Deck Overhang Design

Braden Cyr | Bridge Engineer

May 17, 2017
Topics Covered

• General overview
  • Old practice
  • New practice (Memo 2017-01) and reason for changes
    • http://www.dot.state.mn.us/bridge/lrfd.html
  • Impacts on design
• Detailed updates – deck overhang design
Old Practice

9” MONOLITHIC DECK

7” SLAB WITH 2” W.C.

BARRIER ON WINGWALL
Reason for Change

Discontinuous coping line
Reason for Change

• Provide consistency and clarity for edge of deck (EOD) thickness and coping height

• Slab with wearing course – old practice results in discontinuous coping line

• Old practice – unclear what to use for EOD thickness for thick decks

Section A-A
New Practice

- Slope top of deck to match gutterline elevation at EOD
  
  - Note 1: match EOD thickness with deck thickness per BDM Tables 9.2.1.1 and 9.2.1.2

- No change to monolithic slab
New Practice

- Provide EOD thickness equal to deck thickness specified in BDM Tables 9.2.1.1 (right) and 9.2.1.2 (similar)

- Exception: repair with deck thickness < 9” – provide 9” EOD thickness
• *Note 1:* change coping height to match EOD thickness
Impacts on Design

• Changes to Memo to Designers 2016-01
  • Deck surface no longer level beneath barrier
  • New guidance for deck overhang design
  • Critical section reduced
• Some instances require modifications to BDM Tables 9.2.1.1, 9.2.1.2
Typical design/meets assumptions of BDM Tables 9.2.1.1, 9.2.1.2?

- YES
  - Interior barrier region?
    - YES
      - Gutter line inside the edge of fascia beam flange?
        - YES
          - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
        - NO
          - 54” Type S Barrier?
            - YES
              - 9” Monolithic or 7” + 2” W. Course?
                - YES
                  - Memo 2017-01 Mods (bullet pt. 3)
                - NO
                  - Deck w/ W.C. supported by steel beams w/ spe. > 12”?
                    - YES
                      - Memo 2017-01 Mods (bullet pt. 1)
                    - NO
                      - Memo 2017-01 Mods (bullet pt. 2)
            - NO
          - 42” Type S Barrier?
            - YES
              - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
            - NO
          - 36” Type S Barrier?
            - YES
              - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
            - NO
    - NO
      - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
  - NO

Memo 2017-01 Special Design
• Overhang width ≤ 40% beam spacing
• \( f'_{c} = 4 \text{ ksi} \), \( f_{y} = 60 \text{ ksi} \)
• Typical steel or concrete beams used
• Live load moments taken from AASHTO A4.1-1
• Clear cover of 3” top R/F and 1” bottom R/F
• Yield line occurs in barrier
Typical design/meets assumptions of BDM Tables 9.2.1.1, 9.2.1.2?

- NO
  - Memo 2017-01 Special Design

- YES
  - Interior barrier region?
    - NO
      - Gutter line inside the edge of fascia beam flange?
        - NO
          - 54" Type S Barrier?
            - NO
              - 42" Type S Barrier?
                - NO
                  - 36" Type S Barrier?
                    - YES
                      - Deck w/ W.C. supported by steel beams w/ spc. > 12”?
                        - YES
                          - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
                        - NO
                          - YES
                            - 9” Monolithic or 7” + 2” W. Course?
                              - YES
                                - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
                              - NO
                                - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
                          - NO
                            - 42” Type S Barrier?
                              - YES
                                - 9” Monolithic or 7” + 2” W. Course?
                                  - YES
                                    - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
                                  - NO
                                    - NO
                                      - Memo 2017-01 Mods (bullet pt. 3)
                            - NO
                              - NO
                                - Memo 2017-01 Mods (bullet pt. 2)
                          - YES
                            - 54” Type S Barrier?
                              - YES
                                - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
                            - NO
                              - NO
                                - Memo 2017-01 Mods (bullet pt. 1)
• Adjusted NCHRP 350 TL-4 collision load, \( F_t \), to account for varying barrier heights and heights of load application

• Used \( \min \left( R_w \ (capacity), \frac{4}{3} F_t \right) \) per BDM section 9.2.1

• Adjusted collision loads, \( F_{\text{adj}} \) and \( M_{\text{adj}} \), given in Table 1 of memo:

<table>
<thead>
<tr>
<th></th>
<th>36&quot; Type S</th>
<th>42&quot; Type S</th>
<th>54&quot; Type S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exterior</td>
<td>Interior</td>
<td>Exterior</td>
</tr>
<tr>
<td>( M_{\text{adj}} ) (k-ft/ft)</td>
<td>20.5</td>
<td>9.4</td>
<td>18.8</td>
</tr>
<tr>
<td>( F_{\text{adj}} ) (k/ft)</td>
<td>7.9</td>
<td>3.7</td>
<td>6.1</td>
</tr>
</tbody>
</table>

