Bent (Pier) Protection

Taya Retterer

May 17, 2022

Table of contents

1	Summary of Changes	3-4
2	Bent Protection Guide	5-24

Summary of Changes

- AASTHO LRFD Bridge Design Specification
  - Article 3.6.5
  - 8th Ed.
    - Probability of impact
    - Design for shear of column
  - 9th Ed.
    - Probability of collapse
    - Design for shear and flexure
    - Consider transfer of force

Summary of Changes

- TxDOT Bridge Design Manual (BDM)
  - Overrides AASTHO LRFD Bridge Design Specification
  - Design for
    - Chapter 2, Section 2, Vehicular Collision
      - Probability of impact
      - Optionally, probability of collapse
    - Chapter 4, Section 6
      - Design the column to withstand the collision force in shear and flexure. Consider the transfer of this force to the other elements such as bent caps, footings, piles, or drilled shafts

Summary of Changes

- Supports the manual
- Provides additional guidance and examples

Bent Protection Guide

Table of Contents

Chapter 1 About this Guide 3

Chapter 2 Design Considerations 5

Chapter 3 Load Redirection Design 8

Chapter 4 Structural Resistance Design 11

Chapter 5 Widenings 16

Appendix A 18

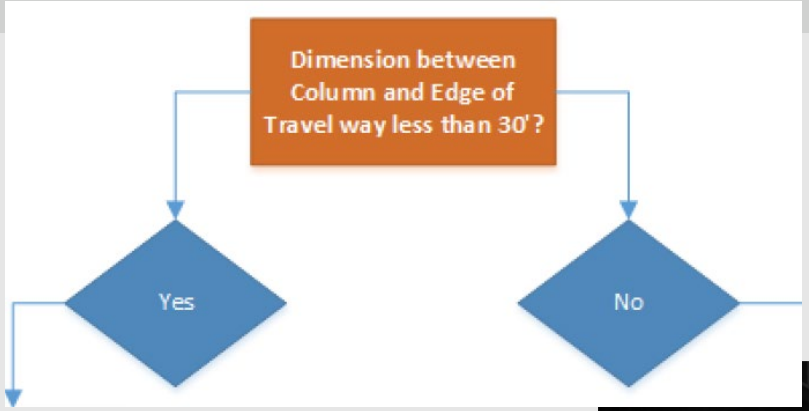
Appendix B 19

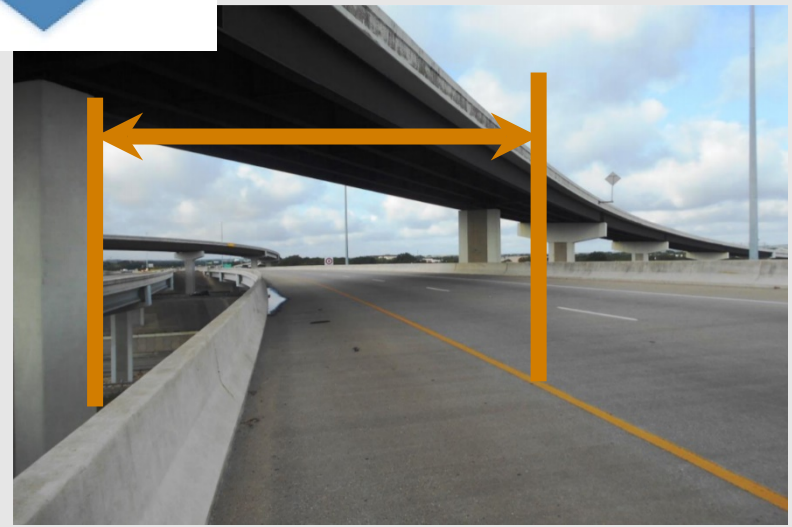
Appendix C 26

Bent Protection Guide

Figure 12 – Design Consideration Flow Chart

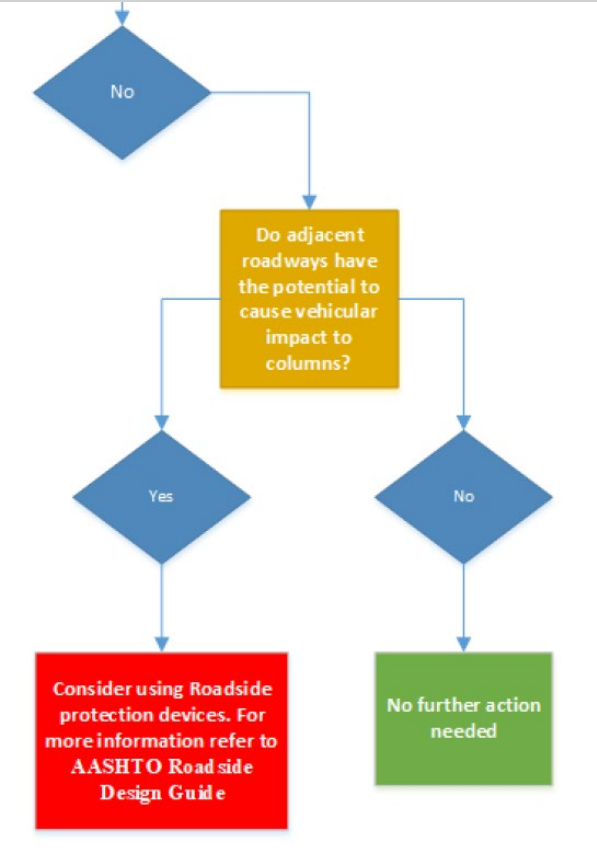
Bent Protection Guide



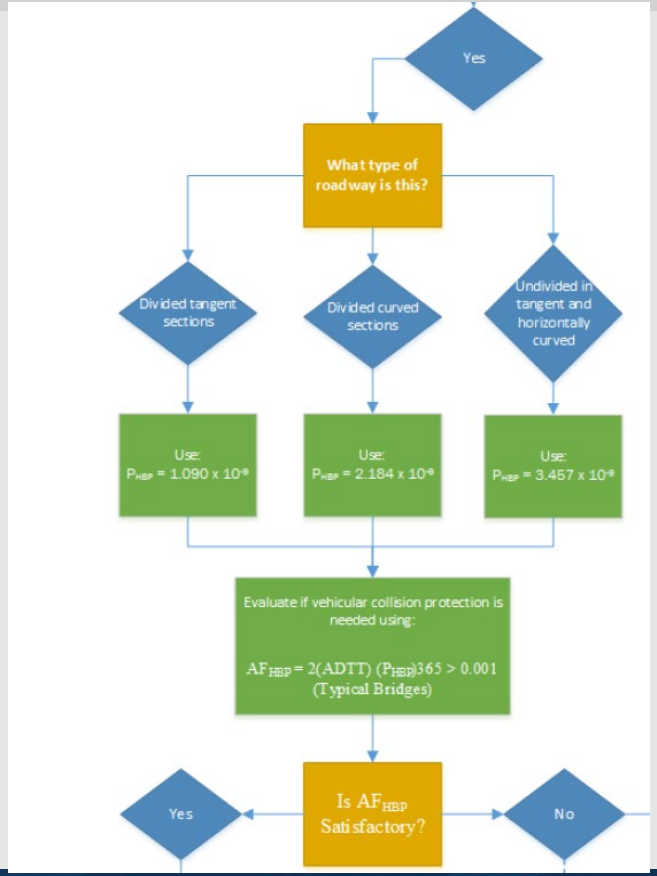


(BDM 2.2)

Bent Protection Guide



Bent Protection Guide



Bent Protection Guide

- Do not investigate bents and piers for collision if the annual frequency for a bridge bent or pier to be hit by a vehicle, AF_{HPB}, is less than 0.001 (BDM 2.2)

$$AF_{HBP} \geq 0.001$$

$$AF_{HBP} = 2(\text{ADTT})\,(P_{HBP})365$$

ADTT = the number of trucks per day in one direction

P_{HBP} = the annual probability for a bridge pier to be hit by a heavy vehicle

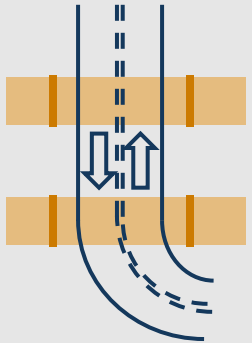
Bent Protection Guide

$P_{HBP} = 3.457 \times 10^{-9}$ for undivided roadways in tangent and horizontally curved sections

