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Full scale field study of sound transmission across plenum windows

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ABSTRACT

A full scale field measurement of the acoustical insertion loss of plenum windows was carried out in the present investigation. Two identical mock-up test rooms with dimensions the same as those commonly adopted for Hong Kong public housing were built side-by-side next to a busy trunk road. One of them was equipped with plenum windows, while the other with the conventional side-hung casement windows. Four internal room settings were included in this study. Results show that both the room modes and the acoustic modes within the plenum window cavities were affecting significantly the low frequency sound transmission. After correcting for the indoor reverberation/absorption effect, the acoustical benefit achieved by replacing side-hung casement windows with the plenum windows tested in the present study was between 7.1 and 9.5 dBA. By comparing the average equivalent sound pressure levels inside the two test rooms with the traffic noise weighted acoustical benefit, it was found that the changes of receiver room reverberation and acoustic modal effects due to such replacement would result in a reduction of plenum window sound insulation performance by 0.2–1.5 dBA. The insulation is stronger for larger room size with stronger indoor sound absorption.

1. Introduction

Road traffic is one of the major noise pollutants in urbanized cities. Such problem becomes severe in densely populated cities where many residential dwellings are built alongside the main traffic networks to satisfy the housing demands of the communities. Noise from traffic roads has been found to have potential adverse impacts on the health of the nearby residents [1–3]. The potential problems include at least annoyances, sleep disturbances and health deterioration. A recent survey in Hong Kong indicates that more than 1/7 of the Hong Kong population are exposed to excessive road traffic noise [4]. The quest for effective mitigation measures to contain noise is always one of the top priorities of the members of public in Hong Kong.

There are many conventional noise mitigation measures that have been proposed and/or adopted to tackle the road traffic noise problem over the past few decades. Roadside barriers, enclosures, setbacks and extended podia were common approaches that have been used in Hong Kong [5–7]. However, these measures may not always be applicable because of space limitation, safety, visual intrusion, land ownership etc. and to some extent are not cost-effective. Hence, acoustic treatment at building façade has become an alternative way to reduce traffic noise exposure in residential units. Double-glazing and triple-glazing windows can produce very impressive insertion loss of as high as 44 dB in term of weighted sound reduction [8]. However, the ventilation of the associated indoor spaces will then have to rely on mechanical means, which tend to consume significant amount of energy. In view of sustainability, a façade noise reducing device which can offer good sound insulation and at the same time can allow for acceptable level of natural ventilation is in need.

Recently, a plenum window, which resembles an elongated plenum chamber normally used in duct silencing [9], is introduced [10]. It is also a kind of partially opened double glazing window, whose sound transmission loss was first tested by Ford and Kerry [11] but with a very narrow opening size. This window's staggered inlet–outlet design leaves an air gap between the two glass panes such that natural ventilation becomes possible under an appropriate outdoor wind pressure. Kang and Brocklesby [10] studied the use of thin micro-perforated panels in improving the acoustic protection capacity of the window. Tong and Tang [12] carried out a scale model study on the acoustical performance of the plenum

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windows. It is found that apart from the window opening size and air gap width, the window's orientation relative to the noise source has great influence on the acoustical protection.

In order to find out the acoustical benefit of installing plenum windows in public housing estates next to busy trunk roads, a full scale mock-up field experiment was carried out in this study. There are many advantages of carrying out full scale field experiment though it is very expensive. First, the noise source is the real traffic whose sound field is not easy to reproduce completely in the laboratory. Second, since all the physical dimensions of the windows as well as the related indoor environment are the same as those to be adopted in real housing estate in the future, the data so obtained are more realistic. In addition, more space is available in the field so that direct comparison between the acoustical performances of different window types can be administered. Scale model test in the laboratory is not easily implemented when the room surfaces are not acoustically hard and/or the changes of indoor sound absorption are involved in the study. Finally, results of full scale field experiment are important for laboratory data validation.

The mock-up in this study was located next to a busy urban trunk road (129,290 vehicles per day, ~7760 vehicles per hour at peark hour traffic, speed limit 70 km/hr). It consisted of two identical side-by-side modular public housing residential units as shown in Fig. 1. One of the test rooms was installed with plenum windows, while the other was equipped with the side-hung casement windows generally adopted for public housing in Hong Kong. Details of the mock-up test setup are given in the next section.

