NCHRP 12-104 Guideline for Improving the Quality of Element Level Bridge Inspection Data

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Agenda

• Goals and objectives of the research
• Overview of work completed
  – Description of modifications to the MBEI
  – Overview of field trials (in review)
• Future work
• Conclusion / questions

This investigation was sponsored by TRB under the NCHRP Program. Data reported are work in progress. The contents of this presentation have not been reviewed by the project panel or NCHRP, nor do they constitute a standard, specification, or regulation.
Research Team

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  – Mohammed Hammed, GRA

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• HDR
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  – Jason Fogg

• Collins Engineering
  – Calvin Karper
  – Jeremy Koonce

• Purdue
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Goals and Objectives of NCHRP12-104

- Goal: Improve the quality of element-level bridge inspection data
- Objective
  - Develop guidelines to improve the quality of element-level data collection for NHS bridges in reference to the AASHTO Manual for Bridge Element Inspection
    - Improve consistency in data collection and assessment of bridge element conditions
    - Establish accuracy levels for element conditions and applicable defect quantities to support bridge management system deterioration forecasting and evaluation
Task Listing

Phase I
- Task 1  Conduct a literature review
- Task 2  Conduct a survey of bridge owners
- Task 3  Define characteristics of quality bridge element inspection data
- Task 4  Identify factors that affect the quality of element-level inspection data
- Task 5  Propose a methodology and field inspection exercise
- Task 6  Prepare interim report No. 1
Phase II

- Task 7 Develop guidelines according to the approved task 5
- Task 8 Revise the field inspection exercise based on the results of Task 7 and panel review
- Task 9 **Prepare Interim Report No. II**

Phase III

- Task 10 Conduct field inspection exercises
- Task 11 Revise guidelines based on results of the field exercises
- Task 12 **Prepare Interim Report III**
  - Panel review of revised guidelines and field test results
- Task 13 *Update proposed Guidelines after consideration of review comments and propose modification to the AASHTO MBEI*
- Task 14 Prepare final report that documents the entire research effort
Some highlights from early tasks.....
Task I Literature Review – Key Findings

• Quality Tools
  – Inspector Calibration
  – Visual Guides
  – Pocket coding guides
  – Video Training Modules
  – Inspector Rotations
  – Performance testing of inspectors
Task 1 Literature Review – Key Findings

• Visual Guides
  – Subjective nature of visual inspection
    • Difficult to match text to conditions
    • Each inspectors interpretation and experience
  – Photographs of condition states provide interpretation that is consistent
    • Condition state photos vs boundary photos
  – Chaney and Teel (1967)
    • 71% increase for group receiving training and visual guides
Task I Literature Review – Key Findings

- See’s factors contributing to errors in VI
  - Task pace (time allowed)
  - Vigilance
  - Individual
    - Physical capability
    - Bias
  - Organization
    - Training on types of defects
    - Standards for decision making
  - SATO – Speed-accuracy trade-off
  - Social
Task 2 Survey (36 respondents)
Condition States (CS’s) Photographs in Bridge Element-level Manuals

Does your agency’s manual include photographs of different condition states?

- $\approx \frac{1}{3}$ of Agencies’ manuals included CS’s photographs
- $\approx \frac{2}{3}$ of the manuals available in a format suitable for using in the field
  - In 5 Agencies via laptop or tablet computers
  - In 7 Agencies in pocket guide

Condition States

![ CONDITIONS STATES PICTURES ]

CS 1  CS 2  CS 3  CS 4
What are some of the challenges that your Agency has faced with bridge element inspection?

a. Time required to complete the inspections (70%)
b. Documentation / data entry of inspection results (52%)
c. Developing initial quantity estimates (45%)
d. Training of inspectors in element-level inspections (45%)
e. Adequate resources (inspection teams) to complete the required inspection (30%)
f. Interpretation of element and condition definitions in the MBEI (48%)
g. Storage of data from inspections (18%)
h. Consistency of element level results among inspectors (48%)
What is the purpose of a visual guide?

• Provide a uniform interpretation of the text description of each CS for each defect
  – Interpret the text
  – Get everyone singing from the same hymnal
• Assist inspectors in the field making decisions regarding the appropriate assignment of CS
  – Provide “Boundary images” that define the boundaries of the CS (where appropriate)
• Provide spatial estimating tools to improve quality and timeliness of inspections
• MBEI modified to include visual guides for many defects
How was the MBEI modified?

