Research Shows Concrete is Safe, Durable and … Quiet

By

John Roberts
Executive Director
International Grooving & Grinding Association
Coxsackie, NY

Gerald F. Voigt, P.E.
Sr. Vice President – Engineering Services &
Chief Operating Officer
American Concrete Pavement Association
Skokie, IL

Michael Ayers, PhD
Director of Highways & Concrete Pavement Technology
American Concrete Pavement Association
Skokie, IL

For people living near a heavily trafficked highway, the issue of noise can be a concern... and it's a concern shared by agencies and industry, too.

Busy highways near residential areas have long been sources of noise to the surrounding residents. In the past, little or nothing was done to mitigate either the causes or effects of highway noise. As noise has become a larger issue, noise walls or sound walls have been used increasingly to mitigate the effects of noise pollution from highways, but these have proven to be very costly.

A truly objective analysis of noise would consider factors such as engine and exhaust stack noise, but the issue recently has focused on tire/pavement noise, and in particular asphalt (especially open-graded friction courses or OGFC's) and concrete pavements.

The purpose of this article is to show that the tire/pavement noise levels between well-designed and constructed concrete and OGFC are minor. Studies have shown only slight – barely perceptible – differences between tire/pavement noise levels of concrete and asphalt pavements.

Rubberized asphalt pavements provide improved noise attenuation characteristics over typical asphalt pavements, but have been reported to require expensive, semi-annual maintenance to maintain these features, thus raising serious questions about why rubberized asphalt friction courses are being used or proposed as overlays on concrete pavements that are in excellent condition.

Questions also have been raised about the technical characteristics of rubberized asphalt, in particular long-term durability under freezing conditions and clogging the voids that provide their noise-reducing characteristics.

What is All the Noise About?

At the center of the tire/pavement noise controversy are the testing methodologies. The more conventional and widely accepted method for measuring vehicle noise is the "statistical pass-by method" (SPB), which measures noise where it would most likely be heard by receptors and provides readings useful for environmental impact analysis.

The "close-proximity" (CPX) method measures noise at the tire/pavement interface and is well suited for investigations of road surface influence on traffic

noise, but does not provide a measurement useful for environmental-impact analysis. Furthermore, this method is not used with tires designed for heavy vehicles. It is known that road-surface sound emission characteristics depend on the tire used, including whether the tire is for light or heavy vehicles. The results obtained with this method, therefore, best describe conditions when sound from light vehicles constitute the major part of traffic noise (<10 percent trucks).

A recent study on tire/pavement noise conducted by the National Center for Asphalt Technology (NCAT) for the Michigan DOT (MDOT)[1] demonstrated that concrete pavements that are textured with a surface that minimizes noise generation are just as quiet as asphalt pavements, and resulted in the decision by MDOT not to overlay the concrete pavement.

In the NCAT study, test sections included longitudinally tined, transverse tined, and diamond ground concrete, as well as stone matrix, conventional dense-graded, and Superpave asphalt. Two types of tires were used: Uniroyal and MasterCraft. (It should be noted that different tire tread patterns have significantly different noise characteristics.)

The diamond ground concrete section was the quietest of both asphalt and concrete sections, based on tests performed with the Uniroyal tire. A few heavily-textured concrete sections increased the concrete pavement noise average, obscuring the quiet concrete section results. The heavy textures on the concrete sections were mandated by the Michigan DOT and the FHWA for skid resistance and public user safety.

Even so, the tire/pavement noise of nearly all of the sections were within about 3 decibels (dBA) of each other. These research findings show concrete is quiet. Figure 1 shows the results in greater detail.

It also should be noted that an excessively deep texture in a pavement is not desirable and will not enhance friction and hydroplaning characteristics.

Pass-By or Close Proximity?

The NCAT study used the CPX method to measure the noise levels on nine different pavement sections. The CPX method, which is ***not*** the standard measuring method recommended by the Federal Highway Administration (FHWA) for noise levels along highways for environmental analysis, involves placing a receiver (microphone) near the tire on a trailer being pulled along at highway speeds.

