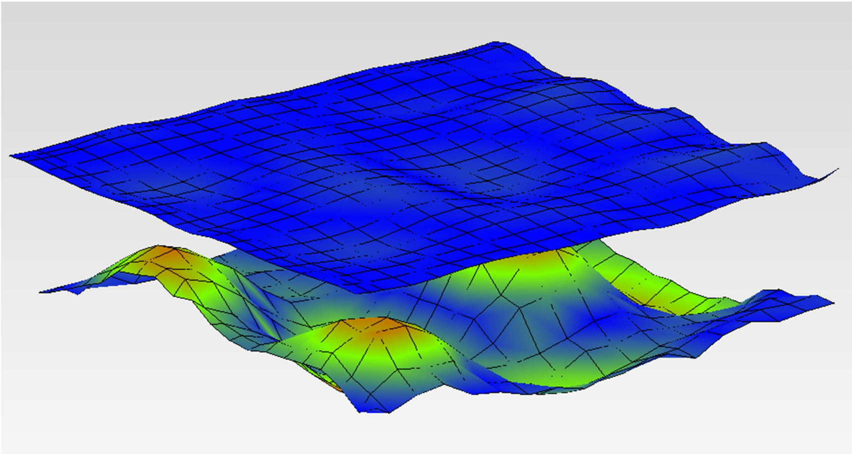
# Summary

## „Low frequency noise with floating screeds on concrete floors in residential buildings“

**SF-10.08.18.7-11.43**




| | |
|---|---|
| Applicant: | Bilfinger Berger Hochbau GmbH<br>Building Technology Center – Abteilung Bauphysik<br>Goldsteinstraße 114<br>60528 Frankfurt am Main |
| Project Manager: | Dr.-Ing. N. Langner |
| Research Institute: | Hochschule für Technik Stuttgart<br>Zentrum für akustische und thermische Bauphysik<br>Schellingstraße 24<br>70174 Stuttgart<br><br>Professor Dr.-Ing. H.-M. Fischer<br>Dipl.-Ing. (FH) M. Sc. M. Schneider |



The Authors acknowledge the financial support by the Bundesamt für Bauwesen und Raumordnung (BBR), Bundesinstitut für Bau-, Stadt- und Raumforschung (BSR)
(File no.: SF-10.08.18.7-11.43 / II 3-F20-10-1-082).

## Introduction

Floating floors are used to improve sound protection and to reduce impact noise of floors and can be seen as standard construction components in multifamily dwellings. While until 15 years ago complaints about poor impact insulation were mainly due to small carelessnesses during the construction process which resulted in sound bridges, in the last decade complaints were expressed that at low frequency a “rumbling” or “rattling” due to the floating floor disturbs residents. Thereby, measurements confirmed the proper construction and the fulfillment of the requirements according to DIN 4109 [1] as well as DIN 4109, Beiblatt 2 [2] or VDI 4100 [3].

The phenomenon of low frequency impact sound was described in different technical papers and publications (e.g. [4], [5], [6], [7], [8], [9]). Nevertheless, the reasons for the low frequency impact sound were not investigated thoroughly. The different ideas and theoretical explanations referring to the problem were never investigated in laboratory measurements nor in in-situ situations. Also some theories are contradictory which leads to an uncertainty in design and construction of floating screeds.

The following research project investigates the question of low frequency annoyance of impact noise when concrete slabs with floating floors are used. The disturbance of the impact noise is investigated with several impact sound insulation measurements on the building site and in the laboratory.

## Laboratory Investigation

A concrete slab (d = 140 mm), without and with screed (m' = 90 kg/m², s' = 15 MN/m³) was measured in the laboratory. Besides the standard measurements of the sound reduction index and the normalized impact sound pressure level (ISPL) additional investigations were performed. For example the velocity level differences between the concrete floor and the floating plate and the loss factor as well as a modal analysis were measured respectively specified.

