Rigid Pavement Repair

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American Concrete Pavement Association - Southwest


IF YOU'D CARRIED AS MANY LOADS AS IT HAS YOU'D BE SHOWING YOUR AGE, TOO.
U.S. ECONOMY
INTERSTATE HIGHWAY SYSTEM

PCCP Repair Techniques

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

Concrete Pavement Preservation

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

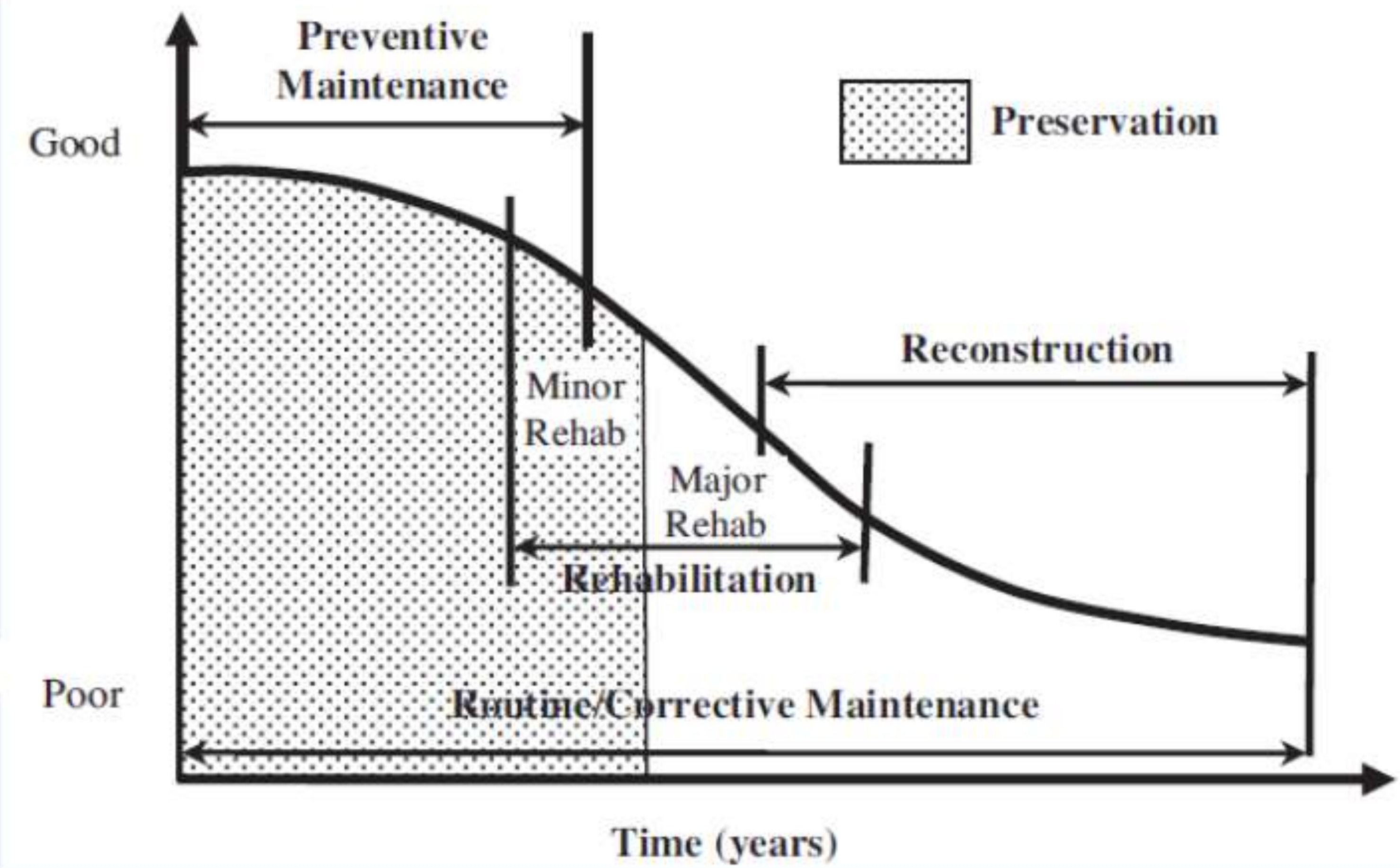
Factors to Consider

- Distress Types
- Ride
- Skid
- Noise
- Durability/Longevity

Purpose of Concrete Pavement Repair

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

Traditional Pavement Managment



Traditional Concrete Pavement Preservation

Treatment	Expected Performance	
	Treatment Life (yr)	Pavement Life Extension (yr)
Concrete joint resealing	2–8	5–6
Concrete crack sealing	4–7	NA
Diamond grinding	8–15	14 - 17
Diamond grooving	10–15	NA
Partial-depth concrete patching	5–15	NA
Full-depth concrete patching	5–15	NA
Dowel bar retrofitting	10–15	NA
Ultra-thin bonded wearing course	6–10	NA
Thin HMA overlay	6–10	NA

?

Sources: Peshkin et al. 1999; Smith et al. 2008; Peshkin et al. 2007; Caltrans 2008; NDOR 2002.

Note: NA = Not available.

Is Sealant Cost Effective?

