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Applying low noise road surfacing to reduce road traffic noise in Hong Kong

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Abstract

Hong Kong is a very small but hyper-dense city with over 7 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 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 highways and road traffic noise in Hong Kong is undoubtedly the major environmental noise problem affecting residents. The Government of Hong Kong is committed to tackle road traffic noise problem and adopts paving of low noise road surfacing (LNRS) as one of practical solutions to reduce the traffic noise impact, especially in the busy urban districts. Researches and trials of different forms of LNRS materials, such as friction course, polymer modified friction course, crumble rubberized asphalt, polymer modified stone mastic asphalt under different traffic conditions have been conducted to evaluate the engineering durability and noise reduction ability. This paper reviews and presents the onsite experiences and the technical findings including noise reduction effectiveness, engineering durability etc. of these materials in Hong Kong traffic situations.

Keywords: LNRS, Noise, Road, Surface

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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 built in close proximity to heavily trafficked expressways and roads which result that about 960,000 people[1] are exposed to road traffic noise at levels higher than 70 dB(A)L_{10}(1 hour). Public concern about the noise environment and its impact on the residents' quality of life is on the rise. Legislative Council members called for case conferences to discuss if solutions could be in place to reverse the situation. The Administration is committed and is actively carrying out action plans to minimize the noise exposure. Proactive works are being done in planning of new land uses and new residential developments so that future residents would not be affected. Also, new major roads are scrutinized through environmental impact assessment process so as to avoid causing unacceptable road traffic noise. Further, programme is in place to address noise through retrofitting barriers on existing roads in practicable manner. Nevertheless, further actions are needed on various front to keep traffic noise at bay. While roadside barriers and enclosure are usually considered effective in reducing noise but only limited to residents in the shadow zone of barriers, however, high construction and maintenance costs are concern. Also, adoption of barriers could lead to other issues like aesthetic and visual impact. Further, there are experiences of diversified public views on use of barriers and some even raised objections to erection of barriers. 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. This paper reviews and presents the onsite experiences and the technical findings including noise reduction effectiveness, engineering durability etc. of these materials in Hong Kong traffic situations.

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

2 LNRS on high speed roads

A trial of polymer modified friction course (PMFC) (in the format of 30mm polymer modified friction course over 20mm cushion course, void content of about 18-25%) on a section of expressway was conducted in 1987 to improve safety driving conditions under heavy raining situation. Because of porous nature, PMFC brought along noise reduction which is mainly road tyre interaction noise. Measurements were conducted to study its traffic noise reduction performance. The noise reduction effect was obtained by comparing the measured noise levels at two neighbouring locations along the expressway. 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 and the noise reduction effect was deteriorated against time to about 1 dB(A) after five years.[2,3] The maintenance records also indicated that the service life of PMFC on high speed roads was around 5 years.[4]

Figure 2: 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.[5]

