SOLUTIONS FOR THE BUILT WORLD

Polymer Resin Concrete for Bridge Deck Overlays

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Guidelines For Selection of Bridge Deck Overlays, Sealers and Treatments – NCHRP Project 20-07, Task 234

- Agency Survey and Guidelines
- Review Literature

- <u>Results:</u>
- Deck Characterization
- Primary Repair Category Selection
- Selection of Repair Options

Overlay Type/Use	New or Experimental	Current Common Practice	Historic Experience (Not Current Practice)	Never
Low slump concrete overlays	4	12	14	11
Asphalt concrete overlay with membrane	0	30	12	3
High performance concrete overlay	9	17	2	16
Silica-fume modified concrete overlays	8	6	6	23
Polymer concrete overlays	12	16	7	9

Types of Polymer Overlays

- Various polymer resins (epoxy, urethane, epoxy-urethane, polyester, other co-polymer)
- Broom and Seed Multiple-Layer – Epoxy Binder, 1/4 – 1/2 in.
- Slurry Overlay – Methacrylate Binder, ~1/4 – 3/8 in.
- Premixed & Screeded – Polyester-Styrene Binder, 3/4 - 1 in. plus

Multiple-Layer Polymer Overlay

Slurry Polymer Overlay

Premixed Polymer Overlay

Why Polymer Overlay ?

- Very low permeability to water and chlorides
- High wear/abrasion resistance (0.015 in./yr)
- Excellent bond strength
- High tensile and flexural strength
- Thin, less deadload, no deck adjustments
- Correct for construction defects:
  - Finishing defects, Grade, Low cover
- Fast setting – traffic in about 2 hours

Deck Conditions

- Commonly used on aged decks with distress
- Best extension of service life on new decks or decks without current damage

- *May not be best for decks at the end of their service life

Older decks - Sounding

- Detecting unsound and deteriorated areas of concrete
- Chain Drag or Hammer-tapping to locate boundary of unsound concrete
- Infrared, Rolling Impact Echo, GPR

Surface Preparation

- Important factor in performance of concrete and polymer overlays

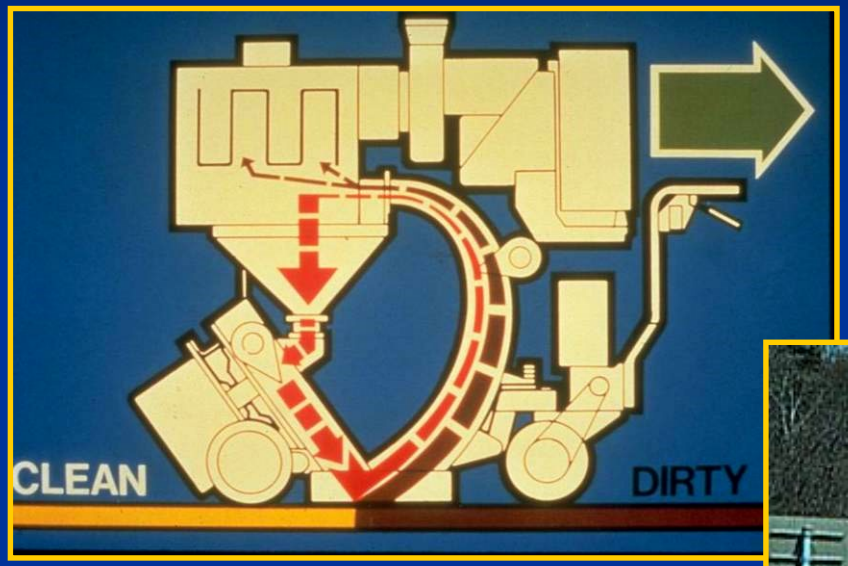
Surface Preparation

- Patching
- Micromilling, if needed – followed by:

- Shotblasting – preferred
- Hydrojetting – must allow to dry after
- Sandblasting (or other blasting types)

- **Dry** and Clean with subsequent passes

Shotblast



Sandblasting or Waterblasting

Hydrodemolition

Surface Profile – ASTM E 965

Tension Pull-off – ASTM C 1583

Polyester Polymer Concrete

- Early use was broom and seed method (1960's)
- 1970's - Oregon DOT 1000 cps resin, roller screed
- First use of current system 1983 – Thomson Creek & Beaver Creek Bridges (Caltrans)
- 1985/86 Highway overlay I-80 (10 lane miles)
- Common use by Caltrans and many other states for night time construction windows on urban bridges

