

# Concrete Pavement Preservation: The Key to Long-Life Pavements



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# Topics of Discussion

- Desirable surface properties
- Machined surface textures
- Refinished surface textures and achieving desired properties
- Pavement Preservation Tool kit

# Texture Goals

- Safe
  - Friction and hydro-planing
- Comfortable for users
- Quiet
- Durable

## Practical testing processes



Inertial Profiler



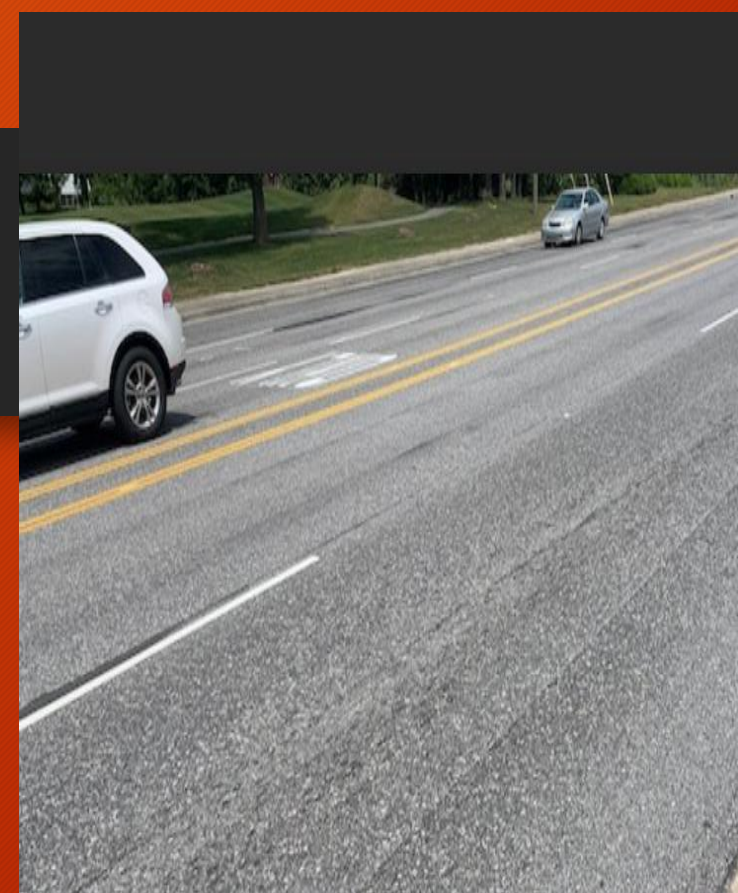
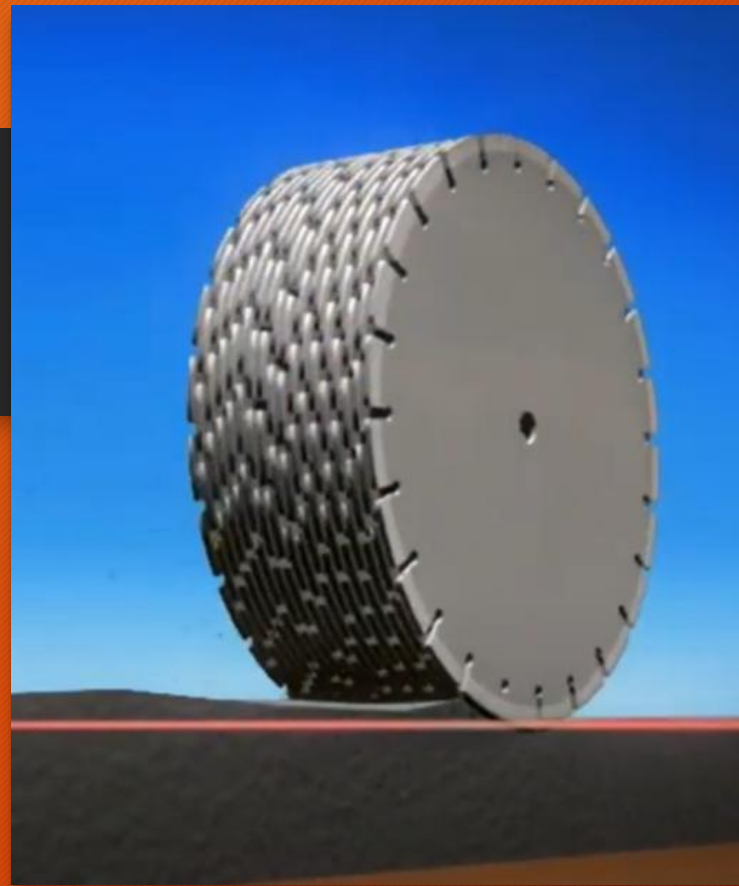
Friction testing

Greater than 35 SN or  
remediation required



Sand patch

Mean Texture depth requires  
remediation if it is below 0.8mm



Diamond grinding- What is it?

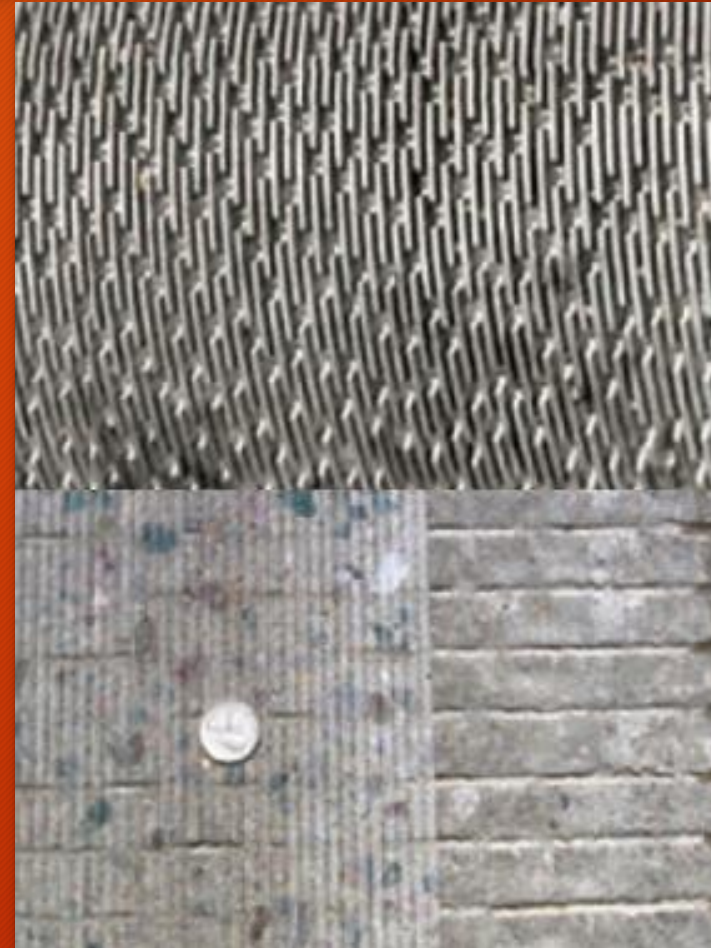
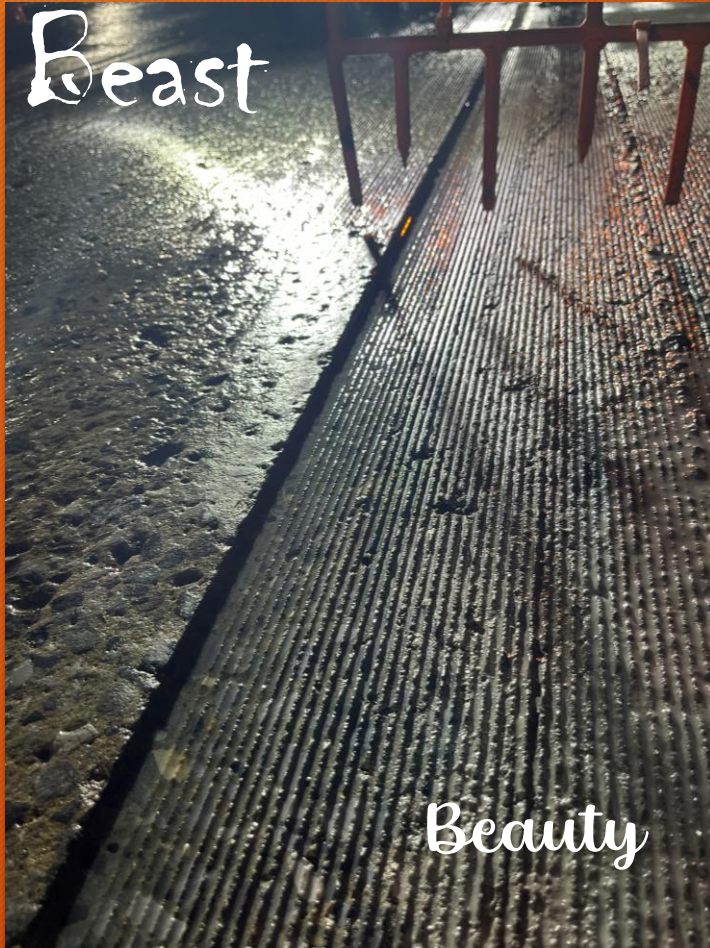
# Diamond Grinding

- Relatively inexpensive to install
  - \$3-5 per square yard
  - About \$30k per lane mile (medium aggregate hardness, about 15 lane miles in size)
- Optimal ride-quality
- Excellent macro-texture
- Desirable noise attributes