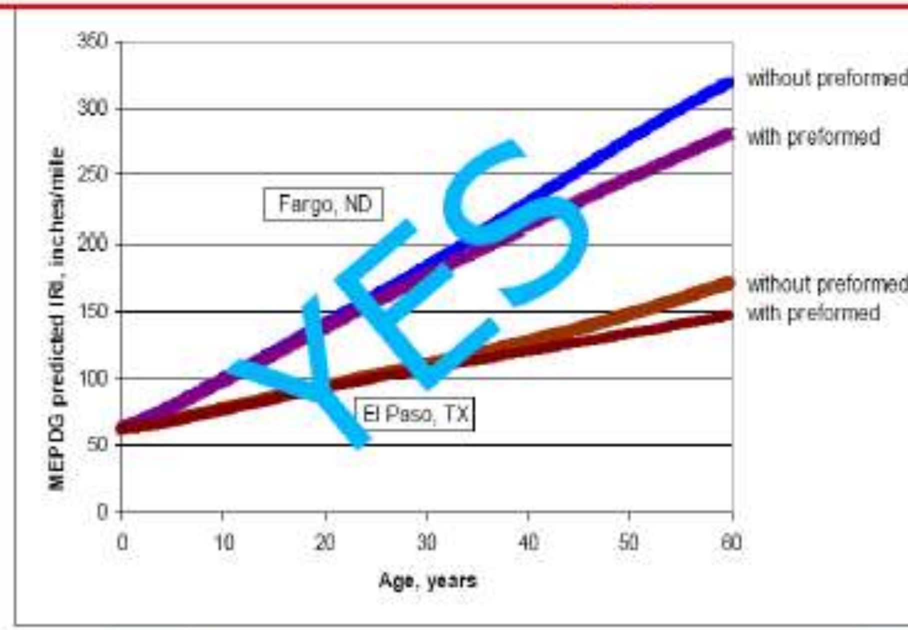
FHWA Sealant Effectiveness Study

CPTP

TechBrief

Performance of Sealed and Unsealed Concrete Pavement Joints

AASHTO New Design Guide



PCCP Repair Techniques

- Full-depth repair
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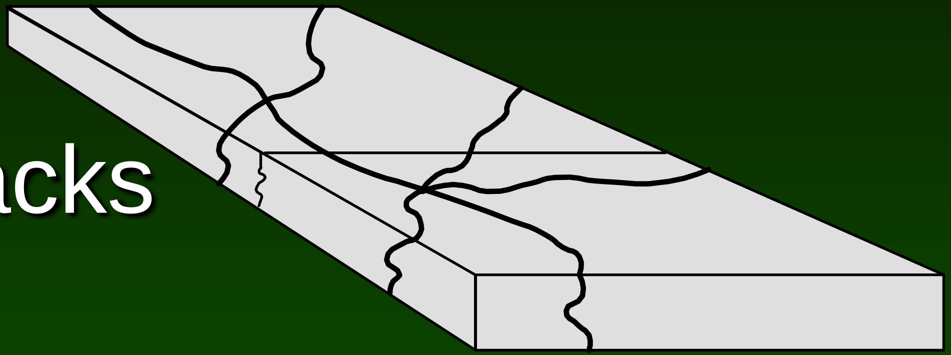
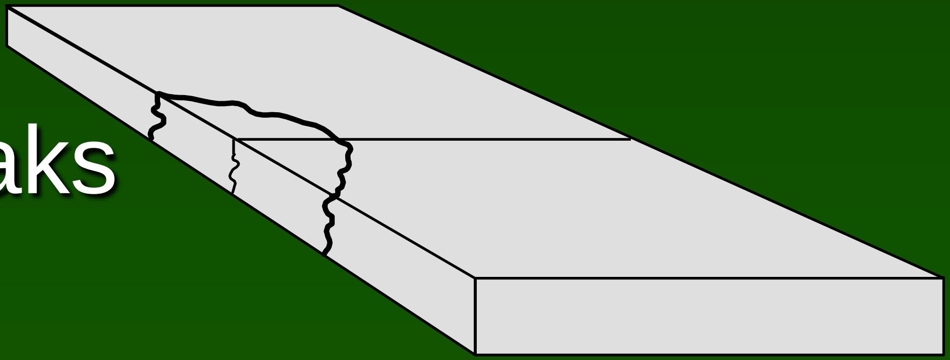
Full-Depth Repair

Multiple Cracks



Corner Breaks



Full Depth Patching

RAPID STRENGTH CONCRETE FOR PAVEMENTS

•Rapid strength concrete (RSC) has been efficiently used for emergency repair and planned rehabilitation of concrete infrastructure and for new construction, where acceleration is a concern. This concrete is produced with hydraulic cements. Accelerators of hardening, if used, are non-chloride in nature.

•Emergency rehabilitation of truck bypass tunnel,

•I-5 and RTE-14, November 2007.

- Total volume of various types of rapid strength concrete specified for construction in 2008 by Caltrans exceeded 190,000 cubic yards. Volume of rapid strength concrete specified for pavement rehabilitation was almost 130,000 cubic yards. Volume of rapid strength lean concrete base was approximately 37,000 cubic yards.

- Pavement replacement at I-10, Pomona, CA, 1999 (4-hrs RSC)

- Replacement HOV lane at I-10, Los Angeles, CA, 2009 (12-hrs RSC)

- Pavement replacement at RTE-710, Los Angeles, CA, 2005 (1.5-hrs RSC)

- **The principle difference in required performance of regular and rapid strength concrete is the time factor. A ten minute delay in opening temporarily closed freeway lanes to traffic may delineate a successful pavement repair shift from one for which the contractor would be penalized.**

Proportioning for ultra-rapid strength gain in early age is one difference in the design of RSC and regular concrete.

