Session 9: Diamond Grinding and Grooving
Learning Outcomes

1. Differentiate between diamond grinding and diamond grooving and list the purpose of each
2. List characteristics of other surface texturing techniques (OTCS, NGCS, cold milling)
3. Identify appropriate blade spacing dimensions for grinding, grooving, and NGCS
4. Describe recommended construction procedures
5. Identify typical construction problems and remedies
Grinding vs. Grooving

- Diamond grinding
  - Removal of thin layer of concrete surface to restore smoothness and friction
- Diamond grooving
  - Creation of channels in concrete pavements to reduce hydroplaning potential
Surface Comparison

Diamond Grinding

Diamond Grooving
Other Surface Textures

- Optimized Texture for City Streets (OTCS)
  - Similar to diamond grinding but reduced land heights/widths

- Next Generation Concrete Surface (NGCS)
  - Manufactured, low-noise surface consisting of flush grinding and grooving

- Cold Milling
  - Removal of concrete layer using carbide blades
Other Texture Comparisons

NGCS

OTCS

Cold Milling
Diamond Grinding
Diamond Grinding

Performance Benefits

- Restores smoothness (by removing built-in roughness and joint/crack faulting)
- Improves friction
- Improves cross slope
- Reduces noise
- Performance life: – 14-17 years
# Diamond Grinding
## Effect on Roughness

Percent decrease in IRI

<table>
<thead>
<tr>
<th>Test Area</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>59%</td>
<td>56%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>53%</td>
</tr>
<tr>
<td>3</td>
<td>64%</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>55%</td>
</tr>
</tbody>
</table>

Source: 2003 ADOT Study
## Diamond Grinding

### Effect on Friction

Percent increase in friction

<table>
<thead>
<tr>
<th>Test Area</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>18%</td>
</tr>
<tr>
<td>3</td>
<td>41%</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>26%</td>
</tr>
</tbody>
</table>

Source: 2003 ADOT Study
Diamond Grinding

Other Advantages

• Can be done lane-at-a-time under a moving operation
• Does not affect overhead clearances
• No new materials introduced
• Limited waste
• Aesthetically blends patching and other irregularities into consistent surface
Diamond Grinding
Project Selection

- Structurally sound pavement
- Triggers:
  - Average faulting $> 0.08$ in (higher for JRCP)
  - Roughness $> 160$ to $220$ in/mi
  - Wheelpath wear $> 0.25$ to $0.40$ in
  - Surface friction below agency standards
  - Excessive noise levels
- Consider hardness of aggregate
- Consider need for associated treatments (e.g., LTR)
- Recommended Evaluation Procedures:
  - Distress surveys
  - Roughness and/or friction testing
Diamond Grinding

Limitations

• Does not address structural or durability issues

• Hardness of aggregate affects costs, productivity, and performance life

• Roughness and deterioration will re-develop if causes are not addressed
  – Full- and partial-depth repairs
  – Dowel bar retrofit
  – Slab stabilization
  – Joint resealing?
Diamond Grinding
Equipment Schematic

Hydraulic Cylinder

Grinding Machine Frame

Leading Bogies

Subframe

Grinding Head

Trailing Bogies

Depth-Control Wheels

Figure 9.15 on p. 9.14
Diamond Grinding

Cutting Head Specifications

- Diamond blades mounted in series on cutting head
- Cutting head width from 1,220 to 1,270 mm (48 to 50 in)
- Spacing of 164 to 197 blades per meter (50 to 60 blades per ft)
Diamond Grinding
Cutting Head and Blades

Figure 9.1 on p. 9.2
Diamond Grinding
Blade and Spacer Pairings

Figure 9.4 on p. 9.4
## Diamond Grinding

### Blade Spacing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Hard Agg</th>
<th>Soft Agg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groove Width</td>
<td>0.09 – 0.15 in</td>
<td>0.09 – 0.15 in</td>
<td>0.09 – 0.15 in</td>
</tr>
<tr>
<td>Land Area</td>
<td>0.07 – 0.13 in</td>
<td>0.07 – 0.11 in</td>
<td>0.09 – 0.13 in</td>
</tr>
<tr>
<td>Depth</td>
<td>0.04 – 0.12 in</td>
<td>0.04 – 0.12 in</td>
<td>0.04 – 0.12 in</td>
</tr>
<tr>
<td>No. of Blades</td>
<td>50 – 60/ft</td>
<td>53 – 60/ft</td>
<td>50 – 54/ft</td>
</tr>
</tbody>
</table>

