Comparing low frequency impact noise using a tapping machine and heavy/hard impact source on various fitness floor assemblies

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ABSTRACT

Energy introduced into a concrete slab by a tapping machine is not sufficient to simulate much larger impact levels as seen in fitness areas. Excitation of the slab is not seen at the lower frequencies, due to the low energy transmission of the tapping machine hammers. When a 7 kg spherical weight is dropped from a height of 1 m and the results are measured using 5 velocity sensors placed radially from the underside concrete slab center, drastically different results are observed in the calculated velocity level values, when compared to tapping machine results. These results are seen in the tested performance of different fitness floor assemblies. The added benefit of using slab-mounted velocity sensors allows for readings to be taken at lower than the 100 Hz one-third octave band. Additionally, placing the sensors radially from the underside concrete slab center allowed for the analysis of energy decay rate as a function of distance from the impact source.

1. INTRODUCTION

Vibration created from weights dropped in fitness facilities radiate throughout a building to a substantial degree due to the high energy transfer associated with the impact of the weight with the floor. Depending on the construction of the building, the nature of the exercises and the size of the weights, vibrations can be heard as much as thirteen stories above or below the fitness facility. In order to mitigate this issue, resilient fitness flooring must be installed. Depending on the application, a specific thickness and design must be chosen in order to best meet the required sound attenuation levels of the fitness facility in question.

2. APARATUS AND PROCEDURE

In order to determine the sound attenuation levels of two fitness flooring materials (a 30 mm and 70 mm thick product), two separate tests were completed. The first was an impact insulation class (IIC) test with a 8 mm rubber rollgood used as a baseline. The second was a heavy/heard impact test using a 7 kg spherical weight (bowling ball) dropped from a 1 meter height with a 2 mm rubber rollgood product as a baseline. The rollgood, baseline products were required in order to protect the slab from cracking when the bowling ball was dropped. Both tests were conducted on a 6 in concrete slab in a laboratory. Measurements below the slab were recorded by both a microphone, measuring sound pressure level for the IIC tests, and five velocity sensors. The velocity sensors were attached to the underside of the slab, radially from the center outwards, as seen in Figure 1, for the heavy/hard impact tests. Measurements from the five velocity sensors were recorded using a five channel analyzer, Norsonic Nor850. The velocity sensors allowed for accurate measurements below 80 Hz and also provided information on how the vibrations dissipated away from the impact location.

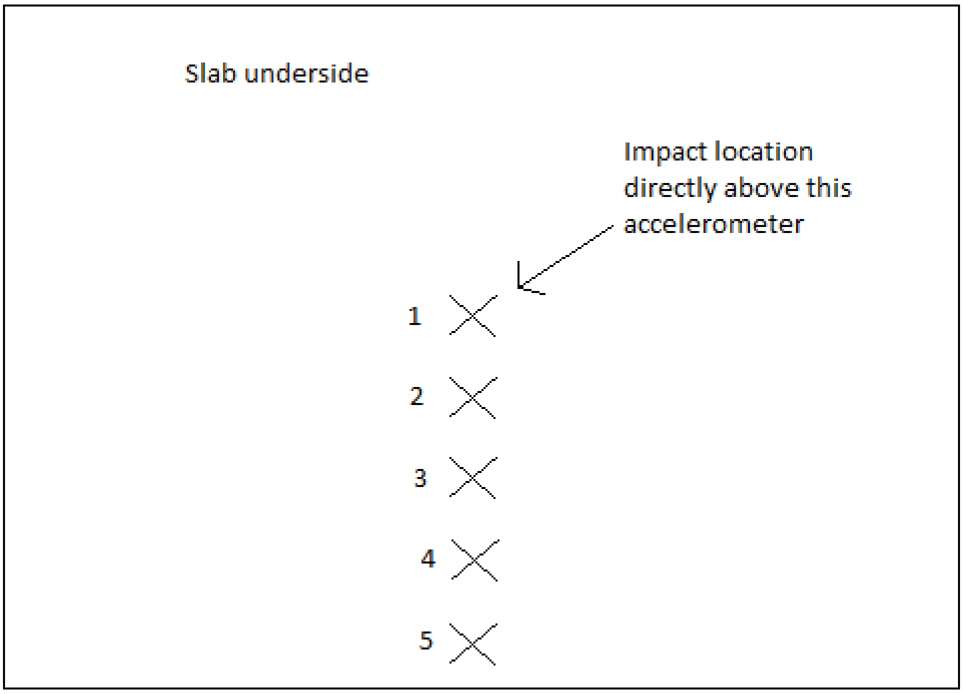

Figure 1 - Accelerometer locations on underside of slab

The heavy/hard impact test setup is shown in figure 2.

