# Diamond Grinding

August 29th 2012
Nashville, TN

Matt Ross P.E.
Penhall Company

# Diamond Grinding

- Purpose
  - Smooth the surface
  - Reestablish skid resistance
  - Correct cross-slope
- Used for:
  - Faulted joints
  - Wheel track wear
  - Drainage slope improvements
  - Polished pavement

# What is Diamond Grinding?

Removal of thin surface layer of hardened PCC using closely spaced diamond saw blades

# Diamond Grinding

- Uses closely-spaced, diamond saw blades mounted on a rotating drum
- Removes weathered concrete
- Corrects surface irregularities
- Provides smooth riding surface

# Diamond Grinding – Candidate Distresses

- Faulting at joints and cracks
- Built-in or construction roughness
- Wheel path rutting caused by studded tires
- Polished concrete surface
- Unacceptable noise level
- Permanent upward slab warping
- Inadequate transverse slope

# Useful Information

- Year the pavement was built
- Pavement type (plain, reinforced)
- Transverse joint spacing
- Aggregate sources
- Aggregate hardness

# Useful Information (cont.)

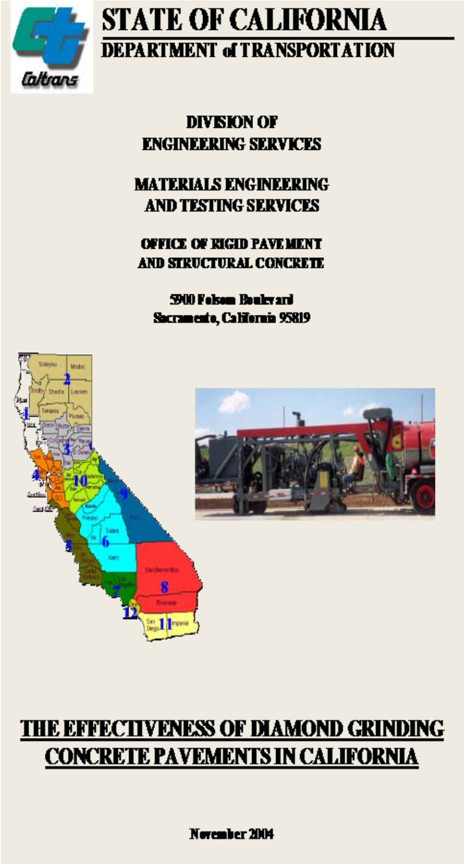
- Aggregate/sand quantity/abrasiveness
- Aggregate size and exposure
- Existing pavement profile (California Profilograph)
- Faulting index or average faulting
- Studded tire rut depth
- Amount of warping

# Diamond Grinding of Roadways Was Invented in California

- Diamond grinding was first used in California in 1965 on a 19-year old section of I-10 to eliminate significant faulting (Neal and Woodstrom 1976).
- In 1983, CPP was conducted on this same pavement section, including the use of additional grinding to restore the rideability and skid resistance of the surface. In 1997, the process was repeated.
- Since its first use in 1965, the use of diamond grinding has grown to become a major element of PCC pavement preservation.

# Effectiveness of Diamond Grinding CALTRANS

- CALTRANS has determined that the average life of a diamond ground pavement surface is 17 years and that a pavement can be ground at least three times without affecting pavement structurally. See ACPA-SW for full report


STATE OF CALIFORNIA
DEPARTMENT of TRANSPORTATION

DIVISION OF
ENGINEERING SERVICES

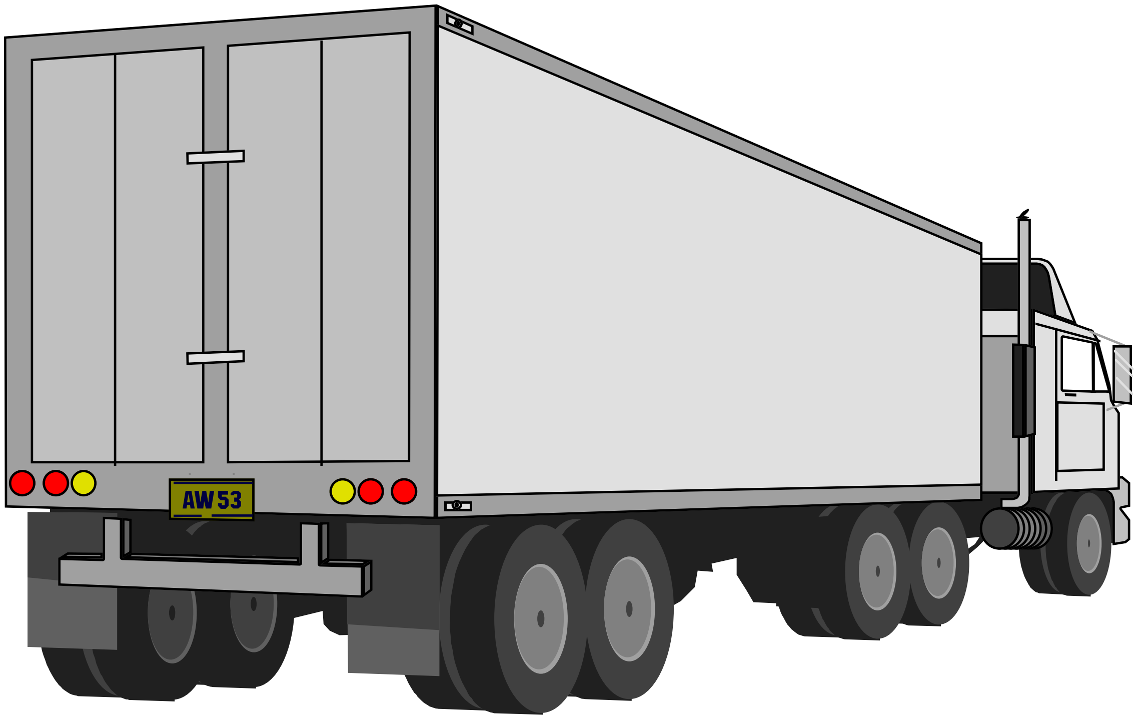
MATERIALS ENGINEERING
AND TESTING SERVICES

