R&T UPDATE
Concrete Pavement Research & Technology

Diamond Grinding Shines in California and Missouri

Reports by State Agencies Demonstrate Advantages of Grinding Concrete Pavements

Diamond grinding is a procedure used to restore or improve pavement ride quality, noise, and surface texture. Although diamond grinding has been an available concrete pavement preservation and restoration procedure since 1965, recent developments and increased experience have made diamond grinding an excellent rehabilitation option for concrete pavements.

Documented performance of diamond ground concrete pavements nationwide has shown that about 80 percent last 11 years and 50 percent last close to 14 years.[1] After reaching its useful life, a diamond ground pavement may be reground to further extend its service life. Regrinding a pavement up to three or more times is possible without significantly compromising its fatigue life. Diamond grinding helps concrete pavements last far longer than their initial design lives.

California Experience

The first-ever continuous diamond grinding project was performed in the fall of 1965 on a section of the San Bernardino Freeway just east of Los Angeles, California. The freeway, a part of Interstate 10, was originally constructed as Route 66 in 1946. The pavement was structurally sound, but there was considerable spalling and joint faulting.

A contractor was hired to grind the pavement using a small and simple, but effective piece of grinding equipment. The ride specifications called for 7 in./mile as measured with the California profilograph and a 0.2-in. blanking band. Diamond grinding was the only remedial step taken on the project. That first-ever grinding project provided 19 years of additional service.

In 1984, the same section of roadway got a third lease on life when the California Department of Transportation (Caltrans) awarded a contract to rehabilitate the pavement again using diamond grinding. In 1997, the 51-year-old concrete pavement was again ground for a third time. At that time, the 8-in. pavement had carried more than 43 million ESALs between 1946 and 1997. After almost 60 years of service and currently carrying more than 200,000 vehicles per day, the original concrete pavement is still carrying heavy traffic.

Ride Quality Improvement

Pavement condition data from the Caltrans Pavement Management System (PMS) database were used to determine the average ride quality improvement due to diamond grinding, and the expected service life of a grinding project.[2] International Roughness Index (IRI) values both before and after grinding were obtained and analyzed for 26 concrete pavement sections in California.

Figure 1 shows the improvement in ride quality as a function of the IRI before grinding. The dotted line shows an average ratio of 1.5 to 2.0 of before-grind IRI to after-grind IRI for the majority of the data points. For example, the ratio of 1.5 means that a pavement with an initial roughness of 150 in./mi before grinding would, on average, have a roughness of 100 in./mi after grinding. The ratio of 2.0 means that the same pavement would be 75 in./mi on average after grinding.

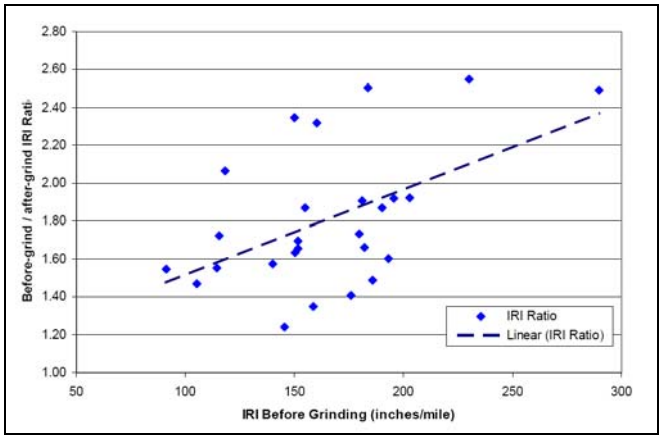

Figure 1. Improvement in Ride Quality (shown as the Ratio of Before-Grind IRI and After-Grind IRI) versus IRI Before Grinding.

Longevity of California Diamond Grinding

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The historical IRI data from Caltrans were also used to determine how long diamond grinding projects can be expected to last as compared to the national average of 14 years. To determine this, the IRI ratios were plotted over time to determine the average number of years before further rehabilitation is required (as shown in Figure 2).

