R&T UPDATE
Concrete Pavement Research & Technology

# DOES DIAMOND GRINDING AFFECT THE STRUCTURAL CAPACITY AND SERVICE LIFE OF CONCRETE PAVEMENTS?

This question is addressed in the report, "The Longevity and Performance of Diamond-Ground Pavements" by Rao, Yu, and Darter, PCA Research and Development Bulletin RD118 (Ref. 1), which concludes that there is no decrease in structural capacity due to diamond grinding. The following discussion summarizes the analytical studies and performance data that lead to this conclusion.

## Diamond Grinding

Diamond grinding is a concrete pavement restoration technique that is used to restore pavement smoothness and safety by correcting a variety of surface distresses, such as faulting of joints, as-constructed roughness, inadequate surface macrotexture, excessive noise, upward warping at joints, and inadequate transverse slope. Diamond grinding provides a smooth riding surface (often as smooth or smoother than a new pavement) with desirable friction and noise characteristics.

Diamond grinding involves removal of a thin layer of the concrete surface using diamond saw blades. The level surface is achieved by running an assembly of closely spaced blades across the pavement surface. This produces saw cut grooves; the uncut surface between the saw cuts breaks off more or less at a constant level leaving a smooth riding surface. This results in significant improvement in pavement ride-quality and skid-resistance characteristics, and the longitudinal texture produced has been shown to be highly effective in reducing accidents in problem areas.

## Structural Effects

Diamond grinding reduces slab thickness by approximately 4 to 6 mm (0.10 to 0.25 in.) Since slab thickness is a factor affecting the performance of concrete pavements, any reduction in thickness may be a concern in relation to original design expectations. Fortunately, reductions in slab thickness due to diamond grinding are offset by the increase in concrete strength over time and the reduction of dynamic loading caused by faulted joints and an uneven pavement surface.

***Fatigue Life (Crack Resistance).*** In the "Longevity" study, the effects of diamond grinding on cracking performance were evaluated based on both analytical results and field observations. For the analytical evaluation, a fatigue analysis was conducted to examine the sensitivity of fatigue life to slab thickness and concrete strength. The results are shown in Figure 1 (Figure 4 in Reference 1). The predicted fatigue life was determined using the jointed plain concrete pavement model developed by Yu (Reference 1).

Although pavement thickness affects the fatigue life, the small reduction in thickness due to diamond grinding is offset by the gain of concrete strength over time and minimum strength specifications. Long-term strength of concrete is significantly greater than the value used in designing the pavement's thickness, which is typically the 28-day strength. The strength of



American Concrete Pavement Association
5420 Old Orchard Rd.
Suite A100
Skokie, IL 60077
Phone: 847-966-2272
Fax: 847-966-9970
www.pavement.com

International Grooving & Grinding Association
126 Mansion Street
P.O. Box 58
Coxsackie, NY 12051
Phone: 518-731-7450
Fax: 518-731-7490
www.igga.net

conventional concrete (non-fast-track) after one year can be up to 20 percent higher than the 28-day strength (Reference 2). If this increase in concrete strength is considered, the small reduction in slab thickness due to diamond grinding has negligible effect on service life.

