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IMPACT NOISE FROM ONE STOREY TO THE NEXT STOREY – FROM SLAB ON THE GROUND AND SLAB BETWEEN FLOORS

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ABSTRACT

There are few studies or little information in the literature about impact noise from one storey to the next storey above. The issue is important when designing shopping centres or other facilities below apartments, when deciding the flooring to be used above the concrete slab. Measurement from apartment building in Kristiansand in Norway shows $L'_{n,w}$ 26 dB to the floor above (from one storey to the next storey above) when a 150 mm thick slab is used on the ground with gap to walls and columns. When slab on ground is in contact with concrete wall (no gap), $L'_{n,w}$ of 51-54 dB is measured to the floor above from a 90 mm slab on ground. Between floors with a main construction of 250-260 mm concrete, $L'_{n,w}$ of 61-65 dB is measured to the floor above. The measured impact level is higher from slab between floors than from ground, and no contact between wall and slab reduces the impact level significantly.

Keywords: *impact noise between floors, impact noise to floor above, impact noise from slab to above*

1. INTRODUCTION

Few or no studies have been made in field on impact noise from one storey to the next floor above [1]. This paper shows impact noise levels from slab on ground to the floor above, and from slab between floors to the next storey above. The issue is important when designing apartments or offices above shopping centres and other facilities. All measurements and analyses are from finished buildings in field with construction as summarized below.

2. MEASUREMENT METHOD

The impact noise levels were measured with tapping machine Norsonic 211 in finished buildings. The results are given for bare concrete slab, corrected for damping effect of floor coating or floating floor and to receiving room volume of 100 m^3. Above the concrete slab, there were different flooring for all the measurements as summarized in each chapter. The frequency spectrum is also given in figures for all measurements.

3. SLAB ON GROUND, IMPACT NOISE TO FLOOR ABOVE

3.1 Slab with airgap to surrounding walls and columns

One measurement was done in a building with parking basement on the ground and apartments in the floor above. For this situation the measurement was done directly on the bare concrete floor in the parking basement. The concrete floor was with gap to surrounding walls and all columns in the parking basement. The construction of the floor in the basement was:

- 150 mm thick concrete slab on 2 layers of plastic and gravel
- Gap to surrounding walls and columns

The receiving room volume was 100 m^3, and the measured $L'_{n,w}$ 26 dB. In general the impact levels are low, and in the lowest frequencies close to 30 dB. In figure 1 the measurement curve is given. The impact levels in the floor above are supposed to be due to movements in polystyrene and/or ground transferred up through walls and columns.

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This construction is transferring the highest levels in the low-frequency range.

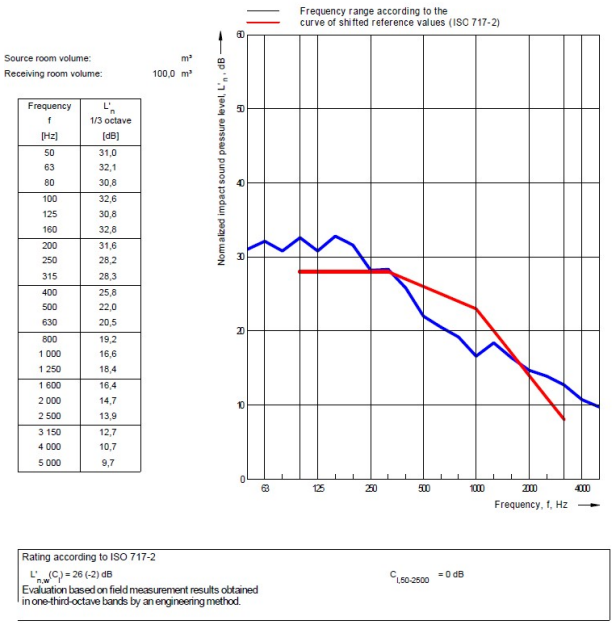


Figure 1. Impact noise from slab on ground to floor above. 150 mm concrete slab on 2 layers of plastic and gravel with gap to surrounding walls and columns.

