

Quieting Concrete Pavement Through Surface Texture Design and Modification

In recent years, various asphalt pavement surfaces have become identified as "quiet pavements" due to their ability to reduce tire/pavement noise and ultimately, traffic noise. Often lost in this perception is the fact that substantial reductions in tire/pavement noise can also be made by texture modifications to existing concrete pavement or by noise sensitive surface texture construction in new pavements.

Concrete surfaces have been found to span a range of as much as 16 dB. As a result, there is the potential to achieve large noise reductions depending on the existing and final surfaces. In California, grinding of bridge decks and elevated structures has been found to reduce tire/pavement source levels 3 to 10 dB with comparable reductions in wayside measurements. In Arizona, grinding of concrete has reduced source levels up to 9 dB relative to some transversely tined surfaces. Measurements conducted in Europe using the same measurement methodology indicated a range of 11 dB including more unique porous concrete surfaces

On-board Sound Intensity (OBSI) Tests

Originating in the early 1980's, the OBSI test method was developed by the auto industry for measuring tire/pavement noise⁽¹⁾. In 2002, it was applied to quantifying the performance of different pavements for their noise performance⁽²⁾. Since that time, Caltrans, through Illingworth and Rodkin, Inc, has developed a database of the performance of almost 200 pavements. It has been established using a single tire design and a consistent measurement methodology at a test speed of 60 mph. This database has been used to estimate the expected tire noise benefit due to pavement overlays and pavement texturing as well as to assess the performance of different pavement groupings. Sound intensity measurements have also been used to document the reductions produced by pavement modifications and to support pavement research work. As the database expanded to include more pavement types, it was noted that a large range in the noise performance of concrete surfaces exists.

In the extreme cases, this difference could be as great as 13 dB. With this realization, it is evident that texturing of concrete surfaces is a viable option for

Did You Know?

- That noise level reductions as high as 9 dBA have been achieved by diamond ground surfaces relative to levels achieved with transverse tined surfaces.
- That changing just the frequency content of the noise can have a significant impact on annoyance.
- That even longitudinal tining, one of the quieter new surfaces, can vary as much as 2-4 dBA on a project.

reducing tire/pavement noise and related traffic noise depending on the initial performance of the surface and type of final texturing used. This option has been exercised in several circumstances to produce noticeable reduction in tire/pavement and traffic noise. Further, data taken in Europe indicates that even further improvement in concrete performance is possible if porous pavements are considered.

Overall Noise Comparison of Different Surface Textures

The tire/pavement noise performance of concrete surfaces in the groupings represented in Fig. 1 is provided in Fig. 2. As may be expected, the ground surfaces are typically the quietest followed by longitudinally tined and finally transversely tined. With only a few exceptions, these groupings do not overlap. Further, the uniform transverse tined surfaces are quieter than the random. However, it should be noted that only a few of the uniform transverse surfaces are included in the database. Typically new concrete surfaces are not initially ground. As a result, longitudi-

nally tined texture would be preferred as the initial texturing for obtaining the quietest noise performance. Within this category, however, a range of more than 4 dB has been measured implying that with a better understanding of the

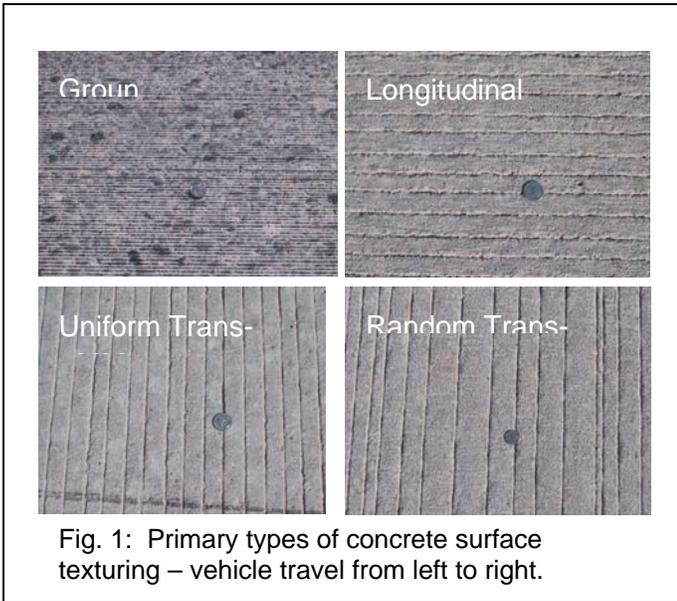


Fig. 1: Primary types of concrete surface texturing – vehicle travel from left to right.

controlling parameters, designing and building quieter longitudinal tining may be possible. Not shown in Fig. 2 are two textures that are not commonly used in California or Arizona. These are a burlap drag and a broomed texture applied in the longitudinal direction. These surfaces produced levels of 101.5 and 101.8 dBA respectively⁽³⁾. This is slightly below that of the quietest longitudinally tined surfaces and could be considered as options if other important pavement criteria, such as pavement skid number, are met by these textures. The large range of concrete surface texture noise levels is not unique to the US. The same test procedures and equipment were used to measure European pavements to benchmark the results of the two continents⁽⁴⁾. Figure 3 indicates the results from that testing.

