Concrete Pavement Preservation

Integrating Engineering, Economics and the Environment

PAVEMENT PRESERVATION & RECYCLING SUMMIT

PPRS PARIS 2015 FEBRUARY 22-25

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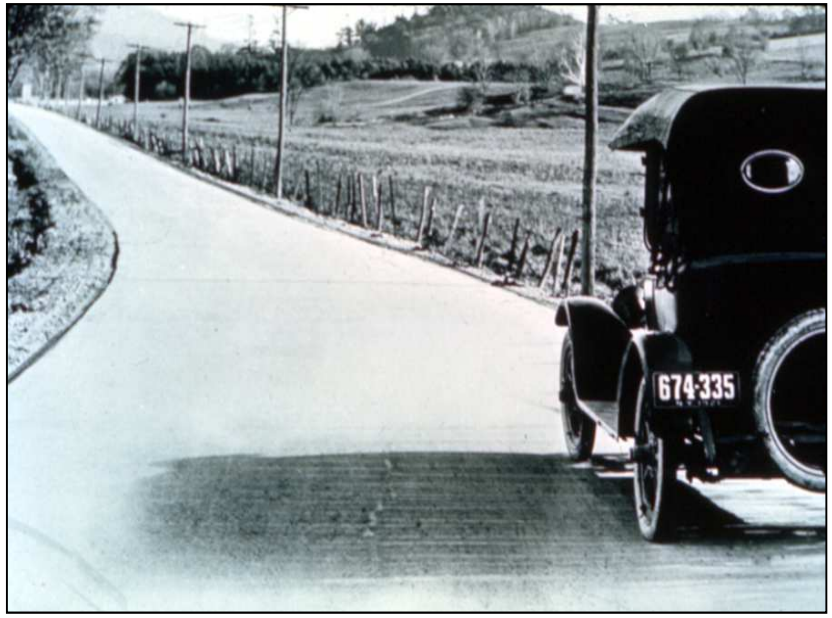
BACKGROUND | 1

Background

- The first Portland Cement Concrete Pavement (PCCP) constructed in US was located in Bellefontaine, Ohio, 1891
- Used two lift construction
  - Hard aggregate was mixed into top layer of concrete so horseshoes wouldn't polish or wear the pavement surface.
  - 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 concrete roads in the US
- A significant portion of the early Interstate Highway System was constructed using concrete pavement



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**

Pavement Preservation is the ONLY Answer

- Diamond grinding was the first treatment used as part of an engineered system to preserve concrete pavement in the 1960's. This event marks the beginning of Concrete Pavement Preservation (CPP).