The CPX method is inexpensive, easily applicable in most cases, measures along the extended length of a road surface, and provides an "absolute level." Unfortunately, CPX poorly represents surface influence on truck-tire noise. Also, the associated propagation effects are not accurately represented; and the results are restricted to tire/pavement noise…not engine, exhaust, and drive-train noise.

The standard pass-by method involves measuring the noise at ground level near the receptors (houses, buildings, etc.) along a roadway and is more representative of actual traffic cuts. The receptors are usually 25 to 50 feet from the noise generator (edge of the roadway). The farther a receptor moves away from the noise generator, the quieter the noise seems - doubling the distance from the source can reduce noise intensity by as much as 6 dB. Therefore, slight differences in noise due to pavement surface type are far less influential at distances normally used for measuring vehicle noise along a roadway.[2]

Performance, Durability Questions

Just as the differences between the SPB of the CPX methods have been called into question, so too have a number of characteristics about open-graded asphalt pavements.

"It is generally not feasible to require rubber asphalt concrete in patches or utility cut repairs."

—Rubberized Asphalt Concrete Technology Center

1. "Tire/Pavement Noise Study" for the Michigan Department of Transportation, conducted by the National Center for Asphalt Technology, October 2002.

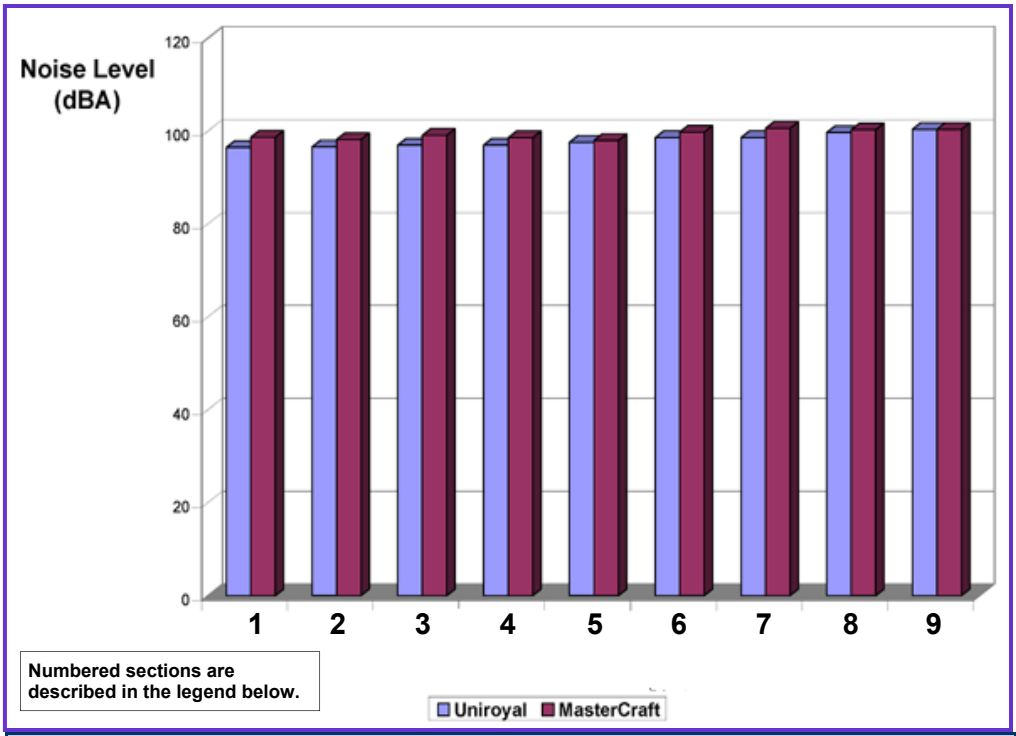
2. "Concrete Pavement Surface Textures" (SR902P), copyright 2000, the American Concrete Pavement Association, Washington, DC.

It's well known that concrete pavements are very durable, but they also are easy repair, even when utility cuts are required. There is, however, some question about the reparability of rubberized asphalt pavements, especially where utility cuts are involved.

According to the Rubberized Asphalt Concrete Technology Center,[3] a technology center formed to promote the use of crumb rubber from scrap tires in roadway rehabilitation projects, "it is generally not feasible to require RAC [rubber asphalt

3. Rubberized Asphalt Concrete Technology Center website's "Frequently-Asked Questions." The Rubberized Asphalt Concrete Technology Center, a cooperative effort by the County of Los Angeles, County of Sacramento, and the California Integrated Waste Management Board.