Figure 2 - Heavy/hard impact test apparatus

The bowling ball was dropped three times and averaged for each product and the Norsonic Nor850 measured the maximum 25 ms Leq in each of the one-third octave bands.

3. LABORATORY MEASUREMENTS

The IIC results are displayed in figure 3.

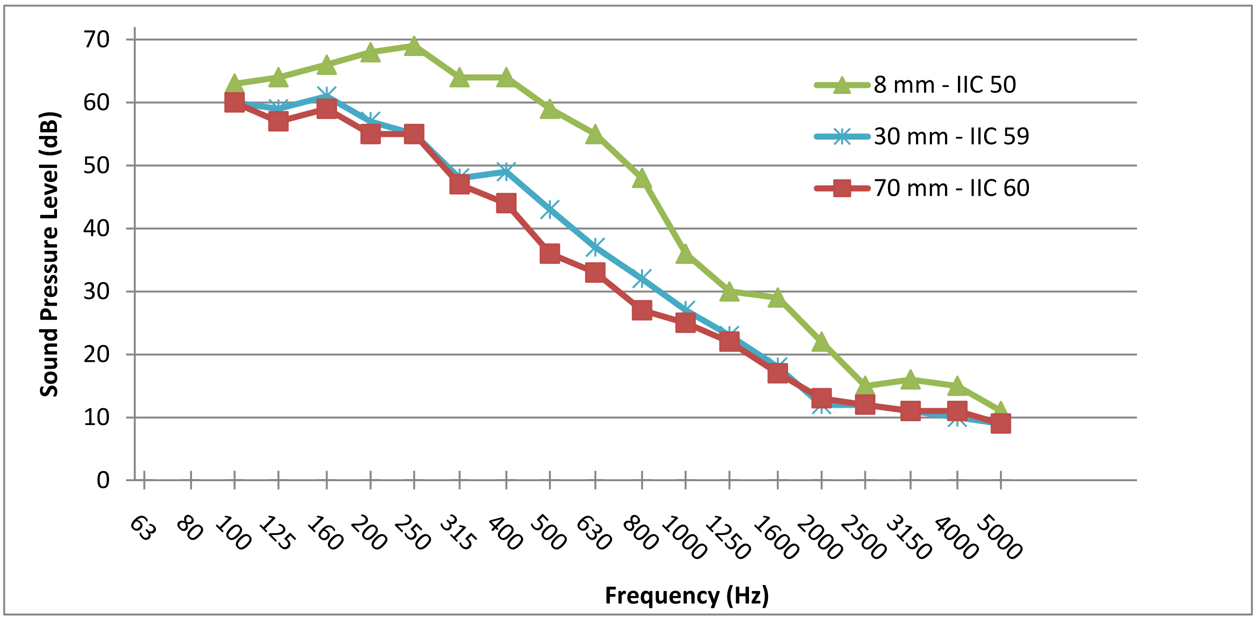

Figure 3 - IIC results measured in accordance with ASTM E492

The heavy/hard impact results from velocity sensors 1 for each flooring thickness are displayed in figure 4.

