SEMINARIO INTERNACIONAL DE PAVIMENTOS DE HORMIGÓN
24 y 25 DE OCTUBRE 2012 • CIUDAD DE CÓRDOBA - ARGENTINA

Concrete Pavement Preservation

Integrating Engineering, Applications and the Environment

Introduction

- John H. Roberts
- Executive Director - International Grooving and Grinding Association
- Vice President – American Concrete Pavement Association's Pavement Restoration Division

Presentation Outline

- Background
- Engineering Long Lasting Pavements Using Pavement Preservation Strategies
- Concrete Pavement Preservation Application Research
- Environmental and Sustainability Considerations
- Summary

Background

- 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

Background

- Concrete roadway construction in the US increased at a rapid rate at the turn of the century
- By 1914, there were 2,348 miles of paved Portland Cement Concrete Pavement in US
- A significant portion of the early Interstate Highway System was constructed using PCCP

Background

- Early traffic predictions greatly underestimated future needs
- Traffic growth outpaces road construction
- Highway funding fails to keep pace with needs
- Many PCCP carry 10 to 20 times predicted traffic due to these factors

Priorities Have Shifted in Modern Times

- Minimal system expansion
- Maintain the present system
- Minimize traffic disruptions
- Increase safety
- Address operator comfort
  - Reduce Roughness
  - Reduce Noise
- Save money
- Protect the Environment

The Industry Seeks New Strategies

- Transportation Departments can no longer replace worn highways every 20 years to keep up with the increased vehicle traffic.
- The Industry needs cost effective, environmentally friendly, engineered strategies to preserve and rehabilitate the aging roadway system to provide additional pavement life (50 years and more).

Pavement Preservation Philosophy

Keeping good roads in Good Condition!

What is Pavement Preservation?

- Network level, long-term strategy
- Applied to structurally sound pavements
- Focused on extending pavement life and restoring functional condition
- Utilizes cost effective treatments
- Does not increase structural capacity

Concrete Pavement Preservation Beginnings

- Diamond grinding was the first treatment used as part of an engineered system to preserve PCC Pavement in the 1960's. Concrete Pavement Preservation (CPP) is born.

PCCP Preservation Techniques

- Slab stabilization/jacking
- Partial-depth repair
- Cross-stitching longitudinal cracks/joints
- Dowel bar retrofit
- Full-depth repair
- Diamond grinding
- Diamond grooving
- Joint & crack resealing

Diamond Grinding

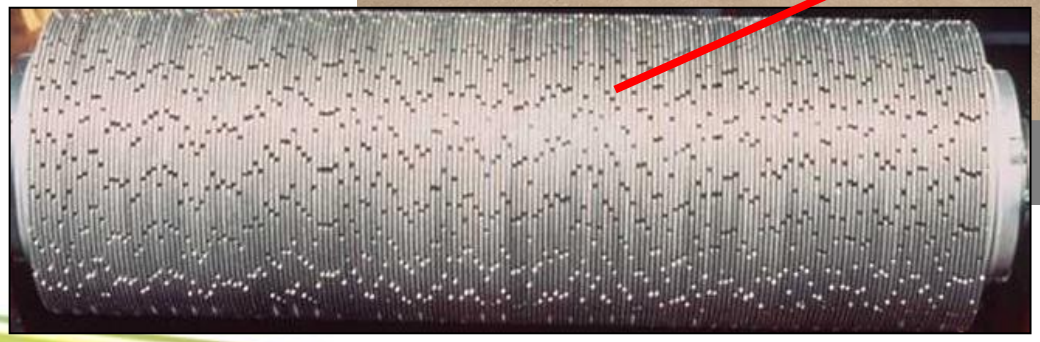
What is Diamond Grinding?

- 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 CPP techniques, such as full-depth repair, dowel bar retrofit, and joint resealing

Blades and Spacers

Diamond Grinding Head

Diamond Grinding Equipment



Diamond Grinding Process

Diamond Grinding Final Surface

Diamond Grinding Origins

- Diamond grinding was first used in California in 1965 on a 19-year old section of I-10 to eliminate significant faulting
- 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 performance

Advantages of Diamond Grinding

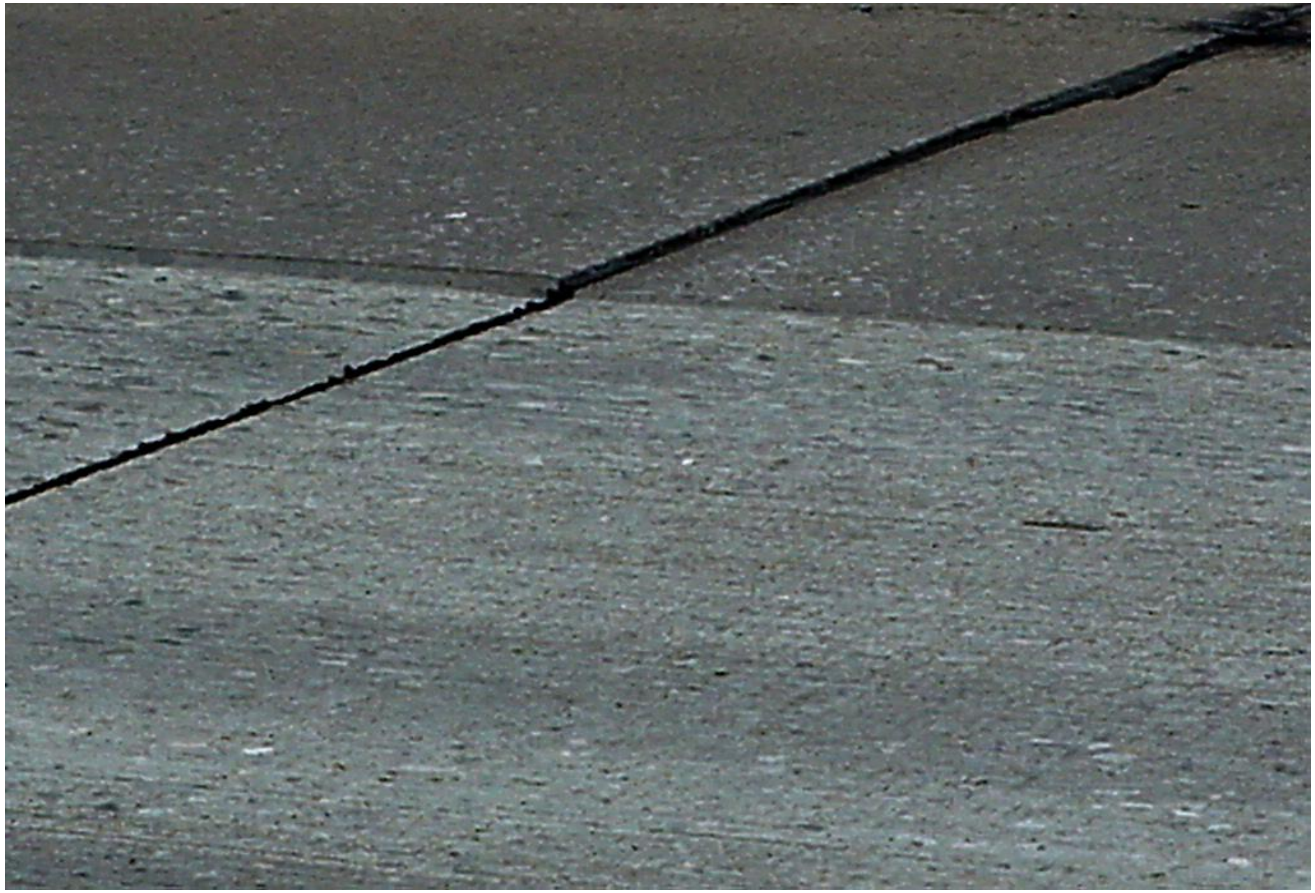
- Costs substantially less than asphalt overlays
- Enhances surface friction and safety
- Can be accomplished during off-peak hours with short lane closures and without encroaching into adjacent lanes
- Grinding of one lane does not require grinding of the adjacent lane
- Does not affect overhead clearances underneath bridges
- Blends patching and other surface irregularities into a consistent, identical surface
- Environmentally friendly