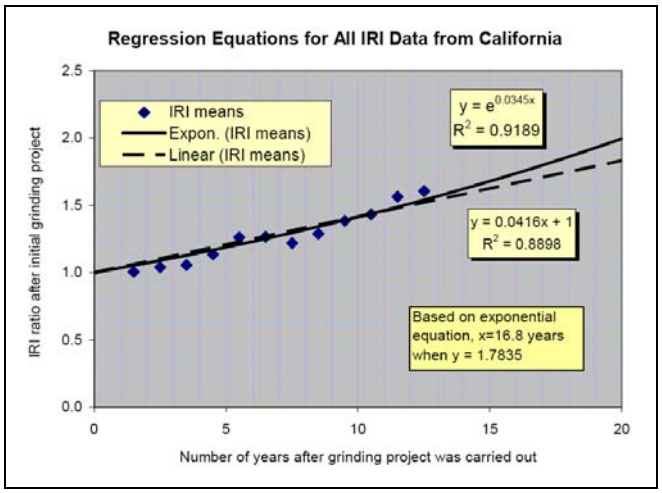

Figure 2. Change in Smoothness from Initial Post-Grind IRI versus Time.

The data show that, when using a maximum IRI ratio of 1.78 (i.e. maximum allowable increase in roughness of 78% as compared to initial post-grind IRI), the average time before additional rehabilitation is needed for a diamond-ground concrete pavement is about 17 years. This compares very favorably with the national average of 14 years, and is likely due to the mild climatic conditions and quality concrete constituents found in much of California, which enhance concrete pavement performance.

The excellent results achieved by Caltrans on diamond grinding projects have been accomplished without a formal design or project selection procedure for a grinding project. Currently, there are no objective criteria (such as maximum joint faulting, maximum percent cracked slabs, or a maximum roughness value) that are used as triggers for the selection of a given concrete pavement as a candidate for diamond grinding. Instead, factors such as a subjective measure of existing roughness and estimated cost versus budgetary constraints are currently considered, and the process is working reasonably well, especially considering the excellent results obtained to date.

Improved Road Safety

Two other major advantages to diamond grinding are also achieved: improved texturing and skid resistance, and reduced tire/pavement interface noise levels. Many documented studies have shown considerable improvement in the skid resistance of diamond-ground concrete pavements. The degree of improvement depends on the skid resistance of the facility before grinding, the hardness of the aggregates in the concrete, and the spacing between the blades on the diamond grinding head. A study in Arizona demonstrated an overall average improvement of 27% in skid resistance numbers after grinding.[3] A study in Wisconsin found that longitudinally ground pavements had better overall crash rates than transversely tined pavements.[4]

Based on current experience, it is possible to diamond grind candidate concrete pavements up to three or more times before major reconstruction is needed.[2] This could extend the service life of a new concrete pavement to twice its normal design life by adding only two or three diamond grinding projects and continuing normal routine maintenance—none of which should disrupt the traffic flow during peak hours.

Quieting Concrete Pavements

Reducing tire/pavement noise by diamond grinding is becoming more common for noisy pavements. Numerous studies in recent years have quantified the benefits of diamond grinding for noise mitigation purposes.

Due to the texturing methods historically used for concrete pavement construction, concrete pavement surfaces have been found to span a range of as large as 16 dBA in noise level.[5] This is extraordinary when one considers that a 10 dBA difference represents a sound that is twice as loud. As a result, there is the potential to achieve large noise reductions depending on the existing and final surfaces selected. Diamond grinding is the preferred choice for quieting existing concrete pavements.

Did You Know?

- On average, over 14 million sq. yds. of concrete pavement get diamond ground every year.
- Diamond grinding can cost anywhere from $1.50 to $9.00 per sq. yd., but is typically $3.00 to $4.00 per sq. yd.
- National studies have shown that diamond-ground concrete pavements last an additional 14 years on average before requiring further treatment.

Figure 3 indicates the range in overall A-weighted sound intensity levels of tire/pavement noise tested in California and Arizona. As indicated, there is a range of over 10 dBA between the different texture types with diamond grinding being the quietest.