Looks like  
*corduroy*, rides  
like **SILK**



# Refinishing pavement texture- Why do it?



# Rough pavement



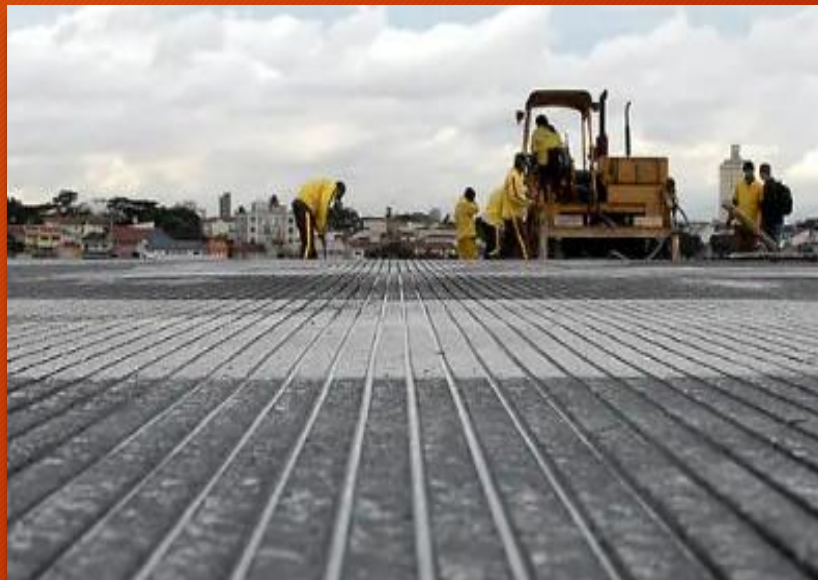
# Repaired pavement



# Safety Grooving

## Transverse

- Good Macro-texture
- Great for stopping
- Not optimal for ride-quality
- Loud
- Very popular in commercial airports world wide
- Reduces hydroplaning

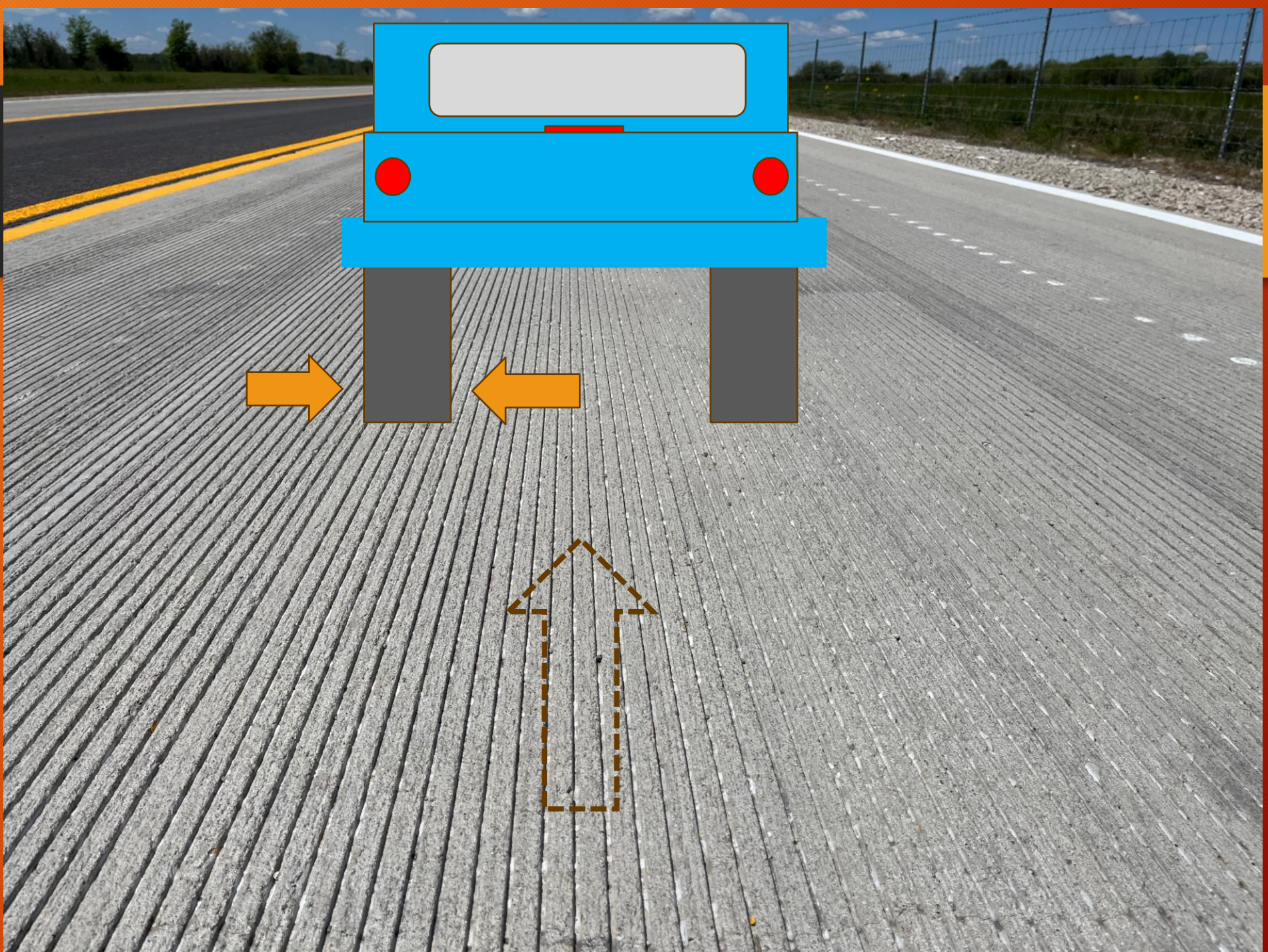


## Longitudinal

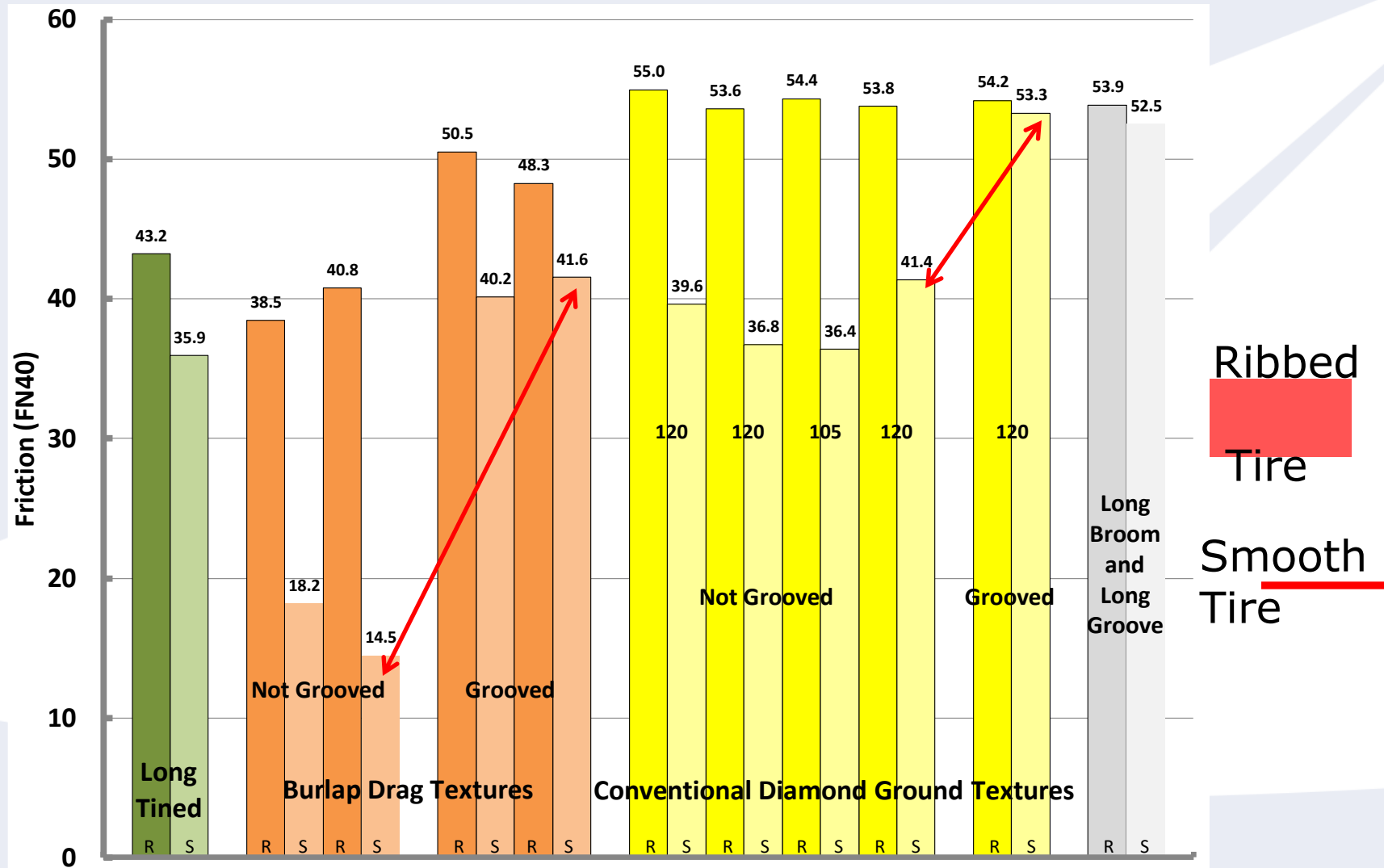
- Good Macro-texture
- Optimal for ride-quality
  - Grooving alone does not improve ride quality of existing pavements
- Quiet
- Reduces hydroplaning and tire spray

# Grooving Promotes directional stability





# California SR 58 QP Test Sections



## Caltrans Research

- Significant reduction in accidents
- FHWA has a goal of zero highway deaths
  - While this is likely impossible to achieve, small changes can save lives

### 16. ABSTRACT

Grooving has proved to be one of the most cost-effective safety programs of the Department of Public Works. Grooving has contributed greatly to savings in lives, injuries and dollars for the travelling public. Rainfall is comparatively moderate in California but the accident rate is four times greater on wet pavement than on dry pavement. This is one of the problem areas for which a positive solution has been found.

