Diamond Grinding

National Trends and Local Challenges

2016
Introduction

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  - Executive Director - International Grooving and Grinding Association
  - Vice President – American Concrete Pavement Association’s Pavement Preservation Partnership
Looking Back In Time

- In the not so distant past noise, ride quality, and customer comfort (functional considerations) took a back seat to structural considerations.
Transportation Authorities React

- Specifiers place greater emphasis on tire/pavement noise, smoothness and construction delays.
  - Development of tighter smoothness and new noise specifications.
  - Development of low noise surface treatments.
  - Increased use of sound walls.
  - Night work becomes the norm.
  - Safety concerns still paramount!
Back to the Future

- The first Portland Cement Concrete Pavement (PCCP) constructed in US was located in Bellefontaine, Ohio, 1891
- Used two lift construction
  - Hard aggregate on surface so horseshoes wouldn’t wear pavement.
  - Surface texture was grooved in 4” squares so horses would not slip
Performance Matters!

- Bristol Motor Speedway 2012
Increasingly Specifiers are utilizing diamond saw cut surfaces to reduce roughness, reduce noise and increase the friction of their pavements, bridges and runways.

- Economical
- Long-lasting
- Effective
- Environmentally Friendly
What is Diamond Grinding?

- Removal of thin surface layer of hardened PCC using closely spaced diamond saw blades
- Results in smooth, level pavement surface
- Provides a longitudinal texture with desirable friction and low noise characteristics
- Frequently performed in conjunction with other CPR/CPP techniques, such as full/partial depth repair, undersealing/slabjacking, dowel bar retrofit, and joint resealing
Blades and Spacers
Typical Conventional Diamond Grinding (CDG) Blade Configuration

- Saw Blade Segment
- Saw Blade Core 0.105 (2.7 mm)
- Spacer 0.110 (2.8 mm)
- Land Area 0.090 (2.3 mm)
- 0.125 0.125 (3.2 mm)
Diamond Grinding Equipment
Diamond Grinding Process
Conventional Diamond Ground Surface

Diamond Grinding

- Width of diamond blades: 0.125 inches (3.2 mm)
- Land area: 0.080 inches (2.3 mm) for hard aggregate, 0.110 inches (2.8 mm) for soft aggregate
Milled Surfaces
Milling Drum
Impact vs Abrasion

Core

Segment
Advantages of Saw-Cut Textures

- Often cost less than AC overlays;
- Enhances smoothness, surface friction and safety;
- Can be accomplished during off-peak hours with short lane closures;
- Texturing of one lane does not require grinding of the adjacent lane;
- Does not affect overhead clearances underneath bridges, signs or tunnels;
- Blends patching and other surface irregularities into a consistent, identical surface;
- Environmentally friendly.
Commodity Price Increases

- Concrete PPI
- Asphalt PPI
- CPI
- 3.6% inflation
- 5.5% inflation
- 3.9% inflation

Last Time Trust Fund Increased
CDG is Cost Effective and Predictable

National CDG Cost for Projects > Than 7,000 SY
Pavement Problems Addressed

- Faulting at joints and cracks
- Built-in or construction roughness
- Polished concrete surface - Increase friction
- Wheel-path rutting
- Inadequate transverse slope
- Unacceptable noise level
Joint Faulting
Diamond Grinding Removes Faults
Rough Pavement

Profile

Wheel Load

27+ kips

18 kips

Distance

wavelength

amplitude
Smooth Profile

Wheel Load

Profile

27+ kips

18 kips

Distance
Diamond Grinding can provide a significant improvement over the pre-grind profile!

Graph showing the comparison of average IRI before and after grinding for I-635 WB Lanes K1, K2, K3, & K4. Before Grinding: 698 Bumps; After Grinding: 29 Bumps.
IRI of KY Interstate Pavements

![Graph showing the IRI of KY Interstate Pavements over time from 2007 to 2012. The IRI value decreases from 112.1 in 2007 to 74.5 in 2012.](image-url)
KTC Diamond Grinding Experience

- IRI Improved from 112.1 to 74.5 in 5 years
- Lowest recorded average IRI ever covering 536 lane miles
- $188,000 per lane mile
- Diamond grinding had an avg. cost of $2.75 per sq. yd. in KY over a 5-year period
- Provides favorable impacts related to the performance criteria attached to Map-21 and the Fast Act
Safety, Surface Texture and Friction

- Increased macro-texture of diamond ground pavement surface provides for improved drainage of water at tire-pavement interface.
- Longitudinal texture provides directional stability and reduces hydroplaning (side-force friction). Grooves provide “escape route” for water trapped between tire and pavement surface.
- In Wisconsin, overall accident rates for ground surfaces were 40% less than for un-ground surfaces over a 6-year period, 57% in wet weather conditions.
Lower Ambient Temperatures and Energy Costs

The light reflective color of PCCP means less energy required for overhead lighting and cooling in urban areas.
Can be used on asphalt too!

