



# Deck Overhang Design

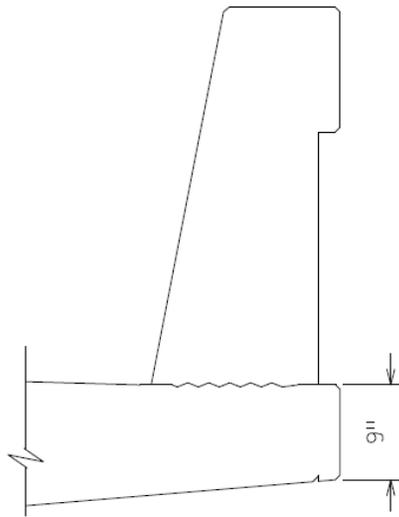
Braden Cyr | Bridge Engineer

May 17, 2017

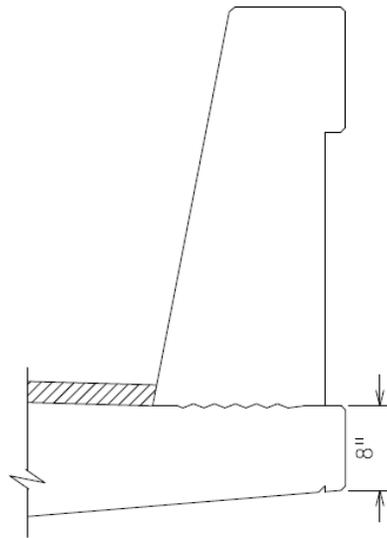
# Topics Covered

- 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

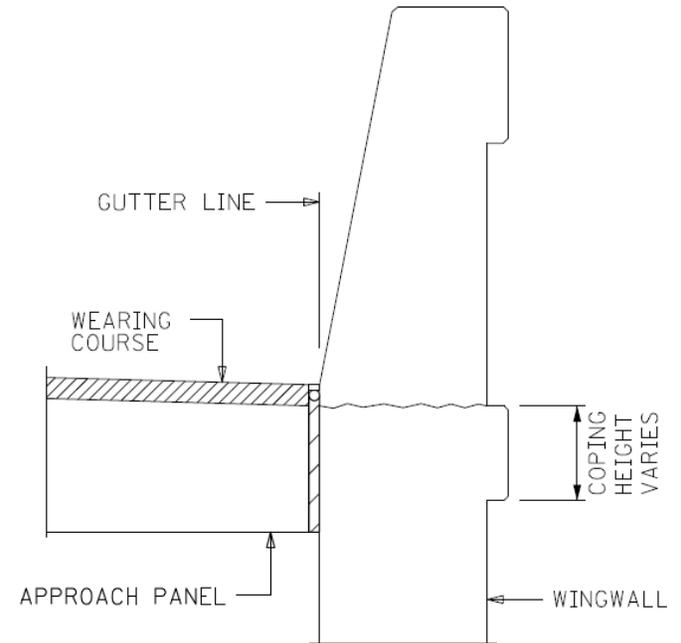
# Old Practice



9" MONOLITHIC DECK

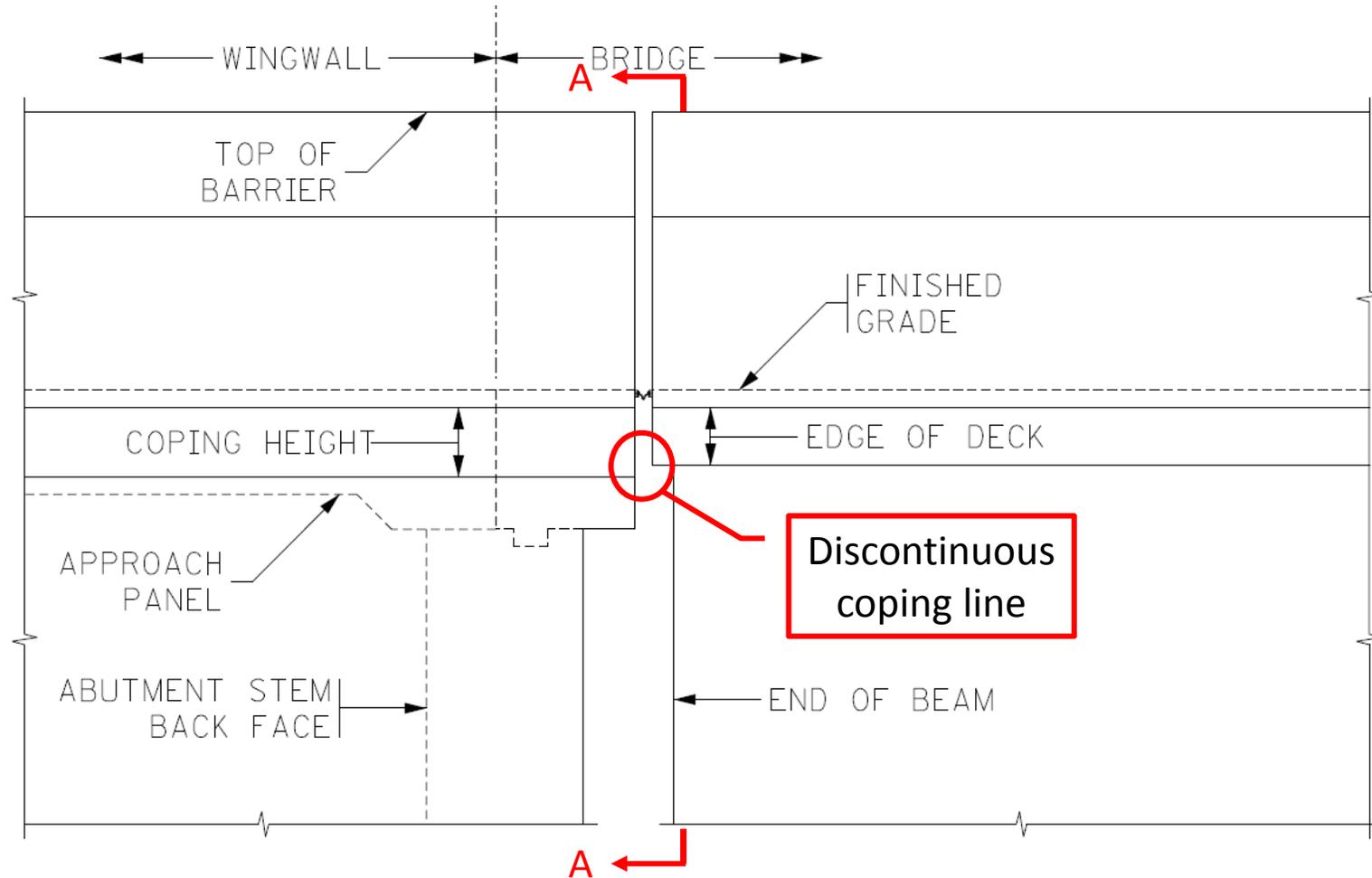


7" SLAB WITH 2" W.C.



