Tech Brief

Concrete Solutions for Quieter Pavements on Existing Roadways

by Paul Wiegand, P.E.

Introduction

One of the most pressing issues facing state departments of transportation (DOTs) is highway noise, particularly in urban areas. Where autos are the predominant vehicles on high-speed facilities, most of the noise is generated at the tire-pavement interface. The impact of tire-pavement noise lessens as the percentage of trucks increase and other elements of highway noise—vehicle drive trains and vehicle exhaust systems—become more predominant. DOTs are facing increasingly significant public concern over highway noise. Currently, many urban projects involve the construction of noise walls to mitigate the problem.

Because of their structural durability, many concrete pavements stay in service long after they have lost some of their functional capabilities. This has contributed to the perception that concrete pavements are not smooth and quiet.

Although not universally true, many of the noisiest concrete pavements are transversely tined pavements. This surface-texturing technique was used for many years because it was thought to develop the greatest level of safety through its friction characteristics. Transverse tining has in fact met friction needs, particularly in wet-weather areas. In recent years, however, citizen demands related to noise have led DOTs to consider remedial actions, such as asphalt overlays and diamond grinding, to quiet these pavements.

DOTs are in need of greater information about long-term, cost-effective options to quiet these existing noisy pavements and to build quieter new pavements. Evaluation of options to address tire-pavement noise should include the expected life of the treatment and the maintenance and rehabilitation required to achieve that potential service life. Another very important factor to consider is the impact on highway users who experience the safety and time-lost impacts that result from frequent construction activities. This impact is especially critical on heavily traveled urban freeways that are frequently at or over their carrying capacities.

Existing noisy concrete pavements can be diamond ground for a quieter tire-pavement interface or a concrete overlay can be placed with a quieter texture.

National Concrete Pavement Technology Center

Uniting agencies, industry, and researchers to advance concrete pavement technology

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Understanding Texture-Noise Relationships

To address current surface characteristics research needs, the National Concrete Pavement Technology Center (CP Tech Center) has tested the surface characteristics of nearly 1,000 pavement sections, totaling more than 44 miles of pavements. The information collected includes on-board sound intensity (OBSI) measurements at the tire-pavement interface, and wayside noise, in-vehicle noise, texture, friction, and smoothness.

Data collected show a wide range of texture and tire-pavement noise values. However, specific texture patterns related to noise levels are beginning to become apparent (see fig. 1).

The OBSI data in figure 1 are divided into three noise zones that can be used to better understand the relationship between texture and noise, and thus facilitate informed decisions related to desired surface characteristics. Zone 1 is the innovation zone. It represents the best solutions for those conditions that merit high-quality noise solutions. New concrete textures will need to be developed to meet the low noise levels of this zone. Zone 2 is the quality zone that includes many conventionally textured concrete pavements that are cost effective and provide a balance between noise, friction, and smoothness. Zone 3, the zone to avoid, includes pavements that exhibit the highest noise levels. These pavements are characterized by highly variable, very aggressive textures and often serious joint deterioration.

The next step in the research is to fully analyze the data and determine what specific texture characteristics impact both loudness and tonal features. This will lead to construction guidelines for building textures that optimize noise, friction, and smoothness characteristics.