3.2 Slab in contact with concrete wall

Other measurement for ground slab was done when the slab had contact with a concrete wall. Such a measurement was done in building with apartments on the ground floor and the floor above. The basement construction was as follows:

- Hard oak parquet
- 2 mm Selit pro parquet flooring
- 90 mm concrete slab
- 300 mm polystyrene

The measured L'$_{n,w}$ was 34 dB to receiving room volume of 100 m^3. The damping effect of the floor coating consisting of oak parquet and 2 mm parquet flooring is 17-20 dB [2] according to experiences in Norway. The impact noise level to the floor above is then L'$_{n,w}$ 51-54 dB for bare concrete slab in contact with concrete wall. In figure 2 it can be seen a much steeper curve from highest to lowest frequencies than in figure 1, and almost similar levels as in figure 1 for the highest frequencies. The effect of splitting a concrete slab against walls and columns is 25-28 dB for the L'$_{n,w}$-value. In the lowest frequencies the levels are 10-20 higher with contact between slab and wall than for the situation with no contact between ground slab and surrounding walls and columns.

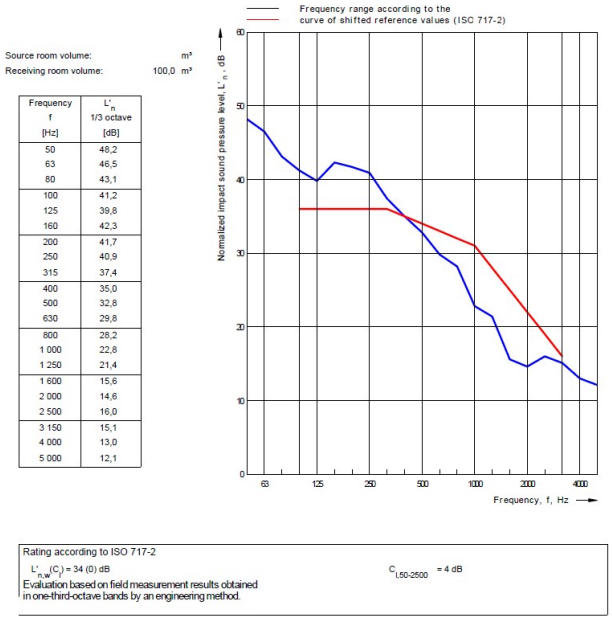


Figure 2. Impact noise from slab on ground to floor above, when the ground slab has contact with concrete wall. Measurement done on oak parquet.

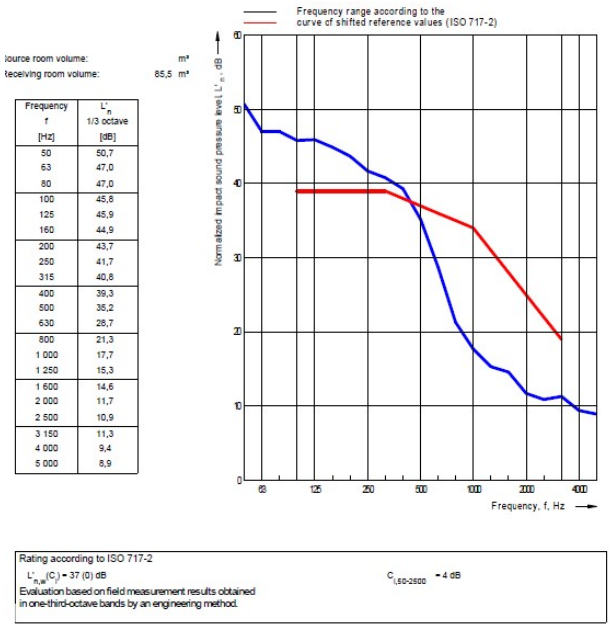
3.3 Slab on ground – lightweight walls

In a building with lightweight walls between apartments, two different measurements of impact noise to living room in the floor above were done. The lightweight walls were in contact with the concrete slab, and mounted directly to the concrete slab. Construction was as follows:

- laminate
- wool cardboard
- 100 concrete slab
- 100 mm polystyrene
- plastic film due to radon gas
- 150 mm polystyrene

The measured L'$_{n,w}$ was 37 dB and given in figure 3. The damping effect of the floor coating consisting of laminate on wool cardboard is 13-15 dB [2] according to experiences in Norway. The impact noise level to the floor above is then