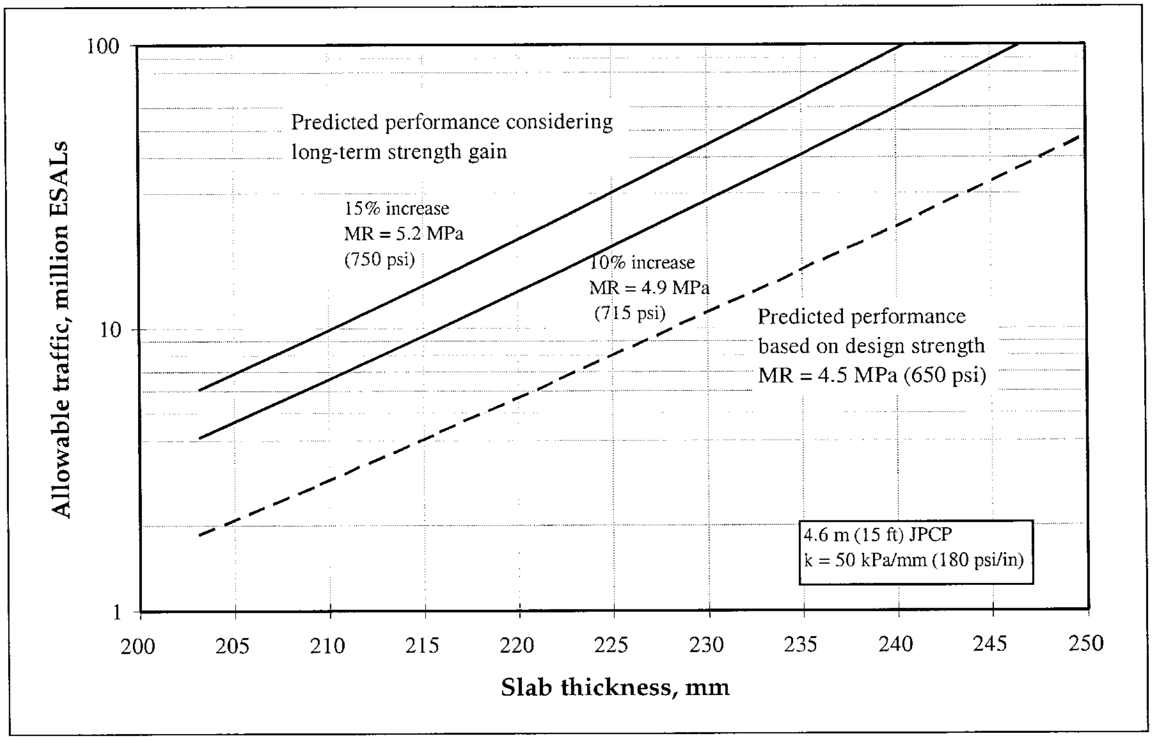



Figure 1. Effects of slab thickness and concrete strength on fatigue life of JPCP.

Figure 1 shows that with 10 percent increase in concrete strength, up to 13 mm (0.5 in.) of thickness can be removed and still achieve the design life predicted based on design strength. If the long-term strength is 15 percent greater than the design strength, up to 18 mm (0.7 in.) may be removed without compromising the projected performance. These results suggest that a typical concrete pavement may be ground three times without reducing its fatigue life.

These predictions, based on analytical evaluations, are consistent with field observations given in the report. None of the pavement sections evaluated in the study exhibited an unusual level of slab cracking. This result is supported by the fact that several diamond-ground concrete pavements are still performing well after 20 years. The reduction of impact loads, due to the removal of pavement roughness, especially at joints, may also be a significant factor contributing to the good cracking performance of diamond-ground pavements.

***Joint Faulting.*** Faulting refers to the difference in elevation across the joint and is the most important factor that affects ride quality of jointed concrete pavements, especially undoweled pavements. Faulting is caused by a combination of factors including repeated heavy axle loads and insufficient load transfer (no dowels). Slab thickness has only minor effect on faulting. Excessive faulting is perhaps the most common reason for grinding pavements. When the average fault reaches 3.8 mm (0.15 in.), diamond grinding or other pavement restoration techniques should be considered.



American Concrete Pavement Association
5420 Old Orchard Rd.
Suite A100
Skokie, IL 60077
Phone: 847-966-2272
Fax: 847-966-9970
www.pavement.com

International Grooving & Grinding Association
126 Mansion Street
P.O. Box 58
Coxsackie, NY 12051
Phone: 518-731-7450
Fax: 518-731-7490
www.igga.net

Increased pavement life will be obtained by reducing the roughness caused by faulting and the associated heavy dynamic loads (see Figures 2 and 3). Dynamic loads caused by rough pavements can be up to 1.5 times the static loading, which decreases a pavement's service life. Diamond grinding often results in a pavement that is 70% smoother than the pre-grinding profile.

Smoother pavements last longer. For example, a concrete pavement can be diamond-ground to improve smoothness, which will allow more traffic loadings and extend the pavement's life. This concept can be demonstrated using the AASHTO 1993 Pavement Design Equation. In that equation, serviceability is analogous to smoothness, which means that increased serviceability (a smoother pavement) will result in more Equivalent Single Axle Loads (ESALs) carried by the pavement.

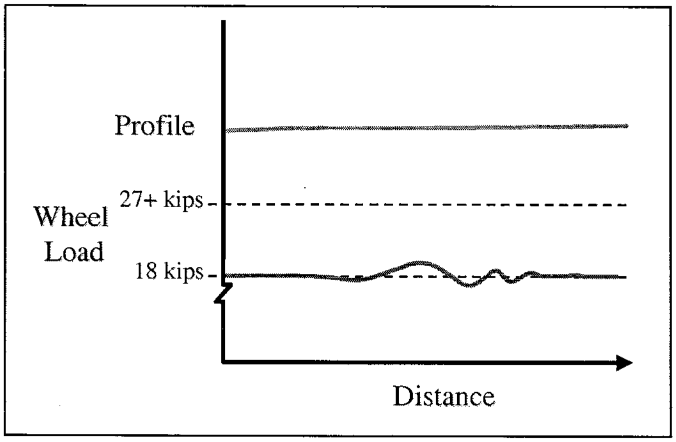



Figure 2. Less variation in load on smooth pavement (Ref. 4)