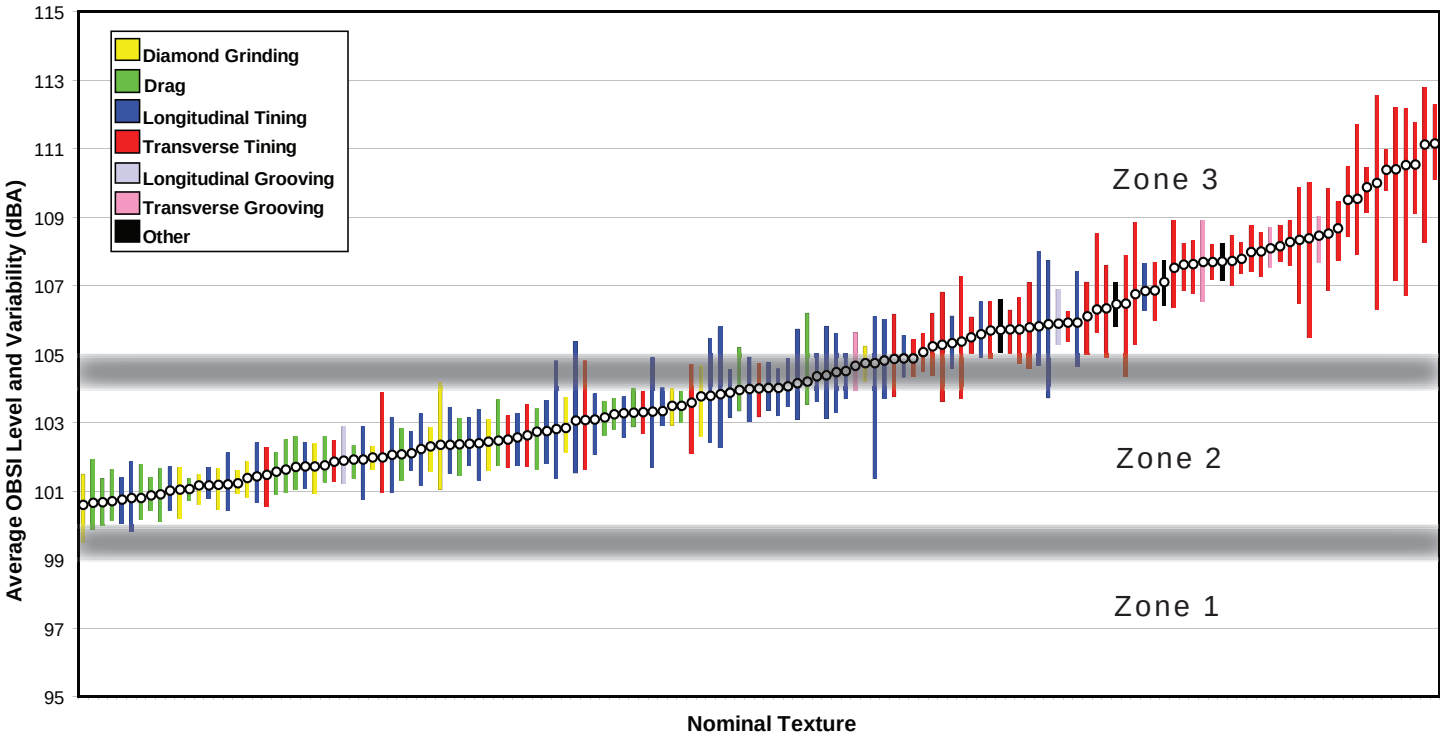

Figure 1. Tire-pavement interface noise by conventional texture type

Methods to Address Noise on Existing Pavements

Two methods to improve tire-pavement noise on existing concrete pavements are diamond grinding and overlays.

Diamond Grinding

Diamond grinding of concrete pavements to address noise concerns has proven successful. In Arizona, grinding of concrete surfaces reduced noise levels by 5 dB based on OBSI testing. Diamond grinding also eliminates the tonal problems sometimes experienced with transverse tining. Since only a very thin layer (about 1/16 inch) is removed, no adverse structural impact is noted after the diamond grinding process.

Diamond ground pavements normally retain their low noise values for the life of the ground surface, unlike other pavement surfaces that experience noise increases over time. Depending on the structural integrity of the pavement that is diamond ground, the extended life of the pavement will reach 15 to 17 years, based on research in California, and in some cases may be ground an additional time.

The cost of diamond grinding varies due to aggregate hardness, depth of removal, and operational restrictions at the worksite. Average costs fell between $2 and $4 per square yard in 2006. Low-end costs were $1.50 per square yard for softer limestone with minor work restrictions, and high-end costs were $10 per square yard for very hard aggregates with significant work restrictions.

Purdue University, in cooperation with ACPA, is undertaking research to identify modifications to the diamond grinding process to produce even quieter pavements. Results of this research should be available in early 2007.

Concrete Overlays

If a pavement is in need of structural and functional enhancement, a concrete overlay may be warranted. The pavement's noise characteristics can be addressed at the same time as its structural elements. As the overlay is being designed, the new surface texture should be chosen to address the noise concerns. The appropriate texture could be drag (turf or heavy burlap) or longitudinally tined. The quality of the small aggregate (hard sand) affects the friction characteristics of drag textures and must be considered in the design. Quiet, safe, long-lasting pavements can be constructed with hard sand and drag textures. With the use of these conventional textures, the noise level can be brought into the lower end of zone 2, and potential exists to reduce the noise level of some transversely tined pavements by 6 to 8 dB. In the future, it will likely also be possible to use innovative textures in combination with an overlay to further reduce the noise levels into zone 1.