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 fatal accidents
- 3) 70 percent reduction in wet pavement accidents

Motorcycle accident reports were reviewed from both grooved and ungrooved sections. Abstracts of these reports are given in the following pages. They show little evidence that grooves constitute a hazard to the cyclist.

# PennDOT data

Skid Test Results Summary

Segment	Test Date	Direction	Lane	Tire Type	Average SN	High SN	Low SN	Number Of Skids
10	10/25/2023	East	Travel	SMOOTH	19	27	16	7
20	10/25/2023	East	Travel	SMOOTH	19	21	18	7
30	10/25/2023	East	Travel	SMOOTH	17	24	14	5
40	10/25/2023	East	Travel	SMOOTH	38	40	35	5
50	10/25/2023	East	Travel	SMOOTH	32	35	30	5
60	10/25/2023	East	Travel	SMOOTH	34	37	25	9
10	10/25/2023	East	Pass 1	SMOOTH	20	22	18	6
20	10/25/2023	East	Pass 1	SMOOTH	22	28	19	7
30	10/25/2023	East	Pass 1	SMOOTH	25	29	23	5
40	10/25/2023	East	Pass 1	SMOOTH	40	42	40	5
50	10/25/2023	East	Pass 1	SMOOTH	35	38	31	5
60	10/25/2023	East	Pass 1	SMOOTH	42	48	29	9
61	10/25/2023	West	Travel	SMOOTH	33	36	24	8
51	10/25/2023	West	Travel	SMOOTH	25	26	25	5
41	10/25/2023	West	Travel	SMOOTH	30	34	28	5
31	10/25/2023	West	Travel	SMOOTH	15	16	14	5
21	10/25/2023	West	Travel	SMOOTH	17	19	15	7
11	10/25/2023	West	Travel	SMOOTH	18	19	16	6
61	10/25/2023	West	Pass 1	SMOOTH	42	48	34	8
51	10/25/2023	West	Pass 1	SMOOTH	35	39	29	5
41	10/25/2023	West	Pass 1	SMOOTH	44	46	43	5
31	10/25/2023	West	Pass 1	SMOOTH	23	25	21	5
21	10/25/2023	West	Pass 1	SMOOTH	26	30	23	7
11	10/25/2023	West	Pass 1	SMOOTH	25	29	22	6

Yellow boxes represent 5 year old diamond grinding on polish prone aggregates

Teal boxes represent those same highway sections (same age and aggregate) with safety grooving applied to the diamond grinding texture

## Next Generation Concrete Surface (NGCS)

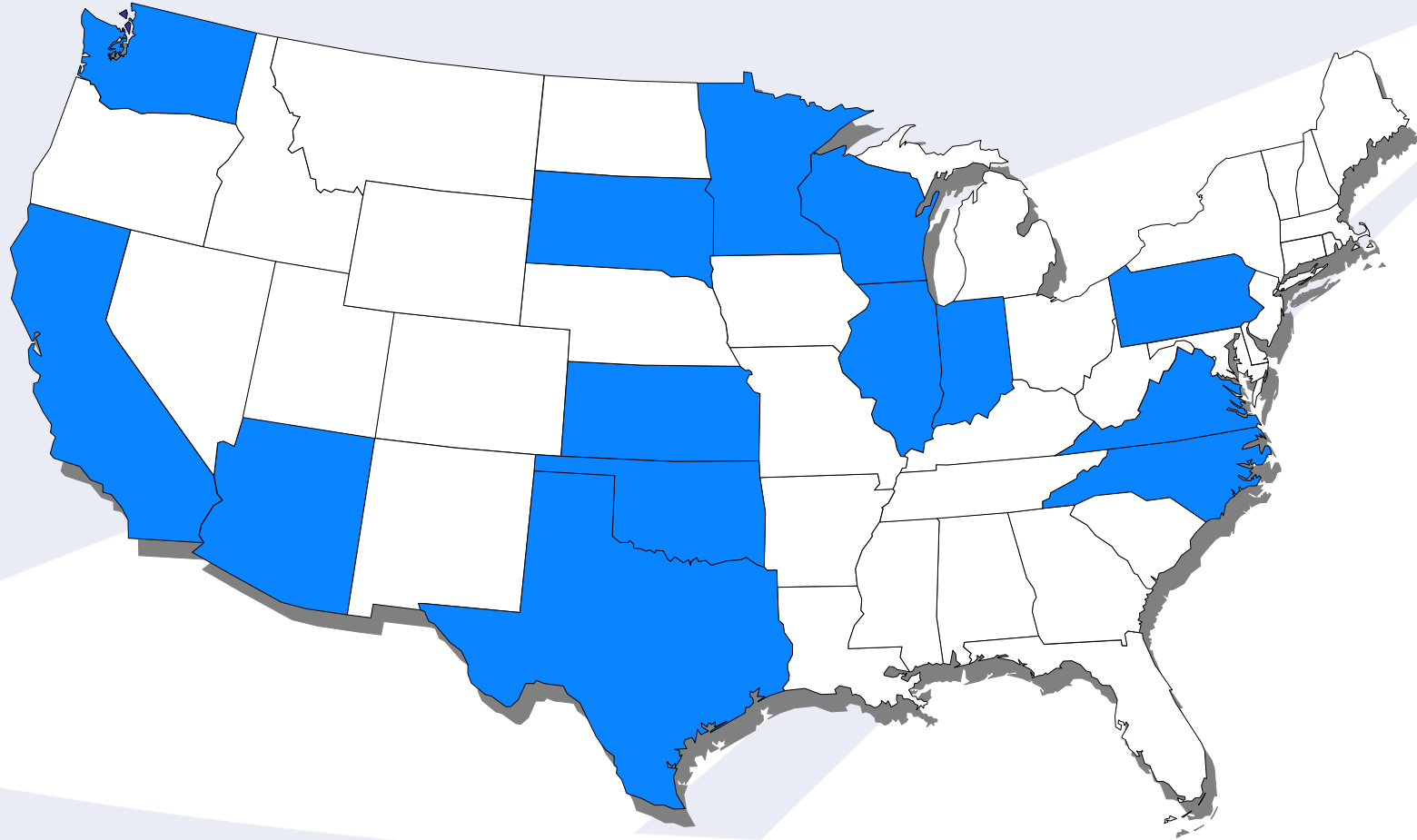
- Optimal ride-quality
- Optimal friction
- Optimal noise
- Optimal Fuel economy

### Three step process

1. Achieve approximately 70 in/mi through good building or conventional diamond grind
2. Production grind using and NGCS head
3. Safety groove for surface drainage



# States with NGCS Construction



# How to mitigate highway noise?

Block the noise with noise barrier



Prevent noise with Noise Generating



(per lane mile)

