Dowel-Bar Retrofit Using Polyester Polymer Concrete

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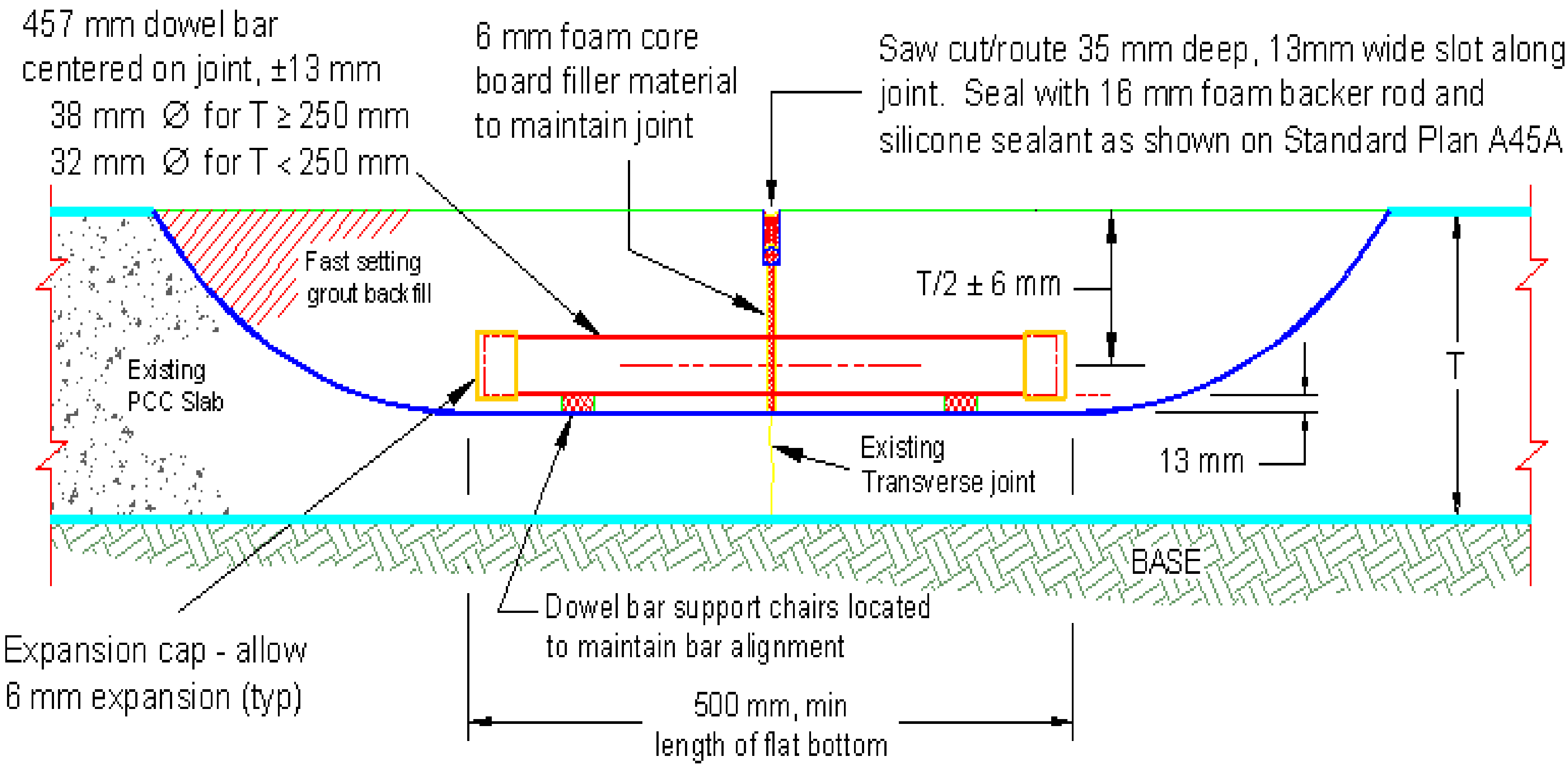
Presentation Outline

