EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF ABSORPTIVE SURFACES ON THE ACOUSTICAL PERFORMANCE OF A BARRIER IN AN ANECHOIC CHAMBER

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1. INTRODUCTION

Roadside noise barriers are an effective way to reduce unwanted traffic noise reaching nearby areas. Barrier performance can be limited by sound reflections from the source side of the barrier, especially in the case of parallel barriers. Making barriers sound absorptive will decrease reflections from the barrier and amplification between parallel barriers. Absorbent barriers are generally more expensive than reflecting ones, and therefore it is important to know the optimum amount and placement of absorbing treatment on a barrier.

In this project, a full-scale reflective barrier was built in an anechoic chamber and absorptive material was added to create an absorptive barrier. The insertion loss (IL) was measured in third-octave bands for various configurations of the reflective and absorptive barriers; from these, total A-weighted values relevant to a typical traffic-noise spectrum were calculated.

2. METHOD

The tests were done in an anechoic chamber with dimensions 4.1 m x 4.7 m x 2.6 m to approximate outdoor conditions. A 3.66 m x 3.66 m plywood floor was built on top of the wire mesh floor, as a strong support and reflective surface for the wall to be placed on, representing a hard ground. The wall was 3.66 m long and 1.22 m high, and was made from 12-mm drywall on either side of a wooden frame, made from 2x4's. An extra layer of 12-mm drywall was screwed onto the source side of the wall to increase the transmission loss. The cavity was filled with fiberglass batt insulation to reduce sound transmission. Air gaps between the barrier and the floor were filled with putty. The wall was set up in the center of the floor in the chamber.

The sound source was placed 1 m behind the barrier, at heights of 0.25 and 1.0 m. The sound sources used were omni-directional point sources - one for high frequency (above 500 Hz) and the other for low frequency (below 500 Hz) [1].

Figure 1 shows the test configuration. The receiver was placed at distances of 0.6, 1.2 and 1.8 m on the non-source side of the barrier, at heights of 0.2 and 1.05 m. The receiver was also placed 1.8 m behind the barrier at a height of 0.75, and 1.2 m behind the barrier at a height of 0.9 m. This allowed for examination of both different angles of diffraction as well as varying distances at a constant angle. A B&K 1/2" type 4190 microphone was used, along with a B&K type 2669 preamp. A SINUS Soundbook was used as the white-noise signal generator and the analyzer, allowing both narrow-band and limited-band analysis.

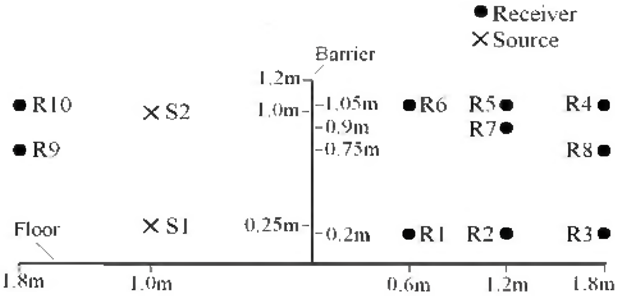

Fig. 1. The barrier configuration, including source and receiver positions.

The absorptive material used on the wall was cotton acoustic baffles. Each baffle was 1.22 m x 0.61 m and 25-mm (1") thick. Two layers of these baffles were used, giving a total thickness of 50 mm. The random-incidence absorption coefficient of these baffles was found using two methods: the spherical decoupling method [2] and the impedance-tube method [3].

3. RESULTS

The baffles were attached to the wall using insulation hangers; they were attached in five different configurations, which covered the barrier as follows: the full source side; the top half of the source side; the full receiver side; the top half of the receiver side; and the top halves of both the source and receiver sides. The ILs of these configurations and of the reflective wall were measured.

The IL in third-octave bands at receiver position R6 is shown in Figure 3 for the different baffle configurations. For the low source position, the absorptive material is more effective at increasing the IL in the frequency ranges where the baffles are highly absorptive. Between 300 and 400 Hz, where the absorption coefficient of the baffles is highest, covering the top halves of both sides increases the IL by 7-8 dB over that of the reflective wall, a 4 dB increase over any other absorptive configuration. At frequencies above 1000 Hz, where porous absorbers are expected to be highly absorptive, there is a 3-5 dB increase in IL due to having the top halves of both sides covered in baffles. For the high source position this high-frequency increase in IL is again seen; however below 1000 Hz there is very little increase in IL due to the absorptive treatment, regardless of the configuration. This is due to the smaller diffraction angles that are present for the high source position. These trends are consistent for the other receiver positions.