Table 1
Interior vs. Exterior Regions

- Interior region - continuous longitudinal R/F
- Exterior region – barrier R/F is discontinuous (i.e. at joints or end of bridge)

BDM Figure 13.3.1.1
Load Distribution

Interior region: \( L_c + 2H \)

Exterior region: \( L_c + H \)
Translate the moment at top of deck to a moment located at deck center:

\[ e = \frac{M_{cadj}}{F_{cadj}} \]

\[ F_{cdes} = F_{cadj} \]

For monolithic decks:

\[ M_{cdes} = F_{cdes} \cdot (e + 0.5 \cdot t_{deck}) \]

For slabs with wearing course:

\[ M_{cdes} = F_{cdes} \cdot (e + 0.5 \cdot t_{str slab}) \]
• Consider the following case:
  • 36” Type S barrier - interior region
  • Beam spacing = 9’
  • Overhang width = 4’
  • 7” deck with 2” wearing course
Special Design Example

• Determine if a special design is required:

\[
\frac{\text{Overhang Width}}{\text{Beam Spacing}} = \frac{4 \text{ ft}}{9 \text{ ft}} = 0.44 > 0.40 \text{ allowed}
\]

• Recall additional assumptions to verify

• Since OH > 40% of beam spacing, must perform special design

• Find adjusted loads in Table 1 of Memo 2017-01:

<table>
<thead>
<tr>
<th></th>
<th>36&quot; Type S</th>
<th>42&quot; Type S</th>
<th>54&quot; Type S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exterior</td>
<td>Interior</td>
<td>Exterior</td>
</tr>
<tr>
<td>(M_{\text{adj}}) (k-ft/ft)</td>
<td>20.5</td>
<td>9.4</td>
<td>18.8</td>
</tr>
<tr>
<td>(F_{\text{adj}}) (k/ft)</td>
<td>7.9</td>
<td>3.7</td>
<td>6.1</td>
</tr>
</tbody>
</table>

Table 1
• Use the equations provided in the memo:

\[
e = \frac{M_{cadj}}{F_{cadj}} = \frac{9.4\ k\cdot ft/ft}{3.7\ k/ft} = 2.54\ ft
\]

\[
F_{cdes} = F_{cadj} = 3.7\ k/ft
\]

For deck with a 7” structural slab plus 2” wearing course:

\[
M_{cdes} = F_{cdes} \cdot (e + 0.5 \cdot t_{str\ slab})
\]

→ How to find \( t_{str\ slab} \)?
• From earlier in the memo, for a 7” slab with 2” wearing course, EOD thickness (and coping thickness) must be 9”

• Using the new geometry for the edge of deck, the critical section depth (i.e. $t_{\text{str slab}}$) is found to be 8.45”
  • Side note: old geometry would have given $t_{\text{str slab}}$ of 8.69” at this location
• Given the value of $t_{str\_slab}$, we can continue with the equations in the memo:

$$M_{cdes} = F_{cdes} \cdot (e + 0.5 \cdot t_{str\_slab}) = 3.7 \frac{k}{ft} \cdot \left(2.54 \text{ ft} + 0.5 \cdot \frac{8.45 \text{ in}}{12 \text{ in/ft}}\right)$$

$$= 10.7 k \cdot ft/ft$$

• Summary:

  • $F_{cdes} = 3.7 k/ft$
  • $M_{cdes} = 10.7 k\cdot ft/ft$

• Use these design values to determine the reinforcement required at the critical section (see BDM section 9.3 for an example)
Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)

Memo 2017-01 Mods (bullet pt. 3)

Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)

Memo 2017-01 Mods (bullet pt. 2)

Memo 2017-01 Mods (bullet pt. 1)
Gutter Line and Flange Edge

- If overlap exists, can use BDM Design Tables
- If no overlap, see memo design criteria
Typical design/meets assumptions of BDM Tables 9.2.1.1, 9.2.1.2?