Because pavement friction is one of the concerns raised in the shift from aggresive texture to more quiet textures, CP Tech Center research examined that characteristic. The research indicates that good initial friction numbers can be obtained with drag textures, and the friction achieved with longitudinal tining is comparable to that of transverse tining (see fig. 2). Additional research into mix type versus drag texture friction may lead to expanded use of this finish.

Concrete overlays can be constructed of varying thicknesses, starting as thin as two inches. They can be bonded to the underlying pavement or separated from the original pavement by a bond breaker. Generally, the thinner overlays are bonded and the thicker ones are unbonded. The decision to use a bonded or unbonded overlay generally relates to the extent to which the underlying pavement will contribute structurally to the pavement system. Bonded overlays rely on the structural characteristics of the underlying pavement to a larger extent than unbonded overlays.

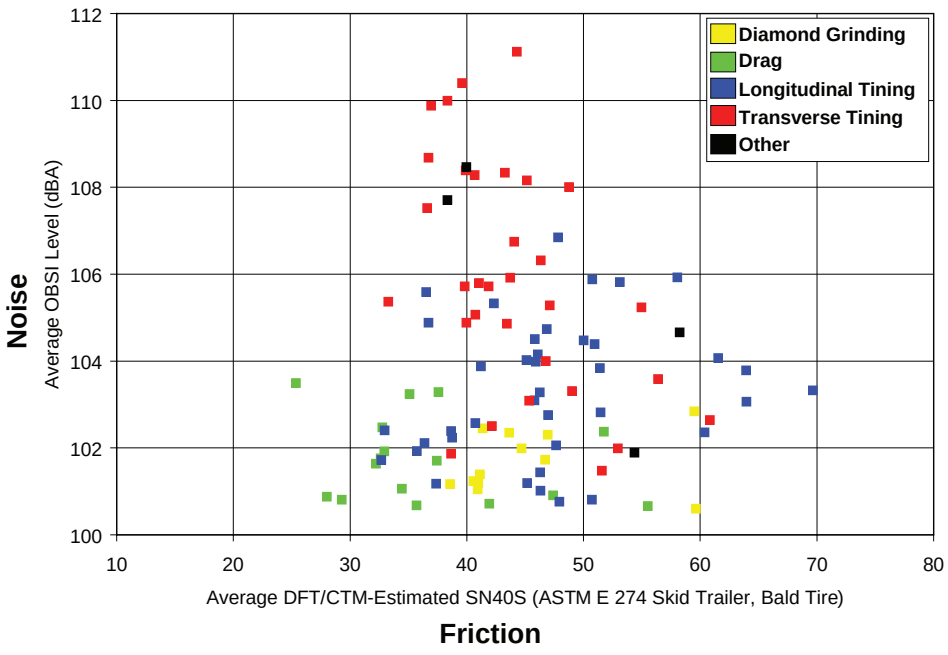

Figure 2. Noise vs. friction, categorized by texture type

Diamond ground pavement

Concrete overlays

Conclusions

Concrete pavements have historically been left in service well beyond their effective functional use while still carrying heavy structural loads. Current research is identifying pavement texturing that can be used to lower tire-pavement noise levels.

Diamond grinding can be used as an intermediate way to lessen tire-pavement noise, improve smoothness, and extend the life of the pavement until structural improvements are warranted. When structural improvement is needed, concrete overlays provide a reasonably long-term structural and functional alternative to major reconstruction. Overlays also provide the opportunity to improve tire-pavement noise through the use of quiet textures.

By maintaining the concrete surface either with diamond grinding or a concrete overlay, the designer can address noise concerns and also improve safety by increasing skid resistance and offering light reflectivity values four to five times greater than asphalt surfaces. In addition, the urban heat impact can also be minimized, since concrete is 10 to 20 degrees cooler than asphalt.

Research at the National Concrete Pavement Technology Center will continue to look at ways to select and optimize surface texturing to provide quieter pavements at the time of initial construction as well as ways to cost-effectively lower noise on existing pavements, without sacrificing safety and smoothness.

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