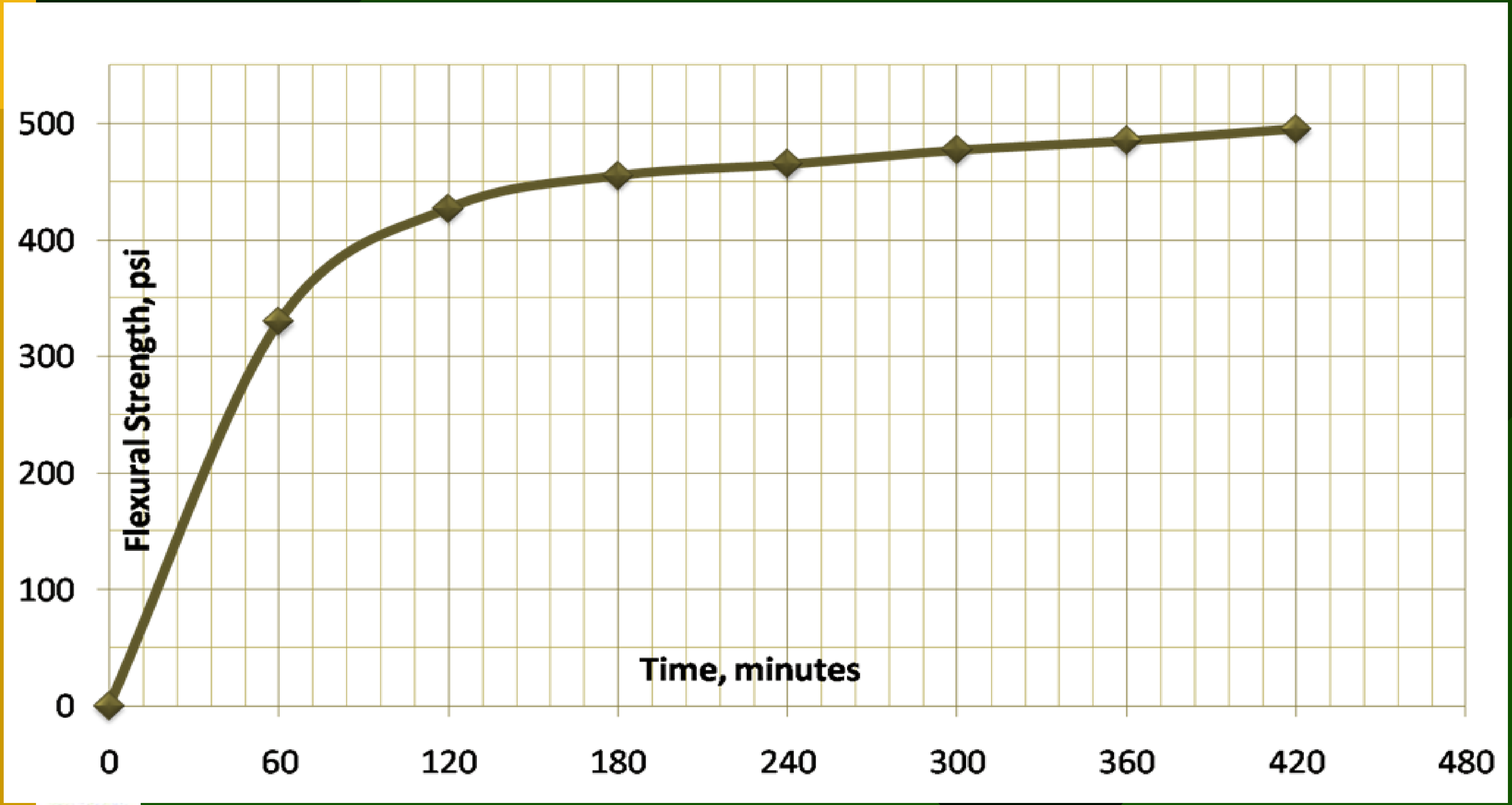
Options:

- Use of faster hardening hydraulic cements (rapid hardening cements, ASTM C1600; Type III portland cement, ASTM C150),
- Use of accelerating admixtures (non-chloride),
- Limiting W/C,
- Optimizing (increasing) initial and curing temperatures of concrete.

Proper design of RSC should account for other properties influencing acceleration of construction, such as:

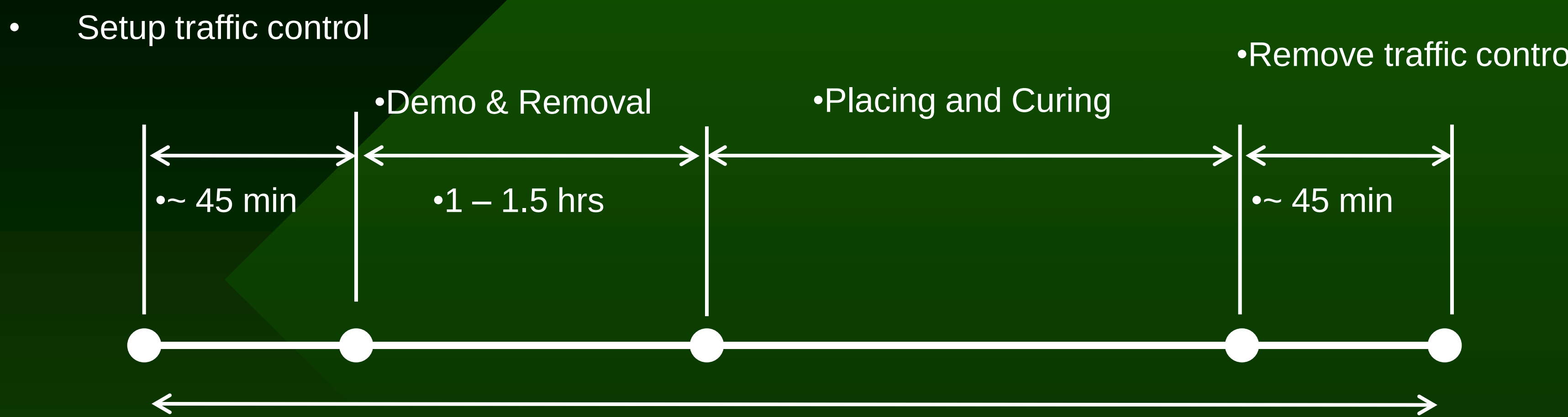
- Ability to be placed, spread and consolidated conveniently and quickly without segregation,
- Time within which fresh RSC retains workable consistency,
- Ability to be finished promptly upon completion of consolidation,
- And more.

