

# CHAPTER 404

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## Bridge Deck

Design Memorandum	Revision Date	Sections Affected
13-11	May 2013	404-2.06(03), 404-2.03
16-33	Sep. 2016	Figure 404-4D
17-16	Aug. 2017	404-2.02(02), 404-2.02(03), 404-2.03(02), Figs. 404-2B and -2C
19-07	Sep. 2019	404-4.05
19-08	Sep. 2019	404-4.0, Figures 404-4A, -4B, and -4C
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21-13	Apr. 2021	404-2.06(03), Figure 404-2J (New)
22-21	Oct. 2022	404-2.06(02), Figure 404-2F

The applicable [design memorandum](#) revision date is date the memo was issued and is noted in brackets next to each section heading below. The date the revision becomes effective may be different and is identified in the design memo.

## TABLE OF CONTENTS

TABLE OF CONTENTS.....	2
LIST OF FIGURES .....	4
404-1.0 STRIP METHOD .....	5
404-1.01 Description .....	5
404-1.02 Application of the Strip Method to a Composite Concrete Deck.....	6
404-2.0 BRIDGE DECK DESIGN.....	6
404-2.01 General Requirements [Rev. Apr. 2021].....	6
404-2.02 Dimensional Requirements for Concrete Deck.....	7
404-2.02(01) Screed Elevations for Cast-in-Place Concrete Deck.....	7
404-2.02(02) Fillet Dimensions for Steel Beams or Girders [Rev. Aug. 2017] .....	8
404-2.02(03) Fillet Dimensions for Concrete Beams [Rev. Aug. 2017] .....	9
404-2.03 Forms for Concrete Deck [Rev. May 2013].....	9
404-2.03(01) Precast Deck Panels [Rev. May 2013].....	10
404-2.03(02) Permanent Metal Forms [Rev. May 2013, Rev. Aug. 2017] .....	10
404-2.03(03) Removable Forms [Rev. May 2013].....	10
404-2.04 Skewed Deck .....	10
404-2.05 Shear Connectors and Vertical Ties .....	11
404-2.06 Deck Joints .....	11
404-2.06(01) Longitudinal Open Joint.....	11
404-2.06(02) Construction Joint [Rev. Oct. 2022] .....	11
404-2.06(03) Expansion Joints [Rev. May 2013, Apr. 2021].....	14
404-2.07 Drainage Outlets.....	16
404-3.0 MISCELLANEOUS STRUCTURAL ITEMS.....	16
404-3.01 Longitudinal Edge Beam.....	16
404-3.02 Deck Overhang.....	17
404-3.02(01) Design Methods .....	17
404-3.02(02) Deck Overhang .....	17
404-3.03 Transverse Edge Beam.....	19
404-3.04 Bridge Railing .....	20
404-4.0 BRIDGE RAILING [Rev. Sep. 2019].....	20
404-4.01 Bridge Railing Criteria [Rev. Sep. 2019] .....	21
404-4.02 Test Level Selection [Rev. Sep. 2019] .....	21
404-4.02(01) TL-2 [Rev. Sep. 2019] .....	23
404-4.02(02) TL-3 [Rev. Sep. 2019] .....	23
404-4.02(03) TL-4 [Rev. Sep. 2019] .....	24
404-4.02(04) TL-5 [Rev. Sep. 2019] .....	24

404-4.02(05) TL-6 [Rev. Sep. 2019] .....	24
404-4.02(06) Test Level Selection Exceptions [Rev. Sep. 2019] .....	25
404-4.03 Bridge Railing Design Considerations .....	25
404-4.03(01) Superelevated Bridge Deck .....	25
404-4.03(02) Barrier Delineators .....	25
404-4.04 Bridge Railing Transition [Rev. Sep. 2019] .....	26
404-4.04(01) Type [Rev. May 2017, Aug. 2017, Sep. 2019] .....	26
404-4.04(02) Location [Rev. May 2017] .....	26
404-4.05 Pedestrian Fence [Rev. Sep. 2019] .....	28
404-4.05(01) Considerations for Use [Rev. Sep. 2019] .....	28
404-4.05(02) Placement and Traffic Separation [Rev. Sep. 2019] .....	29
404-4.05(03) Details [Rev. Sep. 2019] .....	29
404-4.06 Bicycle Railing .....	29
404-4.06(01) Bicycle Path .....	29
404-4.06(02) Other Facility .....	29
404-5.0 BRIDGE APPURTENANCES .....	30
404-5.01 Outside Curbs .....	30
404-5.02 Center Curb or Median Barrier .....	30
404-5.03 Lighting .....	30
404-5.04 Traffic Signal .....	30
404-5.05 Utilities Located on an INDOT Bridge .....	31
FIGURES .....	32

## LIST OF FIGURES

<b><u>Figure</u></b>	<b><u>Title</u></b>
<u>404-1A</u>	<u>Cross Section of Multi-Beam Bridge</u>
<u>404-2A</u>	<u>Plan of Screeds</u>
<u>404-2B</u>	<u>Fillet Treatment for Structural Steel Member [Rev. Aug. 2017]</u>
<u>404-2C</u>	<u>Fillet Treatment for Prestressed Concrete Member [Rev. Aug. 2017]</u>
<u>404-2D</u>	<u>Precast Deck Panels on Bridge with Sag Vertical Curve [Del. May 2013]</u>
<u>404-2E</u>	<u>Combination of Skew Angle and Span Length/Bridge Width Ratio</u>
<u>404-2F</u>	<u>Typical Pour Diagram (Continuous Prestressed Concrete Beams) [Rev. Oct. 2022]</u>
<u>404-2G</u>	<u>Typical Pour Diagrams (Continuous Steel Beams or Plate Girders)</u>
<u>404-2H</u>	<u>Modular Expansion Joint</u>
<u>404-2 I</u>	<u>Modular Expansion Joint (Field Splice)</u>
<u>404-2J</u>	<u>Pre-Compressed Foam Joint [New Apr. 2021]</u>
<u>404-3A</u>	<u>Deck Overhang Treatments (Superelevated Structure)</u>
<u>404-3B</u>	<u>Suggested Transverse Edge Beam Details (Bulb-Tee Beam)</u>
<u>404-3C</u>	<u>Suggested Transverse Edge Beam Details (AASHTO I-Beam)</u>
<u>404-3D</u>	<u>Suggested Transverse Edge Beam Details (Steel Plate Girder)</u>
<u>404-3E</u>	<u>Suggested Alternate Transverse Edge Beam Details (Steel Plate Girder)</u>
<u>404-3F</u>	<u>Suggested Alternate Transverse Edge Beam Details (Bulb-Tee Beam, AASHTO I-Beam, and Steel Plate Girder)</u>
<u>404-4A</u>	<u>Bridge Railing Level Equivalency [Deleted Sep. 2019]</u>
<u>404-4B</u>	<u>Bridge Railing Types [Rev. Sep. 2019]</u>
<u>404-4D</u>	<u>Typical Reinforcement in Bridge Sidewalk [Rev. Sep. 2016]</u>

# BRIDGE DECKS

## 404-1.0 STRIP METHOD

This chapter addresses the design of typical bridge decks using approximate methods of analysis commonly referred to as the equivalent strip method.

### 404-1.01 Description

For the design of the deck, *LRFD* 4.6.2 provides guidance on the use of an approximate method of analysis which is analogous to those described in past *LRFD Specifications*. The strip method is based on a structural simplification in which the deck is replaced by a parallel set of continuous beams running in the primary direction of the deck, supported by unyielding supports with the span lengths taken as the beam spacing. The vehicular loading is represented by a single line of wheel loads acting on this beam. The effective width of this beam is determined from *LRFD* Table 4.6.2.1.3-1.