• Little to no change to sections 1, 2, appendices
• No changes to the text descriptions of defects or elements
• Section 3
  – Reorganized by material
  – Visual standards (pictures) for certain defects
  – Added visual guides
    • Cracking, spatial estimates
  – Consolidated Commentary
  – Restructured element detailed descriptions
Reorganization of the MBEI

- Original organization was according to how an inspector would experience a bridge in the field
  - Organized according to component
    - e.g. deck, superstructure, substructure

SECTION 3: DETAILED ELEMENT DESCRIPTIONS

3.1—Decks and Slabs

3.1.1—Element 12—Reinforced Concrete Deck

3.1.2—Element 13—Prestressed Concrete Deck

3.1.3—Element 18—Reinforced Concrete Slab

3.1.4—Element 15—Prestressed Concrete Top Flange

3.1.5—Element 16—Reinforced Concrete Top Flange

3.1.6—Element 28—Steel Deck with Open Grid

3.1.7—Element 29—Steel Deck with Concrete Filled Grid

3.1.8—Element 30—Steel Deck Corrugated/Orthotropic/Etc

3.1.9—Element 31—Timber Deck

3.1.10—Element 54—Timber Slab

3.1.11—Element 60—Other Deck

3.1.12—Element 65—Other Slab

3.2—Railings

3.2.1—Element 330—Metal Bridge Railing

3.2.2—Element 331—Reinforced Concrete Bridge Railing

Condition State Definitions

<table>
<thead>
<tr>
<th>Defect Description</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delamination/Spall</td>
<td>None</td>
<td>Delaminated Spall 1 in. or less deep or 6 in. or less in diameter. Predominantly found in deck, deck slabs, and other reinforced concrete.</td>
<td>Spall greater than 1 in. deep or greater than 6 in. diameter, Predominantly found in deck, deck slabs, and other reinforced concrete.</td>
<td>Does not warrant structural review.</td>
</tr>
<tr>
<td>Edge Flaking</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efflorescence/Rust Staining</td>
<td>None</td>
<td>Surface white without build-up or backing without rust staining</td>
<td>Many build-up with rust staining</td>
<td></td>
</tr>
<tr>
<td>Cracking (RC and Other)</td>
<td>Width less than 0.015 in. or opening greater than 0.10 in.</td>
<td>Width greater than 0.015 in. or opening greater than 0.10 in.</td>
<td>Width greater than 0.015 in. or opening greater than 0.10 in.</td>
<td></td>
</tr>
<tr>
<td>Abrasion/Wear</td>
<td>No abrasion or wearing</td>
<td>Abrasion or wearing has exposed coarse aggregate but the aggregates remain secure in the concrete.</td>
<td>Coarse aggregates is loose or has popped out of the concrete matrix due to abrasion or wear</td>
<td></td>
</tr>
</tbody>
</table>
MBEI Reorganization by **Material**