5 to 10 dB

10-51 per square  
3.9 million per

6 dB

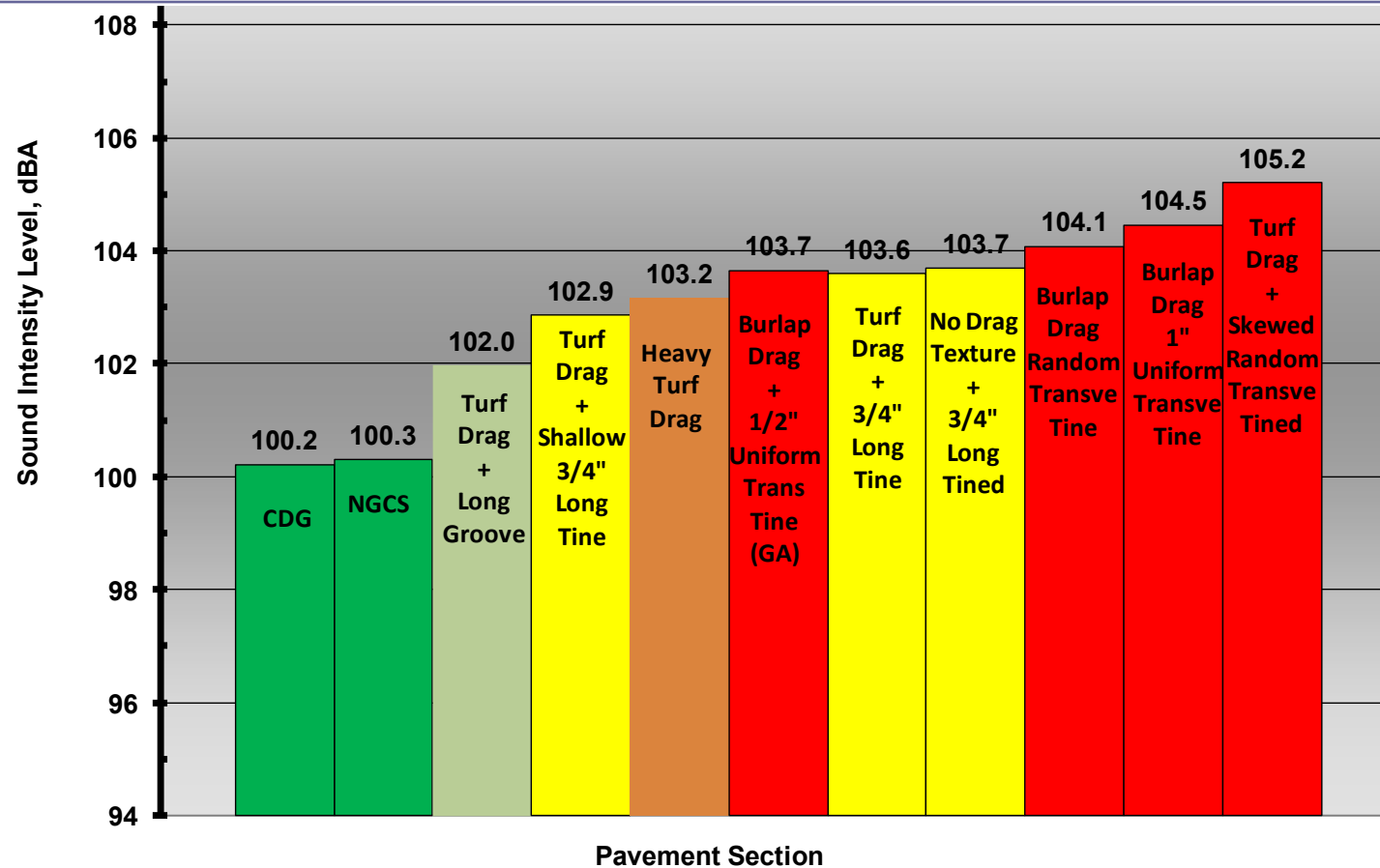
10 per square  
t (<\$100,000

Decibels in an exponential measurement

105 decibels is 2.33 times louder than 100 decibels

# NCHRP Project 10-67

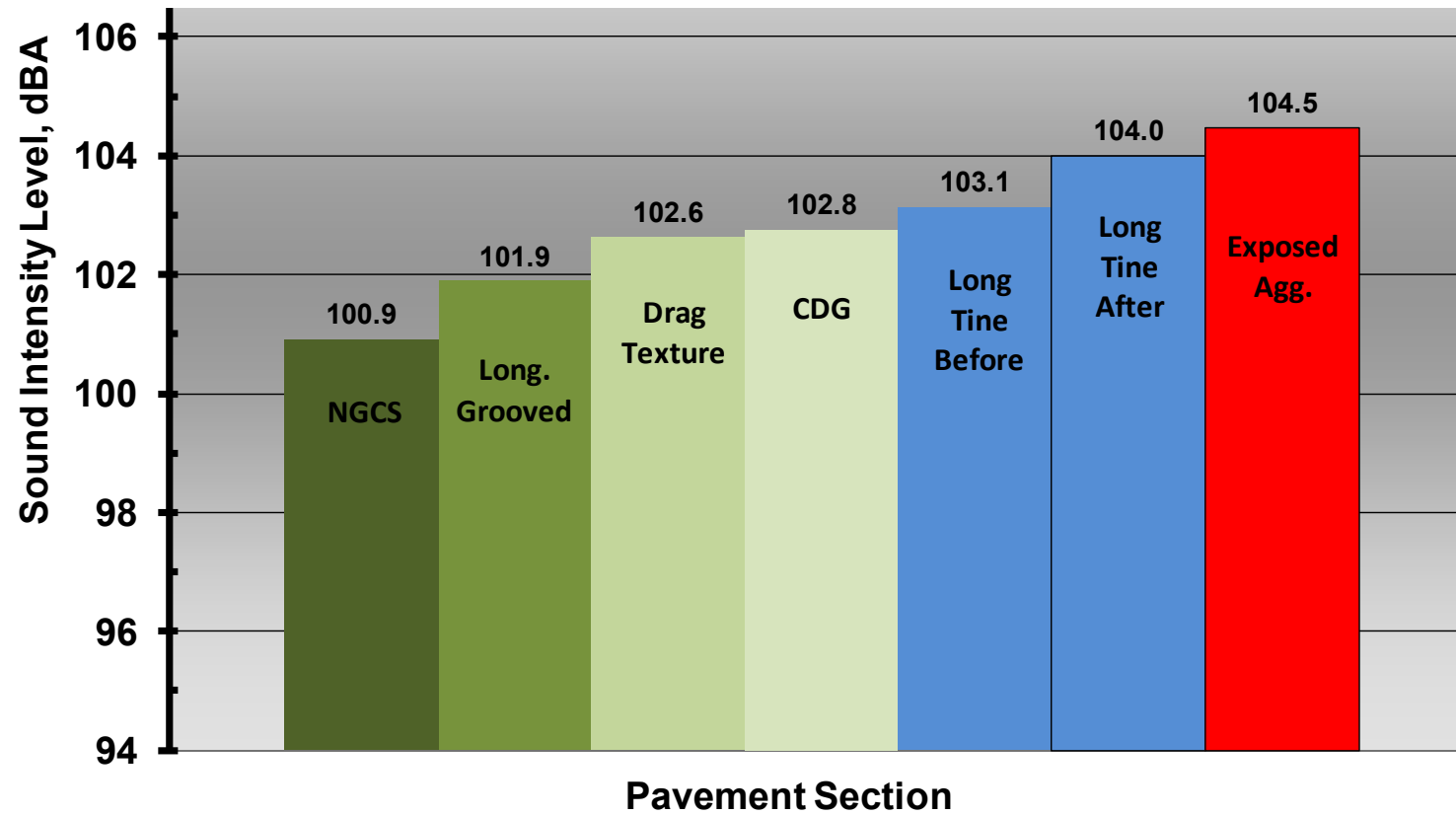
National Center for Highway Research Program



Decibels in an exponential measurement

105 decibels is 2.33 times louder than 100 decibels

# Kansas I-70 Results

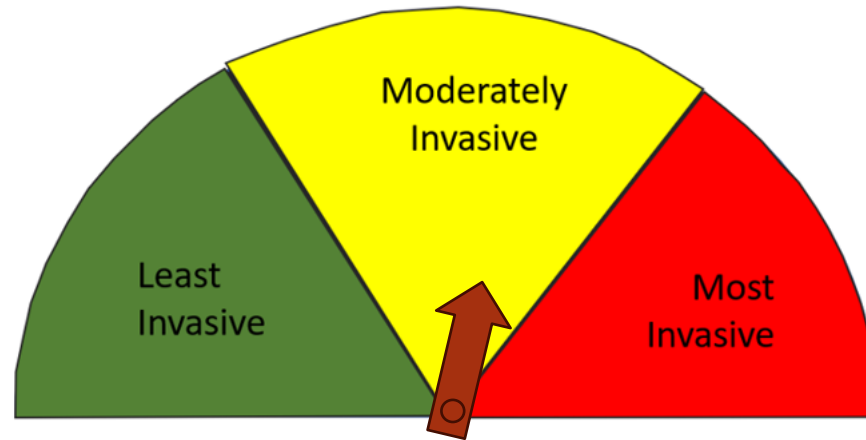


# World Bank's Evaluation

Transport Notes from the World Bank evaluated the relationship between maintenance timing and cost on South African highways.

- It was determined that 3 years of maintenance neglect resulted in 6 times the repair cost.
- 5 years of neglect resulted in up to 18 times the repair cost.

# What is the Cost of Pavement Repairs?



The less invasive a repair procedure is, the more cost effective it is and the less risk it carries.



# Why rehab?-To make pavements smoother

- Reduce dynamic loads and improve life of the pavement
- Reduce maintenance
- Reduce highway
- Improve friction
- Improve ride quality
- Improve fuel economy
- Reduce Use-phase carbon impact???

