Bridge Preservation Beyond the Short Term

Anwar S. Ahmad, P.E.
Bridge Preservation Engineer
Federal Highway Administration

Purdue Road School
Purdue University
March 9, 2011
Presentation Outline

• Bridge Related Facts & Challenges
• Bridge Terminology
• Bridge Preservation Program Parameters
• Systematic Preventive Maintenance
Bridge Facts & Challenges

- More than 600,000 Bridges Nationwide
- Aging Infrastructure
  - 30% of bridges have exceeded their theoretical 50 year design life
  - Average bridge age is 40 years
- Deteriorating Condition
  - 25% of bridges are deemed deficient (SD or FO)
    - 12% structurally deficient
    - 13% functionally obsolete
  - 16% of bridges are at risk of becoming SD (cusp bridges(1))

---

(1) - Based on NBI general condition rating of “5” for deck, superstructure, or substructure.
Bridge Facts & Challenges

- **Increase in Travel Demand**
  - 4.4 billion total ADT carried – *Represents 18% increase since 2000*
  - 413 million total Truck ADT carried - *Represents 23% increase since 2000*

- **Increase in materials and labor costs**
  - National average replacement unit cost = $162/SF – *Represents 82% increase since 2000*
Truck Volumes in 2000
Truck Volumes in 2020
Increasing Congestion 1993-2002

24% Increase in passenger car VMT
33% Increase in single-unit trucks VMT
34% Increase in combination trucks VMT
2% Increase in Lane Miles
Number and Status of Bridges in the US

Number of Bridges

% of Deficient Bridges

Decade Built

Number of Bridges

% of Deficient Bridges

Source: 2007 NBI
Average Bridge Construction Unit Cost Trends

- **Note:** Ave Unit Cost not all inclusive, e.g. does not include indirect cost such as mobilization.
Presentation Outline

• Bridge Related Facts & Challenges

• Bridge Terminology

• Bridge Preservation Program Parameters

• Systematic Preventive Maintenance
Bridge Terminology

Load Carrying Elements:
- Deck
- Superstructure
- Substructure

Waterway

Structurally Deficient

- Structurally Deficient (SD) means there are elements of the bridge that need to be monitored and/or repaired.

  - An element (deck, superstructure or substructure) receives an NBI general condition rating\(^{(1)}\) of a 4 or less (poor or worse condition)

  - Structural Condition or Waterway Adequacy rated a 2 or less
    - Very low load rating
    - Frequently floods

\(^{(1)}\)General Condition Ratings (GCR's): Is a national standard used as a guide in evaluating bridge decks, bridge superstructures, bridge substructures, and culverts. GCR is a numerical system that ranges from 0 (failed condition) to 9 (excellent condition).
Structurally Deficient Structure Examples

Deck  Superstructure  Substructure
## NBI General Condition Ratings

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Commonly Used Feasible Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>EXCELLENT CONDITION</td>
<td>Preventive Maintenance</td>
</tr>
<tr>
<td>8</td>
<td>VERY GOOD CONDITION</td>
<td>No problems noted.</td>
</tr>
<tr>
<td>7</td>
<td>GOOD CONDITION</td>
<td>Some minor problems.</td>
</tr>
<tr>
<td>6</td>
<td>SATISFACTORY CONDITION</td>
<td>Structural elements show some minor deterioration. Preventive Maintenance; Major Repair/Rehabilitation</td>
</tr>
<tr>
<td>5</td>
<td>FAIR CONDITION</td>
<td>All primary structural elements are sound but may have some minor section loss, cracking, spalling or scour</td>
</tr>
<tr>
<td>4</td>
<td>POOR CONDITION</td>
<td>Advanced section loss, deterioration, spalling or scour. Rehabilitation/Replacement</td>
</tr>
<tr>
<td>3</td>
<td>SERIOUS CONDITION</td>
<td>Loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.</td>
</tr>
<tr>
<td>2</td>
<td>CRITICAL CONDITION</td>
<td>Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.</td>
</tr>
<tr>
<td>1</td>
<td>IMMINENT FAILURE CONDITION</td>
<td>Major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service.</td>
</tr>
<tr>
<td>0</td>
<td>FAILED CONDITION</td>
<td>Out of service - beyond corrective action.</td>
</tr>
</tbody>
</table>
Functionally Obsolete

- Functionally Obsolete means that the bridge was built to standards that are not used today.