Table 9.1 on p. 9.3
Diamond Grinding
Blade Spacing Effects

- Correct spacing critical to achieving proper texture
- Hard and large size aggregates require tighter blade spacing

52 blades/foot

60 blades/foot
Diamond Grinding
Grinding Machine
Diamond Grinding
Front of Grinding Head
Diamond Grinding
Behind the Grinding Head
Diamond Grinding
Construction Considerations

• Mobile single-lane closure
• Grind parallel to centerline
  – Max 2-in overlap (1 inch or less preferred)
  – Maintain cross-slope of adjoining passes
  – Limit holidays
• Slurry removal
Diamond Grinding
Grinding Process
Diamond Grinding
After First Pass of Grinding Machine
Diamond Grinding
Final Pass
Diamond Grinding

Feather Pass at Curb and Gutter

Fig. 9.17 on p. 9.16
Diamond Grinding

Holidays

Fig. 9.16 on p. 9.15
Diamond Grinding

Slurry Handling

• Establish slurry handling schemes prior to project (on-site or off-site)
  • On-Site
    – Deposit on foreslopes
    – Avoid wetland areas and natural streams or lakes
  • Off-Site
    – On-board vacuums and water tankers
    – Deposit in settlement ponds
Diamond Grinding

Grinding Machine
Diamond Grinding
Trucks Collecting Slurry
Diamond Grinding

Slurry Disposal
Diamond Grinding

Finished Product
Diamond Grinding

Key Factors for Success

- Selection of proper candidate projects
- Proper design (blade spacing, transverse slope, and project layout)
- Conduct grinding parallel to the centerline
- Check that overlaps are within tolerances
- Monitor grinding depth
- Verify end product meets specification
  - Smoothness testing
  - Friction and/or texture measurements
Troubleshooting
What is wrong here?

Unground Areas (“Holidays”)

Grinding
Troubleshooting
What is wrong here?

Poor Vertical Match Between Passes
Troubleshooting
What is wrong here?

Vacuum Failure
Diamond Grooving

• Cutting parallel grooves into the pavement using diamond saw blades
• Longitudinal (more common) or transverse
• Benefits
  – Reduced hydroplaning potential
  – Reduced wet-weather crashes
  – Reductions in splash and spray
Diamond Grooving
Effect on Friction

Fig. 9.4 on p. 9.6
Diamond Grooving
Project Selection

- High incidence of wet-weather crashes
- Generally performed at localized areas
- Pavements should be structurally and functionally sound
Diamond Grooving
Orientation

• Longitudinal
  – Decreased hydroplaning potential
  – Improved curve tracking
  – Easier to conduct under traffic
  – Lateral “wiggle” of vehicles

• Transverse
  – Most direct channel for water drainage
  – Significant braking traction
  – Difficult to conduct under traffic
  – Noise may be an issue
Diamond Grooving

Longitudinal Grooving
Diamond Grooving
Transverse Grooving

Bridge Deck

Airport
Diamond Grooving

Design Considerations

- Groove entire lane area (but allow for small areas with surface irregularities)
- Use recommended blade spacing

Saw blade thickness
3.2 mm (0.125 in)
19 mm (0.75 in)

3.2 mm (0.125 in) min.
6.4 mm (0.25 in) max.

Fig. 9.5 on p. 9.6
Diamond Grooving
Construction Considerations

- Groove dimensions
- Direction of grooving
- Disposal of slurry
- Procedures similar to diamond grinding
Diamond Grooving Equipment

- Head width: 0.3 to 1.8 m (1 to 6 ft)
- Blade spacing of 19 mm (0.75 in)
- Vacuum system to collect slurry
Diamond Grooving

Key Factors for Success

• Selection of proper candidate projects
• Proper selection of groove dimensions
• Selection of grooving direction
NGCS
NGCS

Description

• Manufactured concrete pavement surface
• Uses conventional grinding equipment in two phase operation:
  – Flush grinding
  – Grooving  \{ Single- or two-pass operation \}
• Combines smoothness of diamond grinding and hydroplaning reduction of grooving into a low-noise surface
• New and rehabilitated pavements
NGCS Equipment Head Comparisons

NGCS Head

Conventional Diamond Grinding Head
NGCS
Construction

Flush Grind

Grooved
NGCS

Future

- NGCS continues to be evaluated by a growing number of highway agencies
- Projects in at least 9 states
- Benefits of low noise but also increased smoothness, improved lateral stability, and reduction in hydroplaning potential
Review: Learning Outcomes

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Thank You For Your Attention!

Questions?