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NOISE CONTROL FOR A BETTER ENVIRONMENT

Effects of sound incidence angle on the effectiveness of noise reduction measures applied to acoustic windows

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ABSTRACT

With more residential buildings being built close to road network systems in Hong Kong, there is an increasing need to find method to combat excessive traffic noise exposure in residentials unit. Several measures have been employed in various places, for example, vertical barrier along road with heavy traffic, acoustic balcony and acoustic windows on the façade of the residential unit.

Recent addition to effective methods of reducing noise into home are micro perforated panels, and 'promute' material. These materials have various characteristic in noise reduction and can help to alleviate noise level. The orientation of the noise source with respect to the window is also an important factor to gauge whether an approach is worth using in different window setup.

We tested different combination of noise reduction method on window setup that are commonly found in Hong Kong with different angle of incidence of noise source to simulate the noise from different sections of road traffic. We find that a sliding panel itself have an insertion loss of 3.5 to 7.9 dBA among different loudspeaker positions. A further 0.6-1.6 dBA is provided with plenum absorption, and the addition of MPP gives another 0.5-1.4 dBA improvement.

Keywords: Noise, Environment, Annoyance
I-INCE Classification of Subject Number: 43.55.Ti

1. INTRODUCTION

Hong Kong is one of the most congested cities with limited land for development of residential zone. Many new high-rise residential buildings are thus located close to busy roads with high volume of traffic, and causing severe impact on noise pollution. According to the Environmental Protection Department of Hong Kong, more than one million people in Hong Kong are affected by excessive traffic noise [1].

Noise mitigation measures in Hong Kong for high density living environment are usually focused at source, along the propagation path, and the receiver end. Most building estates can only focus on solutions that are applicable to the receiver end. Examples include building setback, flat configuration and disposition, acoustic balcony and acoustic windows. However, due to the lack of land availability, there are instances in which

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building setback does not work. As such, our research is focused on improving the noise reduction ability of windows facing traffic. The micro-perforated panel (MPP) as well as pomute material have shown high potential in improving the current performance of acoustic windows [2], without much reduction of natural ventilation effectiveness. They are also easy to maintain.

1.1 NOISESTOP Panel

NOISESTOP Acoustic sliding panel is able to cater for natural ventilation, room acoustics as well as day-lighting. It is made up of transparent Micro-Perforated Plate Acoustic Panel (MPA), which provides high degree of sound absorption without light loss [3]. The sliding design of the panel allows air to flow freely, enhancing indoor air circulation. The following figure shows the performance of the MPA used in our test set-up at different frequencies.

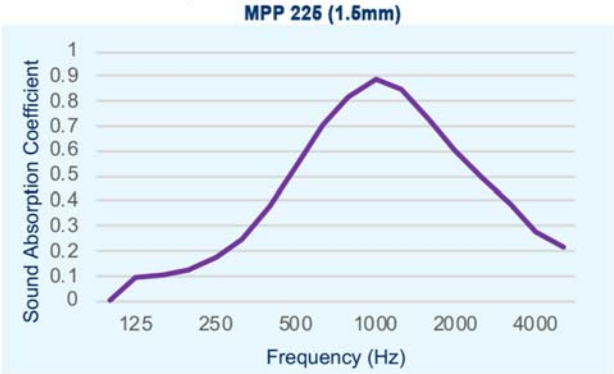

Figure 1. Sound Absorption Performance of NOISESTOP Panel

1.2 Pomute material

Pomute is a breathable metal panel to replace traditional hole punch finish. The structure of the panel provides sound absorption performance on wide range frequency. Pomute can be incorporated into acoustic panel, false ceiling, wall, baffle, noise barrier. The acoustic performance of Pomute is tested in accordance with ASTM C423-09a standard test method for sound absorption and sound absorption coefficients by the reverberation room method, and shown in the following figure 2

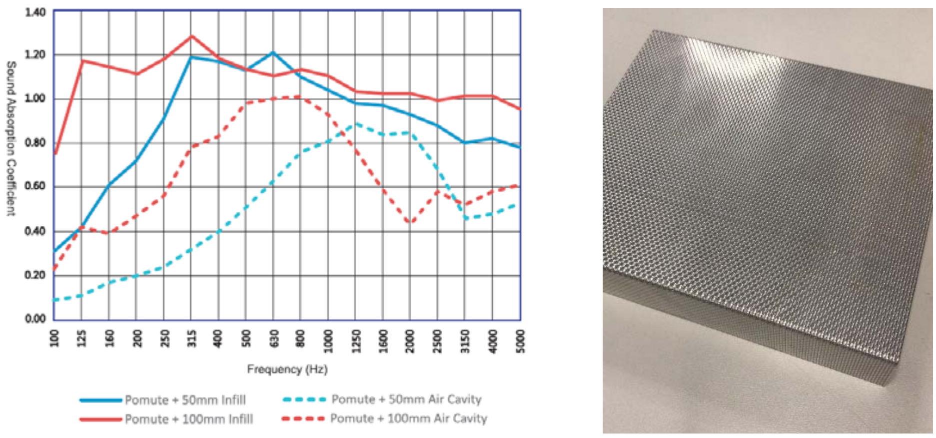

Figure 2. Sound Absorption Performance of Pomute

2. EXPERIMENTAL SETUP

In this study, we conducted the experiment by building an actual mock-up of the proposed window setup. Figure 3 shows the setup and the actual test site. The source was an array of loudspeakers which were spaced equally from each other, and at a linear distance of 15m away from the test window. The loudspeakers were tilted with their normal axes pointed directly at the height level of the window edge, to simulate flats at higher floor level.

