Innovative Measures to Protect Residential Developments from Traffic Noise - Hong Kong Experience

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ABSTRACT

Hong Kong is a hyper-dense city with over 7.3 million people living in 1,100 sq. km in which 85% of land is hilly area. Due to the need to build residential developments to accommodate the ever growing population and at the same time, the need to have very concentrated road network systems to support economic growth, residential buildings are unavoidably built next to roads. As a result, traffic noise is undoubtedly the major environmental noise problem affecting residents in Hong Kong. The Government of Hong Kong Special Administrative Region (the Government) is committed to tackle road traffic noise problem through careful planning of new residential developments and also applying latest advancement of road surfacing to reduce noise at source. Alleviating traffic noise impact on new buildings sitting next to busy highways is never an easy task, nevertheless, the Government is forward looking and has been proactively collaborating with research institutes to develop innovative noise mitigation designs such as acoustic windows and acoustic balconies. Both are capable to reduce noise substantially while allowing natural ventilation for residents. On reducing noise at source, low noise road surfacing is a standard road surfacing material for expressway. New forms of road surfacing like polymer modified stone mastic asphalt with different aggregate size and crumb rubber stone mastic asphalt are being explored and put into trial widely on local roads. This paper summarizes the efforts in addressing traffic noise problems affecting residential developments through applying innovative acoustic windows and acoustic balconies; and overlaying low noise road surfacing on local low speed roads. Both means are novel ways that can be applied under suitable situations to achieve a quieter environment for residents in Hong Kong.

Keywords: *traffic noise, noise mitigation measures and low noise road surface*

1. INTRODUCTION

Hong Kong is one of the most densely populated metropolitan cities and is facing severe and pervasive road traffic noise problems. Due to a host of factors like limited habitable land, the need to provide accommodation for large population and concentrated transport networks to support economic growth, many residential developments are unavoidably built in close proximity to heavily trafficked expressways and roads, e.g. see Figure 1, and as a result, about 960,000 people are exposed to road traffic noise at levels higher than 70 dB(A)L10(1 hour).

There are mounting public concern about the noise environment and its impact on the residents' quality of life. Legislative Council members called for case conferences to look into the situation and pressed for solutions to reverse the situation. In response, the Administration is committed and action plans are in place to minimize the noise exposure. For instance, proactive preventive works are being done in planning of new roads and new residential developments so that future residents would not be affected by excessive road traffic noise. The Government are implementing measures such as retrofitting noise barriers on suitable sections of existing roads to address the existing problems.

For the preventing planning of new residential developments, conventional noise mitigating designs or measures like maximizing the setback from the road; orientating the building block to minimize view angle on the road; single aspect building design with only non-noise sensitive uses facing the road and using noise tolerant building, structure, architectural fin or purposely built barrier to screen off the road are considered for incorporation in the design of development against road traffic noise. However, these conventional noise measures may not be applicable in each and every case due to specific site constraints. Furthermore, these measures can hardly offer adequate noise reduction in the case which noise exceedances are large, say, when the housing block is extremely close to highly trafficked road. Therefore, innovative noise mitigation measures are needed in order to keep the traffic noise at bay. In this respect, the Government has been proactively collaborating with research institutes to develop such mitigation measures in the form of specially designed windows and balconies (acoustic windows and acoustic balconies).

On the other hand, low noise road surfacing (LNRS) delivers promising performance even though noise reduction effect is not large as compared with that from barriers but all residents in the vicinity would be benefitted. As a matter of fact, LNRS has already been adopted for our new high speed (70km/hr or above) roads. The Administration takes further steps to test and to try out different forms of LNRS on local low speed roads.

Figure 1: Trunk roads built right next to residential blocks in the 1980s

2. INNOVATIVE NOISE MITIGATION DESIGNS

Closing of window with suitable pane for better acoustic insulation is a practicable noise mitigation measure in some western countries but not in Hong Kong because of its warm and humid climate, in particular, in summer. It will not only practically deprive the residents of an “open-window” life style but also increase the energy consumption by air-conditioning which is needed for a “closed-window” environment in Hong Kong. Therefore, acoustic insulation is only provided as the “last-resort” for residents to choose closing the window for abatement of traffic noise disturbance.

Therefore, in the context of Hong Kong, it is considered worthwhile to explore innovative designs at façade which can reduce noise transmitted into the housing units while allowing sufficient natural ventilation complying with the relevant statutory requirements. Having conducted studies and mock-up tests, the following special designs of windows or balconies are identified capable of offering sufficient ventilation and very effective in reducing road traffic noise transmitted into housing units.

2.1 Acoustic windows

There are different forms of acoustic windows. One of them is known as acoustic window (baffle type), which basically comprises 2 layers of openable windows separated by an air gap. The opened parts can be staggered on two sides with a vertical gap as shown in Figure 2 or on upper and lower portions with a horizontal gap as shown in Figure 3. For the former, the windows at the outer layer are normally side-hung windows which can be opened by pushing outwards while the window at the inner layer is sliding window. For effective noise reduction, the pane of the sliding window would be slid to the side behind the opened side-hung windows and the side-hung windows on the other side need to be kept close. Under such setting, only small portion of the noise reaching the opened side-hung windows can enter into the housing unit through the gap in-between the overlapping panes at both layers and then the opened part of the sliding window. At the same time, air flow can be maintained through the opened side-hung window, the gap and the opened part of the sliding window as well. The noise reduction mechanism for acoustic window with horizontal gap is basically the same as that for acoustic window with vertical gap.

