Virginia Concrete Conference 2008

PROVAL

ProVAL

Profile Viewing and Analysis Software

Achieve Concrete Pavement Smoothness with ProVAL

Presented By:

George Chang, PhD, P.E.

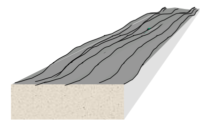
The Transtec Group

THE TRANSTEC GROUP

What is a Profile

PROVAL

- A ***profile*** is a slice of the road surface following an imaginary line



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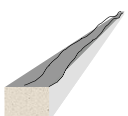

What is a Profile

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Profiler Types

PROVAL

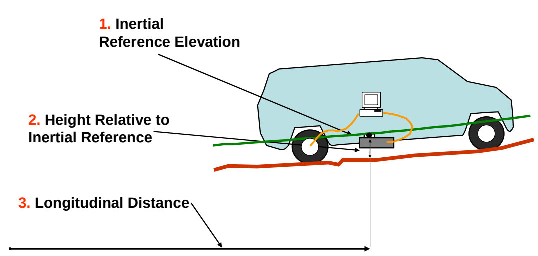
High Speed Inertial Profiler

Profiler Types

PROVAL

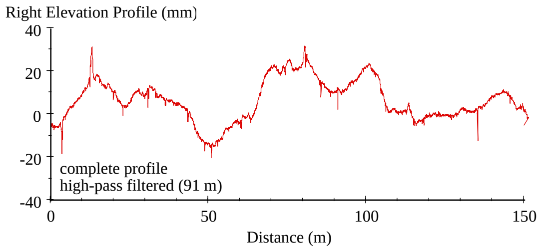
Inertial Profiler

Works by combining three ingredients:



Profiling Analysis

Complete Profile



Achieving Smoothness

- Need a Transition Tool
- Reliable and yet Simple Tool
- The Tool Has to be Industrial Standard
- The Tool Has to be Continuously Improved to Fit Industry's Needs
- The Tool Has to Have Supports (website, workshops)

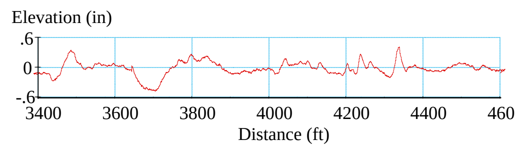
FHWA ProVAL

What Does ProVAL Do?

- **With ProVAL You Can…**

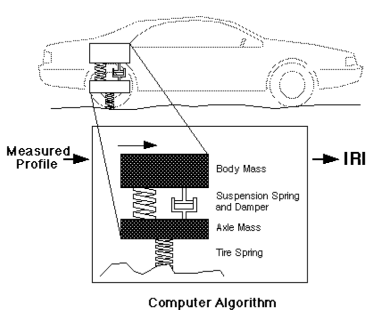
- Create profile analysis projects
- Import profiles in various formats
- Display profiles graphically
- Add information to profile data
- Perform various profile analyses

Profiler Output

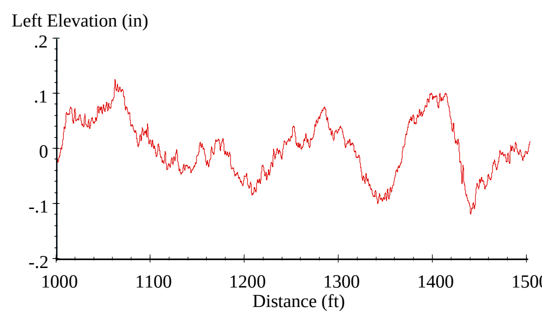


Profiler output can be used to:
1. Estimate ride quality.
2. Determine a grinding strategy.
3. Help improve construction practice for *ride.*

International Roughness Index



Elevation Profile



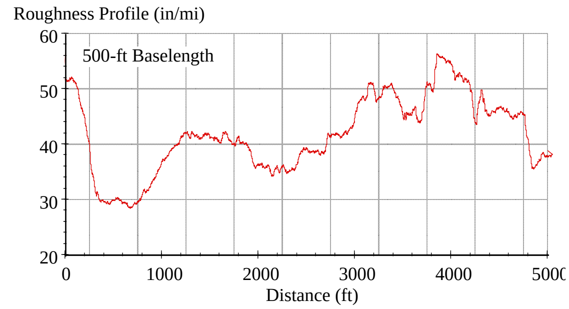
Fixed Interval Report

PROVAL

Start(ft)	End(ft)	HRI(in/mi)
0	500	39.8
500	1000	29.7
1000	1500	42.0
1500	2000	40.1
2000	2500	36.2
2500	3000	41.6
3000	3500	48.5
3500	4000	51.0
4000	4500	44.0
4500	5000	45.5

Continuous Roughness Report

PROVAL



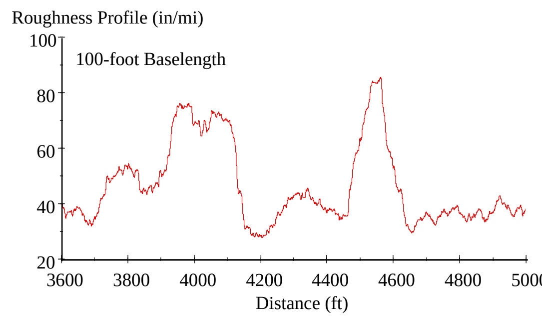
Job Summary

PROVAL

Low IRI (in/mi)	High IRI (in/mi)	Percentage
0	10	0.0
10	20	0.0
20	30	8.3
30	40	35.4
40	50	40.5
50	60	15.8
60	70	0.0
70	80	0.0
80	90	0.0
90	100	0.0

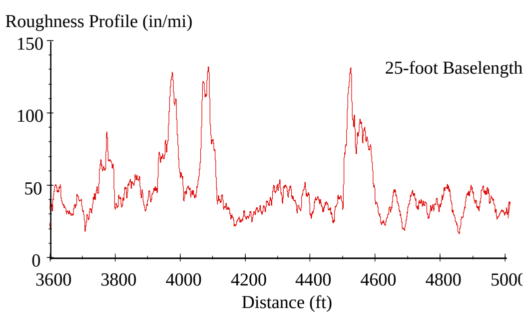
Short Interval Report

PROVAL



Short Interval Report

PROVAL

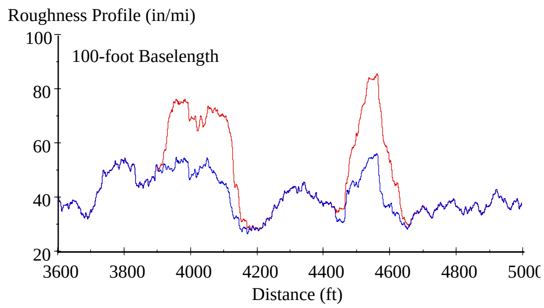


Hot Spot Locations

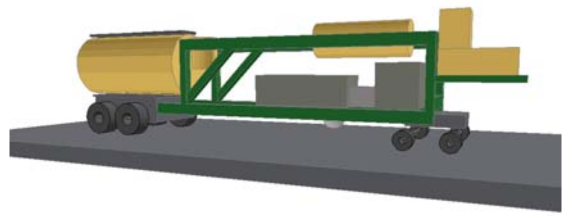
PROVAL

Segment Start (ft)	Segment End (ft)	Peak HRI (in/mi)
3201	3274	64.6
3276	3280	60.3
3925	4123	76.5
4495	4583	85.9

Grinding Simulation

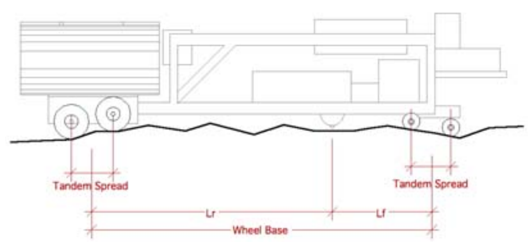


25-foot Grinder



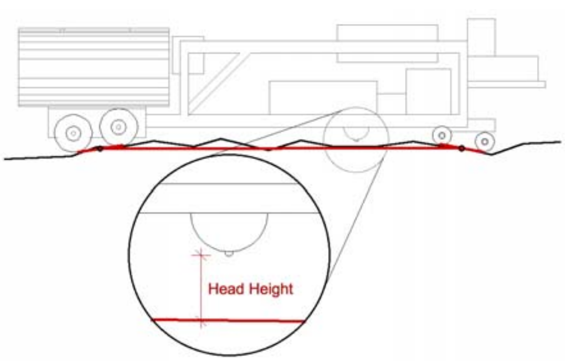
25-foot Grinder

Grinder Setup



Head Position = Lf / Wheel Base

Grinder Setup

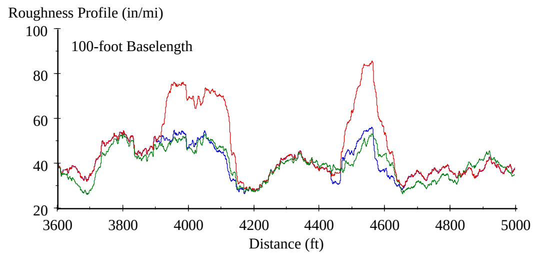


Optimal Grinding Strategy

Grind Start (ft)	Grind End (ft)	HRI Change (in/mi)	Max. Depth (in)
3945	3990	4.8	0.36
4058	4093	5.4	0.33
4473	4587	6.1	0.16

Validation Report

Validation Report

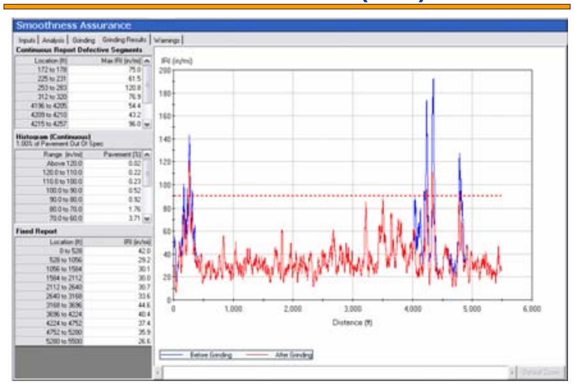


Smoothness Assurance Module

Essential Features

1. Uses Profilers rather than Profilographs
2. Allows a Choice of an Index
3. Make Continuous Reporting Possible
4. Includes both Short and Long Interval Criteria
5. Produces a Grinding Simulation

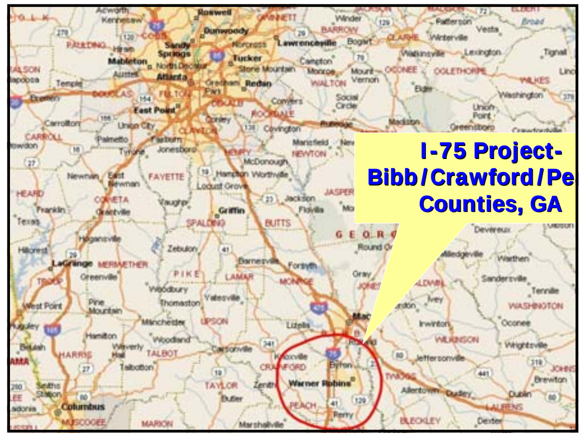
Smoothness Assurance Module (SAM)

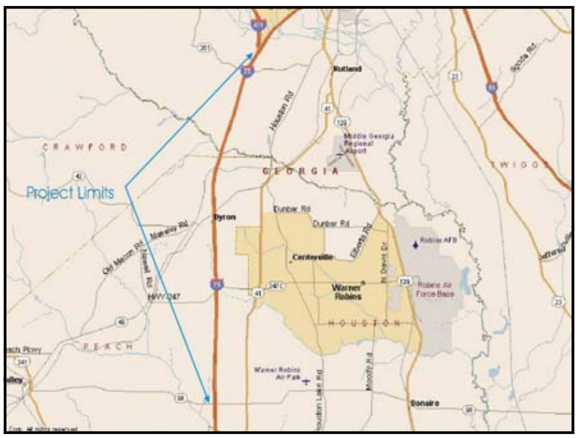


Where to Download ProVAL

Where to Download ProVAL

www.RoadProfile.com





Project Information

I-75 Peach, Crawford, & Bibb Counties, GA

- 141,200 SY Outside Lane Replacement
  - 10 inches thick; 12 ft wide
  - Reconstruction completed in 16 weeks
  - Winter & Spring 2003
  - All major work was done at night
- Project Letting Date: April 19, 2002
- Bid Amount $19,125,146.20
  88.4 Traffic Lane Miles
  29.5 Shoulder Miles
  20.1 Concrete Lane Replacement Miles

Scope of Project

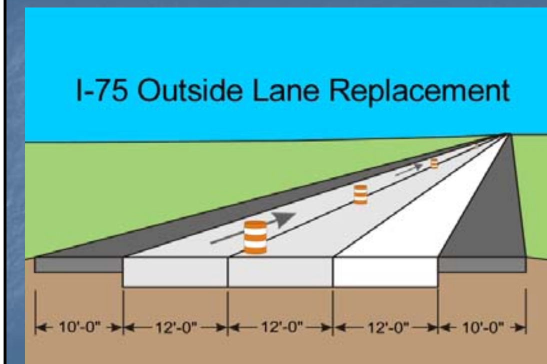
- Removal and Replacement of outside lane
- Full Depth and Partial Depth Patching on the middle lane
- Diamond Grinding of all 3 lanes
- Reconstruction of outside shoulder

Existing Slabs

- No Dowels
- 10 inch thick
- Joint spacing 30 feet
- Base: Soil Aggregate with top three inches bituminous stabilized.