In analyzing a transverse strip, the following procedure may be applied.

1. Determine the number of design lanes in accordance with *LRFD* 3.6.1.1.1.
2. Position the loads on the strip in accordance with the following:
  - a. only full axles of 32 kip (16 kip per wheel) are to be used;
  - b. the center-to-center distance of the wheels is 6 ft;
  - c. the center of the wheel does not become closer than 1 ft to the front face of the bridge railing or curb;
  - d. the axle is positioned to obtain extreme moments irrespective of the position of the design or traffic lanes; and
  - e. the wheel loads may be modeled as concentrated loads.

Calculate the maximum moments by considering dynamic load, multiple lane loads, and multiple-presence factors. For negative moment, see *LRFD* 4.6.2.1.6 for determination of the critical design section.

Live-load moments for the strip method may be obtained from *LRFD* Table A4-1 in lieu of calculating them.

### **404-1.02 Application of the Strip Method to a Composite Concrete Deck**

The strip method is appropriate for each type of supporting members, including AASHTO I-beams, spread box beams, steel beams, or concrete beams with T-shaped flanges. The following will apply to the application of the strip method of analysis.

1. Reinforcing Bars. It is not necessary to use the same bar size or spacing in the top and bottom of the bridge deck in the primary direction.
2. Shear Effects. By using the strip method, an 8-in. deck is designed for flexure, and shear effects can be neglected.

Figure [404-1A](#) illustrates the cross section of a typical beam-slab bridge with four beams spaced at 10 ft, a minimum-depth 8-in. concrete deck, and concrete railings. The deck-overhang width of 4.5 ft shown in Figure [404-1A](#) is intended only as an example. For criteria for deck-overhang-width limitations, see [Section 404-3.02](#). A dead load of 35 lb/ft<sup>2</sup> should be considered as a future wearing surface. The 36-ft width clear roadway accepts three 12-ft width travel lanes.

## **404-2.0 BRIDGE DECK DESIGN**

### **404-2.01 General Requirements [Rev. Apr. 2021]**

1. Load Modifier,  $\eta$ . Due to the conservative deck design produced by the strip method, the  $\eta$  value for a deck should be 1.
2. Thickness. The depth of a reinforced-concrete deck should not be less than 8 in.
3. Reinforcement. The bottom-reinforcement cover should be 1 in. The top-reinforcement cover should be 2½ in. The primary reinforcement should be on the outside and should be a #5 bar or larger.
4. Maximum Bar Spacing. The maximum bar spacing for primary, distribution, and temperature reinforcement is 8 in. This maximum bar spacing is used to control cracking.
5. Sacrificial Wearing Surface. The top ½ in. of the bridge deck should be considered sacrificial and should not be included in the structural design or as part of the composite section.
6. Class of Concrete. Class C concrete should be used.

7. Concrete Strength. The specified 28-day compressive strength of concrete shall not be less than 4 ksi.
8. Reinforcing-Steel Strength. The specified yield strength shall not be less than 60 ksi.
9. Epoxy Coating. All reinforcing steel in both top and bottom layers shall be epoxy coated for a bridge deck supported on beams.
10. Sealing. All exposed surfaces of concrete bridge railings should be sealed. Concrete bridge decks and approach slabs contain pozzolans that reduce permeability, so it is not necessary to seal these elements during initial construction. Sealers approved for use require the concrete to be completely dry and at least 28 days old prior to application. Therefore, the use of surface sealers on newly constructed bridge decks may delay opening to traffic.
11. Length of Reinforcing Steel. The maximum length of individual reinforcing bars shall be 40 ft. All reinforcing-bar splice lengths shall be shown on the plans.
12. Truss Bars. Truss bars shall not be used in a concrete deck supported on longitudinal stringers or beams.

#### **404-2.02 Dimensional Requirements for Concrete Deck**

##### **404-2.02(01) Screed Elevations for Cast-in-Place Concrete Deck**

Screed elevations shall be furnished to ensure that the gutters, or the edges of deck on a bridge without curbs, will be at the proper final elevations. Screed elevations are required for a beam or girder bridge, or a continuous reinforced-concrete slab bridge on a superelevation transition. Screed elevations, if not shown on the plans, shall be provided in tabular form on letter-size sheets.

This information shall include a diagram or table showing the elevations at the top of the concrete deck that are required before the concrete is placed. Elevations shall be shown for both curblines, or sidewalk gutter lines, and crown of the roadway, and above all beam or girder lines for the full length of the bridge, at all bearings, and at a maximum of 10-ft intervals. Elevations at mid-span are optional and need be shown only for short spans where the nearest 10-ft station may be some distance from the point of maximum deflection. Elevations at splice points are required.

A structure on a horizontal curve or in a superelevation transition will require additional elevation points to define the concrete-deck screed elevations. A sufficient number of screed elevations should be provided so that the contractor is not forced to interpolate or make assumptions in the field.

All elevation points should be furnished so as to allow the proper construction and finishing of the deck.

Figure [404-2A](#) illustrates the locations of screed elevations for a bridge deck with curbs and sidewalks. Screed elevations should be determined using the following criteria.

1. Screed lines should be established parallel to the skew and at approximately 10-ft intervals longitudinally within each span.
2. Screed elevations should be provided transversely at both copings and curb lines, at the centerline of each beam or flange tip for wide-flange beams, at the profile grade, crown line if not coincident with profile grade, and longitudinal construction joints.
3. Deflections should be computed on the basis of beam continuity at the time of deck placement.
4. Screed elevations should be rounded to the nearer 0.005 ft.

#### **404-2.02(02) Fillet Dimensions for Steel Beams or Girders [Rev. Aug. 2017]**

Figure [404-2B](#) illustrates fillet dimensions for steel beams or girders. The following will apply to the use of this Figure. Let dimension  $Y$  equal the total depth of the deck and fillet measured to the top of the web.

1. Control dimension  $Y$  should be established so that the theoretical bottom of deck clears the thickest and widest top flange plate by  $\frac{3}{4}$  in. to compensate for the allowed tolerance for beam camber, or so that the bottom reinforcement clears the field-splice plate by  $\frac{1}{2}$  in., whichever controls.
2. Dimension  $Y$  should be shown on deck details and rounded up to the nearer  $\frac{1}{8}$  in.
3. Control dimension  $Y$  should be calculated after the vertical curve, top-flange plate and splice-plate thickness and cross slope have been determined.



4. Dimension  $Y$  should be held constant at each beam or girder, where possible, throughout the structure.
5. Once established, dimension  $Y$  should be used for all elevation computations such as bridge seats, top-of-splice elevations, etc.

#### **404-2.02(03) Fillet Dimensions for Concrete Beams [Rev. Aug. 2017]**

Figure [404-2C](#) illustrates fillet dimensions for concrete beams. The basic requirement is to have the top of beam not higher than 3/4 in. below the bottom of slab at the center of the span. This allows the actual beam camber to exceed the calculated value up to 1 3/4 in. before the top of the beam can begin interfering with the deck steel.

Dimension  $A$  at the center of the span represents an input item required for prestressed-beam design software, and can be determined as follows:

$$A = 0.75 + e * (W / 2)$$

Where:

$W$  = beam top-flange width, in.

$e$  = cross slope (deck crown or superelevation rate)

The following should be considered:

1. The critical location of the 3/4-in. minimum fillet can occur at the center of each span.
2. The critical location of the 3/4-in. minimum fillet can also occur at the ends of the beam. For example, where either the residual beam camber is negative or where the residual beam camber allowance is less than the effect of the crest vertical curve.