Pavement Problems Addressed

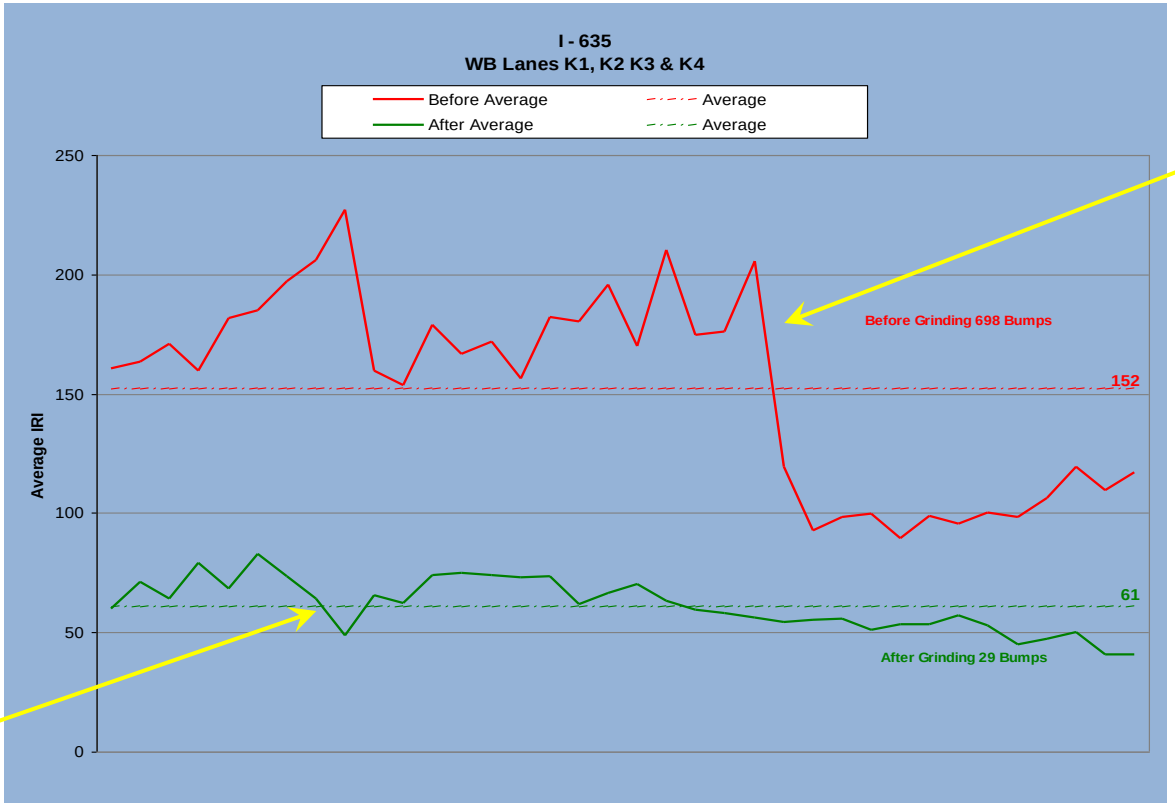
- Faulting at joints and cracks
- Built-in or construction roughness
- Polished concrete surface
- Wheel-path rutting
- Permanent upward slab warping
- Inadequate transverse slope
- Unacceptable noise level

Joint Faulting (Stepping)

Diamond Grinding Removes Faults



Diamond Grinding can provide a 60% to 70% improvement over the pre-grind profile on average!



Before Grinding

After Grinding

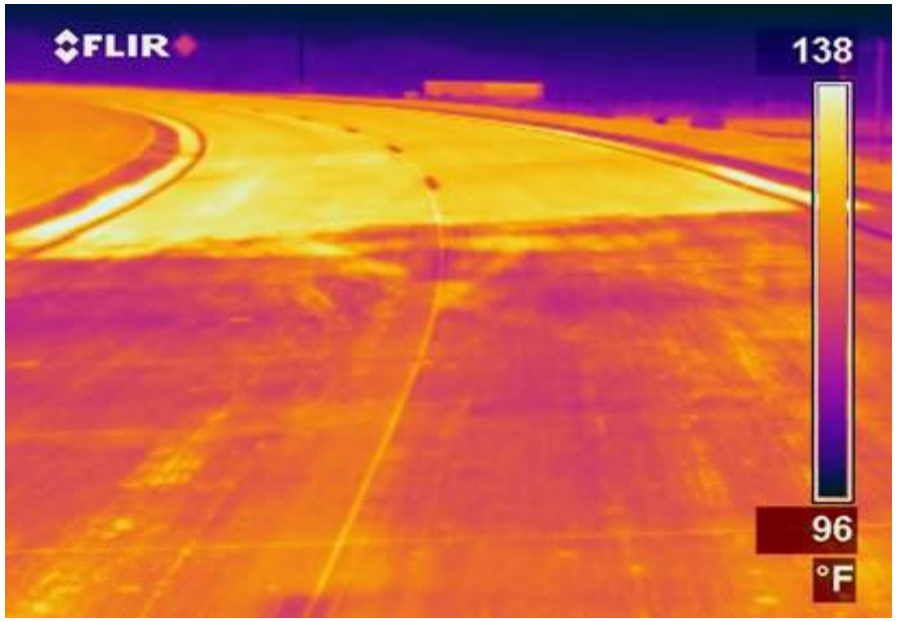
Safety, Surface Texture and Friction

- 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. Grooves provide “escape route” for water trapped between tire and pavement surface
- In Wisconsin Marquette University found that, overall accident rates for ground surfaces were 40% less than for un-ground surfaces over a 6-year period, 57% in wet weather conditions

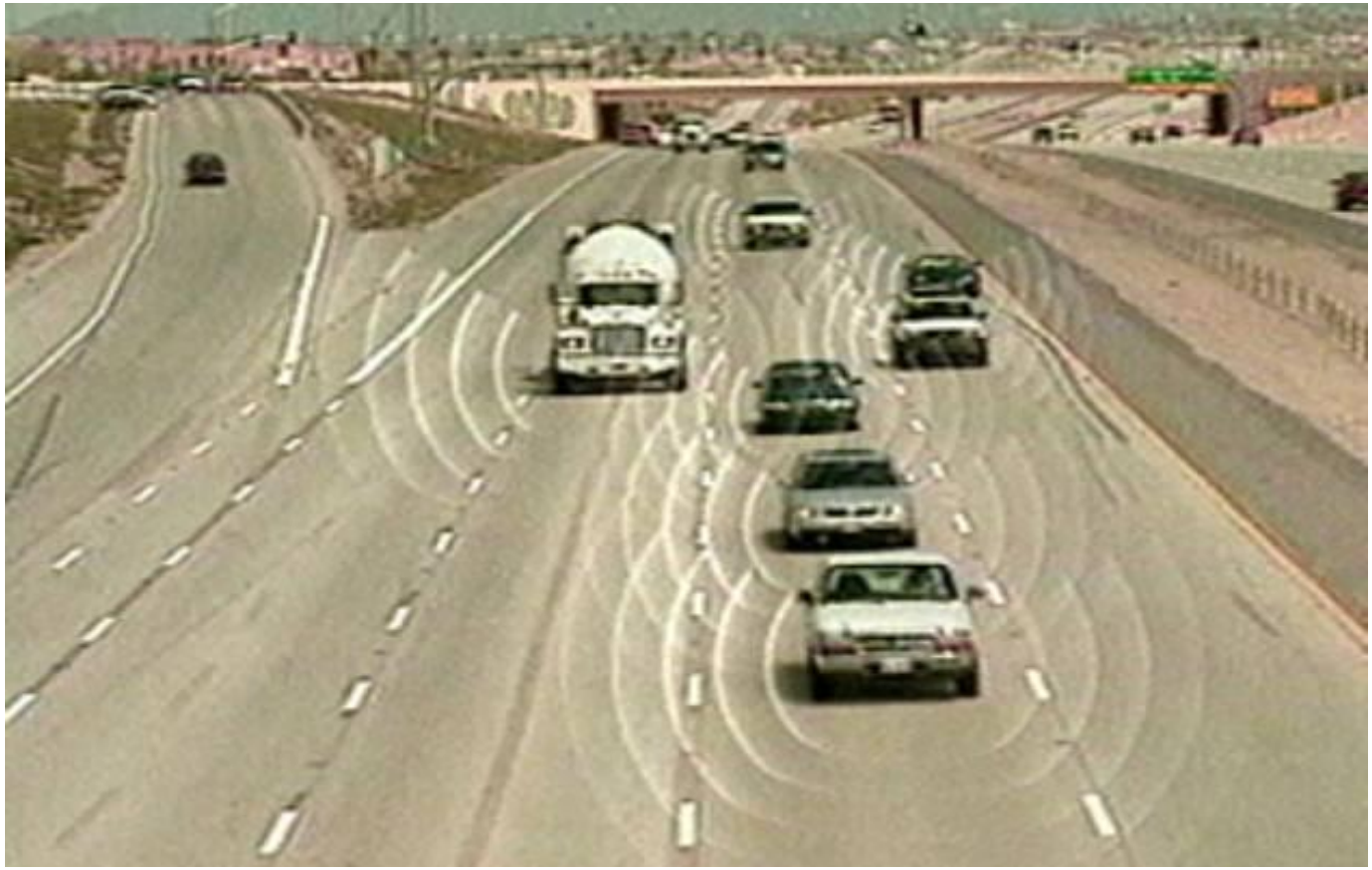
Diamond Grinding Asphalt Pavement

Lower Ambient Temperatures and Energy Costs

The light reflective color of PCCP means less energy required for overhead lighting and cooling in urban areas.