I-70 Missouri
Diamond Grinding Asphalt Pavement

- Asphalt pavement can be ground and grooved just like concrete pavement.

Indianapolis Motor Speedway
Diamond Ground Asphalt Surface
Unacceptable Noise Level
Concrete Sawing Residue - Slurry
What is Slurry?

- Inert, nonhazardous (<12.5 pH) byproduct of the diamond grinding process
- Combination of the cooling water and the concrete fines brought into suspension during the sawing process
- Water is introduced to the saw blades to increase their life expectancy, decrease dust emissions and increase worker safety
Resultant Near-Dry Surface
IGGA - Best Management Practices

- Slurry spreading disposal
- Slurry collection and pond decanting
- Slurry collection and plant processing
- Slurry collection and recycling
- Alternative solutions
IGGA – Best Management Practices
Slurry Spreading Disposal
Slurry Spreading Disposal

- Used in rural areas that have vegetated slopes
- Engineer and Contractor should conduct a site inspection identifying sensitive areas
- Slurry spreading start and stop points should be clearly marked on road shoulder
- Slurry must be picked up and hauled while grinding in these areas
Slurry Spreading Disposal

- Vacuumed slurry should be spread evenly on adjacent slopes
- Slurry should not be spread within 100 ft. of any natural stream or lake, or within 3 ft. of a water filled ditch
- At no time will slurry be allowed to enter a closed drainage system
Liming Effects of Slurry

- One of the main concerns with applying slurry to soils is the liming effect and subsequent increase in soil pH.
- Three things affect the pH of the saw slurry:
  - Composition of the concrete
  - Quality of the water used to cool the blades
  - Amount of removal and quantity of water used
Five slurry samples from widely dispersed sites in the United States were analyzed for particle size distribution and evaluated with a suite of USEPA physical and chemical analyses. Values found for the parameters examined are not considered harmful.
“Current CGR materials, at least those represented in this study, do not present a hazard. While direct deposition of the CGR machine product on the vegetated parts of highway rights-of-way may be unsightly to some, the environmental impact is negligible.”
The fresh water samples and slurry samples for inorganic and organic constituents displayed no hazardous characteristics when compared to Title 22 haz-waste standard

Holmes & Narver 1997
“the Department has determined that the diamond grinding slurry falls within the definition of clean fill (see 6 NYCRR 360-8.2(a)(1)), and it follows that the site proposed for placement is exempt from regulation under Part 360, so long as the site is under the ownership or control of the transportation agency.”
The state of MN recently passed legislation allowing for the deposition of slurry on the roadway shoulders.

MNDOT developed a Slurry Disposal BMP to assist contractors.
“CGR produced from concrete grinding operations is not hazardous waste, but is elevated in pH and requires appropriate management. Best management practices should be implemented for CGR, and examples of such practices are available. If CGR is discharged adjacent to roadways, care must be taken to avoid impact on ecosystems.”
NDOR Slurry Research

“This study showed that it is plausible to apply CGR slurry at rates up to 40 dry tons/acre on medium to fine textured soil without negative effects and provides evidence that rate higher than the current regulated limit of 5 dry tons/acre may be applied on roadside with similar soil characteristics as this study.”
“While the direct discharge of DGS from the grinding machine resulted in application rates that exceeded the recommended agronomic rates, there did not appear to be any short-term (< 3 months) adverse impacts to the soils, vegetation, or surface runoff (as measured by concentrations of TSS, TP, Ca, Mg, Pb, and pH) from the sites.”
National Trends - Performance

What’s New And Exciting?
Noise Performance

- So what is all this noise about tire/pavement noise?!?
Transverse Tining

- For many years the use of transverse tining created the perception that all concrete pavement is noisy.
NCPTC OBSI Testing

- In 5 years the National Concrete Pavement Technology Center tested over 1500 unique textures
  - Transverse Tining
  - Longitudinal Tining
  - Diamond Ground
  - Diamond Grooved (Longitudinal, Transverse)
  - Shot Peened
  - Exposed Aggregate
  - Pervious Concrete
  - HMA and Surface treatments
- Hundreds of Miles in 20 States and 6 Countries
NCPTC OBSI Testing
NCPTC Noise Catalogue

- Research conducted by the National Concrete Pavement Technology Center shows diamond grinding as the most quiet PCCP surface texture commonly used.
Caltrans & ADOT Testing
Purdue-Tire Pavement Testing Apparatus
MNROAD Field Validation of TPTA