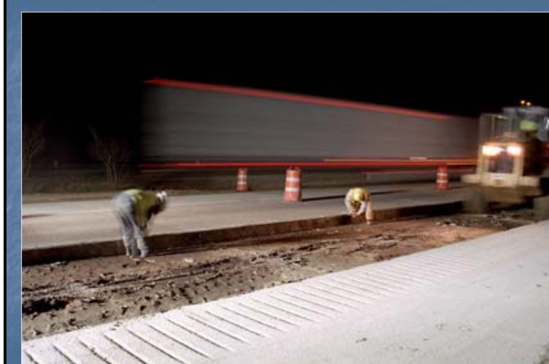
New Slabs

- Thickness 10 ½- 11 inches (Payment by CY as measured in place)
- Maximum Joint Spacing 15 feet
- Dowel Bars
- Structural Welded Wire Reinforcing Grade 80 equivalent to #5 Rebar @ 12" centers
- Strength of concrete 2500 psi in 24 hours
  - 3500 psi in three days.



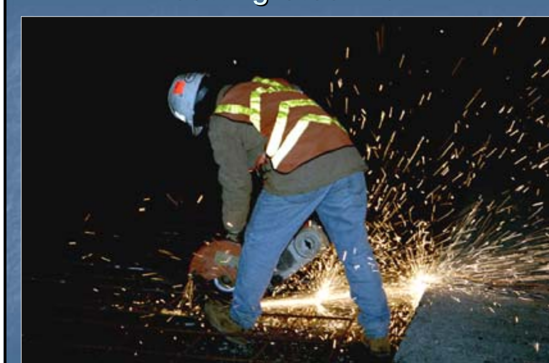
Remove Existing Slabs

Joint Seal Removal



Steel Mat in Place

Cutting Steel Mat

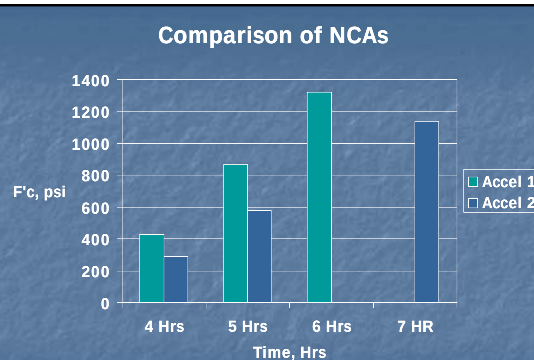


Concrete Plant Site

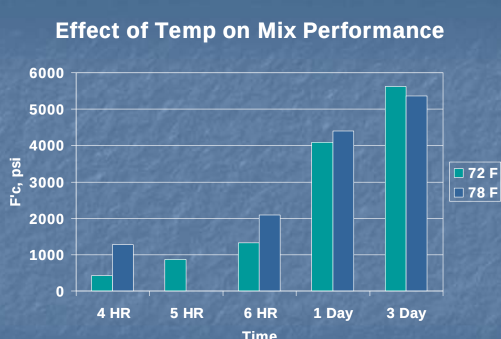
Mix Designing in the laboratory

Bibb Co. Mix Design
October 2002

- 5 Non-Chloride Accelerators
- Cure box vs. floor
- Heated water vs. tap

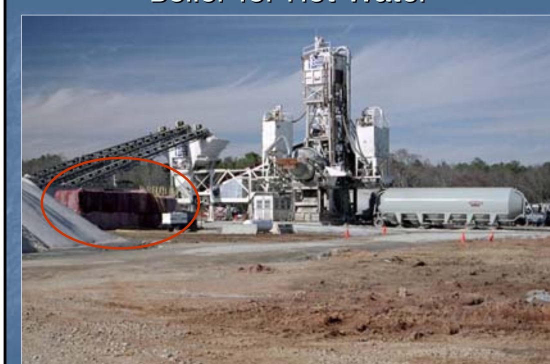


3 gal of Accelerator 1; 3.5 gal of Accelerator 2



2 in slump, 5.4% air vs. 2.5 in slump and 5.5% air

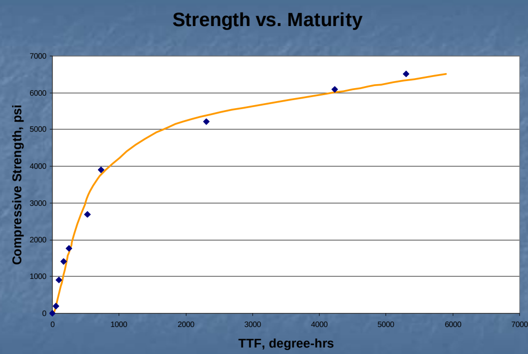
Boiler for Hot Water



Concrete Mix

- 8 sacks Type I cement
- 3 gal NCA
- 0.351 w/c ratio
- Boiler for hot water
- Specified 2,500 psi in 24 hours
  - +/- 1200 psi in 4 hrs
- Target of 5% air
- Slump -- 1.5 inches maximum

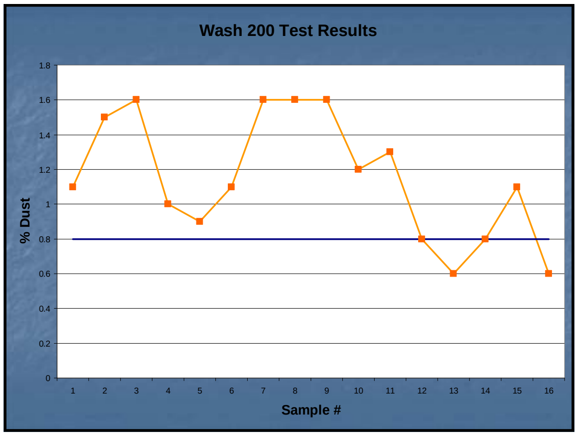
Maturity



Field Laboratory

Consistency

- Materials
- Mixture



Slip-Forming Concrete

Next Day Open to Traffic

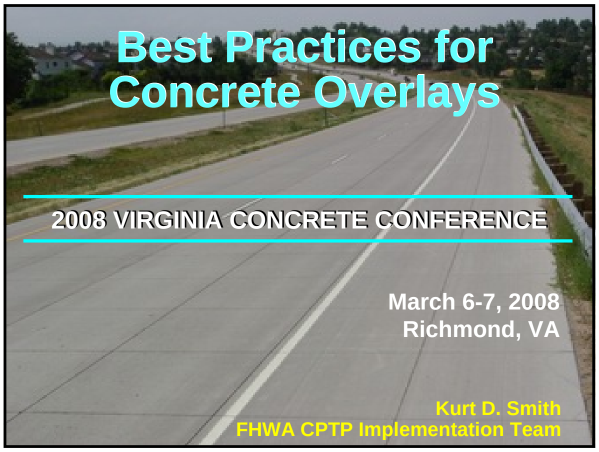
Lessons Learned

- Provide separate bid items for lane removals and for different types of full depth patching.
- Use cubic yard/cubic meter units of measure for replacement items.
- Off-set the longitudinal edge joint of the lane being replaced into the adjacent remaining pavement 1" to 2" to eliminate the seal reservoir so as to reduce the potential for spalling at that joint.
- Re-establish Underdrain outlets/french drains at low points through shoulder.

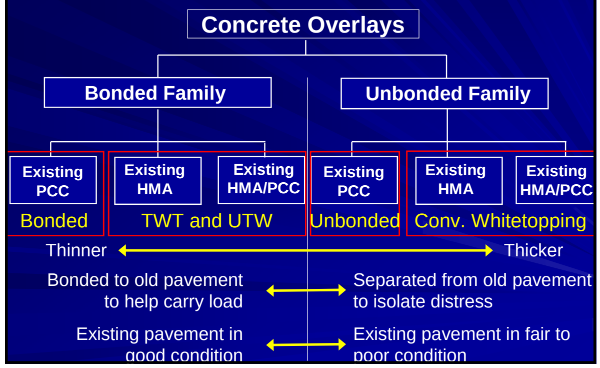
Lessons Learned

- Perform concrete pavement repairs in adjacent lanes prior to lane replacement when possible.
- Perform diamond grinding of adjacent lanes prior to lane replacement when possible.
- Allow the use of maturity for opening to traffic.

Questions or Comments?



Concrete Overlay Families



Concrete Overlays in VA
(courtesy David Kaulfers)

- 1920s: Virginia's first PCC overlay on existing PCC
- 1930s thru 1980s: Some unbonded PCC overlays (primarily airports)
- 1990: Bonded PCC overlay on US-13 in Northhampton County
- 1995: Bonded PCC overlay on I-295 near Richmond
- 1995: Bonded PCC overlay on I-85 near Petersburg
- 1999: UTW on Rt. 29N south of Charlottesville

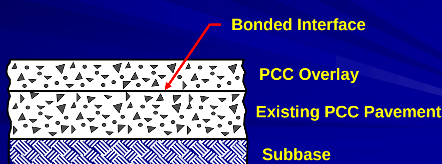
BONDED OVERLAY FAMILY

- PCC/ PCC
- Thin and Ultra-Thin Whitetopping

Bonded PCC/PCC

Bonded PCC/PCC Overlays

- 3 to 4 in PCC
- Bonded to existing PCC (monolithic behavior)
- Aggressive surface preparation
- Increases structural capacity and rideability



Bonded PCC/PCC

Feasibility

- Pavements in good condition with need for:
  - Increased structural capacity
  - Improved surface characteristics

- Unsuitable candidates:
  - Pavements with structural deterioration
  - Pavements with moderate/severe MRD

Bonded PCC/PCC

Key Considerations

- Pre-overlay repair (as needed)
- Effective surface preparation
- Overlay joints match those in underlying pavement
- Effective timing and sawing of transverse & longitudinal joints
  - Through entire overlay thickness + ½ inch
- Effective curing

Bonded PCC/PCC

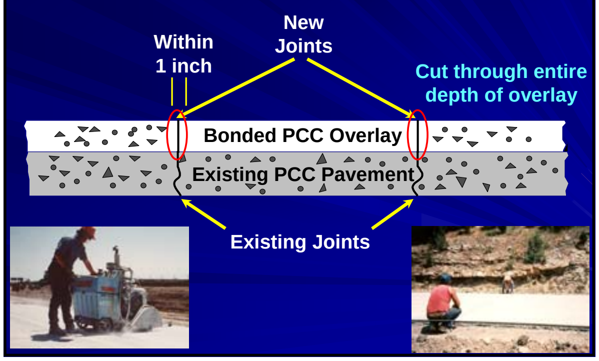
Surface Preparation

- Needed to ensure monolithic behavior
- Process:
  - Mechanical preparation (generally shotblasting or sandblasting)
  - Surface cleaning (e.g., airblasting)

Shotblasting Equipment

Bonded PCC/PCC

Matching of Joints



Bonded PCC/PCC

Performance

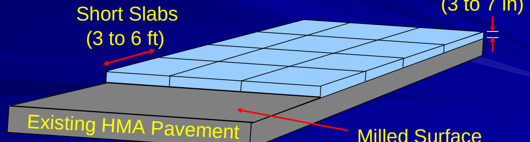
- Mixed performance
- Extensive use in TX and IA
- Performance issues:
  - Inappropriate use (too far deteriorated)
  - Effective bond
  - Joint details

- Virginia projects:
  - US 13: 3.5 in PCC / 8 in JPCP (1990)
  - I-295: 2 in PCC / 8 in CRCP (1995)
  - I-85: 4 in PCC / 8 in CRCP (1995)

TWT/UTW

Thin and Ultra-Thin Whitetopping (TWT/UTW)

- UTW
  - 3 to 4 in
  - 3 to 6 ft slabs
  - Possible fibers
- TWT
  - 4 to 7 in
  - 6 x 6 panels



