November 2017
Publication no. cmr 17-013-TB3

# Diamond Grinding

Missouri Department of Transportation Construction and Materials Division, Research Section, 1617 Missouri Boulevard, Jefferson City, MO 65109 | http://www.modot.org/services/or/

TECH BRIEF

*This document is a brief technical summary of the MoDOT case study* ***Diamond Grinding Case Study for Utah and Other Leading States*** *which is included in a larger report,* ***Concrete Repair Best Practices: A Series of Case Studies****, Publication no. cmr 17-013, November 2017.*

## Introduction

Diamond grinding is a well-established technology that has been utilized extensively since the 1960s to provide a smooth yet textured surface for existing concrete pavements that have been repaired adequately. Diamond grinding in combination with other repairs can reduce the existing pavement International Roughness Index (IRI) from 20 to 80 percent (50 percent is typical). Figure 1 shows a time history of IRI before and after diamond grinding with dowel bar retrofit (DBR) showing no increase in IRI after grinding.

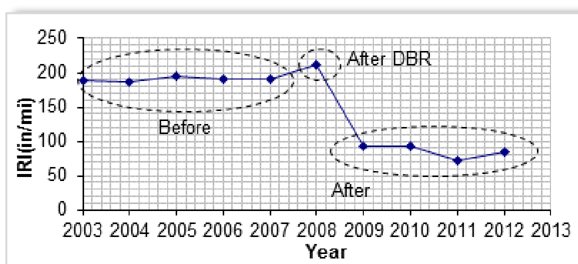


Figure 1. Texas US 69 JPCP diamond grinding (52% IRI reduction).

Diamond grinding is a cost-effective treatment for many existing jointed plain concrete pavements (JPCP) and jointed reinforced concrete pavements (JRCP) that can significantly increase pavement life before more costly treatments such as overlay or reconstruction are required.

Information for this Tech Brief comes from interviews with experts from lead States and contractors, specifications, and other information.

The first grinding project was performed in California in 1965, and grinding became a widely used technique in other States by the 1980s.

Various States have developed improved technology over the past several decades that have resulted in today's highly effective specifications, special provisions, and standard drawings. In addition, inspection and acceptance of projects have improved significantly over time.

Current information indicates that diamond grinding has been very effective in both smoothing rough older pavements and providing good frictional surfaces and noise reduction. Pavement performance data show that diamond grinding (as part of an overall concrete pavement restoration [CPR] preservation program) has extended the life of JPCP until overlay or reconstruction in Utah out to 40 to 50 years, which is more than double the 20-year design life their JPCP. A significant service life extension of JPCP and JRCP was also found in the other States surveyed.

## Diamond Grinding Considerations

The following key pre-diamond grinding aspects are examined by Utah and the other surveyed States:

- Consideration of the pavement age, traffic, design, and past rehabilitation history.
- Past restoration and rehabilitation activity provides clues as to the progression of deterioration. Diamond grinding projects have been repeated at least twice in all of the surveyed States and three to four times in some States.
- Pavement type includes JPCP and JRCP.
- Assessment of the existing pavement condition in terms of distress type.
- Depth of sound concrete at transverse joints.
- Noise level (pavement/tire). Conventional diamond grinding significantly reduces the noise level of the existing pavement, and the Next Generation Concrete Surface (NGCS) can provide the quietest texture available for non-porous concrete pavements.
- Recommended blade spacing to achieve optimum texturing was strongly related to concrete coarse aggregate hardness with softer aggregate requiring a wider blade spacing (or increased land area). Studded tires create major wear down problems in Washington.

## Diamond Grinding Specifications

All of the States included in this survey have up-to-date and highly effective specifications for diamond grinding. All of these States have spent many years refining and improving their specifications, and these specs are available on the State websites and summarized in the main report, "Case Study of Diamond Grinding in Utah and Other Lead States."