The frequency transfer function of the velocity level at a certain reference point and the initiated force were determined for the characterization of the vibration behavior of a floating floor. Therefore, a grid with 360 raster elements was used at the soffit and for the screed on the top side of the floor a grid with 420 raster elements was measured. Each of the raster elements was activated with an “impulse hammer” as point source excitation which led to the vibration of the slab respectively the floating screed. The measured time signal of force and velocity was analyzed with a FFT-model, while the transfer function was calculated with the program ME’scopeVES. The related vibration pattern can be visualized and animated for each frequency within the scope of the measurement. The modal pattern of the concrete slab with floating screed at the first two frequencies (f = 22 Hz and 51 Hz) are shown in figure 1. When the concrete floor is excited by a single force at frequencies well below the resonance frequency, the floating screed and the concrete floor are strongly coupled and move in phase with nearly the same amplitude.

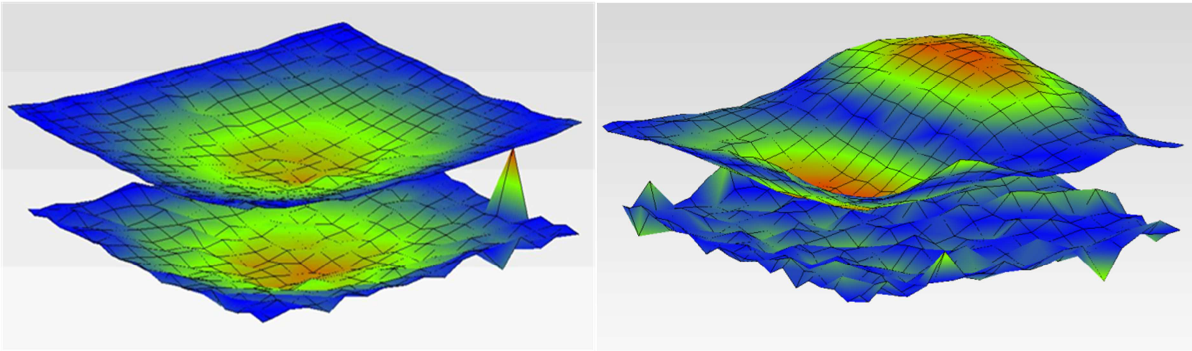


*Fig. 1: Measured amplitudes of the coupled systems floating screed (upper pattern) and concrete floor at f = 22 Hz (left) and f = 51 Hz (right).*

It seems that the floating screed and concrete floor move 180° out of phase in the frequency region around resonance. A high amplitude of the floating screed and different vibration patterns of the screed and the concrete floor characterize this frequency region (left picture in figure 2). The floating floor seems to be decoupled from the concrete floor at frequencies well above the resonance frequency. It can be seen that much smaller amplitudes of the floating screed and different vibration patterns of the two plates indicate the improvement of the resilient layer (right picture in figure 2) in this frequency region.

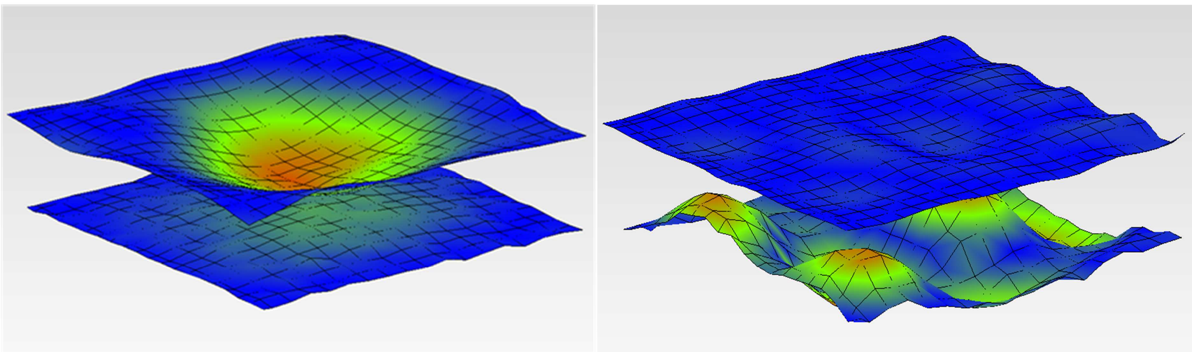


*Fig. 2: Measured amplitudes of the coupled systems floating screed (upper pattern) and concrete floor at f = 70 Hz (left) and f = 186 Hz (right).*

To evaluate the influence of the size of the floating screed, the screed was cut in smaller parts. That was done several times, by cutting the screed in half and again cutting the screed in half after the measurements. The measures normalized impact sound pressure level $L'_n$ of the floating screed, determined for screed fields of different sizes, is shown in figure 3.