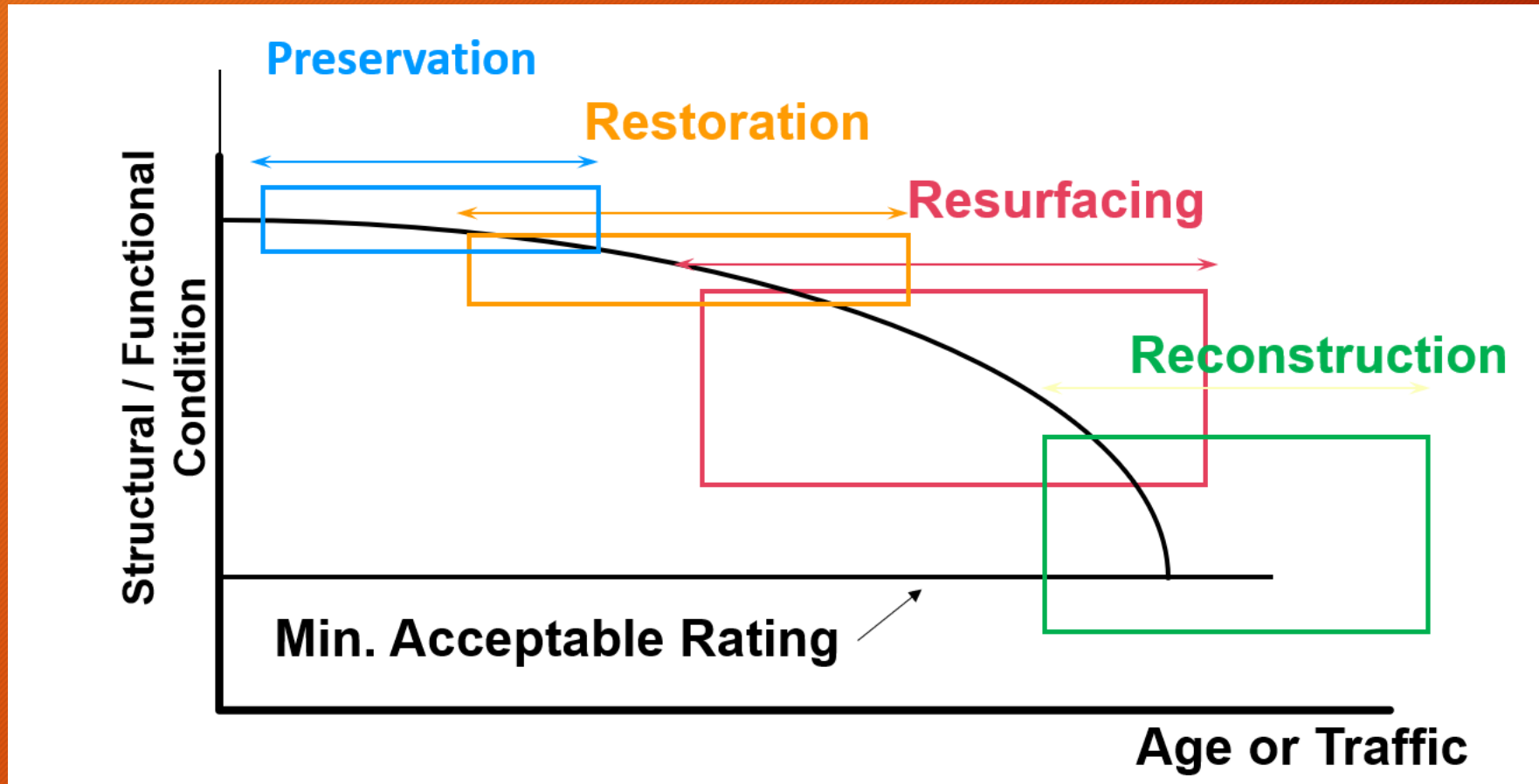


# MIT's Take

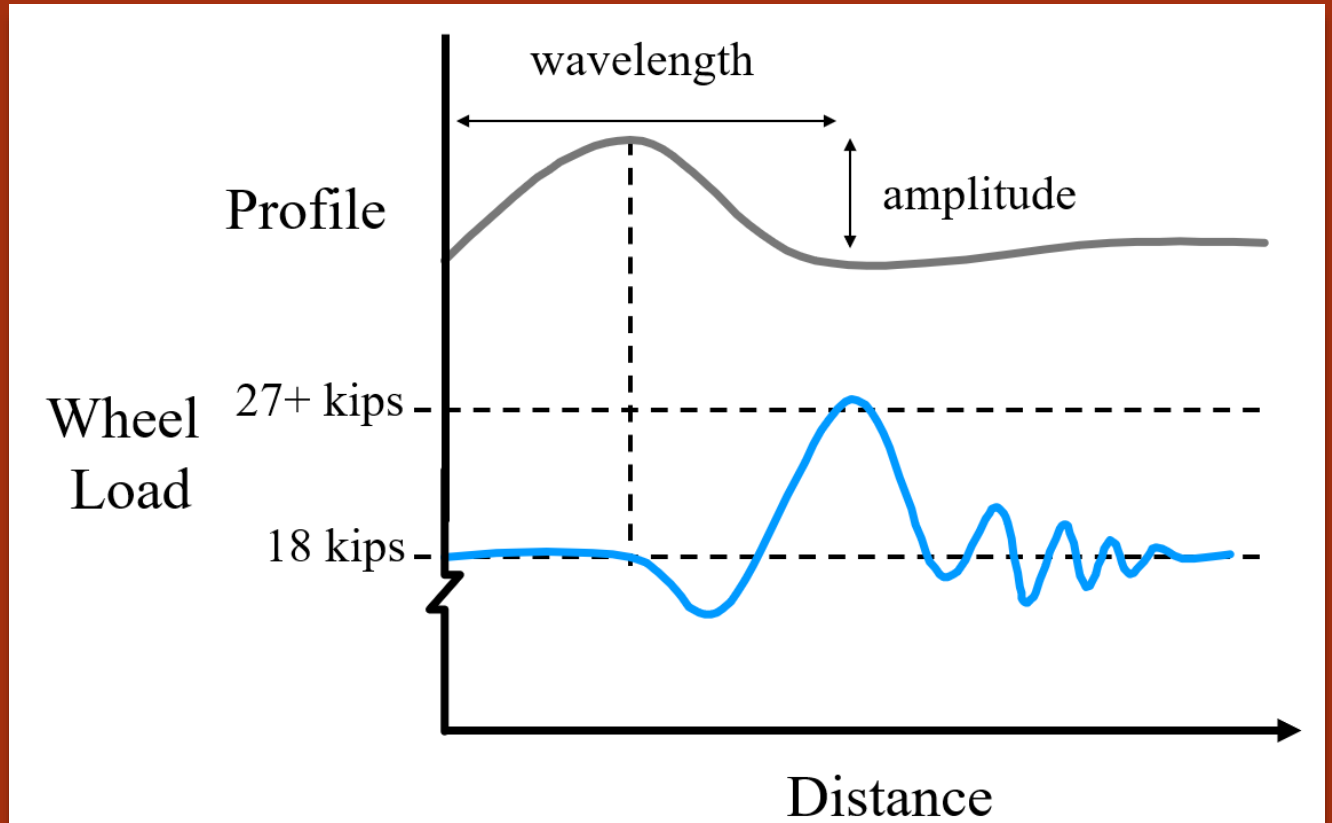
- Researchers at the MIT Concrete Sustainability HUB has suggested that the most carbon conscious approach is to perform CPR and Diamond Grinding every 15 years, as opposed to waiting 20+ years or overlaying with asphalt.