TWT/UTW

Feasibility

- TWT (*moderately loaded routes*)
  - State/county hwys
  - Secondary routes
  - Collectors
- UTW (*lightly loaded routes*)
  - City streets
  - Urban intersections
  - Parking lots

Pavements in relatively good condition and with structural integrity

Key Considerations

TWT/UTW

- Pre-overlay repair (as needed)
- Effective surface preparation
- Joint design
  - Maximum panel spacing: 12 to 15 * D
  - Avoid placement in wheel paths
- Effective timing and sawing of joints
- Effective curing

Surface Preparation

TWT/UTW

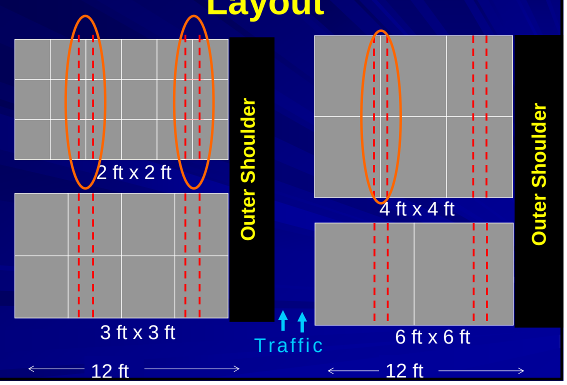
- Milling HMA surface
  - Remove rutting
  - Restore profile
  - Enhance bond
- Minimum HMA thickness remaining after milling: 3 to 5 in
- Surface cleaning (e.g., airblasting)

Milled Surface

TWT/UTW

Longitudinal Joint Layout

TWT/UTW



Performance

TWT/UTW

- TWT: Good performance
  - CO and IL
- UTW: Fair-to-good performance
  - TN, KS, KY
- Performance issues:
  - Proper application
  - Effective bond
  - Effective joint design (layout)
- Virginia Project (1995)
  - Experimental UTW on Rt. 29N
  - Various thicknesses and fiber usage

Colorado TWT Experience

TWT/UTW

- Early 1990s
- 6 x 6 x 6 design
- Conventional concrete mixture
- Milled and cleaned HMA surface
- No dowels
- Deformed tie bars across longitudinal joints
- Single cut, sealed joints (silicone)

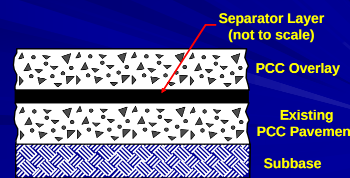
UNBONDED OVERLAY FAMILY

- PCC/ PCC
- Conventional Whitetopping

Unbonded PCC/PCC

Unbonded PCC Overlays

- 8 to 12 in PCC
- Separated from underlying PCC
- Minimal surface preparation
- Virtually any PCC pavement type and condition



Unbonded PCC/PCC

Feasibility

- PCC pavements in poor to fair condition
- Any traffic level
- Any existing PCC pavement type
- Site factor considerations
  - Lane-closure time
  - Overhead clearances
  - Shoulders

Unbonded PCC/PCC

Key Considerations

- Limited pre-overlay repair required
- Placement of separator layer
- Joint design
  - Spacing < 21 * D (max 15 ft)
  - No need to match joints (offset if practical)
  - Dowel as for conventional pavements

Unbonded PCC/PCC

Separator Layer

- Isolates overlay from existing pavement
  - Prevents reflection cracking
  - Prevents mechanical interlocking
- Provides level surface for overlay construction
- Recommended interlayer material:
  - 1-2 inch dense-graded HMA

Unbonded PCC/PCC

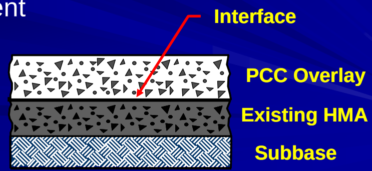
Performance

- Generally good performance
- Extensive use by many highway agencies (e.g., IA, MI, MN, CO)
- Performance issues:
  - Adequate separator layer
  - Adequate structural design
  - Effective joint design
- Virginia: No recent experience

Conv. Whitetopping

Conventional Whitetopping

- Slabs ≥ 6 in thick
- Placed directly on HMA pavement (little preoverlay repair)
- Designed as a new PCC pavement (assuming no bonding)



Conv. Whitetopping

Feasibility

- Badly deteriorated HMA pavements
- Any traffic level
- Site factor considerations
  - Lane-closure time
  - Overhead clearances
  - Shoulders

Conv. Whitetopping

Key Considerations

- Localized pre-overlay repair
- Limited surface preparation
  - Milling if significant distortions
- Joint design
  - Spacing < 21 * D (max 15 ft)
  - Dowel as for conventional pavements

Conv. Whitetopping

Performance

- Good to excellent performance
- Extensive use in Iowa, Nevada, California, Texas
- Performance issues
  - Uniform support
  - Effective joint design
- Virginia: no recent experience

Summary

- PCC overlays offer a long-lasting, low maintenance rehabilitation solution
  - Bonded Solutions:
    - ➢On existing PCC
    - ➢On existing HMA (TWT/UTW)
  - Unbonded Solutions
    - ➢On existing PCC
    - ➢On existing HMA (whitetopping)
- Each a unique structure with specific applications and design/construction considerations

Virginia Concrete Conference 2008

COMPASS

Optimized Mix Design Proportioning Procedures COMPASS

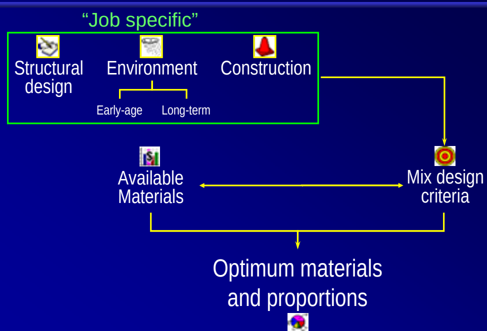
Presented by:
George Chang, PhD, P.E.
The Transtec Group

THE TRANSTEC GROUP

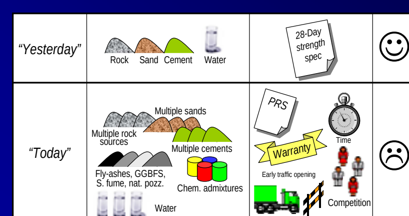
FHWA CPTP Task 64

- Develop computer-based guidelines for job-specific optimization of paving concrete
- Considerations:
  - Used by concrete pavement engineers, materials engineers, and paving concrete suppliers
  - Balance practical and reliable
  - For JPCP, CRCP, and patch/repair mixtures
  - Conventional concrete-making materials

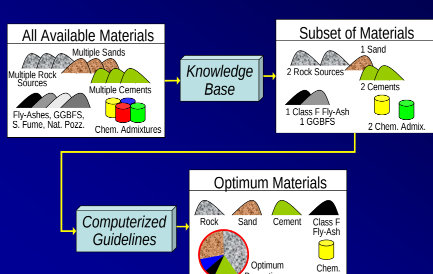
Job-specific optimization



Why optimize?



How to Optimize?



COMPASS

1. Mix Expert
2. Gradation optimization
3. Initial proportioning
4. Proportioning optimization

Mix Expert

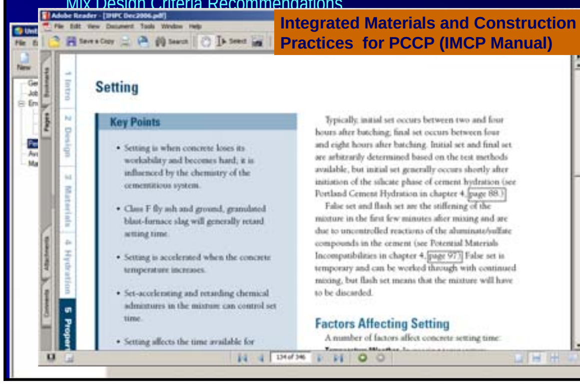
Site Specific Conditions
- Project Type
- Design & Construction Info
- Climate
- Exposure

Design Criteria Recommendations
- Important PCC Properties
- Recommended Test Methods
- Recommended Materials

7

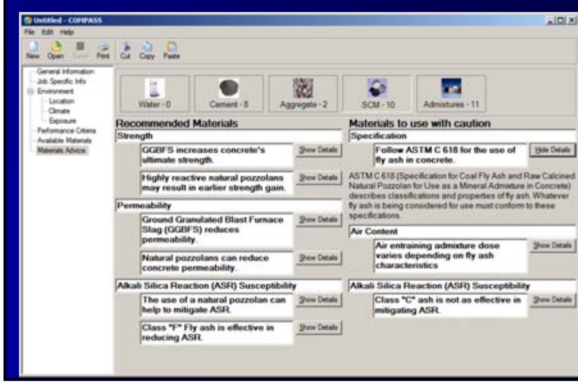
Mix Expert

Mix Design Criteria Recommendations



Mix Expert

Materials Recommendations



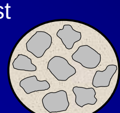
COMPASS

1. *Mix Expert*
2. ***Gradation optimization***
3. *Initial proportioning*
4. *Proportioning optimization*

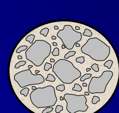
10

Aggregate Gradation Optimization

- Purpose: *to determine optimal proportioning of available aggregates to…*
  - Improve durability
  - Maximize strength potential
  - Achieve workability requirements for paving applications
  - Minimize cost



Gap-Graded Mixture



Well-Graded Mixture

11

Aggregate Packing

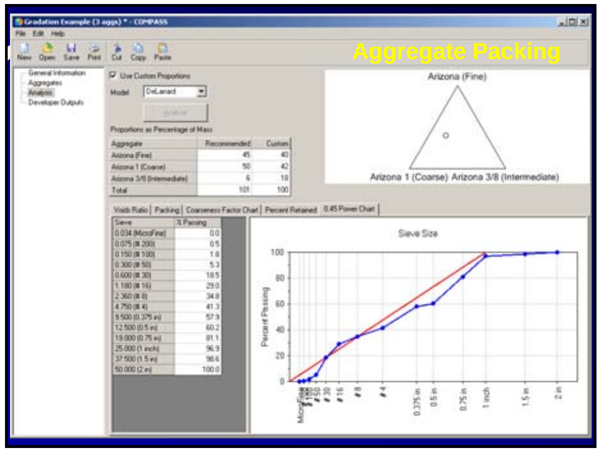
- Packing Models Identified
  - Dewar - Theory of Particle Mixtures
  - De Larrard - Compressible Packing Model
  - Toufar (SHRP)
- Characteristics
  - Volumetric models
  - Minimize voids in aggregate structure
  - All validated with actual mix data

12

Aggregate Packing

- "Reality Checks"
  - Application of practical principles learned from construction practice
  - Aggregate gradation for PCC mixtures
    - Coarseness Factor Chart
    - 0.45 Power Chart (Asphalt Industry)
    - Percent Retained (8-18 Chart)

13



COMPASS

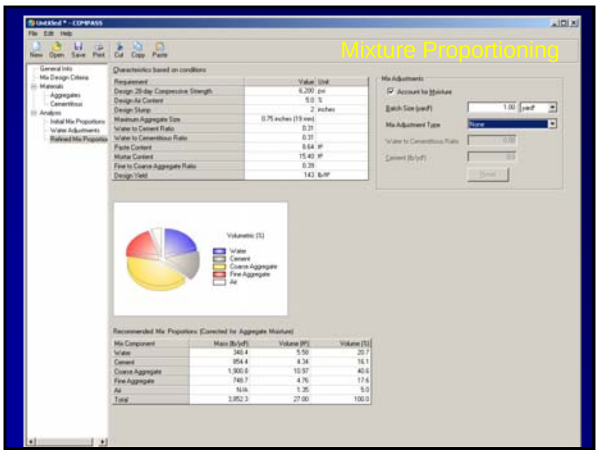
1. *Mix Expert*
2. *Gradation optimization*
3. ***Initial proportioning***
4. *Proportioning optimization*

15

Water Content

Adjustments to Basic Water Requirement			
	Water adjustment	Water adjustment range	Adjustment Percentage Selected
1.	**Aggregate shape & texture** Baseline = cubical crushed stone • Rounded deduct 0-5% • Elongated add 0-3%	(-5 to +5%)	
2.	**Combined aggregate grading** (0 for ACI 211.1 Assumptions)	(-10 to +10%)	
3.	**Air entraining admixture** Effect varies with higher air content and other factors. Zero at 2% air, 10% for about 6% air.	(-10 to 0%)	
4.	**Normal range** water reducing admixture	(- 10 to -5%)	
5.	**Mid-range** water reducing admixture (MRWRA)	(-15 to –8%)	
6.	**High-range** water reducing admixture (HRWRA= *Superplasticizer*)	(-30 to -12%)	
7.	**Mineral Admixtures** Flyash to Silica Fume	(-10 to +15%)	
8.	**Other factors such as:** w/c, cement fineness, temperature	(-10 to +10%)	
9.	Cumulative adjustment percentage = sum of all values.		= sum
10.	Suggested maximum reduction recognizing overlapping effects of individual factors		-30%
11.	Water Adjustment Factor		= 1.00+(sum/100)

(taken from Hover 2001)



COMPASS

1. *Mix Expert*
2. *Gradation optimization*
3. *Initial proportioning*
4. ***Proportioning optimization***

18

Mixture optimization

How to optimize?