With some exceptions, the performance of these surfaces covered about the same range as those contained in the California/Arizona database. On the higher end, if the bridge decks surfaces were excluded from Fig. 2, the highest levels in both Europe and the United States (US) would be similar. On the lower end, one surface was found to be considerably quieter than any in the US. This was a porous and ground concrete surface on a roadway in Germany. This surface performed within 2 dB of the quietest AC pavement, which was of a double layer porous construction. From more limited testing done at 56 km/h, it was found that even unground porous concrete

surfaces could perform similarly close to the quietest AC pavements.

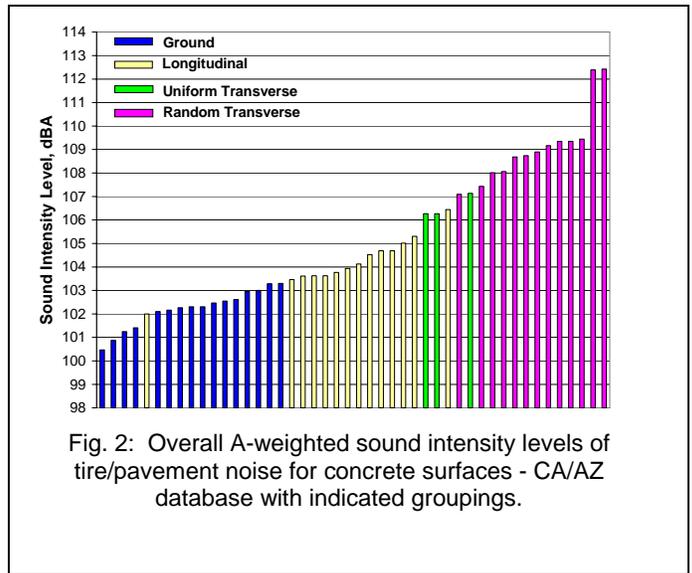


Fig. 2: Overall A-weighted sound intensity levels of tire/pavement noise for concrete surfaces - CA/AZ database with indicated groupings.

Comparison of Frequency Effects

While all regulations and most discussions involve only the overall noise levels, frequency content is a very important consideration in regards to tire-pavement noise annoyance. Figure 4 indicates the range in

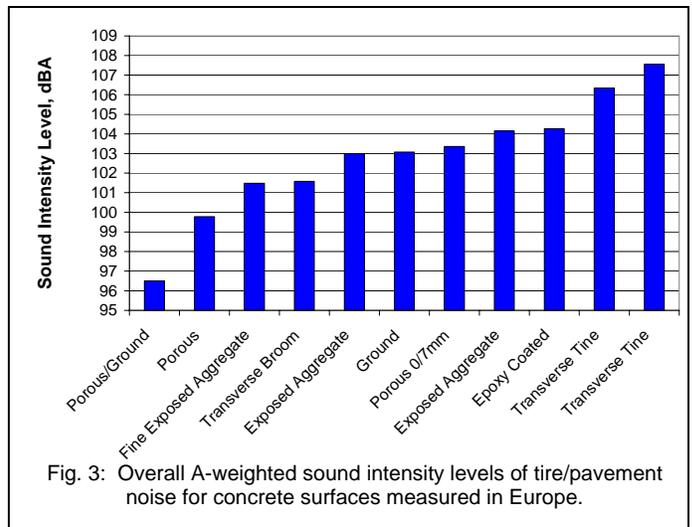


Fig. 3: Overall A-weighted sound intensity levels of tire/pavement noise for concrete surfaces measured in Europe.

overall A-weighted noise levels for selected Arizona textures⁽⁵⁾. From the worst-case random transverse tined surface to the ground section, the reduction is almost 9 dB. The one-third octave band spectra for the four surfaces (Fig. 5) show that most of the improvement between the tined and ground surfaces occurs at frequencies below about 1600 Hertz. In this region, reductions of 10 to 12 dB occur. The spectra plots indicate that there are both overall level and

frequency differences; both of which contribute to annoyance.

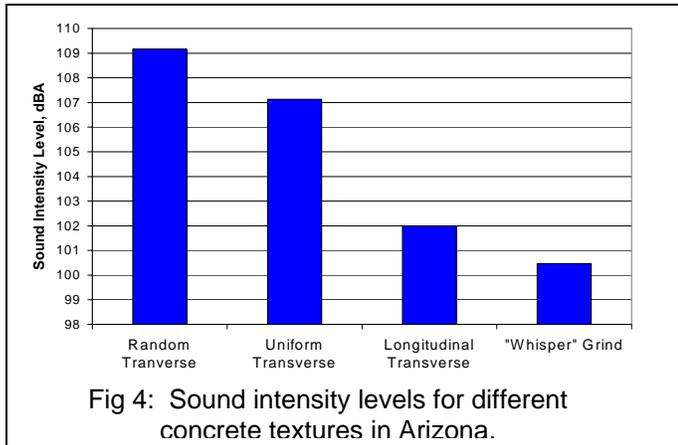


Fig 4: Sound intensity levels for different concrete textures in Arizona.