Figure 1 - Bar chart shows the relative results from the MDOT/NCAT study of tire/pavement noise using the CPX method. Legend below details the sections and surface types.



Legend: Surfaces Tested in the MDOT/NCAT Study	
Section	Surface Type
1. I-275 NB Detroit	Diamond Ground Concrete
2. I-96 EB Detroit	Stone Matrix Asphalt
3. I-96 EB Detroit	Light Transverse Tined Concrete
4. I-96 EB Detroit	Dense Graded Asphalt
5. I-69 SB Coldwater	Stone Matrix Asphalt
6. I-275 NB Detroit	Dense Graded Superpave Asphalt
7. I-96 EB Lansing	Light Transverse Tined Concrete
8. I-69 Coldwater	Heavy Longitudinal Tined Concrete
9. I-69 Coldwater	Heavy Transverse Tined Concrete

concrete] in patches or utility cut repairs." Also, there are reports that question the merits of the noise features as a whole. The National Cooperative Highway Research Program (NCHRP), in a report published by the Transportation Research Board, stated that noise reductions of open-graded asphalt pavements "seem to decline with surface age and in approximately 5 to 7 years, much of the noise benefit has diminished."[4]

The Colorado Department of Transportation, in its report, "Traffic Noise: Assessment and Abatement,"[5] advises: "Note that the long-term structural integrity of rubberized asphalt, particularly in Interstate applications, is not well known. Also, the long-term noise reduction is not well known. Research has shown that the noise benefits of asphalt pavements in general will likely lessen as the pavement wears."

In its Synthesis 268, the NCHRP states that open-graded asphalt "does not have the strong frictional characteristics of PCC pavements, nor the durability."

There also are concerns about environmental and safety issues. MSW Management magazine,[6] in a recent article, cited concerns about "air emission, worker safety, and recyclability of crumb rubber asphalt."

The article further states that "doubts still remain about life expectancy, recyclability, emission safety related to the production and construction of asphalt pavement, and the application techniques for different climates."

Back to Basics

The simple truth is that all pavements produce noise, whether they are asphalt or concrete. Pavements must be designed and constructed to reduce hydroplaning[7] potential, while also factoring in a large number of variables, including cost, smoothness, tire/pavement noise, durability, and, of course, most important, safety.

For concrete pavements, surface textures can be created during construction by dragging various materials or tools across