In this study, detailed examinations on the extent the windows together with the room layouts are affecting the noise fluctuations inside the test rooms and the sound transmission losses across the plenum windows under different indoor conditions (with and without furniture) are carried out. The spectral characteristics of the latters and the effects of acoustic modes on sound transmission are also discussed in details. In addition, the acoustical benefit of replacing the side-hung casement windows in Hong Kong public housing estates with plenum windows is quantified.

2. Mock-up and definitions of acoustical performance

2.1. Details of mock-up construction and measurement setup

The full scale mock-up in this study consisted of two identical side-by-side modular public housing residential units, which were built at 3 m from the near edge of a very busy (and thus noisy), long and straight urban trunk road (Fig. 1). This road was also parallel to the façade of the mock-up. The road traffic was the

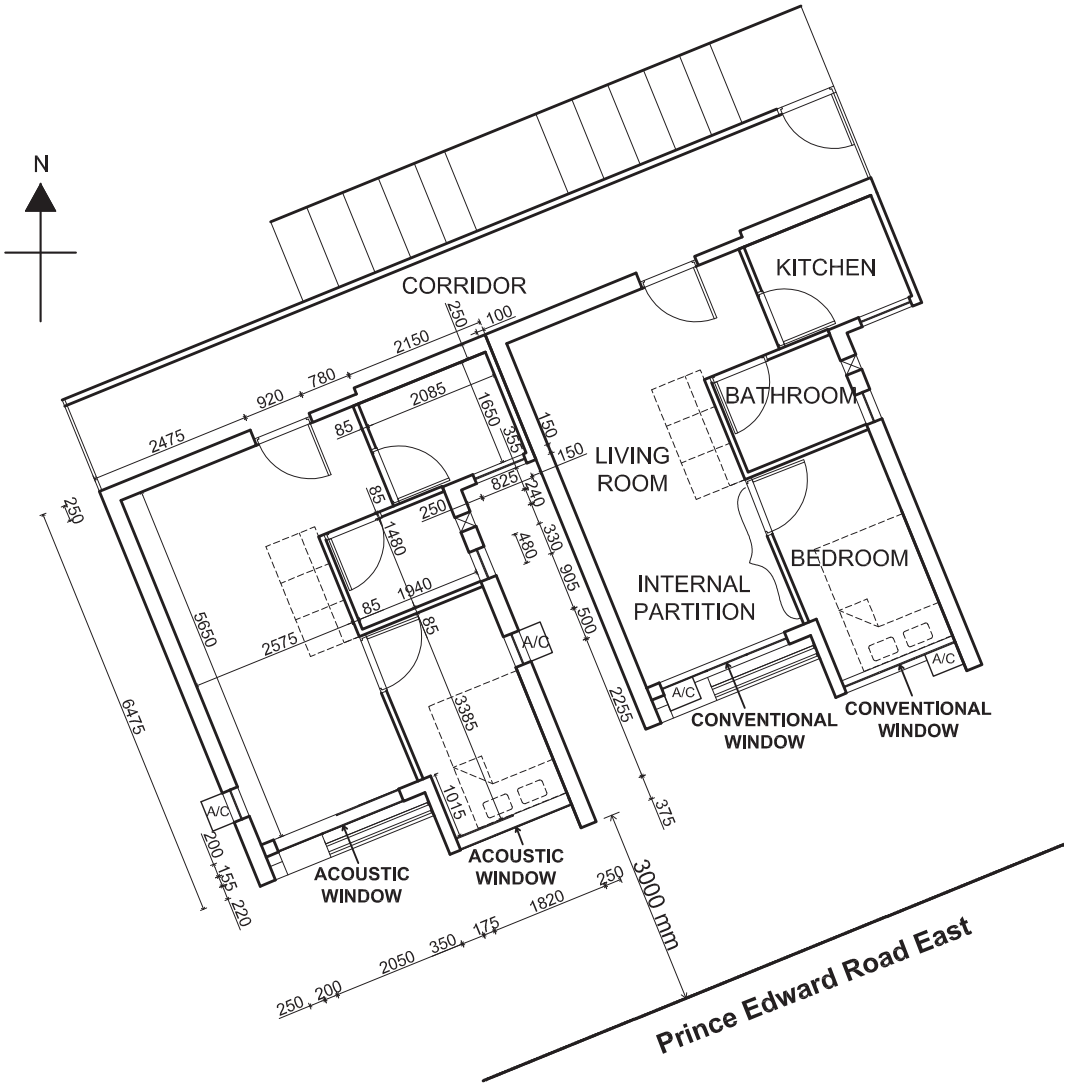

Fig. 1. Layout plan of the mock-up flats (All dimensions in mm).