Another example of the importance of frequency in regards to noise annoyance can be found in a California example on a new freeway segment in Santa Clara County (SCL 85). The newly opened freeway had been constructed using Caltrans standard longitudinal tinning.

However, motivated by public outcry regarding pavement noise upon opening of the freeway, the local transportation commission funded a short, experimental grooving and grinding test section. The test section, located in the city of Saratoga, was constructed to determine if modifying the pavement surface could lower overall traffic noise levels. Initial reaction from the community was quite favorable after the grinding and texturing was complete.

To quantify this effect, sound intensity measurements were made comparing the ground pavement to that of the original tinning. The results produced two observations. First, although the overall average difference between the two surface types was only slightly more than 2 dB, the grinding produced more uniform noise levels with variations of 1 dB or less for different ground sections. The original tined surface had variations ranging from 1 to more than 2 dB. As a result, the worst to best reduction was more than 4 dB with a number of individual sections producing reductions on the order of 3 dB. The second observation was that the largest reductions on a one-third octave band basis were found in bands around 1600 Hertz (Fig. 6). These frequencies are thought to be responsible for a higher frequency "presence", or sizzle sound, which can be noticeable in the community. So although there was not a dramatic difference in overall loudness (e.g. 2 dBA) the community considered it a positive improvement.

Conclusions

From the databases and examples of surface texture modifications, it is apparent that quieter concrete surfaces can be achieved. As with any evaluation of the effectiveness of any pavement change, the amount of reduction depends not only the end "quiet" pavement, but also on the initial pavement performance. From the data accumulated to date, at least in the US, the absolute level of quiet concrete does not approach that of quiet AC.

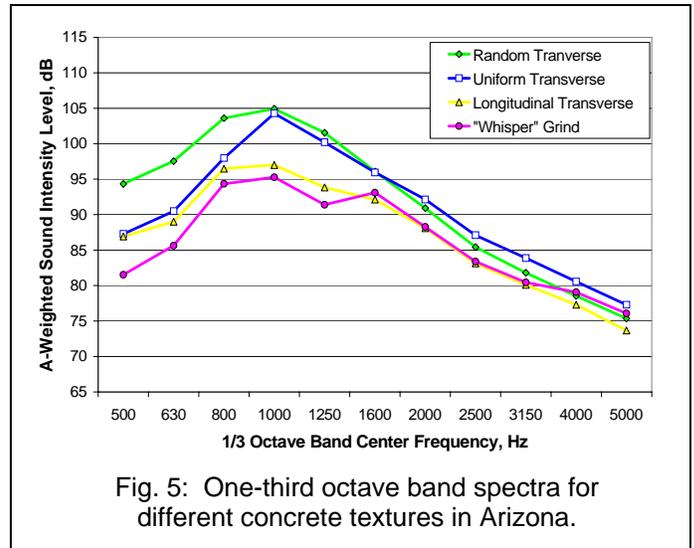


Fig. 5: One-third octave band spectra for different concrete textures in Arizona.

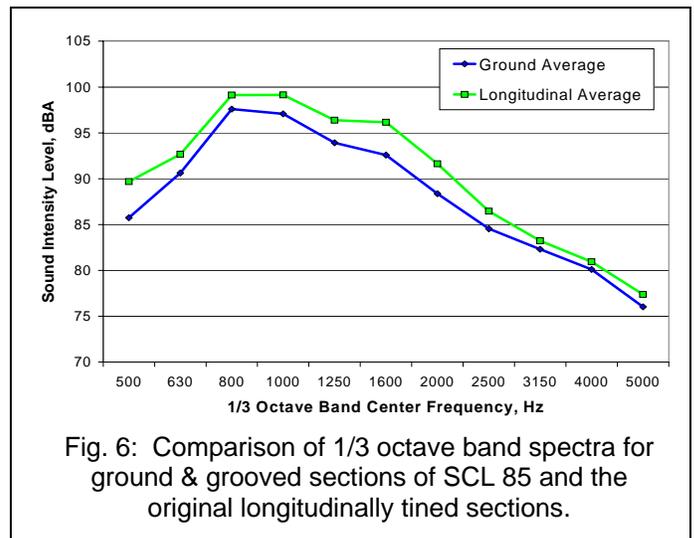


Fig. 6: Comparison of 1/3 octave band spectra for ground & grooved sections of SCL 85 and the original longitudinally tined sections.

However, reductions as large as 10 dB in tire/pavement noise have been demonstrated which would certainly qualify concrete surface texture modification as a legitimate tool in mitigating traffic noise under the appropriate circumstances. To advance this notion, grinding techniques need to be optimized so that sound intensity levels in the range of

100 to 101 dBA, or lower, can be consistently produced. Further, the development and use of porous concrete designs should be explored in the US so that highway engineers have additional options for mitigating traffic noise through pavement selection.

Update. The complete paper is available on the ACPA website. The ACPA would also like to acknowledge the efforts and work under taken by the Arizona DOT and Caltrans in regards to noise research.

Acknowledgements

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