After carrying out preliminary laboratory tests to demonstrate the noise reduction effectiveness of the acoustic windows with vertical gap, mock up units have been set up at a site to be developed for public housing to evaluate noise reduction and air ventilation performances. The mock up tests also aimed at evaluation of other issues like window cleansing, clothes hanging and maintenance etc with a view to facilitating the detailed design. The results of noise measurement at the mock up units facing the concerned highly trafficked road indicated that the achievable noise reductions could be up to 8 dB(A) and the ventilation performance was also found to be satisfactory. The results of other studies indicate that the noise reduction effectiveness depends on a number of factors such as the gap width, the overlapping length and the sizes of the outer and inner openings etc.

For acoustic window with horizontal gap, the outer layer may simply be an opening on the upper part and the pane of the inner sliding window can be slid up and down. As the screen at lower position at the outer layer is very effective in shielding the traffic noise from street level, comparable noise reduction can be achieved even with a much wider gap between the inner and outer layer, which would probably allow for more ventilation.

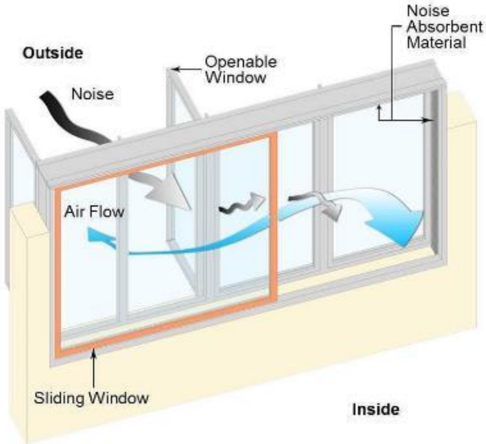

Figure 2: Schematic diagram showing the working mechanism of acoustic window (baffle type)

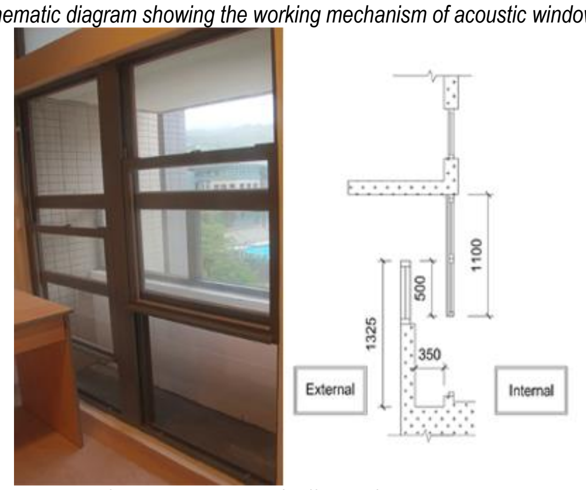

Figure 3: Acoustic window (baffle type) with horizontal gap

Another form of acoustic windows is known as acoustic window (top-hung type), which comprises top-hung windows as upper part close to ceiling and a horizontal panel projecting out from the frame and at the bottom of the windows as shown in Figure 4. The horizontal panel can act as an effective noise screen to reduce traffic noise propagating directly to the opening of the opened top-hung window and, hence, can greatly reduce the noise transmitting into the housing unit. As part of the noise is transmitted into the unit through single or multiple reflections by the pane and the horizontal panel, absorbent may be applied on the side of the pane facing inner and the upward side of the panel to enhance its noise reduction effectiveness. The noise reduction also depends on the height of the window and the extent of the horizontal panel. It is anticipated, with proper design, acoustic window (top-hung type) can achieve a noise reduction of 4-5 dB(A) or even more.

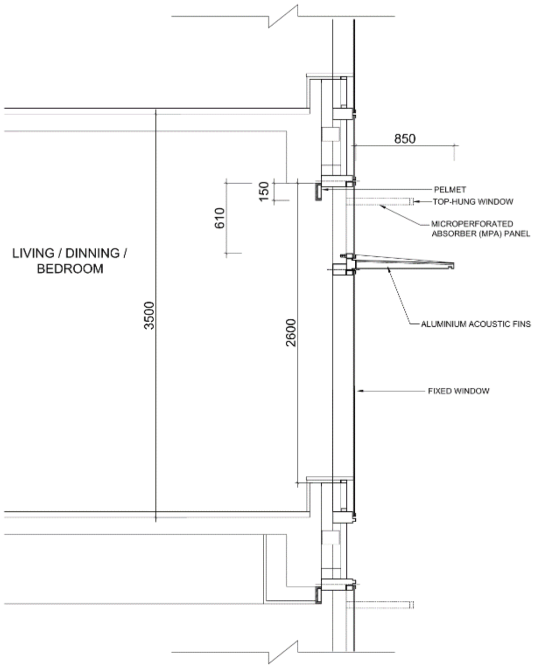

Figure 4: Schematic diagram of acoustic window (top-hung type)

