Acoustic optimization of Unterdeckenabhängern

Andreas Rabold [1.2] Benjamin Schoedel [1], Ulrich Schanda [1]

[1] *Technical University of Rosenheim, 83024 Rosenheim, email: andreas.rabold@th-rosenheim.de*

[2] *ift Rosenheim GmbH, 83026 Rosenheim*

introduction

Compared to conventional solid construction in the Residential and commercial offers the wood construction significantly greater design variety, on the one hand leaves a lot of room for maneuver, on the other hand poses a greater challenge to the building acoustic detectability.

To the current building acoustic requirements [1] in the evidence to meet while allowing economic ceiling structures, different constructive measures are possible. Floor structures, Rohdeckenbeschwerungen and ceilings reduce the airborne and impact sound transmission and are therefore interesting for to acoustic optimization.

In a recent project [2] the optimization of the false ceiling was favored by the involved timber associations for economic reasons. To this end, as part of a bachelor thesis at the Technical University of Rosenheim were investigated [3] the effectiveness of various Unterdeckenabhänger. The findings were used to optimize the ceiling structures, the were tested at ift Rosenheim below [2], [4].

This post is initially a on the basis used for the interpretation of the false ceiling and then displays results of the examined hangers and optimized ceiling structures.

Foundations for suspended ceilings

The improvement of airborne and impact sound through a suspended ceiling depends largely on the location of the natural frequency f_0 and the attenuation from the oscillatory system. Sufficiently far above the resonance frequency the recognizable in Figure 1 improvement occurs through the false ceiling. However, where the range of f_0 deterioration that depends on the magnitude of the damping.

The natural frequency of a mass-spring-mass resonance occurs here in the form can be produced by (1) the mass per unit area m_1', The dynamic rigidity of the trapped air layer s'And the mass per unit area m_2'The Unterdeckenbeplankungen be calculated.

$$f_0 = \frac{1}{2\pi}\sqrt{s'\left(\frac{1}{m_1'}+\frac{1}{m_2'}\right)} \qquad (1)$$

Is expected to have a significantly smaller value for the thus determined response of the suspended ceiling than the floor resonance so can for m_1'The grammage of Rohdeckenbeplankung including Rohdeckenbeschwerung and screed are used.

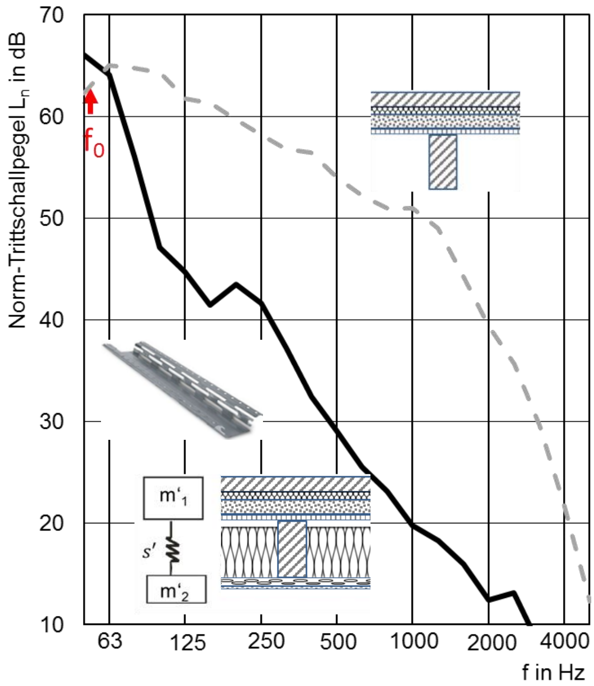


Illustration 1: Standard impact sound one open Beamed ceiling with Rohdeckenbeschwerung and floating floor compared to the same ceiling of suspended ceiling (spring rails). Position of the mass spring mass resonance f_0

However, the predictable according to (1) resonant frequency for the illustrated ceiling structure is significantly lower than would be expected according to figure 1. This suggests that in addition to the dynamic stiffness of the air layer, the spring stiffness of the Unterdeckenabhänger plays a role. Since this is a parallel connection of the two springs, the overall stiffness of the sum of individual rigidities can be determined.

