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The Development of an Innovative Noise Mitigation Measure for Traffic Noise Impact

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ABSTRACT

Hong Kong is one of the densely populated area in the world with residential sites surrounded by traffic roads. Road traffic noise pollution problem becomes a major environmental issue for residents in Hong Kong. In an attempt to tackle road traffic noise impact on residents and ensure good quality of individual's health and well-being, an innovative measure called Baffle Type Acoustic Window has been proposed, which designs to benefit residents from environmental noise planning and building ventilation's aspect. It consists of two glazing: (i) an outer openable window and (ii) an inner sliding panel with air gap in between. The inner sliding panel is situated right behind the outer openable window. To investigate the acoustic performance of Baffle Type Acoustic Windows with different design parameters, a series of acoustic laboratory tests have been carried out in accordance to ISO Standard to discover the relationship between the key design parameters of the window (e.g. width of overlapping between sliding panel and the window system, size of outer window opening and acoustic material used etc.) and its corresponding acoustic performance.
Keywords: Baffle Type Acoustic Window, Acoustic Performance, Traffic Noise

1. INTRODUCTION

1.1 Objectives

The objective of the on-site acoustic test is to investigate the sound attenuation performance of baffle type acoustic window, which would be demonstrated by the additional noise reduction under indoor environment when compared with conventional window system International standard ISO 16283 was adopted.

1.2 Baffle Type Acoustic Window

Baffle type acoustic window consist of two layer of glass pane. The outer layer provides opening for natural ventilation and the inner layer is a sliding panel situated behind outer opening to shield noise. Acoustic performance of the system could be enhanced through applying transparent micro-perforated absorber (MPA) panel to the inner sliding panel and also perforated acoustic panels provided on the top and side window edges for sound absorption. The two-layered baffle type system could create an air path for natural ventilation while reducing noise entering indoors at the same time.

The sound attenuation of the baffle type acoustic windows was determined through field test. Three types of baffle type acoustic windows were chosen for the test. The overlapping sizes of the baffle type acoustic windows are of 100mm and the gap between the outer and inner layer is 100mm. The floor area of the test room for each window is 4.2m^2. Two types of acoustic materials were involved in the test: (i) MPA on the inner sliding panel of the window (Noise Reduction Coefficient = 0.5) and (ii) perforated acoustic panels on the top and side edges of window frame (Noise Reduction Coefficient = 0.9).

This study presents the acoustic performance of baffle type acoustic windows with different sizes of window openings and the provision of acoustic materials. Three types of baffle type acoustic windows- namely Acoustic Window A, B and C were selected in the study. Acoustic Window A is the baffle type acoustic window without any acoustic materials, while B and C have adopted either MPA or MPA together with perforated acoustic panels. Example of baffle type acoustic window with and without acoustic material are shown below:

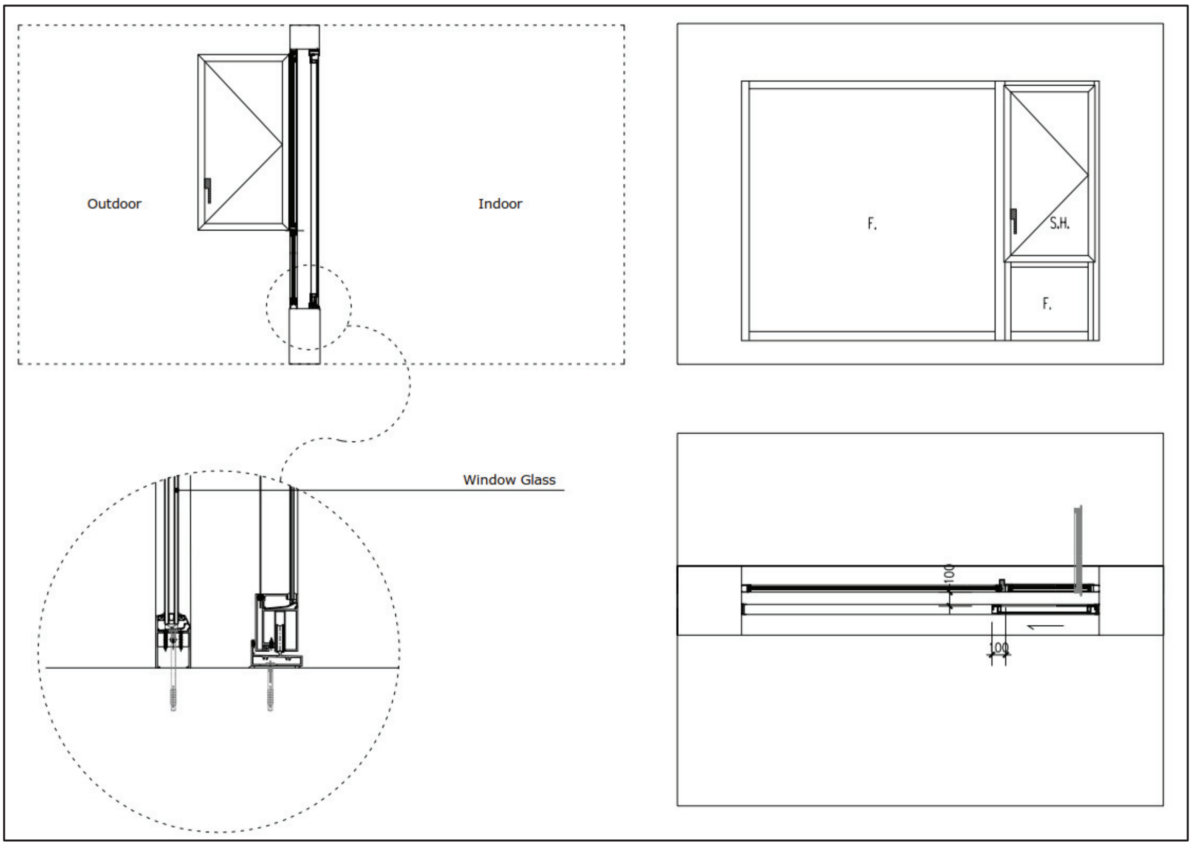

Figure 1 – Baffle type acoustic window without acoustic material

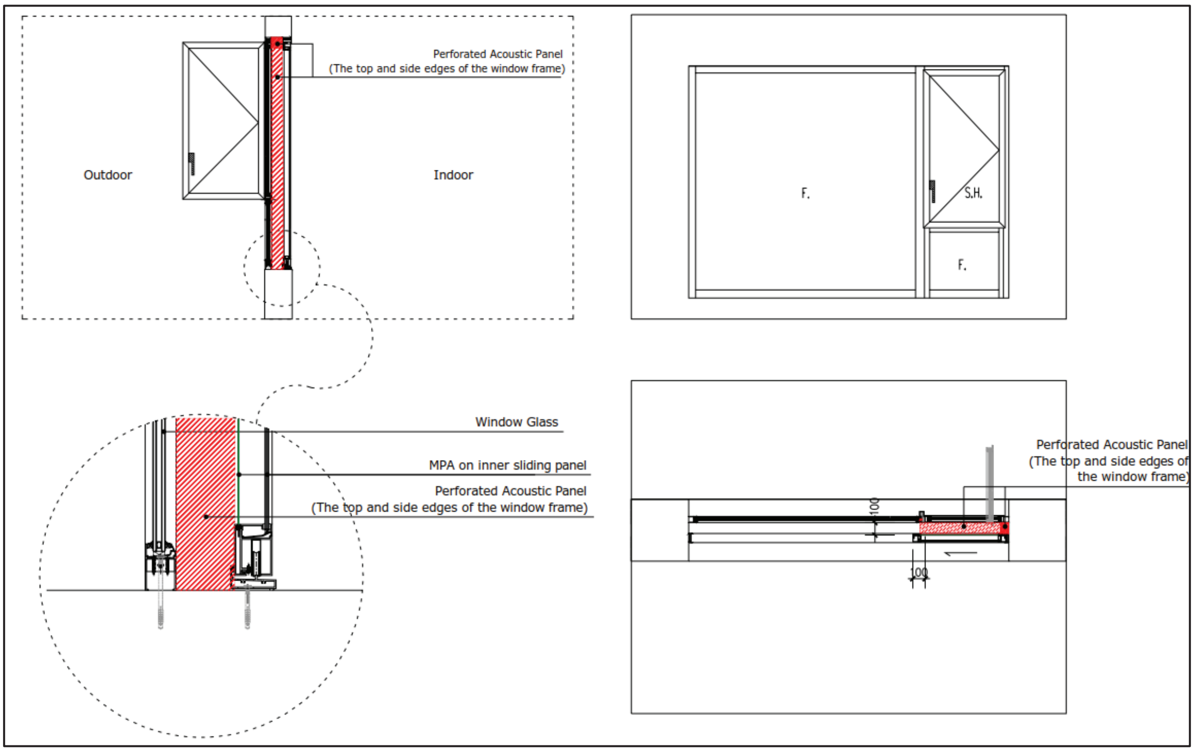

Figure 2 – Baffle type acoustic window with MPA and perforated acoustic panels

1.3 Test Case and Conventional Case

Sound attenuation of baffle type acoustic window is the relative insertion loss of the baffle type acoustic window when compared with the conventional window. The conventional window has been adopted in order to evaluate the additional sound attenuation effect of the baffle type acoustic window provided.

Conventional window system represents the system typically implemented to habitable rooms (such as bedroom and living room) when noise is not regarded as a design constraint. Window system is usually employed in bedroom. The opening size of conventional window follows the prescribed window ventilation requirement under the regulations of Buildings Department.

1.4 Sound Attenuation Definition

In an attempt to determine the sound attenuation, the insertion loss of baffle type acoustic window and conventional window system should be identified and the sound attenuation will then be equal to the difference between insertion loss of baffle type acoustic window system and conventional window system. In other words, the sound attenuation represents the relative insertion loss of baffle type acoustic window system and conventional window system. It can be represented by the formula below:

$ILc = LOc - LIc$ where ILc = insertion loss of conventional window system;

LOc = noise level outdoors before penetrating through the conventional window system; and

LIc = noise level indoors after penetrating through the conventional window system.

$ILs = LOs - LIs$ where ILs = insertion loss of baffle type acoustic window system;

LOs = noise level outdoors before penetrating through the baffle type acoustic window system; and

LIs = noise level indoors after penetrating through the baffle type acoustic window system.

$RIL = ILs - ILc = LOs - LOc + LIc - LIs$ where

RIL = relative insertion loss = sound attenuation of the baffle type acoustic window system

2. METHODOLOGY

2.1 Field Test