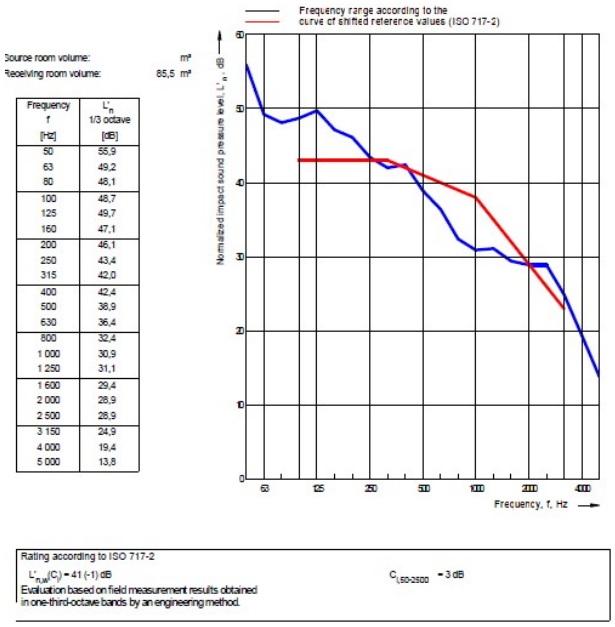
L'$_{n,w}$ 51-53 dB for bare concrete slab in contact to the floor above in building with lightweight walls.



Frequency f [Hz]	L'n 1/3 octave [dB]
50	50,7
63	47,0
80	47,0
100	45,8
125	45,9
160	44,9
200	43,7
250	41,7
315	40,8
400	39,3
500	35,2
630	28,7
800	21,3
1 000	17,7
1 250	15,3
1 600	14,6
2 000	11,7
2 500	10,9
3 150	11,3
4 000	9,4
5 000	8,9

Figure 3. Impact noise from slab on ground to floor above, in building with leightweight walls. Measurement done on laminate floor .

Similar result in the same building is from bathroom to living room, where the flooring was with vinyl coating. The measured L'$_{n,w}$ was 41 dB and given in figure 4. The damping effect of the floor coating consisting of vinyl coating is 7-10 dB [2] according to experiences in Norway. The impact noise level to the floor above is then L'$_{n,w}$ 49-52 dB for bare concrete slab in contact to the floor above in building with lightweight walls.



Frequency f [Hz]	L'n 1/3 octave [dB]
50	55,9
63	49,2
80	48,1
100	46,7
125	49,7
160	47,1
200	46,1
250	43,4
315	42,0
400	42,4
500	38,9
630	36,4
800	32,4
1 000	30,9
1 250	31,1
1 600	29,4
2 000	28,9
2 500	28,9
3 150	24,9
4 000	19,4
5 000	13,8

Figure 4. Impact noise from slab on ground to floor above, in building with lightweight walls. Measurement done on vinyl coating.

By comparing figure 3 and 4 with figure 1, it may be observed that the levels in the lowest frequencies (100-160 Hz) transferred through walls and columns in contact with a slab, are much higher than what is transmitted through movements in polystyrene or ground (figure 1).

4. SLAB BETWEEN FLOORS – IMPACT NOISE TO FLOOR ABOVE

4.1 Slab with no apartment (free space) below

Measurement was done for a slab between 3rd and 4th floor in apartment building, In this case, there was free space below the apartment in 3rd floor. The situation is shown in figure 5. The situation will affect the stiffness of the construction and the levels in the lowest frequencies. The floor construction was as follows:

- 15 mm parquet
- 35 mm putty compound
- 25 mm polystyrene

- 260 mm concrete slab
- 115-145 mm airgap with mineralwool
- 12 mm gypsum

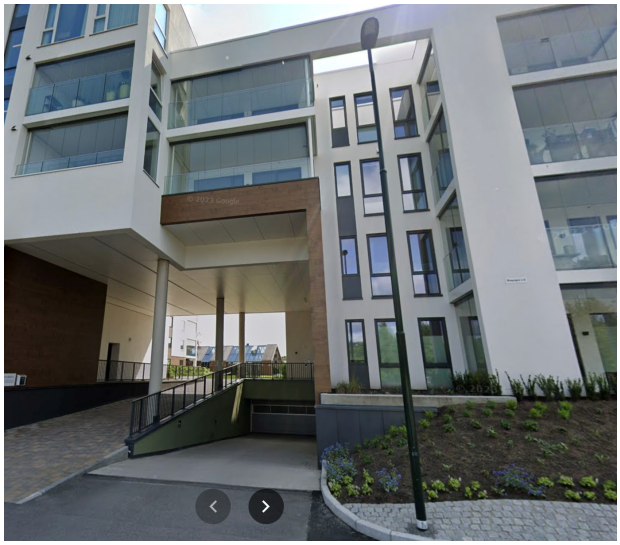


Figure 5. Picture of apartment with free space below where impact measurement was done to floor above.