#### **404-2.03 Forms for Concrete Deck [Rev. May 2013]**

Contractor options regarding the use of permanent and removable forms are provided in the INDOT *Standard Specifications*. The following selection and exception criteria apply to forms for a concrete deck.

#### **404-2.03(01) Precast Deck Panels [Rev. May 2013]**

Precast prestressed-concrete deck panels are no longer permitted as an alternative forming method.

#### **404-2.03(02) Permanent Metal Forms [Rev. May 2013, Rev. Aug. 2017]**

Metal stay-in-place forms may be used to support the deck between beams. Designers should assume the use of metal forms and account for dead load as described in Section 403-2.03.

Plan details should include only the minimum fillet dimensions. The design of permanent metal forms is the responsibility of the contractor. Recurring Special Provision (RSP) 702-B-304, Permanent Deck Form Angles, should be included in contracts with applicable bridge work until such time as the RSP is incorporated into the *Standard Specifications*.

#### **404-2.03(03) Removable Forms [Rev. May 2013]**

Removable forms should be used to support a deck overhang, and may be used to support the deck between girders.

#### **404-2.04 Skewed Deck**

Skew is defined as the angle between the end line of the deck and the normal drawn to the longitudinal centerline of the bridge at that point. The two end skews can be different. In addition to skew, the behavior of the superstructure is also affected by the span-length-to-bridge-width ratio. The *LRFD Specifications* implies that the effects of a skew angle not exceeding 25 deg can be neglected, but only for a bridge with a relatively large span-length-to-bridge-width ratio. Figure [404-2E](#) shows four combinations of skew angles 25 deg and 50 deg, and length-to-width ratios of 3:1 and 1:3. Both the 50-deg skew and the 1:3 length-to-width ratio are considered extreme values, but this often occurs where the deck constitutes the top slab of a culvert. It can be judged visually that both combinations with 25-deg skew may be orthogonally modeled for design.

*LRFD* C9.7.1.3 provides valid arguments supporting the limit of 25 deg concerning the direction of transverse reinforcement. It suggests that placing the transverse reinforcement parallel to a skew larger than 25 deg will create a structurally undesirable situation in which the deck is essentially un-reinforced in the direction of principal stresses. For a skew larger than 25 deg, the transverse reinforcement should be placed perpendicular to the beams.

The combination of 50-deg skew and length-to-width ratio of 1:3, as indicated in Figure [404-2E](#), produces a layout such that if the deck is a cast-in-place concrete slab without beams, the primary direction of structural action is one that is perpendicular to the end line of the deck. Because of the geometry of the layout, consideration should be given to placing the primary reinforcement in that direction and fanning it as appropriate in the side zone. With that arrangement, the secondary reinforcement can then be placed parallel to the skew, thus regaining the orthogonality of the reinforcement as appropriate for this layout.

#### **404-2.05 Shear Connectors and Vertical Ties**

Based on the *LRFD Specifications*, composite action between the deck and its supporting components should be ensured where it is technically feasible. The design of stud or channel shear connectors for steel sections and vertical ties for concrete beams or girders is discussed in the *LRFD Specifications*. Shear connectors and vertical ties between the deck and its supporting members should be designed for force effects calculated on the basis of full composite action, whether or not that composite action is considered in proportioning the primary members.

#### **404-2.06 Deck Joints**

##### **404-2.06(01) Longitudinal Open Joint**

A longitudinal open joint is not required in a concrete bridge deck with a width of 90 ft or less. If a deck of wider than 90 ft is required, a longitudinal open joint may be used, or a longitudinal closure pour not less than 2 ft wide, may be used. Transverse-steel lap splices should be located within the longitudinal closure pour. Such a joint should remain open as long as the construction schedule permits transverse shrinkage of the deck concrete to occur. The bearings supporting a superstructure that has a deck width exceeding 50 ft should be capable of allowing movement in the transverse direction due to temperature and shrinkage movements.

##### **404-2.06(02) Construction Joint [Rev. Oct. 2022]**

A construction joint creates planes of weakness that frequently cause maintenance problems. The use of deck construction joints is discouraged and their number should be minimized. The contractor, however, has the option of requesting additional joints if the number or locations shown on the plans are too restrictive.

1. Longitudinal Construction Joint.

- a. Usage. Construction joints need not be used on a deck having a constant cross section where the pour width is less than 65 ft. This applies if the constant cross section is rotated along the length of the deck, and the angular breaks within the cross section remain constant. Where the angular breaks within the cross section are variable, as in the runout length of a superelevation transition, a construction joint should be provided. Longitudinal construction joints will also be required on a deck with phased construction.
- b. Location. The following applies.
  - (1) Where a construction joint is required, it should preferably be placed along the edge of a traffic lane. A joint which is close to a curb may be placed up to 1 ft outside the traffic lane.
  - (2) A joint should not be located over a beam flange, unless phased construction dictates otherwise.
  - (3) The joint locations should limit the maximum pour width to 50 to 55 ft.
- c. Transverse Reinforcing Steel. The lengths of transverse reinforcing bars should be selected so bar laps do not appear within a longitudinal construction joint.

2. Transverse Construction Joint.

- a. Steel Beam or Girder Structure. Concrete may be placed continuously on a deck requiring less than 260 yd<sup>3</sup> of concrete. A bridge deck that is poured integrally with the end bents may usually be placed with one pour.

For a longer structure that exceeds the pour-volume limitation of 260 yd<sup>3</sup>, an alternative may be considered in which the deck length is subdivided into segments near the points of final dead load contraflexure, with segments in positive flexure placed first and those in negative flexure last.

- b. **Prestressed-Concrete Structure.** A prestressed-concrete beam bridge made continuous for live load only should be treated such that transverse construction joints located 2.5 ft on each side of the pier centerline should be shown on the plans. The short deck segment and diaphragm over the support provide continuity for live load in the superstructure after the previously-poured center regions of the deck have been poured as simple-span loads. This pour sequence will prevent tensile loading of the diaphragm and deck concrete in the negative moment regions while the concrete is beginning to set, which will eliminate the risk of flexural cracking during the deck pour.

A continuous deck pour should be allowed at the Contractor's option and noted on the plans if the following criteria is met:

- (1) The span containing the largest volume of concrete, including the pier diaphragm at the beginning of the span, can be placed within 3 ½ hours, and
- (2) the pour rate is less than 80 cubic yards for per hour.

Notes similar to those shown in Figure 404-2F should be shown on the plans to indicate the calculated minimum required pour rate, if less than 80 cubic yards per hour. If the calculated required pour rate is 80 cubic yards per hour or higher, the optional continuous pour note should not be included on the plans.

If the Contractor requests a continuous pour in their pour sequence submittal, the Designer should verify that the Contractor's proposed pour rate meets or exceeds the calculated minimum required pour rate shown on the design plans and meets the criteria for a continuous deck pour outlined above. Contractor requested continuous pours using pour rates above 80 cubic yards per hour will require approval by INDOT Construction in addition to the approval of the Designer.

The advantages of a continuous deck pour include shorter construction duration, elimination of transverse construction joints, and lower construction costs.

- c. **Location.** Where used, transverse joints should be placed parallel to the transverse reinforcing steel.
3. **Diaphragms.** For a prestressed-concrete beam bridge with a cast-in-place deck, the *LRFD Specifications* requires diaphragms at the bearing points. These diaphragms should be poured at the same time as the deck.

