Road Traffic Noise Pollution Reduction by Poroelastic Road Surfaces: A Review

Kanakabandi Shalini[1], Brind Kumar[2]
Department of Civil Engineering
Indian Institute of Technology (BHU), Varanasi, Varanasi-221005, U.P, India
[1]kskanakabandishalini@gmail.com, [2]kumar_brind.civ@itbhu.ac.in

ABSTRACT

Among the environmental pollutants, noise is considered to be a cause of the widespread occupational and community health problems and consistently ranks high on the list of citizens' concerns. There are many sources of noise, but one of them clearly dominates: road traffic noise. Road traffic noise has traditionally been associated with engine and exhaust noise of vehicles. Poroelastic Road Surface (PERS) is a low noise road surface which reduces the road traffic noise pollution, made entirely of rubber and a binder which can be either polyurethane or bitumen. It could give 5- 10 dB (A) of noise reduction and a potential alternative to noise barriers, especially where such are impractical or not desirable. This gives high air void content (around 30 %), high elasticity and smooth texture, all of which should give low noise properties. This article briefly reviews the road traffic noise reduction with the help of poroelastic road surface.

Keywords: Noise, Pollutants, Road traffic, Poroelastic road surface (PERS)

1. INTRODUCTION

Noise is a recognized pollutant that can cause a wide range of negative social impacts. Noise can be defined as the level of sound which exceeds the acceptable level and creates annoyance. The major sources of noise are Industrial noise, Traffic noise & Community noise Out of above three parameters, the source that affects the most is traffic noise. In traffic noise, almost 70% of noise is contributing by vehicle noise. Vehicle noise is created by engine and exhaust system of vehicles, aerodynamic friction, interaction between the vehicle and road system, and by the interaction among vehicles [12].

In theory, there are a number of options that can be used to reduce or mitigate traffic noise. These include traffic management, highway design, Poroelastic Road Surface (PERS) and noise barriers including earthen berms. In reality, noise mitigation is often infeasible due to space requirements, aesthetic issues and financial costs, or because the costs outweigh the benefits.

The main purpose of this article was to review the traffic noise pollution reduction using poroelastic road surface by several investigators.

Why use poroelastic road surfaces

The primary reason for the development of PERS is to reduce tyre/road noise that is the dominant noise source for most car and truck driving conditions. The porous structure of PERS reduces noise generated by aerodynamically related mechanisms, whereas elasticity reduces vibration-related mechanisms. Altogether, according to the laboratory and road tests, PERS may reduce vehicle noise by 8–10 dB in relation to typical road surfaces used now a days, PERSs should be more durable when studded tyres are used. As a considerable amount of rubber aggregate is used for PERS mixes, the problem of recycling waste tyres may be solved at the same time.

2. POROELASTIC ROAD SURFACE

Poroelastic Road Surface (PERS) is a low noise road surface which reduces the road traffic noise pollution, made entirely of rubber and a binder which can be either polyurethane or bitumen. **Sandberg and Jerzy (2002)** define PERS as follows:

"A PERS is a wearing course for roads with a very high content of interconnecting voids so as to facilitate the passage of air and water through it, while at the same time the surface is elastic due to the use of rubber (or other elastic products) as a main aggregate. The design air void content is at least 20% by volume and the design rubber content is at least 20% by weight".

A poroelastic road surface, consists of an aggregate of rubber granules or fibres, sometimes supplemented by sand, stones or other friction-enhancing additives. This can be either rubber from scrap tyres or "new" rubber. It further consists of a binder to hold the mix together. Finally, one needs a binder to fix the surface onto an existing road base course [9]. This is an effective way of using recycled tyre rubber as large amounts of rubber are required. Use of recycled tyre rubber facilitates a sustainable and clean environment. Some PERS materials have shown excellent wear resistance coupled with low emission of particulates [8]**.** It is believed that PERS materials may provide better acoustical longevity than perhaps any other low-noise surface if they are sufficiently elastic to prevent dirt from permanently getting stuck in pores. PERS pavements have provided substantial acoustical relief when used on a roadway. Traffic noise reductions around 10–12 dB in comparison with a conventional dense asphalt or stone mastic asphalt have been achieved when using PERS mixtures [8].