- Reduces repetition of defect elements

### 3.2 – REINFORCED CONCRETE ELEMENTS

<table>
<thead>
<tr>
<th>Element No.</th>
<th>Element Name</th>
<th>Specification</th>
<th>Units of Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Reinforced Concrete Deck</td>
<td>NBE</td>
<td>ft²</td>
</tr>
<tr>
<td>16</td>
<td>Reinforced Concrete Top Flange</td>
<td>NBE</td>
<td>ft²</td>
</tr>
<tr>
<td>38</td>
<td>Reinforced Concrete Slab</td>
<td>NBE</td>
<td>ft²</td>
</tr>
<tr>
<td>105</td>
<td>Reinforced Concrete Closed Web/Box Girder</td>
<td>NBE</td>
<td>ft</td>
</tr>
<tr>
<td>110</td>
<td>Reinforced Concrete Open Girder/Beam</td>
<td>NBE</td>
<td>ft</td>
</tr>
<tr>
<td>116</td>
<td>Reinforced Concrete Stringer</td>
<td>NBE</td>
<td>ft</td>
</tr>
<tr>
<td>144</td>
<td>Reinforced Concrete Arch</td>
<td>NBE</td>
<td>ft</td>
</tr>
<tr>
<td>155</td>
<td>Reinforced Concrete Floor Beam</td>
<td>NBE</td>
<td>ft</td>
</tr>
<tr>
<td>241</td>
<td>Reinforced Concrete Culvert</td>
<td>NBE</td>
<td>ft</td>
</tr>
<tr>
<td>205</td>
<td>Reinforced Concrete Column</td>
<td>NBE</td>
<td>ea</td>
</tr>
<tr>
<td>210</td>
<td>Reinforced Concrete Pier Wall</td>
<td>NBE</td>
<td>ft</td>
</tr>
<tr>
<td>215</td>
<td>Reinforced Concrete Abutment</td>
<td>NBE</td>
<td>ft</td>
</tr>
<tr>
<td>220</td>
<td>Reinforced Concrete Pile Cap/Footing</td>
<td>NBE</td>
<td>ft</td>
</tr>
<tr>
<td>227</td>
<td>Reinforced Concrete Pile</td>
<td>NBE</td>
<td>ea</td>
</tr>
<tr>
<td>234</td>
<td>Reinforced Concrete Cap</td>
<td>NBE</td>
<td>ft</td>
</tr>
<tr>
<td>321</td>
<td>Reinforced Concrete Approach Slab</td>
<td>BME</td>
<td>ft²</td>
</tr>
<tr>
<td>331</td>
<td>Reinforced Concrete Bridge Rail</td>
<td>NBE</td>
<td>ft</td>
</tr>
</tbody>
</table>
Defect listing for the subject material

- List of defect for material appears only once
- Reduces repetition
- Clarifies the number of defects for each material
- Promotes uniform application of defect definitions
  - e.g. Spalling is the same in deck, super or sub.
  - Improve data quality (i.e. consistency)
### Visual standards for the defects

#### Defect 1088 – Delamination/Spall/Flushed Area

<table>
<thead>
<tr>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>None.</td>
<td>Substantial spall, less than or equal to 3 in. diameter.</td>
<td>Substantial spall, greater than 3 in. diameter.</td>
</tr>
</tbody>
</table>

#### Defect 1085 – Exposed Rebar

<table>
<thead>
<tr>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>None.</td>
<td>Present without measurable areas less than or equal to 3 in. diameter.</td>
<td>Present with measurable areas less than or equal to 3 in. diameter.</td>
</tr>
</tbody>
</table>

#### Defect 1120 – Efflorescence/Rust Staining

<table>
<thead>
<tr>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>None.</td>
<td>Rust stains without build-up or staining within rust stains.</td>
<td>Heavy build-up with rust staining.</td>
</tr>
</tbody>
</table>

#### Defect 1130 – Cracking (RC and Other)

<table>
<thead>
<tr>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>None.</td>
<td>Nitrification cracks or moisture leaks.</td>
<td>Nitrification cracks or moisture leaks, plus cracking.</td>
</tr>
</tbody>
</table>

---

#### Notes

- Condition 1: No visible defects.
- Condition 2: Minor defects detected.
- Condition 3: Significant defects with potential for structural issues.

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**Images:**
- Visual examples of defects are provided for each issue category, illustrating the condition states and their severity.
Modifications

• Concrete cracking is provided two visual standards, one for crack width and one for crack spacing
  – No change to description
• Crack pattern guidance was included
  – Diagrams
• Crack width guide
• Spatial estimating guide
• Purpose: Assist inspectors in the field in estimating quantities and defining cracking CS
### Visual guide examples

#### Defect 1060 – Delamination/Spall/Patched Area

<table>
<thead>
<tr>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>None.</td>
<td>Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Formed area that is scored.</td>
<td>Spall greater than 1 in. deep or greater than 6 in. diameter. Spalled area that is unscored or showing distress. Does not warrant unusual review.</td>
</tr>
</tbody>
</table>

**CS’s Images**

- Boundary Image CS1 – 2
- Boundary Image CS2 – 3

**Boundary Images show CS in-between two CS’s**

**Defect Number and Name**
Example – 4 condition states

- Example of effectiveness defect for steel protective coating

<table>
<thead>
<tr>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
<th>Condition State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully effective</td>
<td>Substantially effective</td>
<td>Limited effectiveness</td>
<td>Failed, no protection of underlying steel</td>
</tr>
</tbody>
</table>