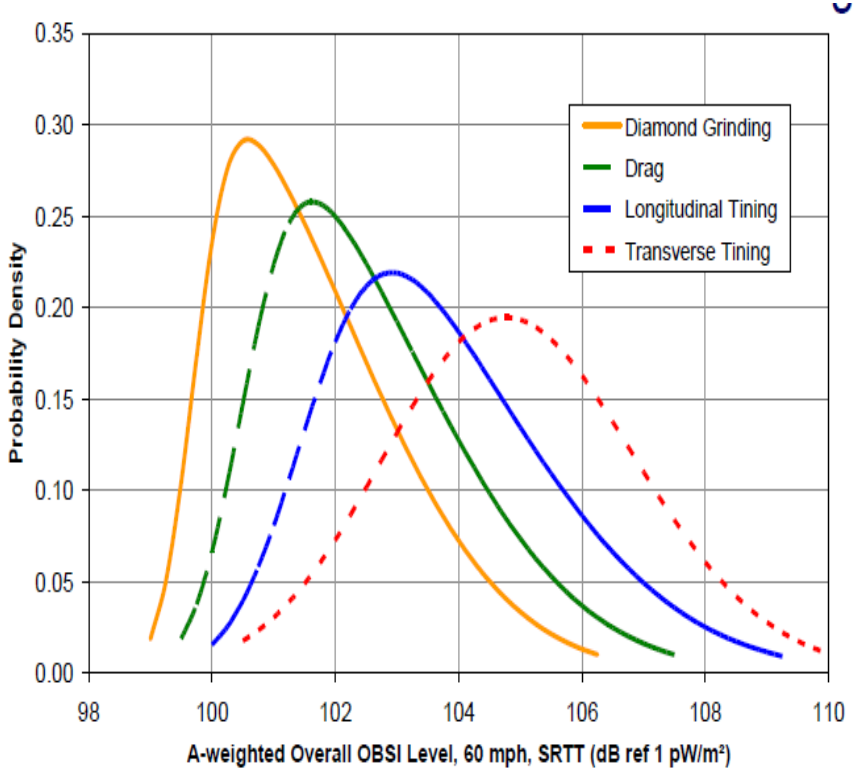


Unacceptable Noise Level

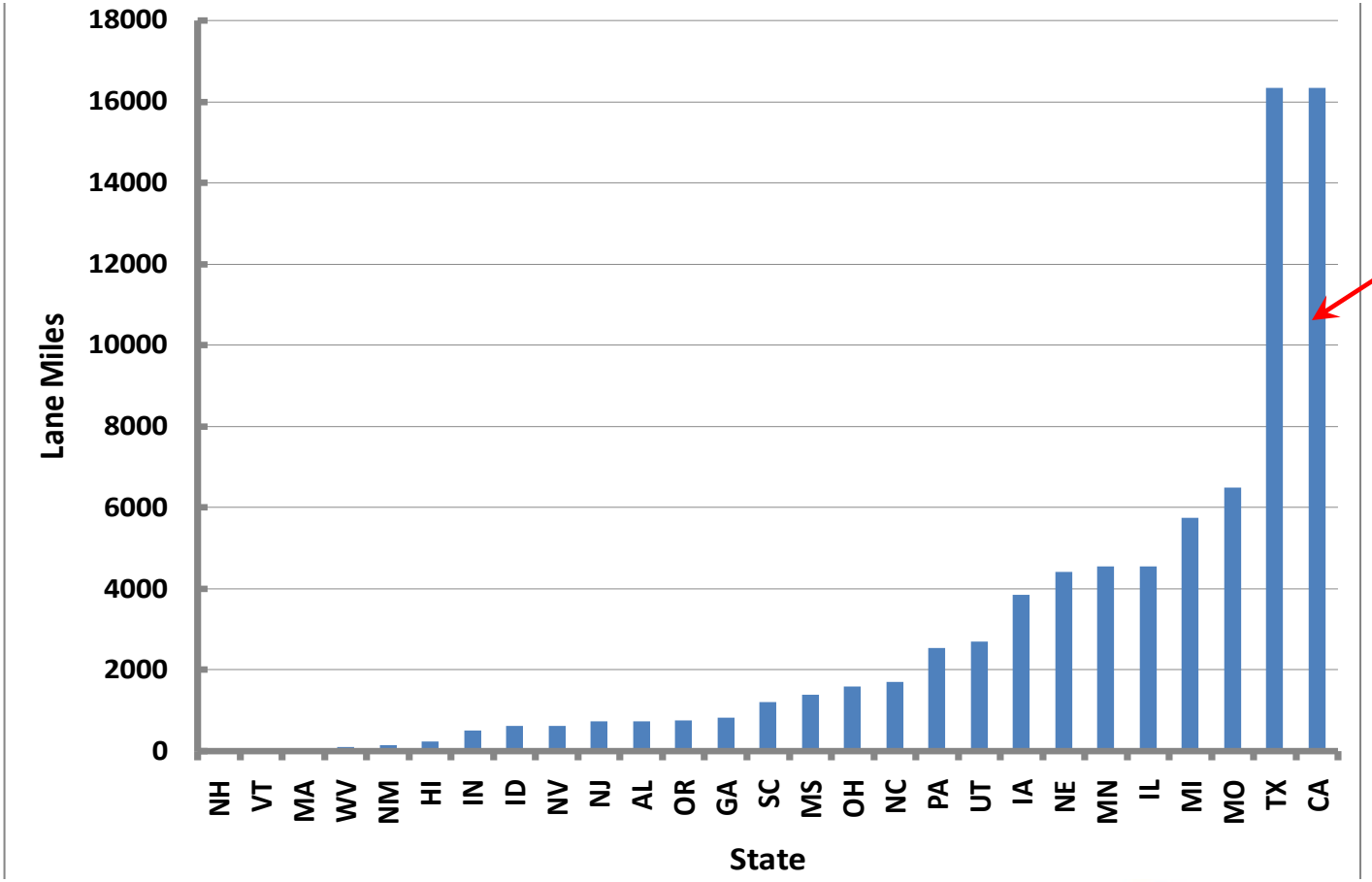


NCPTC Noise Catalogue

- Research conducted by the National Concrete Pavement Technology Center shows diamond grinding as the most quiet PCCP surface texture commonly used.



Concrete Lane Miles by State DOT

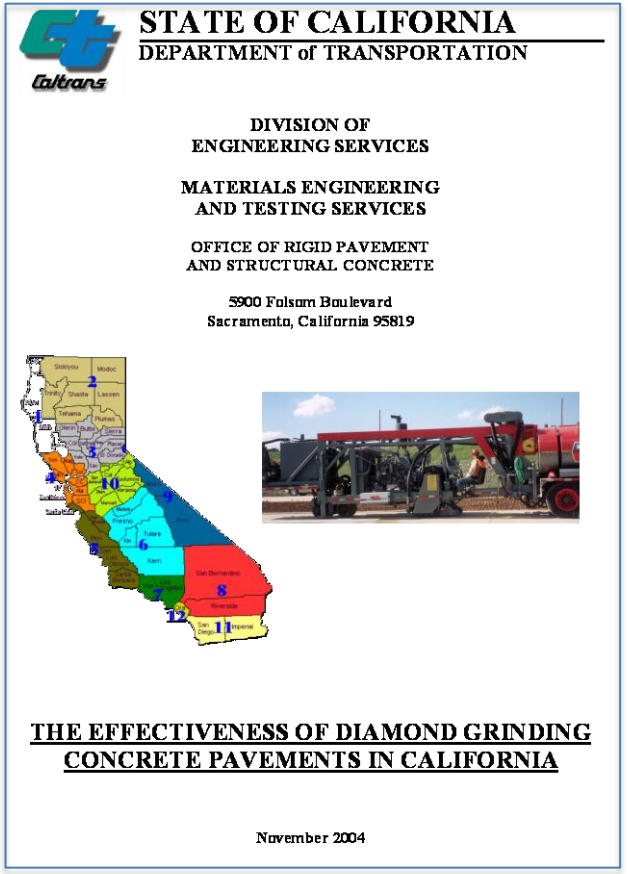


2010 Diamond Grinding Rank by State

State	YDS²	$	State	YDS²	$
CA	11,376,823	$40,778,762	OK	261,976	$650,208
WA	1,497,968	$10,196,334	TN	242,160	$619,453
UT	2,024,955	$7,164,921	IA	174,667	$490,743
MS	983,212	$6,498,776	WI	101,054	$444,496
KY	1,469,974	$4,024,784	AL	155,336	$401,216
FL	1,113,615	$2,818,104	GA	110,616	$359,948
IL	404,637	$2,566,695	PA	85,813	$345,350
MI	480,507	$2,177,617	ND	144,587	$338,221
MN	386,950	$1,681,074	MA	46,000	$334,725
MT	387,991	$1,554,080	VA	97,015	$316,620
AR	371,284	$1,371,624	DE	44,820	$270,105
ID	448,540	$1,188,631	NV	26,396	$260,174
NC	336,491	$815,596	NY	27,130	$194,915
TX	135,318	$774,875	SC	57,011	$193,395
CT	114,325	$764,720	AZ	12,141	$158,753
NE	292,473	$729,374	LA	5,736	$118,338
NM	303,430	$723,195	CO	2,558	$25,697
OH	343,646	$722,439	NH	2,400	$18,000
MO	390,210	$713,594			