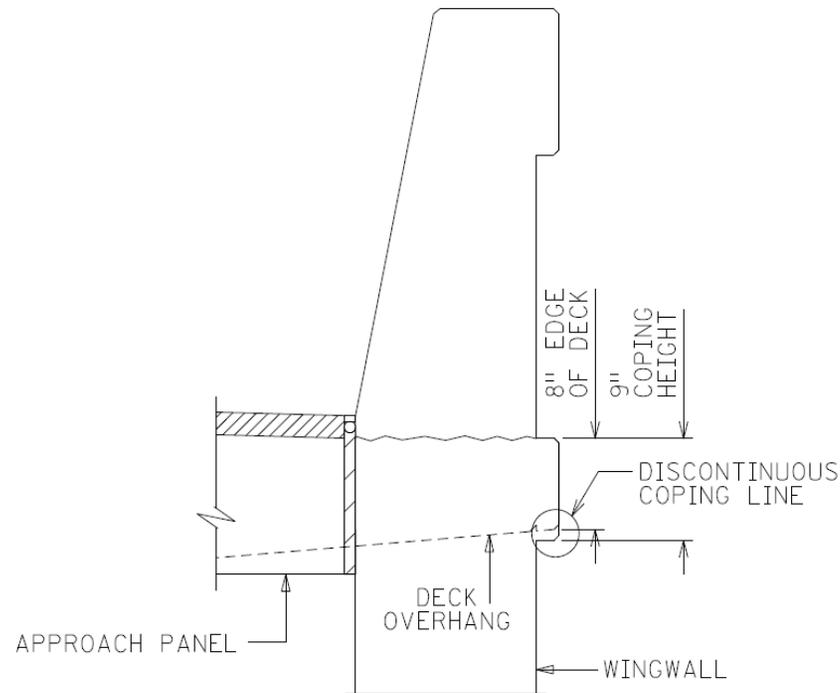
BARRIER ON WINGWALL

# Reason for Change



# Reason for Change

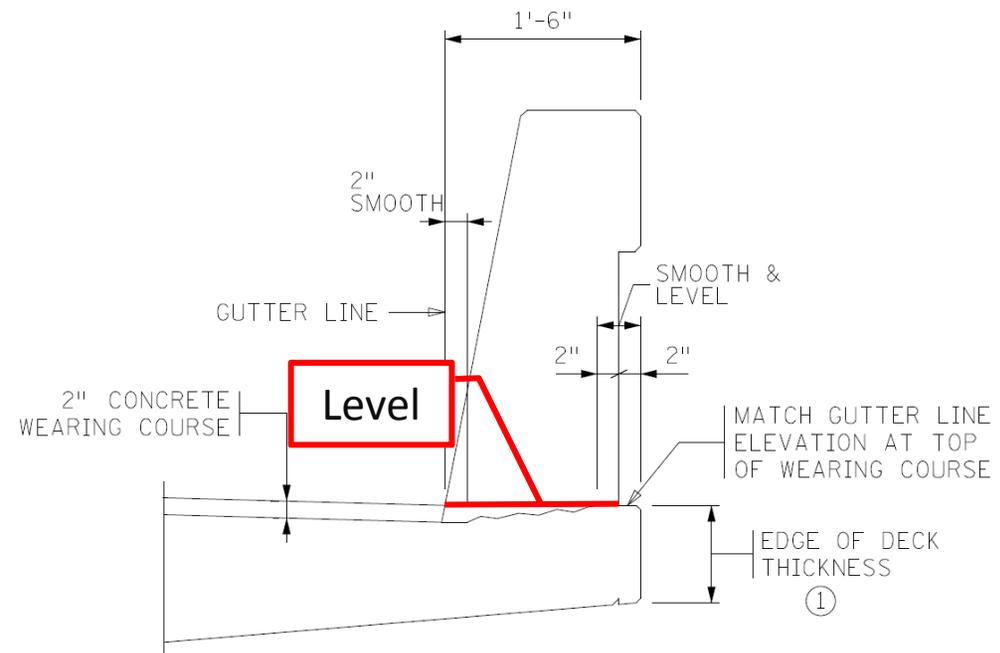
- Provide consistency and clarity for edge of deck (EOD) thickness and coping height
- Slab with wearing course – old practice results in discontinuous coping line
- Old practice – unclear what to use for EOD thickness for thick decks



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



BARRIER SECTION ON DECK

# New Practice

MARCH 2010

LRFD BRIDGE DESIGN

9-9

- 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

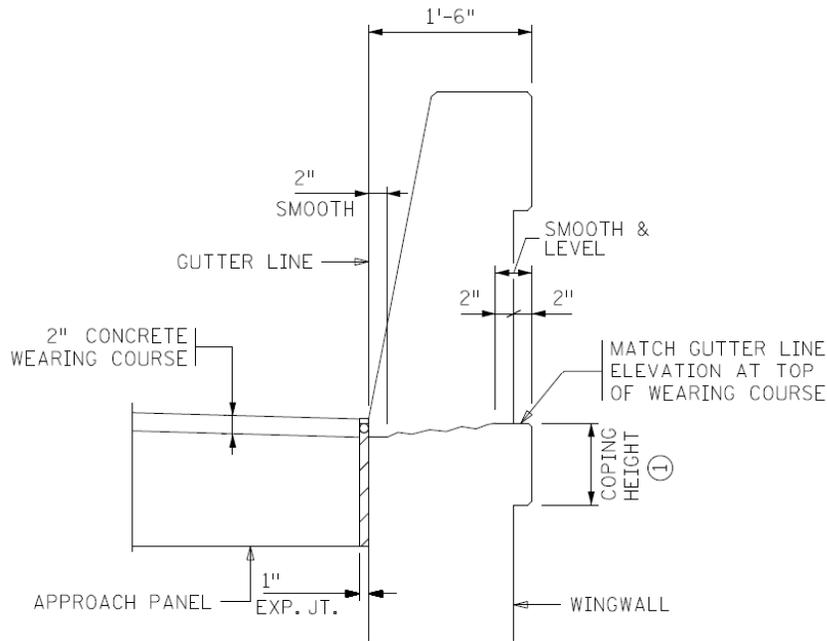
**REINFORCEMENT FOR DECK ON PRESTRESSED CONCRETE BEAMS**  
(Negative Moment @ 10 inches from CL I-Beam & 8.7 inches from CL Rectangular Beam)

Maximum Beam Spacing <sup>①</sup>	Transverse Reinforcement				Deck Thickness <sup>②</sup>	Longitudinal Reinforcement Bottom <sup>③</sup>	Longitudinal Reinforcement Top <sup>③</sup>
	Bottom		Top				
	w/ Wearing Course	w/o Wearing Course	Deck on I-Beam	Deck on Rect. Beam			
5'-0"	13 @ 5"	13 @ 6.5"	13 @ 10"	13 @ 9.5"	9"	13 @ 7"	13 @ 1'-6"
5'-6"	13 @ 5"	13 @ 6"	13 @ 9"	13 @ 8.5"	9"	13 @ 7"	13 @ 1'-6"
6'-0"	16 @ 7"	13 @ 6"	13 @ 8.5"	13 @ 7.5"	9"	16 @ 10"	13 @ 1'-6"
6'-6"	16 @ 7"	13 @ 6"	13 @ 7.5"	13 @ 7"	9"	16 @ 10"	13 @ 1'-6"
7'-0"	16 @ 7"	13 @ 6"	13 @ 6.5"	13 @ 6"	9"	16 @ 10"	13 @ 1'-6"
7'-6"	16 @ 7"	13 @ 6"	13 @ 6"	13 @ 5.5"	9"	16 @ 10"	13 @ 1'-6"
8'-0"	16 @ 7"	13 @ 6"	13 @ 5.5"	13 @ 5"	9"	16 @ 10"	13 @ 1'-6"
8'-6"	16 @ 7"	13 @ 6"	13 @ 5"	13 @ 5"	9"	16 @ 10"	13 @ 1'-6"
9'-0"	16 @ 7"	13 @ 6"	13 @ 5"	16 @ 7"	9"	16 @ 10"	13 @ 1'-6"
9'-6"	16 @ 6.5"	13 @ 5.5"	16 @ 7"	16 @ 7"	9"	16 @ 9"	13 @ 1'-6"
10'-0"	16 @ 6"	13 @ 5"	16 @ 7"	16 @ 6.5"	9"	16 @ 8"	13 @ 1'-6"
10'-6"	16 @ 6"	13 @ 5"	16 @ 6.5"	16 @ 6"	9"	16 @ 8"	13 @ 1'-6"
11'-0"	16 @ 5.5"	16 @ 7.5"	16 @ 6"	16 @ 6"	9"	16 @ 8"	13 @ 1'-6"
11'-6"	16 @ 5.5"	16 @ 7"	16 @ 5.5"	16 @ 5.5"	9"	16 @ 8"	13 @ 1'-6"
12'-0"	19 @ 7"	16 @ 6.5"	16 @ 5.5"	16 @ 5"	9"	16 @ 7"	13 @ 1'-6"
12'-6"	19 @ 7"	16 @ 6.5"	16 @ 5"	16 @ 5"	9"	16 @ 7"	13 @ 1'-6"
13'-0"	19 @ 7"	16 @ 6.5"	16 @ 5"	16 @ 5"	9 1/2"	16 @ 7"	13 @ 1'-6"
13'-6"	19 @ 7"	16 @ 6.5"	16 @ 5"	16 @ 5"	9 3/4"	16 @ 7"	13 @ 1'-6"
14'-0"	19 @ 7.5"	16 @ 6.5"	16 @ 5"	19 @ 6"	10"	16 @ 7"	13 @ 1'-6"
14'-6"	19 @ 7.5"	16 @ 6.5"	16 @ 5"	19 @ 6"	10 1/4"	16 @ 7"	13 @ 1'-6"
15'-0"	19 @ 7.5"	16 @ 6.5"	16 @ 5"	19 @ 6"	10 1/2"	16 @ 7"	13 @ 1'-6"

