EFFECTS OF A CONCRETE TOPPING AND MODIFIED RESILIENT INTERLAYERS ON SOUND TRANSMISSION THROUGH A CONCRETE FLOOR

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1. INTRODUCTION

Concrete floors show good sound insulation properties. In this paper the effect of an added concrete topping on a resilient interlayer and its beneficial modification will be examined.

2. METHOD

2.2 Construction details

Assembly A shown in Figure 1 on the left, consists of a bare 150 mm concrete slab. Assembly B is the identical concrete slab with an added d=25 mm thick resilient interlayer and a 100 mm concrete topping. Assembly C on the right demonstrates the implementation of a modified interlayer of evenly distributed strips, covering 25% of the floor area.

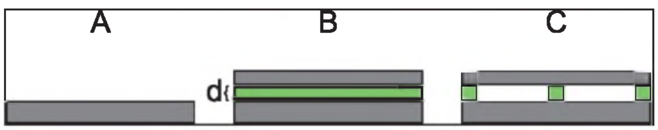

Figure 1: Sketch of the assemblies. Grey: Concrete; Green: Interlayer

2.1 Sources

The assemblies were evaluated using the standard airborne test (ASTM E90) and three standard impact sources: Tapping machine (ASTM E492, henceforth referred to as hammer), ball (JIS A 1418-2, ISO 140-11) and tire (JIS A 1418-2, KS F 2810-2). The standard impact sources can be seen in Figure 2 below and have been described in detail in an earlier paper [1].

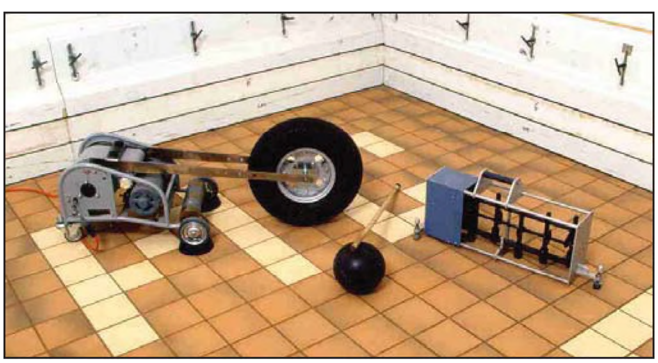

Figure 2: Standard impact sources. Tire, ball, hammer from left to right.

3. RESULTS

3.1 Bare concrete slab

Figure 3 shows the measurement results for the bare concrete slab. The tire causes the highest Impact Sound Pressure Level (ISPL), followed by the ball. Note that these two are the fast weighted maximum level of transient noise events. Compared to the other impact tests, the hammer induces more energy in the high frequency bands and therefore yields the highest signal to noise ratio in this range. The curve of the airborne test rises with increasing frequency, since it is displayed as Transmission Loss (TL).

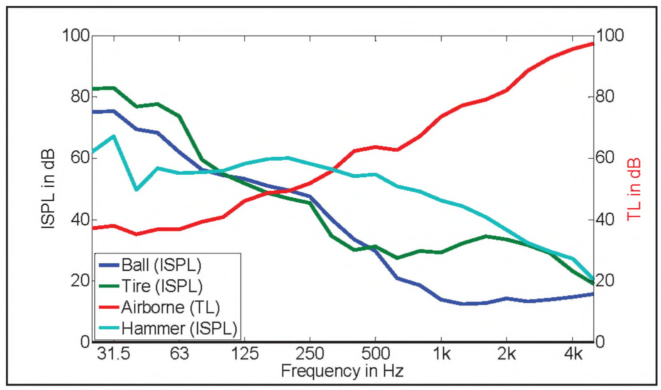

Figure 3: ISPL (left axis) and TL (right axis) measurement results for the bare 150 mm concrete slab.

Different measurements are limited in certain frequency ranges by the influence of background, application and flanking noise. The ball measurement reaches the background noise level at approximately 1 kHz. The same applies to the tire, although the level is significantly higher due to the application noise of the mechanical elements of the device (see Figure 2). The limitation due to flanking is slightly above the TL curve at high frequencies. This will be more apparent in the following measurements.

3.2 Concrete slab with concrete topping and full interlayer

Figure 4 shows the differences between the assemblies A and B. The added concrete topping on the full interlayer provides a major improvement in sound insulation.

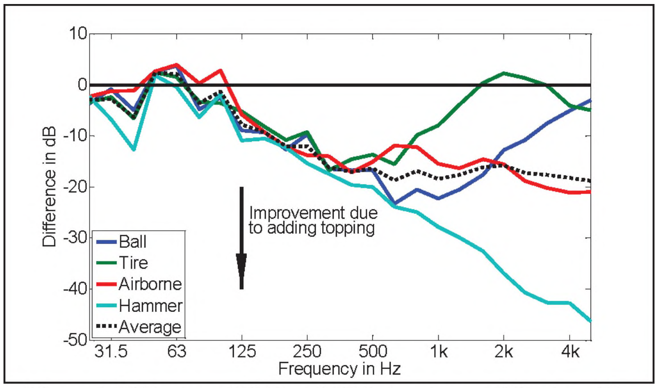

Figure 4: Difference of ISPL and TL between assemblies A and B.