- Examples:
  - Deck Geometry (Insufficient deck roadway width)
  - Low Load Carrying Capacity
  - Insufficient Horizontal and Vertical Clearances
  - Poor Approach Roadway Alignment
  - Low Waterway Adequacy
Functionally Obsolete Examples

• Vertical Clearance
Functionally Obsolete Examples

Shoulder Widths
- Do not meet current standards
Presentation Outline

• Bridge Related Facts & Challenges

• Bridge Terminology

• Bridge Preservation Program Parameters

• Systematic Preventive Maintenance
Vision

- Strategic, Systematic, and Balanced Approach to Managing Existing Bridge Program Needs
  - Preservation
  - Rehabilitation
  - Replacement
Balanced Approach
Bridge Preservation – Draft Definition

Actions or 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 useful life. Preservation actions may be preventive or condition-driven.

Source: Bridge Preservation Expert Task Group
Bridge Preservation

An effective bridge preservation program is one that:

1. Employs long-term network strategies and practices that are aimed to preserve the condition of bridges and extends their useful life;

2. Has adequate tools and processes to ensure that the appropriate treatments are applied at the appropriate time
Preventive Maintenance – Definition

Preventive maintenance is a planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration and maintains or improves the functional condition of the system (without substantially increasing structural capacity).

Source AASHTO Subcommittee on Maintenance
Preventive Maintenance

- Preventive maintenance (PM) is considered a component of preservation
- PM includes cyclical (non-condition based) and condition based maintenance activities
- Examples of condition based PM activities include:
  - Sealing or replacing leaking joints
  - Installation of deck overlays
  - Installation of Cathodic Protection (CP) systems
  - Complete, spot, or zone painting of steel elements
  - Scour countermeasures installation
  - etc.
## Preventive Maintenance

<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wash/clean bridge decks or entire bridge</td>
<td>1 to 2 Years</td>
</tr>
<tr>
<td>Install deck overlay on concrete decks such as:</td>
<td>10 to 15 Years</td>
</tr>
<tr>
<td>- Thin bonded polymer system overlays</td>
<td></td>
</tr>
<tr>
<td>- Asphalt overlays with waterproof membrane</td>
<td></td>
</tr>
<tr>
<td>- Rigid overlays such as silica fume and latex modified</td>
<td>20 to 25 Years</td>
</tr>
<tr>
<td>Seal concrete decks with waterproofing penetrating sealant</td>
<td>3 to 5 Years</td>
</tr>
<tr>
<td>Zone coat steel beam/girder ends</td>
<td>10 to 15 Years</td>
</tr>
<tr>
<td>Lubricate bearing devices</td>
<td>2 to 4 Years</td>
</tr>
<tr>
<td>Coat timber elements with wood preserver sealant</td>
<td>1 to 2 Years</td>
</tr>
</tbody>
</table>

(2) - Frequencies are based on FHWA's knowledge of typical state DOT Practices
Condition Gets Worse
Leads to Limited
Most Costly
Consequences of Deferring Maintenance &
Consequences of Deferring Maintenance & Preservation

• Approach settlement may be a symptom of a more serious problem
Consequences of Deferring Maintenance & Preservation

- The deck drainage system should be unobstructed and function properly.
Consequences of Deferring Maintenance & Preservation

- Leaking deck joints contribute to bearing problems.
Consequences of Deferring Maintenance & Preservation

• Leaking deck joints contribute to bearing problems.
Consequences of Deferring Maintenance & Preservation

- Leaking deck joints cause damage to superstructure
Consequences of Deferring Maintenance & Preservation

- Leaking deck joints cause damage to substructure
Consequences of Deferring Maintenance & Preservation

- Debris accumulation may cause lateral pressure and scour
Consequences of Deferring Maintenance & Preservation

- Deterioration is accelerated from salt on unprotected deck
Time vs. Deterioration

Typical Deterioration Curves

Condition

Very Good

Very Poor

Age

Preventive

Corrective Repairs

Rehab/Replace
Typical PM Activities

• Bridge Cleaning
• Maintain Approaches
• Seal Deck Joints
• Facilitate Drainage
• Seal Concrete
• Paint Steel
• Remove Channel Debris
• Protect Against Scour
• Lubricate Bearings
Typical PM Activities