Thereby, a correlation of the size of the floating screed and the measured normalized impact sound pressure level could not be found. The reduction of the size of the floating screed has no potential to improve the normalized impact sound pressure level in case of complaints about low frequency noise.

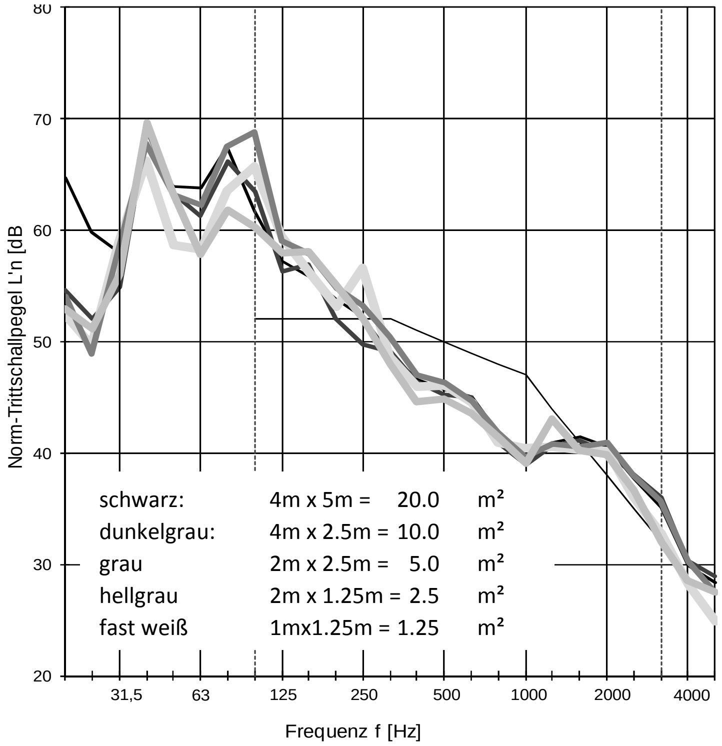



*Fig. 3*
*Normalized impact sound pressure level $L'_n$ of the floating sceed, determined for screed fields of different sizes.*

## Survey of Impact Sound Pressure Levels in Existing Multifamily Dwellings

Measurements on building sites were performed during the research project. Thereby, specific findings were made about the on-site performance of concrete floors and concrete floors with floating screed. Due to the fact that the buildings were still in construction, it was not possible to ask residents about their subjective impression (regarding the impact noise). To evaluate the annoyance of low frequency impact noise in existing multifamily dwellings, a survey among German building acoustic consultants was carried out in a Bachelor thesis [10]. The goal was to gain information about impact sound pressure level measurements on building sites with concrete slabs and floating floors.

The average of the two sets of measurements are displayed in the following figure 4: complaints (blue line) and approvals (red line). It can clearly be seen that there are only small differences in these sets of data above 125 Hz. People who complain about low frequency impact sound do have in the average 5 – 8 dB higher ISPL between 50 Hz and 125 Hz. The maximum of the $L'_n$ value is about 58 dB for the complaints and about 50 dB for the approval measurements. This maximum ISPL will probably appear at the same frequency when the floating floor is excited by the inhabitants and these sounds will be annoying, if they are above the background noise level.