PCCP Preservation Techniques

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

DIAMOND GRINDING | 2

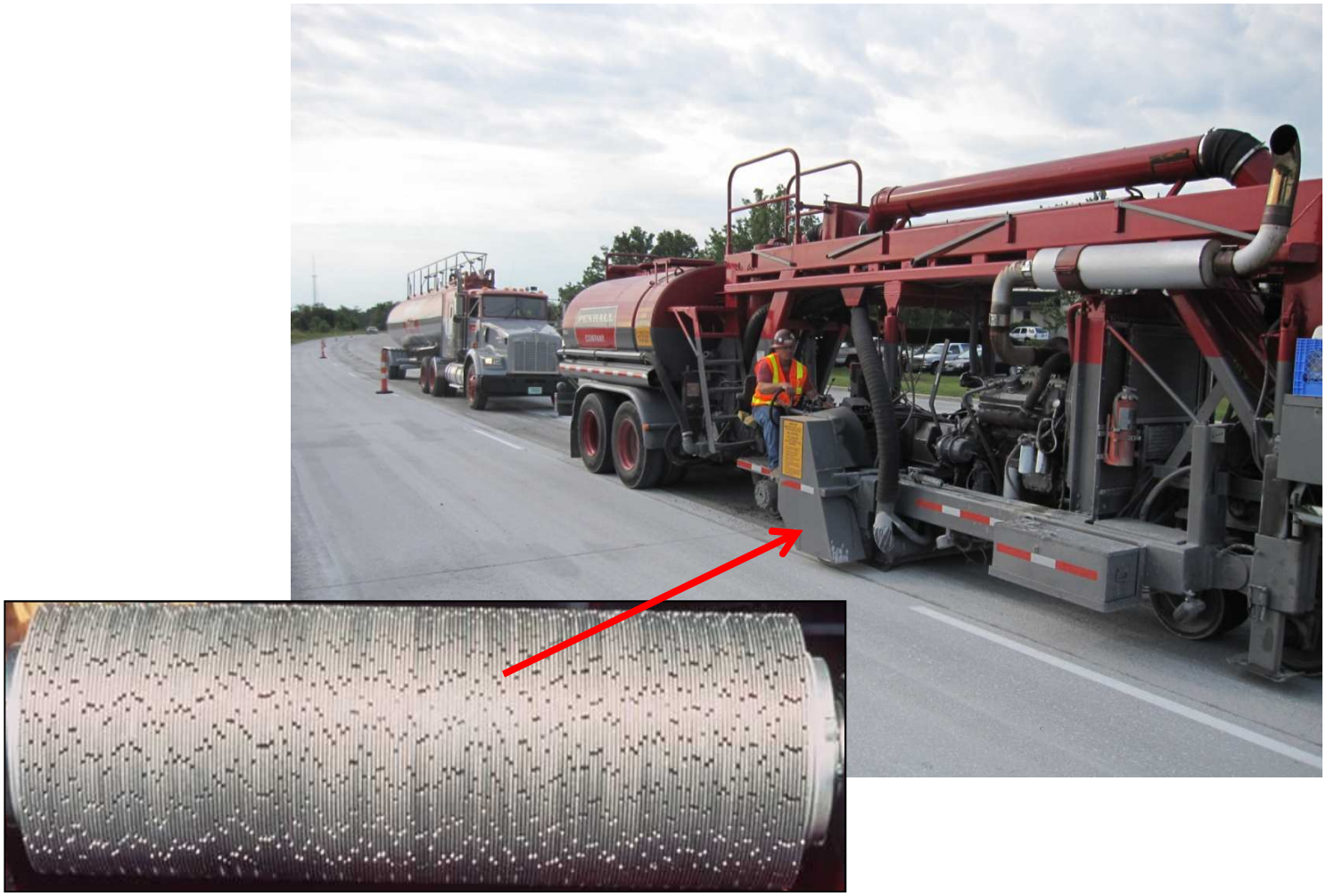
What is Diamond Grinding?

- Removal of thin surface layer of hardened Portland Cement Concrete surface 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 Machine