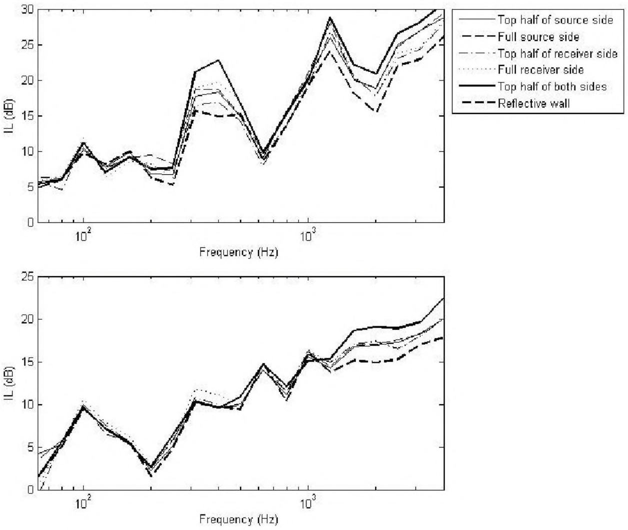

Fig. 2. Measured ILs at receiver position R6 for different baffle configurations, for low (top graph) and high source positions.

Figure 4 shows the total A-weighted IL at each receiver position for both the low and high source positions for each baffle configuration. The reflective wall provides 12-18 dB of attenuation, and the overall IL improvement due to absorption is 1-2 dB. It is seen that placing the absorptive material on the top half of both sides of the wall produces the highest IL for both source positions, while the reflective wall produces the lowest IL, as expected. Covering the full side of the barrier compared to covering half - either the source or receiver side - shows an IL increase of approximately 0.5 dB. Covering the full side of both sides of the barrier was not tested, although based on the other measurements an improvement in IL of 2-3 dB over the reflective wall could be expected.

For the higher source position, R1, R2 and R3 show the highest IL. These are the lowest receiver positions, creating the greatest diffraction angles and greatest path-length differences. Receiver R4 has the lowest IL, as it is the highest and farthest receiver position from the wall, giving it the lowest diffraction angles and the smallest path-length difference. Receivers R6, R7 and R8 are positioned such that they have the same angle of diffraction, and therefore the IL is expected to increase with path-length difference. This is what is seen in the results, increasing from R6 to R8.

For the lower source position, the IL at all receiver positions is increased compared to the higher source position, as expected due to the larger diffraction angles. However the results are not what is expected at several receiver positions. The IL decreases from R6 to R8, as opposed to what is expected. The IL at R3 is higher than at both R1 and R2, where it is expected to be lower. There may be interactions between the direct and reflected waves, either constructive or destructive interference, which affect the sound levels at particular frequencies for different receiver positions.

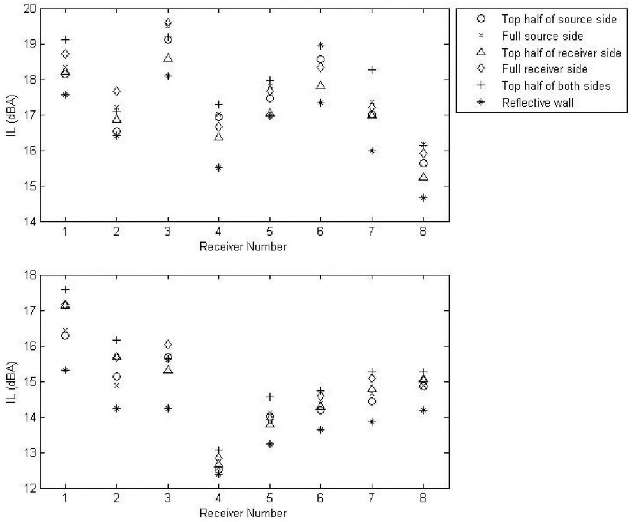

Fig. 3. Measured A-weighted ILs for the low (top graph) and high source positions at the eight receiver positions on the non-source side of the barrier for different baffle configurations.

4. CONCLUSION

Different configurations of absorbent material on a reflective stud wall in an anechoic chamber were examined. It was found that the highest IL came from covering the top half of both sides of the barrier with absorbing material. An IL of 12-18 dB was found for the reflective barrier. Absorptive material improved the IL by 1-2 dB in many of the configurations.

REFERENCES

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