Archipelagos Not Islands: Linking Resilience of Buildings with Infrastructure Lifelines

Municipal Perspective & Post Earthquake Evaluation Tools

Dane Doleman, P.Eng. ENV SP
Structures Engineer
Understanding Risk BC
April 17th, 2018
Overview

• Changing expectations
• Re-assessing network (bridges) vulnerability
• Post earthquake evaluation tools
  – Level 1 Inspection Guide
  – Seismic Performance Drawing
    (we get to test in May 2019)
Changing Expectations

Now

Possible Future

• Performance based design – making us ask questions
• Moving beyond life safety → service disruption → return to service
• Becoming embedded in planning & design projects

Lifeline Connection (DT Core and future Hospital)
Re-assessing Network Vulnerabilities

- Inventory (44 bridges) of varying types and age
- Seismic screening level assessments - complete
- Detailed assessments proceeding (risk, vulnerability, impacts*), upgrades to follow.
- Recent focus on post earthquake response.
Post Earthquake Inspection Guide

- Supports rapid damage assessment
- Tailored to suit City personnel
- Orientation, guided process
- Standardized forms and procedures
Level 1 Evaluation Work Flow for Viaduct A:

Refer to Bridge-Specific Detailed Sheet

Paper copy or digital app
Level 1 Evaluation Work Flow for Viaduct A:

**INSPECTION CHECKLIST**

1. Is bridge open to traffic?
2. Has the bridge collapsed (partially or totally)?
3. Is there any obvious soil cracking/damaging nearby?
4. Has the abutments slid or experienced loss of soil?
5. Is there any cracking in the abutment area?
6. Are the piles intact?
7. Is there any cracking of the abutment columns, crossbeams, bearings?
8. Are the bearings appear faulty?
9. Do the bearings show any displacement?
10. Do the opposite bay grinders appear aligned?
11. Is there any cracking of the concrete box girder?
12. Are there any utilities damaged?
13. In there any vertical or horizontal displacement of the roadway/railing profile?
14. Do the deck joint openings appear excessive?
15. Is there a vertical or horizontal displacement of girder?

**LOCATION**

- **SOUTH SIDE OF STRUCTURE - LOOKING NORTH**
- **WEST ABUTMENT - LOOKING EAST**

**NOT APPLICABLE TO THIS STRUCTURE:** 12

**Q**uestion

**Flip Sheet**
Level 1 Evaluation Work Flow for Viaduct A:

- Review existing photos of actual abutments and pre-existing condition.
- Return to Evaluation Sheet.
Post Earthquake Inspection Guide

- Level 1 Evaluation Work Flow for Hastings Viaduct:

**Sig. Diagonal Cracks are present at East Abutment**

- Have the abutments caved in or experienced a significant loss of soil underneath?
  - Yes (Y), No (N), Not Applicable (NA), Not Accessible (X)

- Is there any cracking in the abutments?
  - Yes (Y), No (N), Not Applicable (NA), Not Accessible (X)

- Have the piles tilted?
  - Yes (Y), No (N), Not Applicable (NA), Not Accessible (X)

Proceed with evaluation of other structural elements

**4. Status of Bridge**

- Concluded Disposition of Bridge (Recommendation):
  - Open / Closed

- Bridge Tagged According to
  - Yes / No

- Bridge Closure in Place
  - Yes / No
Seismic Performance Drawing Template

- Assist owners & inform responders/engineers
- Document design criteria/philosophy
- Identify site specific requirements

### Abutment

<table>
<thead>
<tr>
<th>Return Period</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>475</td>
<td>Little / no misalignment</td>
</tr>
<tr>
<td>975</td>
<td>Visible abutment rotation / cracking in backwall</td>
</tr>
<tr>
<td>2475</td>
<td>Abutment rotated 10deg, span unseating, misalignment &gt; 100mm</td>
</tr>
</tbody>
</table>

### Column Base

<table>
<thead>
<tr>
<th>Return Period</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>475</td>
<td>Minor spalling</td>
</tr>
<tr>
<td>975</td>
<td>Major spalling, rebar strain</td>
</tr>
<tr>
<td>2475</td>
<td>Visible strain, damage to confining rebar, longitudinal bar buckling, bulging visible</td>
</tr>
</tbody>
</table>
Future Improvements:

- Standardized photo library of typical damage states
- Guidance on what states indicate an open, closed or limited access structure
- Decision tree logic for specific damage states

<table>
<thead>
<tr>
<th>Return Period</th>
<th>Damage Description</th>
<th>Reference Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>475</td>
<td>Minor spalling</td>
<td>C##1</td>
</tr>
<tr>
<td>975</td>
<td>Major spalling, rebar strain</td>
<td>C##2</td>
</tr>
<tr>
<td>2475</td>
<td>Visible strain, damage to confining rebar, longitudinal bar buckling, bulging visible</td>
<td>C##3</td>
</tr>
</tbody>
</table>
Thank - You