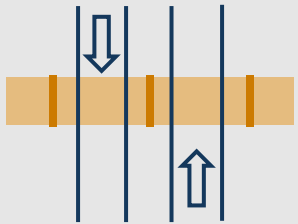
1.090×10^{-9} for divided roadways in tangent sections
2.184×10^{-9} for divided roadways in horizontally curved sections

(BDM 2.2)

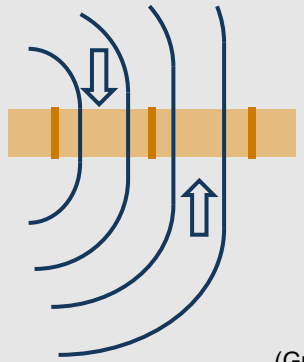
$P_{HBP} = 3.457 \times 10^{-9}$



$P_{HBP} = 1.090 \times 10^{-9}$



$P_{HBP} = 2.184 \times 10^{-9}$



(Guide 2)

Bent Protection Guide

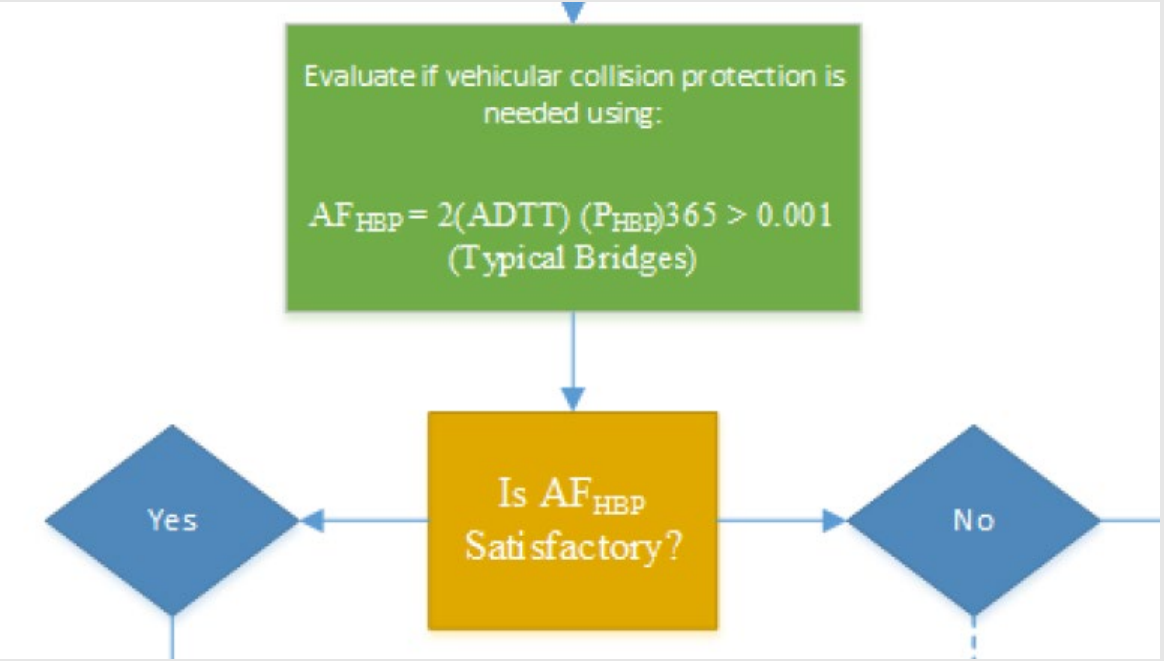
ADT (Both Directions)	ADTT* (One Way)	Undivided	Divided Curved	Divided Tangent
		P_{HBP}=3.457E-09	P_{HBP}=2.184E-09	P_{HBP}=1.09E-09
		$AF_{HPB} = 2 \times ADTT \times 365 \times P_{HBP}$		
1,000	110	0.0003	0.0002	0.0001
2,000	220	0.0006	0.0004	0.0002
3,000	330	0.0008	0.0005	0.0003
3,500	385	0.0010	0.0006	0.0003
4,000	440	0.0011	0.0007	0.0004
5,000	550	0.0014	0.0009	0.0004
5,500	605	0.0015	0.0010	0.0005
6,000	660	0.0017	0.0011	0.0005
8,000	880	0.0022	0.0014	0.0007
10,000	1,100	0.0028	0.0018	0.0009
11,000	1,210	0.0031	0.0019	0.0010
12,000	1,320	0.0033	0.0021	0.0011

*Assumes 55% in one direction and twenty percent of ADT is truck traffic.