OFFICE OF RIGID PAVEMENT
AND STRUCTURAL CONCRETE

5900 Folsom Boulevard
Sacramento, California 95819

THE EFFECTIVENESS OF DIAMOND GRINDING
CONCRETE PAVEMENTS IN CALIFORNIA

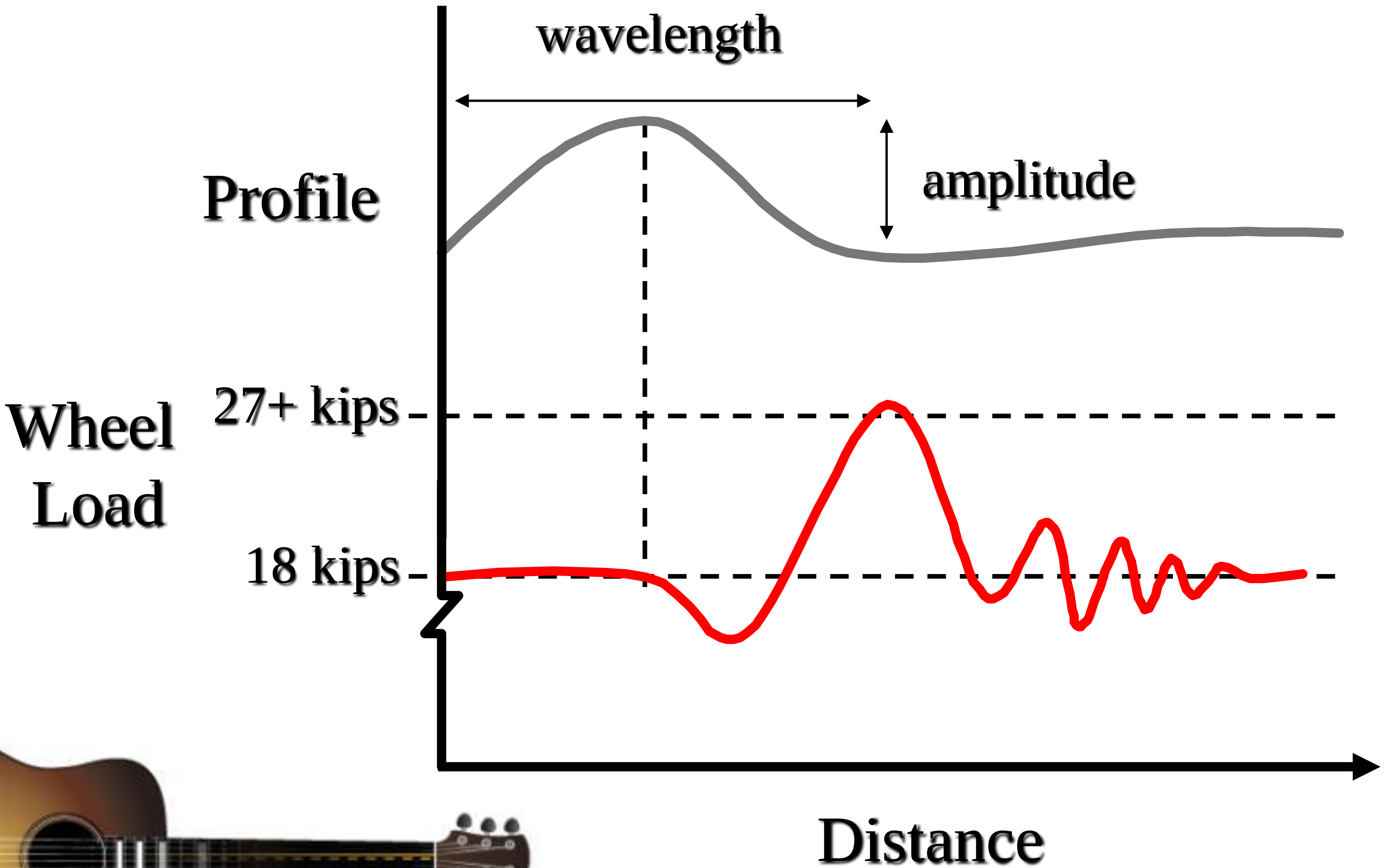
November 2004



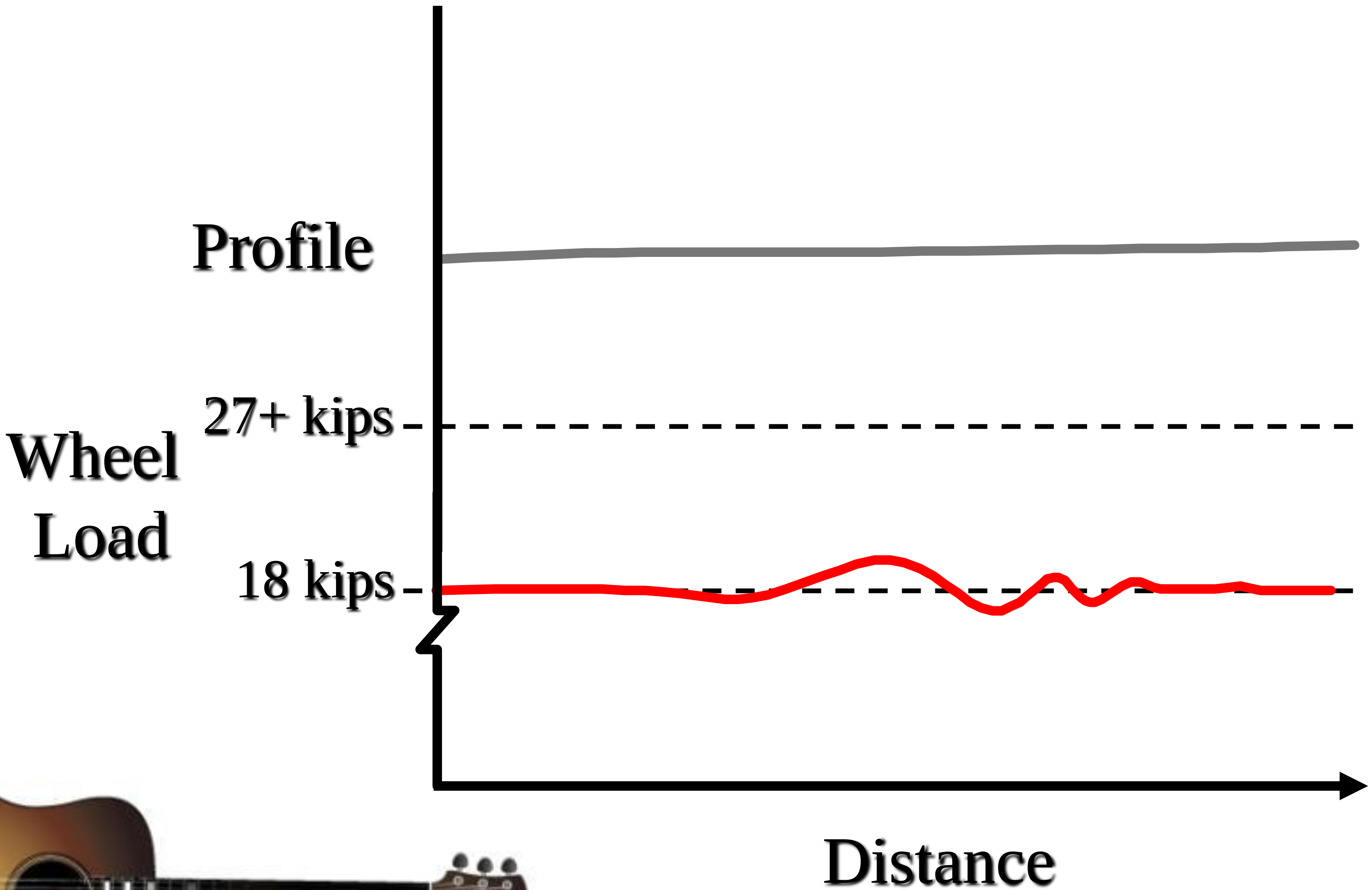

F = m x a

Dynamic Load > Static Load

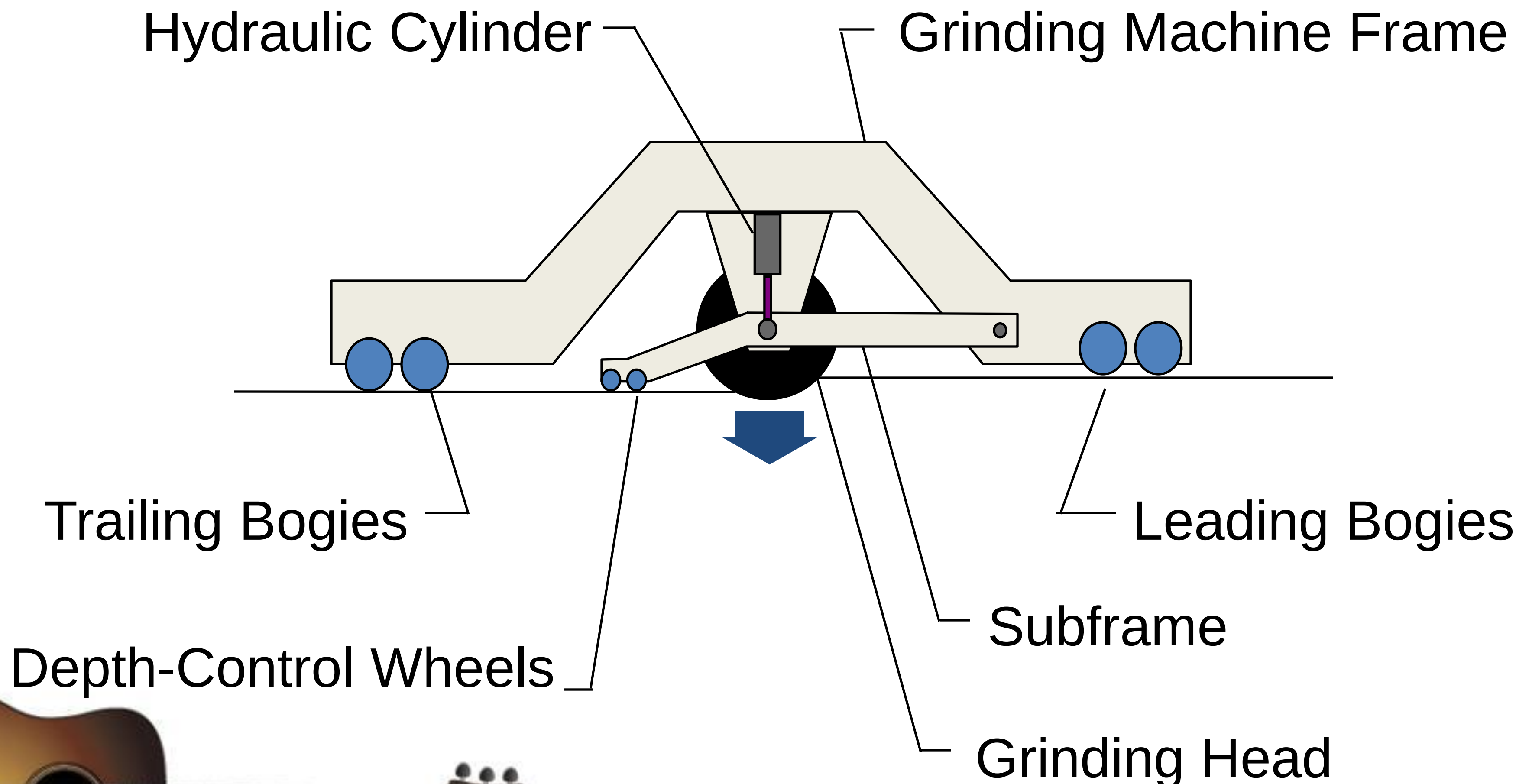
# Rough Pavement

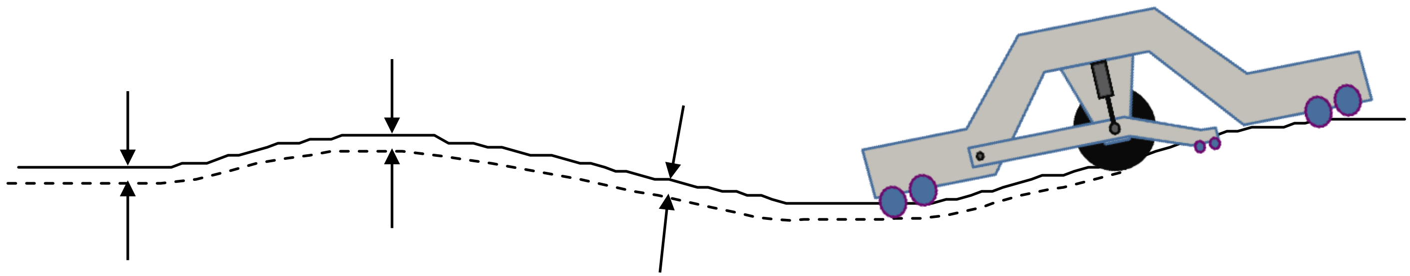


# Smooth Profile

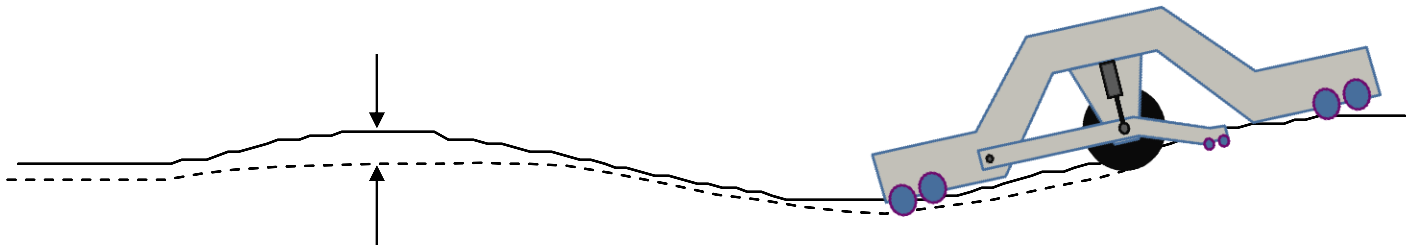


# Basic Components





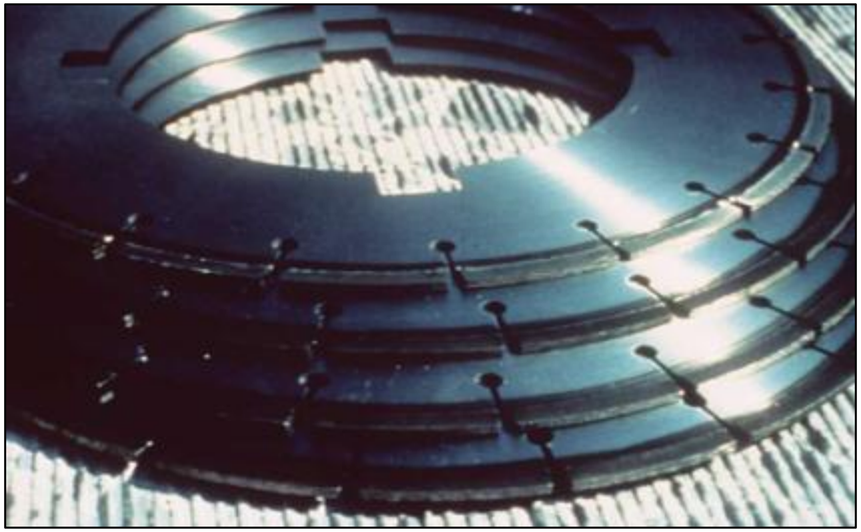