Field test has been conducted to investigate the acoustic performance of the baffle type acoustic window with different sizes of opening and provision of acoustic materials in full scale field test environment. To simulate the noise reduction as close as possible to the future development, the mock-up rooms were constructed in 1:1 scale. The rooms were enclosed with full height acoustic panels as wall, while both ceiling and floor were solid. The traffic noise source would be represented by loudspeakers and noise measurements were taken inside and outside the test rooms.

No opening was allowed in the mock-up room, except windows, to ensure the accuracy of test results. The envelop was sealed with silicon sealant of any gap was identified to cut off the flanking path.

To represent traffic noise source, A total no. of 11 loudspeakers were set to be a line source with total length of 30 m and 3 m in between each loudspeaker at different angles and distances. Lined noise sources will be placed around 0.5m above the ground at a distance of 15 m from the test surface and maintained an elevation angle of 15±5°, which is the worst incident angle for the first residential floor of baffle type acoustic window. In addition, white noise was adopted for the measurement. The noise source orientation is at 0°, which is directly fronting the test specimen.

Measurements were taken for both test case and conventional case to find out the additional noise reduction provided by acoustic window compared to the conventional window. For the noise measurement determined outside the façade of the test room, the average sound pressure level was measured 1 m from the plane of the test specimen and at 1.5 m above the floor of the receiving room.

As for the measurement determined inside the test room (receiver room), the average sound pressure level was determined by using a single microphone positioning at different location inside the room. The microphone setting was based on international acoustic standards *ISO 16283-3 2016– Acoustics -- Field measurement of sound insulation in buildings and building elements -- Part 3: Façade sound insulations*. Minimum five microphone positions were adopted to obtain the average sound pressure level of each sound field. These positions were distributed within the maximum permitted space throughout the receiving room, spaced randomly. No two microphone positions were placed on the same plane relative to the room boundaries and the positions was not in a regular grid.