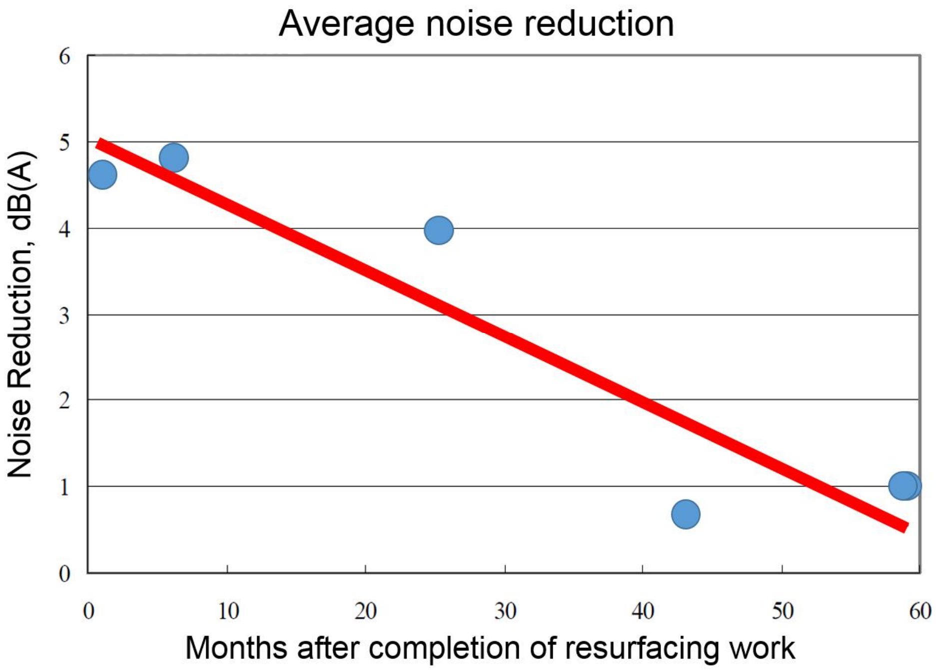

Figure 3: Noise reduction of PMFC over time on high speed roads

3 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, in the format of 30mm polymer modified friction course over 20mm cushion course or 25mm wearing course (WC). Both noise reduction performance and durability performance were monitored for 5 years.

The noise reduction level is determined by comparing the difference in noise levels before and after resurfacing of PMFC at a particular representative measurement point set at the middle of the road sections but away from other influencing noise sources, like bus stops, traffic lights, road junctions, etc. for measuring the free-flow traffic conditions as far as possible. Thereafter, further noise measurements are carried out to assess the ageing effect on noise reduction. The fluctuation of traffic condition, such as traffic volume, percentage of heavy vehicles and traffic speed, between the measurements are normalized with reference to the methodology stipulated in the Calculation of Road Traffic Noise (CRTN)[6]. The noise reduction is estimated by comparing the pre-surfacing noise levels with the normalized post-surfacing noise levels.[7]

The average noise reduction of monitoring data collected has been analyzed and summarized in Figure 4. The results showed that just after resurfacing, an average noise reduction was about 2.7 dB(A). The average noise reduction had decreased with time to about 2.4 dB(A) & 1.9

dB(A) at the end of 2 years & 5 years period respectively with a decreasing rate of about 0.14 dB(A) per year.

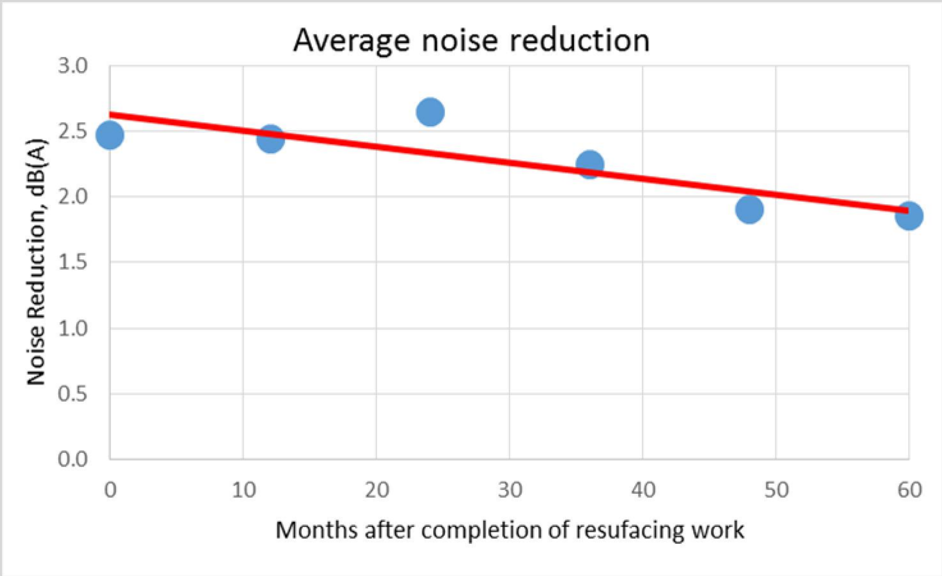

Figure 4: Noise reduction of PMFC over time on local low speed roads

For the durability monitoring, it was found that defects were observed on 44% of the tested roads within 2 years of service life but about 26% of roads did not develop any identifiable defects even after 5 years' service life. Defects were mostly found on locations with sharp turning, frequent stop-and-go, run-in/run-out, roadside parking spaces and bus stops where free-flow traffic condition could not be always maintained. Resurfacing of these PMFC local low speed roads were mostly conducted after 5 years service life.

From the monitoring data, it was found that the larger traffic volume such as daily flow as high as about 20,000 did not have significant negative effect on the durability of PMFC on local low speed road with free-flow traffic condition and only minimal damage was observed over 8 years of service life. On the contrary, frequent stop-and-go, roadside parking or sharp turning in roads even with daily traffic flow as low as 500 was observed to have significant defects development even in less than 2 years of service life. Therefore, 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.