Boundary Image CS1 – 2

Boundary Image CS2 – 3

Boundary Image CS3 – 4
Cracking Guidance

• Diagrams depicting map cracking are included

<table>
<thead>
<tr>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spacing &gt;3 ft.</td>
<td>Moderate pattern (map) cracking, spacing 1-3 ft</td>
<td>Heavy pattern (map) cracking, spacing less than 1 ft</td>
</tr>
</tbody>
</table>

**Crack Pattern Guide**

**Crack Width Measurement**

The surface of concrete erodes at a crack, making the crack appear wider at the surface. Crack width measurements should describe the actual crack width, not the eroded surface.

**Crack Measurement**

Crack widths can be measured using a crack comparator.

<table>
<thead>
<tr>
<th>Width Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/32 in. = 0.0313 in.</td>
</tr>
<tr>
<td>1/16 in. = 0.0625 in.</td>
</tr>
<tr>
<td>3/32 in. = 0.0938 in.</td>
</tr>
<tr>
<td>1/8 in. = 0.1250 in.</td>
</tr>
<tr>
<td>3/16 in. = 0.1875 in.</td>
</tr>
</tbody>
</table>

**Crack Width Guide**

- 0.7 mm Pencil tip Thickness = 0.040 in.
- Credit card thickness ~0.035 in.
- Thickness = 0.069 in.
Spatial Estimation Diagrams

- There are area and length estimation diagrams showing several percentages of defects/damages

Damage spread across the deck

Damage less spread across the deck

Damage concentrated in a single spot

1 % Damage shown on bridge deck
Element Commentary

- Consolidated element commentary
- Reduced repetition, “get it all in one place”
- Tabulated crack width commentary
- Provided “General Commentary” that applied to many different element groups
- Specific commentary for element groups
- Some commentary that further described a particular element was included as a note in the detailed element listing
  - Example: Steel grid decks, Other materials, open expansion joints, etc.
### DECKS AND SLABS

<table>
<thead>
<tr>
<th>Element Description</th>
<th>Classification</th>
<th>NBE</th>
<th>Unit of measure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steel Deck with Open Grid</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description: All open grid steel bridge decks with no fill.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity Calculation: Area of the deck from edge to edge, including any median areas and accounting for any flares or ramps present.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: When the steel grid deck has concrete fill in the wheel tracks only, use Element 29 for the concrete filled portion and Element 28 for the unfilled portion of the deck.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Steel Deck with Concrete Filled Grid</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description: Steel bridge decks with concrete fill either in all of the openings or within the wheel tracks.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity Calculation: Area of the deck from edge to edge, including any median areas and accounting for any flares or ramps present.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: When the steel grid deck has concrete fill in the wheel tracks only, use Element 29 for the concrete filled portion and Element 28 for the unfilled portion of the deck.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Steel Deck Corrugated/Orthotropic/Etc.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description: Those bridge decks constructed of corrugated metal filled with portland cement, asphaltic concrete, or other riding surfaces. Orthotropic steel decks are also included.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity Calculation: Area of the deck from edge to edge, including any median areas and accounting for any flares or ramps present.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### RAILINGS

<table>
<thead>
<tr>
<th>Element Description</th>
<th>Classification</th>
<th>NBE</th>
<th>Unit of measure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metal Bridge Railing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description: All types and shapes of metal bridge railing. Steel, aluminum, metal beam, rolled shapes, etc. will all be considered part of this element. Included in this element are posts of metal, timber, or concrete; blocking; and curb.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reduction in size

269 pages vs 149 pages

- Final revision down to about 129 pages after some further removal of repeated data.
Field-ready format
Field Trials
Task 8 Field Trials– Objectives

• “Test drive” the visual standard
• Compare the use of a visual guide with traditional inspection approach
  – Accuracy of inspection
    ▪ Accuracy of spatial estimates
    ▪ Correct assignment of condition states
    ▪ Data quality
  – Timeliness of inspection
• Assess potential changes to the MBEI
  – Use of different units – ft vs ea for columns, ft vs sq ft for steel protective coatings
Overview of Field Exercises

