CHARACTERISTICS OF DECOMMISSIONED BRIDGES
NCHRP 20-07/Task 397

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Disclaimer

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OVERVIEW

INTRODUCTION
- Background
- Scope
- Survey Findings
- Research Approach

DATA

ANALYSIS

CONCLUSIONS
INTRODUCTION

Research Need

- Earlier studies showed that bridges are decommissioned younger than their intended service-lives.
- What are the main drivers behind bridge decommissioning?

Research Objective

- The main objective of this research project was to determine the reasons of bridge decommissioning for State highway agency-owned bridges in the United States.
Background

- Literature Review
  - Hooks (2011)
    - NBI Data (1992-2009), 20,645 bridges
    - Median service life: 60 years
    - 85% SD or FO, 15% unidentified
  - Sobanjo & Thompson (2013)
    - FL, 1,480 bridge retirements
    - Primary reason for 70%, 30% unidentified
  - Chase (2014)
    - NBI Data (1992-2012), 11,753 structures
    - Median service life: 53 years
    - More than half SD, 14 % FO, 30% unidentified
Project Tasks

Phase 1

• Task 1: Literature Review
• Task 2: Policies on Bridge Replacement Eligibility and Selection
• Task 3: Identifiers of Decommissioned Bridges Based on NBI Data

Phase 2

• Task 4: Compare Phase I Findings to Agency Records for 4 States
• Task 5: Present Findings at the Annual Meeting for the AASHTO SCOBS
• Task 6: Summarize Findings from Both Phases and Identify Needed Research Areas
• Task 7: Final Report
Survey Findings

• 28 States responded to the survey (Spring 2017)
  • Expansion in use of data-driven decision making and performance measures beyond condition
  • Although HBP funding eligibility no longer applies, majority (17 agencies of 28) did not change their eligibility policy
  • More flexibility since 10-year rule and SR thresholds no longer apply
• The most common criteria considered by the agencies in selecting structures for replacement were load rating/posting, NBI Condition Ratings, and vulnerabilities respectively
## Survey Findings

<table>
<thead>
<tr>
<th>Bridge Replacement Criteria</th>
<th>Percentage of Respondent Agencies</th>
<th>Count of Agencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load rating/posting</td>
<td>93%</td>
<td>26</td>
</tr>
<tr>
<td>NBI Condition Ratings</td>
<td>89%</td>
<td>25</td>
</tr>
<tr>
<td>Vulnerabilities (Scour, seismic, fracture critical, fatigue-prone details)</td>
<td>86%</td>
<td>24</td>
</tr>
<tr>
<td>Traffic capacity</td>
<td>82%</td>
<td>23</td>
</tr>
<tr>
<td>Functional aspects</td>
<td>71%</td>
<td>20</td>
</tr>
<tr>
<td>Element condition data</td>
<td>68%</td>
<td>19</td>
</tr>
<tr>
<td>Bridge Management System recommendations</td>
<td>43%</td>
<td>12</td>
</tr>
<tr>
<td>Proximity to other projects</td>
<td>39%</td>
<td>11</td>
</tr>
<tr>
<td>Detour length</td>
<td>39%</td>
<td>11</td>
</tr>
<tr>
<td>Life Cycle Cost Analysis, Benefit-Cost Analysis or similar cost analysis</td>
<td>36%</td>
<td>10</td>
</tr>
<tr>
<td>Age</td>
<td>36%</td>
<td>10</td>
</tr>
<tr>
<td>Other</td>
<td>4%</td>
<td>1</td>
</tr>
</tbody>
</table>
## Research Approach

### Literature Review and Survey
- Review relevant studies
- Survey agency practice on reasons of bridge decommissioning

### Analysis I
- Track structure numbers within NBI files to identify decommissioned structures
- Analyze the NBI data for the decommissioned structures to identify potential drivers of bridge decommissioning
- Discuss single drivers versus multiple drivers

### Analysis II
- Gather agency reasons from participating DOTs
- Match potential drivers from Analysis I to the agency reasons
- Discuss correlations

### Analysis III
- Using location, year of decommissioning and year built, gather a subset of old structures with the new structures that replaced them.
- Do comparison analyses
- Discuss correlations

### Conclusion
- Suggestions
### Data

#### 1992-2016 NBI Data files, state structures

- Each structure unique ID was checked for disappearance across all files.
- 1992-2015, 36,459 structures were identified as decommissioned.
  - 31,803 bridges and 4,656 culverts
- Comparisons of numbers and percentages of decommissioned structures

**Introduction**

**Data**

**Analysis**

**Conclusion**

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**Bridges**

- Not deficient: 26.58%
- Structurally deficient: 49.26%
- Functionally obsolete: 21.10%
- (blank): 3.06%

**Culverts**

- Not deficient: 74.74%
- Structurally deficient: 14.88%
- Functionally obsolete: 6.40%
- (blank): 3.97%
Data

- Agency records on decommissioned structures
  - NBI Data Set from Analysis I
  - Provided Agency Records (PA, FL, UT, CA, MI)
    - 788 obs.