Tracing Profile Only Gives Uniform Depth Cut



Should Remove High Spots

# Selecting Saw Blades

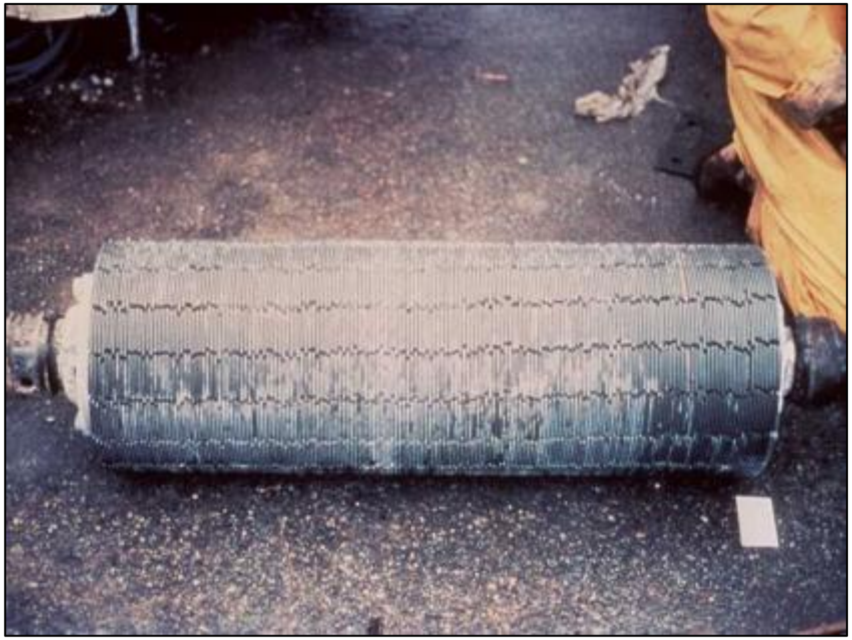
- Choose blades with appropriate:
  - Bond hardness
  - Diamond concentration
- Optimize grinding head cutting life
- Even appearance of final surface

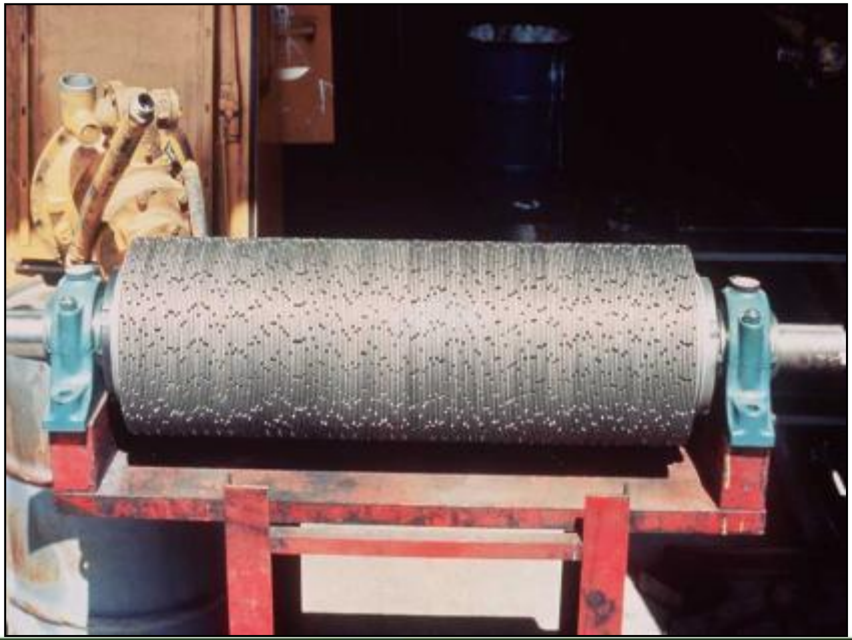


# Blades and Spacers

# Setting up Grinding Head

- Select blade spacing based on aggregate hardness
  - Hard (close spacing)
  - Soft (wide spacing)
- Do not line up blade segments
  - avoids vibration