4. Steel Structure. A steel superstructure with short end spans relative to the adjacent interior span can be subject to uplift at the end bent during the deck pour. This can occur where the far end span is 60% or less of the adjacent interior span. Where this occurs, and if objectionable, a required transverse construction joint should be placed in the far end span and a terminal portion of the end span poured first to counterbalance the uplift. The deck may then be poured from the opposite end forward in the usual manner. The effects of the deck pouring sequence should be investigated, including its effect on camber, screed elevations, and stresses.
5. End Bents. The simply-supported end of a short end span can experience uplift under live load. A counterweight may be poured near the end of the span to counterbalance the uplift, or positive hold-down devices may be installed. The details of counterweights or tie-downs should be shown on the plans. Integral end bent concrete should be considered as a counterweight.
6. Pour Diagrams. Figure [404-2F](#) illustrates the pour diagrams for a continuous, prestressed-concrete beam structure. The plans should include note(s) similar to that shown on Figure [404-2F](#), revised as necessary. Figure [404-2G](#) illustrates the pour diagrams for a continuous steel beam or girder structure.

#### **404-2.06(03) Expansion Joints [Rev. May 2013, Apr. 2021]**

Indiana is considered to have a cold climate for the purpose of expansion-joint design. See *LRFD* Table 3.12.2.1-1 for temperature-range values to use to calculate joint movements due to temperature. The joint opening width must remain between 1 inch and 4 inches using the strength load case maximum movement range, per *LRFD* 14.5.3.2.

The following provides criteria for the use of expansion joints.

1. Compression Seal Type BS. This type of seal has not performed well in the past and should not be used as an expansion joint.
2. Expansion Joint Sealing System. This joint may be used on a bridge to be rehabilitated. The maximum joint opening should not exceed 3 inches at any point in the anticipated movement range, and the maximum joint movement should not exceed 100% of the joint setting width during thermal contraction. This type of joint is recommended to only be used for expansion lengths of 150 ft or less.

3. Pre-compressed Foam Type PCF. This joint may be used on a bridge to be rehabilitated. This expansion joint may be used for any joint opening width allowed per *LRFD* 14.5.3.2. The plans should designate the expansion length, anticipated movement range, and the joint mean opening size at 60°F. Figure [404-2J](#), Pre-Compressed Foam Joint, illustrates typical details for this type of joint.

4. Strip Seal Type SS.

- a. Details. The details are shown on the INDOT *Standard Drawings*.
- b. Expansion Length. This expansion joint may be used for an expansion length up to 400 ft. The plans should designate the expansion length for the contractor's use of the Joint Setting Table shown in the INDOT *Standard Drawings*, which is dependent upon the ambient temperature while the deck is being poured (see item 3.c.). Therefore, the expansion length should be computed in feet for each joint location. This value should be shown on the General Plan at each joint location.
- c. Width of Opening. This joint is designed by the manufacturer to accommodate a maximum of 4 in. of movement. The width of the joint opening at installation depends upon the ambient temperature while the deck is being poured, and the expansion length of the structure at the joint location.

This joint-opening width is shown in the Joint Setting Table in the *Standard Drawings* for a range of ambient temperatures and expansion lengths.

5. Modular Type M.

- a. Details. Figures [404-2H](#) and [404-2 I](#) illustrate typical schematic details for this joint.
- b. Expansion Length. This joint is used only where the anticipated expansion movement exceeds the length that can be accommodated by an expansion joint type SS. For an expansion movement of greater than 4 in., a modular expansion joint is recommended.
- c. Splices. Where practical, a modular joint should be full length with no field splices across the roadway width. If a field splice is required for traffic continuity, the support beams should be spaced at a maximum of 2 ft. See Figure [404-2 I](#), Section A-A

- d. Elastomeric Seal. The elastomeric seal will be one piece across the roadway width, regardless of traffic continuity considerations and the presence of a field splice in the steel armor. See the INDOT *Standard Specifications* for more information.

#### **404-2.07 Drainage Outlets**

Chapter [203](#) discusses the hydrological and hydraulic analyses for a bridge deck. This includes the methodologies for calculating the flow of water on the bridge and for determining the necessary spacing of drainage outlets to prevent the spread of water on the deck from exceeding the acceptable limits. Additional design criteria and details of drainage outlets on a bridge deck and closed drainage systems are also provided in Chapter [203](#).

To make deck-drainage facilities operationally effective and insensitive to blocking by debris or ice, they should be large in size and few in number as suggested by *LRFD* 2.6.6. Where practical, the use of roadway drain type SQ is preferred to roadway drain type OS because it does not accumulate debris as easily. Locations of roadway drains types SQ and OS should be checked to verify that they clear the top flange of the outside beam or girder. The large drainage facility, however, creates a discontinuity in the deck which should be considered. A deck acting monolithically is not too sensitive to this, and for a drainage facility whose maximum dimension does not exceed 1.33 ft, no additional deck reinforcement is required. If the facility interrupts a main bar of a steel-grid deck, the facility should be framed, and the frame should support the interrupted element.

### **404-3.0 MISCELLANEOUS STRUCTURAL ITEMS**

#### **404-3.01 Longitudinal Edge Beam**

The *LRFD Specifications* does not require the presence of side longitudinal edge beams but permits the utilization of solid concrete barriers as structural parts of the deck or deck system. Railing-type barriers consisting of wood, steel, or concrete beams and posts offer only negligible structural contribution, so the usable advantages relate exclusively to solid-concrete wall and safety-shape types. However, the structural contribution of concrete appurtenances to the deck should not be considered for the strength or extreme-event limit states per *LRFD* 9.5.1, because other than immediate repair of an accidentally-damaged railing will result in temporary, yet unacceptable, understrength of the bridge. The structural contribution of the concrete railing should only be considered for the service or fatigue-and-fracture limit states. If the bridge railing is structurally discontinuous, i.e., beam and post, a longitudinal edge beam may be required.



### **404-3.02 Deck Overhang**

Additional top reinforcement to resist the collision load transmitted through a railing may be required in a large overhang. The width in inches of the primary strip for a cast-in-place concrete deck is  $45 + 10X$ , where  $X$  is the distance from load to point of support, as described in *LRFD* 4.6.2.1.3.

#### **404-3.02(01) Design Methods**

Bridge-deck overhang-width restrictions apply only to a multi-girder type superstructure, as follows:

1. Overhang width is defined as the distance from the centerline of the exterior beam to the face of the deck coping. The suggested overhang-width criteria are as follows:
  - a. not more than 0.45 times the beam spacing; and
  - b. not more than 5 ft.
2. The overhang width for a prestressed-concrete box-beam bridge should not exceed 2 ft from the edge of the outside beam.

If deck drains type OS are to be used on a beam or girder structure, the minimum overhang width should be 1.75 ft plus one-half the flange width. The deck-drain locations should always be checked to verify that the drains clear the top flange.

#### **404-3.02(02) Deck Overhang**

For curved deck copings with reference to segmentally spaced straight beams, the above limits on maximum width should be interpreted as the average width within a span. A  $\frac{3}{4}$ -in., half-round drip bead should be placed 6 in. in from the edge of the coping. The depth of the outside coping should be a minimum of 8 in. Once a coping depth is selected, it should be maintained over the full length of the superstructure along that coping.

Because of the geometry of construction jacks used to support an overhang, the bottom of the coping should be made flush with the underside of the top flange of a steel structure. The bottom of the coping may be sloped to match the slope of the top of deck, or at least be made level.

The depth of the outside coping for a superelevated deck should be greater than the minimum 8-in. deck thickness. The coping depth will be dimension  $Y$  minus the superelevation rate times half the flange width at the low side, or, plus the superelevation rate times half the flange width at the high side. See Figure [404-3A](#). The slope of the bottom of the overhang will then be parallel to the top of the deck. The coping depth selected at each coping should be maintained over the full length of the superstructure along that coping.