4 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, sharp turning, roadside parking, loading and unloading will induce repetitive shear forces on the PMFC surface causing development of defects and damage such as potholes, ravelling, rutting and shoving, 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" [8], 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. Both noise reduction performance and durability performance were monitored.

Same as those for PMFC monitoring, the noise reduction is estimated by comparing the pre-surfacing noise levels with the normalized post-surfacing noise levels. The average noise reduction of monitoring data is summarized in Figure 5. It was preliminary found that just after resurfacing, an average noise reduction was about 2.6 dB(A) and the noise reduction had decreased with time to about 2.4 dB(A) at the end of 2½ years.

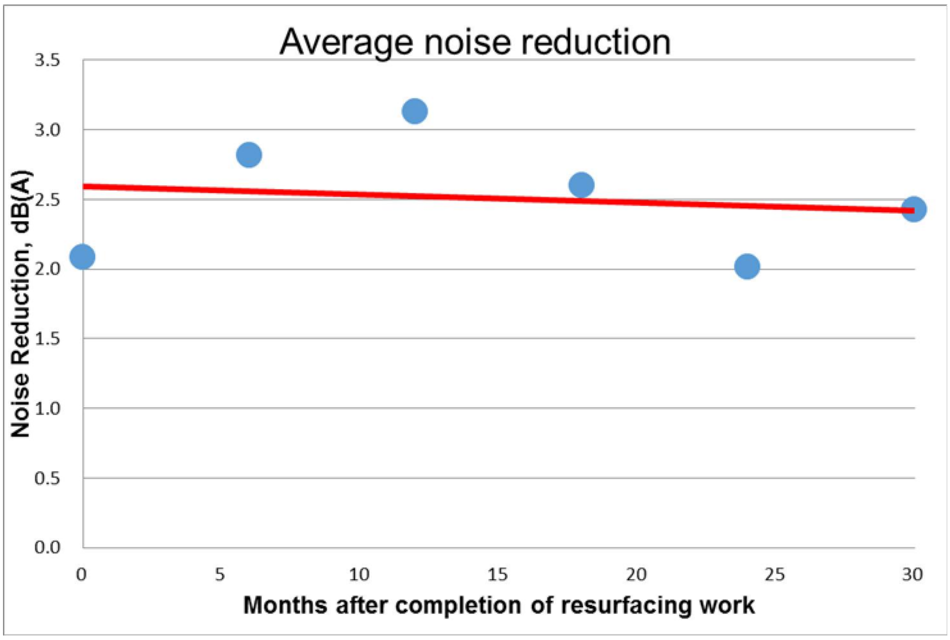

Figure 5: Noise reduction of PMSMA6 over time on local low speed roads

Rutting was found at the harsher locations of bus stops and junctions where frequent stop-and-go was occurring and was similar to the rutting developments of the original WC surfaces. Based on preliminary data collected, it is expected that the engineering performance and durability of PMSMA6 would be comparable to the WC on local low speed road conditions.

5 CRSMA6 on local low speed roads

While monitoring of PMSMA6's performance on Hong Kong's local low speed road condition is still ongoing, other form of LNRS, rubberized asphalt[8] is also under reviewed and considered. 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. The design mix of rubberized asphalt has to meet with both the engineering and acoustic requirements for pavement surfaces in Hong Kong, therefore the more prospective local available base bitumen of Pen 60-70 and the base aggregate skeleton of stone mastic asphalts (SMAs) are selected. As smaller aggregate size could generally achieve better noise reduction ability[8], SMA of 6mm nominal maximum aggregate size is selected as the base mix for the rubberized asphalt. To balance the cost and performance, the crumb rubber size of minus mesh 16 (1.18 mm) and rubber content of 20% in terms of the weight of base bitumen is chosen. To alleviate the odour effect during mixing and compaction of rubberized asphalt, organic additive to lower the mixing temperature and air emission is also used.

Modification base on PMSMA6, rubberized asphalt[8] 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 the field performance under local low speed road conditions.

6 Concluding Remarks

The Administration is committed to keep traffic noise at bay. 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 which was virtually a new area no other Administration has tried out. As shown above, different forms of LNRS have been tried and tested out with promising noise reduction results. With the provision of LNRS, noise barriers and other innovative noise mitigation building designs, it is optimistic that an acceptable acoustical environment for residents in Hong Kong would no longer be out of reach.

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