•**Required rate of hardening of RSC depends on the specified strength and time allowed for its achieving.**



Caltrans Workshop December 2011

- Required rate of strength gain of RSC for pavement replacement depends on the maximum allowed curing time which is largely determined by available closure time and by desired productivity (volume of RSC placed per shift).



Duration of available traffic closure

Duration of Traffic Closure	Duration of Placing and Curing
6 hours	~ 3.5 hours
8 hours	~ 5.5 hours
10 hours	~ 7.5 hours
12 hours	~ 9.5 hours

RSC Design Notes

- Two types of rapid strength concrete (RSC) mostly used in California for pavement rehabilitation within short-time lane closures are:
  - RSC with rapid hardening cements (examples of such cements are CTS Rapid Set® Cement and Ultimax Cement-DOT®)
  - RSC with Type III Portland cement and non-chloride accelerator of hardening (this type of RSC is often called “4 x 4” concrete, because it was first developed to achieve flexural strength of 400 psi in 4 hours)

- The referenced RSC types allow for achieving flexural strength of 400 psi required for opening lanes to traffic (and corresponding compressive strength of ≥ 2,500 psi) as quickly as:
  - 1-hour plus when rapid hardening cements are used
  - 2.5-hour plus when Type III portland cement with accelerators of hardening are used

RSC for pavements is designed for:

- Workability
  - Consistency
  - Cohesiveness
  - Time within which fresh RSC retains workable consistency
- Ability to be finished promptly after placement
- <u>PROPORTIONING OF RSC</u>

RSC for pavements is designed for (continued):

- Flexural strength
  - Maximum curing time prior to opening lanes to traffic
  - Minimum flexural strength prior to opening to traffic
- Temperature of application
- Freezing and thawing resistivity
- Shrinkage
- Resistance to sulfate exposure

- <u>PROPORTIONING OF RSC</u>

•RSC is typically proportioned with superplasticizers for achieving desired (often near-flowable) consistency while maintaining low water to cement ratio (W/C). Hydration controlling admixtures extend time within which RSC retains workable consistency. Optimized consistency and cohesiveness accelerate construction of pavements.

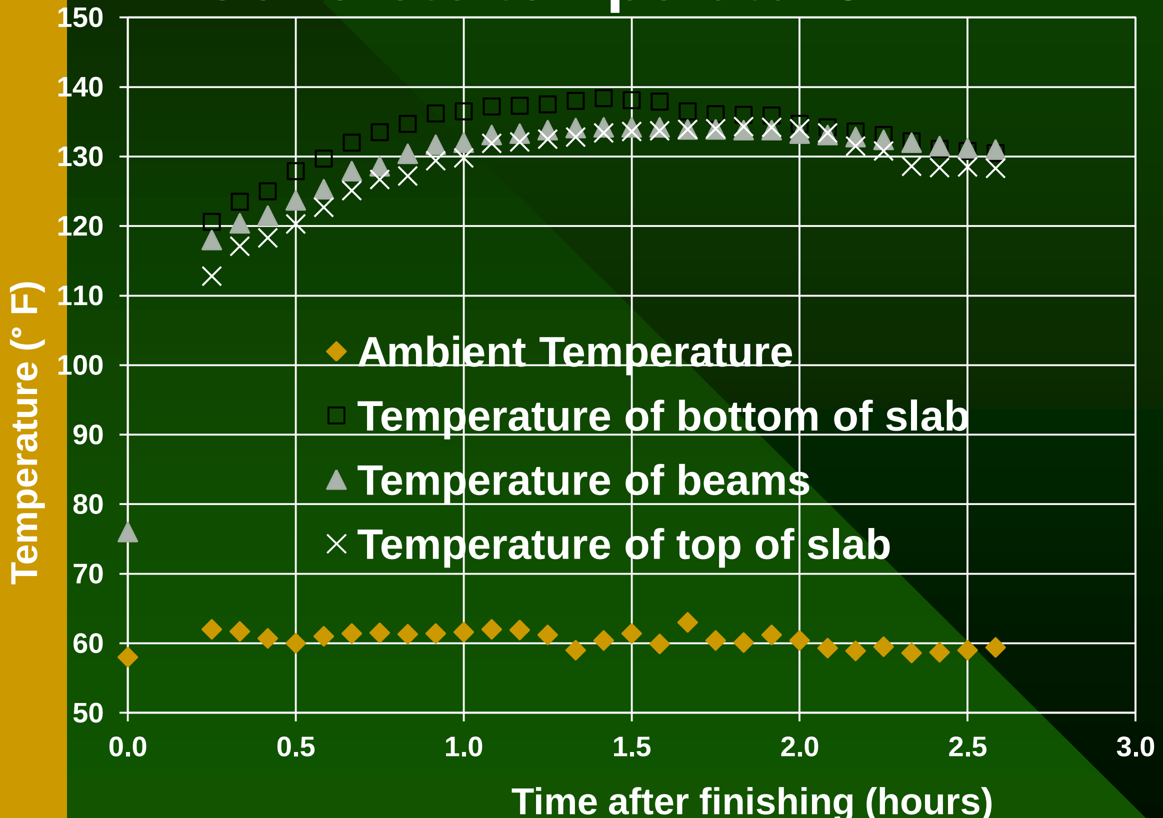
•**WORKABILITY**

- Limited bleeding of RSC allows for prompt finishing. Fast setting of RSC and subsequent accelerated gain of tensile strength mitigate risk of plastic shrinkage cracking associated with the use of low-bleeding concrete.