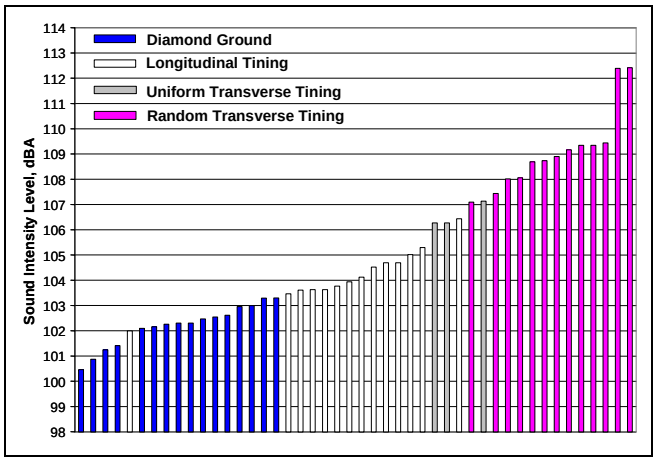

Figure 3. Overall A-weighted Sound Intensity Levels of Tire/Pavement Noise for Concrete Surfaces – Calif./Ariz. database with indicated groupings.
(Reproduced with Permission of Illingworth and Rodkin, Inc.)

Figure 4 indicates overall A-weighted sound intensity levels for different concrete pavement textures in Arizona. Again it should be noted the diamond grinding textures produced the quietest surfaces.

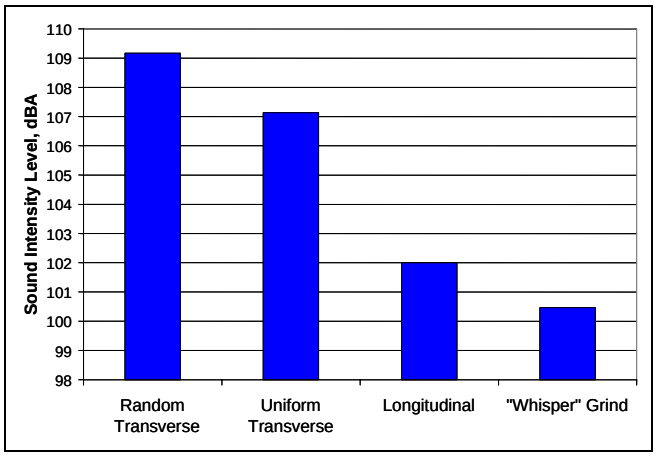

Figure 4. Sound Intensity Levels for Different Concrete Pavement Textures in Arizona.
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Note from the Arizona study that the loudest texture type is that which has in the past been promoted as a quiet concrete texture. Based on the existing pavement texture conditions, significant improvements in noise levels can be attained.

In California, grinding of bridge decks and elevated structures has reduced tire/pavement levels 3 to 10 dBA, with similar reductions in wayside sound levels. In Arizona, grinding of concrete pavements has reduced source levels up to 9 dBA relative to uniformly transverse tined surfaces.[5]

Grinding New Pavements in Missouri

In 1996, the Missouri DOT (MoDOT) began considering the use of diamond grinding as the final surface texture for new concrete pavements in lieu of transverse tining. The main reason for this change was because previous research had shown that pavements built smoother initially will perform better and last longer. Diamond grinding lowers the profile index of a newly constructed concrete pavement by up to 50% or more, producing a very smooth ride.[6]

The first project in Missouri on which diamond grinding was used for new pavement surface texture was a 4½-mile section of eastbound US Route 60 near Poplar Bluff in Butler County, constructed in 1997. The average profile index (as measured with a 0.0-in. blanking band) of the section before diamond grinding was 18.1 in./mile, which was smooth enough for 100% pay, given MoDOT's specification at the time. About 21 days after paving, the surface was diamond ground. The average profile index after grinding was 6.8 in./mile with one section at 5.0 in./mile, earning the contractor a 7% bonus. In comparison, the tined section on the westbound side had an average profile index of 17.0 in./mile following construction, earning the contractor a 3% bonus.[7]