- Description
- Project Selection
- Nationwide Usage
- Typical Distress
- California Experience
- Key Parameters
- Cementitious Grouts
- Polyester Polymer Concrete
- Comparisons
- US 50
- Final Remarks

Description

Description

-DBR Assembly Schematic View



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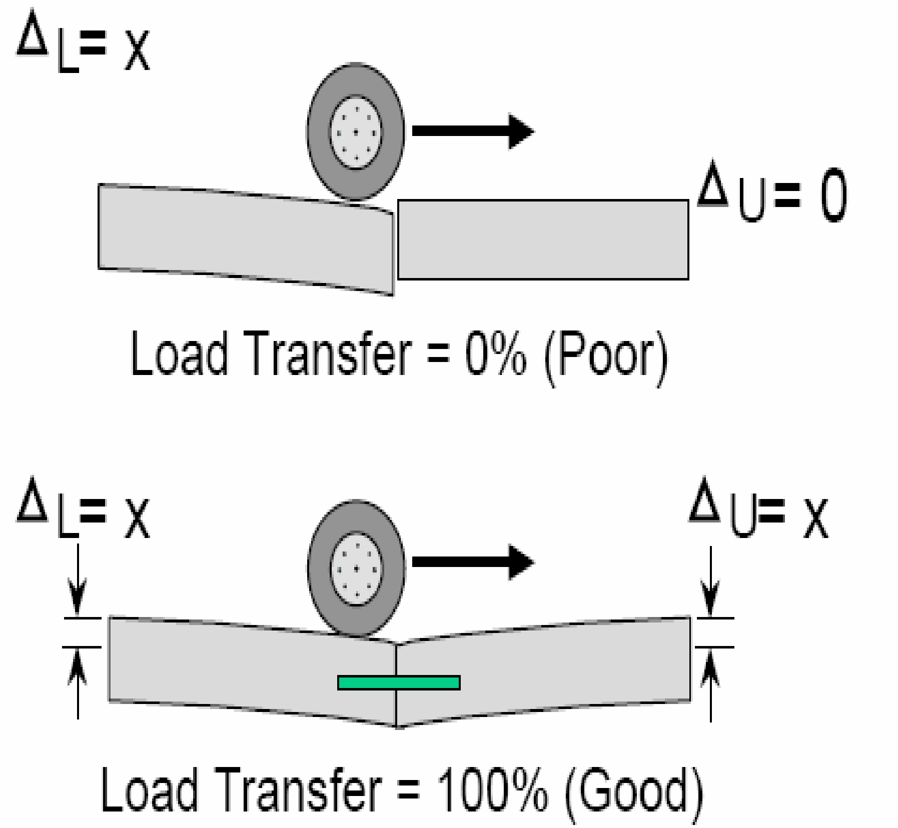