- **FINISHABILITY**

•**Rate of strength gain of RSC is mainly controlled by:**

- ✓**Type of hydraulic cement**
- ✓**Chemical admixtures**
- ✓**Water to cement ratio**
- ✓**Concrete temperature**



•**Testing Notes:**

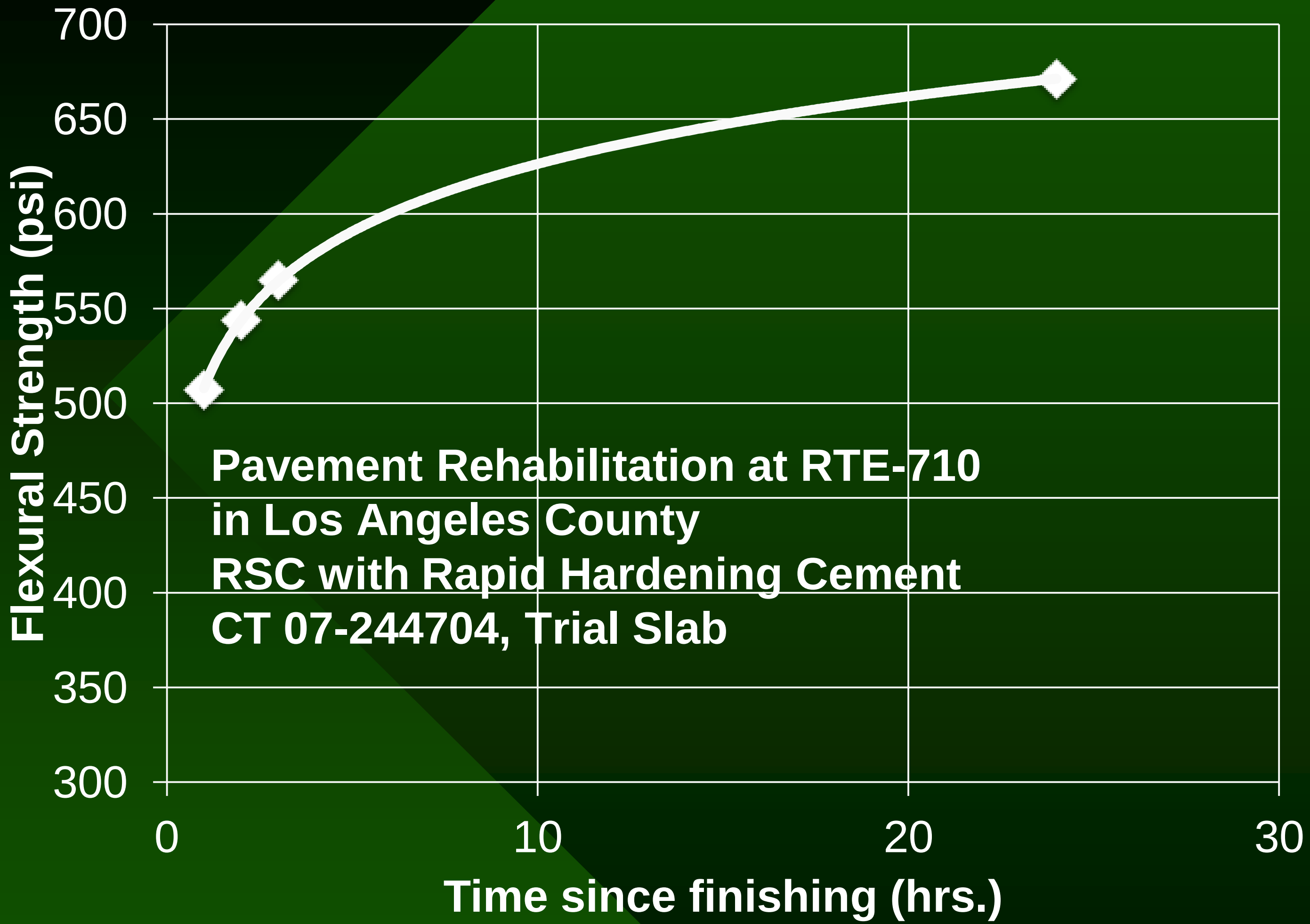
•**Estimation of strength gain requires matching temperature of concrete in specimens and in pavement during curing.**

RATE OF STRENGTH GAIN IN EARLY AGE

Min Curing Time to Achieve MOR (*)		Proportioning for Early Age Flexural Strength		
400 psi	550 psi	Type of Cement	Accelerator, fl. oz./100 # cmt.	Max W/C
1 to 2 hours	2 to 4 hours	Rapid hardening cement, ASTM C1600	-----	~0.41 - 0.43
2.5 to 4 hours	4 to 7 hours	Portland cement Type III, ASTM C150	70 to 100	~0.32 - 0.34
8 to 12 hours	12 to 16 hours	Portland cement Type III, ASTM C150	20 to 40	~034 - 0.36
≥16 hours	≥22 hours	Portland cement Type II, ASTM C150	None	~0.37 - 0.39

- NOTE: (*) Since the time RSC has been formed and finished.