For a curved-deck layout, the distance from the centerline of the girder to the face of the coping along both copings should be shown in a coping offset diagram. These offsets should be shown at 10-ft intervals measured along the centerline of the girder. The offset at all break points of the girders should also be shown.

For the design of a deck overhang with a cantilever not exceeding 6 ft from the centerline of the exterior girder to the face of a structurally-continuous concrete barrier, *LRFD* 3.6.1.3.4 permits replacement of concentrated wheel loads with a line load of 1 kip/ft intensity, located 1 ft from the face of the railing. Thus, an effective longitudinal distribution of wheel loads and an ease of design is realized. If other railings are used, the strip method may be applied.

The design approach, as described in *LRFD* CA13-4.2, is that the vehicular-collision loads are not specified and that the overhangs are designed for the maximum inelastic force effects which can be generated and transmitted by the railing resisting the vehicular impact. *LRFD* CA13.4.2 states, *the crash testing program is oriented toward survival and not necessarily the identification of the ultimate strength of the railing system. This could produce a railing system that is significantly over-designed leading to the possibility that the deck overhang is also over-designed.* The computed railing capacity will be far greater than the required capacity. Designing the overhang for full railing capacity will result in an extremely conservative section that is not in accordance with observed field behaviors. Based on observations of impacted bridge railings, an overhang designed according to previous AASHTO bridge-design specifications shows the desired behavior that the overhang does not fail if a railing failure occurs due to a collision. Accordingly, the overhang should be designed for a collision force of 25% greater than the required capacity, which results in a design approximating present satisfactory practice.

There is a normal concentration of force effects in the end zone of the railing, and the deck may need strengthening therein. An extension of the end beam (hidden or otherwise) to the railing may be necessary to strengthen the overhang. *LRFD* Equations A13.3.1-3 and A13.3.1-4 can be used to check the railing strength for impact near the end of the railing and to compute the magnitude of the loads to be transferred to the deck overhang and the need for extra top-deck reinforcement.

The deck overhang is a cantilever slab that supports the barrier railing and can be designed independently of the deck spans. Sufficient negative moment reinforcement must be provided for the design conditions. The reinforcement must be adequately anchored into the first deck span.

Two limit states are used for design, as described in *LRFD* A13.4.1 and A13.2. Strength I and Extreme Event II requires the deck overhang to be designed for the vertical forces specified in the Extreme Event limit state. However, for a continuous concrete railing, this never controls. The strength-limit state considers vertical gravity loads and will only govern the design if the cantilever span is very large. The extreme-event-limit state considers horizontal forces caused by the collision of a vehicle with the railing, and will usually govern the deck-overhang design.

### **404-3.03 Transverse Edge Beam**

*LRFD* 9.7.1.4 requires the end zone of the deck to have adequate resistance against the increase of force effects due to the structural discontinuity at the deck joint. This additional resistance is provided by the diaphragms that are commonly used for an integral end bent superstructure. In the absence of diaphragms, a transverse edge beam, hidden or exposed, is acceptable. The beam should be designed as described in *LRFD* 4.6.2.1.4.

Typical configurations of transverse edge beams are shown in Figures [404-3B](#) through [404-3F](#) for various types of superstructures. For the positive-moment reinforcement, crankshaft bars should be considered (see Figure [404-3F](#)) instead of straight bars between beams, unless the requirements for tension development length provided in *LRFD* 5.11.2.1 can be satisfied by placement of straight bars between beams. Crankshaft bars that extend from coping to coping can be difficult to handle and install. They should preferably consist of two bars that are lapped above the beam at the centerline of the roadway or above a beam that is adjacent to the centerline of roadway. As shown in Figure [404-3F](#), past designs have included a 45-deg fillet along the inside face of the edge beam. The 45-deg fillet is available as an option for additional resistance to force effects or assurance of a smooth flow of stress at a location where there is a significant change in section depth.

For a deck with no skew or with a skew angle not exceeding 25 deg, the transverse deck reinforcement should be placed parallel to the skew, but for a greater skew angle, it should be placed perpendicular to the supporting beams. For a greater skew angle, the transverse deck reinforcement should be terminated at points encompassed by the edge beam. Hence, it should not be counted as part of the resistance. For a skew angle not exceeding 25 deg, the top transverse deck steel may be included in the design of the edge beam. For a skew angle exceeding 25 deg, the negative-moment reinforcement in the edge beam should be placed below the top longitudinal deck steel.

Although *LRFD* 4.6.2.4c specifies a strip width for positive and negative moment for the edge member, it is acceptable to use the thickened edge beam or diaphragm width. The edge beam should be assumed to carry one truck axle for each vehicle considered.

#### **404-3.04 Bridge Railing**

[Section 404-4.0](#) discusses the types of bridge railings that may be used. [Section 404-3.04](#) discusses the structural evaluation of concrete or steel railings at the copings of a bridge.

A concrete barrier railing is built monolithically and continuous with no contraction joints at either mid-span or over the interior supports. Full-depth open joints should be provided only between the end of the structure and the reinforced-concrete bridge approach and at expansion joints on a structure composed of two or more units.

The INDOT *Standard Drawings* illustrate concrete railings with the preferred arrangement of reinforcement. This arrangement of railing reinforcement is a departure from traditional design in which the railing has essentially been considered as a vertical flexural element and the longitudinal reinforcement, as secondary, being compatible with frequent relief joints. The uninterrupted railing becomes a primary longitudinal flexural element, playing a significant role in resisting both gravitational and impact loading. The longitudinal steel is appropriate for this role, in addition to controlling shrinkage-caused cracking.

Stirrups connecting continuously-placed, whether or not structurally continuous, concrete railing, curb, parapet, sidewalk, or median to the concrete deck should be determined assuming full composite action at the interface, in accordance with *LRFD* 5.8.4.

#### **404-4.0 BRIDGE RAILING [Rev. Sep. 2019]**

All bridges require bridge railing. Bridge-length culverts should have guardrail or bridge railing. Roadways elevated by retaining walls require bridge railing or guardrail for the entire length of the retaining wall. Mechanically stabilized earth (MSE) retaining walls require a moment slab in conjunction with the bridge railing.

INDOT standard bridge railing and concrete bridge railing transition details are shown on INDOT *Standards Drawings* series 706. Figures [404-4B](#) and [404-4C](#) summarizes bridge railing by test level and includes associated bridge railing transition, guardrail transition, and pay items.

#### **404-4.01 Bridge Railing Criteria [Rev. Sep. 2019]**

MASH Implementation. Per the AASHTO-FHWA Joint Implementation Agreement, all new and replacement installations of bridge railing on the National Highway System (NHS), with contract letting date after December 31, 2019, must be evaluated using the AASHTO *Manual for Assessing Safety Hardware* 2016 (MASH) criteria.

FHWA Policy. All new or replacement bridge railing on the NHS must meet MASH crash-test criteria.

New and Replacement Bridge Railing, INDOT. All new and replacement bridge railing on an INDOT bridge should meet MASH crash test criteria, both on and off the NHS. Exceptions should be rare. Exceptions will be considered on a project-by-project basis at the discretion of the Bridge Design Division off the NHS and in cooperation with FHWA on the NHS.

New and Replacement Bridge Railing, LPA. All new and replacement bridge railing on a local agency bridge should meet MASH crash test criteria, both on and off the NHS. On a locally-owned bridge that is not on the NHS, MASH-compliant railing is encouraged, but not required. NCHRP 350-compliant railing may be used at the bridge owner's discretion. The decision to use an NCHRP 350-compliant railing and supporting documentation should be included in the project file.

Existing Bridge Railing. Upgrading existing bridge railing should be considered on bridge preventative maintenance projects where such work is cost-effective. See Chapter 412. In general, existing NCHRP 350-compliant bridge railing in good condition may remain in place.