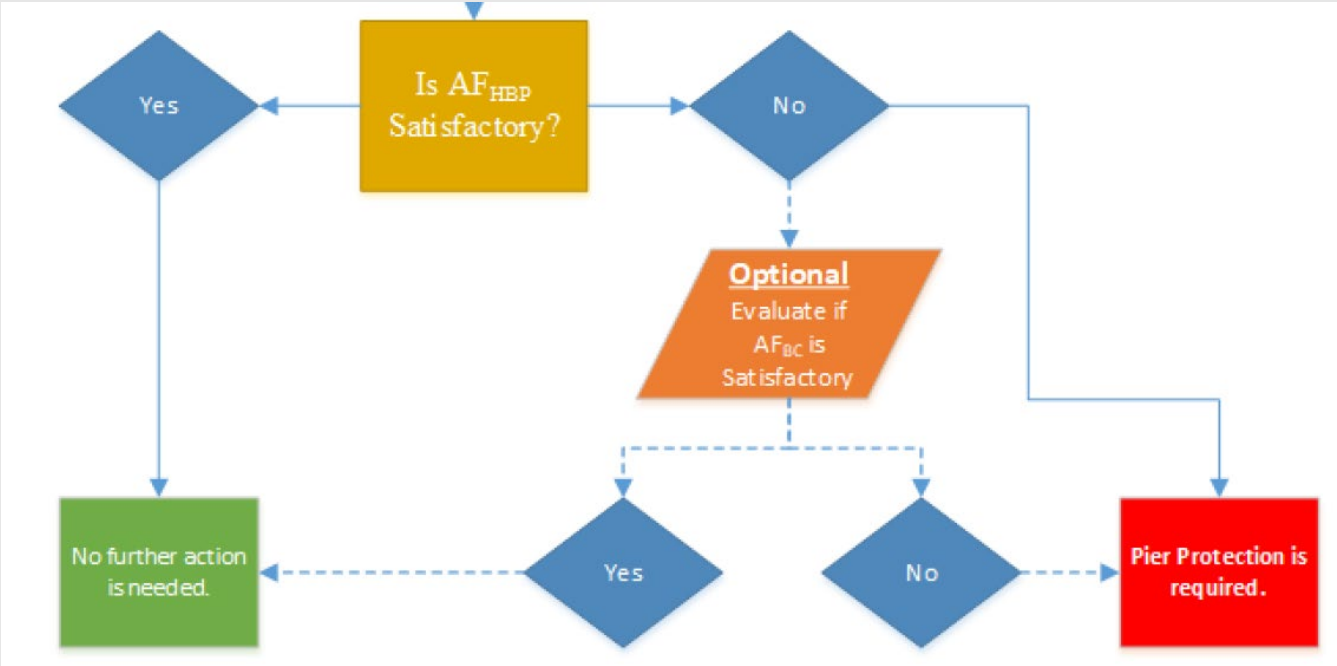
Table 1 – Typical Values of AF_{HBP}

(Guide 2)

Bent Protection Guide



Bent Protection Guide



Bent Protection Guide

- Design for Collision (BDM 2.2)
  - Redirect
    - An embankment
    - Within 3.25 feet, 54” MASH TL-5, structural independent
    - Within 10 feet, 42” MASH TL-5, structural independent
    - More than 10 feet, 42” MASH TL-53

  or

  - Provide Structural Resistance
    - 600-kip equivalent static load
    - acting in a direction of zero to 15 degrees with the edge of the pavement in a horizontal plane,
    - at a distance of 2.0 to 5.0 ft above ground

Bent Protection Guide

- Design for Collision (BDM 4.6)
  - Provide Structural Resistance
    - Design the column to withstand the collision force in shear and flexure. Consider the transfer of this force to the other elements such as bent caps, footings, piles, or drilled shafts.
    - For shear capacity of the column, use a 0.9 load factor for all dead loads and no live load for the axial compression.
    - Use of a vehicular deflection wall between the columns is permitted if necessary. Design vehicular deflection wall assembly (columns plus wall) for the 600-kip equivalent static load as described in Chapter 2 - Limit States and Loads, Section 2 - Loads.
    - No further analysis is required for columns with a gross cross-sectional area no less than 40 sq. ft., a minimum thickness of 5 ft. and column transverse reinforcement is composed of at least No. 4 ties at 12 in. maximum spacing or a No. 4 spiral at 9 in. maximum pitch.