Caltrans Polyester Polymer Concrete

- Polyester-styrene resin (100-200 cps)
- Uniform aggregate gradation – gravels
- Silane coupling agent (1-2%)
- Mobile concrete mixer or common drum
- Slip-form paving machines or vibratory screed

Overlay performance

- Rigid concrete overlays fail by cracking and delamination. Design polymer overlays for:
  - 1. Excellent Adhesion
  - 2. Cracking Resistance
- Performance
  - Prevents water and deicer penetration
  - Slow active corrosion
  - Creates equilibrium conditions
  - Limits oxygen
  - Primer (HMWM) fills and bonds cracks in deck

	Polyester Concrete	Portland Cement (8 sk)	Latex-mod. Concrete	Silica-fume concrete
Compressive Strength, psi	8,000	7,000	7 - 9,000	7 - 10,000
24 hr. Early Strength	4,000	1500	1500	2500
Return to Service	2 - 4 hours	3 - 7 days	3 - 7 days	2 - 4 days
Modulus (E), $x10^6$psi	1 - 2	3 - 5	3 - 4	3-5
Flexural, psi	2,200	800	900	1,100
Abrasion, gms	1 - 2	10 - 20	10 - 20	10 - 20
RCP, coulombs	0 - 100	1,000 - 3,000	500 - 1,000	500 - 1000

Stress Due to Shrinkage or Temperature

$$\sigma_t = \varepsilon_t E_{eff}$$

Where:

ε_t = shrinkage at time *t* after initial drying

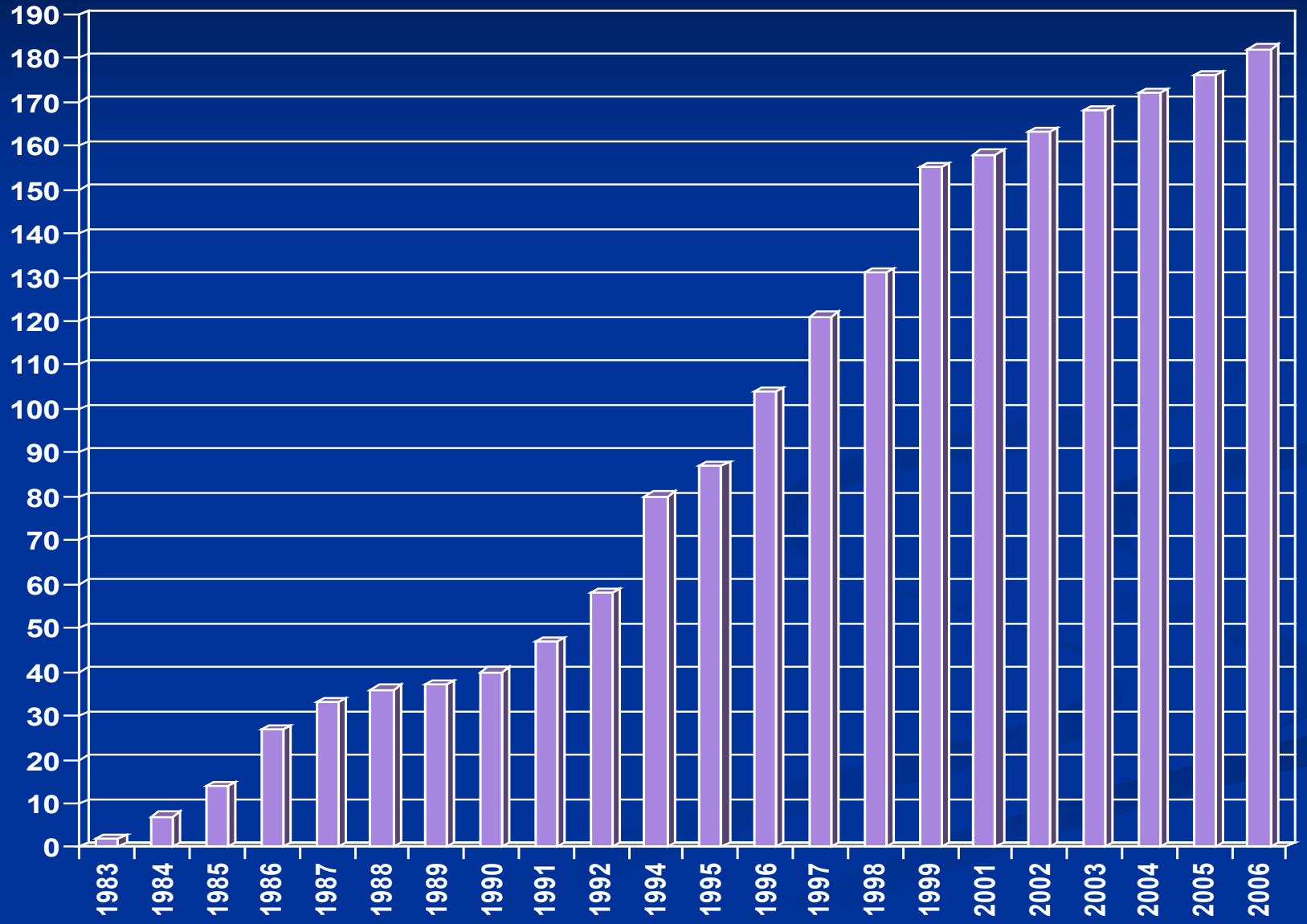
E_{eff} = effective modulus a time *t* (psi)