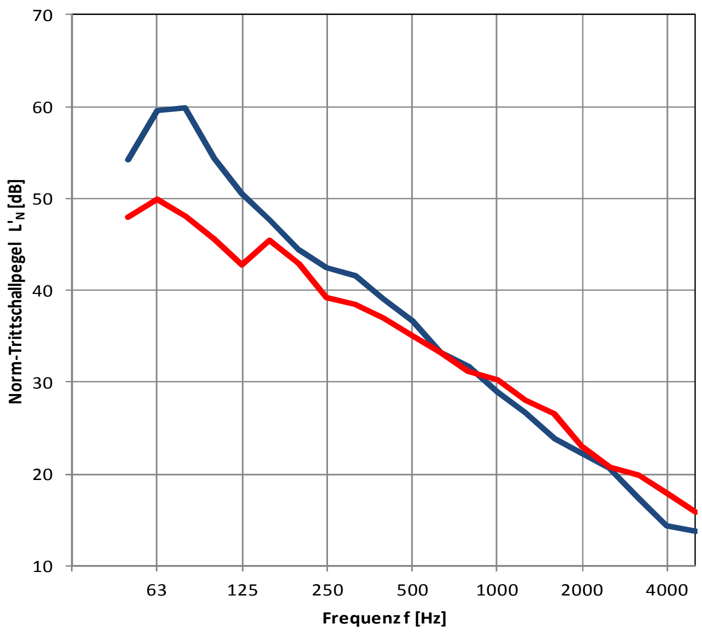



*Fig. 4*
*Mean values of the normalized impact sound pressure level measured on site, ordered due to quality assurance purposes (red) and based on complaints (blue).*

## Listening Tests

Listening tests were carried out with sounds, measured under a concrete slab with a floating floor. Different noise sources e.g. walking persons, standard tapping machine, Japanese rubber ball, heel drops etc. were used to generate the sound. To change the acoustic impression of the receiving room, the room was fitted with different amounts of absorption material to vary the reverberation times. And last but not least, some of the measured sounds were changed in there spectral composition by means of digital filtering. This change in the spectral composition of the sound can be seen equal to a change in the resonance frequency of the floating floor, which would also change the spectral components of the sounds.

The measurements for the listening tests and the listening tests [11] were done in the framework of two bachelor thesis at the acoustic laboratory of the Hochschule für Technik Stuttgart. The presentation of the different sounds and the questionnaire were divided into 4 sections. Section A handles the kind of excitation, section B the spectral contend of the signal, section C handles the influence of the room and section D was used to get an insight into the description of the sounds by the participants using different pairs of adjectives (e.g. loud – quite or damped – booming) for three different sounds with and without a floating floor.

The results of section A, where different kinds of excitation sounds were presented (all set to an equal Loudness of 3.9 sone), show that to push along a chair was the most annoying sound, whereas walking with sports shoes was least annoying; in between these two ratings were walking with heeled shoes, the Japanese rubber ball and heel drops. The significance of the result was not very high, probably due to the well-known fact that the loudness of the sound, which was here set equal, is most crucial to the annoyance.

Changing the spectral components of the signals, as seen for example in figure 5, does not have a significant effect on the annoyance of the sounds. Neither varying the low frequency peak in frequency nor broadening or narrowing the peak (maintaining the loudness of the sound) does change the rating of the sounds significantly.

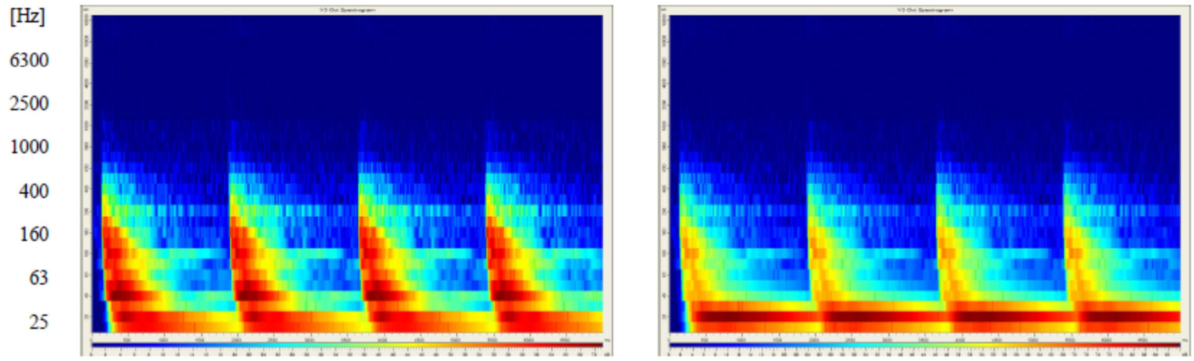



*Fig. 5: Spectrogram of the impact of a Japanese rubber ball. On the left the original third spectrum of the non-modified impulse is depicted, while the right picture shows the concentration of signal energy in low range frequencies. Thereby, the loudness of the signal was not altered [11].*