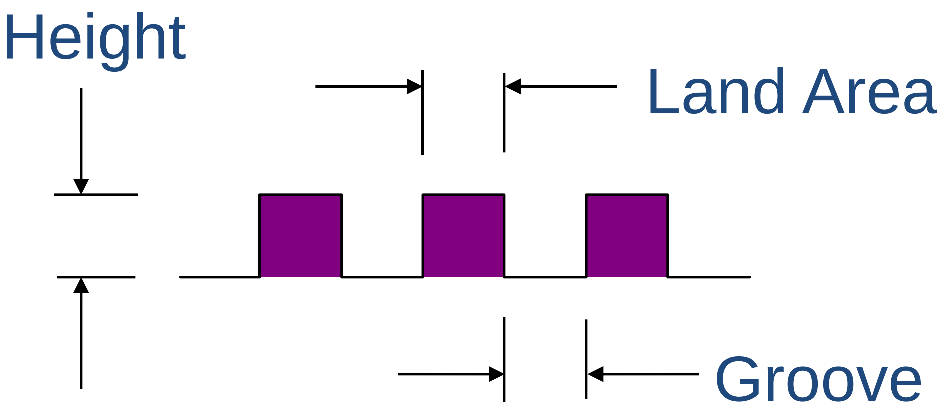
# Operating Grinding Machine

## Important Aspects of Operation:

- Grinding head blade setup
- Grinding head power
- Machine speed
- Steering

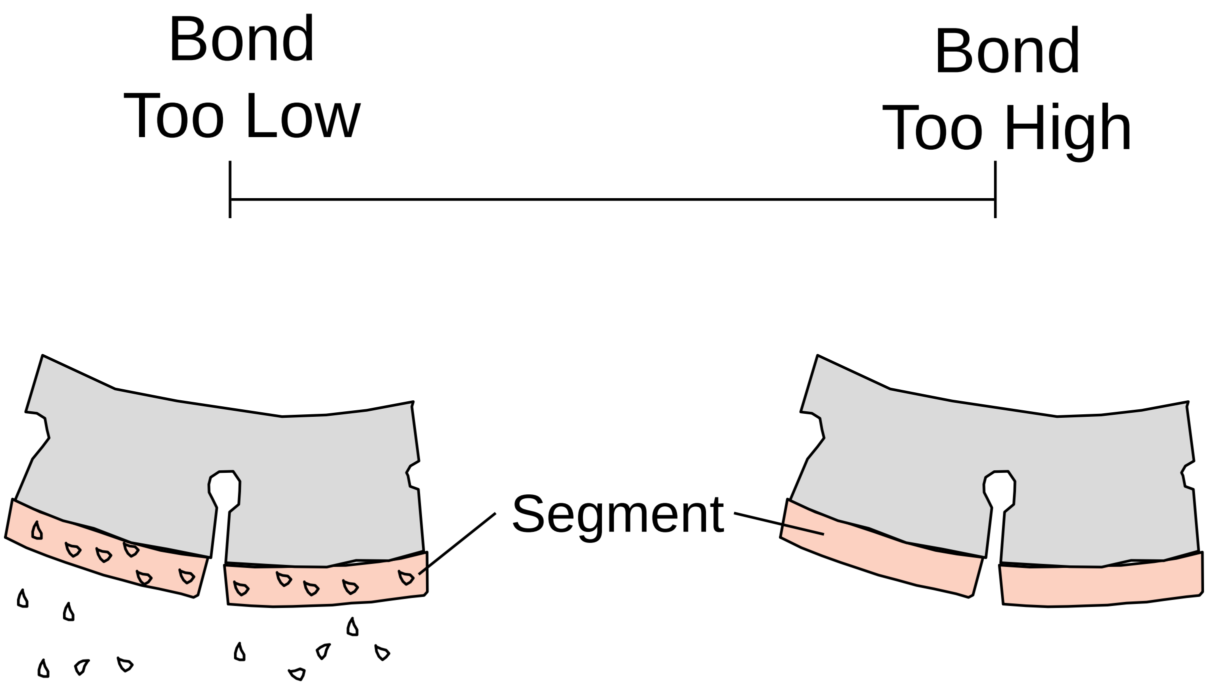
# Aggregate Hardness

| SOFT | MEDIUM | HARD |
|---|---|---|
| Limestone | River Gravel | Granite |
| Dolomite | Trap Rock | Flint |
| Coral | Granite | Chert |
| River Gravel | | Quartz |
| | | River Gravel |




| | Range | Hard Aggregate | Soft Aggregate |
|---|---|---|---|
| Grooves | 0.1”-0.15” | 0.1”-0.15” | 0.1”-0.15” |
| Land Area | 0.06”-0.13” | 0.08” | 0.1” |
| Height | 0.06” | 0.06” | 0.06” |
| Grooves/ft | 50-60 | 53-60 | 50-54 |

# Bond Hardness




Diamonds Break Free

Diamonds Polish Before Metal Segments

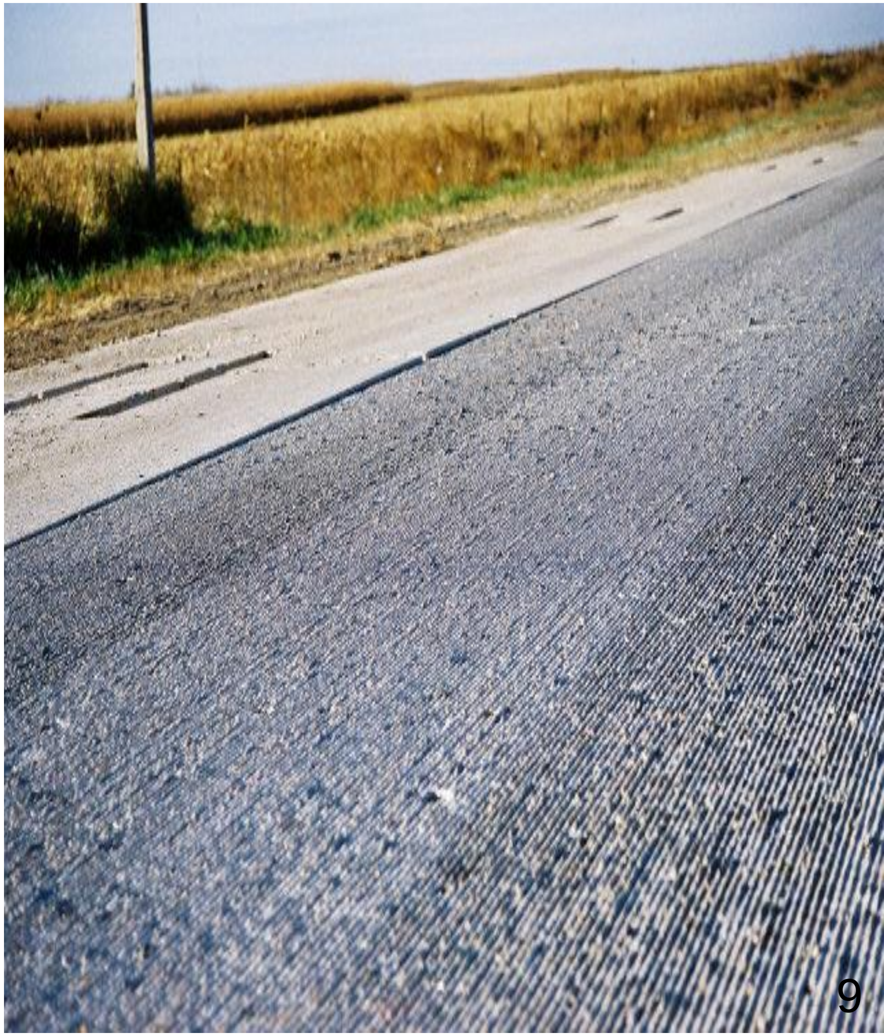
# Holidays

- Result from unground areas
- Lower grinding head to avoid
- Specifications allow up to about 5% of area
- Do not adjust head for holidays less than 2.5 $ft^2$