Effectiveness of Diamond Grinding

- CALTRANS has determined that the average life of a diamond ground pavement surface is 16 to 17 years and that a pavement can be ground at least three times without affecting the pavement structurally. See IGGA.net 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

CALTRANS Research Findings

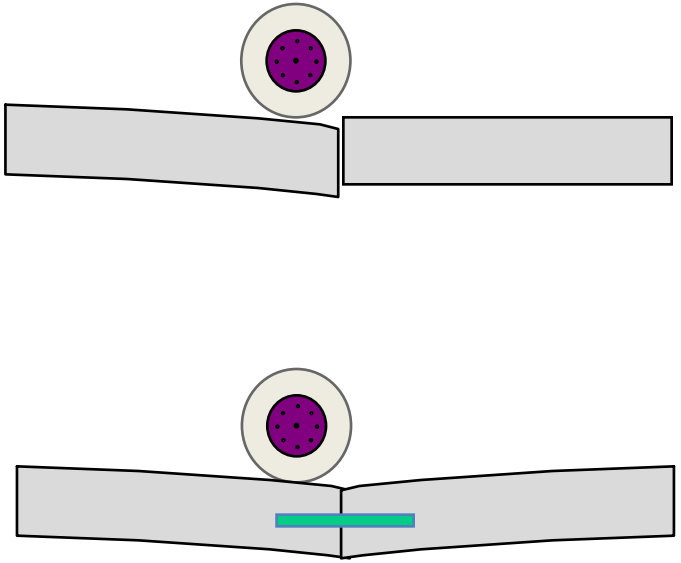
Diamond Grinding

- Extends pavement life
- Reduces tire-pavement interface noise
- Improves texture and skid resistance
- Reduces highway user costs through improved fuel economy and lower vehicle maintenance costs

Long-Term Performance of Dowel Bar Retrofit (DBR) in Washington

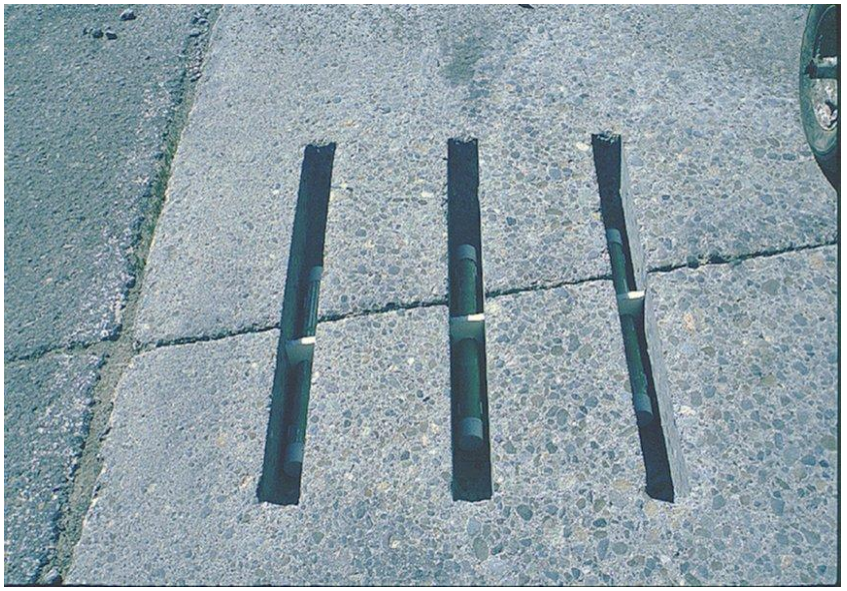
Purpose of Dowel Bar Retrofit

- Reestablishes load-transfer across joints or cracks in PCCP
  - Load-transfer is a slab's ability to transfer part of its load to its neighboring slab
- Used in undoweled pavements to limit future faulting



Dowel Bar Retrofit

- Placement of load transfer devices across joints or cracks of existing pavements
- Candidate projects
  - Poor load transfer
  - Pumping
  - Faulting
  - Corner breaks



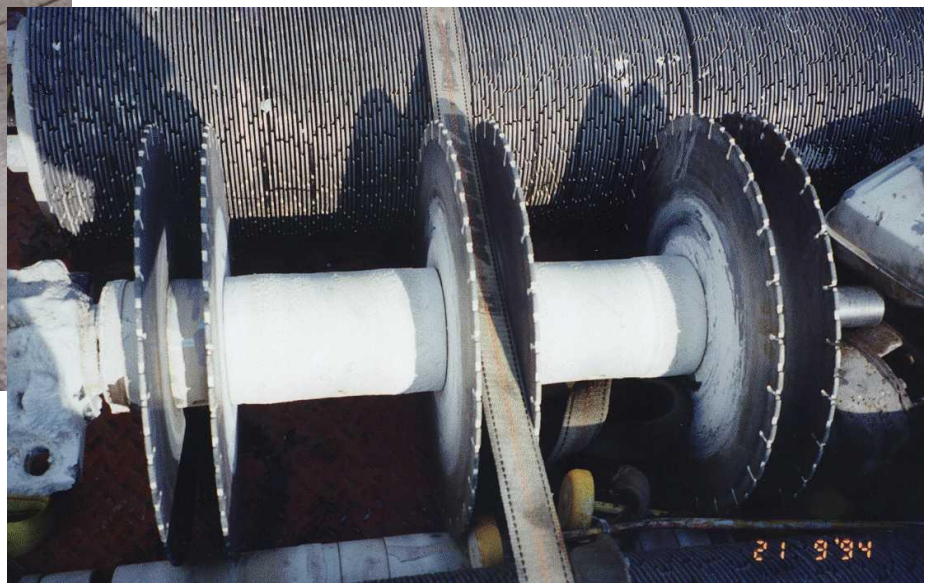
Faulted Joints – Poor Load Transfer

Dowel Bar Retrofit Operations

Consists of 4 main operations:

1. Cutting the slots
2. Preparing the slots
3. Preparing and placing the dowel bars
4. Backfilling the slots

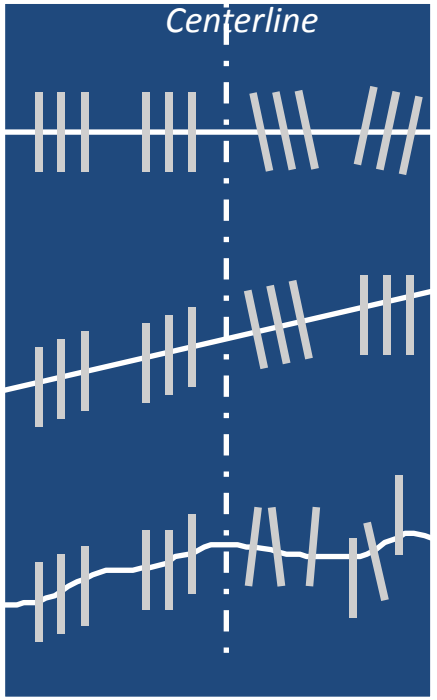
Cutting the Slots



DBR Slots Ready for Removal

Dowel Slot Alignment

- Typically 3 or 4 bars installed per wheel path
- Bars must always be parallel to centerline
- Slots must be cut so at least one-half of dowel can be on each side of the joint or crack