## Conclusion

The impact sound transmission of concrete floors can be reduced significantly with floating floors on top. It seems that residents may complain, if ISPL are above $L'_n$ = 50 – 60 dB in the frequency range of 50 Hz- 125 Hz. Therefore, it is necessary to take the spectrum adaptation term $C_{I50\text{-}2500}$ into account during the design process. To reduce the $L'_{n,w} + C_{I,50\text{-}2500}$ value significantly, it is necessary to design floating floors with resonance frequencies well below 50 Hz which can be achieved by using “soft” elastic interlayers with s´ < 10 MN/m³. Then it might be possible that the sound generated by the neighbor is below the background noise level and will therefore not be annoying.

Listening tests show that the kind of excitation will influence the annoyance. A floating floor reduces the annoyance. Long reverberation times in modern buildings with big sized (living-) rooms also have an influence on perceived loudness. Low background noise levels intensify the problem because in this case even low impact sound pressure levels can be noticed and may disturb.

For the future, a guideline to calculate and to reduce the maximum impact sound pressure levels has to be developed.

## Literature


[1] DIN 4109:1989-11: Schallschutz im Hochbau - Anforderungen und Nachweise, Beuth Verlag, Berlin

[2] DIN 4109 Beiblatt 2:1989-11: Schallschutz im Hochbau - Hinweise für Planung und Ausführung, Vorschläge für einen erhöhten Schallschutz, Empfehlungen für den Schallschutz im eigenen Wohn- und Arbeitsbereich

[3] VDI 4100:2012-10: Schallschutz im Hochbau, Wohnungen, Beurteilung und Vorschläge für einen erhöhten Schallschutz

[4] Burkhart, C.: "Tieffrequenter Trittschall – Messergebnisse, mögliche Ursachen“, Fortschritte der Akustik - DAGA 2002, Bochum.

[5] Burkhart, C.: "Tieffrequenter Trittschall – Messergebnisse, Beurteilung“, Fortschritte der Akustik – DAGA 2003.

[6] Siebel, A. C.: "Guter Trittschallschutz mit voller Dröhnung – zwischen Norm und Realität“, Lärmbekämpfung, Bd. 3, Nr. 4 (2008).

[7] Kühn. B.; Blickle, R.: "Untersuchungen zum Sonderfall des dröhnenden Unterlagsbodens“, Schweizer Ingenieur und Architekt Heft 46/1992 .

[8] Drechsler, A.; Fischer, H.-M., Scheck, J.: Structure borne – sound excitation and transmission of lightweight stairs, Forum Acousticum Budapest (2005)

[9] Schanda, U./Schramm, M.: Absorption tieffrequenten Trittschalls durch in Holzbalkendecken integrierte Helmholtzresonatoren, Forschungsbericht der Forschungsinitiative "Zukunft Bau", Z 6 – 10.08.18.7 – 08.19 / II 2 – F20-08-31(086)

[10] Rittig, C.: "Übertragung tieffrequenter Trittschallgeräusche auf Massivdecken mit schwimmendem Estrich“, Bachelorarbeit im Studiengang Bauphysik an der Hochschule für Technik Stuttgart (2013).

[11] Retzbach, S.: "Beschreibung tieffrequenter Trittschallgeräusche auf Basis von Hörversuchen“, Bachelorarbeit im Studiengang Bauphysik an der Hochschule für Technik Stuttgart (2013).

[14] Burkhart, C.: "Tieffrequenter Trittschall - Messergebnisse, Mögliche Ursachen", 28. Jahrestagung für Akustik an der Ruhr-Universität Bochum - DAGA 2002

[15] Burkhart, C.: "Tieffrequenter Trittschall – Messergebnisse, Beurteilung", 29. Jahrestagung für Akustik an der Rheinisch-Westfälischen Technischen Hochschule Aachen – DAGA 2003