SOUNDS GOOD TO ME

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Background, Purpose, and Hypothesis

The topic of this project was selected to discover why some musical notes can be easily heard through certain materials, and some cannot. For example, when a car drives by that has its music turned up really loud, why can only the loud thumping of the low bass notes be heard, and not the high music pitches? Both frequency and blocking material were evaluated to identify which had a greater impact on reducing the transmission of sound.

There were two experiments in this project. The first part, the relationship between transmission loss and material, was designed to determine which materials attenuate the sound level the most. The hypothesis stated that out of the 11 materials that were used, brick would attenuate the sound the most, and a pad of paper the least. The second part identified the relationship between transmission loss and frequency. The hypothesis stated that if the sound frequency is lower, then it will penetrate through materials more than a higher frequency.

Procedure

The same experimental method was used for both parts of the experiment. A 20x20x20cm box was constructed using 15mm thick melamine particle board, with one side left open, and a frame lid (a square “doughnut”) to fit over the opening to clamp the material under test. The box was then lined with a double layer of foam on the inside, and a single layer of foam plus a layer of concrete board on the outside. This arrangement was intended to prevent the sounds under test from entering the box through its sides. A microphone was placed on the inside, on the back of the box, opposite to the opening. Speakers were placed 25 cm from the box. The microphone was attached through an amplifier to an oscilloscope. As the speaker played the frequency, the microphone, connected to the oscilloscope, measured the sound level.

Experiment #1: Relationship Between Transmission Loss and Material

Procedure

In turn, each of the eleven materials was clamped in place under the frame lid on the open side. The frequency, 800 Hz, was then played, and the sound level was measured. Then the lid was clamped in place with nothing between, and once again the frequency was played and the sound level measured to produce a reference. These two measurements were compared to get the sound transmission. This was repeated for each of the other ten materials. The open, or unblocked, sound level was set the same for all materials.

Results/Observations and Conclusions

The results showed that MDF (Medium Density Fiberboard) was the best sound blocking material, proving the hypothesis incorrect. In order from most attenuating to least attenuating, the results were: MDF, glass, Plexiglas, concrete board, drywall, bricks, pad of paper, cardboard, carpet, foam, and felt. Following the experiments, and to determine why the hypothesis was incorrect, further research was undertaken. One factor which affects the results is mass. If the material has twice as much mass, then the sound that passes through will be half as much[1]. This affected the results because for some of the materials, multiple layers were used to get a consistent thickness, ½". Setting a standard thickness for the tests, however, meant that some materials were tested with higher mass than found in everyday life. For example, a ½" thick panel of glass is uncommon, and the four layers used in the test affected the results because the mass was increased by 4x, making the sound that passes through it one-eighth as much. Furthermore, the materials have different masses. Foam and felt have extremely low masses, and that is a reason why they did so badly. Plexiglas and glass did so well because they had

[1] Canadian Building Digest CBD-239 "Factors Affecting Transmission Loss"

multiple layers in order to get to a ½" thickness and both have a relatively high mass. In summary, this shows why the heavy materials such as MDF, glass, and concrete board did much better than the lighter materials, such as foam and felt. If a material has a higher mass, the sound that passes through will be less.