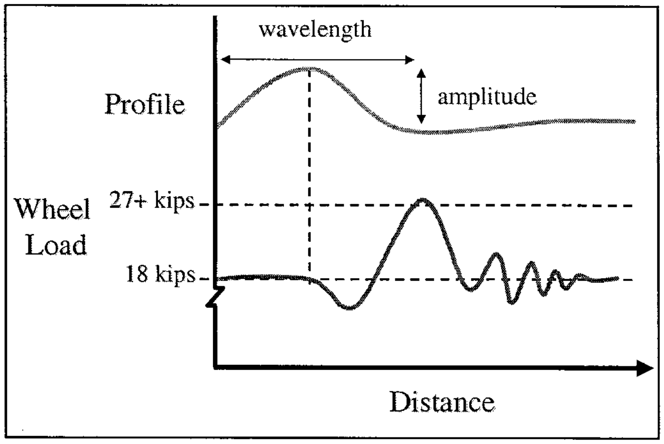



Figure 3. Dynamic load caused by rough pavement (Ref. 4)

Often, other pavement restoration techniques such as dowel bar retrofit or full-depth joint repairs using dowel bars, are used in conjunction with diamond grinding, thus eliminating a major cause of future faulting.

## Conclusion

Analytical studies and field performance data show that diamond grinding of concrete pavements, which provides a smoother and safer pavement surface, actually increases the performance and service life of concrete pavements. Any potential loss in structural capacity caused by reducing the pavement thickness is offset by improved concrete strength and smoothness.

## References


1. Yu, H.T., Smith, K. D., Darter, M.I., Jiang, J., and Khazanovich, L., *Performance of Concrete Pavements, Volume 3—Improving Concrete Pavement Performance,* Report FHWA RD-95-111, Federal Highway Administration, 1997.
2. Mindness, S., and Young, J. F., *Concrete,* Prentice-Hall, Inc., 1981.
3. Rao, S., Yu, H. T., and Darter, M. I., *The Longevity and Performance of Diamond- Ground Pavements*, PCA Research and Development Bulletin RD118, 1999.
4. Unpublished research data, University of Texas at Austin.

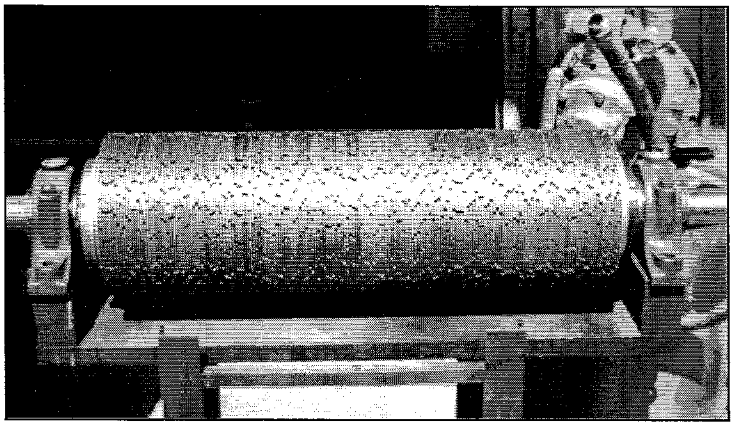


April 2001

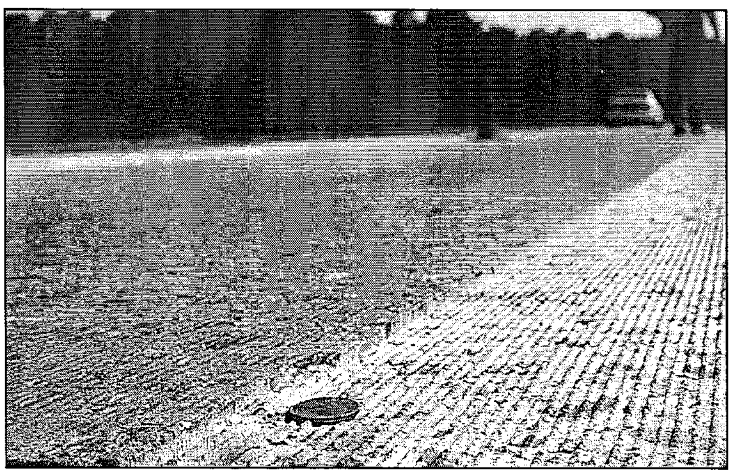
American Concrete Pavement Association
5420 Old Orchard Rd.
Suite A100
Skokie, IL 60077
Phone: 847-966-2272
Fax: 847-966-9970
www.pavement.com

International Grooving & Grinding Association
126 Mansion Street
P.O. Box 58
Coxsackie, NY 12051
Phone: 518-731-7450
Fax: 518-731-7490
www.igga.net

Diamond Grinding Machine



Diamond Grinding Head



Diamond-Ground Surface – smoother, quieter, and safer pavement surface that adds service life to a concrete pavement

April 2001

American Concrete Pavement Association
5420 Old Orchard Rd.
Suite A100
Skokie, IL 60077
Phone: 847-966-2272
Fax: 847-966-9970
www.pavement.com

International Grooving & Grinding Association
126 Mansion Street
P.O. Box 58
Coxsackie, NY 12051
Phone: 518-731-7450
Fax: 518-731-7490
www.igga.net