Diamond Grinding Process

Diamond Grinding Final Surface

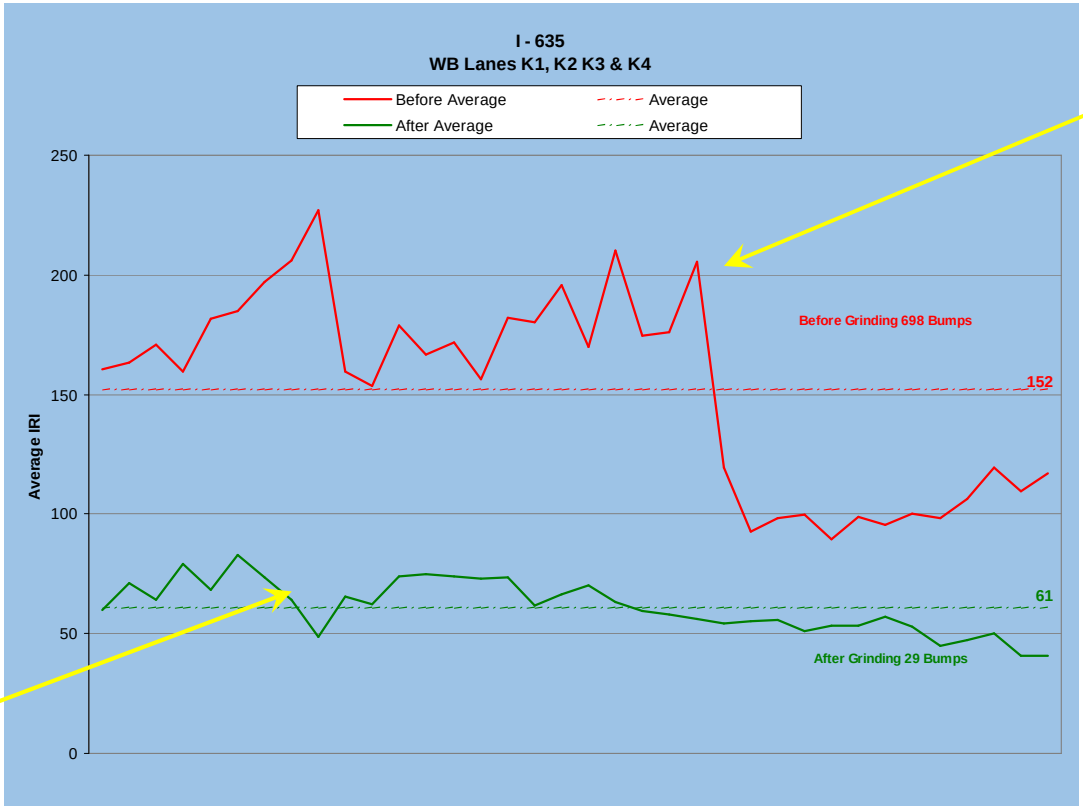
Advantages of Diamond Grinding

- Costs substantially less than an overlay solution
- 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 (stepping) at joints and cracks
- Built-in or construction roughness
- Polished concrete surface
- Wheel-path rutting
- Inadequate transverse slope
- Unacceptable noise level

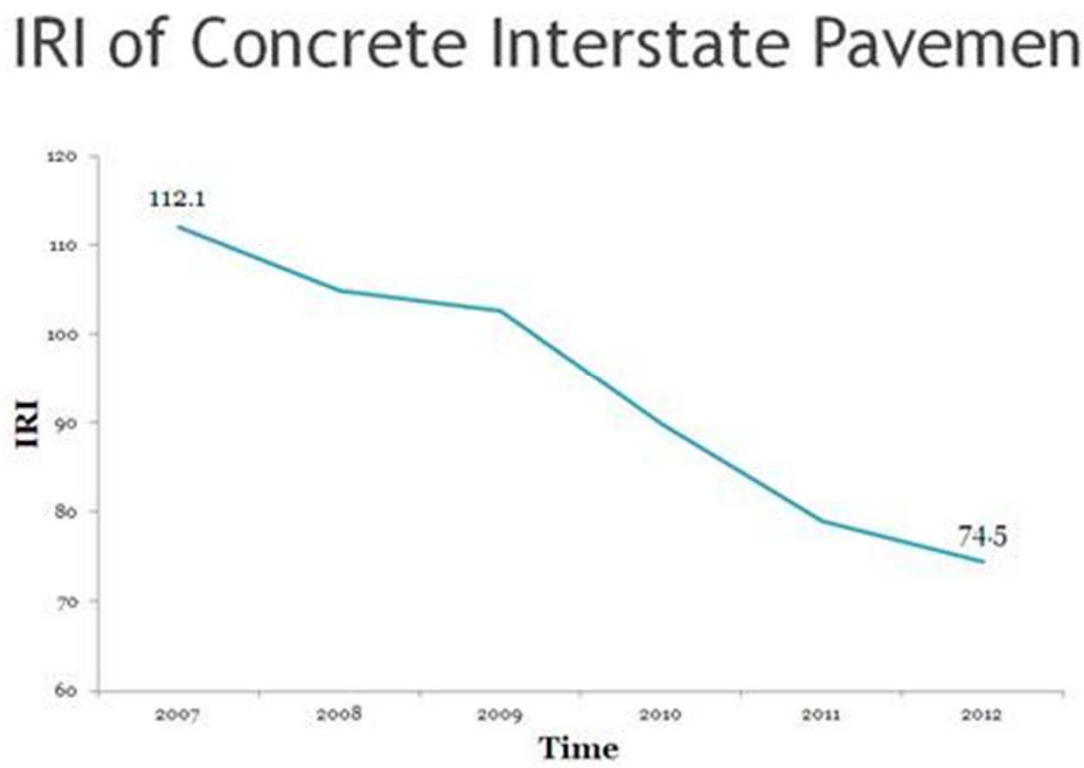
Diamond Grinding will provide a 60% to 70% improvement over the pre-grind profile on average on both asphalt and concrete pavement!



