Validating Common Collapse Conjectures in U.S. Bridges

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Outline

• Introduction
  • Databases
  • Definitions

• Data Analysis
  • Structural Deficiency
  • Scour Critical Rating
  • Age & Condition Ratings
  • Improved Design Specifications

• Conclusions
Introduction

• Databases
  • NYSDOT Database
  • NBI Database
  • Compiled-collapse Database

• Definitions
  • Total Collapse
  • Partial Collapse
NYSDOT Database

• 428 bridges that have collapse between 1992-2014

• Database contains descriptive-collapse information
  ◦ Cause of Collapse
  ◦ Year of Collapse
  ◦ Comments that further describe the collapse
NBI Database

• Inspection data for more than 610,000 bridges from 1992 to 2014
• In-service population from NBI 2014 serves as control data
• Contains bridge descriptive information
  ◦ Type of bridge, material type, and year built
  ◦ Bridge Components Conditions
Compiled-collapse Database

Collapsed Bridge Database

National Bridge Inventory

Project Data
Total Collapse
Partial Collapse
Data Analysis

• Structural Deficiency
• Scour Critical Rating
• Age & Condition Ratings
• Improved Design Specifications
  • Bridge Geometric Characteristics
  • Operating Rating
Structural Deficiency
### Structural Deficiency

<table>
<thead>
<tr>
<th></th>
<th>Failed Bridges</th>
<th>In-service Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD Bridges</td>
<td>197 (46.0%)</td>
<td>53,354 (8.7%)</td>
</tr>
<tr>
<td>NON-SD Bridges</td>
<td>231 (54.0%)</td>
<td>557,073 (91.3%)</td>
</tr>
<tr>
<td>Σ</td>
<td>428</td>
<td>610,427</td>
</tr>
</tbody>
</table>
## Structural Deficiency per Collapse-type

<table>
<thead>
<tr>
<th>Type of Collapse</th>
<th>SD Deck</th>
<th>SD Superstructure</th>
<th>SD Substructure</th>
<th>Median Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overload</td>
<td>14 (23.3%)</td>
<td><strong>32 (53.3%)</strong></td>
<td>25 (41.7%)</td>
<td>68</td>
</tr>
<tr>
<td>Hydraulic</td>
<td>38 (16.0%)</td>
<td>48 (20.2%)</td>
<td><strong>77 (32.5%)</strong></td>
<td>54</td>
</tr>
<tr>
<td>Deterioration</td>
<td>12 (33.3%)</td>
<td>14 (38.9%)</td>
<td>14 (38.9%)</td>
<td>48</td>
</tr>
<tr>
<td>Collision</td>
<td>6 (7.3%)</td>
<td>14 (17.1%)</td>
<td>13 (15.9%)</td>
<td>43</td>
</tr>
<tr>
<td>In-service Population</td>
<td>4,968 (0.8%)</td>
<td>22,264 (3.6%)</td>
<td>29,189 (4.8%)</td>
<td>41</td>
</tr>
</tbody>
</table>
Definition of Scour
## Scour Critical Rating

<table>
<thead>
<tr>
<th></th>
<th>Hydraulic Failure</th>
<th>In-service Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scour Critical ‘3-0’</td>
<td>22 (16.8%)</td>
<td>22,387 (4.8%)</td>
</tr>
<tr>
<td>Non-Scour Critical ‘9-4’</td>
<td>109 (83.2%)</td>
<td>448,572 (95.2%)</td>
</tr>
<tr>
<td>∑</td>
<td>131 (100%)</td>
<td>470,959 (100%)</td>
</tr>
</tbody>
</table>
Possible Solutions

Require more Underwater Inspections
- **19,267 (3.2%)** bridges in the in-service population
- **16 (6.8%)** hydraulic collapse bridges

Revise the current Inspection System
- Improve the rating descriptors
- Account for the probability of floods
- **112 (47.3%)** of hydraulic collapsed are caused by floods
## Bridge Collapse, Age, & Condition Ratings

<table>
<thead>
<tr>
<th>Cause of Collapse</th>
<th>Age (Years)</th>
<th>Deck</th>
<th>Superstructure</th>
<th>Substructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collision</td>
<td>43.0</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Deterioration</td>
<td>47.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Hydraulic</td>
<td>53.5</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Overload</td>
<td>68.0</td>
<td>6</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>In-service Population</td>
<td>41.0</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>
### Improved Design Specifications: Bridge Geometric Characteristic

<table>
<thead>
<tr>
<th>Category</th>
<th>Median Minimum Vertical Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collision-caused Collapse</td>
<td>4.9 m (16.1 ft)</td>
</tr>
<tr>
<td>In-service Population</td>
<td>5.1 m (16.9 ft)</td>
</tr>
</tbody>
</table>
Improved Design Specifications: Operating Rating
Conclusions

• Structural Deficiency (46.0%) and collapse are associated

• A discrepancy is noted with the scour critical ratings, bridges are typically rated as scour stable (46.4%) for hydraulic collapse

• A unique third variable causes an accelerated deterioration for each cause of collapse

• Improvements to design specifications are increasing bridge longevity with higher design loads and higher vertical clearances
Future Work

• Further Investigate third variables that cause an accelerated deterioration
• Underwater Inspections
• Investigate bridge-collapse trends for bridges on the NHS
Questions?