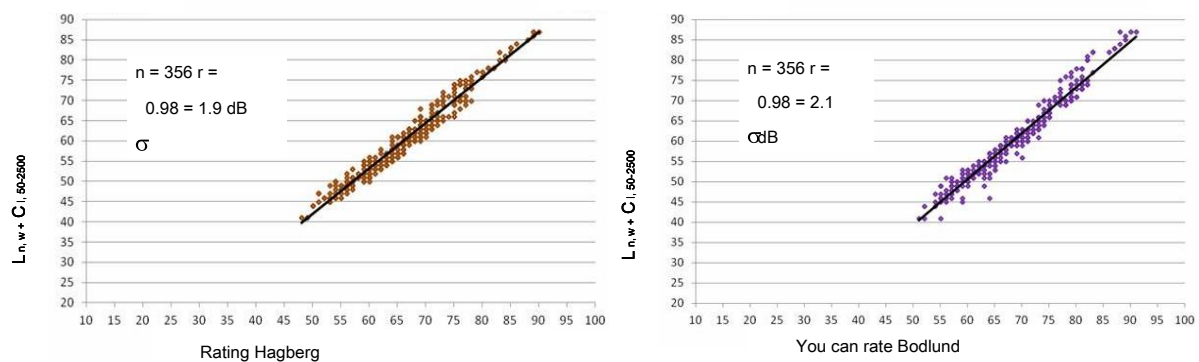


Figure 4: Correlation between $L_{n,w} + C_{l,50-2500}$ and the assessments as Bodlund [18] and Hagberg [19] Number of $n = 356$, correlation coefficient $r = 0.98$, standard deviation = 1.9 and 2.1 dB

4th Target values of component development

Before the correlation between $L_{AFmax,n}$ and $L_{n,w} + C_{l,50-2500}$ can be used for setting the target values is to question whether the assessment of the impact sound when walking on the ceiling is actually aurally by the common A-rating. For this purpose, in Figure 5 - much larger left the A Review of the impact sound and more accurate the rate Zwicker [20] compared. It is found that a good match can be achieved, at least for this type of excitation and in the relevant range of values between 25 and 45 dB (A).

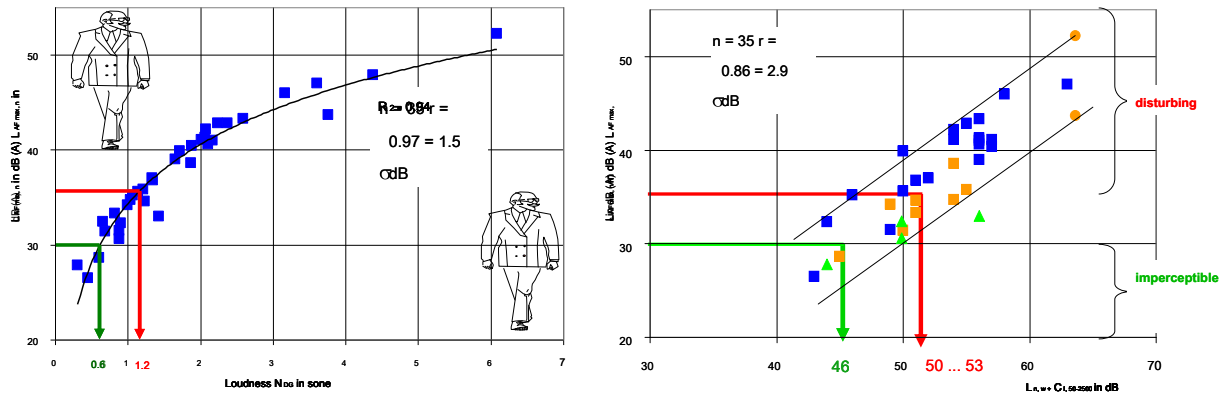


Figure 5: Target values for component development. Links: relationship between the $L_{AFmax,n}$ and loudness according to Zwicker [20]. Right: correlation between the $L_{AFmax,n}$ and $L_{n,w} + C_{i,50-2500}$

Figure 5 shows the right now clearly better link between the A-weighted impact sound leeches when walking on the ceiling and DIN EN ISO 717-2 with $L_{n,w} + C_{i,50-2500}$ rated Hammer plant measurements. This will also be seen that in Figure 2 - Correlation left shown, weak less by the type of excitation with the standard hammer mechanism than by the incorrect evaluation on the $L_{n,w}$ was caused.