#### **404-4.02 Test Level Selection [Rev. Sep. 2019]**

This section provides guidance on selecting bridge railing test level. The guidance in this section is intended for use on INDOT and LPA bridges. Exceptions are discussed in Section 404-4.02(06).

MASH uses the same six Test Levels established under the previous crash testing criteria, National Cooperative Highway Research Program Report 350 (NCHRP 350) *Recommended Procedures for the Safety Performance Evaluation of Highway Features*.

FHWA Policy. All new or replacement railing on the NHS must meet Test Level 3 (TL-3) crash-test criteria at a minimum.

If ...	And...	The minimum (MASH) test level is	Applicable INDOT Bridge Standards	Notes
Bridge carries interstate mainline or system interchange ramp traffic		TL-5	Type FT Type TF-2	Determine the minimum test level. Use the evaluation criteria to below to assess if a higher test level is appropriate.
The design speed is $\geq$ 50 mph		TL-3	Type FC Type PF-1 Type PS-1	
The design speed is $\leq$ 45 mph	The route is on the NHS	TL-3	Type FC Type PF-1 Type PS-1	A higher test level railing may be used to satisfy lower test level requirements.
The design speed is $\leq$ 45 mph	The route is not on the NHS	TL-2	Type TX (LPA only)	

Consider the following evaluation criteria when selecting the bridge railing test level.

- Highway design speed. Use the greater of posted speed or the design speed to establish the minimum test level. A lower test level may be acceptable for low volume roadways.
- Average annual daily traffic and percent trucks. Higher traffic volumes have inherently higher likelihood of crashes. High truck volumes (truck DDHV is 250 vph) are a consideration for selecting a higher test level.
- Highway geometry (grades and horizontal curvature). Steep grades (sustained longitudinal grades greater than 5%) and sharp curves (horizontal curve radius less than 1,500 ft) are considerations for using a higher test level.
- Type of land use below deck. Roadways under are higher risk than waterways under due to the risk of multiple injuries.
- In-service performance. Unsatisfactory in service performance is a consideration for selecting a higher test level.

#### **404-4.02(01) TL-2 [Rev. Sep. 2019]**

The AASHTO *LRFD Bridge Design Specifications* describes TL-2 bridge railing as generally acceptable for most local and collector roadways with favorable site conditions and small numbers of heavy vehicles.

Bridges with speeds of 45 mph and below should have railings that meet TL-2 criteria or higher.

Bridges with low traffic volumes are inherently associated with lower risk. TL-2 railings on low volume roads with design speeds greater than 45 mph will be considered on a project-by-project basis.

Bridges on the NHS must have railings that meet TL-3 criteria or higher, regardless of design speed.

INDOT uses TL-3 railing for these applications. Bridge Railing Type TX may be used for LPA bridges only.

#### **404-4.02(02) TL-3 [Rev. Sep. 2019]**

A TL-3 bridge railing is generally acceptable for applications on typical high-speed high-volume roadways. Bridges with speeds of 50 mph and above should have railings that meet TL-3 criteria or higher.

Bridges with low traffic volumes inherently are associated with lower risk. TL-3 railings on very low volume roads with design speeds greater than 50 mph will be considered on a project-by-project basis.

Bridges on the NHS must have railing that meets TL-3 or higher.

Where any of the conditions listed below exist, a higher test level should be considered.

1. TL-2 criteria are not met;
2. Sustained longitudinal grades greater than 5%;
3. Horizontal curve radius less than 1,500 ft;
4. Truck DDHV is 250 vph or greater; or
5. High hazard environment below the bridge, such as a densely populated area or high-volume roadway.
6. In-service performance history that indicates an existing TL-3 bridge railing is not meeting the site-specific needs.

INDOT uses Bridge Railing Types FC for these applications. Where pedestrian or open railing is desired, INDOT uses Bridge Railing Types PF-1 (deck-mounted) and PS-1 (sidewalk-mounted) for these applications.

#### **404-4.02(03) TL-4 [Rev. Sep. 2019]**

The AASHTO *LRFD Bridge Design Specifications* describes TL-4 as taken to be generally acceptable for the majority of applications on high speed highways, freeways, expressways, and Interstate highways with a mixture of trucks and heavy vehicles. Initial testing of NCHRP 350 compliant TL-4 bridge railing to MASH criteria resulted in a recommendation to increase in the minimum railing height from 32 in. to 36 in.

Considering the minimal increase in cost, the INDOT uses TL-5 for these applications.

#### **404-4.02(04) TL-5 [Rev. Sep. 2019]**

The AASHTO *LRFD Bridge Design Specifications* describes TL-5 as taken to be generally acceptable for the same applications as TL-4 and where large trucks make up a significant portion of the average daily traffic or when unfavorable site conditions justify a higher level of rail resistance.

A TL-5 bridge railing should be used on all interstate bridges carrying mainline interstate routes and system interchange ramps or where the considerations for a higher test level noted in TL-3 exist.

INDOT uses Bridge Railing Types FT and TF-2 for these applications.

#### **404-4.02(05) TL-6 [Rev. Sep. 2019]**

The AASHTO *LRFD Bridge Design Specifications* describes TL-6 taken to be generally acceptable for applications where tanker-type trucks or similar high center of gravity vehicles are anticipated, particularly along with unfavorable site conditions.

INDOT does not have a TL-6 bridge railing standard. The need to use a TL-6 bridge railing should be coordinated with the Bridge Design Division on a project-by-project basis.



#### **404-4.02(06) Test Level Selection Exceptions [Rev. Sep. 2019]**

INDOT Bridge. Designers should coordinate bridge railing test level exception requests with the Bridge Design Division. A formal design exception is not required on non-NHS routes or on NHS routes where at least a TL-3 railing is provided. The request should include project information, scope of work, and a brief discussion of the factors below.

- Test level required and test level proposed.
- Speed of traffic in the bridge location.
- Resistance to impact of the existing railing. Has the railing been crash tested?
- Whether the bridge ends are intersections protected by stop signs or stop lights.
- Whether the geometry is straight into, along, and out of the bridge.
- Whether traffic on the bridge is one-way or two-way.
- Crash history on the bridge, including damages to and repairs of the railing.
- Whether the bridge crosses a roadway or waterway.
- Whether the required railing will further narrow an already narrow lane width.
- Whether the required will reduce sight distance to an unacceptable level due to increased height.
- Any additional pertinent information.

LPA Bridge. Exceptions are not required for bridge railing test level on a locally-owned, non-NHS bridge as the test level is at the discretion of the bridge owner. Designers should coordinate test level selection with the LPA. Documentation to support the selected test level should be included in the project file.

#### **404-4.03 Bridge Railing Design Considerations**

##### **404-4.03(01) Superelevated Bridge Deck**

The INDOT *Standard Drawings* illustrate the orientation of concrete F-shaped bridge railing with the bridge deck surface for a bridge on a superelevated roadway section.

##### **404-4.03(02) Barrier Delineators**

Barrier delineators are to be placed on each bridge railing. However, barrier delineators are not to be placed on a bridge railing at the coping side of a sidewalk. The location of the delineators along the bridge railing should be as described in the INDOT *Standard Specifications*. Barrier delineators should be placed on each roadway face of a bridge-railing transition.

#### **404-4.04 Bridge Railing Transition [Rev. Sep. 2019]**

A steel element roadside barrier (guardrail) deflects upon impact, but a rigid bridge railing normally will not. Therefore, where a steel element roadside barrier approaches a rigid bridge railing, a transition is necessary to gradually stiffen the steel element roadside barrier as it approaches and connects to the bridge railing. The following will apply to such transitions.

