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**OCTOBER 2009**

**ROAD MAP TRACK 4**
**Concrete Pavement Surface Characteristics**

**PRIMARY SOURCE**
***How to Reduce Tire-Pavement Noise: Interim Better Practices for Constructing and Texturing Concrete Pavements* July 2008**
**National Concrete Pavement Technology Center**
**Robert Otto Rasmussen, Sabrina I. Garber, Gary J. Fick, Theodore R. Ferragut, and Paul D. Wiegand**
http://www.cptechcenter.org/publications/ cpscp-interim.pdf

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**Paul Wiegand**
**515-294-7082**
**pwiegand@iastate.edu**

Moving Advancements into Practice (MAP) Briefs describe promising technologies that can be used now to enhance concrete paving practices. MAP Brief 4-1 provides information relevant to Track 4 of the CP Road Map, Concrete Pavement Surface Characteristics.

The Long-Term Plan for Concrete Pavement Research and Technology (CP Road Map) is a national research plan developed and jointly implemented by the concrete pavement stakeholder community. Publications and other support services are provided by the Operations Support Group and funded by TPF-5(185).

MAP Brief 4-1 is available at: http://www.cproadmap.org/publications/ MAPbrief4-1.pdf

**"Moving Advancements into Practice"**
**MAP Brief 4-1:**
Describing promising technologies that can be used now to enhance concrete paving practices

# Diamond Grinding to Reduce Tire-Pavement Noise in Concrete Pavements

## What Is Diamond Grinding?

Diamond grinding has traditionally been viewed as a technique to restore pavement smoothness, since the process inherently grinds away bumps that would otherwise cause a vehicle to bounce as it drives down the road. In most cases, diamond grinding also restores friction—the process creates texture that is needed to channel water away from a rolling tire. The reduction of tire-pavement noise is a benefit that has emerged more recently due to the increasing popularity of noise as an indicator of comfort and, in some cases, a public health issue.

The process of texturing concrete pavements with diamond grinding is not new—it has been routine practice in some areas since the 1970s— and it can occur at any time in the pavement's life. Most States view the technique as a means to rehabilitate an existing concrete pavement, since it reduces the roughness that occurs over time as a pavement surface degrades under traffic.

However, some States are now allowing the use of diamond grinding as a final surface texture for newly paved roads, since it often produces a more consistent, smoother, and quieter surface than other conventional textures.

Diamond grinding is a mechanical process. The idea is to create a new surface on the pavement by means of controlled abrasion. The most intricate component of diamond grinding is the grinding head—a spindle that consists of hundreds of sawblades that are stacked along with spacers to provide the desired pattern.

On the outside edge of each steel sawblade are industrial diamonds that are engineered for the specific application. The widths of the sawblades and the spacers between them can vary, which ultimately dictates the size and shape of the resulting texture, along with its durability (ability to maintain a desirable texture over time).

The grinding head is mounted horizontally onto the grinder, which controls the rotation of the head and the height and speed at which grinding occurs. All of these parameters will affect both the "as constructed" texture and the productivity of the process.

## How Does Diamond Grinding Affect Friction and Noise?

The texture that results from diamond grinding takes the form of grooves and lands, as illustrated in the photographs in figure 1.

The grooves lie just beneath the surface of the pavement and thus provide the drainage necessary to make the pavement safe during wet weather. The grooves also help pro-

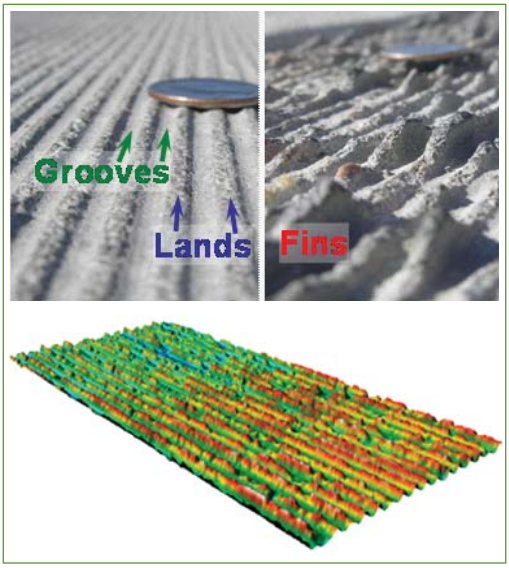


**Figure 1. Diamond ground surface texture showing lands, grooves, and the serrated appearance of the fins**

duce a quiet surface by reducing the contact area between the tire and the road and keeping air from being trapped as the tire rolls.

Lands result from uncut concrete between each sawcut. This concrete typically breaks off to a more or less consistent height above the sawcut grooves. The geometry and uniformity of the lands are important to both noise and friction, since they define the contact between the tire and the road. In some cases, the lands will include irregular remnants of concrete, known as fins, stacked atop them.