Laying down the targets for good sound insulation the subjective perception can now be considered. In some European countries already implemented request to the $L_{n,w} + C_{i,50-2500} \leq 53$ dB [16] corresponds to in Figure 5 - to the right in about one $L_{AFmax,n} \leq 35-37$ dB (A). According to experience, is expected to above this limit with disturbing impact sound transmissions [13]. For a $L_{n,w} + C_{i,50-2500} \leq 46$ dB is the A-weighted impact sound level in approximately $L_{AFmax,n} \leq 30$ dB (A) and, depending on the ambient noise, barely perceptible. The these target values ($L_{n,w} + C_{i,50-2500} \leq 53$ dB or ≤ 46 dB) associated with the A-weighted impact sound level ($L_{AFmax,n} \leq 35$ dB (A) or ≤ 30 dB (A)) result in Figure 5 - the left half of the loudness, which is also in the subjective sensation of halving.

5th design implementation

For the design implementation in component development represent to acoustic optimization essentially two options. The increase in mass and improve the decoupling. By increasing the mass in the form of a Rohdeckenbeschwerung or a weighting of the suspended ceiling the excitability (admittance) is reduced and thus a lower noise emission. The decoupling by a floating screed or a suspended ceiling above the reduced sufficiently deep tuned resonant frequency of the transmission of the component vibrations within the structure.

The development of design tools for acoustically optimized ceiling structures on the basis of these approaches was made by numerical calculations of the impact sound transmission [5]. For this, a calculation model based on the finite was developed Element Method (FEM) at the Technical University of Munich and the basis of measurement results from the database of the ift soundproofing center validated. On the basis of the numerical calculations of the validated model the interactions of the ceiling components were investigated with little effort and optimized designs are developed. After the test measurement of the optimized structures, the results were supported by a systematic evaluation of the ceiling database on iftSchallschutzzentrum, collected in the form of construction aids (see Appendix) As an example of optimized ceiling structures, Figure 6 shows the comparison of the measurement results of a solid wood ceiling and a beamed ceiling with the standard impact sound levels of conventional reinforced concrete slabs. As an optimization approach, the sound-level (solid wood element or sub-ceiling) was complaining here.

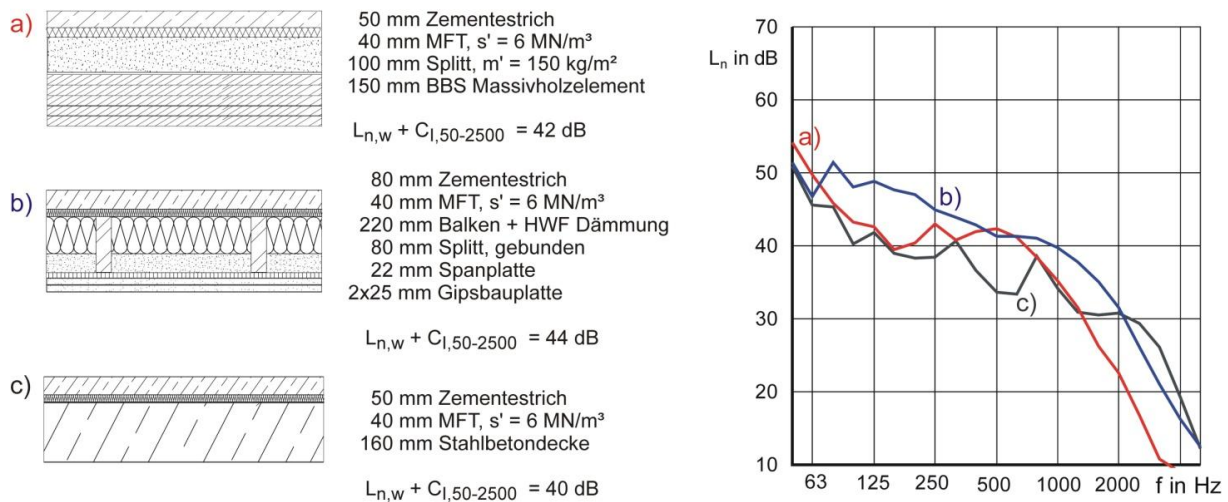


Figure 6: Observations optimized wooden ceilings by increasing the mass compared to reinforced concrete slabs [5]

An example of optimized ceiling by effectively decoupling shown in Figure 7. can be the comparison shows that with appropriate design, the good sound insulation of a reinforced concrete ceiling with much lighter ceiling reached.