Bridge railing transition details are shown on INDOT *Standards Drawings* series 706. MASH-compliant MGS guardrail transition details are shown on the INDOT *Standard Drawings* series 601-MGSA. Guardrail transition type TGB transition may be appropriate to address site-specific constraints. Coordination with the Standards and Policy Division is required.

##### **404-4.04(01) Type [Rev. May 2017, Aug. 2017, Sep. 2019]**

The bridge railing and guardrail transitions for each bridge railing type are shown in Figure [404-4C](#). Most systems include both a guardrail transition and a bridge railing transition. Bridge railing transition details are shown on INDOT *Standards Drawings* series 706. Guardrail transition details are shown on the INDOT *Standard Drawings* series 601.

A transition is typically used at each location. Where an intersecting road or driveway prevents the placement of a proper guardrail transition and end treatment, a curved W-beam guardrail connector terminal system or curved W-beam guardrail system may be used. Details are shown on INDOT *Standard Drawings* series 601-CWGS. This system is placed at 27 ¾ in. to the top of rail and should not be raised to 31 in. Until a MASH-compliant curved system There should be space to place at least 25 ft of roadside barrier between and the beginning of a guardrail transition type TGB.

##### **404-4.04(02) Location [Rev. May 2017]**

The following will apply to the location of a bridge-railing transition.

1. Reinforced Concrete Bridge Approach (RCBA). The ideal treatment is to locate a bridge-railing transition along the RCBA. This will keep the deck drainage not collected in the deck drains from flowing down the spill slopes at the bridge corners, which can cause erosion at the end bents. Placing the transition on the RCBA will require moving the connection between the bridge-railing transition and the guardrail transition a sufficient distance from the wing to allow placement of the posts required with the transition.

2. Bridge Corner. A transition should be used at each bridge corner for each bridge railing type, including the trailing end of a bridge railing on a one-way roadway, such as a ramp, or one roadway of a divided highway.
3. Bridge Deck. If it is necessary to locate the transition on the bridge deck, the wings should be extended laterally a sufficient distance to provide a minimum clearance of 6 in. between the roadside face of the wing and the backs of the guardrail transition posts.
4. Intersecting Road or Drive. The presence of an intersecting road or drive close to the bridge can complicate the location of the transition. Where practical, the intersecting road or drive should be relocated to allow placement of the bridge railing transition on the RCBA. Where this is not practical, the consideration of the bridge railing transition should be determined in the order of preference as follows:
  - a. it should be placed on the bridge deck if the structure has integral or semi-integral end bents;
  - b. a modified version of the bridge railing transition that may be used with a standard guardrail transition should be placed on the RCBA;
  - c. a modified version of the bridge railing transition that may be used with a standard guardrail transition should be placed on the bridge deck if the structure has integral end bents;
  - d. an impact attenuator should be used at the end of the bridge railing; or

Coordination with the Standards and Policy Division is required to utilize a modified versions of bridge railing transition. Details of the modified transition should be included on the plans.

5. Expansion Joint. The bridge-railing transition may not be located on the bridge deck if a deck expansion joint is located between the bridge deck and the mudwall.
6. Alternative Location. In a situation with severe space restrictions, transition location or design modifications which do not comply with the above criteria may be necessary.

#### **404-4.05 Pedestrian Fence [Rev. Sep. 2019]**

##### **404-4.05(01) Considerations for Use [Rev. Sep. 2019]**

Where a pedestrian or bicycle traffic is anticipated on a bridge, INDOT considers the use of pedestrian fence (protective screening) on a project-by-project basis and in conjunction with the Bridge Aesthetics Policy.

Where pedestrians and bicyclists are prohibited, such as an interstate or freeway, pedestrian fence should not be used.

The AASHTO *Roadside Design Guide* includes general considerations where protective screening at overpasses may be appropriate, including, but not limited to:

- Existing structures where incidents of objects being dropped or thrown from the overpass have occurred and where increased surveillance, warning signs, or apprehension of a few individuals has not effectively alleviated the problem;
- An overpass near a school, playground, or other location where it would be expected that the overpass would be frequently used by children not accompanied by adults;
- All overpasses in urban areas used exclusively by pedestrians and not easily kept under surveillance by law enforcement personnel;
- Overpasses with walkways where experience on similar structures indicates a need for such screens; and
- Overpasses where private property that is subject to damage, such as buildings or power stations, is located beneath the structure

Project specific considerations include:

- Design speed;
- Vehicular traffic volume;
- Pedestrian traffic volume;
- Crash history;
- Geometric impacts (for example, sight distance);
- Practicality of providing proper end treatments;
- Construction costs; and
- Local preference.

#### **404-4.05(02) Placement and Traffic Separation [Rev. Sep. 2019]**

Where pedestrian fence is used on a high-speed facility (50 mph or higher), the pedestrian/bikeway area must be separated from adjacent traffic with a traffic or combination (traffic/pedestrian) railing.

Where pedestrian fence is used on a low-speed facility (45 mph or lower), the pedestrian/bikeway area must be either be raised (for example, sidewalk or multi-use path) or separated from adjacent traffic by a traffic or combination (traffic/pedestrian) railing.

#### **404-4.05(03) Details [Rev. Sep. 2019]**

INDOT *Standard Drawings* series 706-BRPF contains pedestrian fence details for use with an F-shaped concrete bridge railing. The details utilize chain link fabric with a 2-in. by 2-in. opening. Requests to use non-standard details should be coordinated with the Bridge Design Division.

#### **404-4.06 Bicycle Railing**

If bicyclists are permitted to use a bridge, a bicycle railing may be warranted. The following will apply.

##### **404-4.06(01) Bicycle Path**

This is defined as a bikeway physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right of way or within an independent right of way. Each bridge which is a part of a bicycle path will require bicycle railing of 42-in. minimum height.

##### **404-4.06(02) Other Facility**

The need for combination vehicular bridge railing/bicycle railing to protect bicyclists should be considered on a site-by-site basis. Additional considerations to be made are as follows:

1. motor-vehicular traffic design speed;
2. motor-vehicular traffic volume;
3. bicycle traffic volume;
4. accident history;
5. geometric impacts (e.g., sight distance);
6. practicality of providing proper end treatments;
7. construction costs; and
8. local preference.

## **404-5.0 BRIDGE APPURTENANCES**

### **404-5.01 Outside Curbs**

Except for the base of a two-tubed curb-mounted bridge railing, outside curbs are only used on a bridge in conjunction with a sidewalk. The typical curb height is 8 in. where used in conjunction with a sidewalk, unless a vehicular bridge railing is placed between the roadway and the sidewalk. For this situation, the roadway and sidewalk will be at the same elevation.

### **404-5.02 Center Curb or Median Barrier**

A center curb or a median barrier on a structure should be a continuation of the curb or median barrier on the approaching roadway. The use of a roughened construction joint between the bridge deck and the center curb or median barrier should be provided. Curb or median barrier should be anchored to the bridge deck with #5 bars spaced at 8 in. maximum.

### **404-5.03 Lighting**

The Highway Management Division's Office of Traffic is responsible for determining warrants for highway lighting. The district traffic office can offer input regarding lighting requirements for an INDOT project in an urban area. Warrants for, and the design of, lighting for a local-public-agency project should be determined by the designer and the LPA. Section 502-4.02(07) discusses warrants for lighting on a bridge structure. Where lighting will be provided on an INDOT bridge, the Traffic Review Team will determine the pole size and spacing and submit this information to the project manager. The INDOT *Standard Drawings* provide the details for attaching standard luminaire supports to a concrete bridge railing.