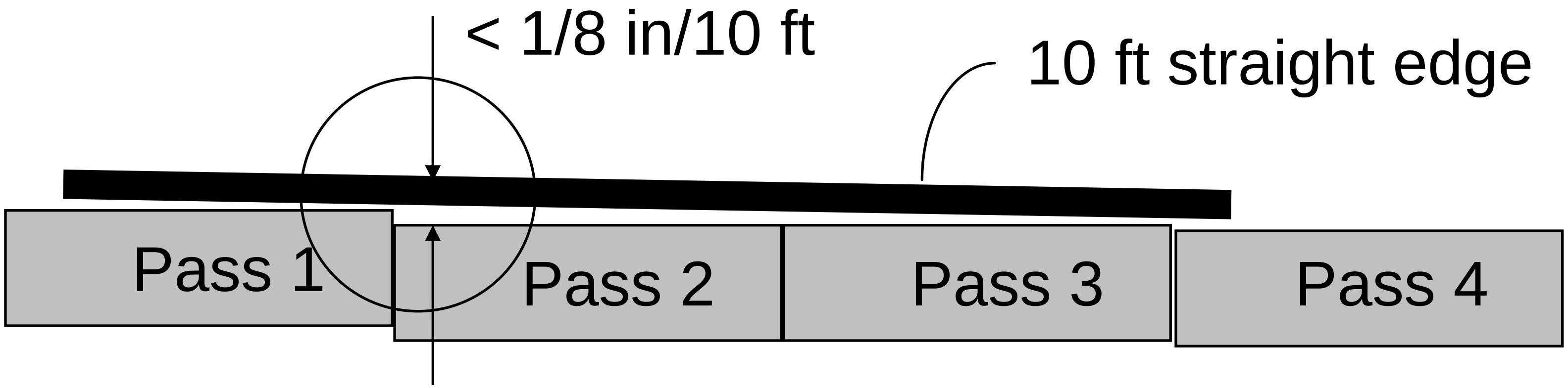
# Cutting Through Bumps

- Machine weight is ballast
- To cut bumps must control:
  - Forward speed
  - Grinding head depth
  - Down pressure
- To verify check for:
  - Variation in cut depth along longitudinal cut line
  - Vertical cut depth match from pass to pass

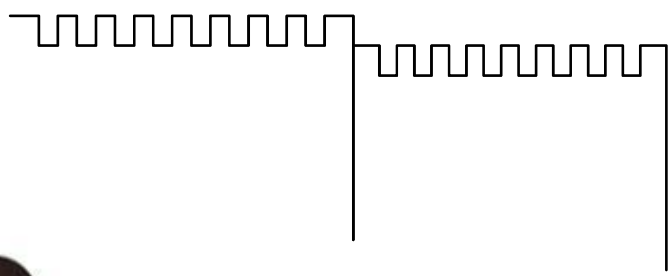
# Diamond Grinding Removes Significant Curling and Warping



# Checking Vertical Match of Passes



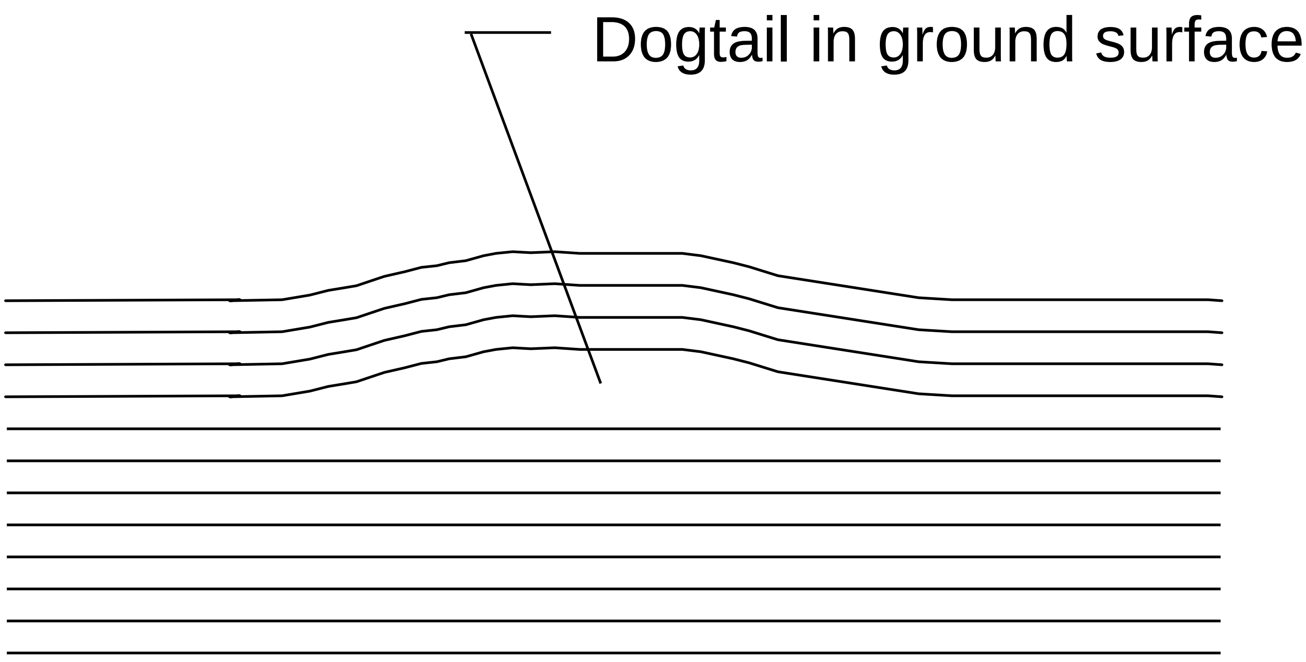

Poor Match Between Passes



# Dogtails

- Result from no horizontal overlap
- Requires steady steering of grinder
- Attempt to maintain 1-2 in (25-50 mm) horizontal overlap

# Poor Overlap Between Passes

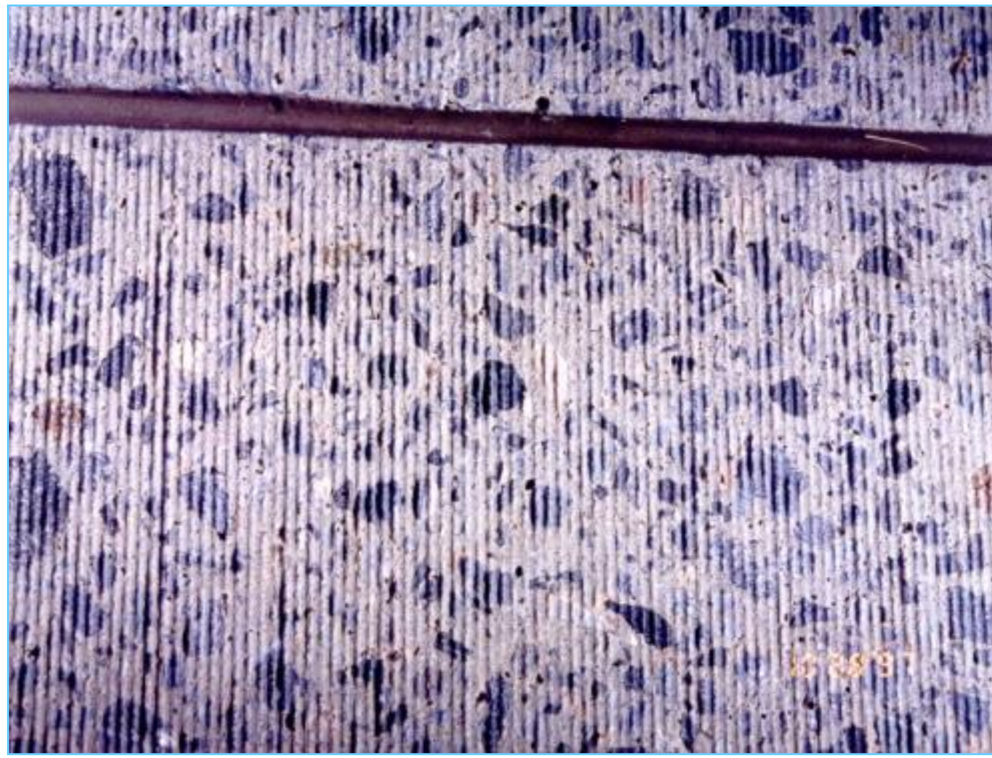


# Improper Blade Spacing

# 60 Blades vs 52 Blades per Foot

# Result of Grinding

Longitudinal texture with desirable friction characteristics



# Friction

# Key Elements for Success

- Understand the pavement conditions
- Set up the grinding head properly
- Operate the grinding machine properly
- Monitor the operation

# Evaluate Ride Quality

- California Profilograph (or similar)
- Take traces before and after grinding
- Should be able to provide 65% improvement over pre-grind profile
- Verify profile index against specification requirement

# Slurry Removal

- Inert material
- Vacuum systems remove most slurry
- Deposit along shoulder (rural)
- Deposit into trucks for disposal (urban)

# Slurry Removal

- Slurry is a by product of diamond grinding
- Slurry can be recycled in a very simple process
- By separating the solids from the water we create two products

  Fine Inert dirt. This can be used for many different things. Fill, re-used in new concrete products or other applications.