- Load Redirection (Guide 3)

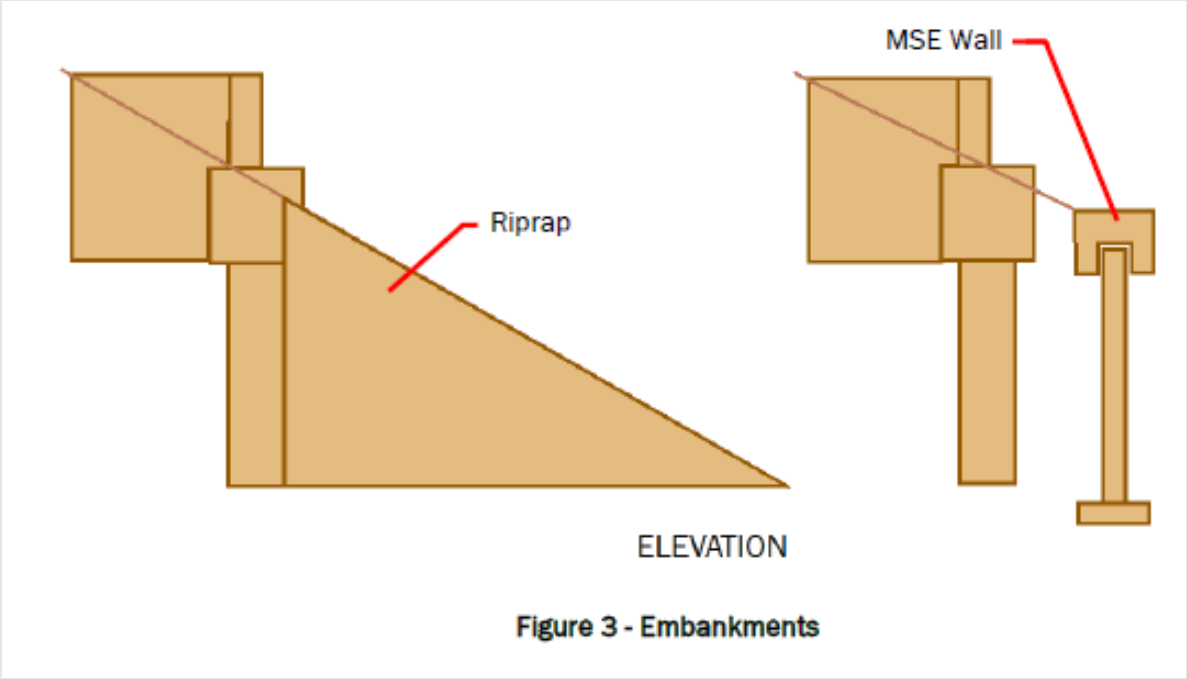


Figure 3 - Embankments

- Load Redirection (Guide 3)