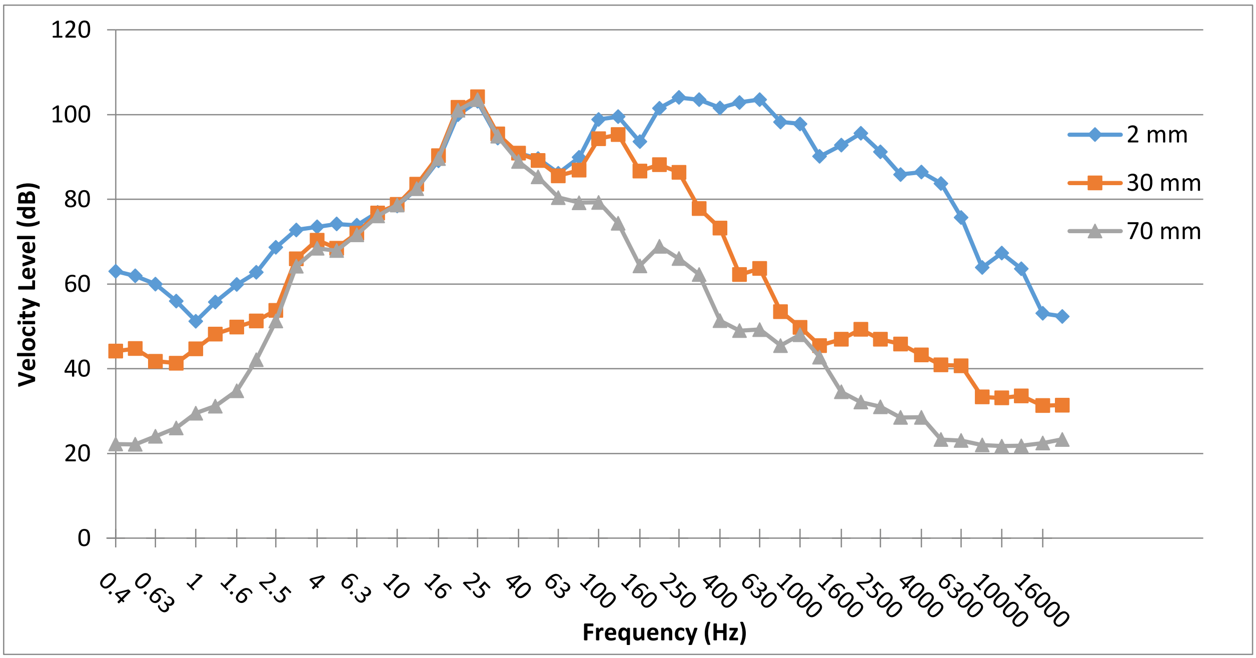

Figure 4 - Heavy/hard impact data recorded from accelerometer 1

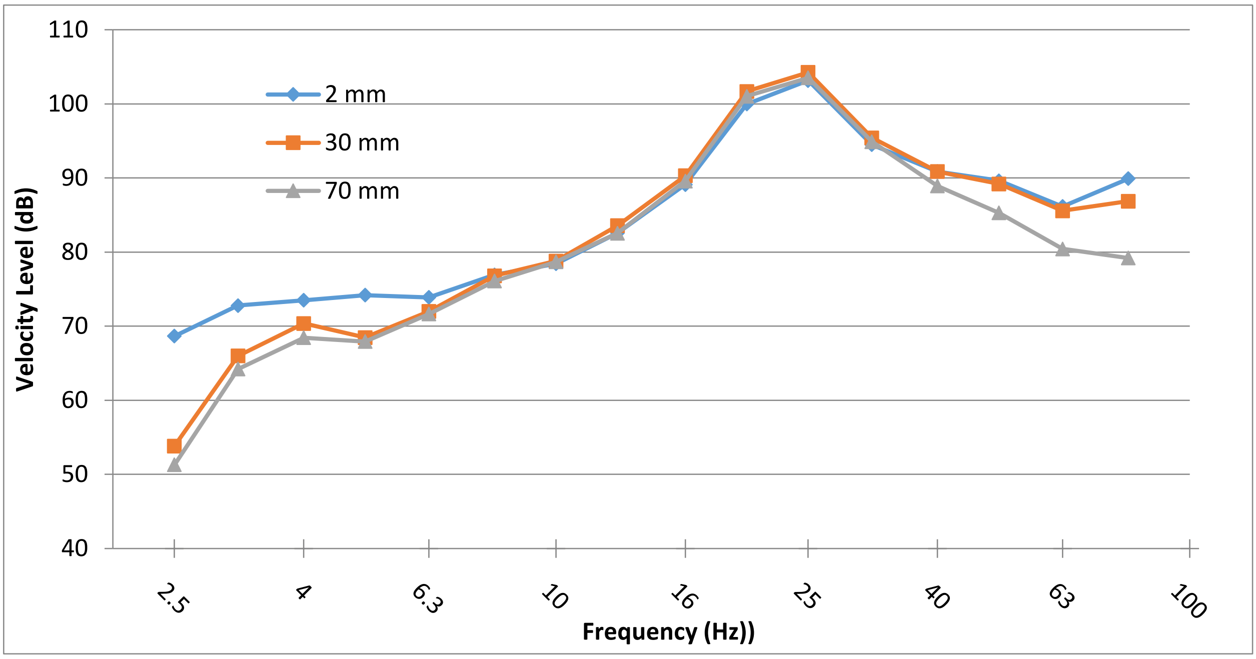

Figure 5 - Data from figure 4 between 2.5 and 80 Hz one-third octave bands

The heavy/hard impact results for the 70 mm fitness flooring product across all 5 velocity sensors are displayed in figure 6.