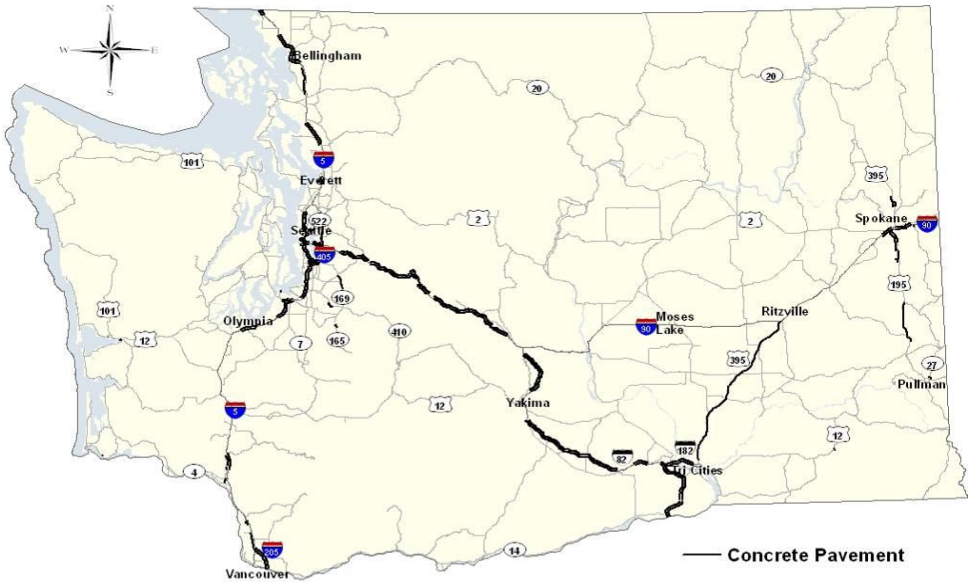


DBR Used to Fix Transverse Crack

DBR Followed by Diamond Grinding

Washington State DBR Experience

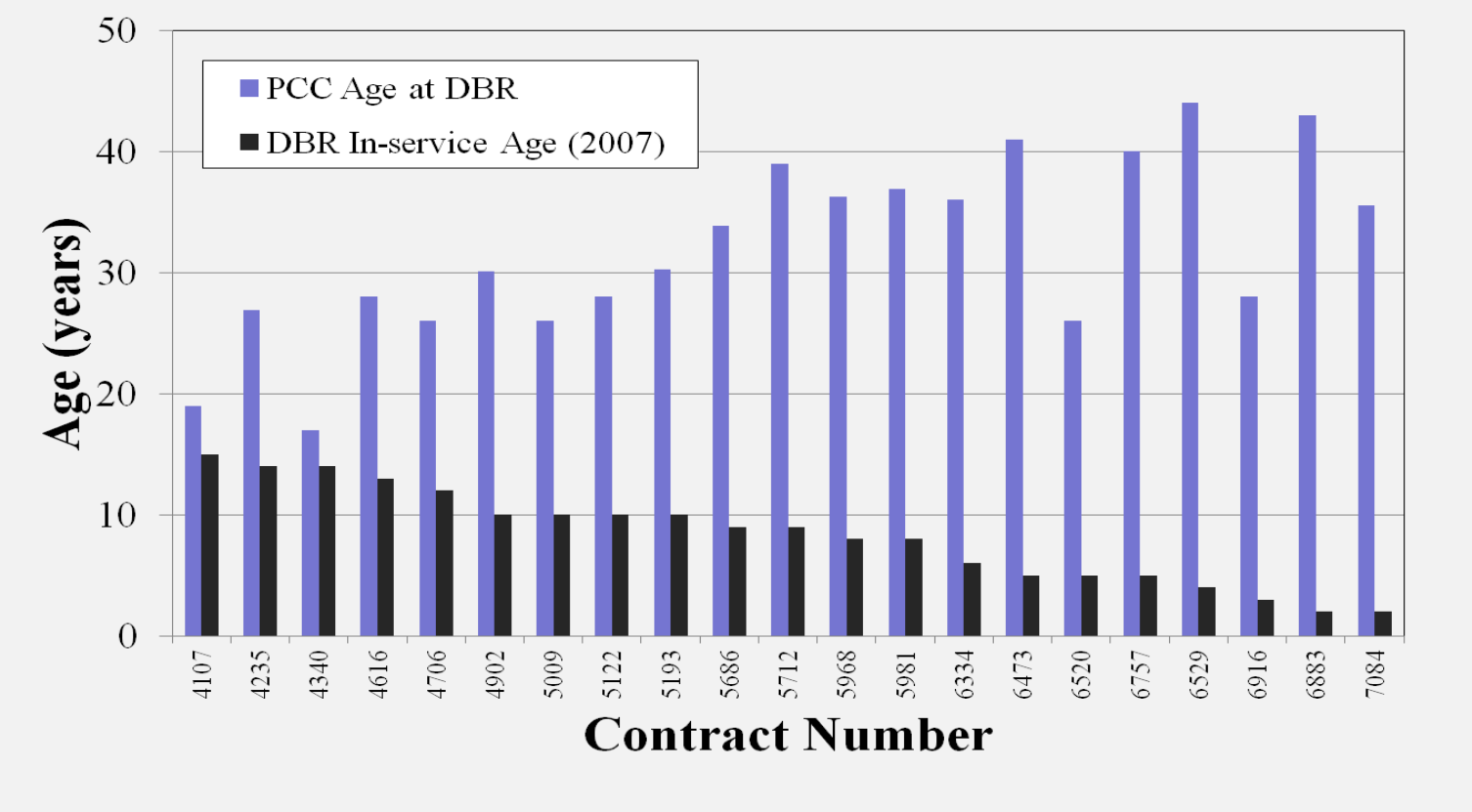
- DBR test section conducted in 1992
- Full-scale use of DBR began in 1993
  - Heavily faulted interstate pavements
  - Undoweled PCCP



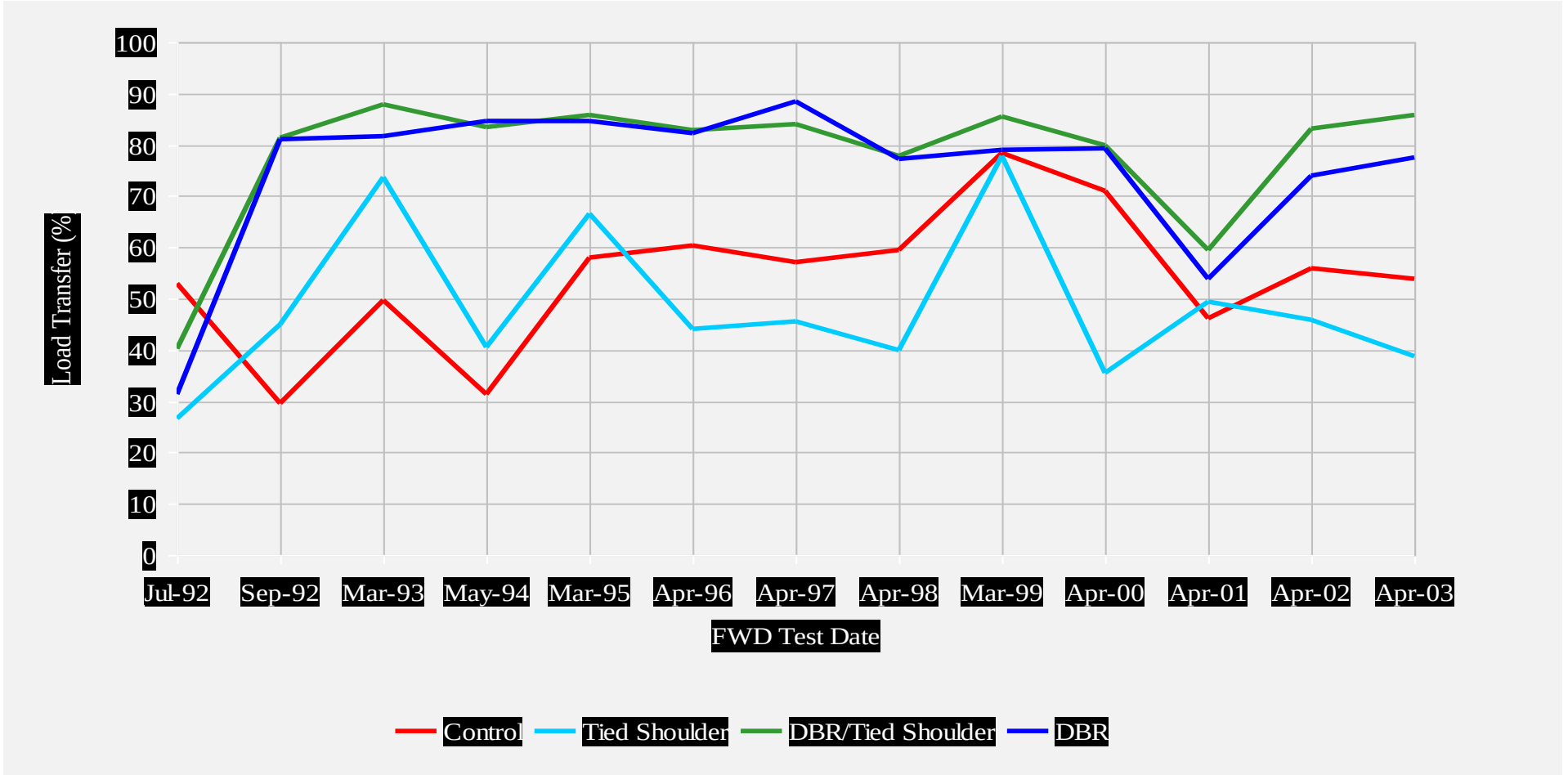
Test Section Overview

- Dowel bars
  - Epoxy coated
  - Length 18”
  - Diameter 1-1/2”
- 4 per wheel path

Pavement Age vs. DBR Placement



Load Transfer



WSDOT DBR Research

- Since 1992, WSDOT has retrofitted 280 Lane-mi (450 Lane-km) or 600,000 bars
- Average age of pavement prior to DBR was 32 yrs.
- DBR provides superior performance when applied to pavements with faulting < 1/8 inch (3 mm)
- Many 30 and 40 year PCCPs successfully retrofitted for additional pavement life at a fraction of the cost of reconstruction