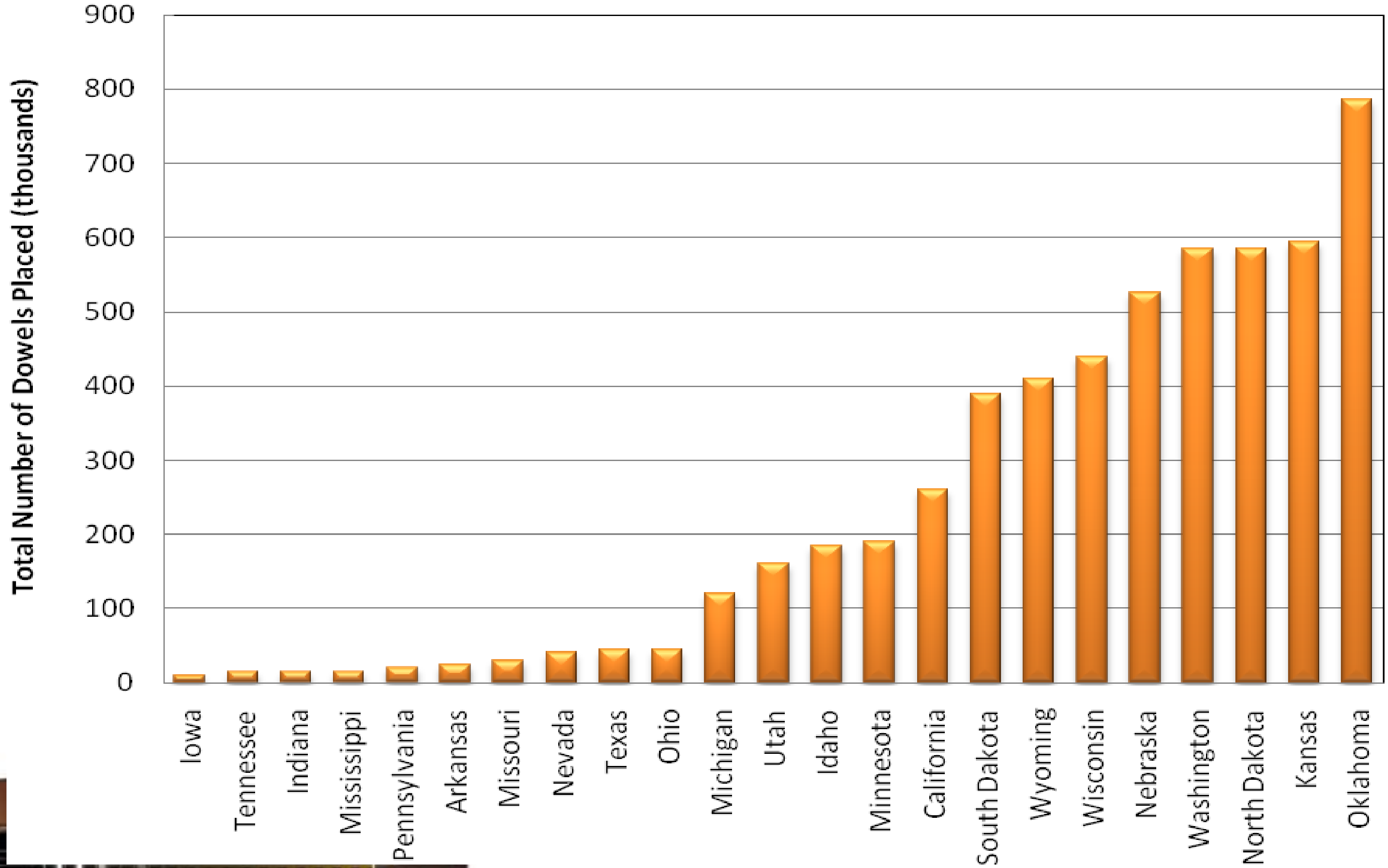
Core showing grout and dowel **Improving load transfer**

Project Selection

- Low Load Transfer: <70%
- Faulting: >0.1 inch
- Cracking: <10%
- Structurally Adequate

Nationwide Usage

>5 Million



Typical Distress

Studded Tire Wear

Backfill Cracking

Typical Distress

Backfill Spalling

Backfill Debonding

Typical Distress

Poor Consolidation   Foam Board Misalignment

California Experience

- Between 1950 and 2000 California did not require dowel bars in JPCP.
- 1998-Colfax, CA was the First DBR Pilot Project. Avg. LTE increased from 30% to 82%. Backfill is still in good condition.

California Experience

- 2001 SR 101-Ukiah DBR Test Sections. LTE increased from 49.2% to 85.3% or higher after 10 months in service
- 2001 SR 14-Palmdale. LTB increased to above 80%. several locations experienced failure of the bond between the backfill and the existing concrete.

California Experience

-2005 Investigation

- Overall, DBR is an effective method for improving joint load transfer efficiency across transverse joints and cracks.
- Distress on various statewide projects was noticed.
- Debonding and deleterious material were found between backfill and existing pavement, and poor consolidation.

California Experience

-2005 Investigation

- Considerable variation in the performance of the backfill material.
- In the same project, and sometime at the same transverse joint, not all slots exhibited backfill material distress.
- Improper construction techniques.