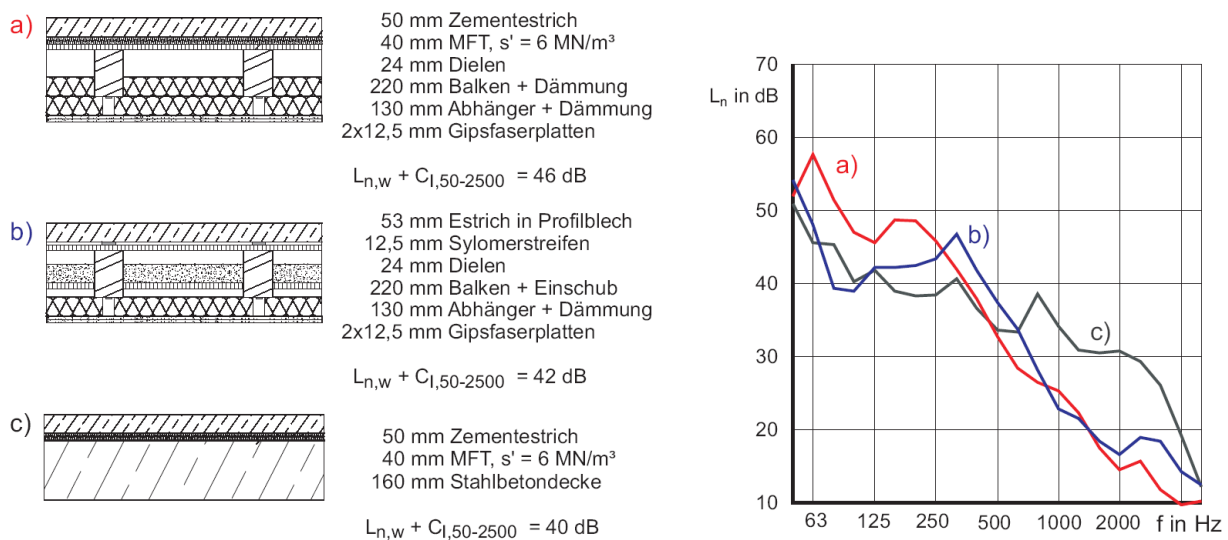


Figure 7: Measured values optimized by wooden ceilings suspended ceilings - new build and refurbishment contracts - compared to reinforced concrete slabs [21]

6th Summary

For the satisfaction of the resident with the sound insulation of the ceiling the subjective perception of the impact sound transmission shall prevail. As a measure of the subjective feeling of the A-weighted impact sound level can be used in committing the ceiling. Since between the A-weighted impact sound level and the $L_{n,w}$ as Einzählbewertung according to DIN EN ISO 717-2, a sufficient connection exists, was for setting the target values to be achieved, the additional assessment by the spectrum adaptation $C_{l,50-2500}$ used. Based on the now sufficient correlation could target values ($L_{n,w} + C_{l,50-2500}$ be set $\leq 53 \text{ dB}$ or $\leq 46 \text{ dB}$), and developed appropriately designed ceiling structures as "demonstrators". In the next step, these demonstrators are implementing optimized designs in cooperation with the manufacturers in cost benefits and to check the executed state in construction.

7th thanksgiving

The author would like to thank for helpful discussions and cooperation particularly with Prof. Schanda (HS Rosenheim), Dr. Rümmler and Mr. Seidel (Knauf Gips KG). And for the financial support of the AiF and the HAF in the cited projects.