PROPORTIONING FOR EARLY AGE MOR

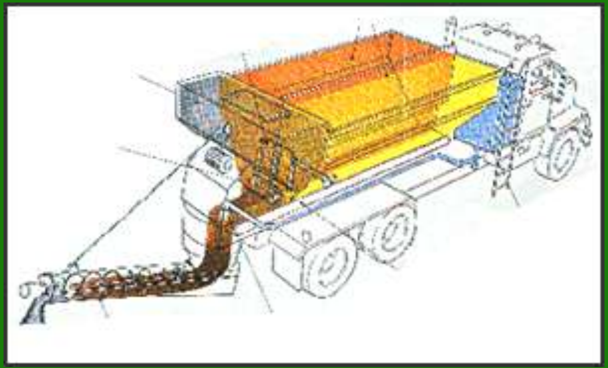


- **Rapid strength concrete mix design should be validated by construction and testing of a trial slab. Ambient conditions during construction of the trial slab shall be representative of those anticipated during construction.**

RATE OF STRENGTH GAIN IN EARLY AGE

Production Notes

PRODUCTION NOTES

- RSC with rapid hardening cements is most often produced by mobile (volumetric) mixers to
- allow for immediate placement. The demand in hydration stabilizers is reduced and uniformity of workability and strength is improved.
- 

- RSC with Type III portland cement typically has been produced using transit mixers. Superplasticizer and set controlling admixture are added at the batch plant. Accelerator of hardening is added on site.

Paving Notes

Time within which RSC retains workable consistency is limited. It may be as short as 15 minutes (typical for RSC with rapid hardening cements designed to achieve flexural strength of 400 psi in 1-hour).

Paving crew should promptly place, consolidate, screed off, finish and texture concrete.

- **PAVING NOTES**

Reduced bleeding eliminates “waiting time” prior to finishing. Rapid development of strength reduces risk of plastic shrinkage cracking. It is still important to protect finished and textured surface promptly with curing compound to provide for more complete hydration and to assure abrasion resistance

- **PAVING NOTES**

- Inadequate curing and protection, as well as excessive application of water to the surface, may reduce abrasion resistance of RSC pavement.

- **PAVING NOTES**

Concrete temperature is critical for workability retention. In hot conditions, consistency (penetration) will decrease faster within time.

The time within which fresh concrete retains workable consistency can be controlled by using hydration stabilizers. Use of hydration stabilizers should be optimized with respect to both workability retention and early age strength gain of RSC.

- **PAVING NOTES**

Temperature influences strength gain of RSC. Higher the temperature, faster the strength gain; lower the temperature, slower the strength gain.

RSC shall be designed for specific temperature of application, which is one of the most important constructability considerations.

- Concrete supplier shall recommend the minimum initial temperature of RSC, especially when work is performed during cooler weather periods. We recommend the RSC temperature shall not be less than 65ºF prior to placement (preferably not less than 70ºF). Use of hot water is one efficient option used by some RSC suppliers.

- PAVING NOTES

RSC sets and hardens dramatically faster than regular portland cement concrete. Sawing window starts earlier and is shorter than for regular pavement concrete.

- **Special Provisions by Caltrans provide for saw cutting no later than in 2 hours.**

- **PAVING NOTES**

Concrete temperature is critical for strength gain. Mass of RSC in a pavement slab is significantly larger than in a test beam. In early age, the temperature of concrete in pavement slab is normally higher than in an unprotected test beam.

- Beams shall be cured in heat retaining enclosures for matching the pavement slab temperature.

- **TESTING NOTES**

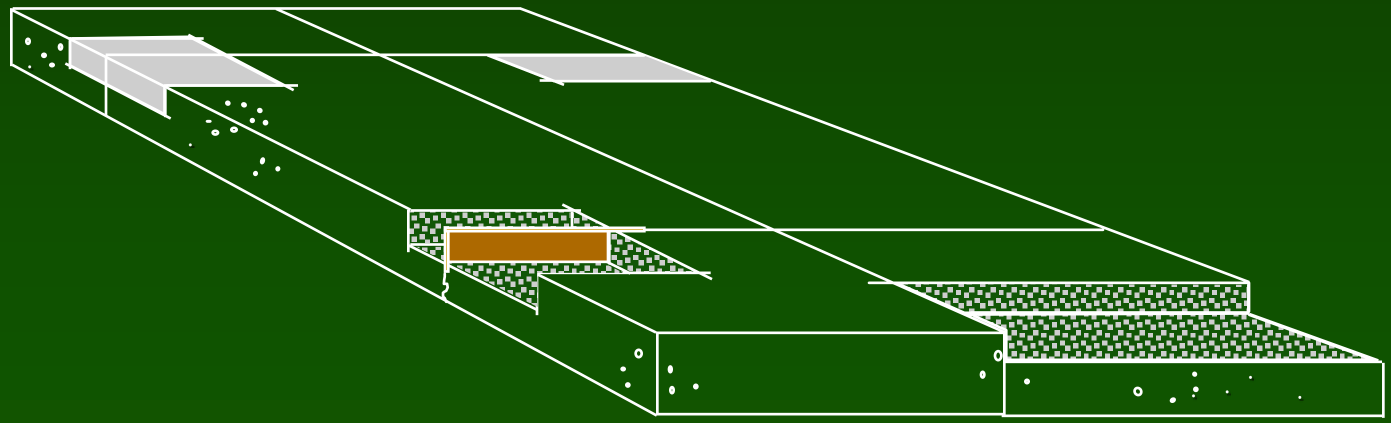

SLAB

Removal for Full Depth Repairs

- Non-impact method
  - Backhoe or lifting devices
  - Preserves existing base
  - Prevents damage to adjacent slabs

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.