On top of the above, noise measurements were made in 1/3 octave bands with center frequencies from 100 Hz to 5000 Hz. The measurement data was then normalized with the traffic noise spectrum under the Standard EN1793-3.

Measurements for the noise levels with the loudspeaker operating were taken simultaneously outside the façade and in the receiving room. 5 sets of measurements were taken to ensure the repeatability and minimize the measurement errors. The average SPL was calculated to ensure the reproducibility to be about 2dB.

3. TEST RESULTS AND DISCUSSION

3.1 Results

The measurement results were indicated as follows.

Table 1 – Measurement Results of the Baffle Type Acoustic Windows

Acoustic Window	OO qty	G (mm)	O (mm)	OOA (m^2)	RA (m^2)	MPA	AP	RIL (dB(A))
A	1	100	100	0.9	4.2	N	N	4.6
B	1	100	100	1.0	4.2	Y	N	5.5
C	1	100	100	1.1	4.2	Y	Y	6.8

Note:
OO qty= quantity of outer opening
G= gap between the outer and inner layer of the window
O= overlapping size of the outer and inner layer of the window
OOA= outer opening area
RA= floor area of the test room
MPA= micro-perforated absorber
AP= perforated acoustic panel on the top and side edges of the window frame
Y= with the application of a specific acoustic material
N= without the application a specific acoustic material
RIL= relative insertion loss of the acoustic window and conventional window

3.2 Discussion

In accordance with the test results, Acoustic Window A to C could achieve at least 4 dB(A) noise reduction, given that the outer opening area of the baffle type acoustic window ranges from 0.9 to 1.1m^2; the overlapping size of outer and inner layers is 100mm, the gap between outer and inner layer is 100mm; and the floor area of the room shall be 4.2m^2.

The sound attenuation of acoustic window would be affected based on different provision of acoustic materials. Acoustic Window B was provided with MPA on the inner sliding panel whereas Acoustic Window C was applied with MPA and perforated acoustic panels on the window frame. Acoustic Window B with MPA achieves 5.5 dB(A) sound attenuation and Acoustic Window C with both MPA and perforated acoustic panels reaches 6.8 dB(A).

Referring to the window opening size, Acoustic Window A is the smallest, followed by Acoustic Window B and Acoustic Window C. Since a larger window opening will allow more sound energy to enter indoors, the acoustic performance of baffle type acoustic window will be less effective. Based on the opening size, it is anticipated that the sound attenuation of Acoustic Window A would be greater than B and C since less sound energy would penetrate indoors due to its smallest window opening size.

However, when acoustic materials were adopted, the test results reflect that the noise reduction level for windows with larger opening would be increased. As reflected in the results of Acoustic Window B and C, the performance of Acoustic Window C is 6.8 dB(A), which is better than 5.5 dB(A) of Acoustic Window B. The difference is due to the provision of acoustic materials where Acoustic Window B adopted fewer acoustic materials than Acoustic Window C.

From the test results, it is found that the level of sound attenuation of baffle type acoustic window increased along with the number of acoustic materials adopted. The sound attenuation increased from 4.6 to 6.8 dB(A) when more acoustic materials are applied. For Acoustic Window A, it represents the baffle type acoustic with the smallest opening size- 0.9m^2. No acoustic material was applied to the window and the noise reduction is 4.6 dB(A). When MPA was adopted, as represented by Acoustic Window B, the noise reduction has been increased to 5.5 dB(A). The noise reduction has been further increased to 6.8 dB(A) when perforated acoustic panels have been added to the top and side edges of the window other than the MPA on inner sliding panel. It is therefore noted that the application of acoustic materials help to enhance the acoustic performance of baffle type acoustic window.

4. CONCULSION

This study demonstrates the sound attenuation of baffle type acoustic systems supported by acoustic field test. The test results show that baffle type acoustic systems could attenuate traffic noise by 4.6 to 6.8 dB(A) depending on the application of MPA and perforated acoustic panel.

REFERENCES

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