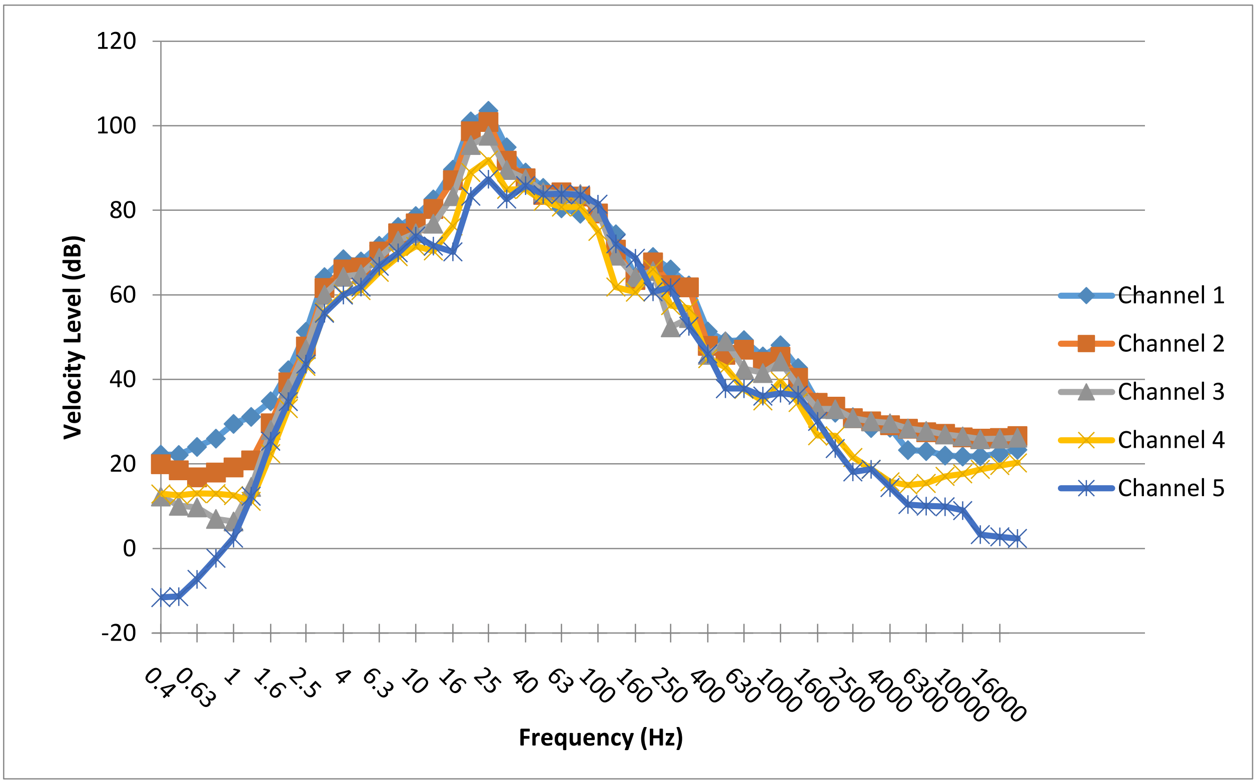

Figure 6 - Heavy/hard impact data for 70 mm fitness flooring across all 5 velocity sensors