California Experience
Summary of Issues

- Poor consolidation is the most common problem. Under-vibration results in honeycombing.
  - No requirement for proper consolidation. Difficulty of backfill to flow below the dowel.
  - Excessive vibration-misalignment and non-uniform strength.
- Inadequate Adhesion to existing pavement.

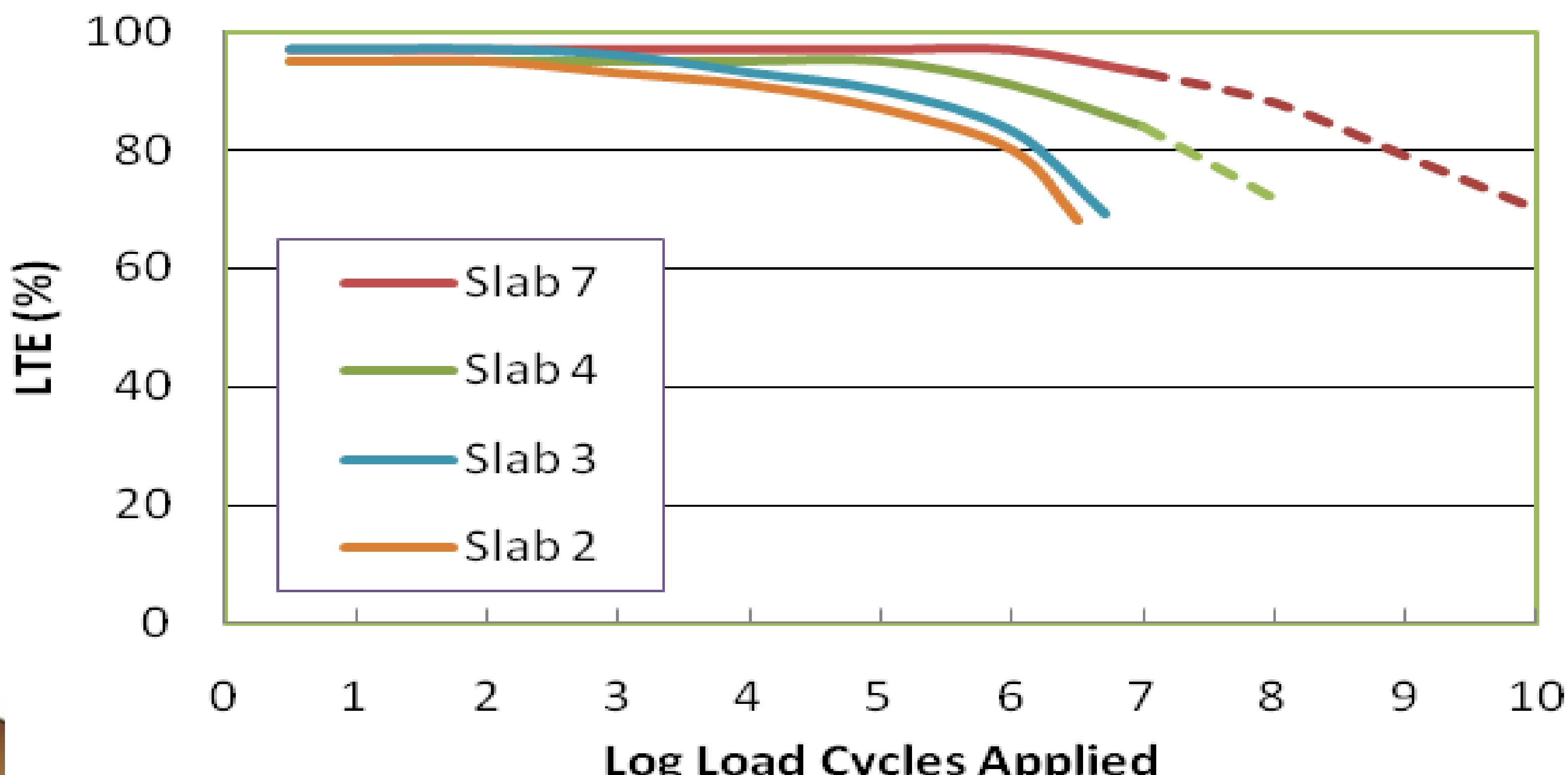
Key Parameters

- Proper consolidation to prevent honeycombing and non-uniform strength
- Adequate compressive strength to sustain Dowel bearing
- Adequate tensile strength to resist cracking
- Adequate Bond strength to ensure a durable slot and monolithic behavior