The composition of PERS mixture was given by **Ministerie van VROM.**

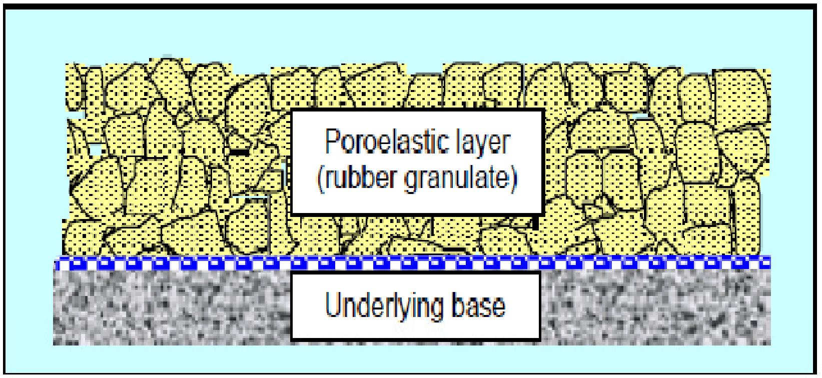

Figure 1: Poroelastic road surface

Coarse aggregate 8/11	87%
Fine aggregate	11 %
Filler	2%
Rubberized bitumen	5.5%

3. SPECIAL FEATURES FOR POROELASTIC ROAD SURFACES

- PERS is usually based on an aggregate of small maximum size. This gives low texture impact excitation to the tire tread, and thus low vibrations and noise emission.
- Prefabricated PERS may be given an extremely smooth surface. This gives exceptional low texture impact on the tire tread.
- The porosity of PERS is usually very high, typically 30-35 % expressed as air voids content. This effectively eliminates the air pumping and air resonant radiation, as air pressure gradients in the tire/road interface and in the tread pattern grooves will be only marginal.
- The high porosity also effectively eliminates the horn amplification effect, as there will be no acoustically dense surface in the "lower horn wall".
- The high porosity of PERS gives sound absorption. However, with the low layer thickness employed in PERS so far (approx 30 mm), the peak sound absorption will hit a frequency range**.**
- Less deformation in the tire when rolling will mean less vibration excitation and less noise emission as well [10].

Literature on Poroelastic road surface

Meiarashi et al., (1996) developed a method for the reduction of road noise by using porous elastic road surfaces. They found that significant total noise reduction of porous elastic road surface for both cars and trucks, 13 and 6 dB(A) respectively.

Nilsson et al., (2008) developed a poroelastic road surface (made from conventional asphalt mixing plants and conventional paving machines) for low tyre/road noise emission. They reported that 6 dB(A) noise reduction achieved with poroelastic road surface depending on the vehicle speed and amount of rubber used.

Nilsson & Zetterling (1990) used poroelastic road surface for measuring the noise data of moving vehicles. They reported that a noise reduction of approximately 10 dB(A) or greater achieved with the poroelastic road surfaces.

Sandberg et al., (1993) used poroelastic road surfaces for noise reduction. They found approximately 8 dB(A) noise reduction with these road surfaces.

Fujiwara et al., (2005) and Meiarashi (2006) measured the road noise with the help of A-weighted sound pressure level method. They improved the noise reduction effect of poroelastic road surface upto 7-9dB.

Sandberg and Kalman (2005) reported that traffic noise reduction on a 50 km/h street is 8-11 dB(A) initially (for light vehicles); slightly better at 70 km/h. Tyre/road noise reduction alone is slightly better.

Goebiewski et al., (2003) derived A prediction model for the traffic noise from a porous road surface. Subjective assessments of drive-by noise suggest that the sound exposure and the road surface coefficient can be used as the acoustical characteristics of a road surface.

The poroelastic road surface is originally a Swedish invention Nilsson, 1979, found to be acoustically very efficient but with unacceptable durability. Instead, Japanese researchers worked further on the concept and made considerable progress. New research by Transport Research Institute in Sweden in the middle of the previous decade made progress too, but failed due to damages appearing in the underlying asphalt pavement.