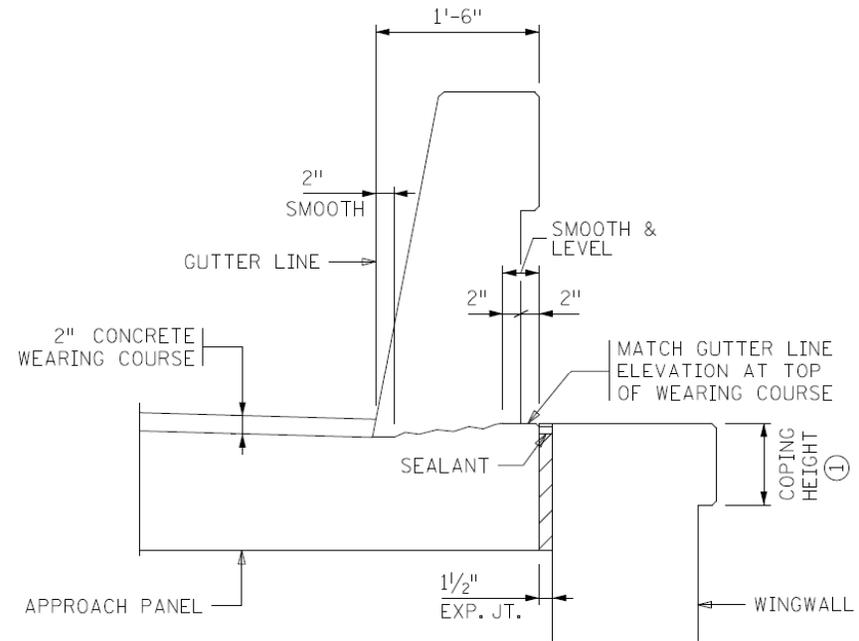
*BDM Table 9.2.1.1*

# New Practice

- *Note 1: change coping height to match EOD thickness*



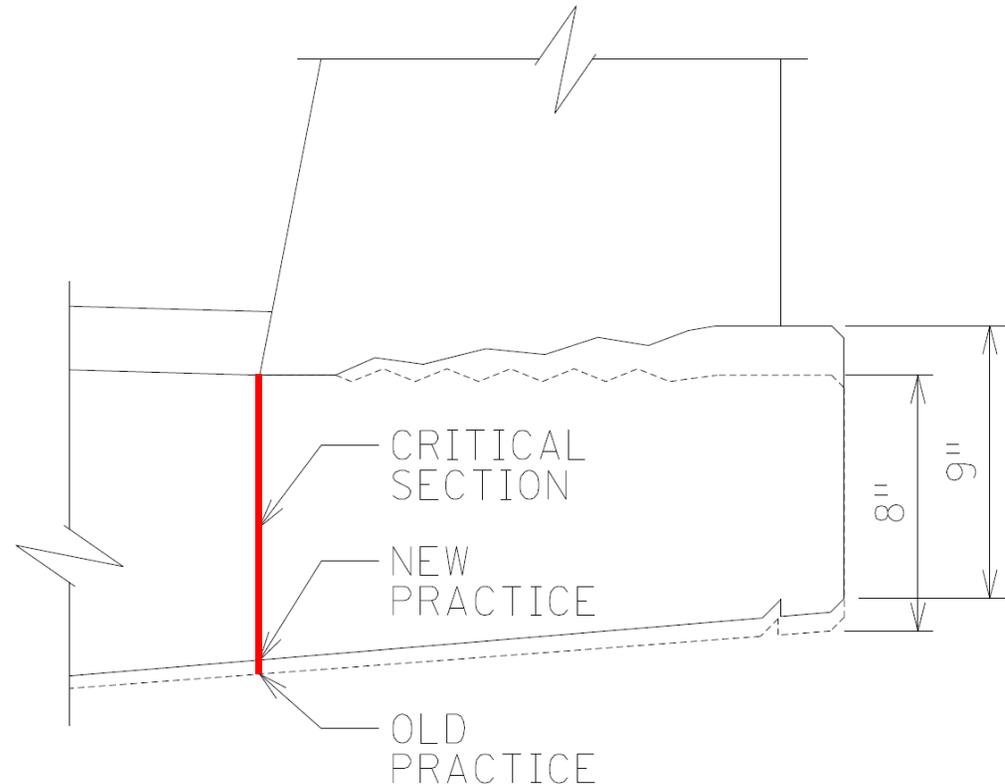
BARRIER SECTION ON WINGWALL

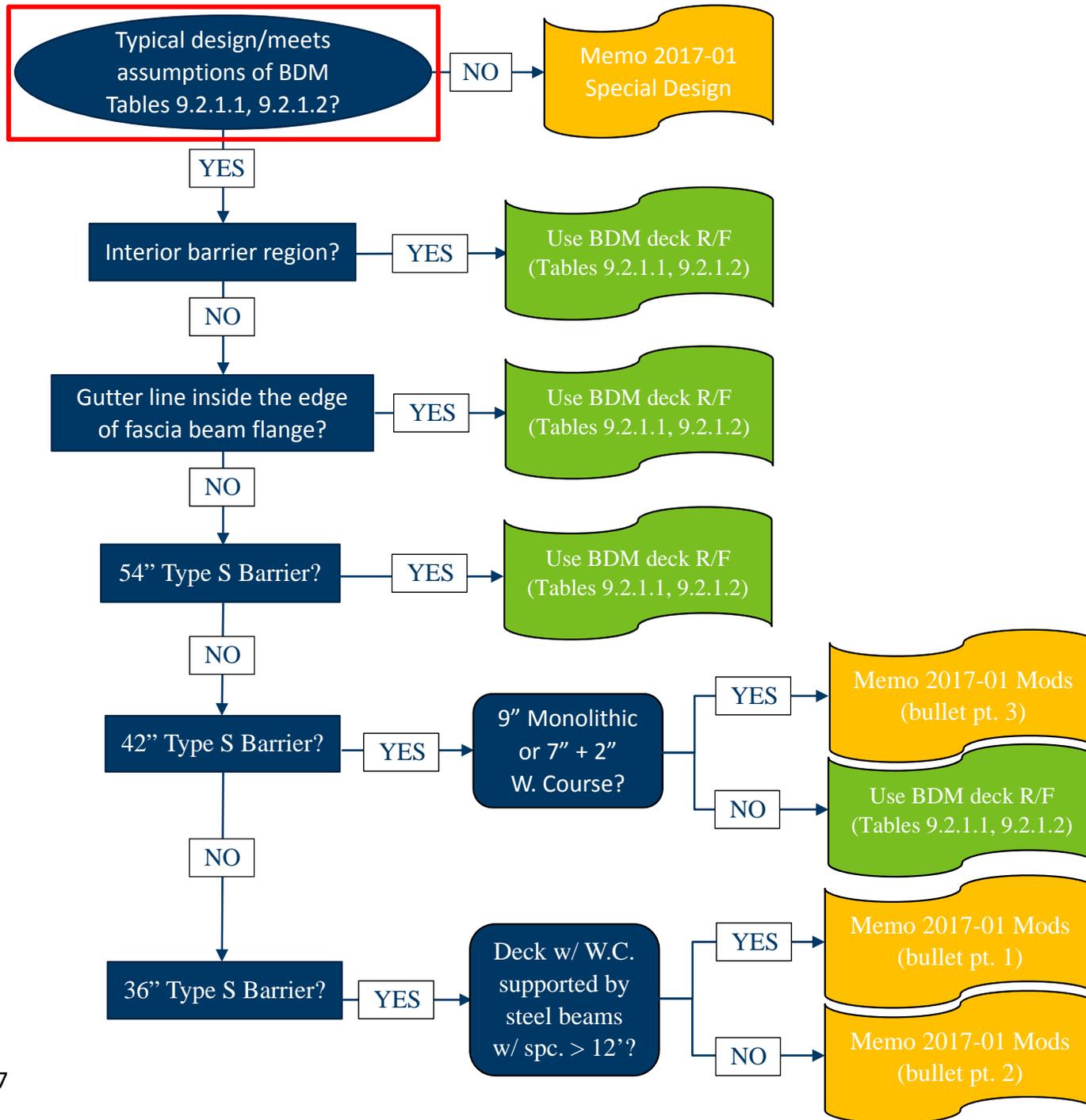


BARRIER SECTION ON APPROACH PANEL

# Impacts on Design

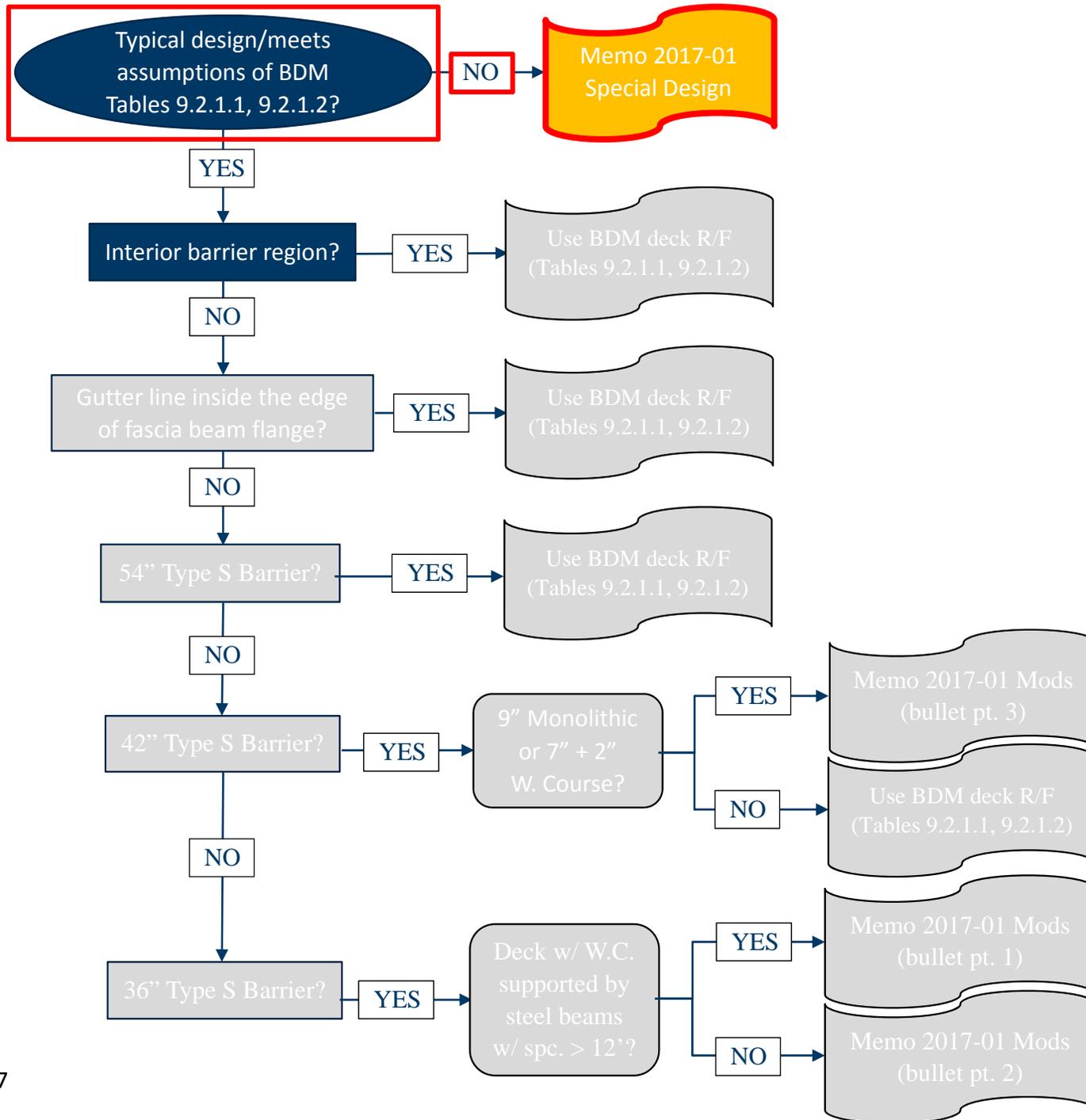
- Changes to Memo to Designers 2016-01
  - Deck surface no longer level beneath barrier
  - New guidance for deck overhang design
  - Critical section reduced
- Some instances require modifications to BDM Tables 9.2.1.1, 9.2.1.2





# General BDM Design Table Assumptions

- Overhang width  $\leq 40\%$  beam spacing