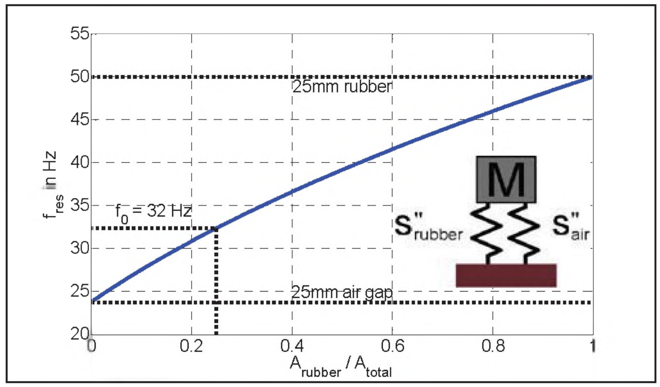

Figure 5: Nominal resonance frequency for different interlayer/air ratios.

The ball and tire measurements are limited by background noise in the high frequencies, thus the differences approach zero. The airborne measurement is restricted by flanking. Therefore there is no further improvement above 1 kHz. The noticeable worsening for the tire measurement at 2 kHz arises from different levels of application noise and can be considered as measurement uncertainty. The results of the hammer match the theory throughout the whole frequency range.

According to Cremer's parallel plate theory [2], if the upper plate is less stiff and has less mass than the lower plate, then the ISPL decreases above the fundamental resonance frequency with 6db/octave. This coincides with the theory of a simple spring mass system on a rigid foundation as investigated below. Such a simplified model is considered valid due to the big bending wave lengths of the regarded frequencies in concrete. The shape of the hammer curve confirms the validity and the fundamental resonance can be identified in the 50 Hz band in Figure 4. The sound insulation can be improved even more by shifting this resonance to lower frequencies.

3.3 Concrete slab with concrete topping on a modified interlayer

As afore mentioned, assembly B can be considered a simple spring mass system at low frequencies. This is represented in the sketch at the bottom right corner of Figure 5, with only the spring component of the resilient interlayer (s''_{rubber}). To shift the fundamental resonance frequency, the area of the rubber can be reduced, causing a rubber dependent and an air dependent spring to act in parallel. The estimate of the stiffness per area of the interlayer itself can be found by using Eq. 1 with Eq. 3 and the resonance frequency of assembly B (50 Hz).

$$\omega = \sqrt{\frac{s''_{rubber}}{m''_i}} \quad \text{Eq. 1;} \qquad \omega = \sqrt{\frac{s''_{rubber} + s''_{air}}{m''_i}} \quad \text{Eq. 2;}$$

$$m''_i = 246 \, {kg}/{m^2} \quad \text{Eq. 3} \qquad s''_{air} = \frac{\rho c^2}{d} \quad \text{Eq. 4}$$

With Eq. 2 for the resonance for the partial interlayer and Eq. 4, the resonance depending on the ratio of the interlayer and air areas can be computed as shown in Fig. 5.

For assembly C, a ratio of 0.25 was chosen, to theoretically shift the fundamental resonance to 32 Hz. The interlayer was cut into strips, filling out 25% of the area.

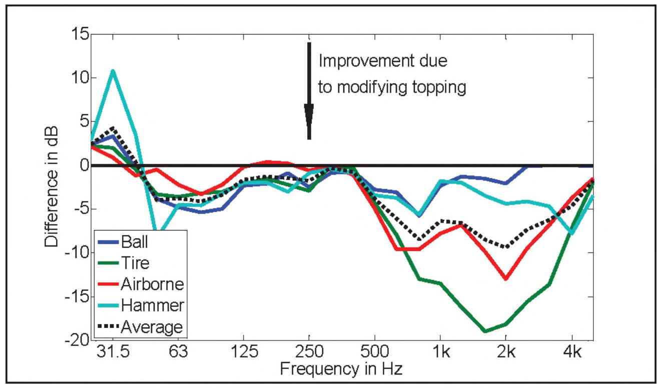

Figure 6: Difference of ISPL and TL between assemblies B and C.

Figure 6 shows the improvement of assembly C compared to assembly B. The fundamental resonance is, as calculated, shifted to the 31.5 Hz band. The new assembly has a similar improvement for all measurement methods up to 500 Hz. The deviations for the tire, ball and airborne tests are again caused by the previously mentioned measurement uncertainties and noise limitations.

4. CONCLUSION

The concrete topping and resilient interlayer improve the sound insulation properties of the concrete floor. Modifying the interlayer optimizes the results by lowering the fundamental resonance frequency of the resulting spring mass system. In this study the STC/IIC was improved from 52/28 (assembly A) to 65/58 (B) and to 66/60 (C). The interlayer strips, which introduce a directional pattern, influence the bending wave attenuation and thus the flanking transmission. Future investigations are planned.

REFERENCES

[1] Zeitler, B. et al. (2010). Parametric Study of Sound Transmission through Lightweight Floors. Proceedings of Inter-Noise 2010, Lisbon 2010

[2] Cremer, L., Heckl, M. (1996). Koerperschall. Springer