- Replaced vs. New Structures
  - Added ~3000 structures in Phase I
  - Panel liked the idea and encouraged expanding the data set
  - Draft report includes analysis with 9810 structure pairs

Analysis II

Analysis III
Analysis I

Create a unique ID for all structures in all NBI files (1992-2016)

• Combine state code (NBI2) and structure number (NBI8)

Compare each unique ID in a year with all unique IDs in the consecutive year

• Select candidate structures whose unique ID does not appear in the consecutive year

Compare the candidate IDs with all unique IDs in all future NBI files

• Repeat this step to avoid errors from skipped years

Assign structures with unique IDs that never appear in future NBI files as "decommissioned"

• Assign the year of the NBI file that such a structure last appears as "year decommissioned"
Analysis I

Drivers (Based on literature review and survey findings)

- Deficiency Status (SD, FO, ND (Non-deficient))
- Bridge Posting (NBI70 & NBI41)
- Structural Evaluation (NBI67)
- Deck Geometry (NBI68)
  - Underclearances (NBI69)
  - Waterway Adequacy (NBI71)
  - Approach Roadway Alignment (NBI72)
- Type of Work (NBI75A)
- NBI Condition Ratings (NBI 58, 59, 60, and 62)
- Sufficiency Rating
- Vulnerabilities
  - Age
  - Reconstruction Age
  - Material
  - Design type
  - Max Span Length
  - Operating Rating
  - Traffic Volume
  - Functional Classification of the Inventory Route (NBI26)
  - Proposed Work (NBI75A)
Analysis I

• Drivers vs. Reasons

Drivers

• Deficiency
• Posting
• Structural Evaluation
• Deck Geometry
• Vulnerabilities
• Fair Condition
• Type of Work

Multiple Drivers

Primary

• Poor Condition
• Functional Inadequacy
• Vulnerabilities

Secondary

• Fair Condition
• Fair Appraisal Ratings
• Defined Bridge Work

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## Analysis I

### Potential Drivers of Bridge Decommissioning

Poor condition was suggested to be based on condition only (current SD definition), while inadequate function was based on appraisal ratings (previous FO classification) plus posting status.

One driver per structure based on the hierarchy

<table>
<thead>
<tr>
<th>Order</th>
<th>Hierarchy</th>
<th>Potential Driver</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Primary</td>
<td>Poor Condition</td>
<td>15093</td>
<td>41.40%</td>
</tr>
<tr>
<td>2</td>
<td>Primary</td>
<td>Functional Inadequacy</td>
<td>9443</td>
<td>25.90%</td>
</tr>
<tr>
<td>3</td>
<td>Primary</td>
<td>Scour Critical</td>
<td>344</td>
<td>0.94%</td>
</tr>
<tr>
<td>4</td>
<td>Primary</td>
<td>Fracture Critical</td>
<td>162</td>
<td>0.44%</td>
</tr>
<tr>
<td>5</td>
<td>Primary</td>
<td>Failed Channel</td>
<td>26</td>
<td>0.07%</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Poor Culvert Condition</td>
<td>326</td>
<td>0.89%</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Fair Structural Evaluation</td>
<td>3245</td>
<td>8.90%</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Fair Deck Geometry</td>
<td>2679</td>
<td>7.35%</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Fair Underclearance</td>
<td>709</td>
<td>1.94%</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Fair Waterway Evaluation</td>
<td>133</td>
<td>0.36%</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>Fair Approach Roadway Alignment</td>
<td>93</td>
<td>0.26%</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>Fair Substructure Condition</td>
<td>384</td>
<td>1.05%</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>Fair Superstructure Condition</td>
<td>173</td>
<td>0.47%</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>Fair Deck Condition</td>
<td>167</td>
<td>0.46%</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>Fair Channel Condition</td>
<td>176</td>
<td>0.48%</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>Fair Culvert Condition</td>
<td>585</td>
<td>1.60%</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>Fair Scour Criticality</td>
<td>110</td>
<td>0.30%</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>Widening Work</td>
<td>93</td>
<td>0.26%</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>Work for Deficient Structures</td>
<td>116</td>
<td>0.32%</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>Work for Strengthening</td>
<td>41</td>
<td>0.11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unidentified</td>
<td>2361</td>
<td>6.48%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>36459</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
### Multiple Drivers