  The water is re-used during the diamond grinding process, thus eliminating the need for large quantities of water

- And can be treated to meet environmental requirements for discharge upon completion of the work.

# Diamond Grinder Collecting Slurry

# Small Projects Collecting Slurry

# Dewatering Pond

# Brandt System

- This process is very cost effective and can be performed very simply by using a shaker, a centrifuge and a vertical clarifier.
- This system has been used by all the diamond grinding contractors for the last 8 years.

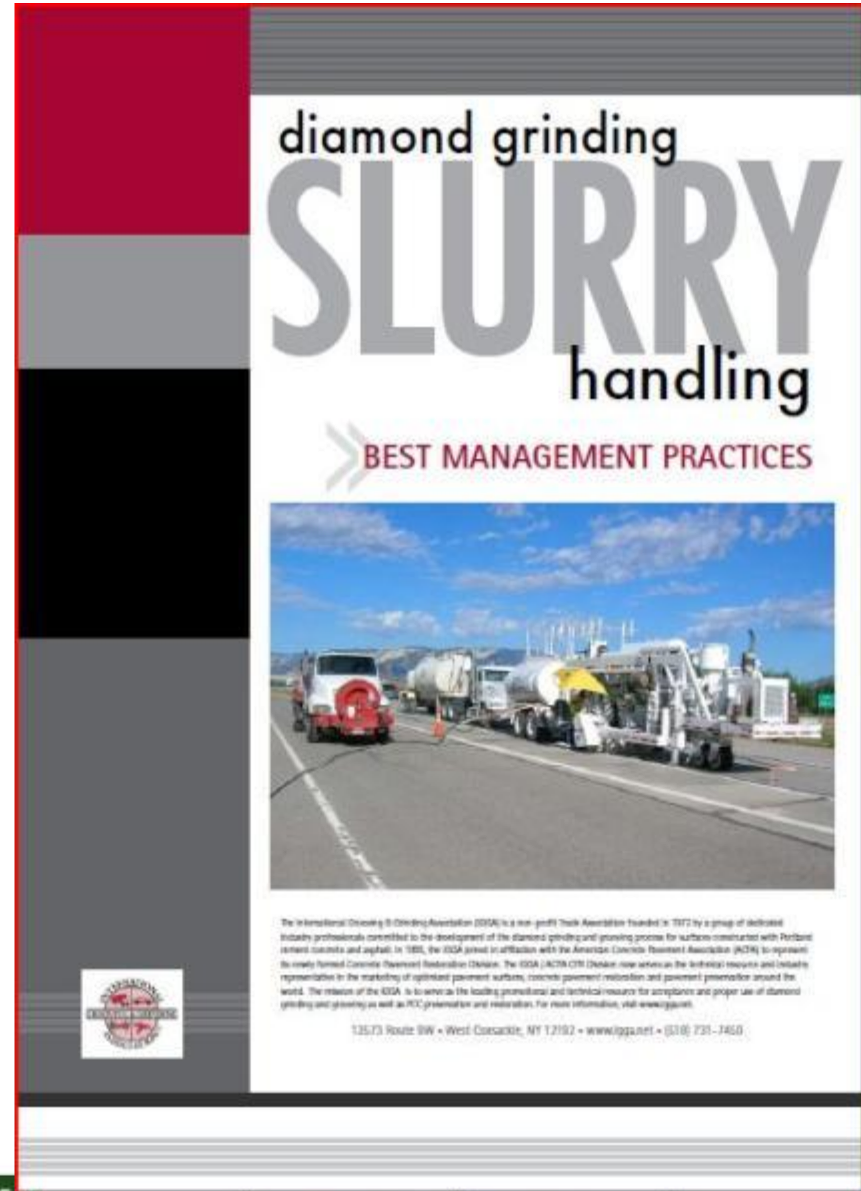
**Mechanical method of separating Solids from Water**

# Mobil Dewatering Plant

# BMP Manual

IGGA
International Grooving & Grinding Association
Your Pavement Preservation Resource since 1972

www.igga.net



# Diamond Grinding Trigger Values



Table 9.1. Trigger values for diamond grinding (Correa and Wong 2001).

| | **JPCP** | | | **JRCP** | | | **CRCP** | | |
|---|---|---|---|---|---|---|---|---|---|
| Traffic Volumes[1] | High | Med | Low | High | Med | Low | High | Med | Low |
| Faulting, mm avg (in avg) | 2.0 (0.08) | 2.0 (0.08) | 2.0 (0.08) | 4.0 (0.16) | 4.0 (0.16) | 4.0 (0.16) | N/A | | |
| Skid Resistance | Minimum Local Acceptable Levels | | | | | | | | |
| PSR[2] | 3.8 | 3.6 | 3.4 | 3.8 | 3.6 | 3.4 | 3.8 | 3.6 | 3.4 |
| IRI, m/km (in/mi ) | 1.0 (63) | 1.2 (76) | 1.4 (90) | 1.0 (63) | 1.2 (76) | 1.4 (90) | 1.0 (63) | 1.2 (76) | 1.4 (90) |

Notes:

1. Volumes: High ADT>10,000; Med 3,000<ADT<10,000; Low ADT<3,000.
2. PSR = Present serviceability rating.

# Proposed Trigger Values and Expected Life - MTAG

| Treatment | Trigger (National) | Climate Region[1] | | | | Traffic ADT | | | Life of Treatment (Year) | Estimated Cost ($)[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Desert | Valley | Coastal | Mountain | <5000 | >5000;<30000 | >30000 | | |
| Crack Resealing | >1/4 inch | >1/4 | >1/4 | >1/4 | >1/4 | >1/4 | >1/4 | >1/4 | 4 - 7 | $27.7k - 42.4 k/ln mi |
| Diamond Grinding | Faulting > 1/4 inch; Ride 95 in/mile | >1/4 >190 | >1/4 >95 | >1/4 >95 | >1/4 >190 | >1/4 >190 | >1/4 >125 | >1/4 >95 | 10 - 18 | $30.0k - 80.1k/ln mi |
| Partial Slab Repair | Surface distress - Patches <1.2 yd$^2$ | <1.2 | <1.2 | <1.2 | <2.4 | <2.4 | <1.2 | <1.2 | 8 - 12 | $135 - 270/yd$^3$ |
| Isolated Slab Replacement | 3rd stage cracking or unstable slabs | Same Trigger Value. For desert, mountain, or ADT<5000, District makes decision to repair. | | | | | | | 8 - 12 | $4000 - $8000/slab |
| Dowel Bar Retrofit | LTE <60%, Faulting>1/4 inch, Max 10% Cracking | <40 >1/4 20 | <70 >1/4 10 | <70 >1/4 10 | <50 >1/4 20 | <50 >1/4 20 | <70 >1/4 10 | <70 >1/4 10 | 8 - 17 | $141k - 177k/ln mi |

# MoDOT Ride Spec

| Table 1 | |
|---|---|
| **International Roughness Index Inches Per Mile** | **Percent of Contract Price** |
| 40 or less | 105 |
| 40.1 - 54 | 103 |
| 54.1 – 80 | 100 |
| 80.1 or greater | 100[a] |

| Table 2 | |
|---|---|
| **International Roughness Index Inches Per Mile** | **Percent of Contract Price** |
| 67 or less | 103 |
| 67.1 – 134 | 100 |
| 134.1 or greater | 100[b] |

[a]After correction to 80 inches per mile or less
[b]After correction to 134 inches per mile or less