• '= • ••••••ℎ••ℎ• + • ••ℎä•••• (2)

To a significant increase in mass of the mass-spring to avoid resonance by the additional stiffness of the suspension, this should be less than the stiffness of the air layer.

Optimization of the hangers

is to determine the properties of a spring Abhängers, as for the evaluation of impact sound insulation panels, measuring the natural frequency of the single-mass oscillator, an obvious method. For this, a test for determining the dynamic stiffness was used footfall sound insulation board, on the underside 4 hangers and a variable number were mounted on steel plates (see Figure 2).

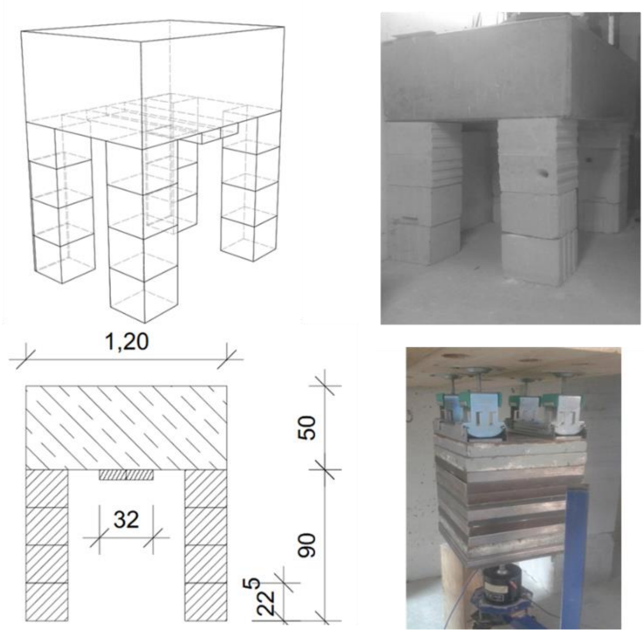


Figure 2: Test to determine the natural frequency of Unterdeckenabhängern. Left: Schematic diagram and dimensions. Bottom right: determining the natural frequency (in this case at the maximum load) by excitation with a shaker and measurement of the acceleration level at 3 impact sound sensor positions.

The measurements of the natural frequency were carried out at various Abhängertypen (see Figure 3).

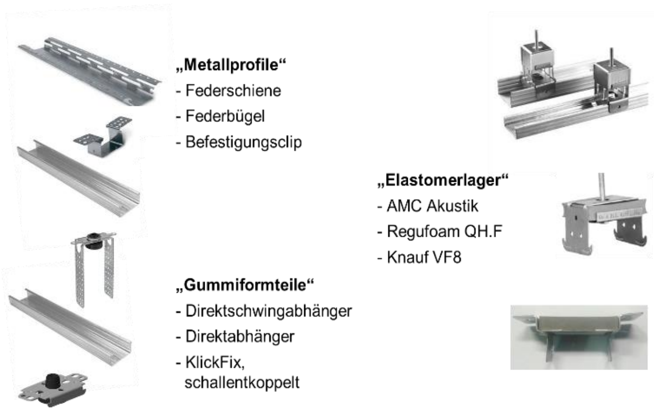


Figure 3: Investigated Unterdeckenabhänger

The measured natural frequency of the Abhängers $f_{0,\text{ hangers}}$ can be specified depending on the different load per hangers. Is the natural frequency used as the evaluation criterion, it should be smaller than if possible, the resulting solely from the layer of air mass spring mass resonance.

As a practical range of the natural frequency $f_{0,\text{ hangers}}$ can be used for the design of ceiling structures

$$12 \text{ Hz} \leq f_{0,\text{ hangers}} \leq 25 \text{ Hz}$$

be sought. the first natural frequency of the floor is here as the lower limit of f_0 recognized ≤ 10 Hz, which should not be achieved by the hangers for the sake of serviceability (vibration detection). The upper limit results from the objective to enable mass-spring-mass resonance <30 Hz. This also allows for the $L_{n,w} + C_{I,50\text{-}2500}$ favorable values are expected.

are measurement results of the natural frequency depending on the load

For various hangers with

Rubber molded parts or elastomeric bearings summarized in Figure 4. The metal profiles the spring rail commonly used was investigated.

your vibration

behavior did not show the expected spring properties but had two natural frequencies. The recognizable in Figure 1 resonant peak can be assigned to the second natural frequency of the spring rail rather.