Before Grinding

After Grinding

Kentucky Transportation Cabinet Smoothness Initiative

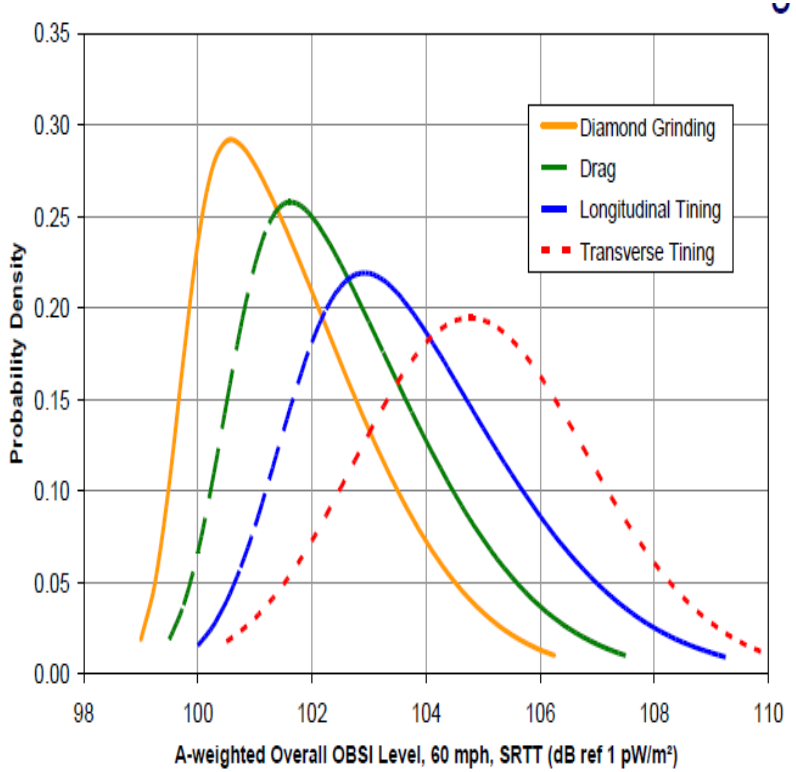


Safety, Surface Texture and Friction

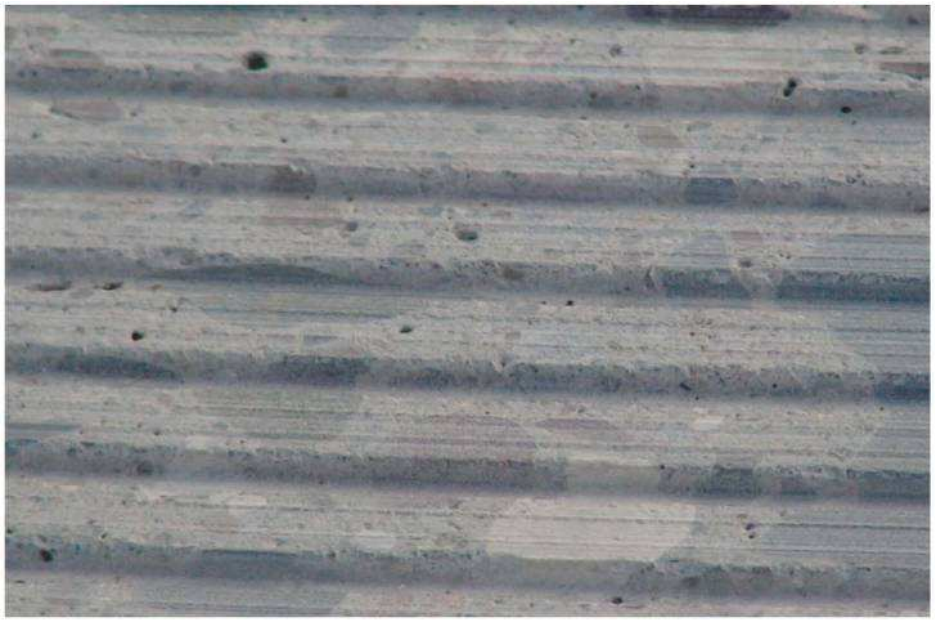
- Research conducted by Marquette University found that wet weather accident rates for ground surfaces were 57% less than for un-ground surfaces over the 6-year study period
- Increased macro-texture of diamond ground pavement surface provides for improved drainage of water at tire-pavement interface