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9th attachment

Konstruktionshilfen	Zielwert:			
	$L_{nw} + C_{1,50-2500} \leq 53 \text{ dB}$		$L_{nw} + C_{1,50-2500} \leq 46 \text{ dB}$	
	Verkehrslast		Verkehrslast	
	$p < 2,5 \text{ kN/m}^2$	$p < 5 \text{ kN/m}^2$	$p < 2,5 \text{ kN/m}^2$	$p < 5 \text{ kN/m}^2$
	$\geq 50 \text{ mm ZE, } m' \geq 120$ $\geq 40 \text{ mm TSD, } s' \leq 7$ $\geq 60 \text{ mm Splitt, } m' \geq 90 \text{ oder}$ $\geq 40 \text{ mm Betonpl., } m' \geq 100$ $\geq 13 \text{ mm V20, } m' \geq 7$ $\geq 24 \text{ mm Dielen, } m' \geq 11$ $\geq 200 \text{ mm Balken}$	$\geq 25 \text{ mm TE, } m' \geq 25$ $\geq 12 \text{ mm TSD, } s' \leq 40$ $\geq 120 \text{ mm Splitt, } m' \geq 180$ $\geq 13 \text{ mm V20, } m' \geq 7$ $\geq 24 \text{ mm Dielen, } m' \geq 11$ $\geq 200 \text{ mm Balken}$	$\geq 80 \text{ mm ZE, } m' \geq 190$ $\geq 20 \text{ mm TSD, } s' \leq 20$ $\geq 100 \text{ mm Splitt, } m' \geq 150$ $\geq 13 \text{ mm V20, } m' \geq 7$ $\geq 24 \text{ mm Dielen, } m' \geq 11$ $\geq 200 \text{ mm Balken}$	$\geq 80 \text{ mm ZE, } m' \geq 190$ $\geq 40 \text{ mm TSD, } s' \leq 7$ $\geq 100 \text{ mm Splitt, } m' \geq 150$ $\geq 13 \text{ mm V20, } m' \geq 7$ $\geq 24 \text{ mm Dielen, } m' \geq 11$ $\geq 200 \text{ mm Balken}$
	$\geq 50 \text{ mm ZE, } m' \geq 120$ $\geq 40 \text{ mm TSD, } s' \leq 7$ $\geq 60 \text{ mm Splitt, } m' \geq 90 \text{ oder}$ $\geq 50 \text{ mm Betonpl., } m' \geq 120$ $\geq 22 \text{ mm V20, } m' \geq 14$ $\geq 220 \text{ mm Balken + Däm.}$ $\geq 24 \text{ mm Lattung}$ $\geq 12,5 \text{ mm GKB, } m' \geq 10$ $\geq 12,5 \text{ mm GKB, } m' \geq 10$	$\geq 25 \text{ mm TE, } m' \geq 25$ $\geq 12 \text{ mm TSD, } s' \leq 40$ $\geq 30 \text{ mm Splitt, } m' \geq 45 \text{ oder}$ $\geq 50 \text{ mm Betonpl., } m' \geq 120$ $\geq 22 \text{ mm V20, } m' \geq 14$ $\geq 220 \text{ mm Balken + Däm.}$ $\geq 100 \text{ mm Abh. + Däm.}$ $\geq 12,5 \text{ mm GF, } m' \geq 13$ $\geq 12,5 \text{ mm GF, } m' \geq 13$	$\geq 50 \text{ mm ZE, } m' \geq 120$ $\geq 20 \text{ mm TSD, } s' \leq 20$ $\geq 60 \text{ mm Splitt, } m' \geq 90$ $\geq 22 \text{ mm V20, } m' \geq 14$ $\geq 220 \text{ mm Balken + Däm.}$ $\geq 100 \text{ mm Abh. + Däm.}$ $\geq 12,5 \text{ mm GF, } m' \geq 13$ $\geq 12,5 \text{ mm GF, } m' \geq 13$	$\geq 50 \text{ mm ZE, } m' \geq 120$ $\geq 40 \text{ mm TSD, } s' \leq 7$ $\geq 22 \text{ mm V20, } m' \geq 14$ $\geq 220 \text{ mm Balken + Däm.}$ $\geq 100 \text{ mm Abh. + Däm.}$ $\geq 12,5 \text{ mm GF, } m' \geq 13$ $\geq 25 \text{ mm GKB, } m' \geq 20$ $\geq 25 \text{ mm GKB, } m' \geq 20$
	$\geq 50 \text{ mm ZE, } m' \geq 120$ $\geq 40 \text{ mm TSD, } s' \leq 7$ $\geq 220 \text{ mm Balken mit}$ $\geq 220 \text{ mm HWF, druckfest}$ $\geq 22 \text{ mm V20, } m' \geq 14$ $\geq 25 \text{ mm GKB, } m' \geq 20$ $\geq 25 \text{ mm GKB, } m' \geq 20$			$\geq 80 \text{ mm ZE, } m' \geq 120$ $\geq 40 \text{ mm TSD, } s' \leq 7$ $\geq 220 \text{ mm Balken mit}$ $\geq 140 \text{ mm HWF, druckfest}$ $\geq 80 \text{ mm Splitt, geb.}$ $\geq 22 \text{ mm V20, } m' \geq 14$ $\geq 25 \text{ mm GKB, } m' \geq 20$ $\geq 25 \text{ mm GKB, } m' \geq 20$