Criteria: Cost, Permeability, Strength, Stiffness, Workability, Plastic shrink., Performance

Models

Materials: Coarse aggregate, Fine aggregate, Cement, Water, SCMs, Chemical admixtures, Fibers

"Optimum" PCC mixture

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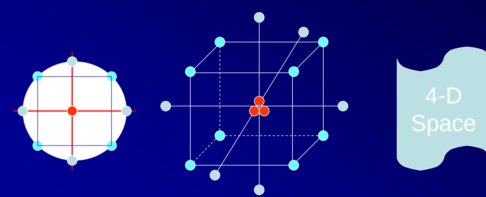
Statistical Optimization

Design of Experiments



2-factor model 3-factror model 4-factor model

Number of trial batches increases
based on number of factors

20

Response Models

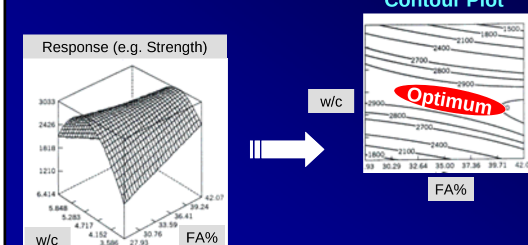
- In general, a response is a property of interest that can be expressed in terms of one or more factors
- For concrete, response models relate the materials proportions to concrete properties (mix design criteria)

21

Statistical Optimization

Response Surface Methodology (RSM)

Contour Plot



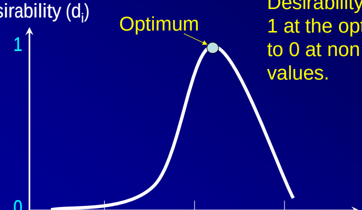
Response Surface

22

Optimization

Desirability functions

Desirability functions are used to optimize for <u>several</u> mix design criteria simultaneously.



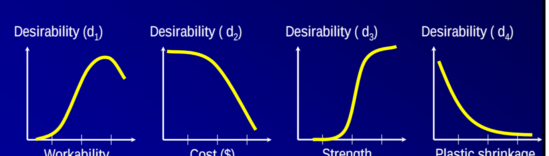
Desirability varies from 1 at the optimum value to 0 at non acceptable values.

23

Optimization

Desirability functions

For each mix design criterion an individual desirability function d_i is defined:



<u>Overall</u> desirability is a combination of the individual desirabilities reflecting the relative importance of each criterion

24

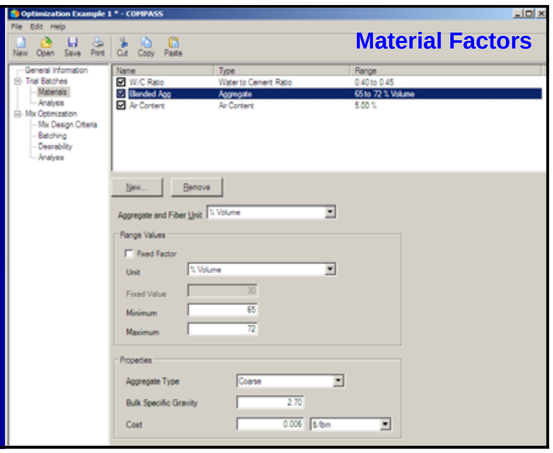
Optimization

Overall desirability

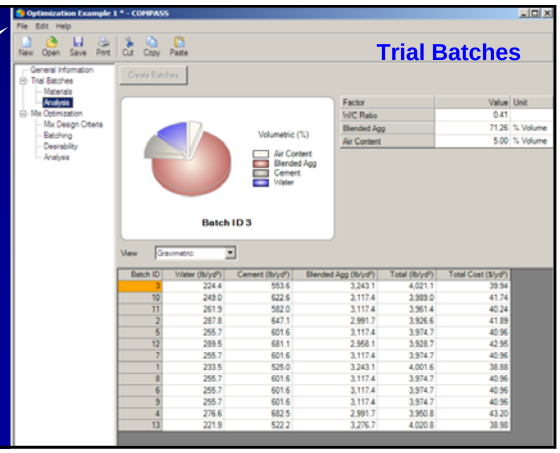
Optimization process

1. Define mix design criteria
2. Define initial set of trial mixtures
3. Develop response models
4. Predict properties from response models for extended set of mixtures
5. Identify optimal mix using desirability functions

Material Factors

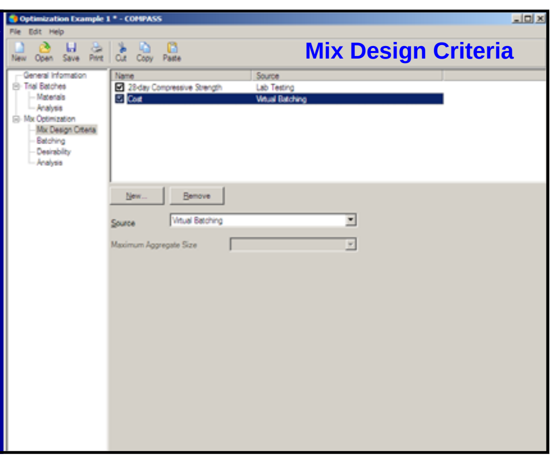


Trial Batches

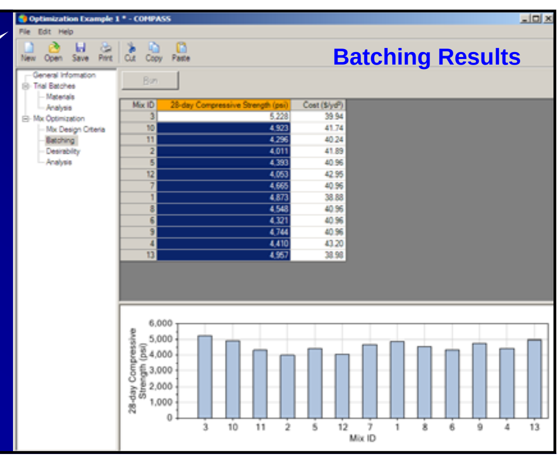


Batch ID	Water (lb/yd³)	Cement (lb/yd³)	Blended Agg (lb/yd³)	Total (lb/yd³)	Total Cost ($/yd³)
3	224.4	553.6	3,243.1	4,021.1	39.94
10	249.0	622.6	3,117.4	3,989.0	41.74
11	261.9	582.0	3,117.4	3,961.4	40.24
2	287.8	647.1	2,991.7	3,926.6	41.89
5	255.7	601.6	3,117.4	3,974.7	40.96
12	289.5	681.1	2,958.1	3,928.7	42.95
7	255.7	601.6	3,117.4	3,974.7	40.96
1	233.5	525.0	3,243.1	4,001.6	38.88
8	255.7	601.6	3,117.4	3,974.7	40.96
6	255.7	601.6	3,117.4	3,974.7	40.96
9	255.7	601.6	3,117.4	3,974.7	40.96
4	276.6	682.5	2,991.7	3,950.8	43.20
13	221.9	522.2	3,276.7	4,020.8	38.98

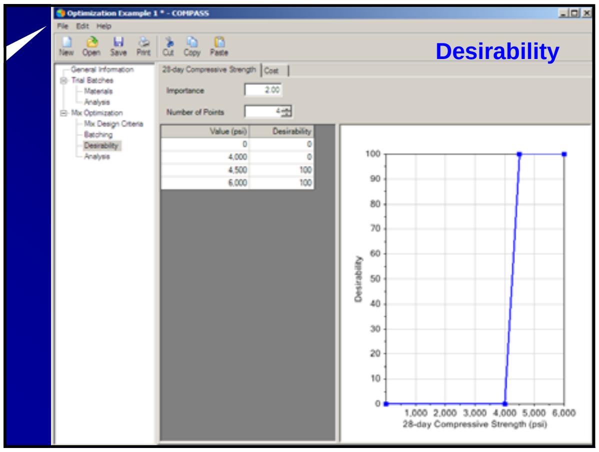
Mix Design Criteria

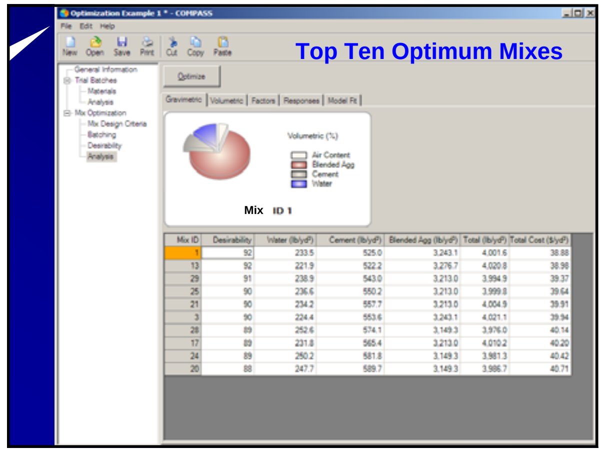


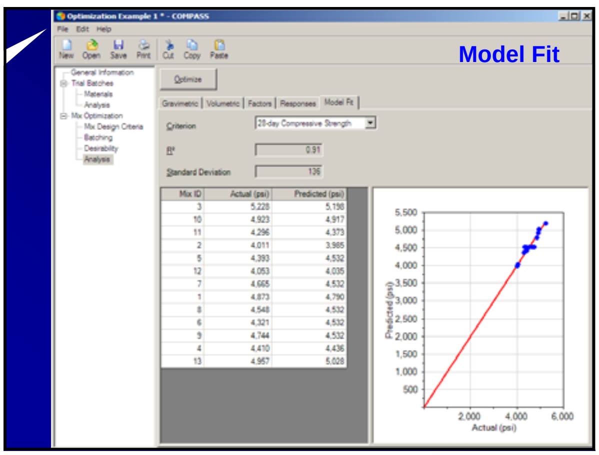
Batching Results



Mix ID	28-day Compressive Strength (psi)	Cost ($/yd³)
3	5,228	39.94
10	4,923	41.74
11	4,296	40.24
2	4,011	41.89
5	4,393	40.96
12	4,053	42.95
7	4,665	40.96
1	4,873	38.88
8	4,548	40.96
6	4,321	40.96
9	4,744	40.96
4	4,410	43.20
13	4,957	38.98


Optimization Example 1 * - COMPASS
Desirability
28-day Compressive Strength
Cost
Importance 2.00
Number of Points 4
Value (psi) | Desirability
0 | 0
4,000 | 0
4,500 | 100
6,000 | 100
Desirability
28-day Compressive Strength (psi)


Optimization Example 1 * - COMPASS
Top Ten Optimum Mixes
Optimize
Gravimetric | Volumetric | Factors | Responses | Model Fit
Volumetric (%)
Air Content
Blended Agg
Cement
Water
Mix ID 1
Mix ID | Desirability | Water (lb/yd³) | Cement (lb/yd³) | Blended Agg (lb/yd³) | Total (lb/yd³) | Total Cost ($/yd³)
1 | 92 | 233.5 | 525.0 | 3,243.1 | 4,001.6 | 38.88
13 | 92 | 221.9 | 522.2 | 3,276.7 | 4,020.8 | 38.98
29 | 91 | 238.9 | 543.0 | 3,213.0 | 3,994.9 | 39.37
25 | 90 | 236.6 | 550.2 | 3,213.0 | 3,999.8 | 39.64
21 | 90 | 234.2 | 557.7 | 3,213.0 | 4,004.9 | 39.91
3 | 90 | 224.4 | 553.6 | 3,243.1 | 4,021.1 | 39.94
28 | 89 | 252.6 | 574.1 | 3,149.3 | 3,976.0 | 40.14
17 | 89 | 231.8 | 565.4 | 3,213.0 | 4,010.2 | 40.20
24 | 89 | 250.2 | 581.8 | 3,149.3 | 3,981.3 | 40.42
20 | 88 | 247.7 | 589.7 | 3,149.3 | 3,986.7 | 40.71