Key Parameters
-Effect of Strength & Consolidation

MN Minne-ALF Experiment (2001)
9000 Single Load Cycles

Slabs 2&3: 4000 PSI C. Strength
Slabs 4&7: 5000 PSI C. Strength
Slab 4 is poorly Consolidated



LTE=70%: Slab 7---Nf=100,000,000,000 Cycles
Slabs 2&3----Nf=10,000,000 Cycles (<1000 times)

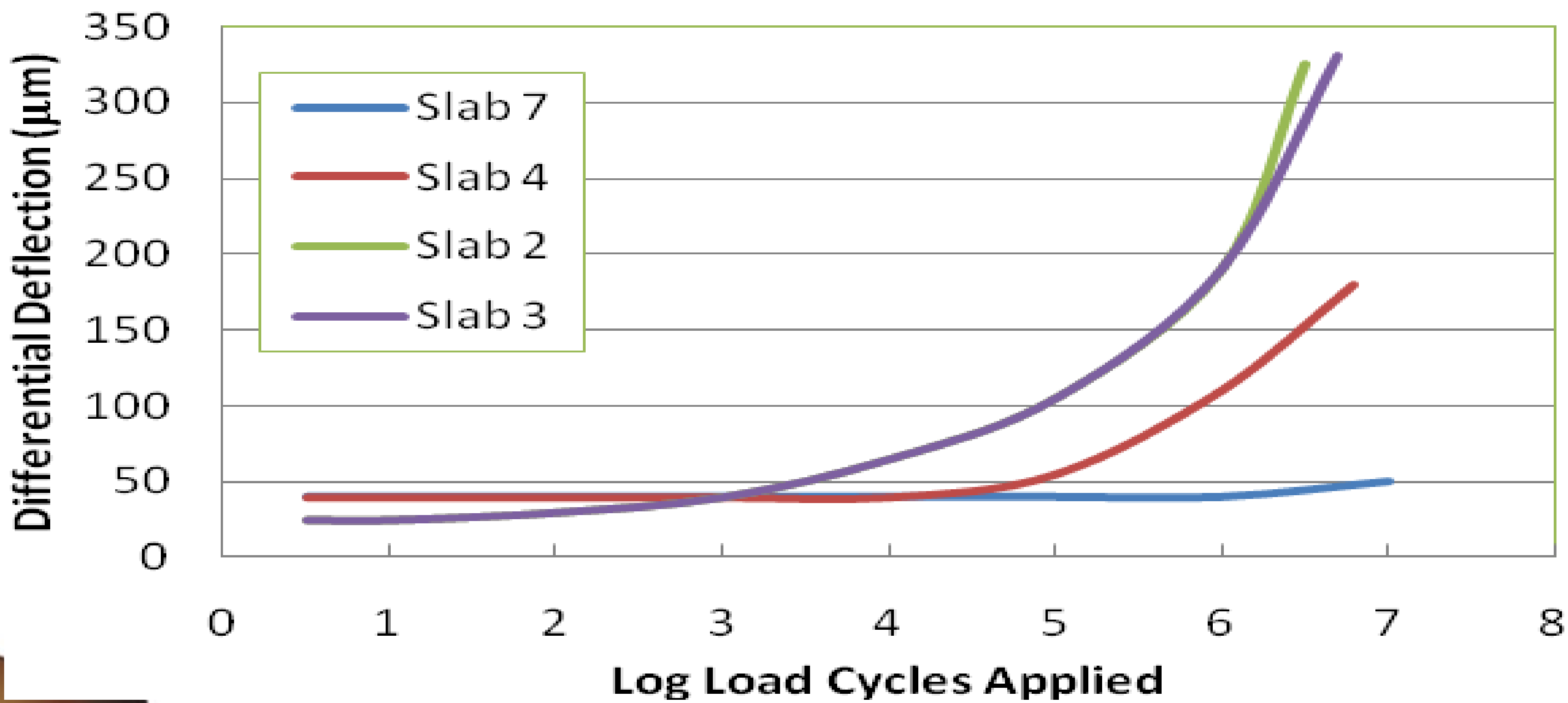
Key Parameters

-Effect of Strength and Consolidation

Minne-ALF Experiment-Embacher et al. (2001)

