Best Practices for Bridge Deck Overlay

Tommy E. Nantung PhD PE
INDOT
Division of Research and Development

Robert J. Frosch PhD PE
Purdue University
Roadmap to Presentation

- Objective of Presentation
- General information and paradigm shift in field practice
- Source of deterioration of bridge deck
- Protection system for bridge deck
- Best practices
- Conclusions
Objectives of Presentation

- Evaluate Deck Protection Alternatives
- Discuss Best Practices
- Access Best Alternatives
General information

- Corrosion damage is a multi-billion dollar problem
- A cost figure of 1% of GNP is related to the bridge deck corrosion, direct or indirect
- The worst bridge disaster, Silver Bridge over Ohio River in 1967, 46 fatality
Paradigm Shift

- Maintaining a State of Good Repair Using Cost Effective Investment Strategies
  - Bridge Preservation
  - Bridge Preventive Maintenance

- Definition:
  - Strategies that prevent, delay or reduce deterioration of bridges or bridge elements, restore the function of existing bridges, keep bridges in good condition and extend their life.
## Cyclical PM Activities

<table>
<thead>
<tr>
<th>Cyclical PM Activity Examples</th>
<th>Commonly Used Frequencies (Years)(^{(4)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wash/clean bridge decks or entire bridge</td>
<td>1 to 2</td>
</tr>
<tr>
<td>Install deck overlay on concrete decks such as:</td>
<td></td>
</tr>
<tr>
<td>- Thin bonded polymer system overlays</td>
<td>10 to 15</td>
</tr>
<tr>
<td>- Asphalt overlays with waterproof membrane</td>
<td>10 to 15</td>
</tr>
<tr>
<td>- Rigid overlays such as silica fume and latex modified</td>
<td>20 to 25</td>
</tr>
<tr>
<td>Seal concrete decks with waterproofing penetrating sealant</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Zone coat steel beam/girder ends</td>
<td>10 to 15</td>
</tr>
<tr>
<td>Lubricate bearing devices</td>
<td>2 to 4</td>
</tr>
</tbody>
</table>

\(^{(4)}\) Frequencies are based on FHWA’s knowledge of typical State DOT practices
Preventive Maintenance

- PM activities that may extend the life of bridge decks
  - Seal or replace leaking joints.
  - Deck overlays - significantly increase the life of the deck by sealing of aging and weathering.
  - Cathodic Protection systems for bridge decks.
  - Electrochemical Chloride Extraction treatment
  - Concrete deck repairs in conjunction with installation of deck overlays
Cause of Deterioration

- Corrosion of the reinforcing bars and deterioration of the riding surface
- All are related to the co-existence of:
  - Water
  - Salt (chloride)
  - Oxygen
Corrosion of Steel in Concrete

PASSIVE STEEL AS CATHODE

CORROSION CURRENT

O₂
H₂O
Cl⁻

Fe⁺

O₂
H₂O
Cl⁻

REBAR

ANODIC DISSOLUTION OF IRON

CONCRETE
Principle of Deck Protection

- Remove at least one component of the source of corrosion
- Not necessarily to remove all three components
Good Protection Systems

![Image of two graphs showing longitudinal and transverse length with color gradients indicating protection levels.](image-url)
Waterproofing Membrane
Preformed System Components

Preparation, primer, membrane, protection layer, tack coat, asphalt

Preformed sheet vs. liquid applied
Preparation, primer, membrane, protection layer, tack coat, asphalt

Preformed sheet vs. liquid applied
In New England states and Canadian provinces it was first recognized that water and chlorides were being trapped under asphalt overlays. As a solution membranes were installed.

Maine, Massachusetts, Montana, Ohio, Rhode Island, Vermont and West Virginia all have specs for waterproofing membranes.