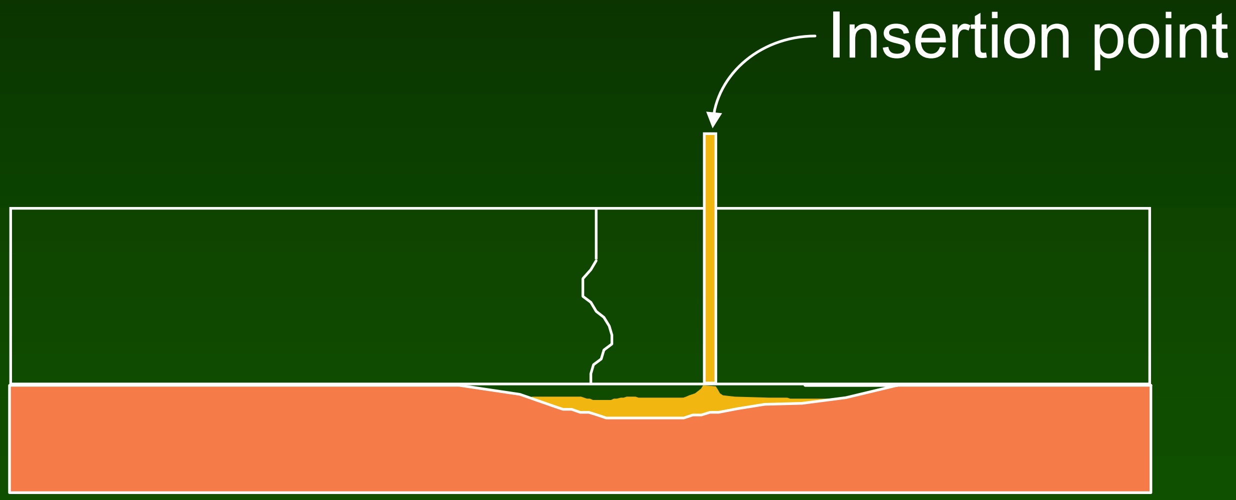
Partial Depth Patching

I-10 Indio, CA Aug 2010

courtesy of CeraTech

Slab Stabilization / Slab Jacking

Pressure insertion of flowable material beneath the PCC slab



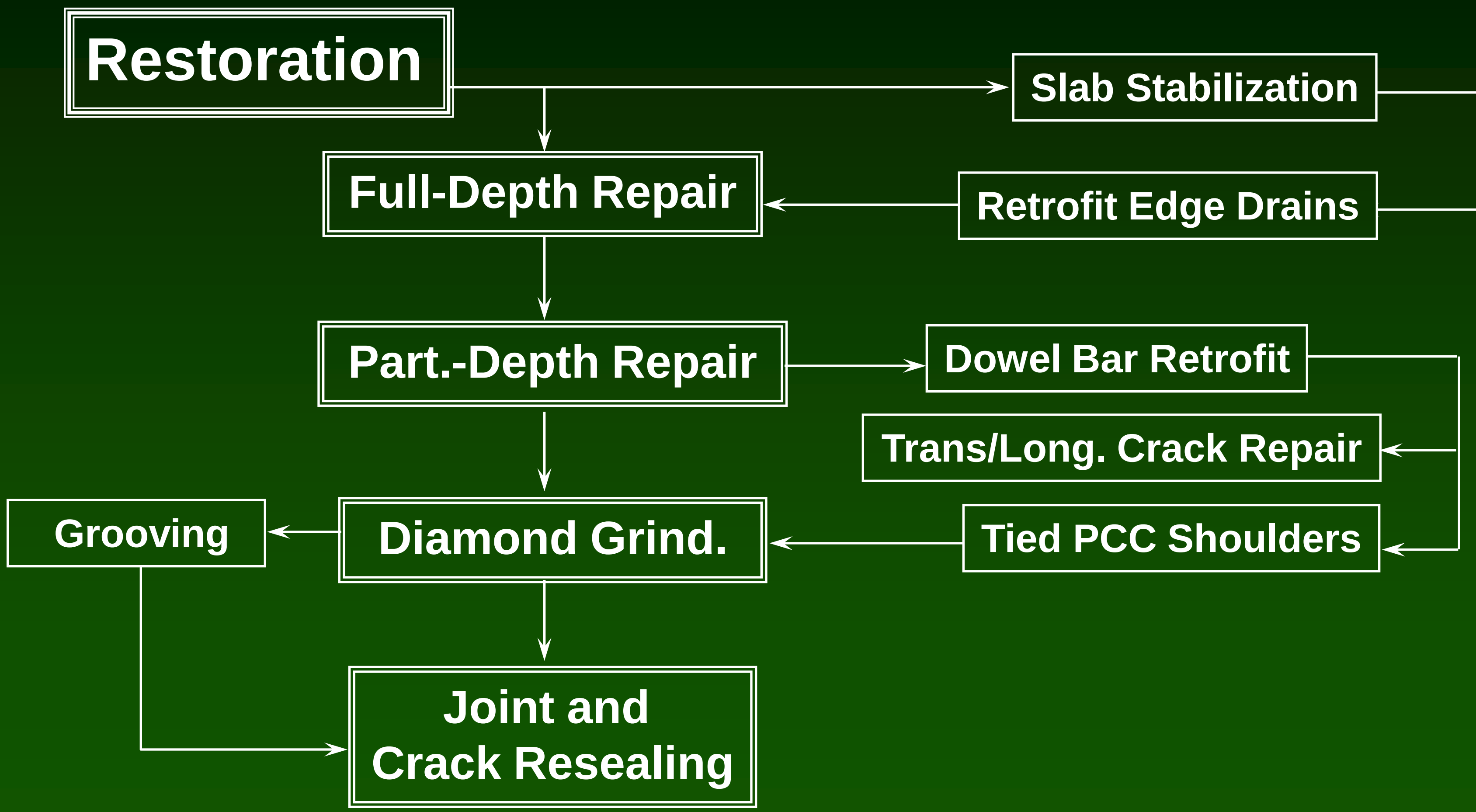
Slab Stabilization/ Jacking

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

Joint and Crack Resealing

Sequencing of Techniques



Repair/Rehabilitation Strategy Selection

Determining correct strategy is NOT complicated.

- Determine the <u>cause</u> of distress.
  - Structural, Functional , Material, Drainage
- Consider multiple perspectives
  - Ride Quality, Traffic, Noise, Maintenance Requirements, Lane-Condition Uniformity, Future Performance, Cost

DOT Approach to Selecting Maintenance Treatments

- Assess Existing Pavement Conditions
  - – Conduct visual site inspection and/or review project information
  - – Perform testing on the existing pavement, as conditions require
  - – Define the performance requirements for the treatment

Pavement Distress Types

Concrete Pavement

- Structural Distress
  - Cracking
  - Joint / Crack deterioration
  - Durability distress
  - Punchouts (CRCP)
- Functional Distress
  - Faulting
  - Noise
  - Surface polishing & surface defects

DOT Approach to Selecting Maintenance Treatments

Data Item	Grind-ing	Load Transfer Restor-ation	Partial-Depth Repair	Full-Depth Repair
Existing Pavement Structure	X	X	X	X
Original Construction Data	*	*	*	*
Age	*		*	*
Materials Properties	X		*	*
Subgrade				
Climate				
Distress	X	X	X	X
Skid	*			
Accidents	*			
NDT		X		*
Destructive Testing/ Sampling	*	*	X	X
Roughness	*			
Surface Profile	X			
Drainage	X			X
Previous Maintenance	*		*	*
Utilities				X
Traffic Control Options	X	X	X	X

Proposed Trigger Values and Expected Life

Treatment	Trigger (National)	Climate Region[1]				Traffic ADT			Life of Treatment (Year)	Estimated Cost ($)[2]