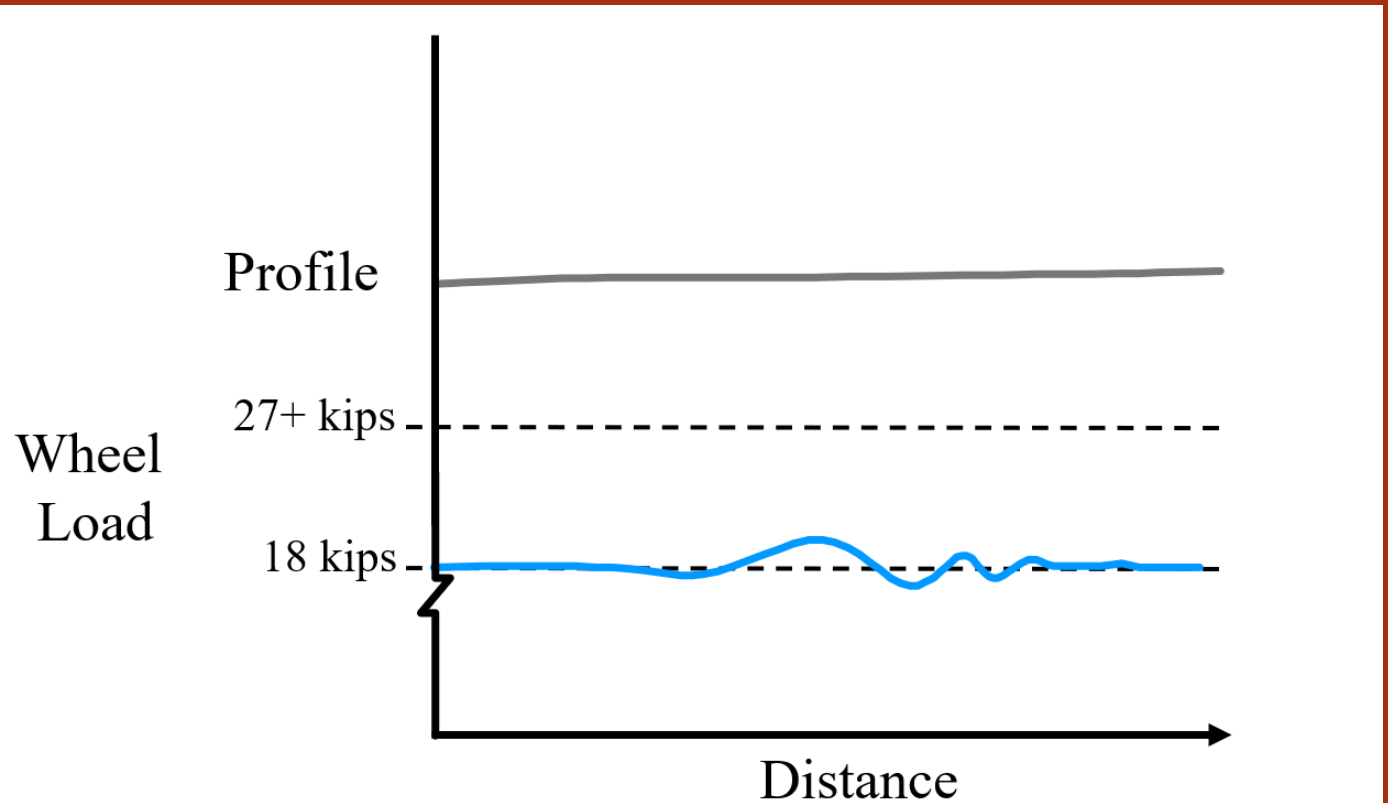
# Rehabilitation Timing



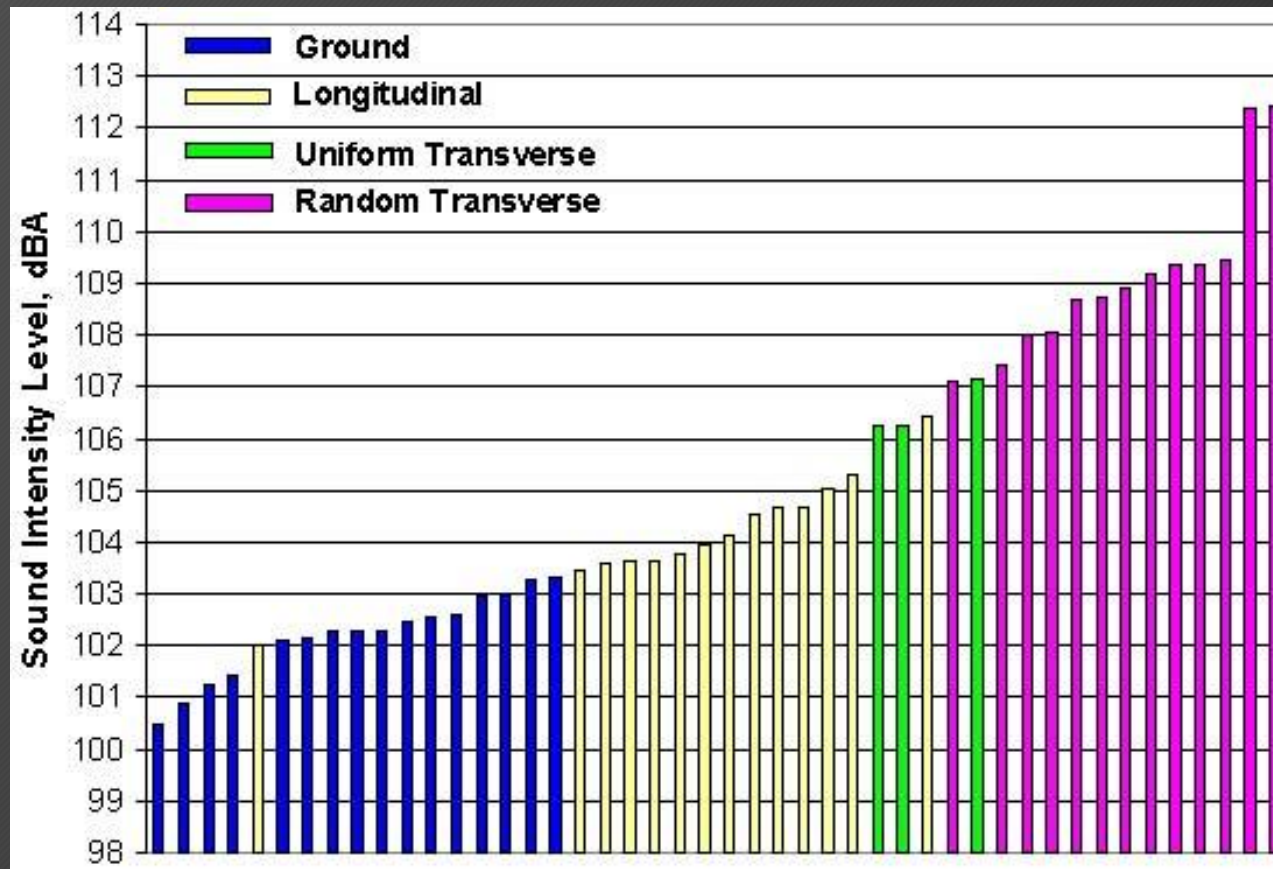
# Rough Pavement



# Smooth Pavement

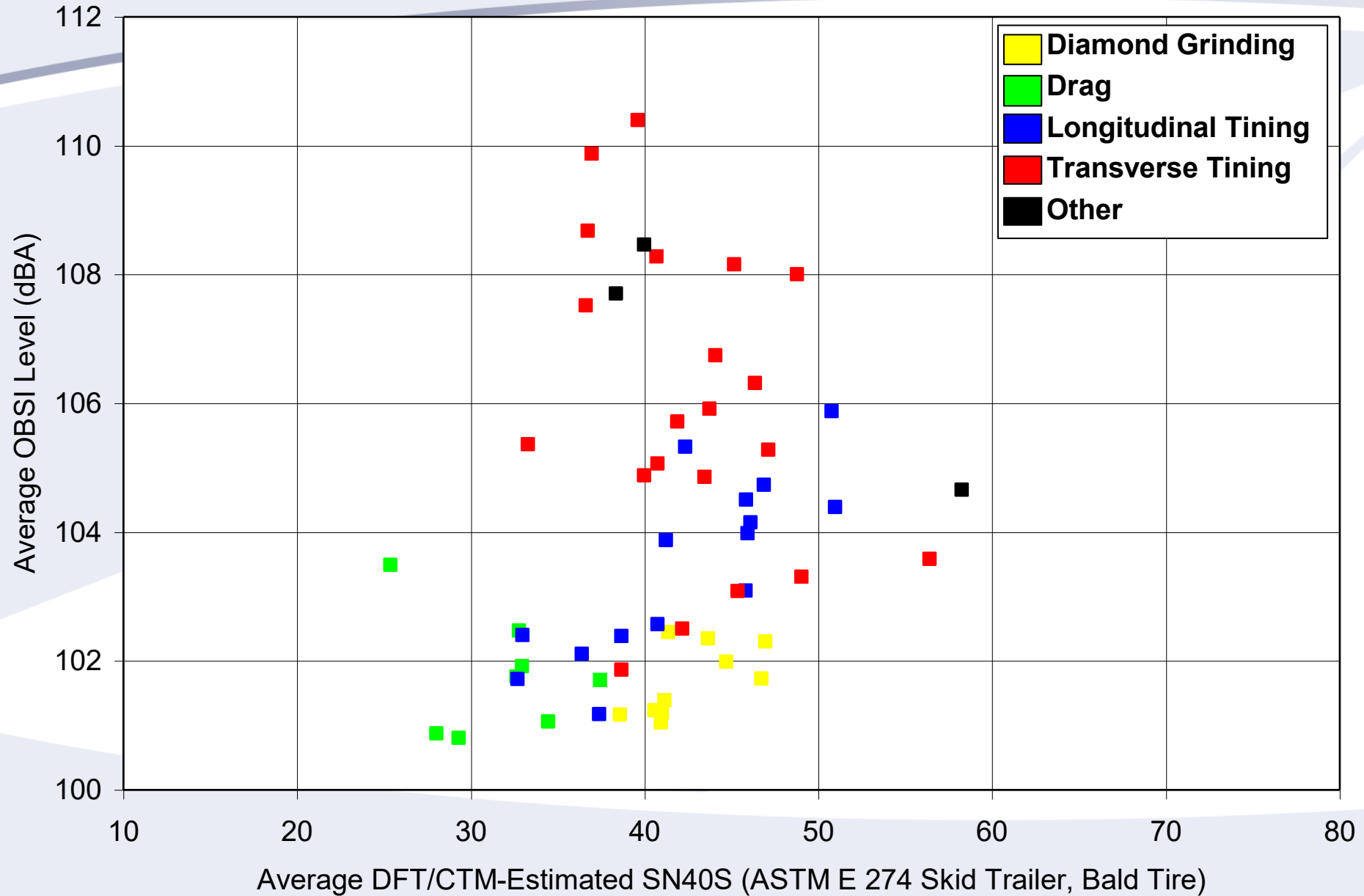


# Sound benefit



# Noise vs. Friction

# Trafficked Pavements



Fun Fact!