- $f'_c = 4$  ksi,  $f_y = 60$  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



# Special Design

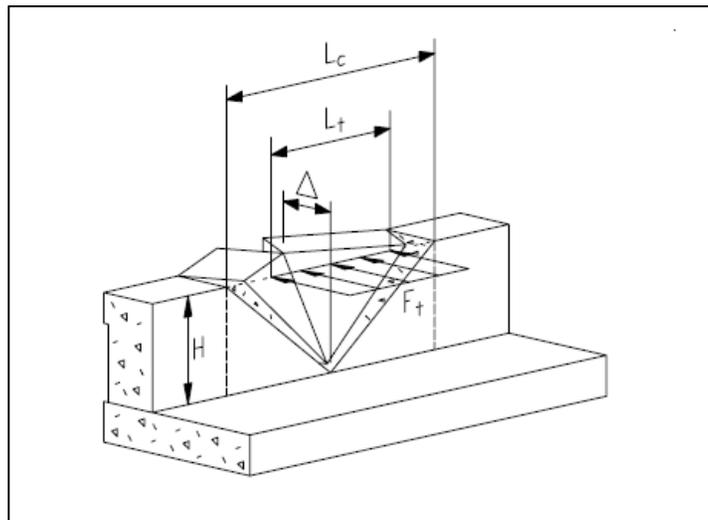
- Adjusted NCHRP 350 TL-4 collision load,  $F_t$ , to account for varying barrier heights and heights of load application
- Used  $\min\left(R_w (\text{capacity}), \frac{4}{3} F_t\right)$  per BDM section 9.2.1
- Adjusted collision loads,  $F_{\text{cadj}}$  and  $M_{\text{cadj}}$ , given in Table 1 of memo:

	36" Type S		42" Type S		54" Type S	
	Exterior	Interior	Exterior	Interior	Exterior	Interior
$M_{\text{cadj}}$ (k-ft/ft)	20.5	9.4	18.8	7.8	17.4	6.7
$F_{\text{cadj}}$ (k/ft)	7.9	3.7	6.1	2.7	4.1	1.8