**Table 1. State grinding texturing requirements.**

| State | Groove Width | Land Area, Between Groves* | Grove Depth |
|---|---|---|---|
| UT | 0.09 to 0.15 in | 0.06-0.13 in | 1/16 in (0.06 in) |
| CA | 0.08 to 0.12 in 55 to 60 grooves per foot of width | | 0.06 to 0.08 in from the top of the ridge to groove bottom. |
| GA | Select grooves per foot to produce the surface finish for each coarse aggregate type | Want the minimum blades that will allow land area to break | 1/16 in (0.06) +/- 1/32 in (0.03) |
| MN | | Limestone: 0.09 to 0.11 in Granite/gravel / quartzite: 0.08 to 0.095 in | 1/8 in (0.125) +/- 1/16 (0.06 in) when measured from peak of groove to groove bottom |
| MO | 0.22-0.24 in | | 1/32 in (0.03 in) |
| WA | 3⁄32 and 5⁄32 in wide | 1/16 to 1/8 in | <1/16 in (0.06 in) |

For all of these States, it is the contractor's responsibility to select the number of blades per foot to be used to provide the proper surface finish for the aggregate type and concrete present on the project.

## Project Scoping Considerations

Pavements are profiled after grinding to measure the improvement in smoothness. To fairly compare quality control results, the State and contractor need to perform the roughness tests during the same time period.

Widening projects such as lane replacements cause some States to require grinding the entire adjacent lane width to establish a smooth profile for concrete paving equipment to work against.

Diamond grinding of projects patched with viscoelastic type materials require special care. The past decade has brought about new partial depth patching materials generically called hot applied synthetic resin compounds (HASRC). These materials are much softer than cementitious materials traditionally used to repair concrete pavements.

If there are numerous large HASRC patches, one recommendation is to complete the diamond grinding prior to placement of the HASRC patches if they are not already in place.

Significant studded tire wear exists in a few States on their concrete pavements that literally create “ruts” in the wheel paths. In these cases it is common to grind 1.5 inches from the surface (due to surface ruts or channels), which requires multiple passes.

Incentives/disincentives are used by a number of States for grinding smoothness. The incentive has to be enough to make it worth it to the contractor to increase their effort to achieve a smoother surface. Knowing they can acquire a bonus allows experienced contractors to lower their diamond grinding unit bid price by an amount equivalent to the bonus.

## Performance/Survival

Figure 2 shows the results of a survival analysis of 60 diamond ground largely non-doweled JPCP in Utah (about 10 had received DBR). The mean CPR service life until 50 percent of these diamond ground JPCP had received another CPR, or an overlay, or reconstruction is approximately 15 years. Survival drops of rapidly after that due to re-faulting (no DBR) primarily.

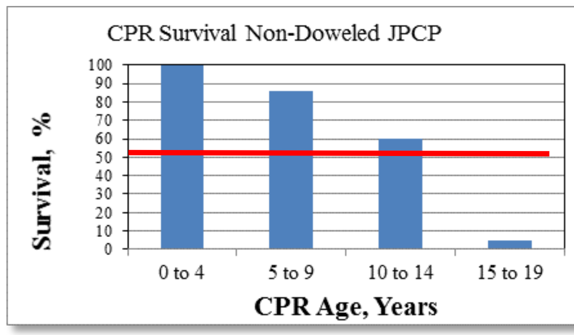


**Figure 2. Survival analysis of diamond grinding of Utah non-doweled JPCP.**

What about life extension of these non-doweled JPCP beyond their 20 year design life? Analysis results of all 108 JPCP projects in Utah are shown in Figure 3.

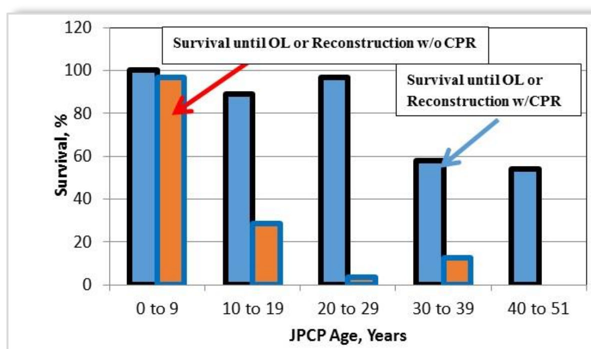


**Figure 3. Comparison of service life of non-doweled JPCP with and without CPR in Utah.**

Two sets survival results are illustrated:

- The blue bars on the left indicate the percent survival of the 108 JPCP projects until either an overlay or reconstruction occurred, during which time however CPR was performed as part of a preservation program. About 50 percent of these projects have survived a total of 40 to 51 years of service.
- The orange bars on the right indicate the percent survival of the 108 JPCP projects until either an overlay (HMA or PCC) or reconstruction occurred during which time no CPR (diamond grinding) was performed. Approximately 50 percent of these projects survived between 10 to 19 years of service.
- These results indicate that the application of CPR with diamond grinding preservation program extended the life of JPCP significantly (more than double) until a much more costly application of overlay or reconstruction was needed.