Optimization Example 1 * - COMPASS
Model Fit
Optimize
Gravimetric | Volumetric | Factors | Responses | Model Fit
Criterion 28-day Compressive Strength
R² 0.91
Standard Deviation 136
Mix ID | Actual (psi) | Predicted (psi)
3 | 5,228 | 5,198
10 | 4,923 | 4,917
11 | 4,296 | 4,373
2 | 4,011 | 3,985
5 | 4,393 | 4,532
12 | 4,053 | 4,035
7 | 4,665 | 4,532
1 | 4,873 | 4,790
8 | 4,548 | 4,532
6 | 4,321 | 4,532
9 | 4,744 | 4,532
4 | 4,410 | 4,436
13 | 4,957 | 5,028
Predicted (psi)
Actual (psi)


U.S. Department of Transportation
Federal Highway Administration
www.PCCMix.com
THE TRANSTEC GROUP

Concrete Pavement Maintenance

Making The Most of Your Concrete Assets

Some Things Last Forever

3/11/2008 2

And others need a little TLC

3/11/2008 3

PCCP Withstands the Test Of Time &Traffic

3/11/2008 4

Priorities Have Shifted

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

3/11/2008 6

The Marketplace Has Changed

3/11/2008 7

Preservation and Restoration

- First level of response for deteriorating concrete pavements should always be Preservation/Restoration
  - Least cost – Cheaper than reconstruction
  - Least service disruption
  - Increases safety
  - Environmentally sound
  - Addresses operator comfort

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PCCP Preservation Techniques

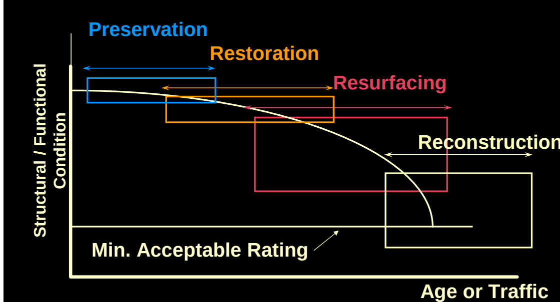
- Full-depth repair
- Partial-depth repair
- Slab stabilization
- Retrofitting dowels
- Cross-stitching longitudinal cracks/joints
- Diamond grinding
- Joint & crack resealing

3/11/2008 10

How do preventive treatments differ from routine/reactive treatments?

Same treatments …different TIMING!

Rehabilitation Timing



Purpose of CPP

- Used early when pavement has little deterioration.
  - Repairs isolated areas of distress.
  - Repairs some construction defects.
  - Manages the rate of deterioration.

3/11/2008

Expected Benefits

- Preservation of investment
  - Improved pavement performance
  - Long term cost savings/leveling
- Maintain a high level of service
  - Increased safety
  - Greater customer satisfaction

3/11/2008 14

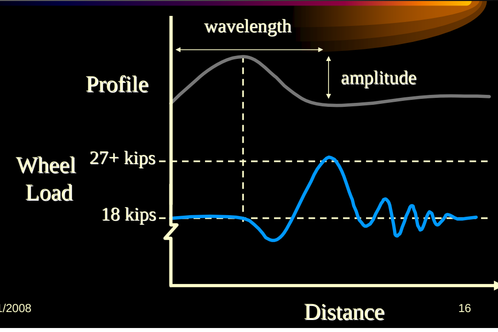
Preserving the Investment

- Keep water out!
- Reduce debris infiltration into joints or cracks
- Minimize dynamic loads

SMOOTH PAVEMENTS LAST LONGER!

3/11/2008 15

Rough Pavement



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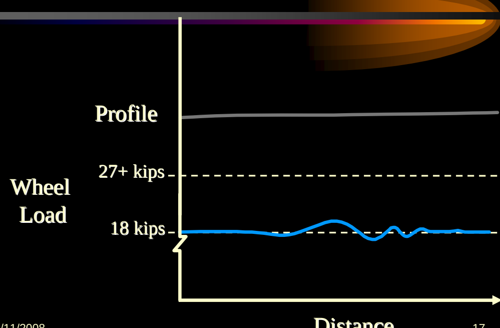
Smooth Profile



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Diamond Grinding

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What is Diamond Grinding?

- Removal of thin surface layer of hardened PCC using closely spaced diamond saw blades;
- Results in smooth, level pavement surface;
- Longitudinal texture with desirable friction and low noise characteristics;
- Frequently performed in conjunction with other CPR techniques, such as full-depth repair, dowel bar retrofit, and joint resealing.
- Comprehensive part of any PCC Pavement Preservation program;

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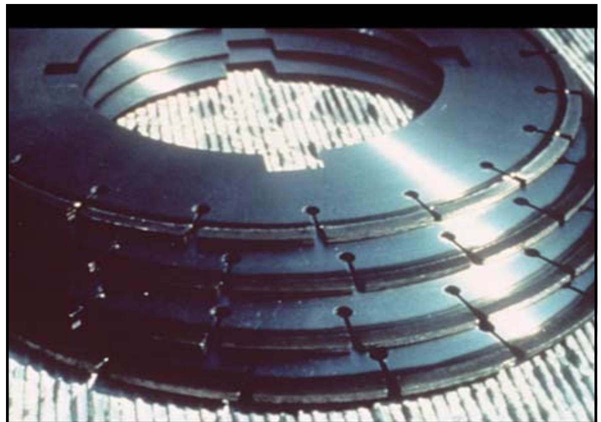

Diamond Grinding

Cutting Head

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Diamond Grinding

Grinding Machine

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Diamond Grinding

Grinding Process

3/11/2008 23

Diamond Grinding

Finished Product

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Advantages of Diamond Grinding

- Cost competitive;
- 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;
- Provides a low noise surface texture!

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Surface Characteristic Research

- CALTRANS Diamond Grinding Research
- WSDOT Safety Research
- National Concrete Pvmt Technology Center
- Purdue Tire Pavement Testing Apparatus
- ACPA Sound Intensity Testing
- California and Arizona PCCP SI Testing
- NITE Sound Intensity Testing (CALTRANS)

3/11/2008 26

Effectiveness of Diamond Grinding - CALTRANS

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

MODOT- Safer, Smoother, Sooner

- MODOT initiates Safer, Smoother, Sooner program in 2005 – 2007
- The initiative invests $400 million on 2,200 miles
- Improve customer satisfaction through
  - Safer pavements
  - Smoother ride quality
  - Quiet ride quality
- Approx 18,000,000 sq yds let since 1st Qtr 2005
- See IGGA.Net for MODOT's BMP on diamond grinding new PCCP

LOAD TRANSFER RESTORATION

Dowel Bar Retrofit

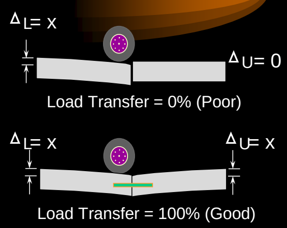
Load Transfer Restoration

- Placement of load transfer devices across joints or cracks of existing pavements
- Candidate projects
  - Poor load transfer (< 70 %)
  - Pumping
  - Faulting
  - Corner breaks

3/11/2008 30

Purpose of Load Transfer Restoration

- Reestablish load-transfer across joints or cracks
  - Load-transfer is a slab's ability to transfer part of its load to its neighboring slab
- Used in JRC and JPC pavements to limit future faulting



3/11/2008 31

Performance of DBR Concrete Pavement Under HVS Loading *by CALTRANS, UC Davis and UC Berkeley*

- Tested two retrofitted PCCPs under a Heavy Vehicle Simulator (HVS) aka accelerated loading frame
- HVS results demonstrated large improvement in LTE and decrease in vertical deflections
- DBR sections not damaged by HVS loading, unlike control section
- DBR less sensitive to temp changes than control section
- Total of 11,000,000 ESALS applied to DBR sections without failure occurring

3/11/2008 32

Ten-Year Performance of DBR Application … *by WASHDOT*

- First production DBR project completed in Washington in 1992
- WASHDOT has retrofitted 225 miles since 1992
- Subject DBR sections still maintain average LTE of 70% to 90%
- Determined that carbide roto-milling is NOT a viable alternative for diamond grinding
- Based on 10 yr results, DBR is considered a successful alternative for rehabilitation of aging PCCPs in WS

3/11/2008 33

Full-Depth Patching Operations

Full-Depth Repair

- Purpose
  - Restore structure
  - Restore ride
- Used for:
  - Joint deterioration
  - Transverse cracking
  - Longitudinal cracking
  - Broken slabs & corner breaks

3/11/2008 35

Pre-cast Pavement Panels

3/11/2008 36

Insitu Full Depth Repair

3/11/2008 37

Sizing a Patch

- Go beyond deterioration
- Remember to check for below-surface spalling
- Minimum length 6 feet
- Adjust as necessary
- Combine closely spaced patches

3/11/2008 38

Combine Patches!!

3/11/20… 39

Load Transfer

Jointed Pavements:

- 1.5 inch dowels
- At least 6 inches of embedment on either side
- Minimum of 3 dowels in each wheelpath
- Corrosion resistance necessary if deicing chemicals will be used

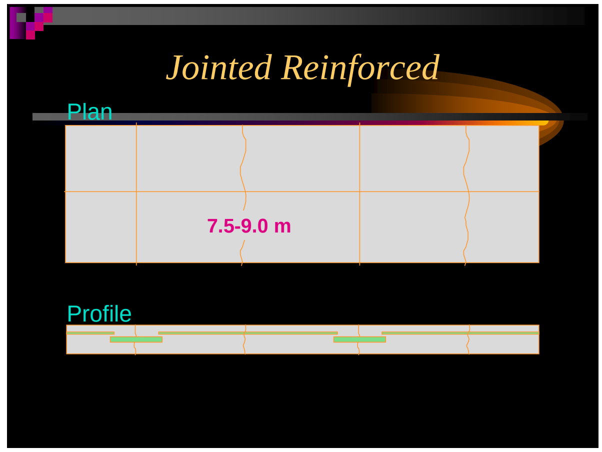
3/11/2008 41

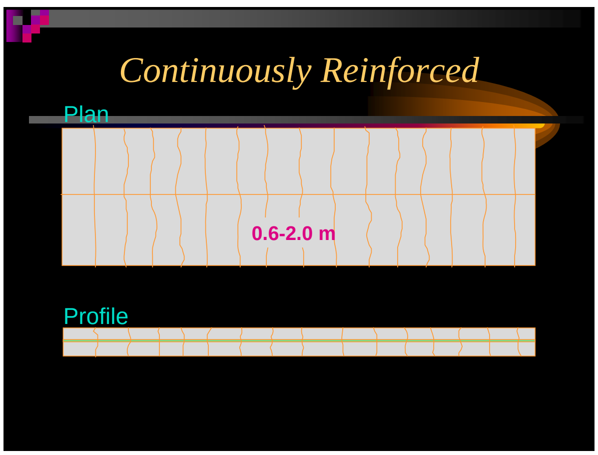
Performance of Full-Depth Repairs

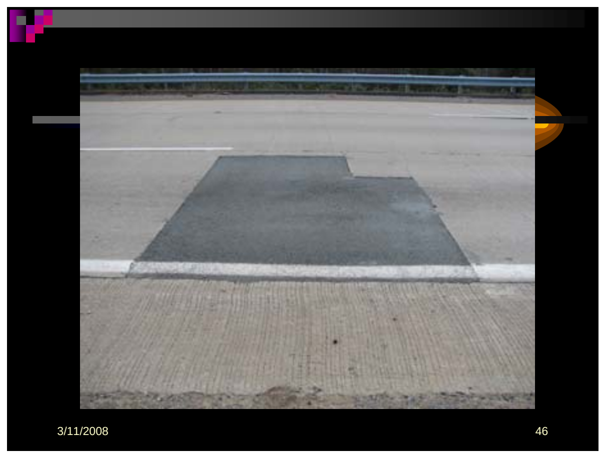
- Can provide 20 or more years of service when properly designed and constructed
- High-early strength materials allow early opening to traffic and limited lane closures