## Diamond Grinding- Fun Fact

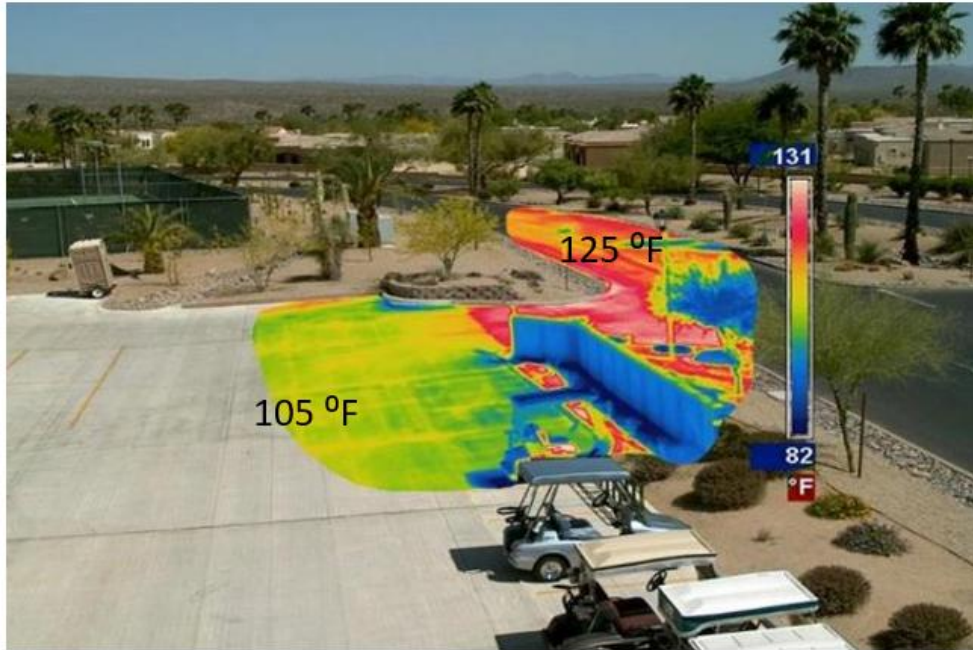
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In Wisconsin, overall accident rates for ground surfaces were 40% less than for un-ground surfaces over a 6-year period, 57% in wet weather conditions

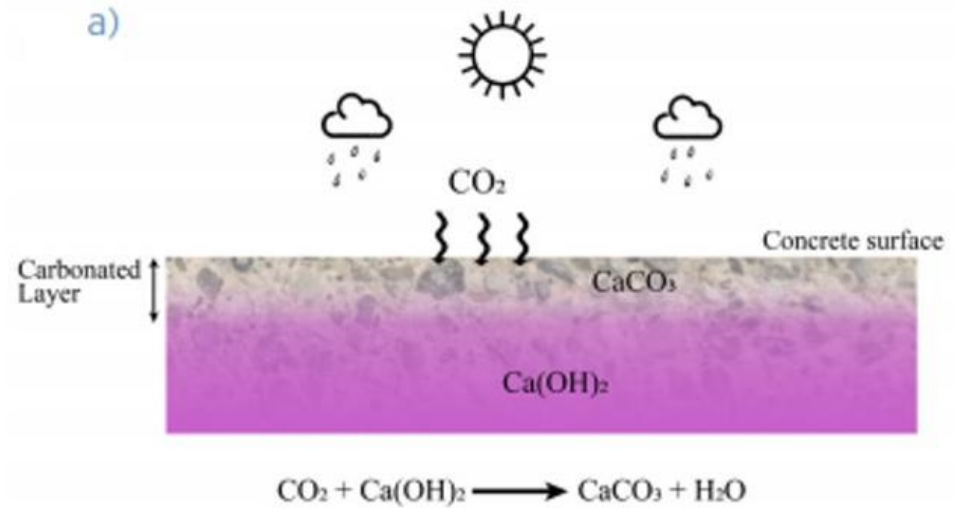


Marquette University Transportation Research Center

# Other benefits of Diamond Grinding



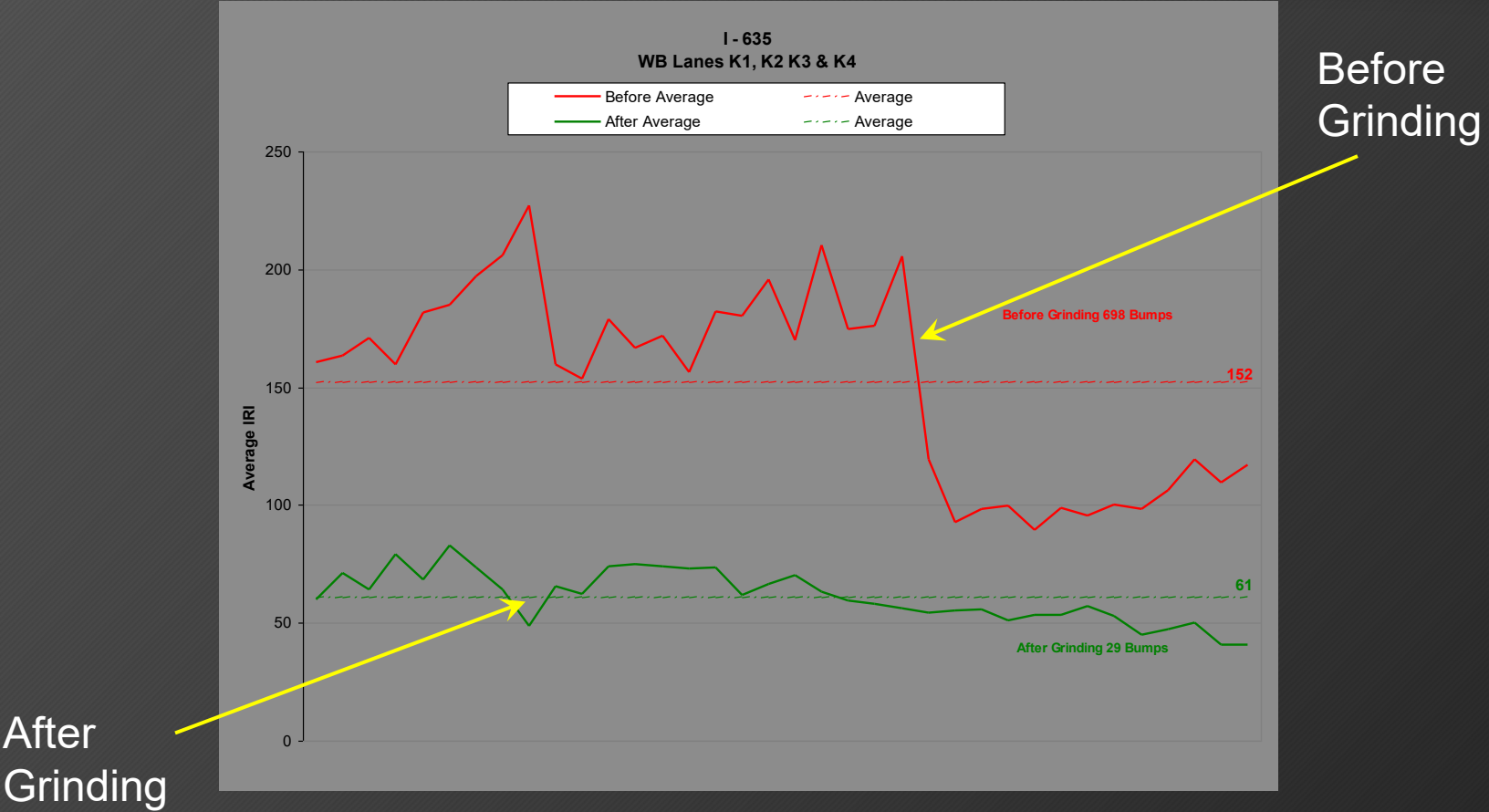
**Albedo** is the ability of surfaces to reflect sunlight



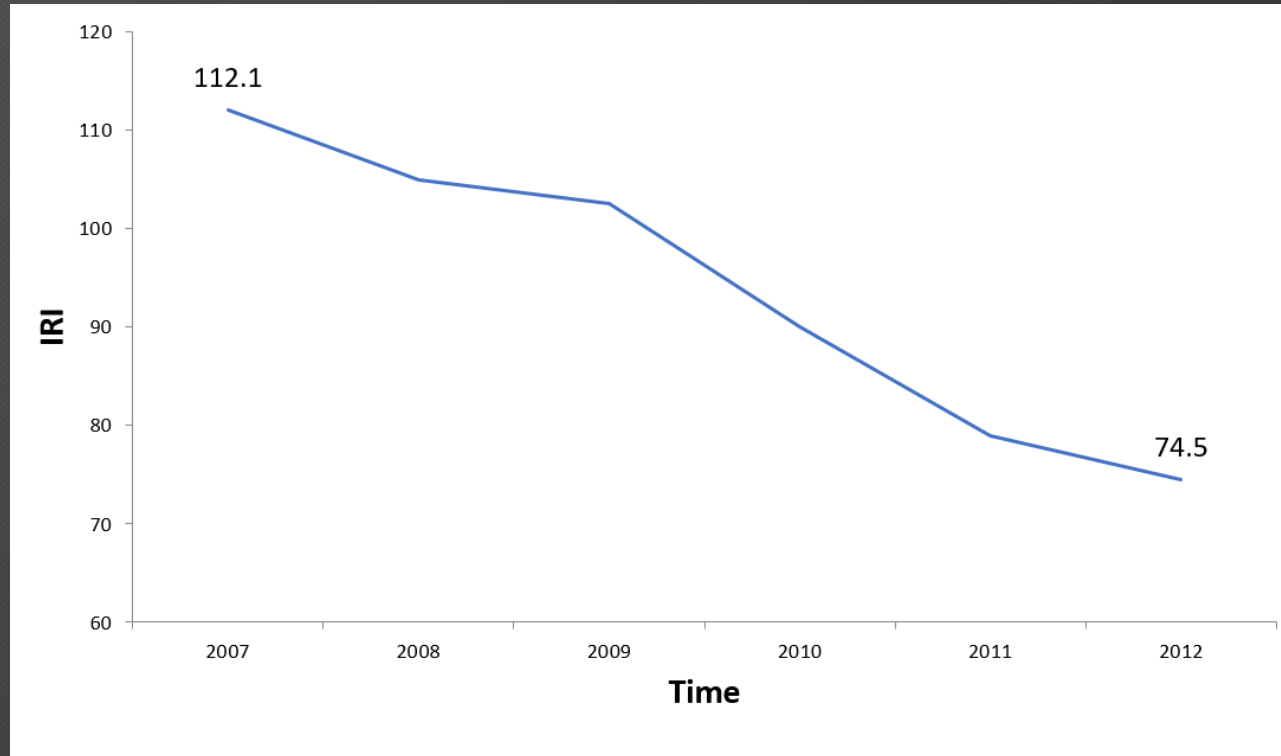
Year 0 to 10: 6298lbs of carbon sequestered