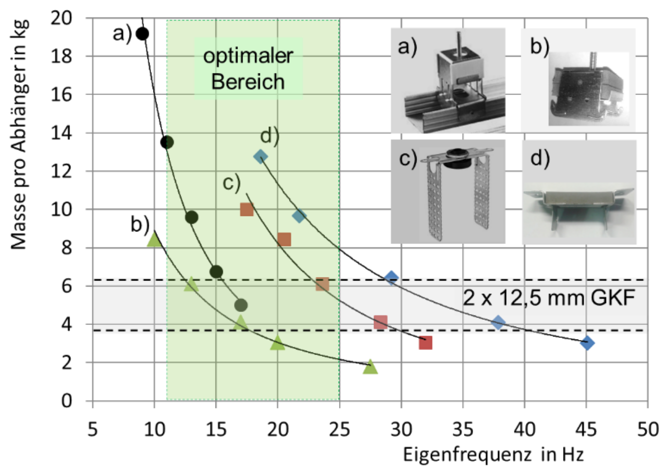


Figure 4: Natural frequency different Unterdeckenabhänger depending on the load mass in kg / hangers. In green: Optimal range 12 Hz ≤ $f_{0,\text{ hangers}}$ ≤ 25 Hz in gray: Typical loading area of the hanger for suspended ceilings clothing from 2 x 12.5 mm GKF

As Figure 4 shows, the natural frequencies for suspenders a) and b) for the displayed sub-ceiling lining (gray shaded area) are already in a favorable range, whereas hangers d) has significantly higher values. In order to achieve better decoupling here, a softer elastomer is loaded for ceiling tests and a natural frequency $f_{0,\text{ hangers}} <$ 25 Hz achieved.

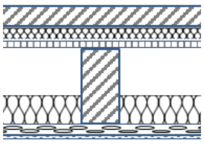
Suspended a) with two layers of cross-wise mounted C-profiles used, whereby a significantly reduced number of hangers and thus a higher load per hanger (been possible up to 13.5 kg / hangers). The resulting very low natural frequency and good decoupling on the other hand showed a greater material and installation costs, as well as a larger suspension height.

Optimized ceiling structures

For participating in the project [2] timber associations, the primary optimization criterion consisted in a ceiling structure corresponding to no extra Rohdeckenbeschwerung the current demands on Intermediate floor according to DIN 4109-1 [1]. The weighting should also be avoided for reasons of cost of both Static. A two-layer Unterdeckenbeplankung however, was neutral rated, as they often already necessary in the construction of flats due to the fire protection requirements. An increase in the insulation thickness

was in the bar space accepted, since the additional costs resulting are low.

Figure 5 and Table 1 show a typical in wood and prefabricated construction for Intermediate floor that will serve for the optimization as compared ceiling.



50 mm 40 mm 22 mm 220 mm 27 mm 12.5 mm

Cement screed MW footfall wood panel bar + 100 MW spring rail mm plasterboard

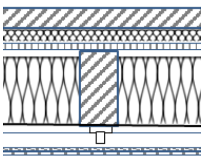
Figure 5: Ceiling mounted as compared ceiling

T able 1: Measurement and Pr O gnoseergeb nit

$f_{0,\ hangers}$	R_w	$L_{n,w}$	$L_{n,w} + C_{I,\ 50\text{-}2500}$	$L'_{n,w}$ 1)
-	70 dB	46 dB	53 dB	50 ± 3 dB

1) planked flanking Holztafelbauwände with GK + HWS

Based on this structure, the above optimization approaches have been implemented (see Figure 6). The lower blanket was charged with hangers d) of Figure 4 decoupled which is suitable according to the manufacturer's instructions for prefabricated ceiling elements.