3/11/2008 42


Jointed Plain
Plan
3.5-6.0 m
Profile
or


Jointed Reinforced
Plan
7.5-9.0 m
Profile


Continuously Reinforced
Plan
0.6-2.0 m
Profile


3/11/2008
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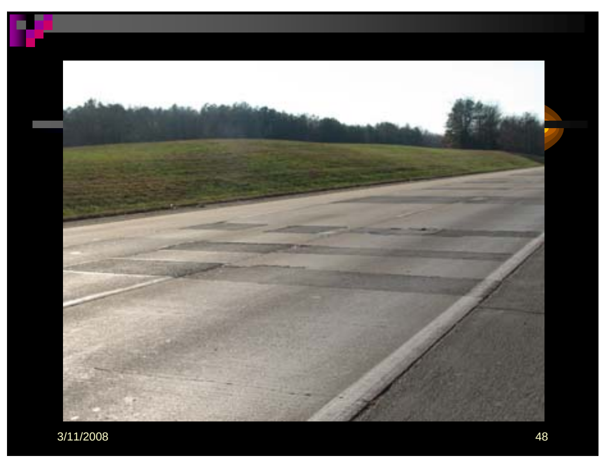
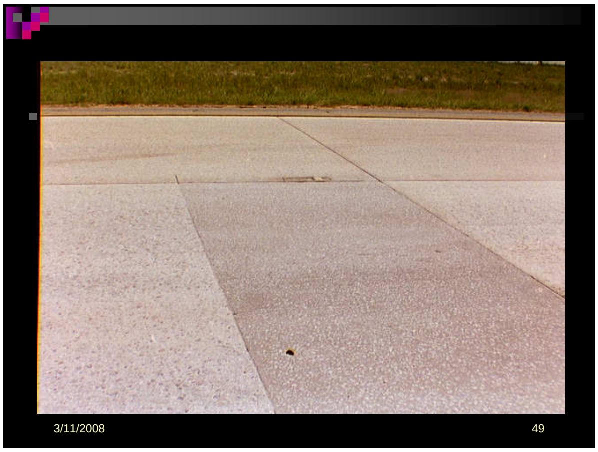
3/11/2008
47

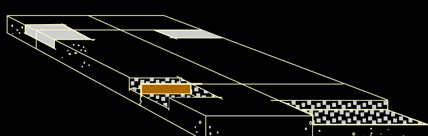

3/11/2008
48

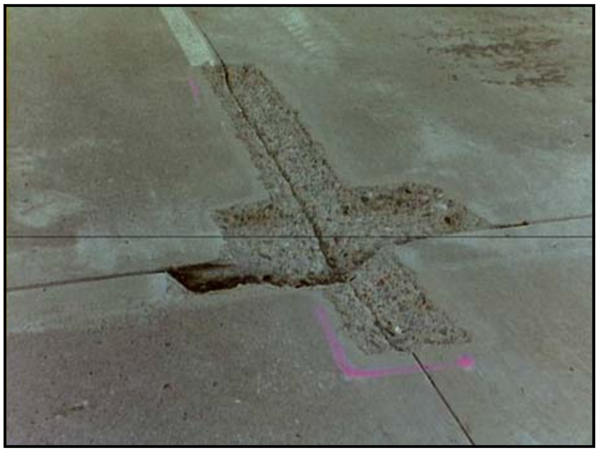


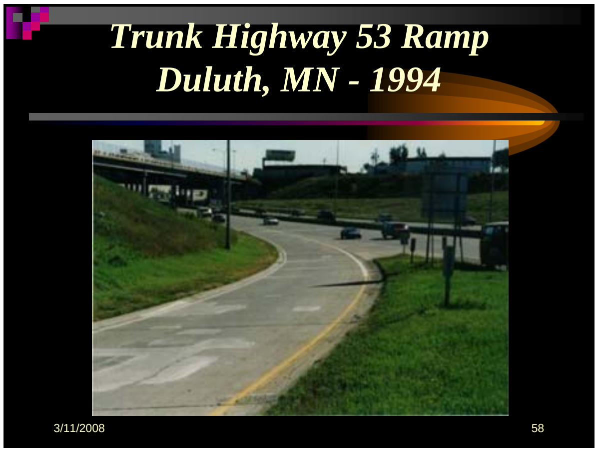
Partial-Depth (Joint Spall) Patching Operations

Partial Depth Repairs

- Repairs deterioration in the top 1/3 of the slab.
- Generally located at joints, but can be placed anywhere surface defects occur.






Trunk Highway 53 Ramp
Duluth, MN - 1994
3/11/2008
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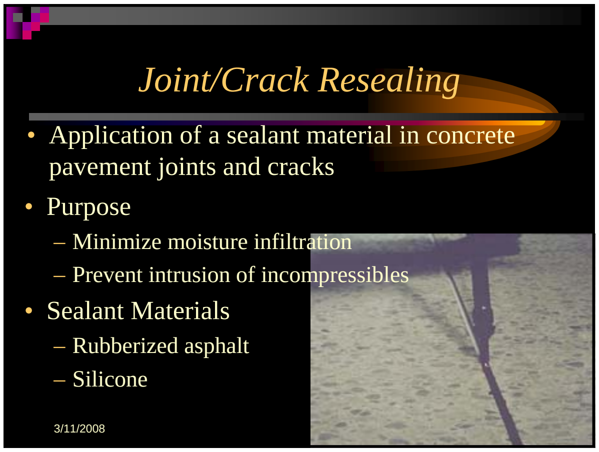
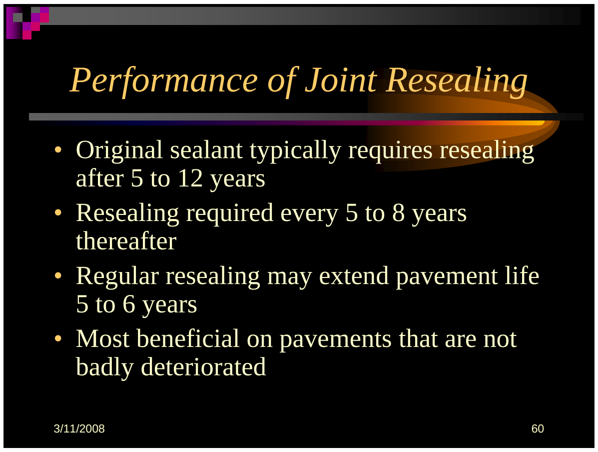

Joint/Crack Resealing
• Application of a sealant material in concrete pavement joints and cracks
• Purpose
– Minimize moisture infiltration
– Prevent intrusion of incompressibles
• Sealant Materials
– Rubberized asphalt
– Silicone
3/11/2008


Performance of Joint Resealing
• Original sealant typically requires resealing after 5 to 12 years
• Resealing required every 5 to 8 years thereafter
• Regular resealing may extend pavement life 5 to 6 years
• Most beneficial on pavements that are not badly deteriorated
3/11/2008
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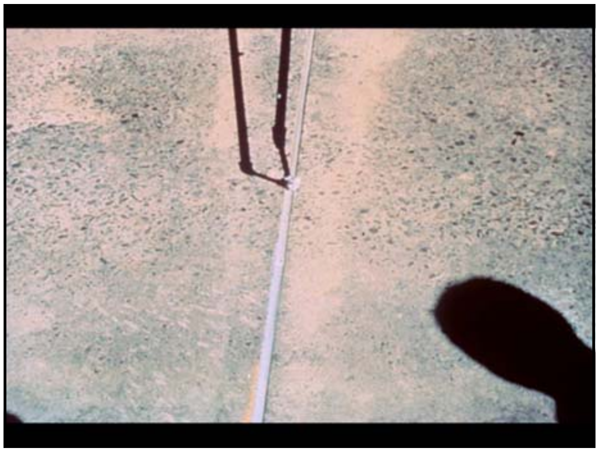

Good Candidate Pavements for Preventive Maintenance

- Minimal distress (extent and severity)
- Relatively young in age
- *Minor* functional problems
- Few historical problems with similar projects

3/11/2008 62

Colorado Project # IM 0701-169 Rifle to Silt, Garfield County

Existing PCCP History

- **I-70, Rifle to Silt, MP 86.5 to MP 97**
  - Only section of PCCP along I-70 from West of Denver to Utah border.
- **Portland Cement Concrete Pavement**
  - Consisted of only one project which included base and PCCP placement
  - Construction from November 1975 to November 1976.
  - PCCP was selected over ACP as there were oil shortages and the cost of asphalt skyrocketed.

3/11/2008 64

PCCP Condition Prior to Restoration

- **Cracked / broken concrete slabs**
- **Exposed aggregate surface**
- **Wheel Rutting (wear)**
  - 25% of the existing pavement had average rutting of 5/16" to 3/8"
- **Settlement in drive lane at the edge of traveled way**
  - Settlement of up to one inch below the adjacent shoulder slab
  - Surface runoff pooling at the edge of the traveled way
- **Minor faulting**

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Faulted Panel

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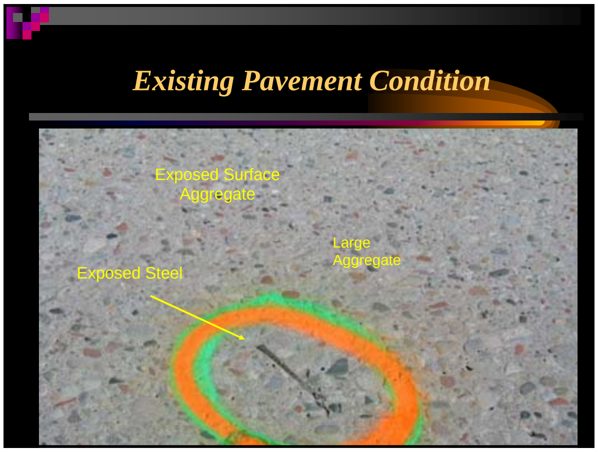

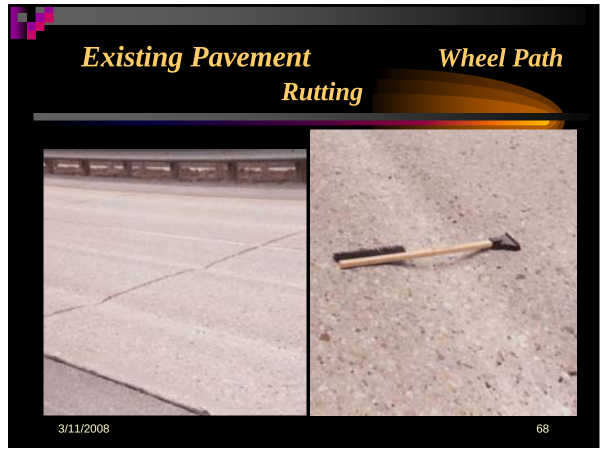

Concrete Pavement Restoration Project Scope

- **Remove and replace broken and cracked concrete slabs**
- **Re-establish a uniform textured surface**
- **Remove rutting/reduce significant rutting – drainage improvement**
- **Feather the outside shoulder – drainage improvement**
  - Removing lip at edge of traveled way, allowing positive runoff flow
- **Reduce noise**

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Salient Items of Work

Grinding & Texturing Concrete Pavement	330,000 SY
Concrete Pavement (Full Depth Patching)	1,200 SY
Rumble Strip	22,500 LF
Epoxy Pavement Marking	985 GAL

Contract Amount $1,797,384

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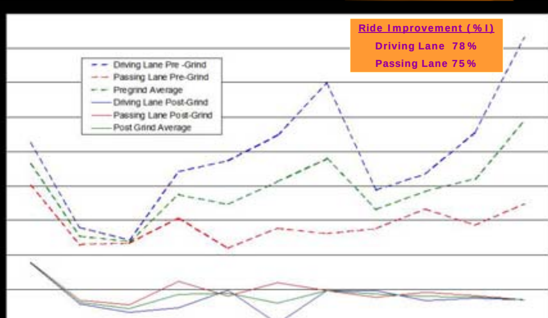
Ride Specification

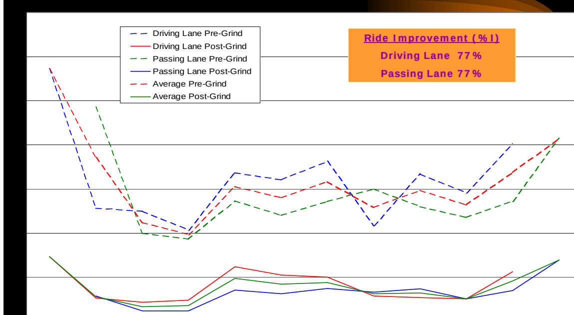
Improved Smoothness

IM 0701-169 Rifle to Silt, Garfield County
East Bound



Improved Smoothness

IM 0701-169 Rifle to Silt, Garfield County
West Bound



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Summary

- Many available treatments for PCC pavements
- Each has advantages and limitations
- Performance and cost vary with given conditions
- Applying the right treatment to the right pavement *at the right time*
- No universal method available
- Take advantage of local contractor experience
- IGGA & ACPA Mid Atlantic Chpt is ready to assist

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Visit Us on the Web

International Grooving and Grinding Association

- igga.net

American Concrete Pavement Association

- midatlantic.pavement.com

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What's New with ASR?