Year 10 to 20: 2609lbs of carbon sequestered

# Improve International Roughness Index by 50-70%



# Kentucky PCC Interstate Improvement Project



# Costs and Impact

IRI Improved from 112.1 to 74.5 in 5 years

Lowest recorded average IRI ever covering 536 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

Reconstruction cost would have been \$1.5 - \$2.5 million/lane mile

Preservation saved over \$1 Billion

# Use-phase is the primary environmental impact

- Minor adjustments can show major impact
- When we save on use-phase carbon (fuel consumption) we also save our taxpayers at the pump





 Fuel/Carbon Savings Calculator

 Rigid Pavement Savings Calculator



# MIT Concrete Sustainability Hub

## MIT Fuel/Carbon Savings Calculator

This app was developed using the concepts and models discussed in [Journal of Cleaner Production](#) in 2016. The Fuel/Carbon Saving App looks at an instantaneous improvement in IRI for a set amount of traffic on a daily basis. This daily savings can then be used to estimate annual savings for a set period of time. Estimating actual IRI for future years was considered but not used due to the fact that the estimates could never be confirmed. Allowing the user to extrapolate the findings on a daily level to an annual level was seen as the best estimate. Users should understand these are only estimates based on current traffic and smoothness calculations.

Estimated IRI Pre-Grind

 in/mi

Estimated IRI Post-Grind

 in/mi

Traffic Speed

 mph

Average Daily Traffic

Percent Trucks

 %

### Calculations

Cars Per Day 27,000

Trucks Per Day 3,000

Daily Fuel Savings Per Mile \$74.08

Annual Fuel Savings Per Mile \$27,040.13

# Cost/Carbon Savings Calculator- Actual Project Data

- What is the environmental and Financial benefit of IRI improvement?
  - [Fuel/Carbon Savings Calculator - IGGA | The International Grooving and Grinding Association](#)

## Example project

- Initial IRI: 98 in/mi
- Actual Final IRI: 43 in/mi
- AADT:39,152
- Percent trucks: 15%
- Length:6.6 miles
- Width: 4 lanes
- Cost to Grind: \$4.60 sqyd

Cost Carbon Benefit Table Print

Category	10 Year Benefit		20 Year Benefit	
	Cost (\$)	Carbon (Metric Tons)	Cost (\$)	Carbon (Metric Tons)
Fuel Savings for IRI	\$3,918,999.72	4559.63	\$7,837,999.45	9119.27
Carbon Sequestration		20.78		29.39
Cost of Grinding	(\$854,937.60)	(250.91)	(\$854,937.60)	(250.91)
<b>Total (savings)</b>	<b>\$3,064,062.12</b>	<b>4329.51</b>	<b>\$6,983,061.85</b>	<b>8897.76</b>

# Revisiting Kentucky's Preservation effort

IRI Improved from 112.1 to 74.5 in 5 years

Lowest recorded average IRI ever covering 536 miles

\$188,000 per lane mile

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Reconstruction cost would have been \$1.5 - \$2.5 million/lane mile

Preservation saved over \$1 Billion

Estimated IRI Pre-Grind

112 in/mi

Estimated IRI Post-Grind

75 in/mi

Traffic Speed

60 mph

Average Daily Traffic

30000

Percent Trucks

10 %

Gasoline Cost Per Gallon

\$ 3.5 USD

Diesel Cost Per Gallon

\$ 5 USD

Length Of Road

536 miles

Total Project Lane

Width (Cost

Estimate)

12 feet

Diamond Grinding Cost Per Yard

\$ 2.75 USD

## Cost Carbon Benefit Table

Print

Category	10 Year Benefit		20 Year Benefit
	Cost (\$)	Carbon (Metric Tons)	Cost (\$)
Fuel Savings for IRI	\$144,935,113.43	345246.12	\$289,870,226.85
Carbon Sequestration		4910.48	
Cost of Grinding	(\$10,376,960.00)	(10188.29)	(\$10,376,960.00)
<b>Total (savings)</b>	<b>\$134,558,153.43</b>	<b>339968.32</b>	<b>\$279,493,266.85</b>

# How Good is it?



Pavement Diamond Grinding is the only highway treatment that can be cost and carbon negative!

MIT's Concrete Sustainability HUB suggests that grinding and pavement repair should be conducted every 15-20 years to optimize carbon impact

# Why Is It The Most Cost-Effective Preservation Technique?

Material  
mining

Material  
hauling

Smaller crew  
than asphalt  
paving

Rolling road  
closures

# Alternative?

- Asphaltmagazine.com says an asphalt overlay of concrete can last 12 years when properly maintained



**\$100 per ton**  
**\$86,000 per lane mile**

# Arizona Buried Treasure

- Phoenix had loud, transverse tines pavements
- They decided to put rubberized asphalt on these highways to reduce noise
  - Noise reduction was temporary until rubberized asphalt began to deteriorate and debond
  - Raveled asphalt has led to a spike in broken windshields and friction concerns
- Diamond grinding was performed as an alternative to replacing rubberized asphalt
- Roughly 8-10 million sq yds treated already. 1 mil sq yds in 2026 alone
- It was determined the grinding effort resulted in over \$4 billion in savings over the life of the pavements treated

### Least Invasive

- Joint and crack sealing
  - Prevents subbase degradation
    - Faulting
    - Rocking Slabs
    - Corner breaks

### Moderately Invasive

- Partial depth repairs
- Dowel Bar retrofits
- Cross stitching
- Slab jacking

### Most Invasive

- Full depth pavement repair

Before Grinding Deploy Proper Repairs

Identify your pavement's problem area. Click on the photo that represents your pavement problem:

# Interactive CPP Toolkit

- Helps DOT's and Designers select the appropriate repairs for PCC pavement to help optimize repair spending.



**Spalled Joints and Cracks**



**Faulted Joints**



**Subsurface Voids**



**Cracked Slabs**



**Low-Severity Longitudinal Cracks or Joints**



**Low-Severity Transverse Cracks**



**Slab Warping or Unevenness**



**Joint Sealant Failure**



**Hydroplaning on Pavement**

# CRACKED SLABS

## Learn About the Repair

Images, information, and resources on the appropriate repair



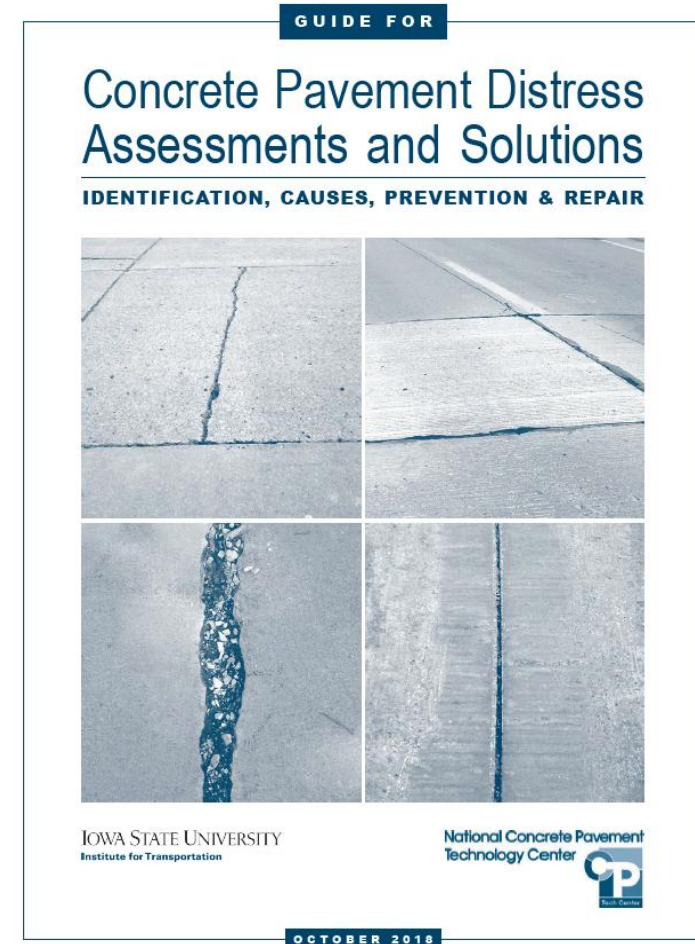
If you have cracked slabs, you need to perform:

### Full-Depth Repairs

Full-depth repair is the removal and replacement of full slab thickness sections of deteriorated pavement. Length can vary based on conditions present. A common minimum patch size is four to six feet long and a full lane width wide. This type of repair can be completed on both jointed and continuously reinforced concrete pavement. On jointed pavement, the transverse construction joints at the patch ends are typically doweled and/or tied to restore load transfer across the joints. Additionally, on longer patch sections, dowel bar assemblies are placed at intervals to coincide with the existing transverse joint pattern present. On continuously reinforced concrete, the reinforcing steel pattern of the existing pavement is removed and replaced with new steel within the repair section. The transverse repair boundaries are first sawed and jackhammered to

# Other resources

Pavement repair guides produced by the National Concrete Pavement Technology Center (CPTECH Center)



Thank You!

Preserved Texture  
and Riding Surface  
is Preserved  
Pavement

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