<u>Experiment #2: Relationship Between Transmission Loss and Frequency</u>

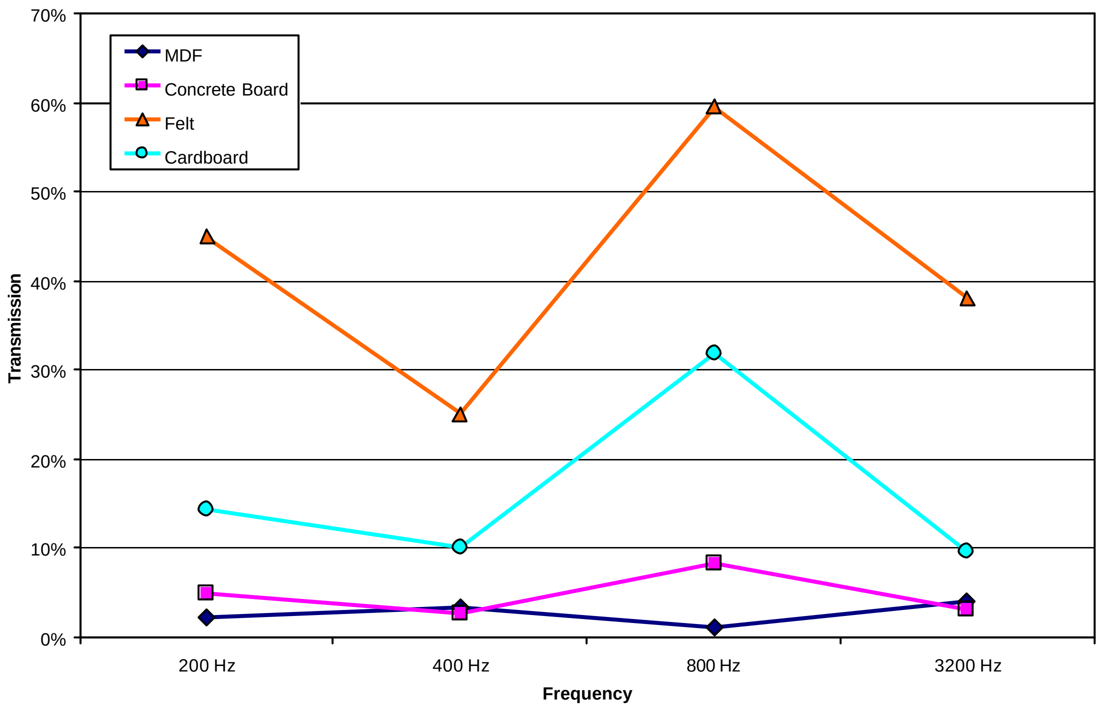
Procedure

Four materials were used from the first experiment: MDF, concrete board, felt, and corrugated cardboard. One of these materials was clamped under the lid on the opening of the box, and then four frequencies were played: 200 Hz, 400 Hz, 800 Hz, and 3200 Hz. The sound level was measured for each. Then the sound level was measured with nothing clamped between the lid and the box, and this was compared to each of the measurements for the different frequencies. This was repeated for the other three materials. 1600 Hz was not measured because the microphone had a response non-uniformity between 1500 and 2000Hz, and did not give reliable results at this frequency.

Results/Observations and Conclusions

The hypothesis stated that if the frequency was lower, then it would penetrate through materials more than a higher frequency, but the results showed that it was not simply a question of high or low frequency. For each of the four materials, 400 Hz was attenuated the most, and 800 Hz the least, except for in MDF, where 800 Hz was attenuated most overall. 200 Hz and 3200 Hz were somewhere in between the transmission for 400 Hz and 800 Hz (see figure 1) Depending on the material and the frequency, the sound may be attenuated more or less. Generally as frequency is increased by 2x, the sound that passes through will be half as much. Research carried out after the experiments showed that "coincidence effects" at higher frequencies, and resonances in lower frequencies, caused the transmission loss to behave differently (see figure 1). The coincidence effect is caused by the stiffness of the material[2]. This could explain why for MDF, 800 Hz was attenuated most overall, as opposed to least overall, as was measured with the other materials.

Figure 1 - Relationship Between Transmission and Frequency



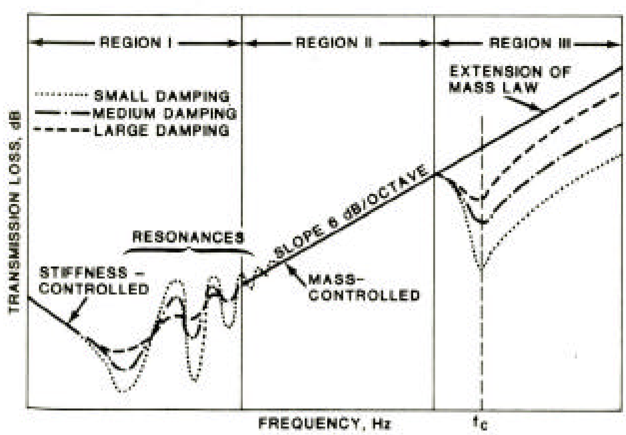


Figure 2 – Coincidence Effects[3]

[2] Canadian Building Digest CBD-239 "Factors Affection Transmission Loss"
[3] pg 7.7 ASHRAE Handbook 1981 Fundamentals

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