Gina M. Ahlstrom
Pavement Engineer
Federal Highway Administration
Office of Pavement Technology

March 7, 2008 2008 Virginia Concrete Conference

What is ASR?

Alkali-Silica Reactivity

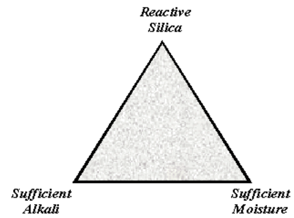
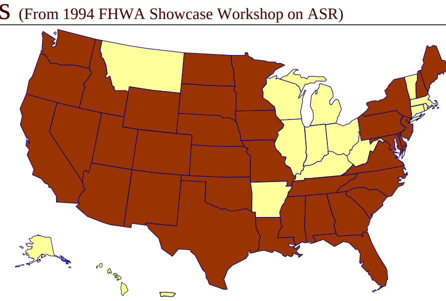


Figure from: FHWA-RD-03-047, Folliard et al., 2003




Occurrences of ASR in the United States (From 1994 FHWA Showcase Workshop on ASR)



ASR Occurrence Identified
Uncertain

SAFETEA-LU Legislation

- Sec. 5203. (e) Demonstration Projects and Studies
  - (3) **Alkali Silica Reactivity**. Of the funds made available by 5101(a)(1) of this Act, $2,450,000 shall be made available by the Secretary for each of fiscal years 2006 through 2009 **for further development and deployment of techniques to prevent and mitigate alkali silica reactivity**.

Before FHWA Started a New Program

ASR Benchmarking Workshop

Stakeholders and customers provide input and identify potential program elements toward development of a comprehensive program of development and deployment activities addressing techniques to prevent and mitigate alkali silica reactivity

Main Points from the Workshop

- Develop protocols/framework/decision tree for ASR prevention and mitigation using existing techniques and guide specifications
- Field trials, field trials, and more field trials
- Develop a framework for inventorying and prioritizing structures through existing Pavement Management and Bridge Management systems
- Provide technology transfer through delivery of information and training/education

ASR Program Goals

- Increase durability, performance, and reduce life cycle costs
- More effectively deploy current technologies
- Develop new technologies, develop rapid lab methods, and develop NDE techniques to assess ASR in the field

FHWA's ASR Development and Deployment Program

(1.) Understanding the ASR Mechanism Process for Prevention

(2.) Develop Testing and Evaluation Protocols

(3.) Selection, Implementation, and Maintenance of Field Application and Demonstration Projects

FHWA's ASR Development and Deployment Program

(4.) Assist States in Inventorying Existing Structures for ASR

(5.) Deployment and Technology Transfer

Establishment of a Technical Working Group (TWG) to monitor the Program

(1.) Understanding the ASR Mechanism

- Task Goal:
  - Obtain a better understanding of the ASR mechanism
- Applied Research Strategies:
  - Quantify various chemical reactions and rates between constituents
  - Identification of formed products
  - Consideration of environmental effects such as deicers
- Applied Research Products:
  - Development of prescriptive methodology to produce durable concrete mix designs

(2.) Develop Testing and Evaluation Protocols

- Task Goal:
  - Develop a reasonable, effective, and clear decision-making process for methods and techniques to prevent and mitigate ASR
- Deployment Strategies:
  - Develop protocols for rapid testing and evaluation for ASR prevention in new construction, ASR mitigation in existing concrete, and determination of future deterioration

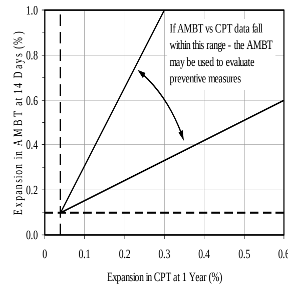
(2.) Develop Testing and Evaluation Protocols

- Deployment Products:
  - Guidance on evaluation of aggregates and mixtures appropriate to prevent against ASR
  - Guidance on the determination of existence and extent of ASR
  - Guidance on mitigation measures to reduce the severity of ASR

Determining Aggregate Reactivity and Selecting Measures to Prevent ASR

Guidance on using results from

ASTM C 1293
Concrete Prism Test
and
ASTM C 1260
Accelerated Mortar Bar Test



Diagnosis and Prognosis of ASR

Guidance on how to use results from of the Cracking Index and the Petrographic Examination to determine next steps in ASR diagnosis

Criteria	Comments and Action
"Cracking" > criteria and Low probability of AAR (from petrography)	• Significant cracking is affecting the element investigated. On the other hand, there is no conclusive evidence of AAR in the concrete (based on petrography). • Action: initiate further investigations for other mechanisms of deterioration, if required.

Selection of Mitigation Measures

Treat the Cause	Treat the Symptom
Chemical Treatment/Injection □ CO_2 □ Lithium Compounds *Drying* □ Sealants □ Cladding □ Improved Drainage	*Crack Filling* □ Aesthetics □ Protection (e.g. from Chloride ingress) *Restraint* □ Prevent Expansion □ Strengthen/Stabilize *Relieve Stress* □ Sawcutting/Slot Cutting

Guidance on decision factors for considering various mitigation options

(2.) Develop Testing and Evaluation Protocols

- Applied Research Strategies:
  - Identify the most viable rapid test methods to accurately predict field performance of ASR
- Applied Research Products:
  - Modifications to existing test procedures or recommendation for the development of a new test procedure

(3.) Field Trials

- Task Goal:
  - Gather long-term data on the effectiveness and service life of methods and techniques to prevent ASR in new concrete and mitigate ASR in existing concrete
- Deployment Strategies:
  - Implementation of existing techniques to prevent and mitigate ASR
  - Explore new methods and techniques to prevent and mitigate ASR

(3.) Field Trials

- Deployment Products:
  - Implementation and monitoring of field trials
  - Analysis of the best methods and techniques to prevent and mitigate ASR

(3.) Field Trials

- Applied Research Strategies:
  - Controlled laboratory experiments coordinated with field trials
- Applied Research Products:
  - Cost effective methods for ASR mitigation

(4.) Assist States with Inventorying Existing Structures for ASR

- Task Goal:
  - "Assist States in inventorying existing structures for ASR" per SAFETEA-LU legislation
- Deployment Strategies:
  - Provide tools for States to successfully track and monitor ASR affected structures

(4.) Assist States with Inventorying Existing Structures for ASR

- Deployment Products:
  - Track ASR affected structures utilizing States Pavement Management and Bridge Management Systems
  - Development of a severity rating system
  - Training

(4.) Assist States with Inventorying Existing Structures for ASR

- Applied Research Strategies:
  - Distinguish ASR and subsequent damage from other deterioration mechanisms to make decisions regarding mitigation, rehabilitation, and reconstruction
- Applied Research Products:
  - Development of a simple reliable non-destructive field test for the determination of ASR

(5.) Deployment and Technology Transfer

- Task Goals:
  - Provide tools, assistance, and efficient and effective technology transfer to educate and train
- Deployment Strategies:
  - ASR Data Center
  - Technology Transfer

(5.) Deployment and Technology Transfer

- Deployment Products:
  - Data center that serves as a clearing house for information
  - Training (presentations, workshops, etc.)
  - ASR Newsletter – ***Reactive Solutions***

A.sk S.end R.ecieve

Stump The Experts

Featured Photo

ASR Technical Working Group

States ☆ Academia ☆ Industry ☆ Federal Agencies

- Information Sharing
- Technical Input on the Program
- Monitor Program Implementation

2007	2008	2009	2010	2011	2012
Task 1 – Mechanism of ASR					
Task 2 – Develop Test and Evaluation Protocols					
Task 3 – Field Trials					
Task 4 – Assist States with Inventory for ASR					
Task 5 – Deployment and Technology Transfer					

What's Next

- Looking for ASR field trials
  - Prevention of ASR in new concrete
  - Mitigation of ASR in existing concrete

What's Next

- ***Reactive Solutions***
  - Looking for interesting stories, photos, questions, YOUR INVOLVEMENT & INTEREST
- Survey State Structures
  - States to pilot the system developed

For Questions or Information Regarding FHWA's ASR Program:

Gina Ahlstrom
202-366-4612
gina.ahlstrom@dot.gov

Concrete Pavements for City Streets

Virginia Concrete Conference
March 7, 2008

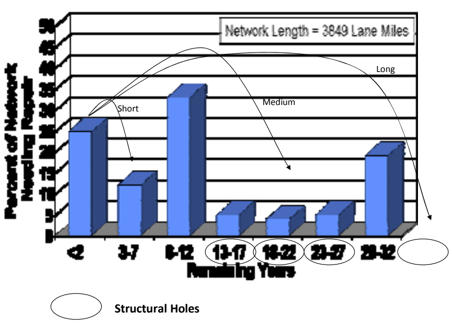
Scott Haislip
Director of Streets & Roads

Count on Concrete

S&R Pavement Markets

- New/Reconstruction of Concrete Pavements
- Concrete Pavement Restoration - Utility Cuts
- Concrete Overlays
  - Bonded (UTW)
  - Unbonded (Whitetopping)
- Concrete Inlays
  - Intersections
  - Roundabouts
  - Bus Pads
  - Alleys

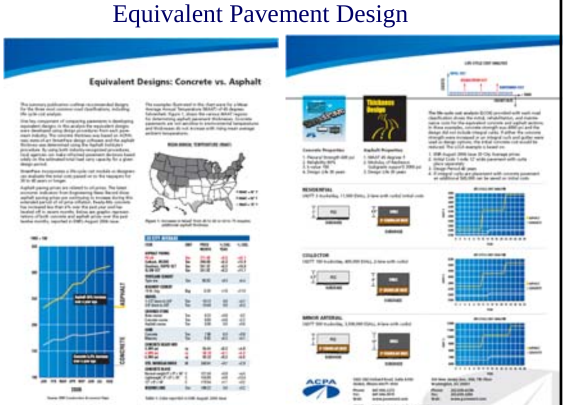
Remaining Service Life Model



New Design Tools for SLR

- StreetPave Software
  - Concrete Thickness
  - Asphalt Institute Design Thickness
  - Life Cycle Cost Analysis
- Information Sheet IS184
- Equivalent Pavement Design Charts

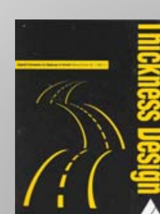
Equivalent Pavement Design



StreetPave Software

- Concrete pavement thickness design based on revised criteria
- Asphalt equivalent section based on converted total carrying capacity
- Life-Cycle cost analysis based on initial costs of equivalent pavements and predicted maintenance

What's Equivalent



Concrete Pavement Types

- Jointed Plain
  - Undoweled
  - Doweled
- Jointed Reinforced
- Continuously Reinforced
- Prestressed

Municipal Pavement Design

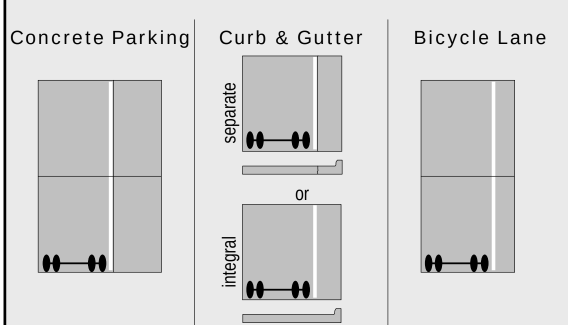
- Street classification and traffic
- Geometric design
- Subgrades and subbases
- Concrete quality
- Thickness design
- Jointing
- Construction specifications

Street Class	Description	Two-way Average Daily Traffic (ADT)	Two-way Average Daily Truck Traffic (ADTT)	Typical Range of Slab Thickness
Light Residential	Short streets in subdivisions and similar residential areas – often not through-streets.	Less than 200	2-4	4.0 - 5.0 in. (100-125 mm)
Residential	Through-streets in subdivisions and similar residential areas that occasionally carry a heavy vehicle (truck or bus).	200-1,000	10-50	5.0 - 7.0 in. (125-175 mm)
Collector	Streets that collect traffic from several residential subdivisions, and that may serve buses and trucks.	1,000-8,000	50-500	5.5 - 9.0 in. (135-225 mm)
Business	Streets that provide access to shopping and urban central business districts.	11,000-17,000	400-700	6.0 - 9.0 in. (150-225 mm)
Industrial	Streets that provide access to industrial areas or parks, and typically carry heavier trucks than the business class.	2,000-4,000	300-800	7.0 - 10.5 in. (175-260 mm)
Arterial	Streets that serve traffic from major expressways and carry traffic through metropolitan areas. Truck and bus routes are primarily on these roads.	4,000-15,000 (minor) 4,000-30,000 (major)	300-600 700-1,500	6.0 - 9.0 in. (150-225 mm) 7.0 - 11.0 in. (175-275 mm)