- Clean Routinely
Typical PM Activities

- Clean Routinely
- Maintain Approaches
Typical PM Activities

- Clean Routinely
- Maintain Approaches
- Seal Deck Joints
Typical PM Activities

- Clean Routinely
- Maintain Approaches
- Seal Deck Joints
- Facilitate Drainage
Typical PM Activities

- Clean Routinely
- Maintain Approaches
- Seal Deck Joints
- Facilitate Drainage
- Seal Concrete
Typical PM Activities

- Clean Routinely
- Maintain Approaches
- Seal Deck Joints
- Facilitate Drainage
- Seal Concrete
- Paint Steel
Typical PM Activities

- Clean Routinely
- Maintain Approaches
- Seal Deck Joints
- Facilitate Drainage
- Seal Concrete
- Paint Steel
- Remove Channel Debris
Typical PM Activities

- Clean Routinely
- Maintain Approaches
- Seal Deck Joints
- Facilitate Drainage
- Seal Concrete
- Paint Steel
- Remove Channel Debris
- Protect Against Scour
Typical PM Activities

- Clean Routinely
- Maintain Approaches
- Seal Deck Joints
- Facilitate Drainage
- Seal Concrete
- Paint Steel
- Remove Channel Debris
- Protect Against Scour
- Lubricate Bearings
Benefits of PM & Preservation

- Cost Effective
- Minimum Traffic Disruption
- Lower User Costs
- Public Safety
- Reduce Need to Rehab and Replace
Benefits of PM & Preservation

“Investment in maintenance pays dividends for years to come; a dollar we spend today on (maintaining) a bridge or culvert can save as much as ten dollars for a full replacement. It is an approach that just makes sense.”

Vermont Governor Jim Douglas
Quoted in AGC/VT Build Board, January 2008
Benefits of PM & Preservation

"We have made it no secret here at the agency about the need to focus on existing infrastructure, including our bridges... We've recognized this problem for some time, and that's why we've made this focus on maintenance and preservation the priority at the agency."

Vermont Transportation Secretary Neale Lunderville
Quoted in the Rutland Herald, June 9, 2008
Presentation Outline

• Bridge Related Facts & Challenges

• Bridge Terminology

• Bridge Preservation Program Parameters

• Systematic Preventive Maintenance
Systematic Preventive Maintenance

• Title 23 U.S.C. 144(d) allows HBP funds to be expended for systematic preventive maintenance without regard to whether the bridge is eligible for replacement or rehabilitation.

• This flexibility allows State Highway Agencies to determine whether to spend HBP funds on replacement, rehabilitation or systematic preventive maintenance.
Systematic Preventive Maintenance

- **Systematic** means a documented methodology regularly applied to repeatedly achieve a desired outcome or goal.

- **Systematic Preventive Maintenance (SPM)** can be defined as a planned strategy of cost effective treatments to existing bridges that are intended to maintain or preserve the structural integrity and functionality of bridge elements and/or components, and retard future deterioration, thus maintaining or extending the useful life of the bridge assets.
Systematic Approach

Goals & Measures

Inventory & Condition Assessment

Needs Assessment

Budgeting & Alternatives

Evaluation

Work Plan

Implementation

Performance Evaluation
Components of a Systematic PM Program

Goals and Measures Examples:

- The goal of the SPM program is to implement timely preservation treatments on structurally sound bridges thereby extending their useful life.

- Structurally sound shall be defined as; overall NBI general condition rating of 5 or greater or AASHTO CoRe element State Condition of 1 or 2 for the Deck, Superstructure, and Substructure units.
Components of a Systematic PM Program

Goals and Measures Examples:

❖ Goal – Maintaining X% of bridges in good states of repair
  • Measure: Percent of bridges with Health Index ≥ 85
  • Measure: Percent of bridges with NBI general condition rating ≥ 6
  • Measure: Percent of bridges with a sufficiency rating ≥ 80

❖ Goal - Maintaining X% of expansion joints in good and not leaking condition
  • Measure: Percent of expansion joints in State Condition 2 or better
Components of a Systematic PM Program

Goals and Measures Examples:

- Goal – Maintaining X% of coated steel surfaces in good condition
  - Measure: Percent of steel bridges with NBI condition rating of 6 or better for the Superstructure
  - Measure: Percent of superstructure steel elements in state condition 2 or better

- Goal – X% of bridge decks in good condition
  - Measure: Percent of bridges with NBI condition rating of 6 or better for the Deck
  - Measure: Percent of deck and slab elements in state condition 2 or better
Components of a Systematic PM Program

Goals and Measures Examples:

- **Goal** - All bridges are clean and free of debris and contaminating chemicals.