One extraordinary JPCP in southern California on the San Bernardino Freeway just east of Los Angles was constructed in 1946 as part of Route 66 and later became I-10. This JPCP was 19 years old when first ground in 1965 due to joint faulting (it was noted that it was structurally sound, probably low cracking). This 8 inch JPCP/CTB was ground again due to faulting in 1984, 1997, 2005, and 2017, carrying traffic for 70 years.Summary of Diamond Grinding

Diamond Grinding has been very effective in (1) smoothing rough older pavements, (2) providing good frictional surfaces, (3) significant noise reduction, and (4) providing multiple pavement life extensions until major OL or reconstruction.

The key factors to long life of diamond grinding include the following:

- Project does not have serious durability problems.
- For non-doweled projects, dowel bar retrofit can be specified to eliminate re-faulting.
- If the existing concrete slab has a softer type aggregate (e.g., limestone), then wider diamond grinding blade spacing must be considered to minimize texture wear.
- Proper construction of all CPR repairs must be accomplished.
- Conventional diamond grinding reduces pavement/tire noise significantly. The NGCS texture has resulted in a lower tire/pavement noise than conventional diamond grinding.
- Multiple diamond grindings on projects over the years (reduction in slab thickness) has not shown much evidence of an increase in structural fatigue cracking. Use AASHTO ME "Restoration" to check future cracking, faulting, and IRI.

With proper project selection, design, construction, and inspection of CPR projects involving diamond grinding in widely varying climates, these States have demonstrated that the vast majority of restored pavements can last from 10 to beyond 20 years before another restoration or rehabilitation is needed. Some projects in these States have had CPR with diamond grinding up to four times with acceptable service lives.

The future of diamond grinding holds great promise. The most innovative technology uses 3D surveying to preplan the full pavement profile and determine how to grind a specific project to achieve optimal results. New machines are now available that allow for 6-ft grinding widths instead of traditional 4 ft.

## References

Crafco, Inc. *Installation Instructions, TECHCRETE™-R, TECHCRETE™-TBR.* Chandler: Crafco, 2015.

Crafco, Inc. *TechCrete Grinding Installation Instructions (Supplement).* Chandler: Crafco, 2012.

Darter, M., and S. Rao, *Diamond Grinding New Jersey I-280 and State Route 21 with Extensive HASRC Patches.* Technical Report Prepared for Diamond Coring Co. Inc., 2014.

Darter, M. I., and T. Biel. "Survival of JPCP in Utah." Presentation at the 15th Annual Concrete Pavement Workshop of the Utah Chapter of the American Concrete Pavement Association, Salt Lake City, UT, January 2016.

Frentress, Daniel. *Finding Buried Treasure with Diamond Grinding of a Concrete Pavement After Removal of an Asphalt Overlay*. West Coxsackie, NY: International Grooving and Grinding Association, 2010.

Rao, S., H. T. Yu, L. Khazanovich, M. I. Darter, and J. W. Mack. "Longevity of Diamond-Ground Concrete Pavements." *Transportation Research Record: Journal of the Transportation Research Board* No. 1684 (1999):128–136.

Scofield, Larry. *Development and Implementation of the Next Generation Concrete Surface.* Rosemont: American Concrete Pavement Association, 2016. http://www.acpa.org/wp-content/uploads/2016/11/NGCS-Development-and-Implementation-6-7-16.pdf

Stubstad, R., M. Darter, C. Rao, T. Pyle, and W. Tabet. *The Effectiveness of Diamond Grinding Concrete Pavements in California*. Sacramento: California Department of Transportation, 2005. https://www.csuchico.edu/cp2c/documents/Library/dg1.pdf

**Researchers**—This study was performed by Applied Research Associates, Inc. The principal investigator was Michael Darter.

**Contact**—John Donahue, MoDOT CM Liaison Engineer at 573.526.4334 or john.donahue@modot.mo.gov.

**Funding**—This study was sponsored by the U.S. Federal Highway Administration.

**TRT Terms/Keywords**— Diamond grinding, Concrete pavements, Reinforced concrete pavements, Surface course (Pavements), Pavement maintenance

**Availability**—This Tech Brief is available from the MoDOT Innovation Library at http://www.modot.org/services/or/byDate.htm