Preservation Role in Risk-Based Inspections

Glenn A. Washer, PhD
University of Missouri
Columbia, MO
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Midwest Bridge Preservation Partnership
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NCHRP 12-82 Goals

• Goal: Improve the safety and reliability of bridges
  – focusing inspection efforts where most needed

• Optimize the use of resources
  – Better match inspection requirements to inspection needs
  – Develop a rational process for assessing inspection needs using reliability theories
Agenda

• What is Risk-Based Inspection
• How does Preservation fit in?
• Conclusion
Risk-Based Bridge Inspection

• Inspections that consider
  – The reliability of bridge elements
    • Likelihood of deterioration and damage
    • Condition, design, materials and loading
  – The consequences of that damage
    • Minor serviceability issues, safety issue?

• Inspection interval and scope
  – Match inspection requirements with inspection needs for a bridge
Motivation

Typical lifetime performance

Time to corrosion initiation for RC
Example Guidelines

• API (2002). "Risk-Based Inspection, API Recommended Practice 580." 45. (updated)
• API (2008). "Risk-Based Inspection Technology, API Recommended Practice 581."
• INTERIM ADVICE NOTE 148/12, Risk Based Principal Inspection Intervals
• Transport Wales Framework Lot 5, Task Order 5/2, BD 63/07 Risk Based Inspections Guidance Note February 2010
• NRC docs
Definitions

• **Reliability**: Ability of an item, component or system to operate safely under designated operating conditions for a designated period of time or number of cycles.

• **Risk**: Combination of the probability of an event and its consequence.
Risk – Based Approaches

\[ R = POF \times C \]
\[ R = \text{Likelihood} \times C \]
\[ R = \text{Frequency} \times C \]
\[ R = \text{Occurrence} \times C \]

Consequences:
- Economic
- Environmental
- Safety

Requires time interval
Reliability-Based Inspection (RBI)

• What can go wrong?
  – Identify damage modes for elements
  – Deterioration mechanisms

• How likely is it?
  • Categorization based on reliability characteristics of bridge elements
  • Based on expert judgment and expert elicitations
    • Past experience
    • Analysis of existing or potential damage modes
    • Deterioration data if available (and relevant)
    • Preservation activities

• What are the consequences?
  – How important is it?
Factors in RBI

• Damage Modes and deterioration mechanisms
  – Attributes affecting likelihood
• Occurrence factor (POF)
• Consequences
  – Experience, redundancy, situation (ADT, traffic speed), analysis, etc.
Damage Modes

Damage Mode: Section Loss
Det. Mechanism: Corrosion

Damage Mode: Impact?
Det. Mechanism: Impact
Identifying Damage Modes

<table>
<thead>
<tr>
<th>Cause of death</th>
<th>Likelihood (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart attack</td>
<td>●●●●●●●●●●●●●●●</td>
</tr>
<tr>
<td>Hit by car</td>
<td>●●●●●●●●●●●●●●●</td>
</tr>
<tr>
<td>Murdered</td>
<td>●●●●●●●●●●●●●●●</td>
</tr>
<tr>
<td>Brain Aneurism</td>
<td>●●●●●●●●●●●●●●●</td>
</tr>
<tr>
<td>Lightning</td>
<td>●●●●●●●●●●●●●●●</td>
</tr>
</tbody>
</table>

http://thewritepractice.com/emergency-your-creativity-is-dying/
Concept - Likelihood

Bad attributes

Unique
Where does a bridge fall on the distribution?

Yr. in Condition Rating

Loc 1.544
Scale 0.7701
N 357
Concept - Consequences

• Water = low consequence
• Nuclear waste = Severe
Consequences…

- Ex. Multi-girder 3 span PS vs. pin and hanger in two-girder (fracture critical) bridge
- Low, moderate, high and severe
- Design characteristics, scenario, documented experience, calculation
Risk Matrix

- Plot values of likelihood and consequence
- Components in the top right corner are “high risk”
- High likelihood may not mean high risk, if consequence is small
- High consequence may not be high risk, if the likelihood is low
Preservation Effect

![Graph showing the preservation effect over time](image)
Example
Potential Benefits of RBI

• Better, more effective and purposeful inspections
  – Inspection plan (scope and interval) supported by engineering assessment by RAP
    • Vs. Calendar-based inspection strategy
  – Rational inspection strategies
    • Flexible intervals based on need and engineering analysis

• Allocate resources more effectively
  – Focus inspections resources where most needed

• Value-added to preservation activities

• Improved bridge reliability and safety
Preservation Role in RBI

- Preservation can reduce the POF and thereby reduce the risk
  - Reduce unnecessary inspections
  - Focus inspection where most needed
  - Allocate resources more effectively
Questions