29 states (58%)

North East
Midwest
South
West

Some states that claim to “use” membranes only use them as last resort options (Kansas and Illinois)

States in the US have always been sharply divided over the merits of waterproofing membranes, and the ones that use membranes are divided over what systems are best.
International Practice

- United Kingdom
- Spain
- Germany
- Sweden
- Japan
- Canada
- Denmark
- Australia

Unique Features
## Indiana Toll Road

![Map of Indiana Toll Road](map_image)

<table>
<thead>
<tr>
<th>Description</th>
<th>Milepost</th>
<th>Structure Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gary Sanitary Plant</td>
<td>11.6 to 12.0</td>
<td>8-3</td>
</tr>
<tr>
<td>Grand Calumet River West</td>
<td>12.3</td>
<td>8-5</td>
</tr>
<tr>
<td>Bridge Street</td>
<td>12.7</td>
<td>8-7</td>
</tr>
<tr>
<td>Grant Street</td>
<td>13.3</td>
<td>9-6</td>
</tr>
<tr>
<td>Buchanan Street</td>
<td>13.7</td>
<td>9-4</td>
</tr>
<tr>
<td>Grand Calumet River East</td>
<td>13.9</td>
<td>9-3</td>
</tr>
<tr>
<td>Broadway Street</td>
<td>14.5 to 15.2</td>
<td>9-1</td>
</tr>
<tr>
<td>Tennessee Street</td>
<td>15.4</td>
<td>10-7</td>
</tr>
</tbody>
</table>
Toll road Installations

Images courtesy of Jim Wallen, Soprema
Toll Road Installations

Images courtesy of Jim Wallen, Soprema
Japanese Robot System
Overlay Thickness

\[
\frac{\text{INDOT Allowable Weight of W. S.}}{\text{Weight of Bituminous W. S.}} = \frac{35 \text{ lb/ft}^2}{140 \text{ lb/ft}^3} = 3 \text{ in. (75mm)}
\]

- UK – 120 mm (4.7 in.)
- Denmark – 100 mm (4.0 in.)
- Maine DOT – 3 in.
- Conn DOT – minimum 3 in.
Inductive Stiffness Joint
Toll Road Specs
Expansion Joint
Toll Road Installations

Soprema “Antirock” w/ 2½ in. SMA Overlay

Images courtesy of Jim Wallen, Soprema
Drainage
After 2 years of service, all of the bridge decks received a 9 (excellent condition) and the wearing surface received either a 7 (good condition) or 8 (very good condition)
Many failures have been observed in the Midwest
Most demanding installation procedure
Installations can require long lane closures
Substantially increases dead load
Proper drainage of the asphalt overlay is difficult to achieve
Difficult to inspect
Difficult to replace
Expensive option

Membrane System Merits

- Largest potential
- Flexible
- Waterproofing maintained during resurfacing
- Proven successful in many parts of world
Concrete Overlay
Latex-modified concrete overlays are placed at a thickness of 1-¼ in. after ¼ in. of the concrete deck is removed by milling or hydrodemolition.
Latex-modified concrete overlays are placed at a thickness of 1-3/4 in. after ¾ in. of the concrete deck is removed by milling or hydrodemolition.
Early-age cracking compromises the overlay
Long installation time due to curing procedures
Substantially increases dead load
Requires the use of mobile mixers
Expensive option

Concrete Overlay Merits

- Improves load carrying capacity
- Beneficial when patching required
- Experienced installers
- Longest established service life
- Proven successful in Indiana
Epoxy Overlay

- Mostly proprietary systems
- Open to traffic after one or two days
- Good friction during wet weather
- Sensitive to temperature and construction practice
Two Part Epoxy
Aggregate - Oklahoma Flint Rock
Application Truck

Aggregate

Temp Readings @ 100’
Epoxy Test Batch

- Gel Time
- Monitor
  - Temperature
  - Time to set
Details - Drain Covers
Volume Monitoring

Gallons Applied
US231 Installation
Transpo “E-Bond”
SR26 Installation
POLY-CARB “Flexogrid”
Finished Application

2 Lifts  Prepared Surface
Thin Polymer Overlay Merits

- Easily installed
- Short installation time
- Thin application
- Proven successful in Indiana
New Bridge Decks

Options for preventative maintenance

• Membrane system
• Thin polymer overlay
Existing Bridge Decks

Critical bridges and bridges w/ patching
  • Latex-modified concrete overlay

Quick
  • Trenching

Extend
  • Mat
Field Performance

- Better field coordination/communication
- Better preparation of the substrate concrete
- Follow the specifications, manufacturer recommendation, and materials data sheet
- Temperature dependent materials
- Quality of construction/workmanship
Conclusions

- Each bridge deck protection system has advantages and disadvantages
- Selection of bridge deck candidate is very important to achieve good performance
- Workmanship during construction influences the performance the most
- The protection systems have been proven effective in the field
QUESTIONS?