Layer Depth (Inches):
- Sand: 6.4" 5'
- Clay: 6.4" 5'
- 6.4" 5'
- 6.3" 6'
- Clay

Panel Width:
- 12'
- 15'
- 1 '
- 1 
- 1 '

Pavement Length:
- 12'
- 15'
- 1'
- 1
- 1

Dowel Bar Diameter:
- none
- 0.5" 5
- 0.5 5
- 0.5 5
- 0.5 5
- 0.5 5

Subgrade "R" Value:
- 70
- 70
- 70
- 70
- 70

Construction Date:
- Jul-93
- Jul-93
- Jul-93
- Jul-93
- Jul-93

Gravel Section:
- 12'
- 15'
- 15'
- 15'
- 15'

Section:
- 12'
- 15'
- 15'
- 15'
- 15'

Varies

Miscellaneous:
- 6" Culverts
- 7.5" 5
- 7.5" 5
- 7.5" 5
- 7.5" 5

International Grooving and Grinding Association
Duluth Minnesota NGCS
NGCS is Built Using DG Technologies
Comparison to Other Pavement Surfaces

<table>
<thead>
<tr>
<th>Pavement Section</th>
<th>Sound Intensity Level, dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGCS Lane 2</td>
<td>99.0</td>
</tr>
<tr>
<td>NGCS Lane 1</td>
<td>99.4</td>
</tr>
<tr>
<td>CDG</td>
<td>102.1</td>
</tr>
<tr>
<td>Typical 4-5 Yr Old ARFC</td>
<td>102.8</td>
</tr>
<tr>
<td>2002 ARFC Test Section</td>
<td>103.2</td>
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<tr>
<td>Longitudinal Tining</td>
<td>103.9</td>
</tr>
</tbody>
</table>

International Grooving and Grinding Association
Kansas I-70 Results

Pavement Section

- NGCS
- Long. Grooved
- Drag Texture
- CDG
- Long Tine Before
- Long Tine After
- Exposed Agg.
Acoustic Durability

Sound Intensity Level, dBA

Pavement Section

NGCS

LITE CDG

International Grooving and Grinding Association
Typical ARFC Noise Research Results - ADOT

- “The results shown represent the average of twenty projects. The projects were located on I-8, and I-10, and ranged in age from three years to twelve years. The regression indicates approximately a 5 dBA increase in noise generation in a ten year period.
Why Grooving?

- Reduce the number of wet pavement accidents
- The wet pavement accident occurs when the vehicle pavement friction demand exceeds the ability of the pavement-tire contact to produce the required amount of friction
Improved Internal Water Drainage

- Grooves provide “escape route” for water trapped between tire and pavement surface
- Increases macro-texture of pavement surface.
- Reduces the potential for hydroplaning
Reduced Splash and Spray
CALTRANS Grooved Pavement Study

- Study conducted over a four-year period
- All grooved and un-grooved control sections located on freeways in urban Los Angeles County
- Study includes 322 lane-miles of grooved pavement
- Study includes 750 lane-miles of un-grooved control sections
The Department of Public Works' accident experience reveals that grooving has yielded a:

1) 20 percent reduction in total accidents
2) 50 percent reduction in total accidents
3) 70 percent reduction in wet pavement accidents
Effects of Groove Geometry
California SR 58 - 10 Years Old

Friction (FN40)

- Long Tined
- Burlap Drag Textures
- Conventional Diamond Ground Textures

Not Grooved
Grooved

120 120 105 120 120 120 55.0 54.4 53.8 54.2 53.9 52.5

18.2 14.5 41.6 39.6 36.8 36.4 41.4 53.3
Noise vs. Friction

![Graph showing Noise vs. Friction with various data points for Diamond Grinding, Drag, Longitudinal Tining, Transverse Tining, and Other categories.](image-url)
Mean Texture Depths – KDOT1-70

![Bar chart showing mean texture depths for different pavement sections.](chart.png)
NGCS Site Locations in The USA
In Summary

- Motorists are increasingly demanding safe, smooth, quiet and delay free roadways while funding necessary to meet these needs remains elusive.
- Diamond saw-cut textures are a time proven, cost effective means of providing consistently smooth, quiet and safe textures at a cost often lower than asphalt overlays.
- Diamond saw-cut textures are not as subject to inflationary pressures as asphalt based products.
In Summary

- Diamond grinding can provide sustainable benefits such as increased pavement longevity, increased fuel economy, reduced noise and resource conservation
- Diamond grinding can extend pavement life significantly at a competitive cost
- IGGA is ready to assist!
Visit Us on the Web

International Grooving and Grinding Association
at
igga.net

THANK YOU!