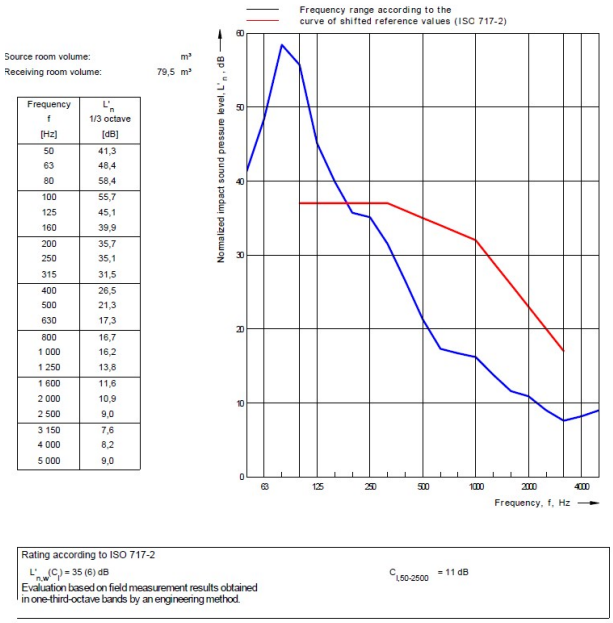


Figure 6. Measurement result to floor above with free space below.

The measurement was done to a room with receiving room volume of 80 m^3. The damping effect of the floor coating consisting of parquet, putty compound and polystyrene is 25-28 dB [2] according to experiences in Norway. The impact noise level to the floor above is then $L'_{n,w}$ 61-64 dB for bare concrete slab of thickness 260 mm and with receiving volume of 100 m^3. This shows that there in general is a need for a coating or floating floor, to satisfy the demands for impact noise values to the floor above in Norway. The impact levels to the floor above are quite high in 80 and 100 Hz compared to surrounding frequencies. Comparison of figure 6 with figure 1 and 2 verifies that there will be much more annoyance due to low frequency noise from a general slab between different floors than from a slab on ground.

4.2 Slab between floors – stiff fastened to concrete walls

Impact noise for a situation with concrete slab between floors of thickness 250 mm was measured. In this case there were concrete walls in the building with the concrete slab stiff fastened to these concrete walls. The construction was as follows:

- parquet
- 35 mm putty compound
- 25 mm polystyrene
- 250 mm concrete slab

The damping effect of the floor coating consisting of parquet, putty compound and polystyrene is 25-28 dB [2]. The impact noise level to the floor above is then $L'_{n,w}$ 62-65 dB for bare concrete slab of 250 mm and corrected to receiving room volume of 100 m^3. The result is shown in figure 7 below. Even with a floating floor (with no contact to walls) on slab between floors, there is still significant level of low-frequency noise transferred to the floor above.

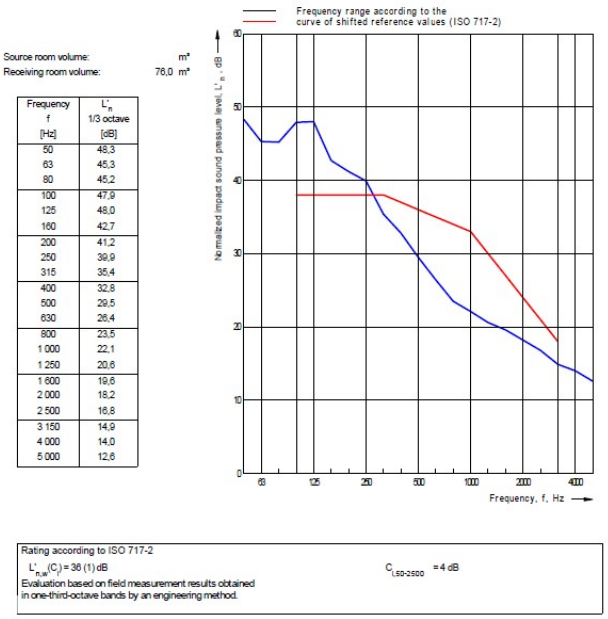


Figure 7. Measurement result to floor above from 250 mm slab between floors, stiff fastened to concrete walls in the building

4.3 Hollow core slab between floors – lightweight walls in building

Impact noise for a situation with hollow core slab between floors of thickness 200 mm was measured, between 1st and 2nd floor. In this case there were lightweight walls in the building between apartments. The construction was as follows:

- parquet
- 40 mm putty compound
- 30 mm impact reducing plate
- 280 mm polystyrene
- 200 mm hollow core slab

The damping effect of the floor coating consisting of parquet, putty compound and polystyrene is 30 dB [2]. The impact noise level to the floor above is then $L'_{n,w}$ 64 dB for bare hollow concrete slab of 200 mm and corrected to receiving room volume of 100 m^3. The result is shown in figure 8 below.