50 mm 40 mm 22 mm 220 mm 57 mm 12.5 mm 12.5 mm

Cement screed MW footfall wood panel beam + 200 mm MW VF8 + lathing plasterboard plasterboard

Figure 6: Optimized ceiling structure with hangers d)

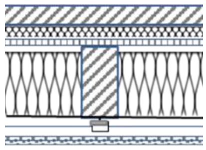
To the natural frequency of Abhängers to move in the desired range ($f_{0,\ hangers} \leq 25$ Hz), was a suitable elastomer used. The so-optimized design results in the desired target value for $L'_{n,w}$ at flanking Holztafelbauwänden in platform-framing construction with conventional planking and can additionally be a higher degree of prefabrication of the ceiling elements.

T able 2: Measurement and Pr O gnoseergeb nit

$f_{0,\ hangers}$	R_w	$L_{n,w}$	$L_{n,w} + C_{I,\ 50\text{-}2500}$	$L'_{n,w}$ 1)
22 Hz	80 dB	39 dB	50 dB	46 ± 3 dB

1) planked flanking Holztafelbauwände with GK + HWS

For an alternative structure a slightly stiffer and has been chosen thinner impact insulation that is better combined with heated screeds. The suspended ceiling was b with hangers) of Figure 4 uncoupled, which is designed for effective suspended ceiling assembly on site by dry construction companies. The remaining structure remained unchanged (see Figure 8).



50 mm 30 mm 22 mm 220 mm 70 mm 12.5 mm 12.5 mm [illegible]

Figure 7: Optimized ceiling mounted with suspenders b)

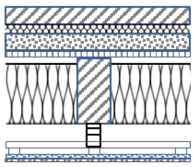
The natural frequency of Abhängers was $f_{0,\ Suspended}$ = perfectly matched 13 Hz. This resulted despite the stiffer impact insulation to the desired target values (see Table 3).

T able 3: Measurement and Pr O gnoseergeb nit

$f_{0,\ hangers}$	R_w	$L_{n,w}$	$L_{n,w} + C_{I,\ 50\text{-}2500}$	$L'_{n,w}$ 1)
13 Hz	82 dB	37 dB	49 dB	45 ± 3 dB

1) planked flanking Holztafelbauwände with GK + HWS

In a second project [4], the use of insulation material from renewable raw materials was the focus. For this wood fiber impact sound insulation boards were in Combination with a Rohdeckenbeschwerung and a Jute insulation between the joists used (see Figure 8). The false ceiling is decoupled with suspenders a) in Figure. 4 The Unterdeckenbeplankung was attached to cross-mounted CD profiles, reducing the number of necessary Unterdeckenabhänger significantly reduced and thus its impact could be increased.



50 mm 30 mm 60 mm 22 mm 220 mm 140 mm 12.5 mm 12.5 mm [illegible]

Figure 8: Optimized ceiling mounted with suspenders a)

The ceiling construction comprises an $L_{n,w} + C_{I,\ 50\text{-}2500}$ = 40 dB at low frequencies also values which are the comfort noise protection in the area. For the $L'_{n,w}$ The flanking transmission of the scheduled Holztafelbauwände forms a limiting size. Here a further improvement can be achieved through the use of installation levels as facings before the flanking walls.

T able 4: Measurement and Pr O gnoseergeb nit

$f_{0,\ hangers}$	R_w	$L_{n,w}$	$L_{n,w} + C_{I,\ 50\text{-}2500}$	$L'_{n,w}$ 1)
11 Hz	82 dB	30 dB	40 dB	45 ± 3 dB

1) planked flanking Holztafelbauwände with GK + HWS

The frequency-dependent comparisons of the structures are shown in Figure 9 and Figure 10 degrees.