After 6 years of service, the diamond-ground section is still smoother than the tined section. Figure 5 illustrates the change in profile index over time.[8]

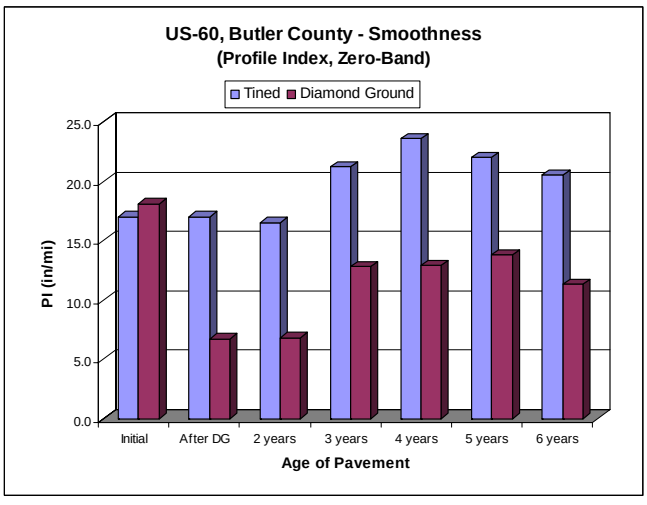

Figure 5. Change in Smoothness over Time for US-60, Butler County, Missouri. (Ref. 8)

Another section of newly-placed diamond ground pavement was built in 2000 on the westbound lanes of Interstate 44 in Webster and Greene Counties, Missouri. Three test sections of 1,000-feet were placed within the project to be monitored over time. Figure 6 demonstrates a similar trend to that of the diamond ground section in the US-60 project, although it is not quite as old.

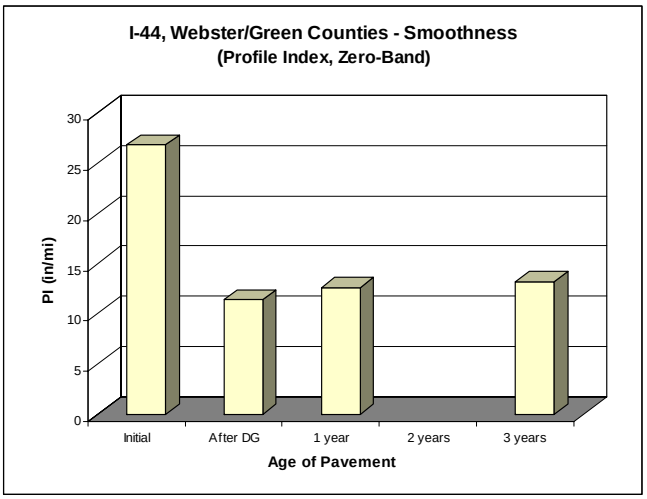

Figure 6. Change in Smoothness over Time for I-44, Webster/ Greene Counties, Missouri. (Ref. 8)

MoDOT reported that "diamond grinding is a viable method for providing surface smoothness and texture to newly placed PCCP, and it sustains pavement smoothness longer than conventional texture methods." [6]

Missouri has adopted diamond grinding as the final surface texture for many new concrete pavements. Although it might be viewed as additional cost, some money can be saved on the placement of the concrete pavement due to less finishing and texturing, as well as less stringent requirements for smoothness directly behind the paver. In addition, there are no delays in curing to allow for tining operations. Pavements with better curing should provide added service life.

Conclusion

The studies summarized in this R&T Update demonstrate that diamond grinding is a viable and cost-effective technique for improving smoothness, lowering noise, and enhancing pavement surface texture. Data from California shows that diamond grinding is very effective, lengthening pavement lives by 17 years on average. In Missouri, pavement engineers are using diamond grinding on many new pavements, expecting that those pavements will stay smoother longer and therefore last longer because of the enhancements provided by diamond grinding. The addition of the Whisper Grinding technique for improved noise characteristics provides an additional tool in the pavement rehabilitation tool kit.

References

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