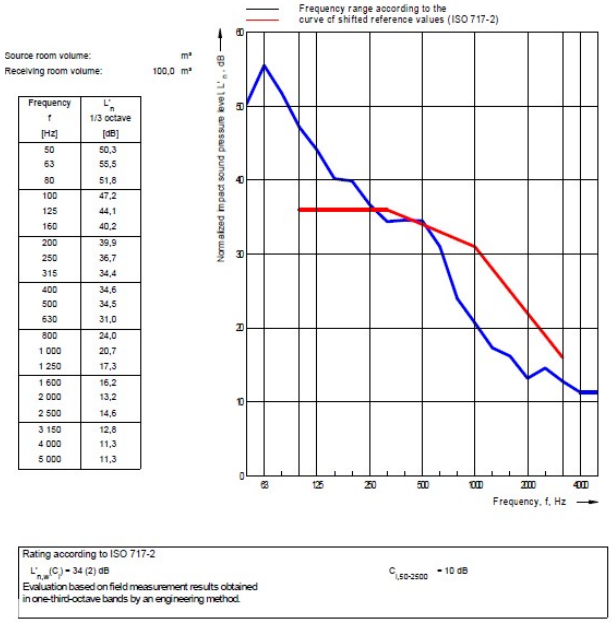


Figure 8. Measurement result to floor above from 200 mm hollow core slab between floors, lightweight walls in the building. The levels below 100 Hz is due to stiffness of the construction.

5. CONCLUSIONS

5.1 Slab on ground to floor above

Measurement shows $L'_{n,w}$ of 26 dB when slab on ground is with airgap to surrounding walls and columns, and with low levels of low frequency noise. When the concrete slab is in contact with concrete wall, columns or lightweight walls, the $L'_{n,w}$ for bare concrete slab to the floor above increases to 51-54 dB. The difference is 25-28 dB with connections to walls and colums, compared with the situation with airgap. To fulfill demands in Norwegian standard from shopping centre or parking basement to apartment ($L'_{n,w} \leq 48$ dB), there is a need for thick enough slab or a flooring reducing impact noise with 6 dB or more, when the slab is in contact with surrounding walls and columns.

5.2 Slab between floors

From slab between floors of concrete and thickness 250-260 mm to the floor above, impact noise from bare slab is

$L'_{n,w}$ 61-65 dB. There will then be a need for impact noise reduction of 13-17 dB to fulfill the requirement of $L'_{n,w} \leq 48$ dB from shopping centre to apartments above.

The measurements show approximately 10 dB higher $L'_{n,w}$ from a slab between floors to the floor above than from a slab on ground to floor above. The reason for this difference is thought to be due to different stiffness. By comparison of the levels from slab on ground with slab between floors, the main difference is related to the levels in the frequency range from 100-160 Hz. It can be seen that a slab between floors stiff fastened to concrete walls gives lower levels to floor above than other situations and is closer to impact noise from slab on ground. By comparison of concrete slab in buildings stiff fastened to concrete walls with concrete slab in buildings with lighweight walls, it can be seen much higher levels in the lowest frequencies for building with lightweight walls.

5.3 Consequences for solutions in buidlings

The measurements summarized from buildings show a need for a good enough solution with both slab on ground and slab between floors, to satisfy $L'_{n,w} \leq 48$ dB from shopping centre or parking basement to apartments in floor above for combined buildings.

6. SUMMARIZING POEM

Impact noise to storey above is studied by few
That's why this paper passed conference review
A splitted concrete slab on the ground
Is really the best for low impact sound
Connection with walls transfers frequency low
That is what this presentation should show
What damping you need on the slab below
Is after all this something you will know

7. ACKNOWLEDGMENTS

May I give my biggest acknowledgements to the companies Mur I Sør and Aamodt Bygg for data from measurements in their projects. In the future it would be interesting with more results and experiences from finished buildings. This could increase the knowledge and improve the necessary solutions in different buildings.

8. REFERENCES

[1] John LoVerde and Wayland Dong, Measurement of Lateral impact noise isolation, *24th International Congress on Sound and Vibration (2017)*.

[2] SINTEF: "522.513 Lydisolerende tunge etasjeskillere"