- **YES**
  - Interior barrier region?
    - **YES**
      - Gutter line inside the edge of fascia beam flange?
        - **YES**
          - 54" Type S Barrier?
            - **YES**
              - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
            - **NO**
              - 42" Type S Barrier?
                - **YES**
                  - 9" Monolithic or 7" + 2" W. Course?
                    - **YES**
                      - Deck w/ W.C. supported by steel beams w/ spc. > 12”?
                        - **YES**
                          - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
                        - **NO**
                          - Deck w/ W.C. supported by steel beams w/ spc. > 12”?
                            - **YES**
                              - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
                            - **NO**
                              - Memo 2017-01 Mods (bullet pt. 2)
        - **NO**
          - 42" Type S Barrier?
            - **YES**
              - 9" Monolithic or 7" + 2" W. Course?
                - **YES**
                  - Deck w/ W.C. supported by steel beams w/ spc. > 12”?
                    - **YES**
                      - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
                    - **NO**
                      - Memo 2017-01 Mods (bullet pt. 3)
                - **NO**
                  - Memo 2017-01 Mods (bullet pt. 1)
            - **NO**
              - 36" Type S Barrier?
                - **YES**
                  - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
                - **NO**
                  - Memo 2017-01 Mods (bullet pt. 3)
          - **NO**
            - Memo 2017-01 Mods (bullet pt. 1)
    - **NO**
      - Gutter line inside the edge of fascia beam flange?
        - **YES**
          - Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)
        - **NO**
          - Memo 2017-01 Mods (bullet pt. 3)
- **NO**
  - Memo 2017-01 Special Design
Typical design/meets assumptions of BDM Tables 9.2.1.1, 9.2.1.2?

- **NO**
  - **Memo 2017-01 Special Design**

- **YES**
  - Interior barrier region?
    - **NO**
      - **Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)**
    - **YES**
      - Gutter line inside the edge of fascia beam flange?
        - **NO**
          - **54” Type S Barrier?**
            - **NO**
              - **42” Type S Barrier?**
                - **NO**
                  - **36” Type S Barrier?**
                    - **YES**
                      - **9” Monolithic or 7” + 2” W. Course?**
                        - **YES**
                          - **Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)**
                        - **NO**
                          - **Deck w/ W.C. supported by steel beams w/ spc. > 12”?**
                            - **YES**
                              - **Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)**
                            - **NO**

- **YES**
  - **Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)**

- **Memo 2017-01 Mods (bullet pt. 3)**
  - **Memo 2017-01 Mods (bullet pt. 1)**
  - **Memo 2017-01 Mods (bullet pt. 2)**
Typical design/meets assumptions of BDM Tables 9.2.1.1, 9.2.1.2?

**NO**

Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)

**YES**

Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)

Interior barrier region?

**YES**

Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)

**NO**

Gutter line inside the edge of fascia beam flange?

**YES**

Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)

**NO**

54” Type S Barrier?

**YES**

9” Monolithic or 7” + 2” W. Course?

**YES**

Memo 2017-01 Mods (bullet pt. 3)

**NO**

Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)

42” Type S Barrier?

**YES**

Memo 2017-01 Mods (bullet pt. 1)

**NO**

36” Type S Barrier?

**YES**

Memo 2017-01 Mods (bullet pt. 2)

**NO**

Deck w/ W.C. supported by steel beams w/ spc. > 12”?

**YES**

**NO**

Not in Memo
42” Barrier Modifications

- Include 180° hooks on top transverse bars minimum of 9’ from joint
  - Splice hooks to main transverse deck bars (match sizing)
  - Provide hooked transverse bars that run from EOD to EOD

- Applicability
  - 9” monolithic slab
  - 7” deck with 2” wearing course
Typical design/meets assumptions of BDM Tables 9.2.1.1, 9.2.1.2?

YES

NO

Memo 2017-01 Special Design

Interior barrier region?

YES

Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)

NO

Gutter line inside the edge of fascia beam flange?

YES

Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)

NO

54” Type S Barrier?

YES

9” Monolithic or 7” + 2” W. Course?

NO

42” Type S Barrier?

YES

Use BDM deck R/F (Tables 9.2.1.1, 9.2.1.2)

NO

36” Type S Barrier?

YES

Deck w/ W.C. supported by steel beams w/ spec. > 12”?

NO

Memo 2017-01 Mods (bullet pt. 3)

Memo 2017-01 Mods (bullet pt. 1)

Memo 2017-01 Mods (bullet pt. 2)
36” Barrier Modifications

• Deck w/ W.C. supported by steel beams spaced > 12’
  • Provide top transverse standard 180° hooked #5 bars at 6” spacing for a minimum of 8’ from joint for EOD (#5 because #6 won’t fit)
  • Lap these hooks to the top #6 transverse bars (at 6”, from Table 9.2.1.2)

• All other cases
  • Provide #5 bars at 5” spacing or \( A_s = 0.74 \text{ in}^2/\text{ft} \) for top transverse bars for a minimum of 8’ from joint
  • Include 180° standard hooks on the EOD ends of these #5 bars
    • Splice hooks to main transverse deck bars
    • Provide hooked transverse bars that run from EOD to EOD
Thank you!

Braden Cyr

braden.cyr@state.mn.us

651-366-4540