σ_t = stress induced by restrained shrinkage (psi)

PPC Overlay Properties vs. PCC

- Thermal coefficient of expansion – similar to pcc (14.6 x 10-6 deg C) due to mixer blended gradation
- Lower modulus equals less stress
- Higher creep capacity
- Higher tensile and flexural strength
- Excellent bond strength
- High wear/abrasion resistance (0.015 in./yr)
- Very low permeability to water and chlorides
- ¾ in. to several inches thick
- Fast setting – traffic in about 2 hours

Number of Projects
*Since 2001 30-50/yr



Examples of Major Bridge Projects in SF Bay Area

- Benicia-Martinez Bridge (1990)
- Marina Viaduct Approach to Golden Gate Bridge (July 1992)
- Oakland Bay Bridge (2006)
- Richmond - San Rafael Bridge (2006)

SF Bay Area Projects

- Marina Viaduct Approach to Golden Gate Bridge July 1992
  - 250,000 square feet
  - All night construction – open each morning
  - Cured in 2 hours
  - Temperatures below 45F, mist and fog
  - Continuous mixer and paving machines

San Francisco-Oakland Bay Bridge

- Treasure Island to the San Francisco Anchorage
- 300,000 cars per day
- Two miles long with 5 lanes on the upper deck and 5 lanes on the lower deck
- No extra weight was to be added
- ¾" modified asphalt surface that had been failing
- 2 hour paving window –min. ¼ lane mile/shift
- Completed within 5 months - planners estimated two seasons

San Rafael-Richmond Bridge

- Built in the early 50's -lt wt concrete structural deck topped with a high density grout
- Long bay crossing spanning 3.6 miles - 3 top deck lanes & 3 bottom deck lanes
- 80,000 vehicles per day - high % of truck traffic
- 8 hours of paving time per night
- Kwik Bond Polymers PPC 1121
- > 1 lane mile/night
- Completed in two months

The Process

- Remove the modified asphalt or high density grout surfaces using micro mill technology
- Repair underlying deck using PPC, clean and roughen surface using Disa Goff 30" shot blast machine
- Prime with a 100% reactive, high molecular weight methacrylate HMWM resin
- Place Polyester Polymer Concrete using specialty volumetric mixers and a two track slip-form paving machines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Health and Safety

- Resins, peroxide, cleaning solvents
- Odor is present – can cause nausea, etc.
- Monitoring shown less than PEL of 100
  - (Permissible exposure level)
- Face respirators recommended for workers – esp. at mixer and immediately behind screed
- Resin suppliers add volatile suppressant to reduce emissions (wax)


OVERSIZE LOAD


KWIKBOND
POLYMERS
1866
Trimac
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CBI Concrete Barrier Inc.
Haulmark
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157
NO
SMOKING
158
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SAFETY
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CBI Concrete Barrier Inc.
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Conclusions

- Polymer overlays provide a valuable option in our toolboxes: esp. need speed, lightweight, & long life
- Polyester polymer concrete used successfully by Caltrans for the past 35 years
- Can be used on major urban structures with all construction at off-peak night hours (6 hour traffic closure windows are possible)

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