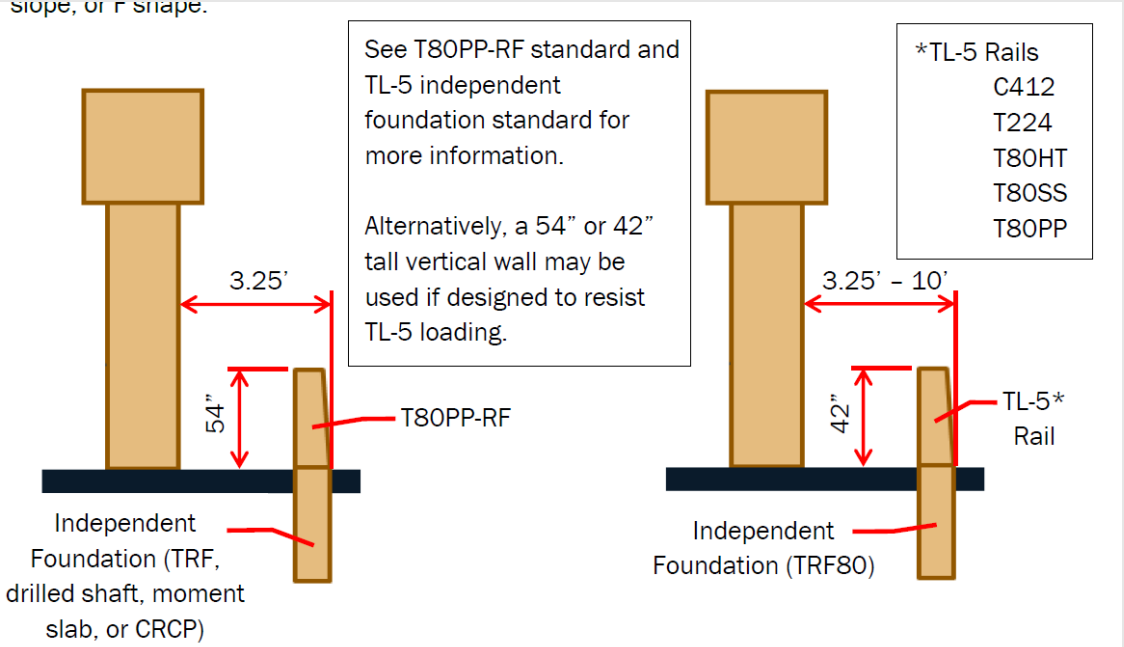
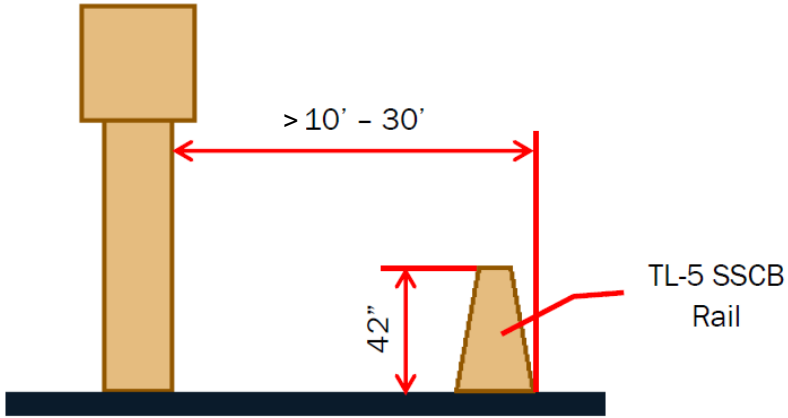


Figure 4 – Barriers at less than 10'

- Load Redirection (Guide 3)



An SSCB rail may be modified for reinforcement similar to the T80SS.

Barriers shown in Figure 4 may also be used.

Figure 5 – Barriers between 10’ and 30’

- Structural Resistance Design (Guide 4)