# Profile Testing Equipment


# NGCS

Development of the Next Generation Low Maintenance Concrete Surface

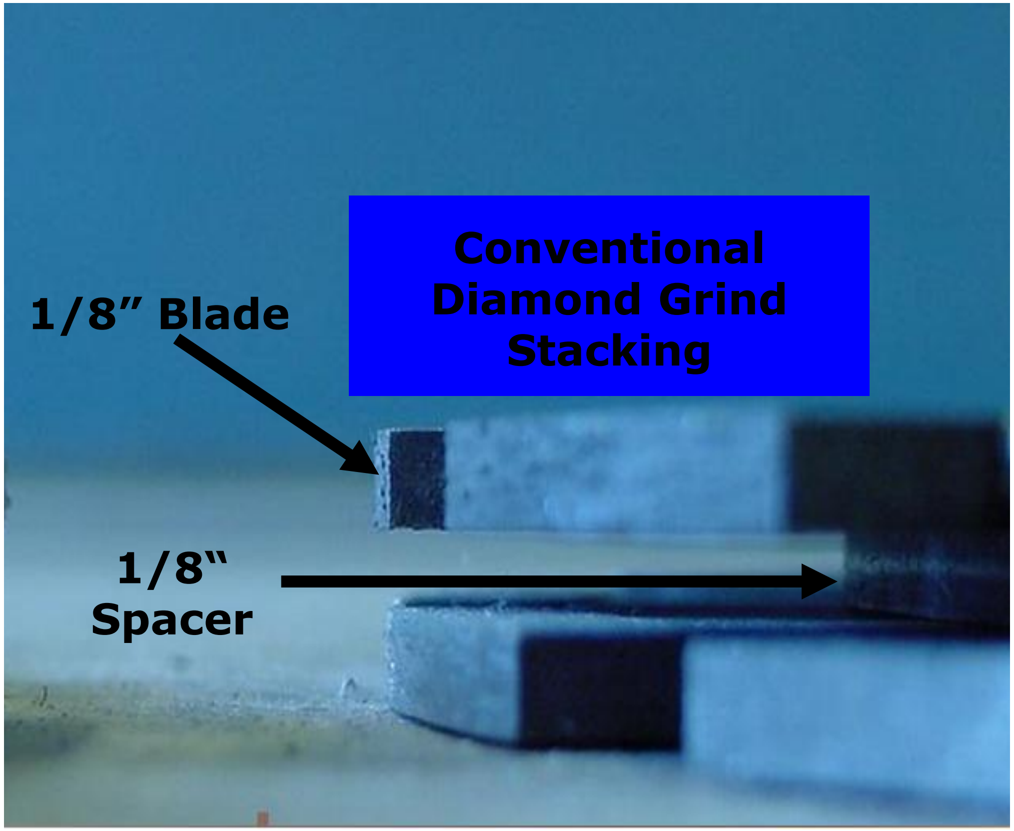
# The Process

- Development Work-TPTA
- Proof of Concept- MnROADs Low Volume Roads Test Sections

- Full Scale Test Section with Production Grinders

# NGCS Compared to CDG


# What's Different about NGCS



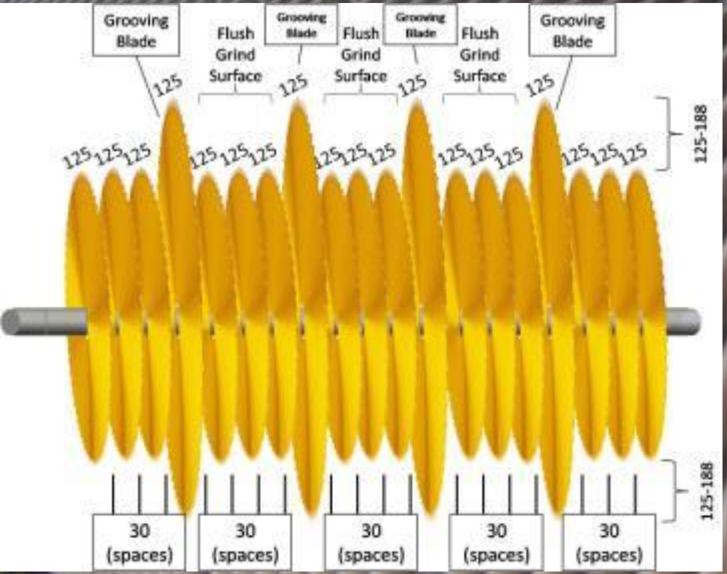

Space Provides Cooling and Debris Removal

# Equipment Head Differences

**NGCS Head**

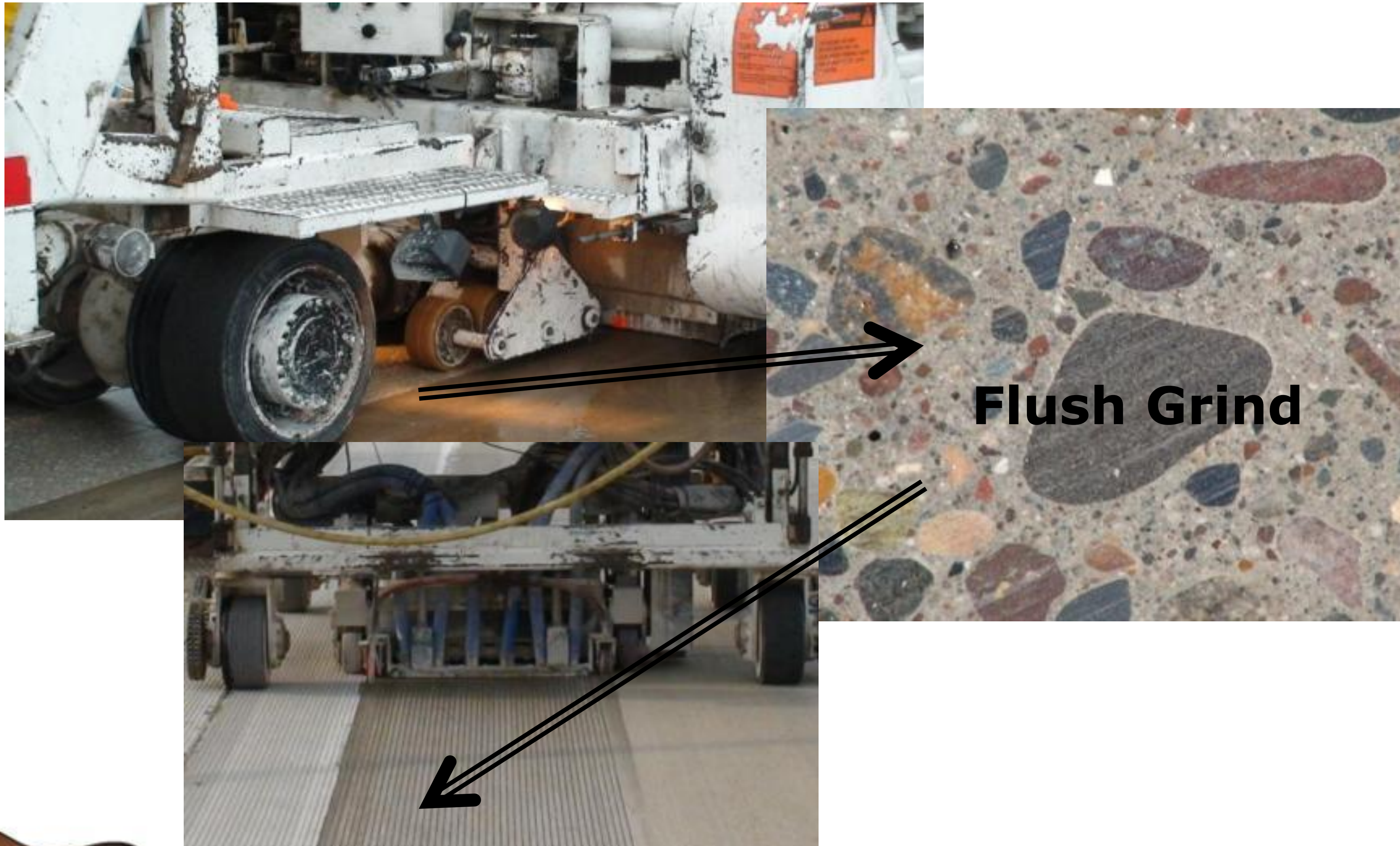
**Conventional Diamond Grinding Head**

# NGCS Head



Grooving Blade
Flush Grind Surface
Grooving Blade
Flush Grind Surface
Grooving Blade
Flush Grind Surface
Grooving Blade
125
125 125 125
125 125 125
125 125 125
125 125 125
125 125 125
125-188
125-188
30 (spaces)
30 (spaces)
30 (spaces)
30 (spaces)
30 (spaces)