Table 1

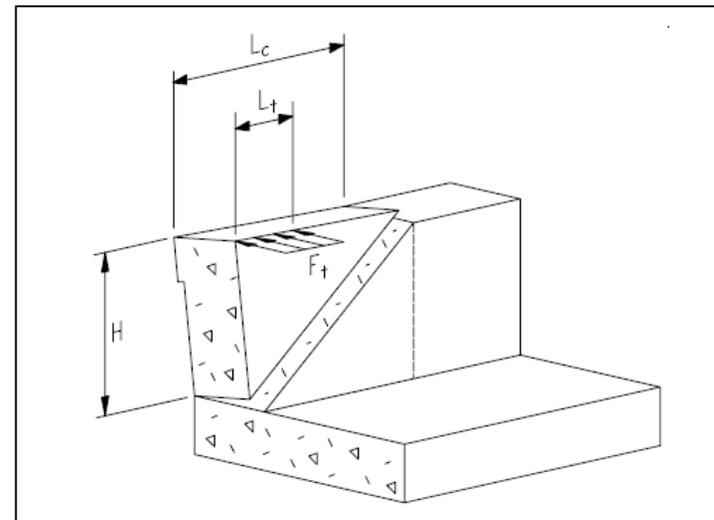
# Interior vs. Exterior Regions

- Interior region - continuous longitudinal R/F



*BDM Figure 13.3.1.1*

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

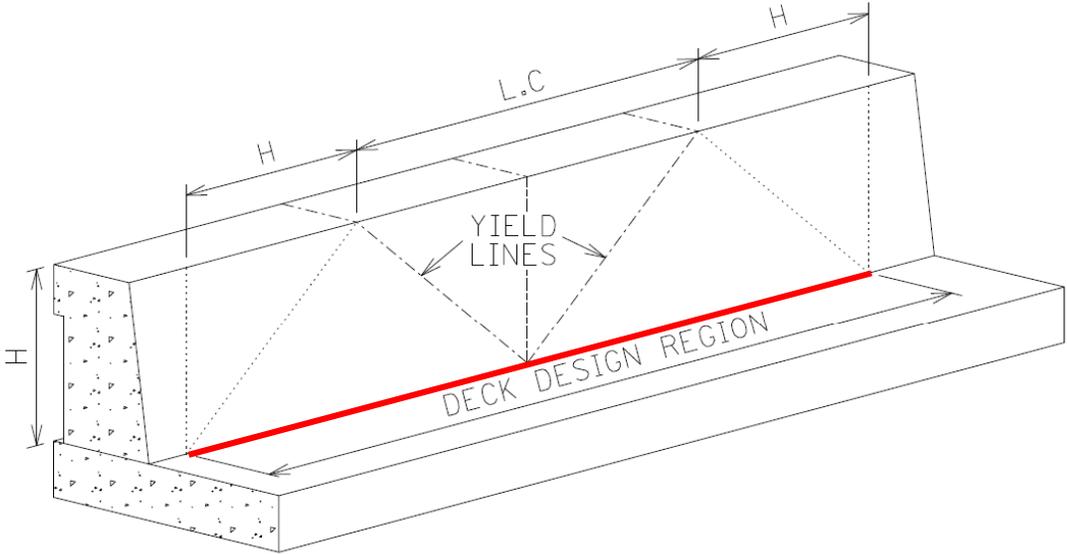


*BDM Figure 13.3.1.1*

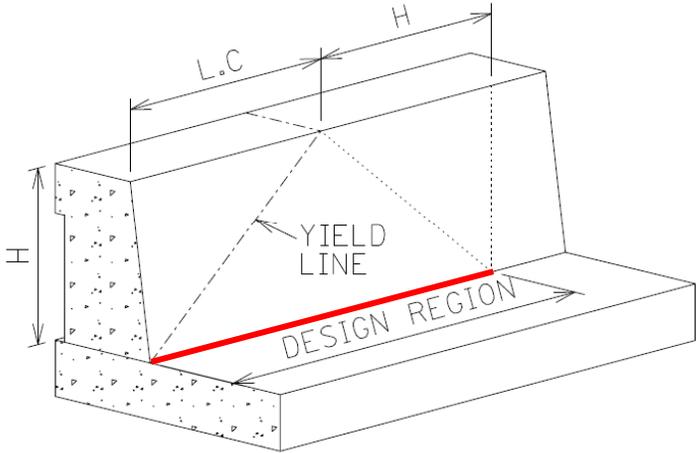
# Load Distribution

Interior region:  $L_c + 2H$

Exterior region:  $L_c + H$



INTERIOR REGION



EXTERIOR REGION

# Special Design

Translate the moment at top of deck to a moment located at deck center:

$$e = \frac{M_{cadj}}{F_{cadj}}$$

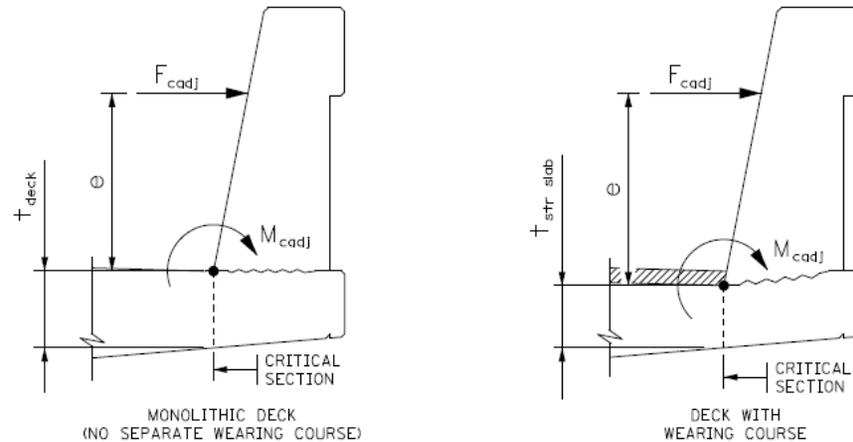
$$F_{cdes} = F_{cadj}$$

For monolithic decks:

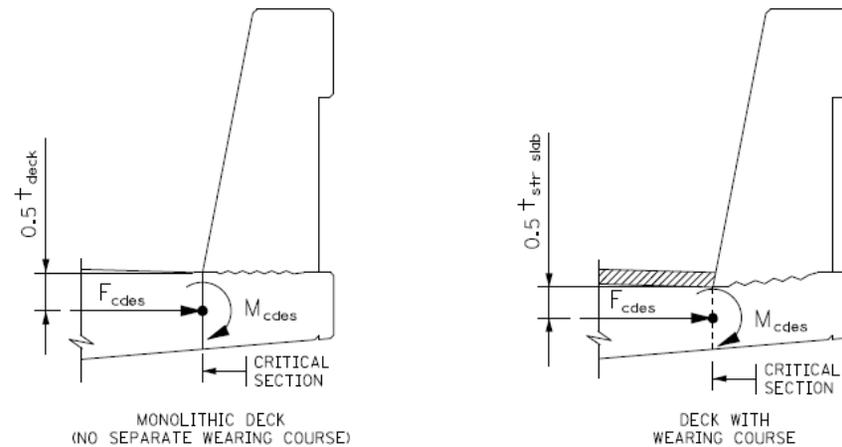
$$M_{cdes} = F_{cdes} \cdot (e + 0.5 \cdot t_{deck})$$

For slabs with wearing course:

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



COLLISION LOADS ADJUSTED FOR BARRIER HEIGHT



# Special Design Example

- 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:

	36" Type S		42" Type S		54" Type S	
	Exterior	Interior	Exterior	Interior	Exterior	Interior
M <sub>cadj</sub> (k-ft/ft)	20.5	9.4	18.8	7.8	17.4	6.7
F <sub>cadj</sub> (k/ft)	7.9	3.7	6.1	2.7	4.1	1.8

Table 1

# Special Design Example

- Use the equations provided in the memo:

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

$$F_{cdes} = F_{cadj} = 3.7 \text{ k}/\text{ft}$$

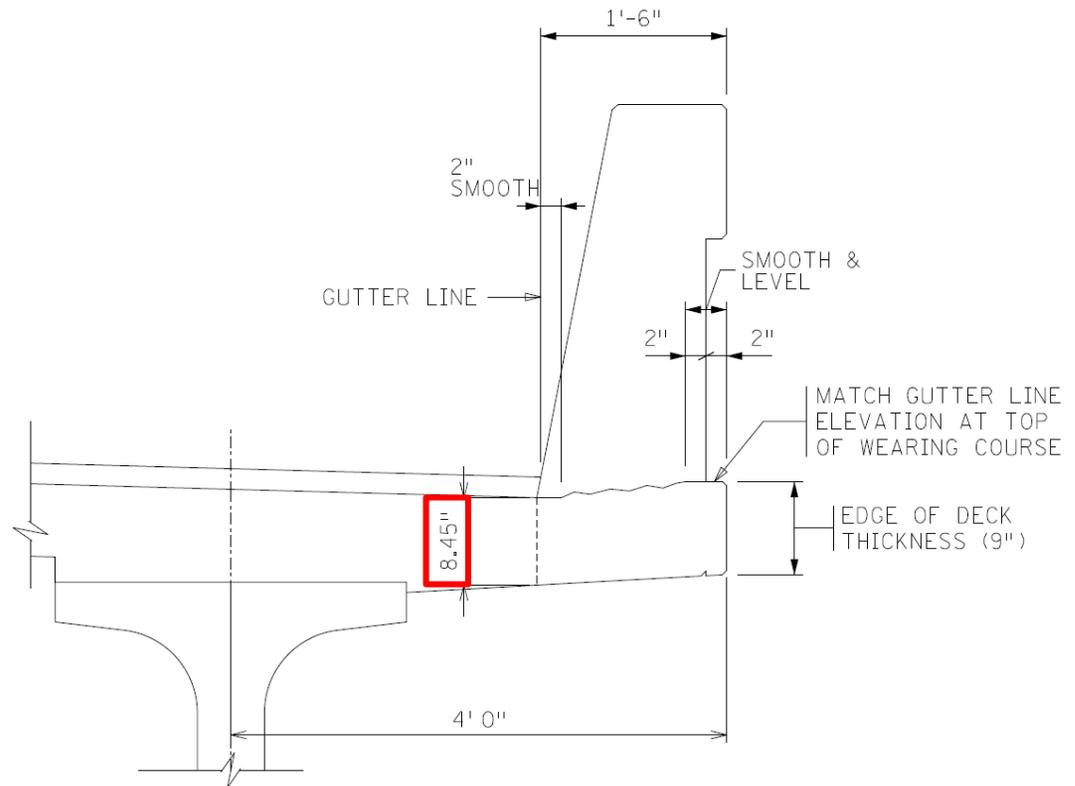
For deck with a 7" structural slab plus 2" wearing course:

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

→ How to find  $t_{str \text{ slab}}$ ?

