Comparison Of Laboratory And Field Measurements Of Sound Transmission Loss For Aircraft Noise

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Introduction

The sound insulation of building façade components is most accurately measured in laboratory tests involving pairs of reverberation chambers. This paper reports on the problems of converting from laboratory to field measurements of sound insulation, and is part of a larger project to develop new data and procedures for predicting the sound insulation of buildings against aircraft noise.

Laboratory and Field Measurements

Laboratory sound transmission loss measurements were obtained following the standard ASTM E90 procedure with some extensions, that included increasing the frequency range to extend from 50 to 5k Hz.

Field measurements of sound insulation were obtained in a small wood frame test house located close to Ottawa Airport. The construction was based on 38 mm by 140 mm wood studs with glass fibre insulation in the wall cavity. Interior surfaces were gypsum board and the external surfaces were vinyl siding on OSB sheathing. The house had a sloping roof with 264 mm thick glass fibre insulation in the attic space. For the current results, the ceiling was two 13 mm layers of gypsum board mounted on resilient channels. The details of the construction were changed between tests so that various constructions could be evaluated. Temporary masking walls could be added making it possible to simplify comparisons to single walls having one particular orientation to passing aircraft.

Field measurements were obtained simultaneously from 8 microphones: an outdoor microphone on a mast 10 m high, an external façade microphone, and 3 microphones in each room. Some measurements included an outdoor microphone mounted 2 m away from the building façade.

Differences between Laboratory and Field Conditions

(a) **Effect of angle of incidence.** The transmission loss of a limp panel varies with $\cos^2(\theta)$, where θ is the angle of incidence. In random-incidence lab tests, sound is incident approximately equally from all directions. In the field, the sound is incident from specific angles.

(b) **Directionality of noise from aircraft.** The directionality of noise from aircraft affects the variation of incident sound levels with time. Data obtained by the Swiss lab, EMPA, shows large variations of directionality with both frequency and aircraft type. There is a trend for more modem aircraft to be less directional. Fig. 1 shows the horizontal directionality of a B737 aircraft.

(c) **Effect of aircraft speed and distance.** The incident intensity also varies with time and this depends on the speed of the aircraft and on the distance to the flight track. Fig. 2 compares the variation with time for an omni-directional source with the calculated effect for a B737 aircraft. Time zero corresponds to the aircraft being closest to the receiver. Sound levels peak after the aircraft has passed the house and the time and amplitude of the delayed peaks vary considerably with frequency. Thus we cannot determine the position of the aircraft, and angles of incidence of the sound from only recorded sound levels.

(d) **Orientation of the building façade.** The total incident sound energy on a particular façade element also depends

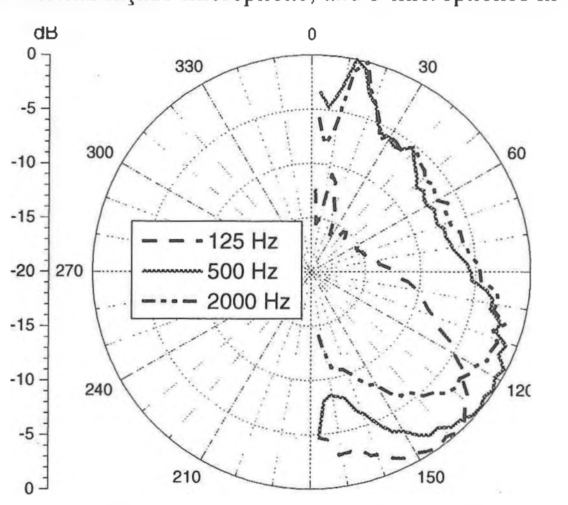

Fig. 1. B737 aircraft directionality at 3 frequencies.

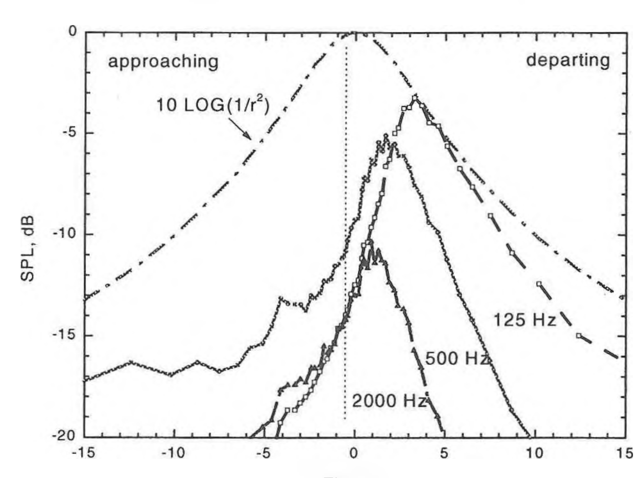

Fig. 2. Calculated pass-bys for B737 and point source.