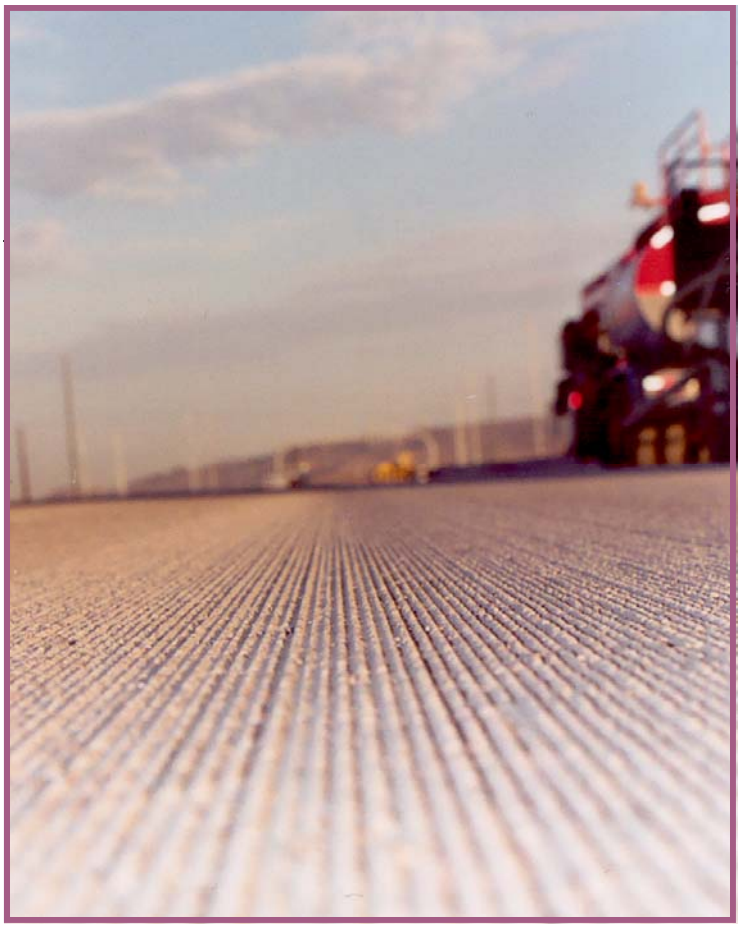


Photo depicts diamond ground pavement. Diamond grinding is used to restore pavement surfaces, remove joint faulting, and improve skid resistance. (Photo: Bill Davenport, ACPA)

4. "Relationship Between Pavement Surface Texture and Highway Traffic Noise: A Synthesis of Highway Practice," (NCHRP Synthesis 268), Transportation Research Board, National Research Council, published by National Academy Press, Washington, DC, 1998.

5. "Traffic Noise: Abatement and Assessment," The Colorado Department of Transportation, pamphlet 246893, December 2002.

6. "Manufacturing and Utilizing Crumb Rubber from Recycled Tires," MSW Management: The Journal for Municipal Solid Waste Management Professionals, by Nongnard Sunthonpagasit and H. Lanier Hickman Jr., November/December 2003.

7. A condition caused by a vehicle's tires planning on accumulated water and sliding across the surface, often resulting in loss of control.

Recent research shows that improved forms of tining reduce noise levels.

Photo depicts diamond grinding on one of four sections of highway in Arizona. Diamond grinding reduced the tire/pavement noise to 95.5 dbA (using the CPX method). An Arizona DOT report stated: "the use of pavement grinding as a traffic noise abatement could be beneficial for both reducing tire pavement noise levels and muting the tire whine pure tone sound of the older concrete pavement transverse tining texture." (Photo: Bill Davenport, ACPA)

the fresh concrete. These techniques impart a continuous series of undulations or grooves in the surface before the concrete hardens. The spacing, width and depth of the grooves affect surface friction, skid resistance and tire/pavement noise. Ultimately, the surface texture of an asphalt or concrete pavement is to reduce wet-weather accidents caused by hydroplaning and skidding, as well as to promote good braking and steering on dry pavements.

For concrete streets and local roads, where vehicle speeds are not a major factor in hydroplaning, burlap-drag or broom textures are typical. For higher-volume roads, particularly highways, tining is the most-often used surface texturing technique.

In the early 1970s, the Federal Highway Administration (FHWA) mandated transverse tining as the surface texture of choice for Federal-aid highway pavements constructed with concrete. There is currently a shift away from transverse tining to longitudinal tining because of the latter's demonstrated benefits in producing excellent, long-term skid resistance and much lower tire/road noise qualities.

Solutions to Tire/Pavement Noise

So, given the challenges of addressing the concerns about tire/pavement noise, what options exist to address the issue of tire/pavement noise? In terms of concrete pavement construction or rehabilitation, there are two effective means of mitigating tire/pavement noise – proper tining or diamond grinding.

Recent research shows that improved forms of tining – such as longitudinal tining – reduce noise levels. Research conducted by Marquette University[8] measured noise, texture and friction at 57 test sites in Colorado, Iowa, Michigan, Minnesota, North Dakota and Wisconsin. Among the study's findings:

- Longitudinally tined concrete pavements and an asphalt pavement exhibited the lowest exterior noise.
- One asphalt pavement, and the longitudinally tined and random skew tined

8. "Noise and Texture on PCC Pavements – Results of a Multi-State Study," David Kuemmel, *et al*, Marquette University team research for the Wisconsin Department of Transportation, June 2000.

Photo depicts trailer equipped with instruments to measure tire/pavement noise using the close-proximity or CPX method. The CPX method, which measures noise at the tire/pavement interface, was used by the Arizona DOT, which measured diamond ground pavements and found tire/pavement noise was reduced significantly. (Photo: Bill Davenport, ACPA)

To mitigate the noise factor, a number of state DOT's have recently shifted away from uniformly spaced transverse tining of concrete pavements.