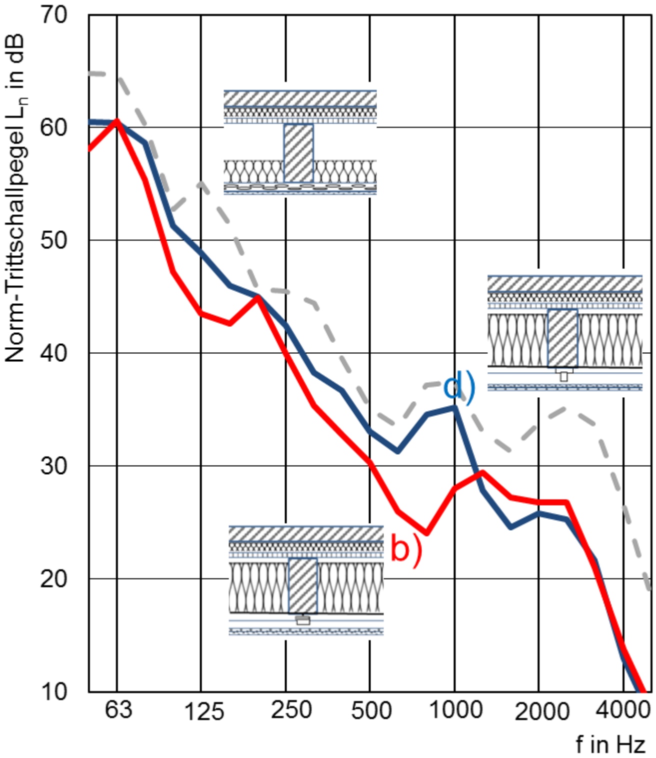


Figure 9: Standard impact sound of the comparison blanket according to Figure 5 as well as the optimized ceilings with the hangers b) and d).

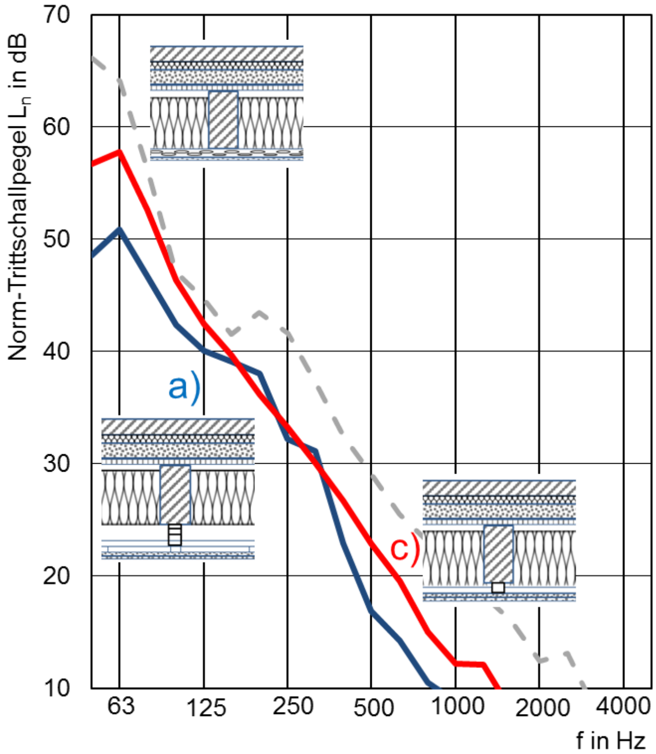


Figure 10: Standard impact sound of the optimized structures according to Figure 8 with the hangers a) and c) in comparison with a single-layer false ceiling to the spring rails. Suspenders a): $L_{n,w}$ = 30 dB, $L_{n,w} + C_{I,50\text{-}2500}$ = 40 dB hangers c): $L_{n,w}$ = 32 dB, $L_{n,w} + C_{I,50\text{-}2500}$ = 46 dB spring rail: $L_{n,w}$ = 36 dB, $L_{n,w} + C_{I,50\text{-}2500}$ = 54 dB

planning data

The planning data for the displayed ceiling structures were summarized in [5]. The parts catalogs contained therein originate from theses at the Technical University of Rosenheim and form the basis for the next revision round of component catalog in DIN 4109-33. The data are also deposited in VBAcoustic [6], a building acoustics planning tool for the prediction of airborne and impact sound insulation in the timber.

thanksgiving

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(FNR) with the

Project number 22,005,516th A second part of the component testing was funded by the DBU project

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literature

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