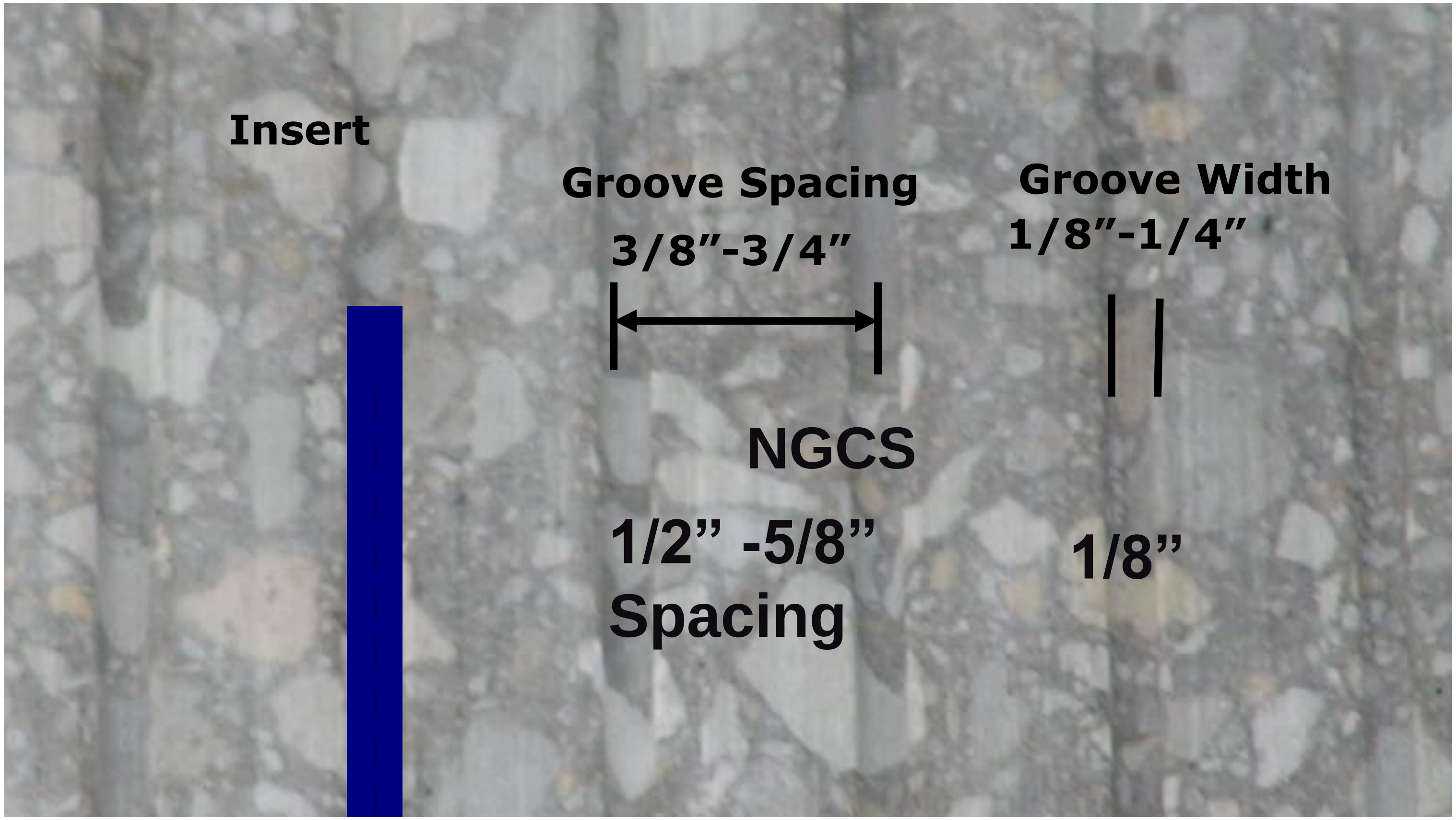
# Single or Two Pass Construction




**Grooved**

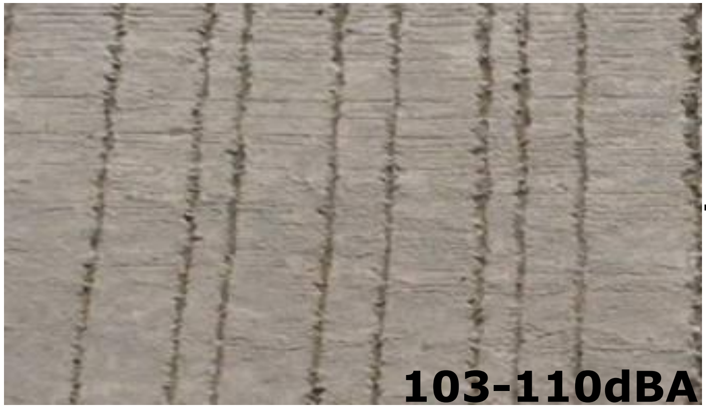
# TPTA NGCS Research

- Effect of Groove Spacing, Width, Depth, Insert



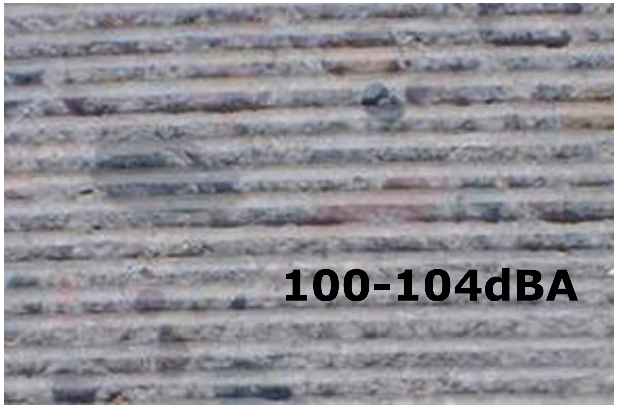
# Concrete Texture Types

**Transverse Tine**

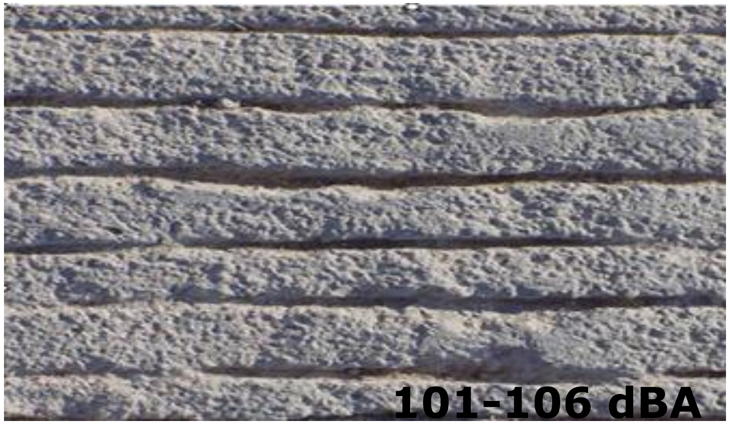



**Twice as Loud**

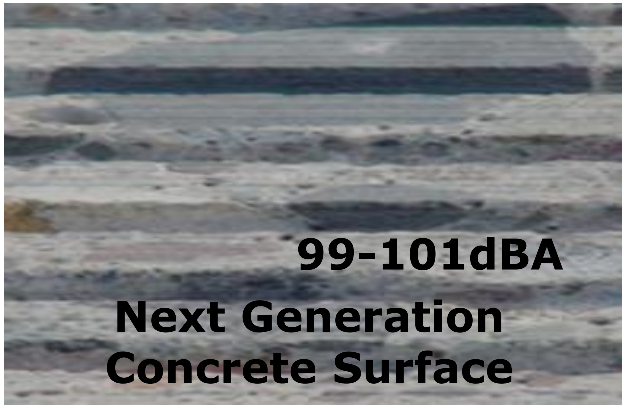
**Conventional Diamond Grinding**




Traffic




**Longitudinal Tine**




**Next Generation Concrete Surface**

# Conventional Diamond Grind
# vs Next Generation Concrete Surface

# QUESTIONS OR COMMENTS

**International Grooving and Grinding Association**
[IGGA.net](IGGA.net)

**American Concrete Pavement Association** [ACPA.org](ACPA.org)

**Matt Ross P.E.**
**Penhall Company**
**9407 W 146th Place**
**Overland Park, Ks 66221**
**(816) 803-9331**
**Mross@Penhall.com**