- **Measures:**
  - 100% of bridges washed annually.
  - Any reported debris cleared within 30 days of notification.
  - Brush cleared from around abutments and piers at least once every 4 years.

Consider establishing different goals for different highway systems, or different functional classification, or certain ADT ranges.
Components of a Systematic PM Program

Condition Assessment

- NBIS
- Element Level Inspections
- Assessment Frequency
- QA/QC
Components of a Systematic PM Program

Needs Assessment

Examples:

- A schedule of predetermined intervals for conducting a needs assessment such as annually or biennially.
- The data collected from the needs assessment should be stored in such a fashion as to allow it to be queried and to identify, quantify and rank qualifying PM work candidates.
- The SPM program should include the means to estimate the cost of the work needed to achieve the established program goals.
- The needs assessment methodology should be based upon a repeatable, unbiased data collection process.
Components of a Systematic PM Program

Budgeting & Alternative Evaluations

- Linking the needs to the goals
- Network vs. Project Levels
- Secure adequate and sustained funding level
Components of a Systematic PM Program

Work Plan & Plan Implementation

- In-house Crews
- Contracts

Reporting and Evaluation

- Track and report on:
  - Planned and accomplished PM work
  - Costs
  - Expenditures over time
Examples of Preservation Activities

- Following are examples of preservation activities that can extend the life of bridges when applied to the appropriate bridge at the appropriate time:

  1. Seal or replace leaking joints or elimination of deck joints
Examples of Preservation Activities

2. Deck overlays consisting of proven effective systems, which significantly increase the life of the deck by sealing the deck surface from aggressive solutions and reducing the impact of aging and weathering.
Examples of Preservation Activities

3. Spot and zone coating of structural steel elements
   (Target areas where the paint deteriorates the fastest and slows down the deterioration process and extends the life of the paint system.)

4. Complete coating and overcoating of structural steel
Examples of Preservation Activities

5. Cathodic Protection (CP) Systems
   (Proven technology for stopping the corrosion of reinforcing steel.)
Examples of Preservation Activities

6. Electrochemical Chloride Extraction (ECE) Treatment for decks and substructure elements
Examples of Preservation Activities

7. Installations of scour countermeasures.
8. Removing large debris from channels.
Examples of Preservation Activities

9. Retrofit of fracture critical members

10. Retrofit of fatigue prone details
Examples of Preservation Activities


12. Bridge cleaning and/or washing service.
TANK YOU!

... More Ribbon Cutting Ceremonies

Like this one on a preservation project
Resources

• **AASHTO’s TSP2 web site** – AASHTO has created the Transportation System Preservation Technical Services Program that provides services on pavement and bridge related preservation topics. Their website is: [http://www.tsp2.org](http://www.tsp2.org)

• **FHWA Resource Center** – The Structures Technical Services Team provides technical assistance, technology deployment and training. Their web site is: [http://www.fhwa.dot.gov/resourcecenter/teams/structures/index.cfm](http://www.fhwa.dot.gov/resourcecenter/teams/structures/index.cfm)

• **FHWA Turner–Fairbank Highway Research Center** - The FHWA Infrastructure Research and Development (R&D) program provides technologies and solutions to advance practices in highway infrastructure engineering. Their web site is: [http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/index.cfm](http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/index.cfm)

• **FHWA Office of Bridge Technology** - Offers assistance in the areas of bridge designs, construction, and preservation. Their website is: [http://www.fhwa.dot.gov/bridge/](http://www.fhwa.dot.gov/bridge/)

• **FHWA Office of Asset Management** - offers assistance in the areas of system preservation techniques, pavement and bridge management systems, materials usage and economic analysis tools. Their website is: [http://www.fhwa.dot.gov/infrastructure/asstmgmt/index.cfm](http://www.fhwa.dot.gov/infrastructure/asstmgmt/index.cfm)
Thank you!

Anwar S. Ahmad, P.E.
Bridge Preservation Engineer
Federal Highway Administration
Telephone: (202) 366-8501
Email: Anwar.Ahmad@dot.gov