<table>
<thead>
<tr>
<th>Sum of Primary Drivers</th>
<th>Sum of Secondary Drivers</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>6.50%</td>
<td>6.70%</td>
<td>5.10%</td>
<td>4.10%</td>
<td>3.10%</td>
<td>2.50%</td>
<td>1.50%</td>
<td>0.60%</td>
<td>0.10%</td>
<td>30.30%</td>
</tr>
<tr>
<td>1</td>
<td>1.90%</td>
<td>3.40%</td>
<td>4.80%</td>
<td>6.00%</td>
<td>7.30%</td>
<td>6.70%</td>
<td>3.10%</td>
<td>0.80%</td>
<td>0.10%</td>
<td></td>
<td>34.10%</td>
</tr>
<tr>
<td>2</td>
<td>0.40%</td>
<td>2.50%</td>
<td>5.50%</td>
<td>7.40%</td>
<td>7.10%</td>
<td>3.80%</td>
<td>1.30%</td>
<td>0.30%</td>
<td></td>
<td></td>
<td>28.40%</td>
</tr>
<tr>
<td>3</td>
<td>0.10%</td>
<td>0.70%</td>
<td>1.50%</td>
<td>1.80%</td>
<td>1.50%</td>
<td>0.80%</td>
<td>0.20%</td>
<td>0.10%</td>
<td></td>
<td></td>
<td>6.60%</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>0.10%</td>
<td>0.20%</td>
<td>0.10%</td>
<td>0.10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.60%</td>
</tr>
<tr>
<td>Grand Total</td>
<td></td>
<td>8.80%</td>
<td>13.50%</td>
<td>17.10%</td>
<td>19.40%</td>
<td>19.10%</td>
<td>13.90%</td>
<td>6.10%</td>
<td>1.80%</td>
<td>0.30%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
## Analysis I

### Percentages of Decommissioned Structures by Combined Primary Drivers

<table>
<thead>
<tr>
<th>Order</th>
<th>Combined Primary Drivers</th>
<th>Percentage of Decommissioned Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Driver</td>
<td>30.3%</td>
</tr>
<tr>
<td>2</td>
<td>Functionally Inadequate-Poor Condition</td>
<td>24.4%</td>
</tr>
<tr>
<td>3</td>
<td>Functionally Inadequate</td>
<td>23.1%</td>
</tr>
<tr>
<td>4</td>
<td>Poor Condition</td>
<td>8.8%</td>
</tr>
<tr>
<td>5</td>
<td>Functionally Inadequate-Fracture Critical</td>
<td>4.2%</td>
</tr>
<tr>
<td>6</td>
<td>Functionally Inadequate-Scour Critical</td>
<td>2.6%</td>
</tr>
<tr>
<td>7</td>
<td>Poor Culvert Condition</td>
<td>0.9%</td>
</tr>
<tr>
<td>8</td>
<td>Scour Critical</td>
<td>0.9%</td>
</tr>
<tr>
<td>9</td>
<td>Poor Condition-Scour Critical</td>
<td>0.8%</td>
</tr>
<tr>
<td>10</td>
<td>Functionally Inadequate-Scour Critical</td>
<td>0.8%</td>
</tr>
<tr>
<td>11</td>
<td>Functionally Inadequate-Failed Channel</td>
<td>0.6%</td>
</tr>
<tr>
<td>12</td>
<td>Functionally Inadequate-Poor Culvert Condition</td>
<td>0.6%</td>
</tr>
<tr>
<td>13</td>
<td>Fracture Critical</td>
<td>0.4%</td>
</tr>
<tr>
<td>14</td>
<td>Poor Condition- Fracture Critical</td>
<td>0.4%</td>
</tr>
<tr>
<td>15</td>
<td>Functionally Inadequate-Poor Condition- Scour Critical -Failed Channel</td>
<td>0.5%</td>
</tr>
<tr>
<td>16</td>
<td>Functionally Inadequate- Failed Channel-Poor Culvert Condition</td>
<td>0.1%</td>
</tr>
<tr>
<td>17</td>
<td>Poor Condition- Failed Channel</td>
<td>0.1%</td>
</tr>
<tr>
<td>18</td>
<td>Poor Condition-Scour Critical -Fracture Critical</td>
<td>0.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>99.6%</td>
</tr>
</tbody>
</table>
Analysis I

Relative frequency of decommissioned structures by the most common (top 20) combinations of primary drivers.
Analysis II