# Special Design Example

- 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

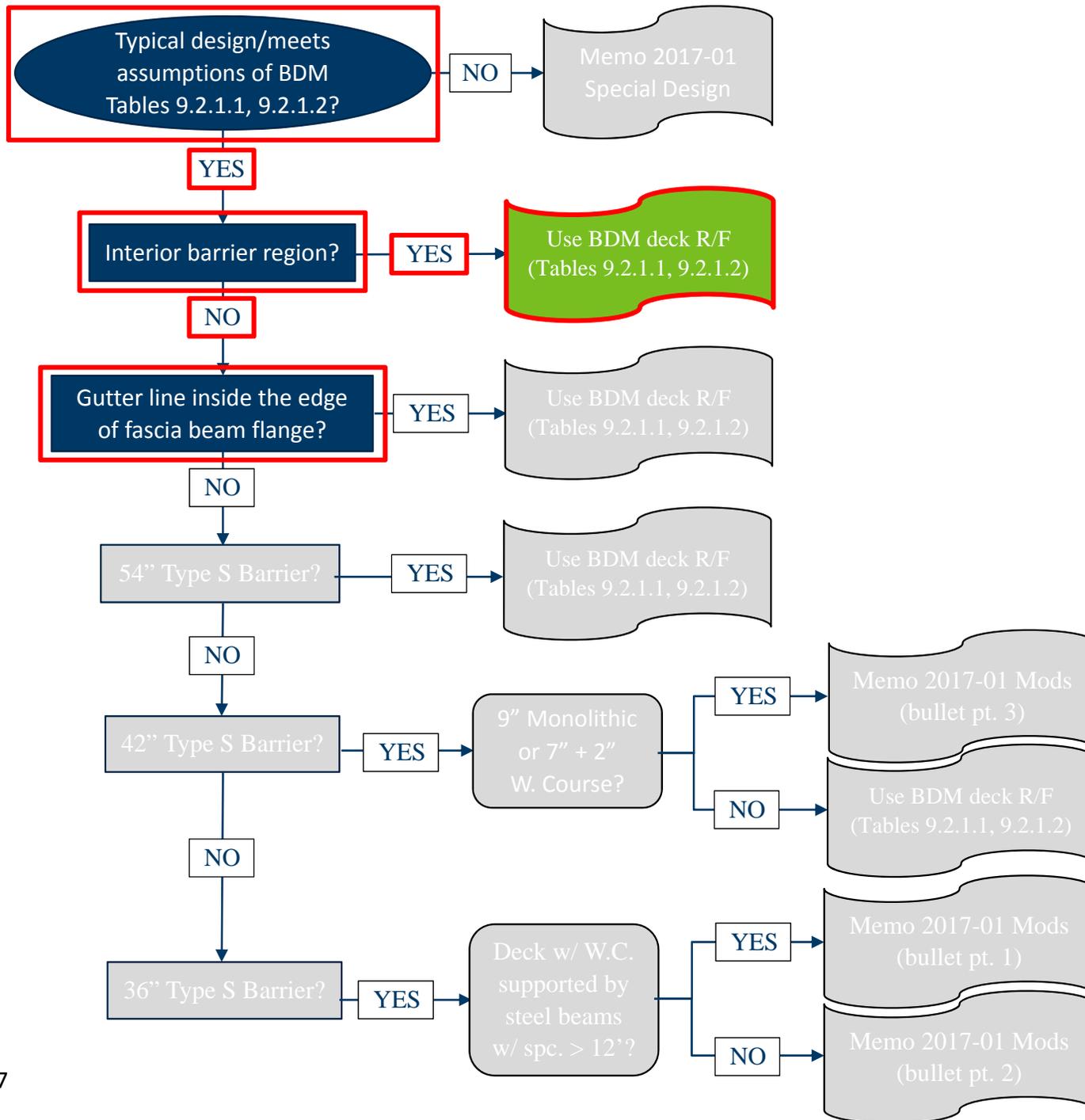


# Special Design Example

- Given the value of  $t_{str\ slab}$ , we can continue with the equations in the memo:

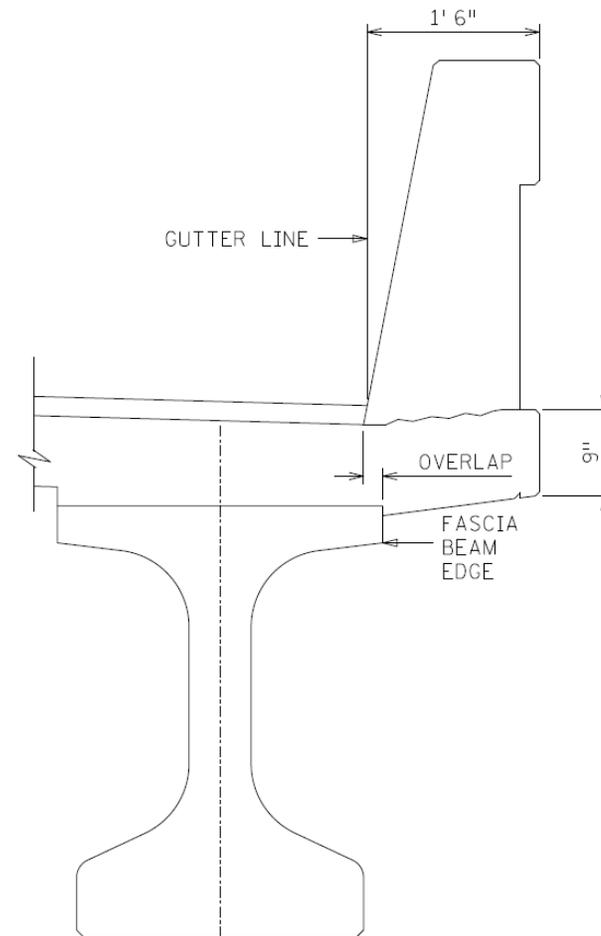
$$\begin{aligned}M_{cdes} &= F_{cdes} \cdot (e + 0.5 \cdot t_{str\ slab}) = 3.7 \frac{k}{ft} \cdot \left( 2.54 ft + 0.5 \cdot \frac{8.45 in}{12 in/ft} \right) \\ &= 10.7 k \cdot ft/ft\end{aligned}$$