NCPTC Noise Catalogue

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



Next Generation Concrete Surface - NGCS



2012 Diamond Grinding Rank by State- USA

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 (California Department of Transportation) 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

- 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

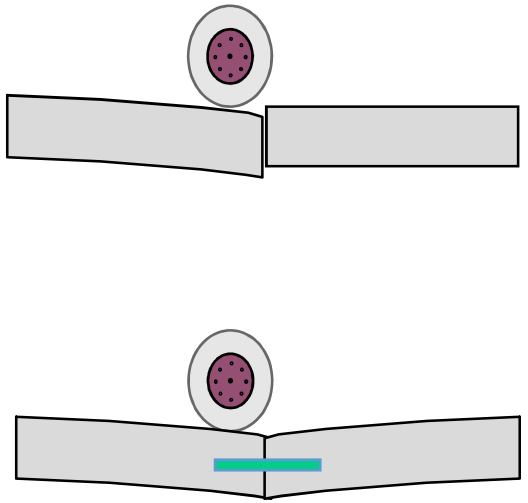
Diamond Grinding Across the Globe

- United States
- United Kingdom
- Germany
- Austria
- Australia
- Korea
- Poland
- Czech republic
- Slovakia
- Sweden
- Canada
- Mexico
- Chile
- Argentina
- Brazil
- Afghanistan
- India
- Japan
- Kyrgyzstan
- Next?