IGGA DBR Project Database

- Includes individual project data including:
  - Project Location
  - Project Date
  - Number of bars installed
- Over 6.5 million bars installed in the US since 1992

Joint and Crack Resealing

Introduction

- Definition

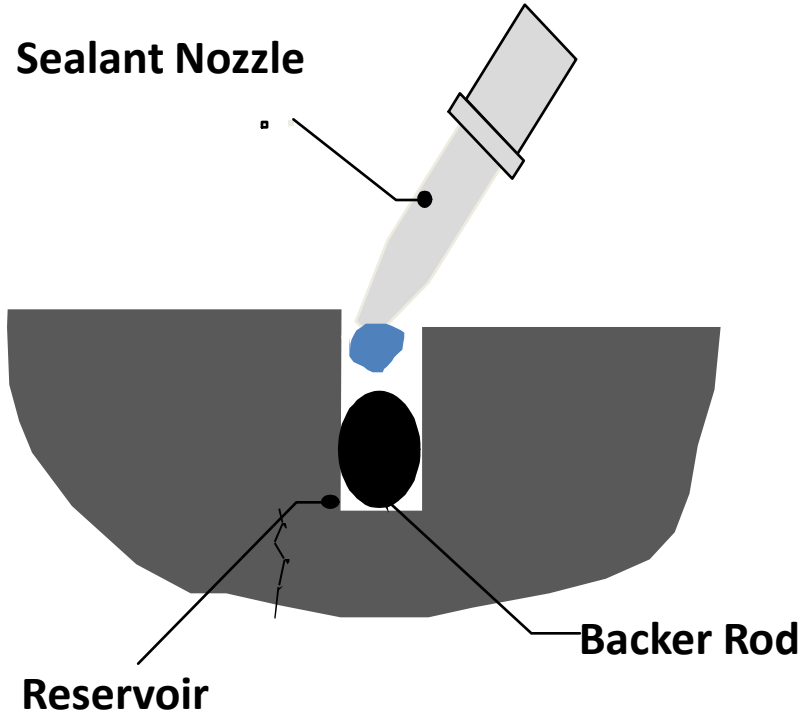
  Placement of an approved sealant material in an existing joint or crack to reduce moisture infiltration and prevent intrusion of incompressibles

Joint and Crack Resealing

- Minimizes water & incompressibles into pavement system

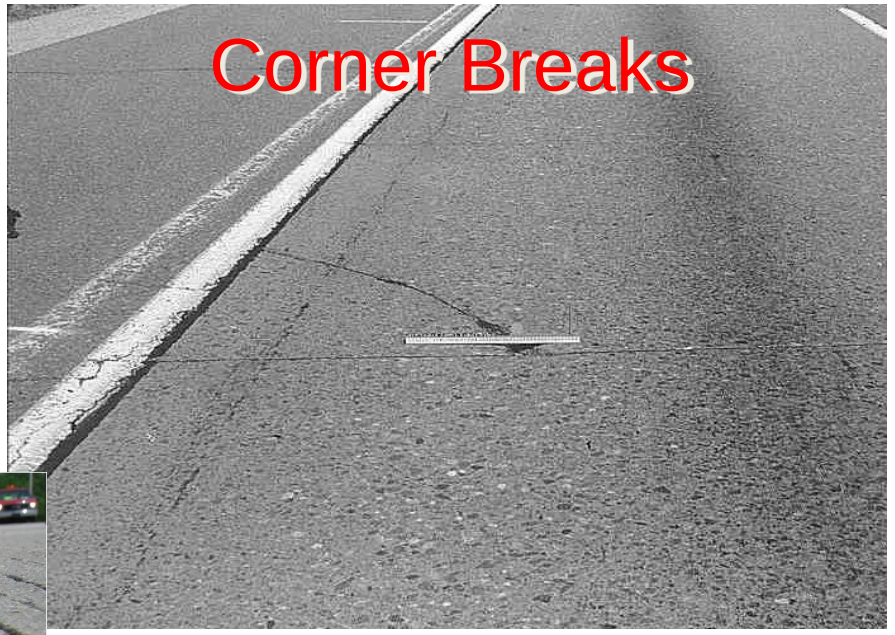
  Reduces:

  – Subgrade softening
  – Pumping
  – Erosion of fines
  – Spalling



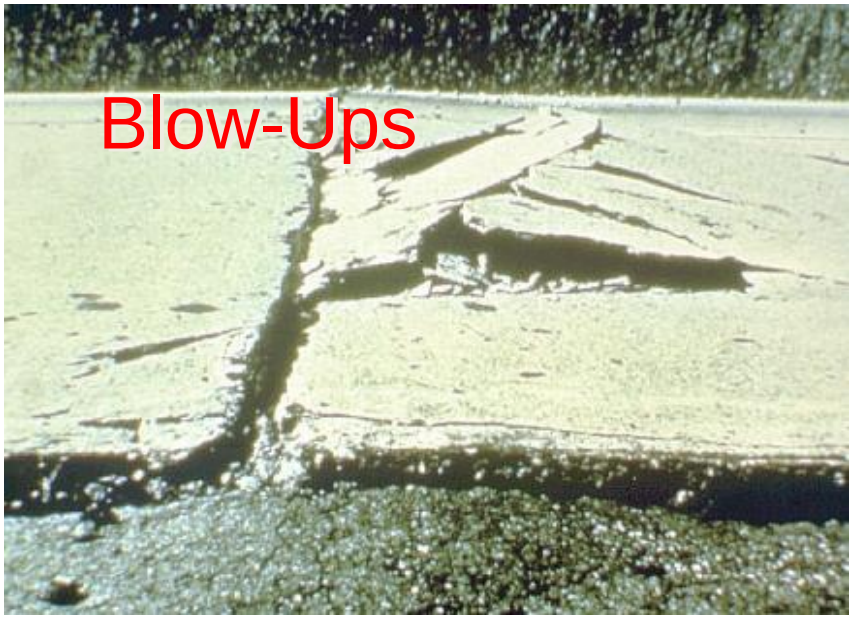
PCC Pavement Deterioration

Influence of Moisture Infiltration

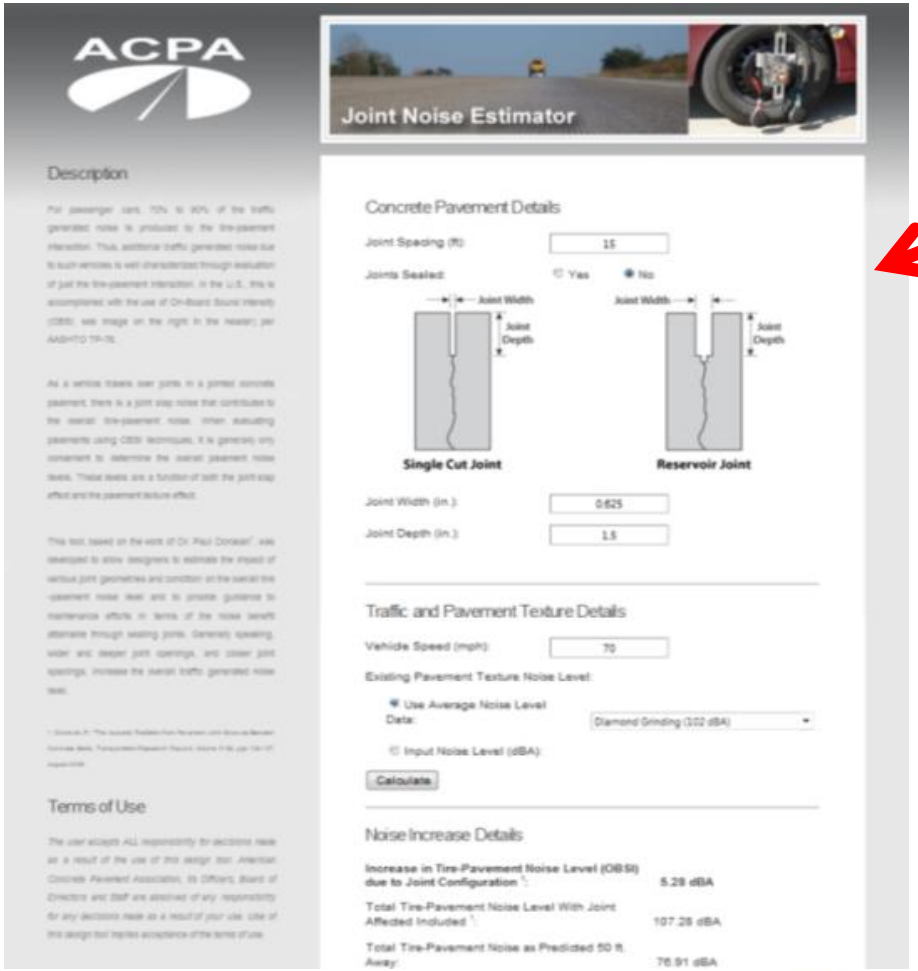


PCC Pavement Deterioration

Influence of Incompressibles



Sealing Affects Pavement Noise



Unsealed vs Sealed Joint is about 5 dBA

What Is the Compelling Issue

- As cost pressures continue, there is increased interest in eliminating joint sealants as a means of lowering the cost of concrete pavements. However, there is a lack of data in the industry to help guide owners about sealant effectiveness and the long-term impact of using or not using such sealants
  - Alternate Bid Projects (AC versus Concrete)
  - Concerns for Low Initial Cost Due to Budget

Is Sealant Cost Effective?