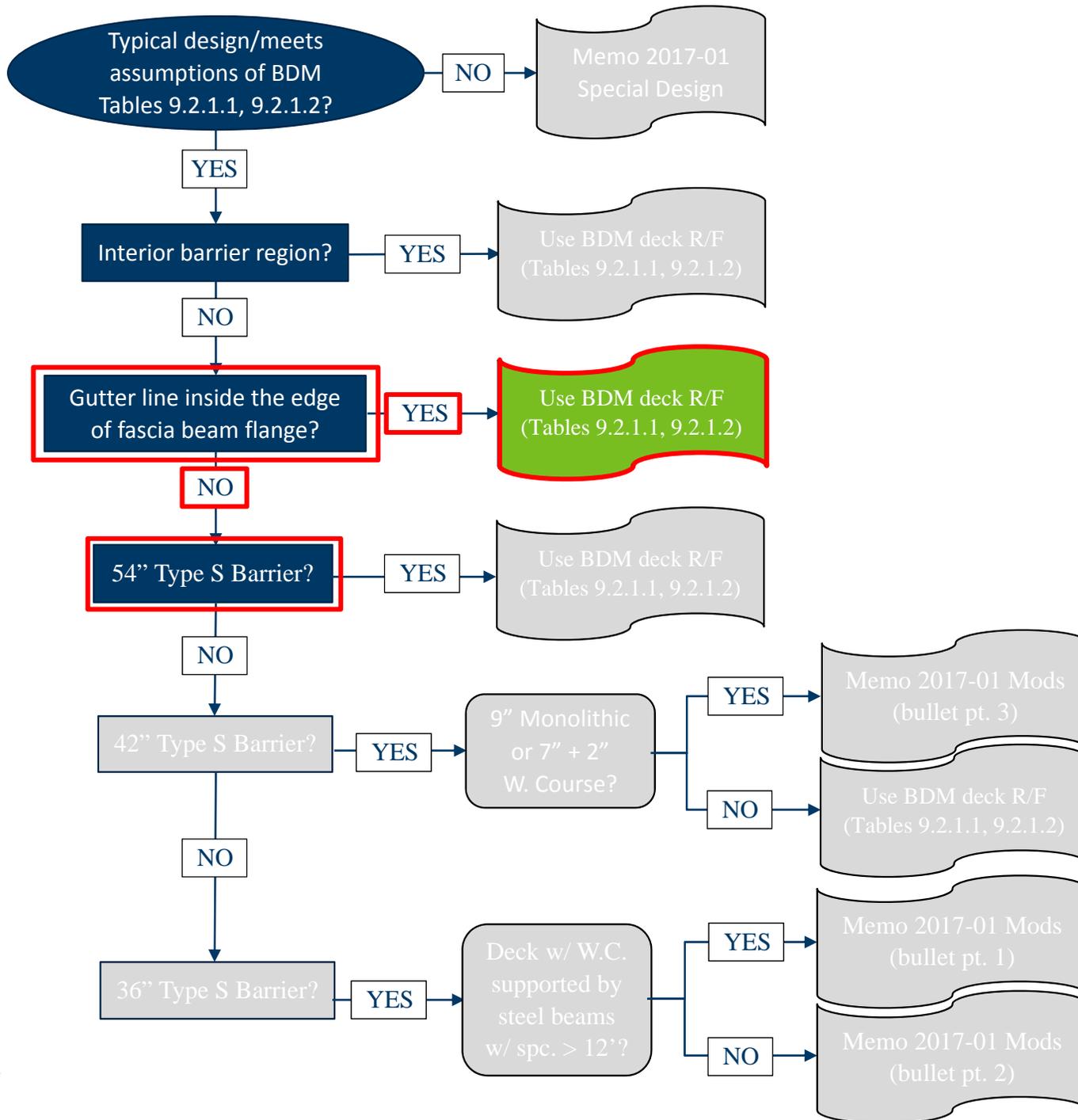
- Summary:
  - $F_{cdes} = 3.7 k/ft$
  - $M_{cdes} = 10.7 k \cdot ft/ft$
- Use these design values to determine the reinforcement required at the critical section (see BDM section 9.3 for an example)