DOWEL BAR RETROFIT | 3

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

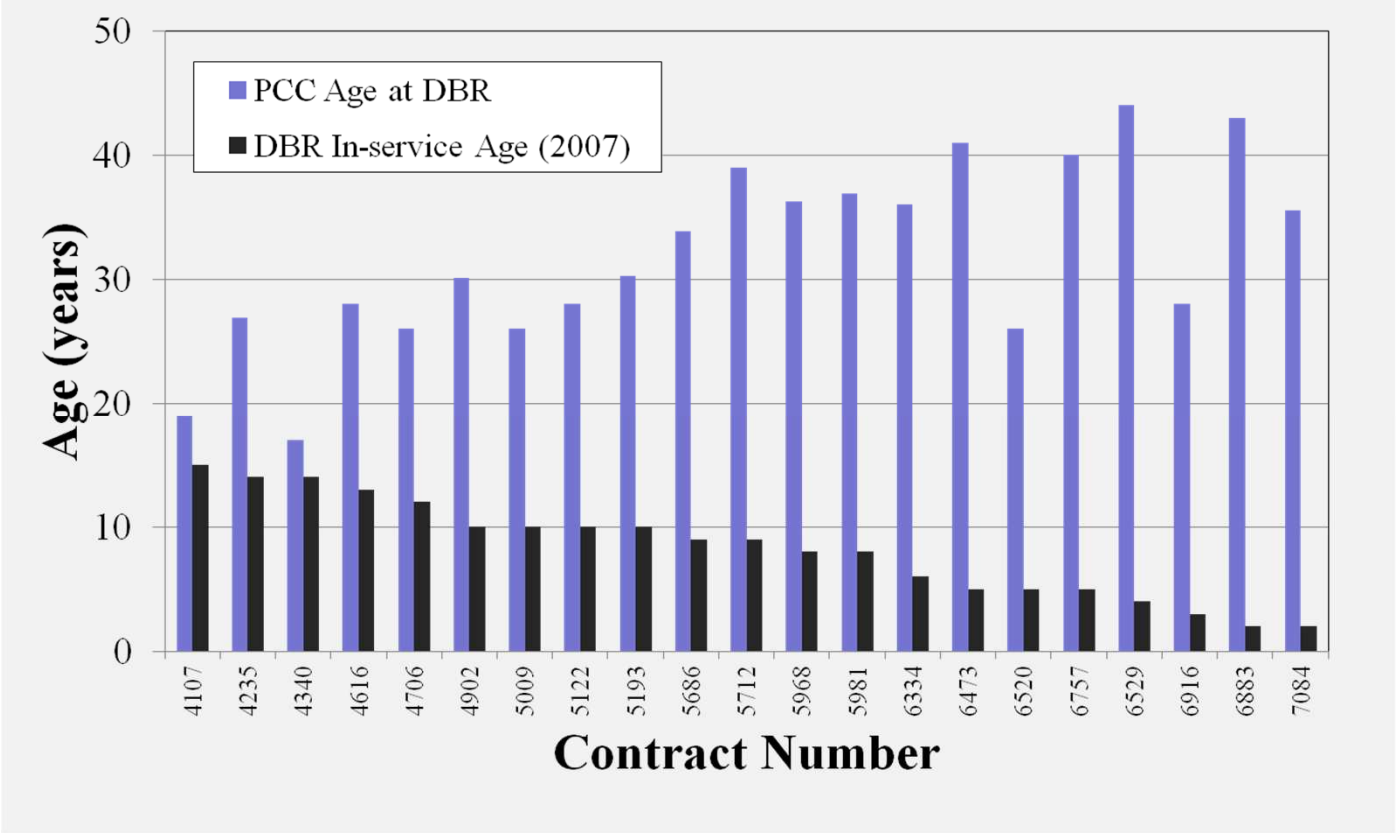


DBR Followed by Diamond Grinding

Washington State DBR Experience

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

Pavement Age vs. DBR Placement



WSDOT DBR Research

- Since 1992, WSDOT has retrofitted 280 Lane-mi (450 Lane-km) or 600,000 bars
- Original pavement design lives of 20 years
- Average age of pavement prior to DBR was 32 yrs.
- Many 30 and 40 year concrete pavements can be preserved for additional pavement life at a fraction of the cost of an overlay or reconstruction
- Concrete Pavement Preservation can extend the life of pavement many times over when used on the appropriate pavement at the appropriate time

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

ENVIRONMENTAL | 4

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 many overlay solutions. (See igga.net for complete report)

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.

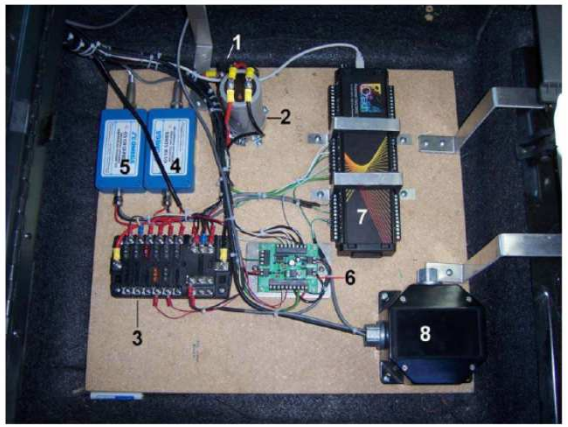
Please visit the ACPA's website at www.pavement.com or the IGGA's website at www.igga.net for more information on the best rehabilitation methods for concrete roads as well as further data on additional environmental advantages to choosing concrete roads!

CALTRANS Fuel Efficiency Research

- CALTRANS hired ARA Consulting to conduct research focused on vehicle fuel efficiency comparing various pavement 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

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 both passenger and commercial vehicles on sections where the IRI is improved, all other things being equal

Consistent with

- Passenger cars: Decrease in IRI of 63 in/mi results in a 2% fuel savings (Chatti and Zaabar 2012)
- Trucks: Decrease in IRI of 63 in/mi results in a 1% fuel savings at highway speeds and 2% at low speeds (35 mph) (Chatti and Zaabar 2012)

CONCLUSION

- 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!

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