• Michigan and Indiana
  – PS Concrete Bridges in Michigan
    • 2 PS super and sub. inspection
    • 2 RC decks
  – Steel bridges in Indiana
    • Routine inspections on twin steel bridges
    • S-BRITE Center testing on focused activities
  – ~10 inspectors in each state
    • 1/2 use guideline, receive training
    • 1/2 use normal procedure and practices
  – Inspector characteristics measured
    • Experience, eyesight, etc.
S-BRITE Tasks

• Controlled inspection conditions
• Assess accuracy of spatial estimates
• Compare use of units in a standardized way
  – Sq ft vs ft
Indiana field exercises

• Twin steel bridges with corrosion and coatings damage
  – High traffic volume deck (inspection from shoulder)
  – Good access to super and sub
Michigan exercises

- PS bridge superstructure and substructure
- Deck of 2 separate, low traffic bridges
- Columns units ea vs ft
General field exercise results (in review)

- Small sample set
- Provides data from standardized tests indicating variation in inspection results
  - Quantity of damage recorded
  - Assignment of defects
- Choice of units affect quantity of recorded damage and quality of results
  - May be obvious
- Different methods of estimating quantities results in different values
  - Data provided to help in decision-making regarding future developments of the manual
- More to come.....
Future Possibilities

- 28 defects do not have images
- Modify examples to use visual standards as needed
- Develop database of images for states to use
- Training materials and tech transfer

<table>
<thead>
<tr>
<th>No.</th>
<th>Defect Number</th>
<th>Defect Name</th>
<th>No.</th>
<th>Defect Number</th>
<th>Defect Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1100</td>
<td>Exposed Prestressing</td>
<td>15</td>
<td>2230</td>
<td>Bulging, Splitting or Tearing</td>
</tr>
<tr>
<td>2</td>
<td>7000</td>
<td>Damage</td>
<td>16</td>
<td>4000</td>
<td>Settlement</td>
</tr>
<tr>
<td>3</td>
<td>1140</td>
<td>Decay/Section Loss</td>
<td>17</td>
<td>6000</td>
<td>Scour</td>
</tr>
<tr>
<td>4</td>
<td>1150</td>
<td>Check/Shake</td>
<td>18</td>
<td>2310</td>
<td>Leakage</td>
</tr>
<tr>
<td>5</td>
<td>1160</td>
<td>Crack (Timber)</td>
<td>19</td>
<td>2320</td>
<td>Seal Adhesion</td>
</tr>
<tr>
<td>6</td>
<td>1170</td>
<td>Split/Delamination (Timber)</td>
<td>20</td>
<td>2340</td>
<td>Seal Cracking</td>
</tr>
<tr>
<td>7</td>
<td>1180</td>
<td>Abrasion/Wear (Timber)</td>
<td>21</td>
<td>2360</td>
<td>Adjacent Deck or Header</td>
</tr>
<tr>
<td>8</td>
<td>1220</td>
<td>Deterioration (other)</td>
<td>22</td>
<td>2370</td>
<td>Metal Deterioration or damage</td>
</tr>
<tr>
<td>9</td>
<td>1900</td>
<td>Distortion</td>
<td>23</td>
<td>3210</td>
<td>Delamination/Spall/Patched Area/Pothole (Wearing surface)</td>
</tr>
<tr>
<td>10</td>
<td>1610</td>
<td>Mortar Breakdown (Masonry)</td>
<td>24</td>
<td>3220</td>
<td>Crack (Wearing Surface)</td>
</tr>
<tr>
<td>11</td>
<td>1620</td>
<td>Split/Spall (Masonry)</td>
<td>25</td>
<td>3230</td>
<td>Efflorescence (Wearing Surface)</td>
</tr>
<tr>
<td>12</td>
<td>1630</td>
<td>Patched Area (Masonry)</td>
<td>26</td>
<td>3510</td>
<td>Wear (Concrete Protective Coating)</td>
</tr>
<tr>
<td>13</td>
<td>1640</td>
<td>Masonry Displacement</td>
<td>27</td>
<td>3540</td>
<td>Effectiveness (Concrete Protective Coating)</td>
</tr>
<tr>
<td>14</td>
<td>2210</td>
<td>Movement</td>
<td>28</td>
<td>3600</td>
<td>Effectiveness – Protective System (e.g. Cathodic)</td>
</tr>
</tbody>
</table>
Conclusions