Michigan

Pennsylvania

Florida

Utah

California

Introduction  Data  Analysis  Conclusion
Analysis II

- Removed from NBI: 1.78%
- Vulnerability: 6.86%
- Removed: 1.65%
- Poor Condition: 9.40%
- None: 14.49%
- Functional: 39.64%
- Fair Condition: 0.25%
- Deficient: 17.66%
- Damage: 0.13%
- Change of Ownership: 8.13%

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Analysis II

<table>
<thead>
<tr>
<th>Condition</th>
<th>High-Growth</th>
<th>Low-Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vulnerability</td>
<td>10.06%</td>
<td>0.71%</td>
</tr>
<tr>
<td>Removed from NBI</td>
<td>5.00%</td>
<td>4.64%</td>
</tr>
<tr>
<td>Removed</td>
<td>10.26%</td>
<td>7.86%</td>
</tr>
<tr>
<td>Poor Condition</td>
<td>21.30%</td>
<td>2.14%</td>
</tr>
<tr>
<td>None</td>
<td>46.55%</td>
<td></td>
</tr>
<tr>
<td>Functional</td>
<td></td>
<td>27.50%</td>
</tr>
<tr>
<td>Fair Condition</td>
<td>0.39%</td>
<td></td>
</tr>
<tr>
<td>Deficient</td>
<td>8.68%</td>
<td>33.93%</td>
</tr>
<tr>
<td>Damage</td>
<td>0.20%</td>
<td></td>
</tr>
<tr>
<td>Change of Ownership</td>
<td>18.21%</td>
<td>2.56%</td>
</tr>
</tbody>
</table>
Analysis II

- Almost 40% of the structures decommissioned due to functional reasons.
- Poor condition and deficiency collectively account for 32% of the decommissioning in comparison.
- Relevant ISU-identified drivers matched a majority of the structures decommissioned due to each reason provided by the agency.
- However, it was not possible to assign these drivers as reasons, particularly when combinations of drivers were identified.
Analysis III

• 9810 structure pairs.
• 27% of the main sample in Analysis I.
• The median age of replacement is 58 years (54, main sample).
• Percentage of replacements with no drivers is similar to the main sample.

<table>
<thead>
<tr>
<th>Functional Adequacy</th>
<th>Poor Condition</th>
<th>Not Poor Condition</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate Function</td>
<td>13.59%</td>
<td>15.72%</td>
<td>29.32%</td>
</tr>
<tr>
<td>Inadequate Function</td>
<td>46.03%</td>
<td>24.65%</td>
<td>70.68%</td>
</tr>
<tr>
<td>Total</td>
<td>59.63%</td>
<td>40.37%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

![Image of bar chart showing functional adequacy and condition for various categories]
Analysis III

• 10% of all of the old structures (71% of the old structures with no drivers) in this sample had no drivers associated with them but were replaced with wider bridges on wider roads.

• Most likely, these structures were replaced due to functional improvement projects.
Conclusion

- Analysis I: Drivers gathered by tracking structure numbers within historic NBI files
  - 41.4% in poor condition, 32.7% not in poor condition but had inadequate function, and 25.9% neither in poor condition nor functionally inadequate.
  - 26% to 33% of the decommissioned structures did not have an obvious reason for replacement based on these numbers.
  - Poor condition, functional inadequacy, and vulnerabilities were the primary drivers.
  - Among the 20 most frequent combinations for primary drivers, functional inadequacy was the most frequent with almost 57% of decommissioned structures being functionally inadequate.
  - For the same data set, 36% of decommissioned structures had poor condition as one of the drivers.
Conclusion

• Analysis II: Comparison of the drivers from Analysis I with reasons provided by study agencies.
  • 27.4% of the decommissioning in this subset was due to deficiency and poor condition, 40% due to functional reasons, and 15% did not have an identified reason.
  • Functional reasons were the most common reasons for decommissioning in high-growth states while poor condition and deficiency were the most common reasons for low-growth states.
Conclusion

• Analysis III: Comparison of new structures with the structures they replaced
  • Replaced structures were mostly functionally inadequate and in poor condition (35%), only functionally inadequate (22%), or only in poor condition (12%).
  • Approximately 14% of the old structures had no drivers associated with them.
  • Further analysis of the 14% of the decommissioned structures with no drivers revealed that 71% of these structures were replaced with wider bridges on wider roads, alluding to functional improvement projects.
Conclusion

• Future Research?
  • High percentage of replacements driven by functional reasons.
    • Bridge management and performance management
    • Financial planning
    • Coordination of planning and management across offices
  • Research on bridges that are older and in good condition?
    • Agency documentation of preservation efforts
Thank you!

Questions?