		Desert	Valley	Coastal	Mountain	<5000	>5000;<30000	>30000		
Crack Resealing	>1/4 inch	>1/4	>1/4	>1/4	>1/4	>1/4	>1/4	>1/4	4 - 7	$27.7k - 42.4 k/ln mi
Diamond Grinding	Faulting > 1/4 inch; Ride 95 in/mile	>1/4 >190	>1/4 >95	>1/4 >95	>1/4 >190	>1/4 >190	>1/4 >125	>1/4 >95	10 - 18	$30.0k - 80.1k/ln mi
Partial Slab Repair	Surface distress - Patches <1.2 yd^2	<1.2	<1.2	<1.2	<2.4	<2.4	<1.2	<1.2	8 - 12	$135 - $270/yd^3$
Isolated Slab Replacement	3rd stage cracking or unstable slabs	Same Trigger Value. For desert, mountain, or ADT<5000, District makes decision to repair.							8 - 12	$4000 - $8000/slab
Dowel Bar Retrofit	LTE <60%, Faulting>1/4 inch, Max 10% Cracking	<40 >1/4 20	<70 >1/4 10	<70 >1/4 10	<50 >1/4 20	<50 >1/4 20	<70 >1/4 10	<70 >1/4 10	8 - 17	$141k - 177k/ln mi

Approach for Selecting Maintenance Treatments

Decision Factor Names ⇨	DECISION FACTORS							
	Initial Cost	Life Cycle Costs	Expected Life	Ease of Repairing/ Maintaining	Construction Traffic Control	Proven Design in Agency	Total Score	Rank
Weightings ⇨	25	15	20	15	10	15		
Alternative 1	60 / 15	60 / 9	100 / 20	80 / 12	90 / 9	100 / 15	80	1
Alternative 2	60 / 15	60 / 9	100 / 20	80 / 12	90 / 9	100 / 15	80	1
Alternative 3	60 / 15	60 / 9	70 / 14	50 / 7.5	60 / 6	40 / 6	57.5	6
Alternative 4	60 / 15	60 / 9	70 / 14	50 / 7.5	60 / 6	40 / 6	57.5	6
Alternative 5	60 / 15	40 / 6	100 / 20	80 / 12	100 / 10	90 / 13.5	76.5	3
Alternative 6	60 / 15	80 / 12	40 / 8	20 / 3	40 / 4	20 / 3	45	9
Alternative 7	40 / 10	60 / 9	40 / 8	50 / 7.5	50 / 5	30 / 4.5	44	10
Alternative 8	70 / 17.5	80 / 12	60 / 12	50 / 7.5	80 / 8	40 / 6	63	5
Alternative 9	100 / 25	100 / 15	20 / 4	20 / 3	40 / 4	40 / 6	57	8
Alternative 10	30 / 7.5	60 / 9	100 / 20	100 / 15	100 / 10	30 / 4.5	66	4

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
- ACPA is ready to assist