• MBEI has been modified and submitted for consideration
• Field exercise results are in review
  – Provided data on consistency in element-level inspection
• Final report pending
MIZ...
Pattern and isolated cracking
Comparison of defect-based guide vs element-based guide

- Visual guides are defect-based
- States often have used element-based
- Provides context for defects, but may increase variation
  - Different definitions for different elements
- Valuable for training, enhance the standards in the guide

Element 205&227 –
RC Column or Pile

<table>
<thead>
<tr>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Delaminated, Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.</td>
<td>Spall greater than 1 in. deep or 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.</td>
</tr>
</tbody>
</table>

Element 205/227 - RC Column or Pile – Defect 1080 - Delamination/Spall/Patched Area
Visual guide examples

• Scales are used to measure the defects
  – Provide scale for inspector
• Red color rectangular shapes are used to point out the defects
  – Focus of the image
• Only CS 2 and 3 are generally included
  – CS 1 is the absence of a defect
  – CS 4 is a judgement
  • Needs to consider not just the defect, but the context of the defected, therefore not suitable for a visual guide
Outline of Guidelines

1. Introduction
2. Purpose and Use of the Guidelines
   - 2.1 Objectives
   - 2.2 Scope and Applicability
   - 2.3 How to Use the Visual Guide
   - 2.4 Spatial Estimation Diagrams
3. Accuracy Requirements for Decision Making
   - 3.1 Relationship Between Accuracy, Inspection Quality and Decision Making
   - 3.2 Procedure for Developing an Accuracy Requirement
   - 3.3 Methods for Improving and Measuring Inspection Quality
   - 3.4 Sample Data Analysis for Assessing Inspection Accuracy
4. Visual Guide
   - Standard photos for defect condition states
3.11.1 – General Commentary

3.11.1.1 Condition evaluation for open elements includes the web face and the top and bottom faces of the flange.
3.11.1.2 Box girder evaluation is three-dimensional in nature, with the defects observed including exterior and interior surfaces being used to capture the condition states.
3.11.1.3 Cracking in Reinforced and Prestressed Concrete Elements: The inspector should use judgment when utilizing the condition state defect definitions, especially for concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation, and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. Table 1 provides quantitative crack widths describing insignificant, moderate, and wide cracking.

Table 1. Crack width commentary for reinforced and prestressed concrete elements.

<table>
<thead>
<tr>
<th>Material</th>
<th>Insignificant cracking, defect not warranted (in.)</th>
<th>Moderate cracking (in.)</th>
<th>Wide cracking (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced Concrete</td>
<td>Less than 0.012 wide</td>
<td>0.012 to 0.05 wide</td>
<td>Greater than 0.05 wide</td>
</tr>
<tr>
<td>Prestressed Concrete</td>
<td>Less than 0.004 wide</td>
<td>0.004 to 0.009 wide</td>
<td>Greater than 0.009 wide</td>
</tr>
</tbody>
</table>

3.11.1.4 Elements identified as “other” materials are intended for elements formed of composite materials or other materials that cannot be classified using any other defined element or material.

3.11.2 – Decks and Slabs

These elements describe the component that is transferring load from the vehicle to the bridge. This Section does not include secondary deck elements such as joints, deck/slab protection systems, or wearing surfaces. Deck elements transmit the loads into superstructure elements. Slab elements transmit the load into the substructure elements. Structures that include slab elements typically do not have superstructure elements. These elements transmit traffic loads directly into the substructure. All deck or slab elements can be supplemented with one or more associated protection systems or wearing surface elements.

3.11.2.1 Deck, slab, and flange evaluation is three-dimensional in nature with the defects observed on the top and bottom surface, edges, or all; and being captured using the defined condition states. Top or bottom surfaces that are not visible for inspection shall be assessed based on the available visible surface. If both top and bottom surfaces are not visible, the condition shall be assessed based ondestructive and nondestructive testing or indicators in the materials covering the surfaces.

3.11.2.2 Where traffic rides directly on the structural element regardless of the wearing surface, evaluation of the top flange above the fillet is considered with the appropriate deck element.