FHWA Sealant Effectiveness Study

TechBrief

The Concrete Pavement Technology Program (CPTP) is an integrated, national effort to improve the long-term performance and cost-effectiveness of concrete pavements. Managed by the Federal Highway Administration through partnerships with State highway agencies, industry, and academia, CPTP's primary goals are to reduce congestion, improve safety, lower costs, improve performance, and foster innovation. The program was designed to produce user-friendly specifications, procedures, methods, guidelines, and other tools for use in materials selection, mixture proportioning, and the design, construction, and rehabilitation of concrete pavements.

www.tfhrc.gov/pavement/concrete

U.S. Department of Transportation
Federal Highway Administration

CONCRETE PAVEMENT
CPTP
TECHNOLOGY PROGRAM

Performance of Sealed and Unsealed Concrete Pavement Joints

This TechBrief presents the results of a nationwide study of the effects of transverse joint sealing on performance of jointed plain concrete pavement (JPCP). This study was conducted to assess whether JPCP designs with unsealed transverse joints performed differently from JPCP designs with sealed transverse joints. Distress and deflection data were collected from 117 test sections at 26 experimental joint sealing projects located in 11 states. Performance of the pavement test sections with unsealed joints was compared with the performance of pavement test sections with one or more types of sealed joints.

BACKGROUND

The sealing of transverse contraction joints in JPCP has been standard practice throughout much of the United States for many years. Its widespread use is due to the common belief that sealing joints improves concrete pavement performance in two ways: by reducing water infiltration into the pavement structure, thereby reducing the occurrence of moisture-related distresses such as pumping and faulting, and by preventing the infiltration of incompressibles (sand and small stones) into the joints, thereby reducing the likelihood of pressure-related joint distresses such as joint spalling and blowups.

Transverse joints in jointed concrete pavement (JCP) are typically created by making an initial saw cut to force controlled cracking, followed by a second, wider saw cut to produce a reservoir for the joint sealant material. This traditional approach of sawing and sealing transverse contraction joints is estimated to account for between 2 and 7 percent of the initial construction cost of a JCP. Moreover, these sealed transverse joints require resealing one or more times over the service life of the pavement, leading to additional costs in terms of labor, materials, operations, and lane closures.

Recently, several State departments of transportation (DOTs) have been questioning conventional transverse joint sawing and sealing practices. These agencies contend that the benefits derived from sealing do not offset the costs associated with the placement and continued upkeep of the sealant over the life of the pavement. As a result, they have been experimenting with different sawing and sealing alternatives, for example:

- Narrow unsealed joints, consisting of single saw cuts that are left unsealed.
- Narrow filled joints, consisting of single saw cuts that are filled with sealant that adheres to the sides and bottom of the saw cut.
- Narrow sealed joints, consisting of single saw cuts that contain a narrow backer rod and sealant material.

NO

AASHTO New Design Guide

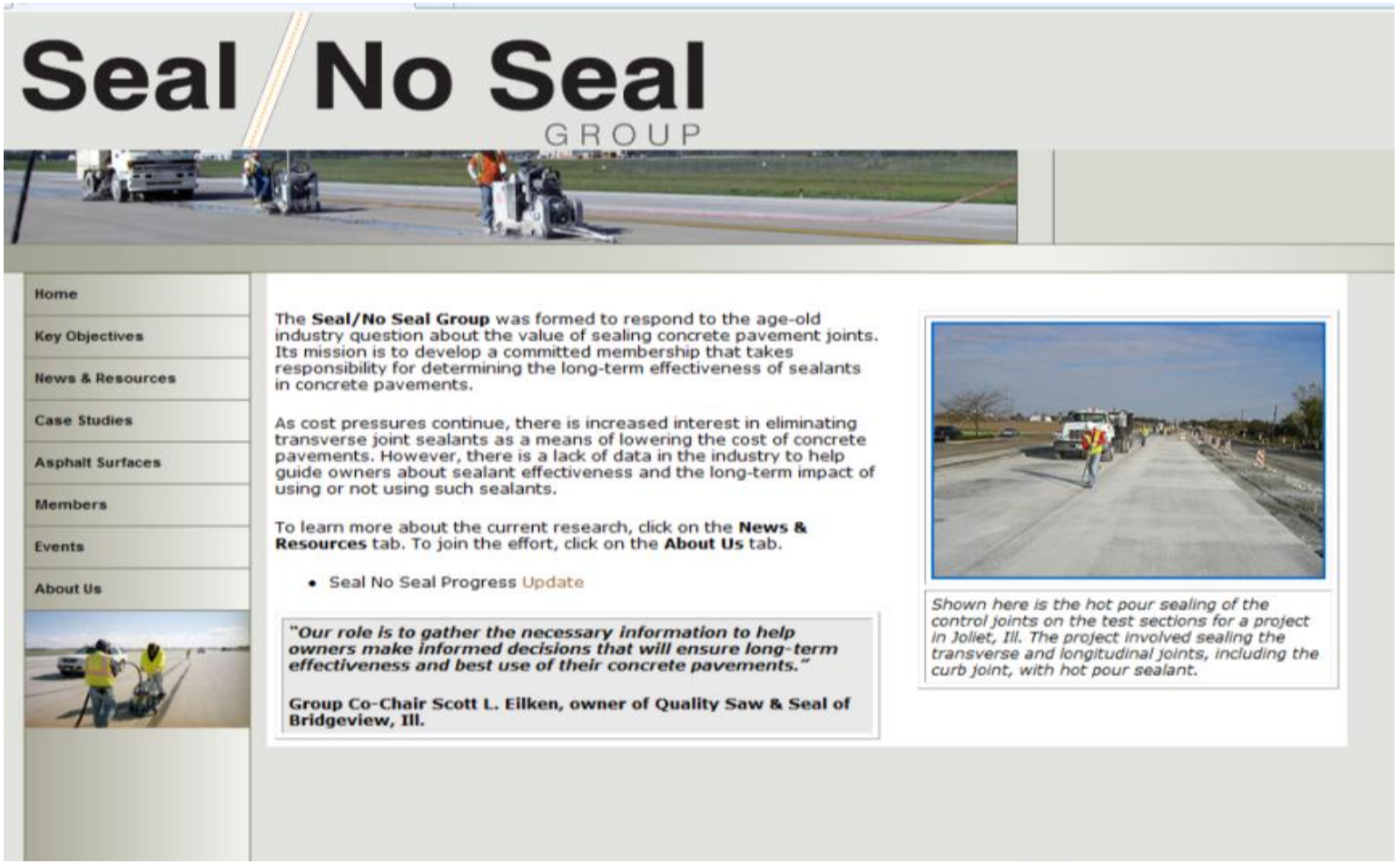
YES

SEMINARIO INTERNACIONAL
DE PAVIMENTOS DE HORMIGÓN

Guidelines for Resealing Joints

- Recommendation: continue to reseal joints if they were originally sealed!
- Reseal when sealant no longer functional
- Reseal when pavement not severely deteriorated
- Perform in conjunction with other CPR activities
- Proper material selection and joint preparation is essential

Seal/No Seal Group



Environmental and Sustainability Considerations

PCCP Uses Less Fuel During Construction

- FHWA TA T5080.3 on *Price Adjustment Contract Provisions* give Fuel Usage Factors
- Construction of HMA roadways consumes **5½ times** as much fuel (diesel) as construction of concrete roadways

Diesel Fuel Used During Construction
(Gallons/Mile)

Asphalt Pavement	Low	Avg.	High
Production	6,468	**8,981**	12,936
Hauling (0-10 miles)	1,035	**1,220**	1,257
Placing (3 layers required)	222	**517**	739
Asphalt Total:	7,725	**10,718**	14,932

Concrete Pavement	Low	Avg.	High
Production	293	**548**	880
Hauling (0-10 miles)	645	**939**	1,310
Placing (1 layer required)	254	**430**	606
Concrete Total:	1,193	**1,916**	2,796

Fuel Consumed During Rehab

- Gallons per Mile on a 12 Foot Wide Pavement

Asphalt Overlay (3")	Low	Average	High
Production	1940	2694	3880
Hauling (0-10 miles)	310	366	377
Placing	66	155	221
Asphalt Total	**2316**	**3215**	**4478**

Fuel Consumed During Rehab

- Gallons per Mile on a 12 Foot Wide Pavement

Mill & Asphalt Overlay (2")			
Mill & Sweep	785	900	1035
Production	1350	1796	2510
Hauling	215	244	250
Placing	43	103	145
Mill & Asphalt Overlay Total	**2393**	**3043**	**3940**

Fuel Consumed During Rehab

- Gallons per Mile on a 12 Foot Wide Pavement

Diamond Grind & Joint Reseal			
Diamond Grinding Operation (includes all support vehicles)	585	670	825
Joint Sawing & Resealing	255	265	280
Grind & Reseal Total	**840**	**935**	**1105**

Fuel Conservation thru Grinding

- Rehabilitation using diamond grinding and joint resealing on a concrete pavement is 3 times more energy efficient than a typical asphalt overlay.

conserving fuel

when rehabilitating concrete roads

How the choice of road repair methods can save fuel and reduce our dependence on oil imports

WITH MORE ATTENTION THAN EVER being focused on energy conservation, vehicle fuel efficiency and new alternatives such as hybrid cars and biodiesel, few people realize the significant impact that road rehabilitation methods can have on energy use. The difference is black and white:

Just How Much Fuel is Consumed Rehabilitating Pavements ...