ZE: Zement-, Anhydrit-, oder Flieseestrich mit der angegebenen flächenbezogenen Masse m' in kg/m^2
TE: Gipsfaser Trockenestrichelemente, mit der angegebenen flächenbezogenen Masse m' in kg/m^2
V20, Dielen: Verlegespanplatten und Massivholzdielen mit der angegebenen flächenbezogenen Masse m' in kg/m^2
TSD: Mineralfaser- oder Holzweichfaser Trittschalldämmplatte mit der angegebenen dynamischen Steifigkeit s' in MN/m^3
Splitt: Kalksplitt in Pappwaben, oder gebundener Splitt mit Latexmilch oder Zementemulsion, mit der angegebenen flächenbezogenen Masse m' in kg/m^2
Betonpl.: Betonplatten, auf der Rohdecke verklebt oder im Sandbett verlegt, Kantenlänge $\leq 0,30 \text{ m}$, mit der angegebenen flächenbezogenen Masse m' in kg/m^2
Balken, Däm.: Balkenlage nach Statik mit Hohlraumdämmung aus Faserdämmstoff, $d \geq 100 \text{ mm}$
HWF: Druckfeste Holzweichfaser Dämmplatte, Rohdichte $\rho \approx 140 \text{ kg/m}^3$
Lattung: Massivholzlatten, $24 \times 48 \text{ mm}$, geschraubt, geklammert oder genagelt, Achsabstand 417 mm
Abh.: Federschienen und Abhänger mit Entkopplung durch Sylomer und Hohlraumdämmung aus Faserdämmstoff, $d \geq 100 \text{ mm}$
GF, GKB: Gipsfaserplatten und Gipskartonplatten mit der angegebenen flächenbezogenen Masse m' in kg/m^2

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	$\geq 50 \text{ mm ZE, } m' \geq 120$ $\geq 40 \text{ mm TSD, } s' \leq 7$ $\geq 70 \text{ mm Beton, } m' \geq 170$ $\geq 150 \text{ mm MHD, } m' \geq 50$	$\geq 12 \text{ mm TE, } m' \geq 13$ $\geq 28 \text{ mm V20, } m' \geq 16$ $\geq 30 \text{ mm TSD, } s' \leq 15$ $\geq 120 \text{ mm Beton, } m' \geq 290$ $\geq 150 \text{ mm MHD, } m' \geq 50$	$\geq 80 \text{ mm ZE, } m' \geq 190$ $\geq 30 \text{ mm TSD, } s' \leq 15$ $\geq 120 \text{ mm Beton, } m' \geq 290$ $\geq 150 \text{ mm MHD, } m' \geq 50$	$\geq 50 \text{ mm ZE, } m' \geq 120$ $\geq 40 \text{ mm TSD, } s' \leq 7$ $\geq 120 \text{ mm Beton, } m' \geq 290$ $\geq 150 \text{ mm MHD, } m' \geq 50$
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Beton: Holzbetonverbund, mit der angegebenen flächenbezogenen Masse m' in kg/m^2
MHD: Brettstapel-, Brettstichholz-, Brettsperrholz-, Hohlkasten- oder Leimprofilholzdecken, mit der angegebenen flächenbezogenen Masse m' in kg/m^2 , Elementhöhe nach Statik