In the latest years there have also been some trials with PERS in the Netherlands, but also these have failed to be durable. The Japanese trials were the most successful, but finally also those were discontinued.

The PERS materials tested before 2008 typically contained 75-85 % by weight of rubber (most of the rest was polyure-thane as binder), whereas after 2008 sand and stone aggregates have been added at the expense of rubber. Thus, the latest materials have had 15-30 % of rubber by weight. This has been considered as the best way to obtain sufficient wet friction [11].

Environmental issues:

In addition to the exceptional acoustical features, PERS has a number of other environmental issues.

The fine rubber particles which are worn off the PERS by the tyres may be harmful to the lungs, both as particles contaminating the lungs and by containing harmful chemical substances. In case of accidents on the road covered with PERS, a fire fuelled by petrol or oil, or by the rubber, may create harmful fumes, may propagate rather fast and be difficult to distinguish. An important disadvantage of PERS will be that its lifetime will most likely be lower than that of conventional road surfaces [13].

4. CONCLUSION

Poroelastic road surfaces demonstrate a very big potential for the reduction of traffic noise, especially on low and moderate speed roads. In fact, they are less noisy than any other road surfaces that are commercially used nowadays. PERS reduces vehicle and traffic noise by 5-10 dB(A) in relation to a conventional, dense asphalt surface. Japanese experiments were partial success of some extent. It is also expensive but it could, nevertheless, be motivated in many cases as an alternative to noise screens. Since a poroelastic surface has not yet been tried over a long period of time, it is not possible to say that it is a durable surface.

REFERENCES

[1] Fujiwara T, Meiarashi S, Namikawa Y, Hasebe M. Reduction of equivalent continuous A-weighted sound pressure levels by porous elastic road surfaces. Applied Acoustics, 66(2005), 766-778.

[2] Jerzy A, Grzegorz R. Laboratory tests of poroelastic road surface. 16th International Congress on Sound and Vibration, Kraków, Poland, 5–9 July 2009

[3] Meiarashi S, Ishida M, Fujiwara T, Hasebe M, Nakatsuji, T. Noise reduction characteristics of porous elastic road surfaces. Applied Acoustics, (1996) 47(3), 239-250.

[4] Meiarashi S, Ishida M, Fujiwara T, Hasebe M, Nakatsuji T. Noise reduction characteristics of porous elastic road surfaces. Applied Acoustics, 47(1996), 239-250.

[5] Nilsson NA, Ulmgren U, Sandin A. A quiet poroelastic road surface manufactured in a normal asphalt mixing plant. Journal of the Acoustical Society of America, 123(2008), 3390.

[6] Nilsson NA, Zetterling T. Noise reduction mechanisms for poroelastic road surface. Proceedings of the International Tire/Road Noise Conference 1990, pp. 47-66.

[7] Sandberg U, Jerzy A. Tyre/Road Noise Reference Book. Informex HB, Kisa, Sweden, 2002.

[8] Sandberg U, Bendtsen H, Kragh J, Johansen J, Arnevik A, Storeheier SA. Low noise road surfaces-a Nordic co-operation project. VT1 Rapport 388, Swedish Road and Transport Research Institute, (1993), pp. 26-27.

[9] Sandberg U, Kalman B, The poro-elastic road surface–Results of an experiment in Stockholm. In Proceedings of Forum Acusticum , (2005, August) , pp. 1205-1210.

[10] Sandberg, Goubert L. Poroelastic Road Surface (PERS): A review of 30 years of R&D work. Proc. of Inter-Noise 2011, (2011), Osaka, Japan

[11] Sandberg U, Zurek S, Ejsmont, A, Ronowski G. Tyre/road noise reduction of poroelastic road surface tested in a laboratory. Proceedings of Acoustics 2013, 17-20 November 2013, Victor Harbor, Australia

[12] Subramani T, Kavitha M, Sivaraj K. Modelling Of Traffic Noise Pollution. International Journal of Engineering Research and Applications (IJERA), 2 (2012), 3176.

[13] SwieczkoZurek B, Ejsmont J, Motrycz G, Stryjek P. "Risks related to car fire on innovative Poroelastic Road Surfaces—PERS." Fire and Materials (2014).