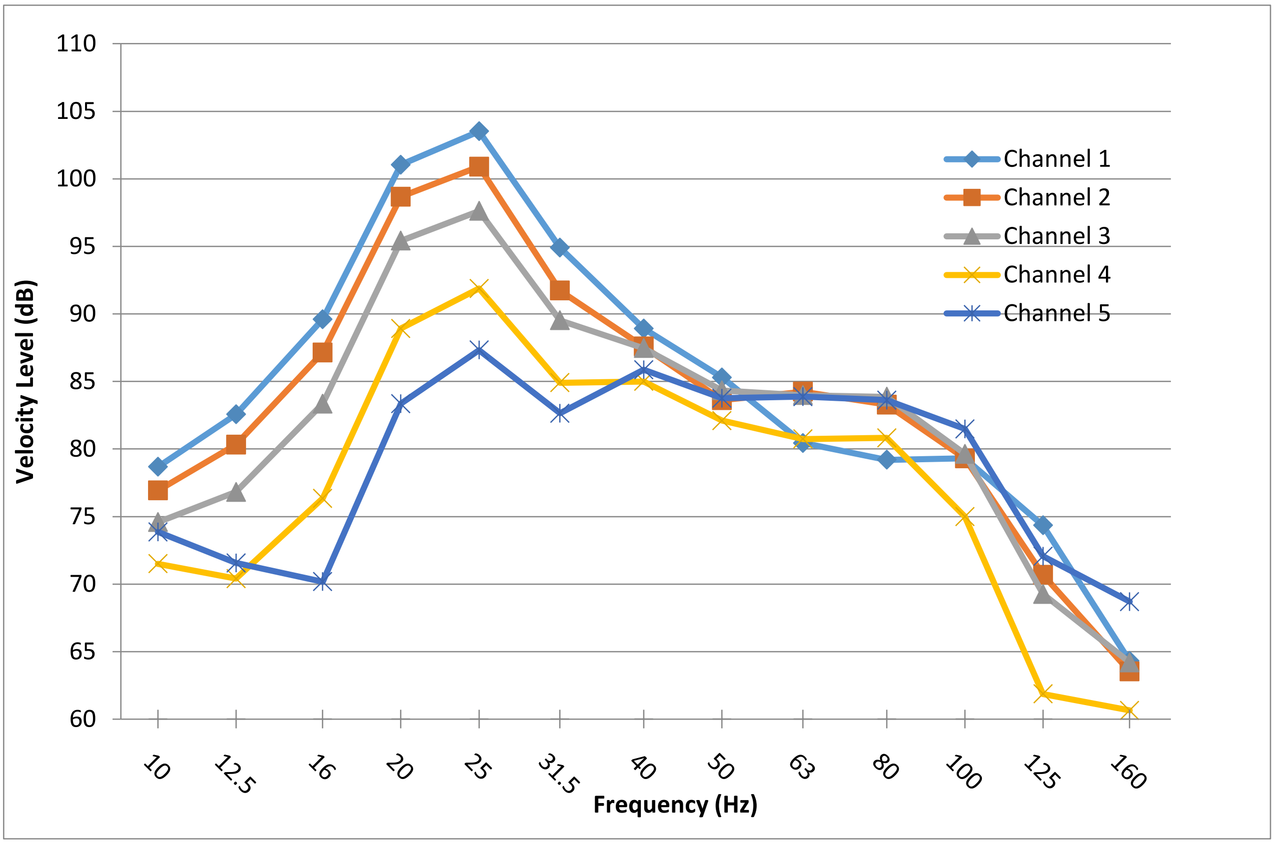

Figure 7 - Data from figure 6 between 10 and 160 Hz one-third octave bands

4. DISCUSSION

Analysis of the IIC data in figure 3 shows that there is very little sound attenuation improvement from the 30 mm product to the 70 mm product across all one-third octave bands. At 100 Hz, the separation of both products from the 8 mm baseline product is only 3 dB. When analyzing the heavy/hard impact data (figures 4 and 5), however, much more separation between the three products is observed. At 100 Hz, there is now a 15 dB separation between the 30 mm and 70 mm products and a 20 dB separation between the baseline and 70 mm products. This is due to the fact that the tapping machine does not introduce enough energy in the assembly in order to properly observe the sound attenuation of fitness flooring materials, especially at the low frequencies. Additionally, the heavy/hard impact is much more representative of the conditions present in a fitness facility and therefore is a much better tool for quantifying sound attenuation properties of fitness flooring materials.

Analysis of the data obtained from all five velocity sensors of the 70 mm product (figures 6 and 7), shows that, for the most part, the data appears as expected. The expected result is that the vibrations decay uniformly from the center of the slab outwards. The only piece of data that does not fit this trend is channel 5 between 40 and 160 Hz where the vibrations are larger than all other frequencies. This is being attributed to resonant effects in the slab occurring at the boundary that will be investigating further.

5. CONCLUSIONS

Based on the data acquired and presented in this paper, dropping a bowling ball from a set height and recording vibration levels in the slab using velocity sensors is the most effective way of measuring and assessing the acoustical attenuation properties of fitness flooring materials. The uniformity of the bowling ball allows for consistent, repeatable measurements that are not obtainable from dropping dumbbell weights, which is the current method for assessing fitness flooring effectiveness in the field. The use of velocity sensors have the added benefit of being able to accurately record frequencies to a much lower level than the capability of microphones. This is especially important as it is the low frequencies that are most problematic in buildings with fitness facilities. They also remove any issues from room modes in the receiving room.