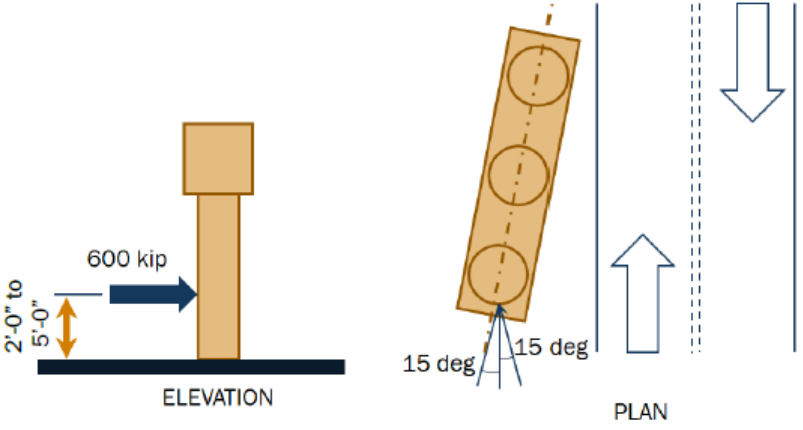


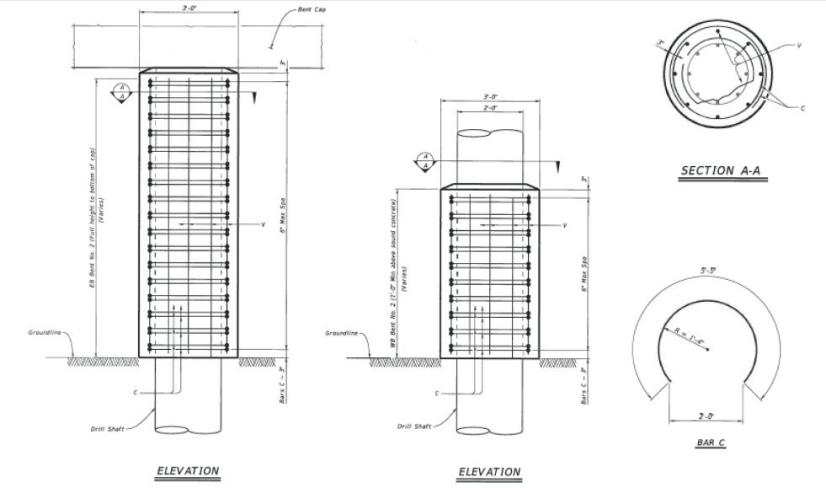
Figure 7 – Design Guidelines

Bent Protection Guide

- Additional information in the Guide
  - Treatment of Existing Facilities
    - Vehicular Deflection Wall (Guide 3)
      - Appendix B – Example Details
      - Appendix C – Example failure mode for yield line analysis

Bent Protection Guide

- Additional information in the Guide
  - Treatment of Existing Facilities
    - Column Jacketing (Guide 3)
      - Appendix B – Example Details



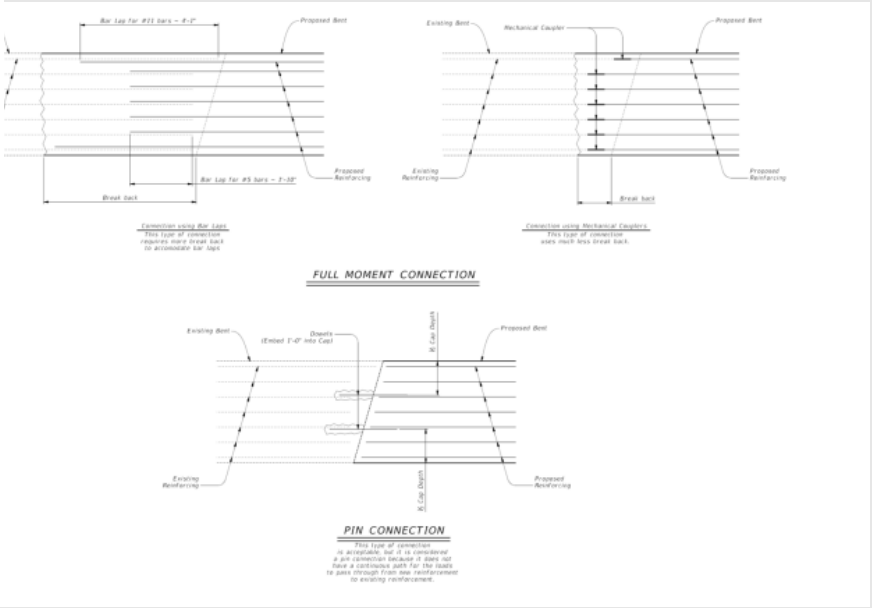
Bent Protection Guide

- Additional information in the Guide
  - Widenings

For the existing structure, analyse the column capacity for the vehicular collision force.

- Can the bent resist the load as is?
- Does a VDW need to be added to increase the capacity of the bent/columns?
- Consider the roadside safety concerns.
  - Will adding a VDW adversely affect sight distances at an intersection?
  - Is adding the VDW going to increase the ponding of the design storm to where it encroaches on the travel lane?

If all the design criteria cannot be met, this includes structural design criteria as well as roadway design criteria, discuss with the District's project lead and decide which criteria takes precedence. All conflicts and decisions need to be identified and addressed on a case-by-case basis. The sooner these conflicts are brought to the attention of the District's project lead the better.



Questions?

Taya Retterer, P.E.
TxDOT--Bridge Division
Taya.Retterer@txdot.gov