As illustrated in figure 1, the fins can have a serrated appearance that will eventually wear to a more consistent height under traffic. However, for the first days or weeks under traffic, the presence of these fins can affect the surface properties. For example, the friction of newly-ground surfaces is often higher than the more stable levels measured after this break-in period. The tire-pavement noise level will also generally be higher immediately after grinding because the irregular fins will penetrate the tire, causing it to vibrate and generate additional noise. As the fins wear to a more even height, this additional noise can sometimes decrease on the order of 2 to 3 dB—a perceptible difference.

## Is Diamond Grinding Quiet?

Before analyzing the quietness of diamond grinding as compared to other concrete pavement surface textures, it should first be recognized that there is a great deal of variability among pavements of the same nominal texture type. Diamond grinding has been identified as a viable solution for quieter pavements, and the process to optimize its use is ongoing. In the meantime, the variety of equipment and techniques currently being used is leading to a variety of as-ground surfaces with varying noise levels. The specifications used today for diamond grinding are intended to improve smoothness, and are thus not optimized for reducing tire-pavement noise.

Figure 2 shows the range of tire-pavement noise levels that have been measured on hundreds of concrete pavements nationwide as part of the Concrete Pavement Surface Characteristics Program (CPSCP). These curves represent concrete pavements of varying age, materials, traffic and weather exposure, and construction techniques. However, while there is variability among all nominal concrete pavement surface textures, diamond grinding does emerge as a consistently quieter alternative, and thus one to consider if noise is an important factor.

Figure 3 illustrates data from the CPSCP sites that were used to develop the diamond grinding distribution in figure 2. The intent of this perspective is to assess what can happen to noise levels over time, often called the acoustical durability. Different symbols represent individual test results—some measured directly with the Standard Reference Test Tire (SRTT), and others (with small circles) measured with the now-obsolete Aquatred III test tire. In the latter case, adjustments are made to the on-board sound instrument (OBSI) levels to make them directly comparable. Test sections that were evaluated numerous times during their lives are connected by lines. The oval in the upper left portion of the figure is intended to illustrate typical OBSI levels of older pavements that would be candidates for diamond grinding.