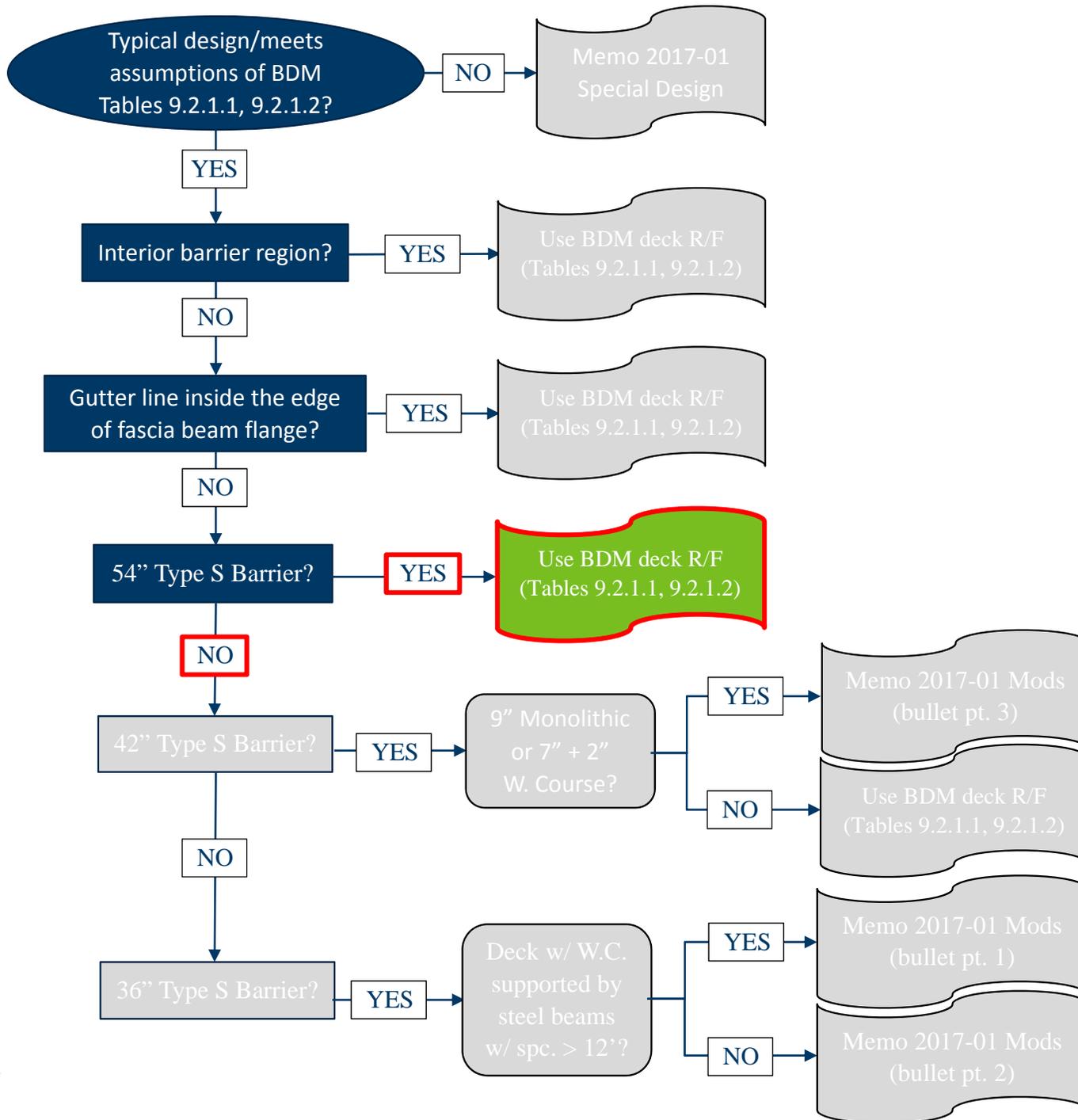


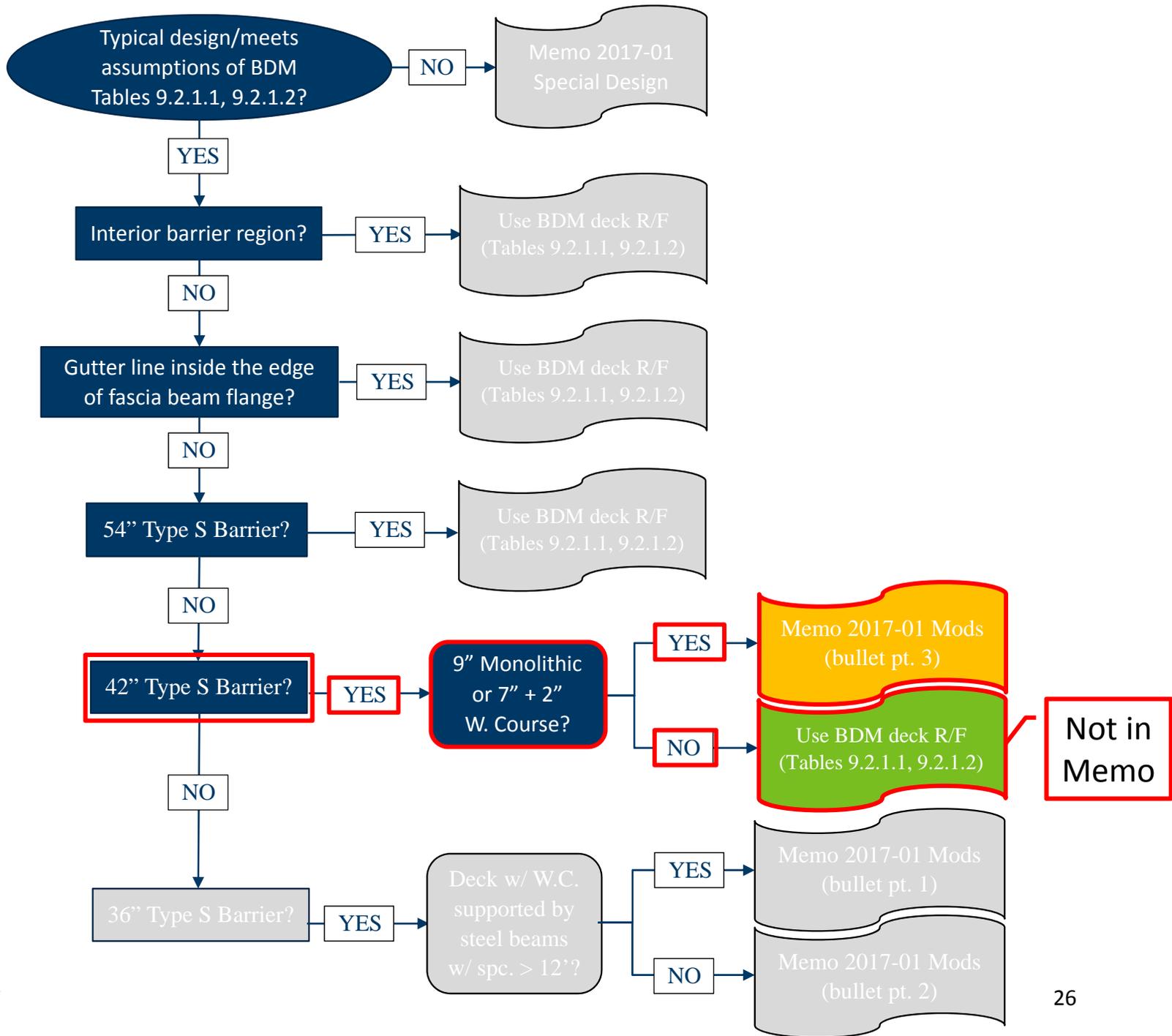
# Gutter Line and Flange Edge

- If overlap exists, can use BDM Design Tables
- If no overlap, see memo design criteria



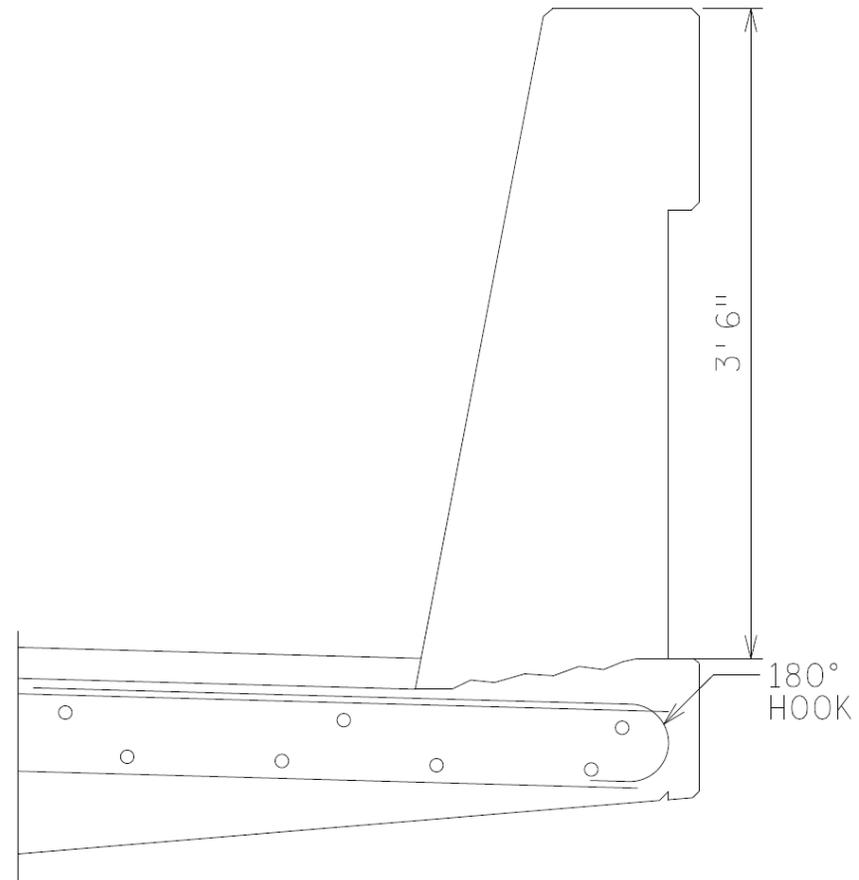


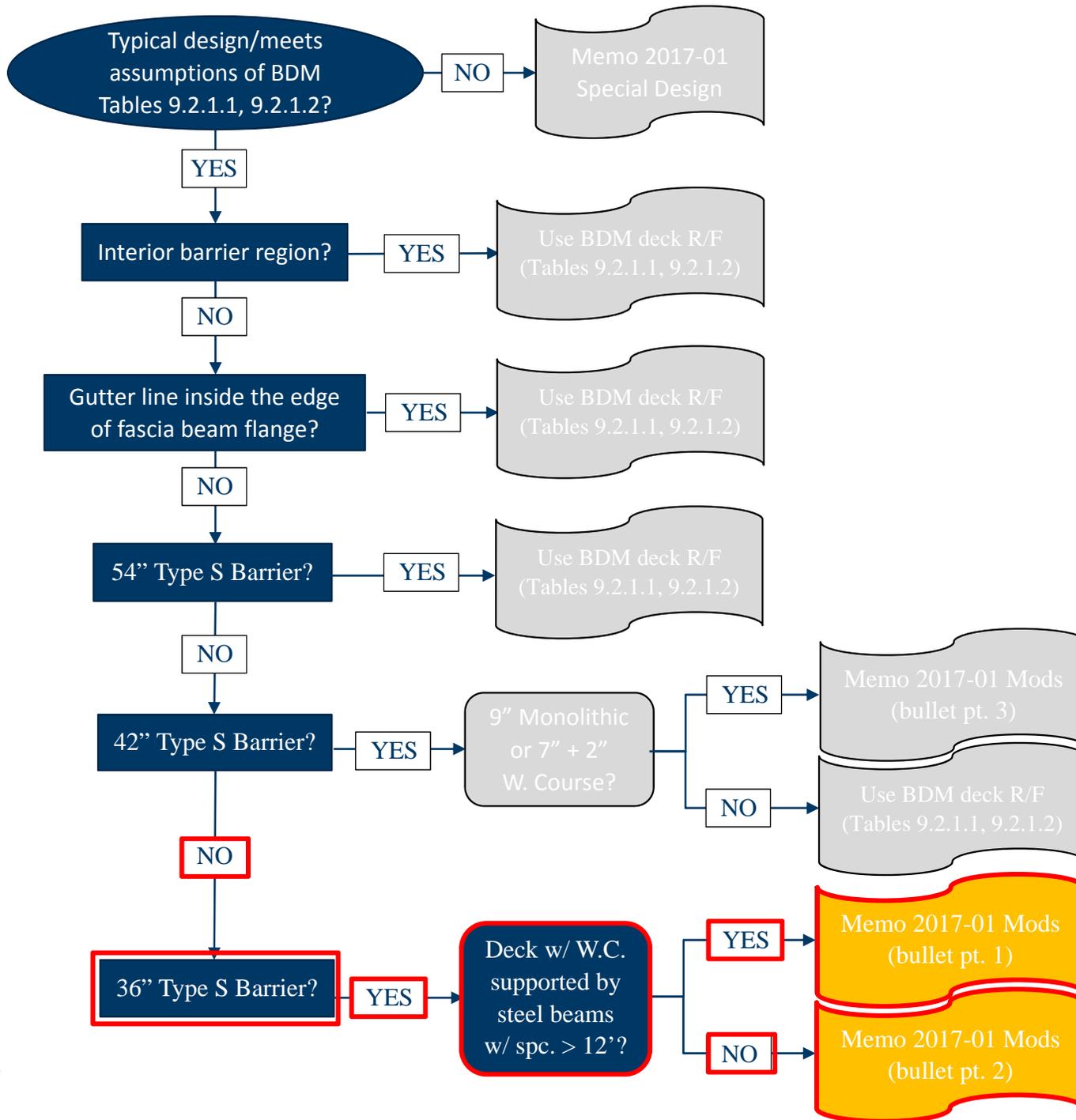




# 42" Barrier Modifications

- 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





# 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!

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