Study on reduction of pavement noise using porous concrete

Discussion by N. Subramanian

Replies by Abhijeet S. Gandage

This has reference to the paper titled 'Study on reduction of pavement noise using porous concrete', authored by Abhijeet S. Gandage, V. Vinayaka Ram, Manish Panwar, Meet Shah and Rishabh Singhvi, published in The Indian Concrete Journal (Vol. 90, No. 3, pp. 12-21).

I am happy to note that considerable efforts are taking place in India to develop quality infrastructure. The Indian finance minister has announced an outlay of Rs 97,000 crore for the roads sector in the 2016 budget. He also announced that the thrust areas include the construction and award of 10,000 km roads each over the next fiscal, upgradation of 50,000 km of state highways into national highways and rolling out of 85 per cent of the stuck projects involving investment of Rs 1 lakh crore. In this perspective, I am glad to note that the noise pollution aspect is also being considered and the current initiative taken at the Birla Institute of Technology and Science (BITS), Pilani, Hyderabad Campus, and reported in this paper is to be appreciated.

Having lived in India for more than 50 years and also in Germany and USA for about 15 years, the undersigned is well aware of the road conditions in India as well as abroad. In Indian city roads, the major noise pollution is due to drivers honking the horns of their vehicles and not the noise produced at the contact between tiers and the road surface. Moreover, the maximum speed at which one can drive in city roads in India may be around 40 km/h only (the mixed traffic prevailing in Indian cities may also be one of the reasons for the slow speed and also the poor quality of roads). On the contrary, in countries like USA and Germany, drivers will not honk, unless there is an emergency. Of course, the situation on highways and expressways may be different, where the speed may reach about 100–120 km/h; expressways however are very few in India, the most notable being the Mumbai-Pune Expressway (In 2007, a law was proposed to set a nationwide 100 km/h speed limit for cars and 65 km/h for motorcycles, but unfortunately not implemented. The recently constructed Outer Ring Road in Hyderabad is designed for speeds up to 120 km/h. However, some vehicles can reach speeds well over 160 km/h, making it one of the fastest expressways in Asia). Compared to these, speed limits in the United States are set by each state or territory- speed limits can range from an urban low of 35 mph (56 km/h) to a rural high of 85 mph (137 km/h). Of course, in German Autobahns there is no speed limit in most of the places, but recently a speed limit of 130 km/h (81 mph) was imposed. The quality of city roads in India is not very desirable and many are with lot of potholes, though the

Figure 9. Noise barrier along a highway in Virginia, USA

quality of highways and expressways are comparable to the highways in USA. All these factors affect the noise pollution generated on the road surface.

Till now, in India the noise pollution due to tyre pavement interaction was not considered as nuisance, may be because it is dominant only when the speed exceeds 35 km/h. In other countries where high speed is allowed on highways, noise barriers such as sloping mounds of earth, walls and fences constructed of a variety of materials (concrete walls are usually built with attractive concrete surface designs), thick plantings of trees and shrubs, and combinations of these materials, have been used successfully. Noise barriers have been built in the United States since the mid-twentieth century and Figure 9 shows such a wall constructed along a highway (see References 21 and 22 provide complete details of these walls and the materials that can be used). Strict zoning rules in USA prevent houses and offices to be built along the roads. Usually, buildings are built at sufficient distance (60 m is specified in Virginia, USA) away from the freeway with vegetation in buffer zones, so that sound effects are controlled.

Using porous asphalt/concrete material over normal asphalt/concrete roads is not new (Bendtsen et al., 2008). For more than a decade, roads with fast traffic in Europe were often constructed with porous asphalt, to reduce water splash and vehicle spray behind vehicles during heavy rainfall and also to abate the noise pollution. But their use in Europe resulted in problems such as clogging, and increased slipperiness in winter. It has also been found that porous concrete (also called *pervious concrete*) has the same disadvantage as porous asphalt such as voids silting up in due course, and slipperiness in winter. Of course, full depth pervious concrete pavements can store large quantities of rain water, allow it to percolate into the underlying soils and at the same time reduce the entrance of pollutants in storm water systems (Subramanian, 2016).

Author's reply

The authors thank the discusser for his encouraging words. Some of the facts mentioned in the preceding paragraphs are informative and motivate the authors to explore further scope in this area of research. The authors take this opportunity to thank the discusser for sharing valuable information which will help the authors to undertake more detailed investigation in further stages.