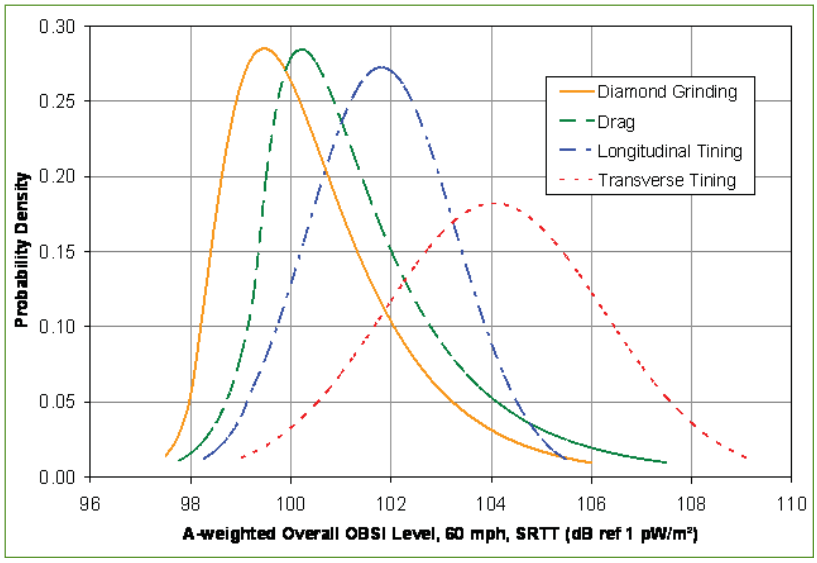


**Figure 2. Noise level populations for all concrete pavements**

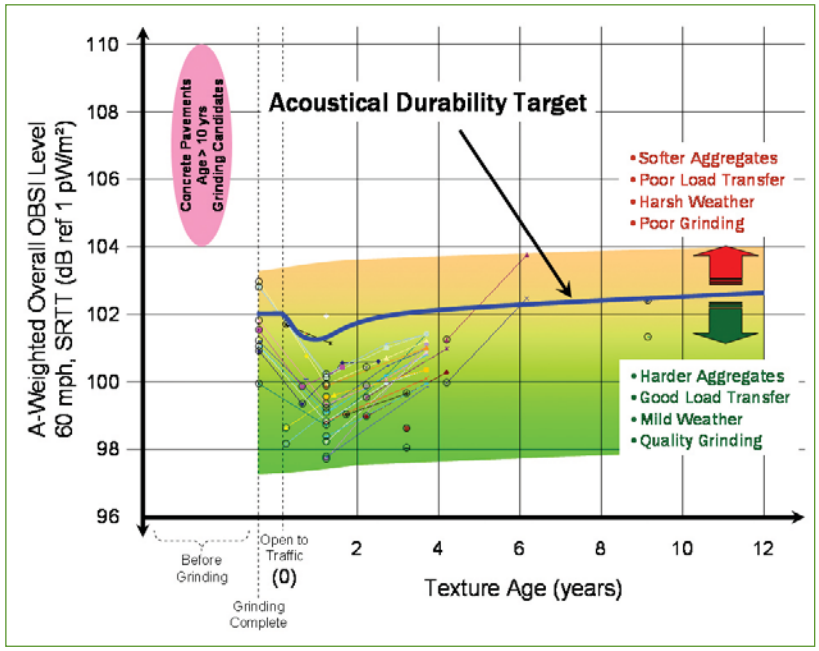


**Figure 3. Acoustical durability of diamond ground surfaces**

The data shown in figure 3 are used to derive a reasonable durability target—one where the measurements of most of the diamond ground sections will fall given the diversity in materials, contractors, climate, and traffic. In situations with warm, dry climates, little traffic, and/or hard aggregates, very little change in the OBSI level over time can be expected, thus, the slopes will be relatively flat. In harsher winter climates, high traffic, and/or with softer aggregates, the slopes can be more significant.

The OBSI levels provided here are measured using equipment operated under the CPSCP. While in compliance with best practices and all relevant standards (e.g., AASHTO TP76), bias among operators can be expected. Before specification or policy using OBSI is considered, ongoing work under Pooled Fund TPF-5(135), Tire/Pavement Noise Research Consortium, should be consulted.

Figures 4 and 5 further illustrate this variability through photographs of the louder and quieter diamond ground projects measured under the CPSCP. Note that the louder surfaces tend to be heavily worn, again stressing the need for texture durability. Friction on these smoother surfaces tends to also be lower.

## Optimizing Diamond Grinding for Quieter Pavements without Compromising Friction

The CPSCP has developed better practices for texturing concrete pavements to reduce noise. These practices include specific guidance to improve concrete pavement surfaces of all nominal textures, including diamond ground surfaces.

Figure 4. Photographs of quietest diamond ground surfaces – Overall OBSI Level of 97-98 dBA

Figure 5. Photographs of loudest diamond ground surfaces – Overall OBSI Level of 102-104 dBA

The following are highlights of this guidance for diamond grinding that can be implemented immediately:

- **Concrete aggregate type** – When diamond grinding, the makeup of the concrete is exposed at the surface. Because the majority of the concrete used in paving consists of coarse aggregate (rock), the nature of this constituent will significantly affect the ability of the surface to retain the texture necessary for both a quiet and a safe surface. As with any pavement-related decision, careful consideration should be given to friction. With respect to diamond grinding, selection of projects and grinding patterns should be based on experience and/or a careful evaluation of the concrete material and, more specifically, the coarse aggregate type.
- **Grinding head** – There does not appear to be an optimum size and spacing of blades and spacers for reducing tire-pavement noise as there is for improving friction (as a function of aggregate type). Conventional practice involves selecting these components based on the specific concrete being ground in order to optimize the production rate and the durability of the surface from subsequent wear under traffic and maintenance. This practice is still recommended to better ensure that safety, cost, and durability are not compromised for the sake of noise.
- **Equipment size** – Larger, heavier grinding equipment is more likely to have the control necessary to consistently impart the texture at the intended depth and lateral coverage.
- **Holidays and overlap** – Care should be taken to ensure that the match line between passes of the grinder does not coincide with the wheel path, as this can be a source of irregular grinding patterns. Wider grinding heads (e.g., 4 ft.) will minimize the number of match lines, keep them out of the wheel path, and potentially impart better control.
- **Grinder bogie wheels** – Any imperfections in the bogie wheels that support the grinding head can manifest as texture variations in the as-ground surface. Care should be taken to ensure that the wheels are true (round).
- **Fins** – Machine adjustments should be taken to minimize the variability in the height of the remaining fins of concrete. While wear will occur under traffic and from winter maintenance activities, additional means of knocking down excess fin height can be done. Dragging the surface with a steel blade or beam prior to opening to traffic can reduce fin height, but may also damage pavement joints, and is therefore not recommended.
- **Vibrations** – While inevitable due to the nature of grinding, excessive vibrations should be avoided. If unchecked, these vibrations can impart themselves as undesirable texture in the pavement that can, in turn, increase noise levels, especially that texture which repeats itself on the order of one inch or longer.

In addition to the above information, FHWA has guidance on selection of projects and equipment requirements in its publication, *Concrete Pavement Rehabilitation Guide for Diamond Grinding*. This can be found at http://www.fhwa.dot.gov/PAVEMENT/concrete/diamond.cfm.

## Additional Resources

*How to Reduce Tire-Pavement Noise: Interim Better Practices for Constructing and Texturing Concrete Pavement Surfaces*, National CP Technology Center Report, July 2008.

*The Little Book of Quieter Pavements*, Report FHWA-IF-08-004, 2008.

Website of the International Grooving & Grinding Association: http://www.IGGA.net/

Website of the Concrete Pavement Surface Characteristics Program: http://www.SurfaceCharacteristics.com

## Sponsors

The Concrete Pavement Surface Characteristics Program is sponsored by the following agencies and organizations:

- The Federal Highway Administration.
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- The National Concrete Pavement Technology Center.
- The American Concrete Pavement Association.
- The International Grooving and Grinding Association.