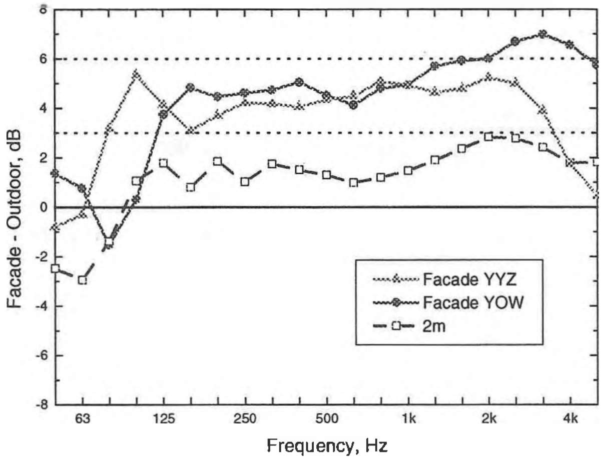

Fig. 3. Average level increases due to the building

the orientation of the façade relative to the aircraft flight path. This is partly a question of the portion of the complete flyby that is visible to the façade, but there is an interaction with the directionality of the aircraft noise. This is further complicated by the diffraction of sound around the corners of the building.

Measurement of Incident Sound Levels

Standards recommend 3 options for measuring the level of the incident sound. It can be measured in the free field, (far from reflecting surfaces), at the façade, or 2 m from the façade. Measurements at the façade are said to lead to 6 dB (pressure doubling) increases and at the 2 m position to 3 dB (energy doubling) increases relative to the free field.

Fig. 3 shows average results at the test house (YOW) and at new homes near Toronto airport (YYZ). Increases at façade microphone locations vary with frequency and rarely reach +6 dB. Measurements at a position 2 m from the façade provide less than 3 dB increases at all frequencies.

Level increases at a façade microphone location for varied angles of incidence are in qualitative agreement with diffraction theory and demonstrate that a simple 6 dB increase is an over-simplification of what actually occurs.

Comparisons with Measured Noise Reductions

Laboratory TL results and reverberation times measured in the test house were used to calculate expected noise reductions (NR). In Fig. 4 these are compared with NR values measured in the field. Masking walls were positioned in front of the end walls so that only the facing walls transmitted significant sound energy. The results for both rooms A and B are quite similar because both walls are exposed in the same way to the complete aircraft flyby.

The figure shows systematic differences between lab and field results around 125 Hz and 1600 Hz. The 125 Hz dip is found in lab tests of walls with the same 406 mm stud spacing, but does not occur where normally incident sound energy is minimal as in these field tests. The high frequency difference may be due to leaks or different edge conditions.

Fig. 5 compares NR values for the end walls of each room. Here the differences between the two rooms are larger. For room B, the aircraft are approaching and the incident sound will be lower than for the other end of the building (room A) where the aircraft are departing. This leads to higher apparent NR values for room B than room A as was expected.

Conclusions

Although it is important to understand the differences between lab and field situations, practical considerations suggest that it is not possible to explicitly include all of the details in conversions from lab to field results.

Acknowledgements

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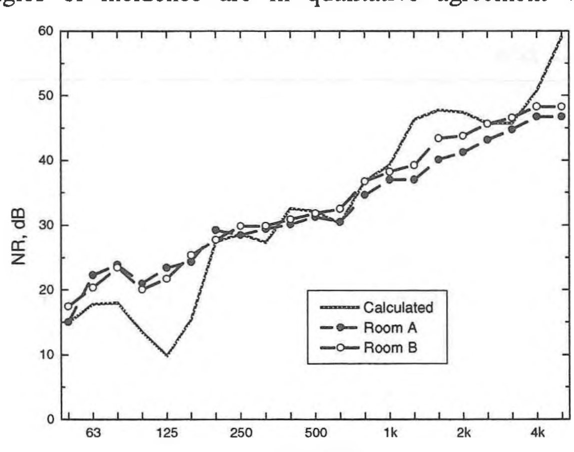

Fig. 4. NR values for walls facing the flight track.

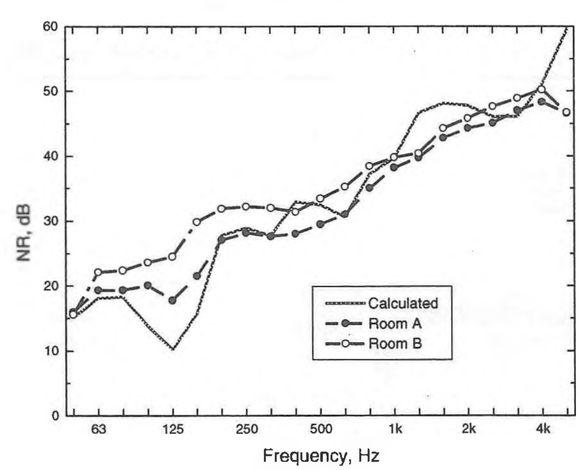

Fig. 5. NR values for walls perpendicular to flight track.