2.2 Acoustic balconies

Balconies have been used in Hong Kong for long time. Features were added enabling noise reduction and hence could be adopted as a measure for mitigating traffic noise impact. The original design of acoustic balcony is just with solid parapets to screen off the noise from entering into the unit through the balcony door and with absorbents applied on the ceiling of the balcony to reduce the noise reflected by the ceiling to the balcony door. It is expected that such acoustic balcony can offer 2-3 dB(A) noise reduction. To enhance the noise reduction effectiveness, further additional features including extending the side parapets to full height side walls, providing a laminated glass panel projecting out from the top of the front parapet and adding sound absorption panels on side walls have been explored into the balcony design. Based on the results of noise measurements at mock up units, these additional features were found capable of offering significant extra noise reduction. Hence, the enhanced acoustic balcony were adopted and implemented in a public housing development in Sham Shui Po, Hong Kong as shown in Figure 5. The noise measurements at some completed housing units on different floors reveal that the noise reduction can be up to 5.5 dB(A).

However, for some extreme difficult cases with large noise exceedance, the above enhanced acoustic balcony is still not able to offer adequate noise reduction. Hence, efforts have been spent to study including other features to enhance the noise reduction further. It was found that, by putting a vertical panel above the front parapet and in front of the balcony door, the noise reduction can be increased significantly and may be above 10 dB(A) on higher floors.

Figure 5: Acoustic balcony in the public housing development in Sham Shui Po

3. LOW NOISE ROAD SURFACE

3.1 Low noise road surface on high speed road

The first trial of polymer modified friction course (PMFC) on a section of expressway was conducted in 1987 in Hong Kong to improve driving safety conditions under heavy raining situation, see Figure 6. Because of porous nature, PMFC brought along noise reduction which was mainly road tyre interaction noise. Measurements were conducted to study its traffic noise reduction performance. It was found that there would be around 5 dB(A) noise reduction in comparing the newly laid PMFC with the neighbouring brushed concrete surface. The maintenance records also indicated that the service life of PMFC on high speed roads was around 5 years .

Figure 6: First PMFC trial on high speed road in Hong Kong

As a result, noise abatement programme was embarked so that 11 kilometres of high speed roads were subsequently resurfaced with PMFC and was completed in 1999, bringing relief to about 16,000 dwellings. PMFC is now standard materials for high speed roads in Hong Kong for the dual effect of noise reduction and reduction of the potential for vehicles to aquaplane .

3.2 PMFC on local low speed roads

To investigate the applicability of PMFC on local low speed roads, some 60 existing road sections with different traffic conditions and road geometries were resurfaced with PMFC. Both noise reduction performance and durability performance were monitored for 5 years. The results showed that just after resurfacing, an average noise reduction was about 2.7 dB(A). From the monitoring data, it is considered that free flow traffic is almost a pre-requisition for PMFC to perform well in durability on local low speed road condition.

3.3 PMSMA6 on local low speed roads

Since not all local low speed roads are suitable for resurfacing with PMFC as locations with frequent stop-and-go etc. will induce repetitive shear forces on the PMFC surface causing development of defects and damage on the porous non-structural PMFC surfaces, following the recommendations of “Review and evaluation of the low-noise road surface programme for low speed-roads in Hong Kong”, thin layer asphalt in the form of polymer modified stone mastic asphalt of 6mm nominal maximum aggregate size (PMSMA6) was trial in different local low speed roads. It is noted that smaller aggregate size could generally achieve better noise reduction ability, stone mastic asphalt of 6mm nominal maximum aggregate size is selected as the base mix. Both noise reduction performance and durability performance are monitored.

3.4 CRSMA6 on local low speed roads

In parallel to trial of PMSMA6 on Hong Kong’s local low speed road condition, feasibility of rubberized asphalt on local low speed roads is also reviewed and explored. Modification based on PMSMA6, rubberized asphalt in the form of crumb rubber modified stone mastic asphalt of 6mm nominal maximum aggregate size (CRSMA6) will be explored in Hong Kong to investigate its field performance under local low speed road conditions.

This idea stemmed from reuse of waste rubber tyre in which on one hand looking for appropriate LNRS for noise reduction and on the other hand providing way out for waste rubber tyres saving space of our very precious and limited landfill areas.

4. CONCLUDING REMARKS

The Administration is committed to keep traffic noise at bay. The innovative noise mitigation designs such as acoustic windows and acoustic balconies are relatively new approaches for reducing traffic noise problems in Hong Kong. Adoption of these designs could offer noise attenuation effect while allowing natural ventilation. Apart from adopting proactive planning approach and also use of noise barriers, the Administration takes big steps forward in exploring use of LNRS particularly on local low speed roads. Different forms of LNRS have been tried and tested out with promising noise reduction results. With the provision of innovative noise mitigation building designs and LNRS, it is optimistic that an acceptable acoustical environment for residents in Hong Kong would no longer be out of reach.

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