(1:6 skew) concrete pavements exhibit the lowest exterior noise. The random skewed can be easily built and eliminates discrete frequencies.

- When comparing different pavement textures with mean texture depths of about 0.276 in. (0.7 mm), the following exterior noise reductions were observed, compared to a uniform, transversely tined concrete pavement: random transverse, 1 to 3 dBA; random skewed, 4 dBA; longitudinal, 4 to 7 dBA; open textured asphalt, 5 dBA. (Random transverse or random skewed means the teeth on the concrete rake are spaced at random intervals.)

To mitigate the noise factor, a number of state DOT's have recently shifted away from uniformly spaced transverse tining of concrete pavements. A survey of states by ACPA reveals that nine states have either changed to longitudinal tining or are considering doing so.

As mentioned previously, all pavements produce noise, and equally important, all pavements eventually will need to be resurfaced, restored, or reconstructed. Unfortunately, when pavement rehabilitation is performed prematurely, it represents a huge waste of taxpayer money that otherwise could be used to address serious safety and road-user delay issues. Diamond grinding of pavements has been shown as an effective means of not only restoring or improving the original surface characteristics of the pavement when constructed, but also reducing noise.

In another research project, Marquette University researchers showed that diamond ground pavements exhibited no discrete frequencies, and compared to transverse tining, lowered noise levels by about 3 dBA. The study also reported that diamond grinding, if deep enough to remove most of a uniform transverse texture, can be considered for existing concrete pavements with excessive whine.

Also, a report by the Arizona DOT underscores how diamond grinding can be used to address tire/pavement noise associated with concrete pavements.[9] The report detailed a test project to compare the effectiveness of diamond grinding on reducing traffic-generated noise characteristics. The project involved four sections of SR-202 near its intersection with I-10. The project resulted in decibel read-

9. "SR202 PCCP Whisper Grinding Test Sections: Construction Report," (final report) prepared by Larry Scofield, Arizona Department of Transportation, October 21, 2003.

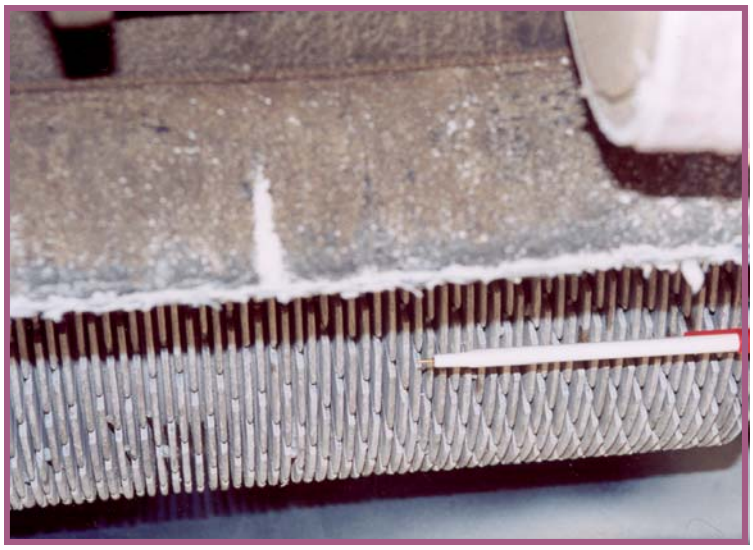


Photo illustrates close-up of diamond grinding blades. Diamond grinding is one technique that can be used to mitigate tire/pavement noise. (Photo: Bill Davenport, ACPA)

A number of resources are available from ACPA and IGGA to address surface texturing and noise questions.

ings being reduced to as low as 95.5 dbA, as measured using the CPX method.

The report stated that as a result of the diamond grinding, "the high frequency pure tone noise, commonly known as tire whine, has been significantly reduced."

The report continues, "the use of pavement grinding as a traffic noise abatement could be beneficial for both reducing tire pavement noise levels and muting the tire whine pure tone sound of the older concrete pavement transverse tining texture."