>> BY DIAMOND GRINDING?

935 Gallons
(fuel use per mile)

BY REMOVING FAULTING, slab warping, studded tire wear and unevenness resulting from patches, diamond grinding creates a smooth, uniform pavement profile. Diamond grinding also reduces road noise by providing a longitudinal texture, which is quieter than transverse textures. The longitudinal texture also enhances macro texture and skid resistance in polished pavements. Further, joint and crack resealing minimizes the infiltration of surface water and incompressible material into the joint system. Minimizing water entering the joint reduces sub-grade softening, slows pumping and erosion of the sub-base fines, and may limit dowel bar corrosion caused by deicing chemicals. Diamond grinding can be completed with a short lane closure for a shorter period of time than the typical asphalt overlay project.

In comparison, asphalt pavements require a large amount of energy to heat materials to 325-degrees-Fahrenheit at the production plant. Hot asphalt is delivered by a diesel powered truck to the construction site where diesel powered pavers and compaction rollers use even more fossil fuel to place the overlay.

THE RESULT: Diamond grinding and joint resealing a concrete pavement is three times more energy efficient than a typical asphalt overlay.

>> BY ASPHALT OVERLAY?

3,215 Gallons
(fuel use per mile)

It is also important to consider the life-cycle cost of paving and rehabilitating both types of pavement surfaces. An asphalt surface should be replaced approximately 8 to 15 years into its life with a new layer of asphalt. This reality dramatically increases the fuel usage per mile of road for asphalt roads over the road's life.

Since concrete roads can be rehabilitated by much more cost-effective techniques, life-cycle fuel consumption is dramatically less for concrete pavements. Further, concrete pavements often last 30-40 years before diamond grinding becomes necessary and a road can usually be rehabilitated up to three times using this technique, taking the potential life-cycle for a concrete pavement out to the 50 to 70 year range.

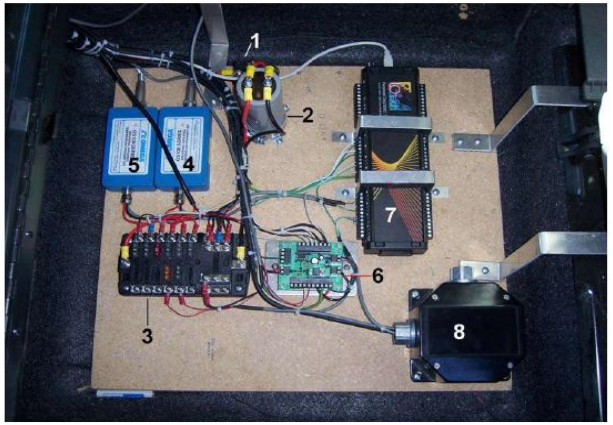
Please visit the ACPA's website at www.pavement.com or the IGGA's website at www.igga.net for more information on the best rehabilitation methods for concrete roads as well as further data on additional environmental advantages to choosing concrete roads!

CALTRANS Fuel Efficiency Research

- CALTRANS hired ARA to conduct research focused on vehicle fuel efficiency comparing concrete and asphalt surfaces as well as smooth vs. rough surfaces

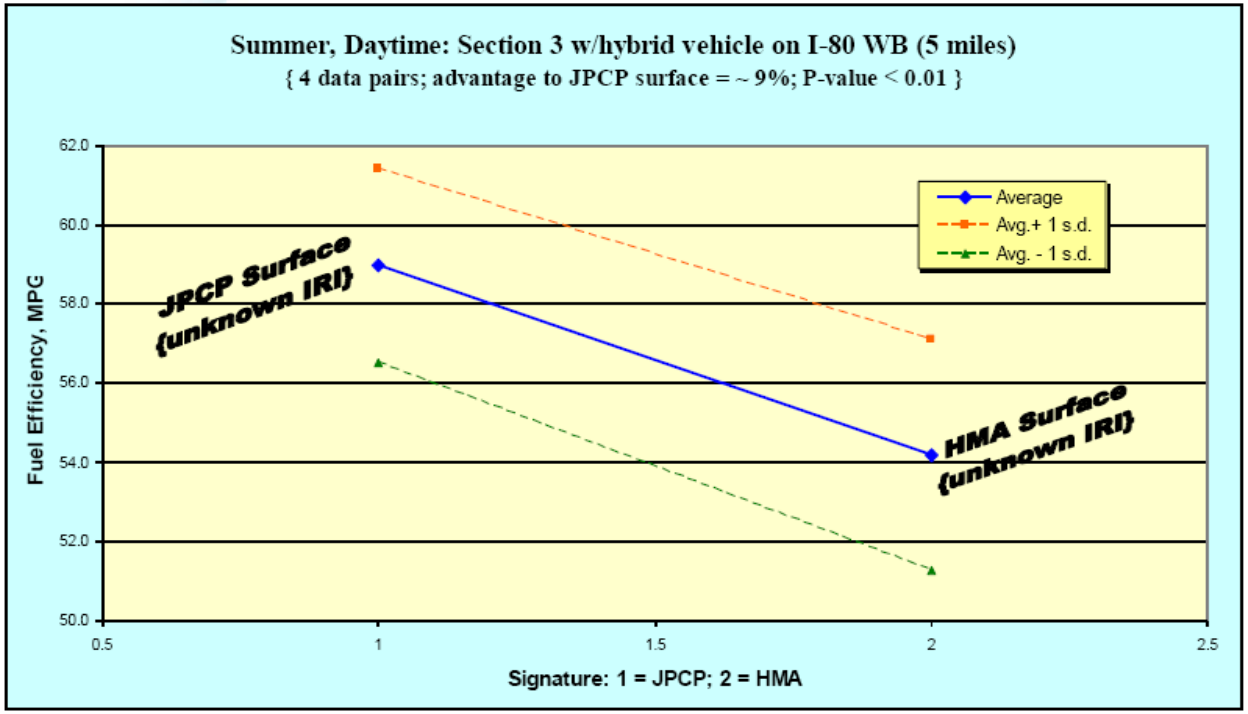
Passenger Vehicle Used in the Study

- 12 V DC Input (# 1)
- DC Capacitor (# 2)
- Power Distributor (# 3)
- Diodes (# 4 & 5)
- Signal Conditioning Board (# 6)
- Data Acquisition System (# 7)
- Signal Conditioner (# 8)



Hardware & Sensors for Fuel Flow Monitoring

CALTRANS Fuel Efficiency Research



Surface Type vs. MPG on I-80 WB w/Hybrid – Section 3

CALTRANS Fuel Efficiency Research

Summary of Fuel Efficiency Test Results

Test Performed		Fuel Savings (approximate)
Effect of vehicle speed on PCC		6.5 % (for every 5 mph decrease in vehicle speed)
AC vs. PCC	Fuel efficiency van on I-80	1.9 % to 3.2 % (in favor of PCC)
Diamond grinding PCC pavements that result in a significant improvement in IRI		1.8 % to 2.7 % * (for every IRI decrease in IRI of 50 in/mile)
Effect of tire pressure on PCC and AC pavements, respectively		1.0 % to 1.7 % (for every 4 psi increase in tire pressure)
AC vs. PCC	Fuel efficiency van on I-5	-0.1 % to 0.8 % (however no statistically significant differences were noted)

CALTRANS Fuel Efficiency Research

Report Conclusions:

- Diamond Grinding of PCCP reduces fuel consumption for sections where the IRI is also improved, all other things being equal

Summary

- This is a challenging time for the transportation industry
- Innovative, cost-effective solutions are needed to meet these challenges
- Many CPP techniques provide sustainable benefits such as increased pavement longevity, increased fuel economy, reduced noise and resource conservation
- Diamond grinding, DBR and joint resealing can extend pavement life significantly at a competitive cost
- When building roadways we must begin with the end in mind
- IGGA is ready to assist!

Visit Us on the Web

International Grooving and Grinding Association

at

igga.net

THANK YOU!