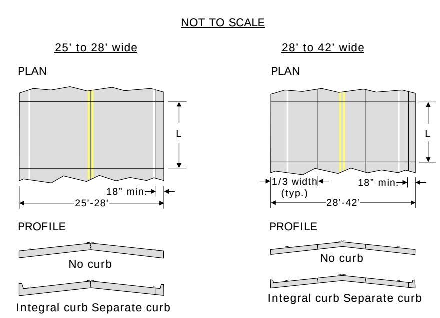
Geometric Design

- Increase Edge Support
  - Integral Curb
  - Tied Curb & Gutter
  - Widened Lanes (2 feet no parking)
  - Parking Lanes
  - Rural Areas – Tied Concrete Shoulders
- Street Widths
  - Minimum width of 25 ft.
  - Maximum Cross Slope of 2 percent (¼” per ft.)
  - Traffic Lanes 10-12 feet
  - Parking Lanes 7-8 feet

Edge Support



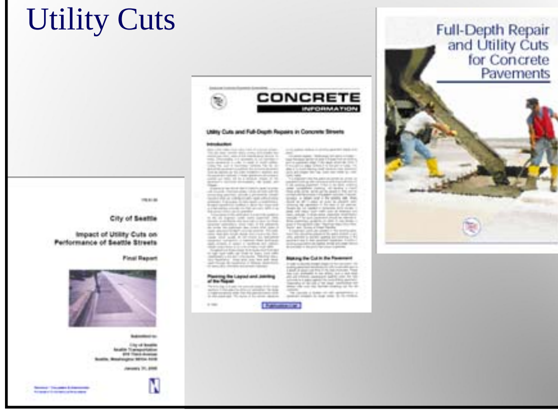
Basic Two-Lane Section



Concrete Pavement Restoration

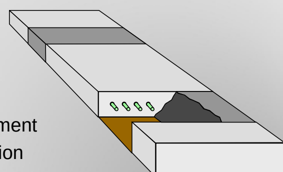
- CPR Focused:
  - Full Depth Pavement Patching
  - Partial Depth Pavement Patching
  - Surface Grinding
- Utility Cuts

Utility Cuts



Full-Depth Utility Cut Patches

- Purpose
  - Restore structure
  - Restore ride
- Used for
  - Utility repair, replacement
  - Joint/crack deterioration
  - Broken panels



Planning Utility Cut Repairs

- If patch near joint (within 3-4 ft), extend to joint
- For small patches in interior of slab, simply tie into surrounding pavement with tiebars
- For long, trench patches, re-form joints in same locations as before
- Avoid odd-shaped patches
- Max. aspect ratio (length/width) = 1.5 to 2.0

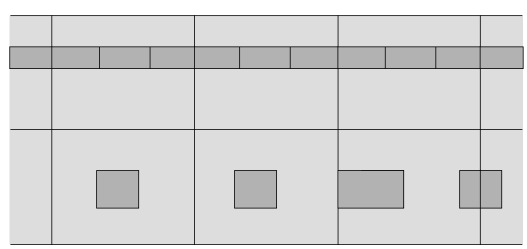
ACPA Count on Concrete

Joint Types

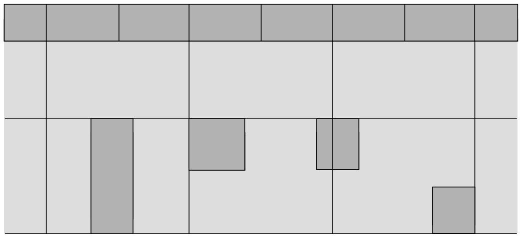
- Replace existing joints with same
- Tie (i.e. deformed bars) to existing slab for interior patches, longitudinal joints, and transverse joints that are not full lane width
- Dowel (i.e. smooth bars) at all existing transverse joints, and new transverse joints that are full lane width

ACPA Count on Concrete

Planning Utility Cut Repairs



Planning Utility Cut Repairs



Steps in Utility Cut Repairs

7 steps:

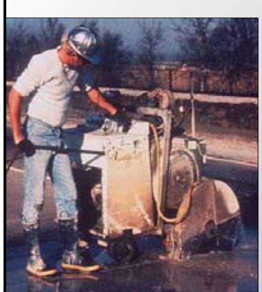
- Isolate area to be removed with full-depth saw cuts
- Remove old concrete
- Place utility, compact backfill (or use CLSM), drain rainwater (if necessary)
- Provide load transfer at joint faces
- Place & finish new concrete
- Cure & insulate concrete
- Saw & seal perimeters

Defining Repair Limits

- If edge of patch within 3-4 feet of any joint, extend to joint (after utility work completed)
- Combine patches if close together

Combine Patches!

Sawing Boundaries Full-Depth



Perform Utility Work

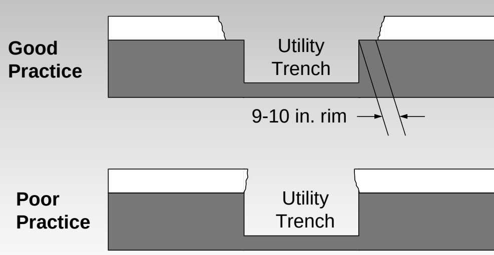
Trench Compaction

Flowable Fill

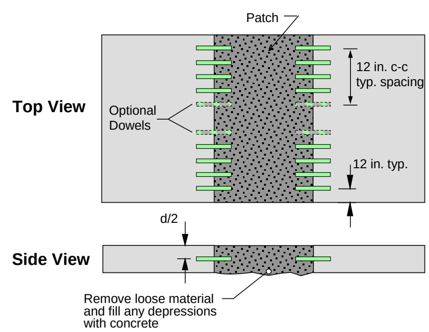
- Controlled Low-Strength Material (CLSM)
- ½ to 1 sack of cement per cu.yd.
- No compaction needed
- Retains ability to be excavated
- Offers better support than granular fill
  - For utilities and for pavement

Count on Concrete

Load Transfer



Load Transfer



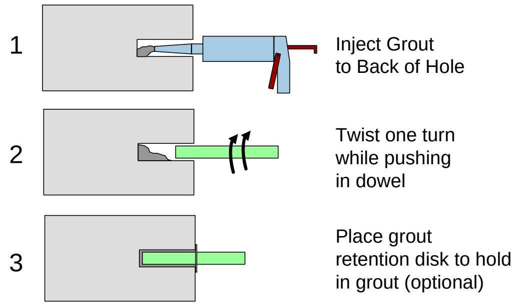
Drilling Dowel Holes

Dowel Sizes

Pavement Thickness, in.	Dowel Diameter, in.	Drilled Hole Diameter, in. *	
		Cement-Based Grout	Epoxy-Based Grout
6	0.75	0.95	0.83
7	1.0	1.2	1.08
8	1.0	1.2	1.08
9	1.25	1.45	1.33
10	1.25	1.45	1.33

* Cement-based, Dowel diam. + 0.2" Epoxy-based, Dowel diam. + 0.08"

Installing Dowels



Injecting Grout

ACPA

Count on Concrete

What **NOT** To Do

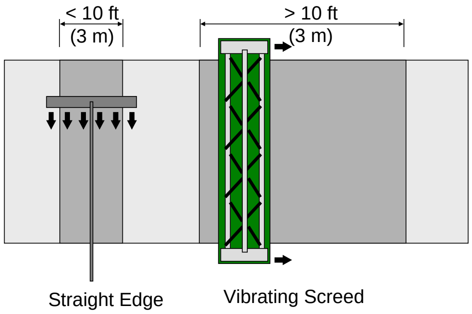
What **NOT** To Do

Dry out the grade!!

Placement of Bond-Breaking Board

Concrete Placement

Finishing



Finishing

Texturing

Curing

Curing

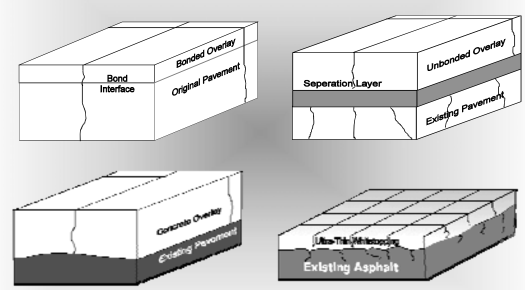
Keys to Success

- Full-depth perimeter sawcuts
- Proper trench compaction is key in utility cuts; flowable fill (controlled low-strength material) can help
- Establish proper load transfer to existing pavement
- Finish smooth & level with surrounding pavement; and with a similar texture

Summary

- A few key details for repairs will help improve their performance
- Maintenance crews can be easily trained to do concrete repair work
- Tools, equipment, and materials required are readily available
- Proper maintenance & repair will extend concrete's inherent long-life even further

Concrete Overlays - *General Types*



Concrete Overlay History

- Bonded Overlays (1913 Warsaw St. Toledo, OH)
- Unbonded Overlays (1916 Grand River Ave. Wayne County, MI)
- Whitetopping (1918 S. 7th St. Terre Haute, IN)
- Ultra-Thin Whitetopping (1991 Landfill Access Road near Louisville, KY)

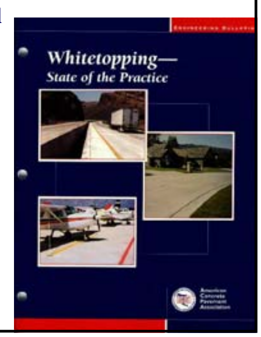
Bellefontaine, Ohio, 1891

Whitetopping – State of the Practice

ACPA
Engineering Bulletin Published
(1998)

Std. Whitetopping
- Design
- Construction
- Performance

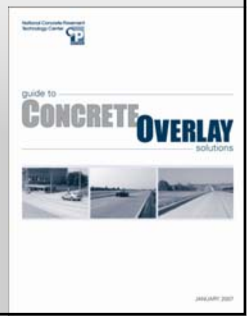
Ultra-Thin Whitetopping
- Design
- Construction
- Performance



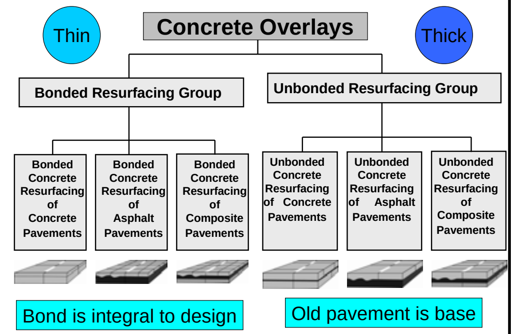
Guide Contents

Available through
www.pavement.com
publication # TB021P

- Introduction
- Overview of the two overlay classes
- Six overlay types described in detail
- Design of concrete overlays
- Standard design details
- Materials
- Key points



Classes of Concrete Overlays



Bonded (UTW)

Before

After

Unbonded (Whitetopping)

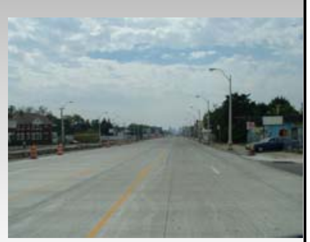
Before

After

Unbonded

Before

After



Unbonded

Before

After

Bonded Composite

Before

After

Bonded Summary

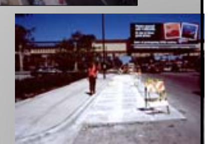
- Bonded overlays are rapidly gaining in popularity, particularly in urban environments
- They have been used at intersections, bus pads , highway ramps, parking areas, subdivision streets
- Performance has generally been excellent
- Where problems occurred, improper placement reducing bond

Unbonded Summary

- Conventional whitetopping is probably over designed by not accounting for bond
- The new StreetPave Mechanistic Pavement Design software will produce a more optimized design than previous design methods
- Projects can be constructed and opened to traffic in a relatively short time (fast-track techniques)
- Performance has been excellent

Concrete Inlays

- Intersections
- Bus Stops
  (Chicago 1000 full and partial depth pads)
- Alleys
- Turn Lanes

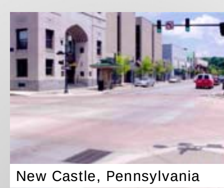


Concrete Inlays (cont.)

- Turn Lanes
- Any Stopping Area

Main Street USA Award


City of Muskegon, Michigan


New Castle, Pennsylvania

Questions

- Thank you
- For additional information, please contact Scott Haislip at shaislip@pavement.com or visit the American Concrete Pavement Association website at www.pavement.com