9000 Single Load Cycles

Slabs 2&3: 4000 PSI C. Strength
Slabs 4&7:5000 PSI C. Strength
Slab 4 is poorly Consolidated



Slab 7--------DD=53 micro-m

Slabs 2&3----DD=325 and 331 Micro-m

Key Parameters
-Effect of Strength and Consolidation

- Minnesota Test Sections-Trunk Highway TH 23 near Mora, Minnesota built 1998
  - 1999 Investigation-Majority of the slots using lower strength backfill material had shrinkage cracks along one of the slot edges at the interface indicating debonding. However, the higher strength backfill material showed very little cracking along the edges of the slots.

Cementitious Grouts

-Specifications

Property	Test Method	Requirements
Compressive Strength		
at 3 hours, psi	California Test 551	3,000 min.
at 24 hours, psi	California Test 551	5,000 min.
Flexure Strength		
at 24 hours, psi	California Test 551	500 min.
Bond Strength: at 24 hours		
SSD Concrete, psi	California Test 551	300 min.
Dry Concrete, psi	California Test 551	400 min.
Water Absorption, %	California Test 551	10 max.
Abrasion Resistance		
at 24 hours, ounces	California Test 550	1 max.
Drying Shrinkage at 4 days, %	ASTM Designation: C 596	0.13 max.
Soluble Chlorides by weight, %	California Test 422	0.05 max.
Water Soluble Sulfates by weight, %	California Test 417	0.25 max.

Polyester Polymer Concrete

- Successfully used in repairing spalls, rut fills and bridge deck overlays
- High strength
- Strong bond characteristics
- High flowability
- High toughness
- Fast curing
- Impact and abrasion resistance
- High resiliency
- Age hardening resistance
- Water impermeability and de-icing salts
- Forgiving
- Creep characteristics-Less shrinkage cracking

Polyester Polymer Concrete

-Pertinent Specifications

Test	Property	Value
ASTM D38	Grout Tensile Strength	2500 PSI
CT 551	Bond Strength (SSD)	500 PSI
ASTM D2196	Viscosity	75-300 cP
	Styrene Content	40-50%

Comparisons

-Properties

Property	PCC	PPC
Compressive Strength (MPa)	**13.0-35.0**	**50.0-150.0**
Tensile Strength (MPa)	**1.5-3.5**	**8.0-25.0**
Flexural Strength (MPa)	**2.0-8.0**	**15.0-45.0**
Modulus of Elasticity (GPa)	**20.0-30.0**	**20.0-40.0**
Abrasion-CT 550 Ball Bearing	**40 grams**	**2-4 grams**
T. Coefficient of Expansion (106×C-1)	**10.0-12.0**	**10.0-30.0**

Comparisons
-Bond Strength CT-551

- PPC: 1200-1800 psi
- Min 500 PSI (SSD)