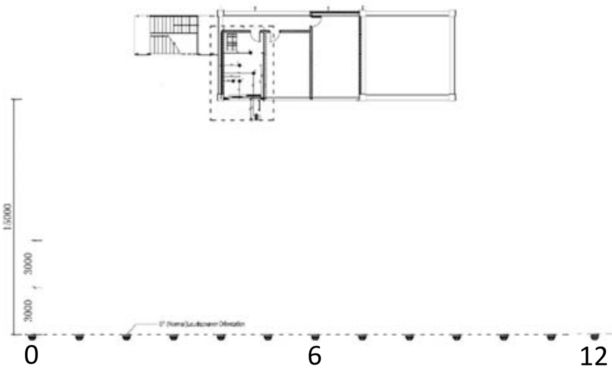

Figure 3. Experimental Setup

Figure 4. Microphones setup (left: facade; right: indoor) and the locations of the installed absorption

We set up 13 loudspeakers facing the window at different angles from it, with all speakers having the same orientation, to simulate road traffic. Four different test cases were tested:

1. Open window scenario, with no sliding door, no MPA, and no pomute material infill
2. Open window scenario, with sliding door, no MPA, and no pomute material infill
3. Open window scenario, with sliding door, no MPA, and pomute material infill
4. Open window scenario, with sliding door and MPA, and pomute material infill

The window size in the test was 1515 mm tall, with a width of 600mm. The MPA panel used for the test was 1.5mm thick, with an air cavity of 40mm separating it from the sliding door. Pomute material was aluminum and 1 mm thick

3. RESULTS AND DISCUSSIONS

Referring to Figure 5, which plots the insertion loss of the window when each loudspeaker was used individually (Horizontal axis). Test case 1 is plotted by the green line, test case 2 the red line, test case 3 the purple line and test case 4 the blue line. We see improvement on the insertion loss after noise absorption material was added in each test case. Comparing test case 1 and test case 2, the sliding panel without MPP and plenum provided an additional insertion loss of about 3.5-7.9dB. Adding plenum absorption material provided further additional 0.6-1.6dB reduction. In the final test case, with the MPP installed on the sliding window, further improvement of 0.5-1.4dB of insertion loss was observed.

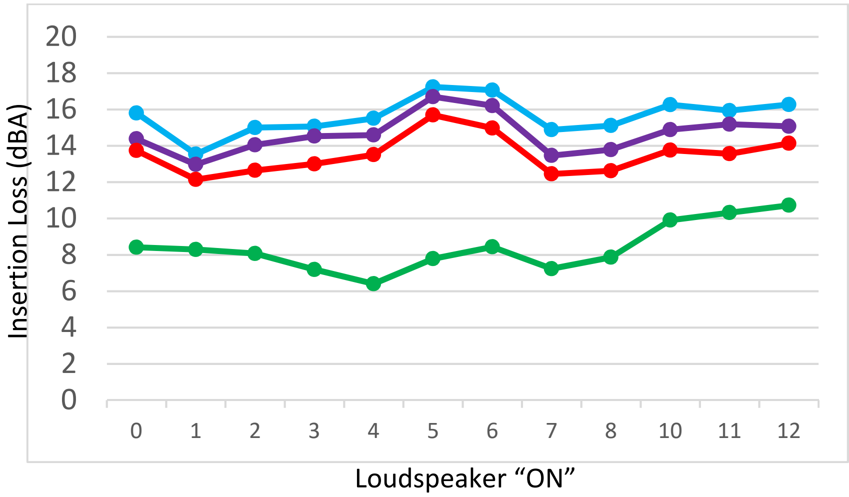

Figure 5. Noise Absorption Performance at all speakers' position (See Figure 3)

Figure 6. Insertion Loss per Loudspeaker (From top-left: Position 0 to position 12)

For every loudspeaker position, we observe a constant trend of improvement per test case, regardless of where the source is located, the MPA, pomute material and infill showed good performance in enhancing the sound insulation of the acoustic window. The performance of noise reduction is comparatively better where the sound source was located on the left hand side of the window normal axis, due to the out-swinging window pane which acted as a barrier along the propagation path of the noise. Certainly, the normal incidences performance is the best for all cases, and more investigation should be carried out to understand the performance at noise source which are angled away from the window. For example, in test case 4, the noise absorption recorded was much lower then test case 3 and 5. This may be an error in measurement, as we expected the trend to be linear.

4. CONCLUSIONS

A full-scaled mockup test was carried out to investigate the effectiveness of different noise absorbing material performance on noise from different angles and comparing how the acoustical performance of the window could be improved. It is found that an improvement of sound insulation of 1.1 to 3.0 dBA can be attached by installing sound absorption into a plenum window with a narrow gap width.

5. REFERENCES

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