The authors in their paper discuss about source control and have provided a nice review of the tire pavement noise and present the results of laboratory experiments conducted by them using porous concrete. In pp.17, under section 3.0 Porous concrete, they indicate at two places the void ratio of porous concrete. In the beginning of the paragraph it is indicated as 18% to 35% and at the end it is indicated as 15% to 20%. Which one is correct? (Anyway, they have stated that porosity greater than 15% will result in efficient noise reduction). The discusser believes that the percentage of void space is partially dependent on the size of aggregate used: 10 mm aggregate may produce 15 to 25 percent void content; and 12 mm aggregate may yield 30 to 40 percent void content and a noticeably coarser surface (Subramanian, 2008). ACI 522.1-08 restricts the maximum size of aggregate to one-third of the specified pavement thickness.

Author's reply

The voids ratio of 18% to 35% is a statement cited from a review paper (reference number 16). This voids ratio is considered for porous concrete without any specific mention of the application of such concrete. In the later half of the paragraph the voids ratio mentioned is 15% to 20%. This value is reported from reference number 6 which specifically prescribes the range of voids ratio to be adopted in the porous concrete for pavement application to address the tire pavement interaction noise.

Their test setup shown in Figure 7 of the paper is interesting. The authors state that it is an indirect measure of noise absorption by the cube specimen. Is this setup based on any standard? How will the results of these tests correlated with the actual pavement conditions? The authors used 10 mm aggregates- Tian et al. (2014) also found from their experimental investigations that porous concretes with a maximum aggregate size of 9.5 mm has the highest acoustical absorption coefficient. Tian et al. (2014) also showed that the peak absorption coefficient depends on the mixture characteristics and the thickness of the specimen and found that a thickness of 80 mm had optimum absorption. The field-measured tire-pavement noise clearly showed that the porous cement concrete significantly reduced the tire-pavement generated noise by 4 to 8 dB.

Author's reply

The test setup proposed in the study is not based upon any standard. It's setup designed with an objective of laboratory investigations. In light of the limitations of use of more advanced and sophisticated measuring instruments available (as exhibited in figure number 4), the authors proposed to develop a low cost test setup that is easy to understand and operate as well.

Though quieter pavements offer a range of noise reduction (3 to 7 dB), they are not always durable and found to have shorter pavement lives of about 8 to 12 years(WSDoT Report,2005). Shorter pavement lives correlate to an increase in life cycle costs, compared to traditional pavements. However, they may have better performance in warmer and drier areas (for example, they performed poorly in Washington State but performed better in states like Arizona, California, Texas, and Florida (WSDoT Report,2005). It has also been found that the noise reductions degrade over time. As the authors have rightly stated, pervious concrete cannot be used on highways with truck traffic as they have low flexural strength. However, porous concrete has been found to have longer life when adopted in parking lots; one of the best-known porous parking lots, located at the Walden Pond State Reservation in Massachusetts, was constructed in 1977. While it has never been repaved, it is still in good condition and drains rainwater effectively.

Author's reply

Thank you for the informative note. In India too number of organizations have used porous concrete as a pavement material. However due to low flexural strength factor of porous concrete the entire campus has been categorized as no vehicle campus. The objective of laying porous concrete pavement is ground water recharge.

References

19. ACI Committee 522, Specifications for pervious concrete pavement (ACI 522.1-08), American Concrete Institute, Farmington Hills, MI, 2008, pp. 7.

20. Bendtsen, H., Kragh, J., and Nielsen, E., Use of noise reducing pavements - European experience, Danish Road Institute, Technical note 69, 2008, 90pp.

21. Kotzen, B., and English, C. (2009) *Environmental Noise Barriers: A Guide to Their Acoustic and Visual Design*, 2nd Edition, Taylor & Francis, New York, 257 pp.

22. www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/design/design05.cfm

23. Subramanian, N., Pervious concrete – A 'green' material that helps reduce water run-off and pollution, *The Indian Concrete Journal*, Dec. 2008, Vol.82, No. 12, pp.16-34.

24. Subramanian, N. *The Principles of Sustainable Building Design*, in "Green Building with Concrete: Sustainable Design and Construction", Sabnis, G.M., Ed., 2nd edition, CRC Press, Boca Raton, FL., 2016, pp. 35-88.

25. Tian, B., Liu, Y., Niu, K., Li, S., Xie, J., and Li, X. (2014). "Reduction of Tire-Pavement Noise by Porous Concrete Pavement" *Journal of Materials in Civil Engineering*, ASCE, Vol. 26, No.2, pp. 233-239.

26. WSDoT Report "Quieter Pavements: Options and Challenges for Washington State, Washington State Department of Transportation, May 2005, 52 pp.[www.wsdot.wa.gov/NR/rdonlyres/74A3E245-5B7D-49A0-8EEE-5D6C2B9521A5/0/QuieterPavements.pdf]

Discussion by

Dr. N. Subramanian, 23, Napa Valley Road, Gaithersburg, MD 20878, USA

Replies by

Abhijeet S. Gandage, Research Scholar, Department of Civil Engineering, Birla Institute of Technology and Science, Jawahar Nagar, Shameerpet Mandal, Hyderabad.