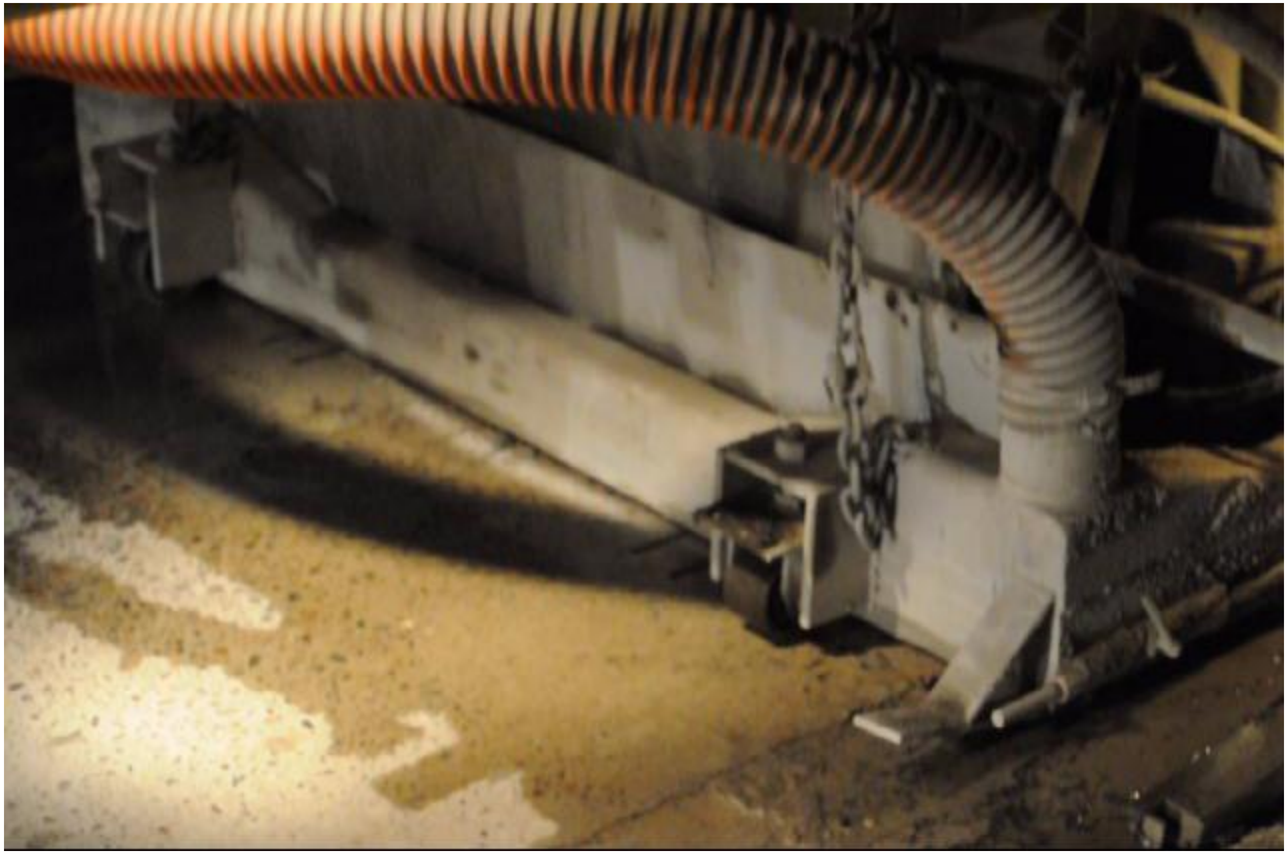
- **PCC: 400-500 psi**
- **Min 300 psi (SSD) & 400 PSI (Dry)**

US-50 DBR Project

- 8 inch thick PCC
- 2004 ADT: 149,000-184,000
- 2030 ADT: Forecasted at 246,000-299,000.
- Polyester Polymer Grout (Kwik Bond) in 2010
- 61,200 dowels
- Diamond Grinding

US-50 DBR Construction

Cutting the Slots



US-50 DBR Construction

Cutting the Slots

US-50 DBR Construction

Ready to Pour PPC Grout

US-50 DBR Construction

Low Viscosity PPC Grout

US-50 DBR Construction

Minimum Vibration

US-50 DBR Construction

Making Sure Slots are Filled Completely

US-50 DBR Construction

Completed DBR Installation

US-50 DBR Construction

Extracted Core

US-50 DBR Construction

Before Grinding

US-50 DBR Construction

After Grinding

Final Remarks

- DBR is an effective pavement preservation strategy
- Distress mainly due to failure of cementitious backfill (cracking, debonding & spalling)
- Improper consolidation & low strength are major culprits

Final Remarks

- DBR with polymer polyester gout reduces risk of failure due to superior properties
- US 50 DBR project have been placed successfully.
- Recommend more projects with polyester polymer concrete grouts.

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