Other research also confirms the tire/pavement noise reduction possible with diamond grinding. Research conducted by Parsons Brinkerhoff for the Utah DOT showed a 1.0 dBA to 5.0 dBA reduction in tire/pavement noise due to pavement grinding – and showed post-grinding noise levels in the range of 76.2 to 79.2 dBA, as measured using the SPB method.[10]

Research funded by the New York State Thruway Authority and the FHWA showed diamond ground pavements to be 2 to 5 dBA quieter than transverse-tined surfaces.[11] The research also showed greater wet-weather skid resistance, and after one year, showed the diamond ground concrete's skid resistance to be "superior."

In addition to the research that substantiates that properly textured concrete pavements are just a quiet as asphalt pavements, it's important to note that a number of resources are available from the American Concrete Pavement Association and the International Grooving & Grinding Association to address surface texturing and noise questions.

Policies Guide the Way

A wide range of research substantiates that concrete pavements generally provide superior skid resistance and durability. Research also shows that well-designed and constructed concrete pavements can be as quiet—or quieter—than asphalt. There are also stated policies that generally advise a common sense approach to address noise, emphasizing a balanced approach that does not trade off safety or performance.

Federal and state transportation agencies, through policies and official posi-

10. "Final Report: Roadway Pavement Grinding Noise Study: I-215 Salt Lake City," prepared for the Utah Department of Transportation by Parsons, Brinkerhoff, Quade & Douglas, Inc., November 2000.

11. "A Comparison of Transverse Tined and Longitudinal Diamond Ground Pavement Texturing for Newly Constructed Concrete Pavements," by Paul L. Burge, *et al*. Presented at the 81st Annual Meeting of the Transportation Research Board, 13-17 January 2002, Washington, DC.

tions, have generally acknowledged the relatively small amount of noise reduction associated with surface type and have urged specifiers not to trade off safety.

In a June 1995 policy and guidance statement, FHWA wrote: "While it is true that noise levels do vary with changes in pavements and tires, it is not clear that these variations are substantial when compared to the noise from exhaust and engines, especially when there are a large number of trucks on the highway."

In its Synthesis 268, the NCHRP reported: "It is the official policy of the FHWA, and in the opinion of the American Association of State Highway Officials, that a small amount of noise reduction is not worth sacrificing safety and durability. This means that the practicing highway design engineer must try to find a 'happy medium' between noise control and maintaining a high level of safety."

FHWA's environmental policy[12] also states that "unless definite knowledge is available on the pavement type and condition and its noise generating characteristics, no adjustments should be made for pavement type in the prediction of highway traffic noise levels...The use of specific pavement types or surface textures **must not be considered** as a noise abatement measure."

With sound policies and solid research firmly in place, it raises the question why surface texture continues to be a subject of debate, particularly when the proposed solutions require so much maintenance and repair.

Our concern is that this issue detracts from the fundamental issue of safety, which is a top priority with the U.S. Department of Transportation (DOT), the U.S. Congress, state departments of transportation, and other stakeholders, including the American Concrete Pavement Association.

Safety should be a key part of any discussion about highways and roadway construction or rehabilitation. The reason is simple. The U.S. DOT estimates 43,000 people die on the nation's highways each year, with 13,000 of those deaths are attributable to road conditions. There are also an estimated 1,200 work zone fatalities and 40,000 injuries per year in construction work zones, which is why the concrete pavement industry is so committed to "getting in, doing it right, getting out … and staying out."

The practice of overlaying concrete pavements with materials that require frequent maintenance and repairs raises serious concerns, particularly when there are so many questions about long term performance characteristics, including those related to noise abatement.

The bottom line is it's time to put the tire/pavement noise issue in its proper perspective … and turn up the volume on the issue of building safer, more durable highways and roadways.

It's time to put the tire/pavement noise issue in its proper perspective … and turn up the volume on the issue of building safer, more durable highways and roadways.

12. "A Comparison of Transverse Tined and Longitudinal Diamond Ground Pavement Texturing for Newly Constructed Concrete Pavements," by Paul L. Burge, *et al*. Presented at the 81st Annual Meeting of the Transportation Research Board, 13-17 January 2002, Washington, DC.

This article was the basis for the story, "Soft Spoken," which appeared in the March 2004 issue of **Roads & Bridges** magazine.