### **404-5.04 Traffic Signal**

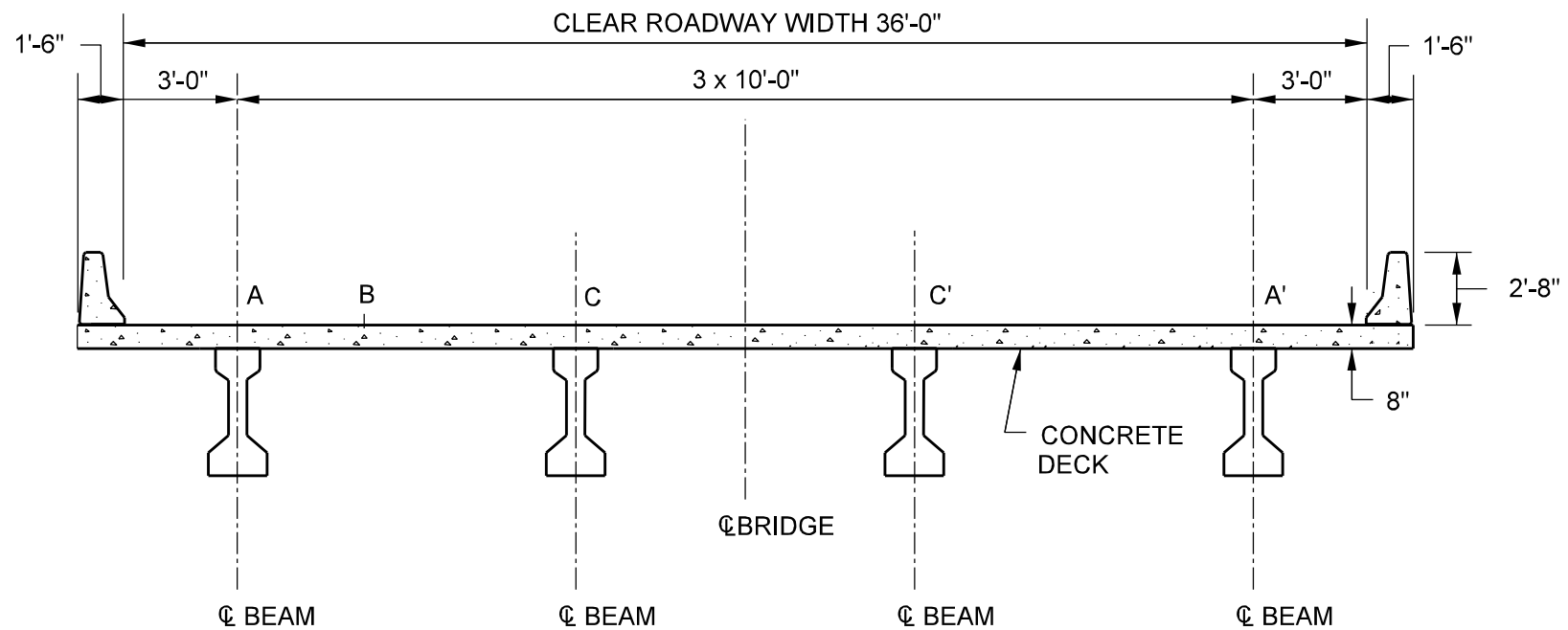
A traffic signal can currently be, or be proposed to be, located near a bridge. Conduits may be provided across the bridge for the electrical service. The following will apply.

1. Bridge Location. For each bridge located within an urbanized area, or within 2 mi of its boundary, the designer should contact the Office of Traffic. The Office will determine the need for conduits across the bridge.
2. Junction Boxes. Where conduits will be provided, junction boxes should be located at approximately 250-ft intervals. The Office of Traffic will provide details for the junction boxes for incorporation into the plans.

#### **404-5.05 Utilities Located on an INDOT Bridge**

The Office of Utilities and Railroads' Utilities Team and the designer should work together to determine the proper accommodation of utilities across a highway structure. Chapter 104 describes the policy regarding the attachment of utility lines to a bridge. Chapter 104 also discusses procedures regarding permit applications and cost reimbursement. For approved utility attachments to a bridge, the following procedure applies.

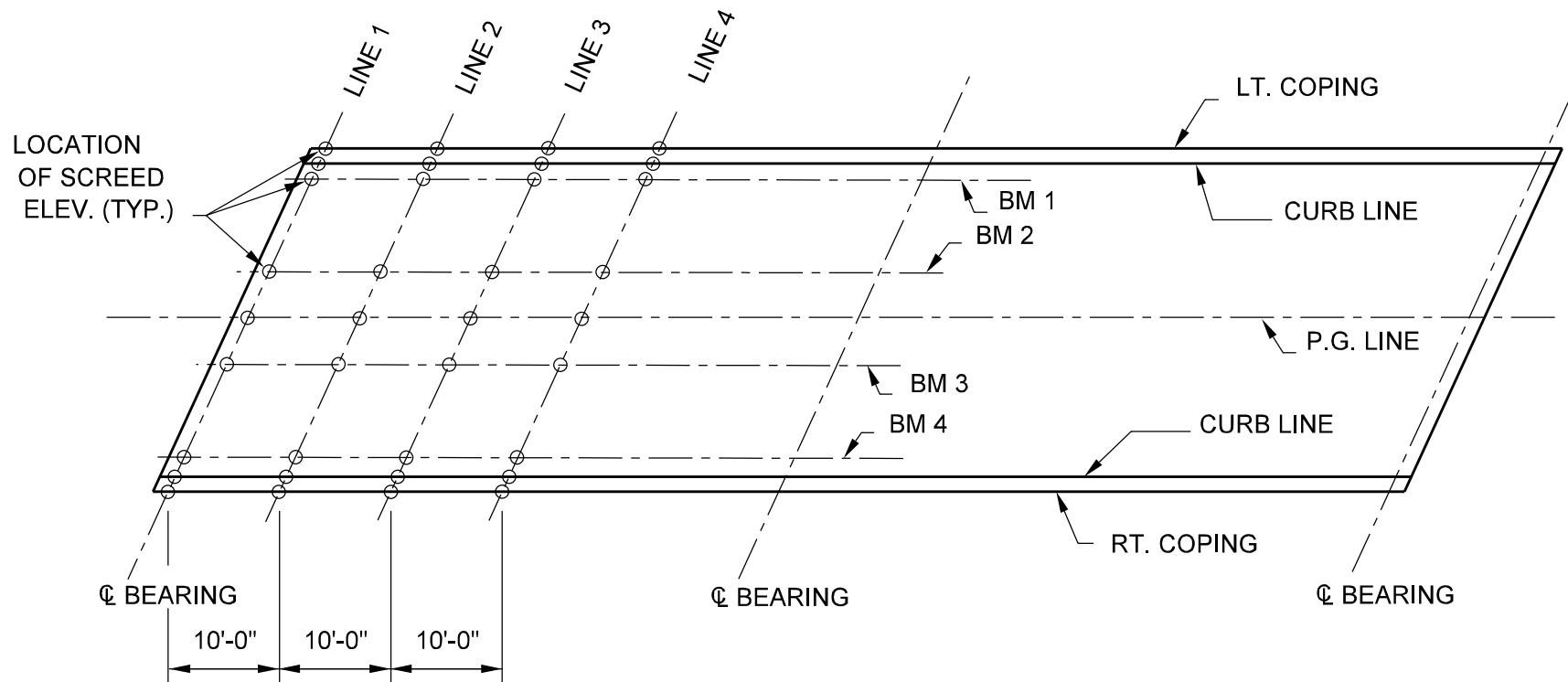
1. Preparation. The utility company must prepare the attachment details for the utility. These are submitted to the Utilities Team.
1. Review and Approval. The Utilities Team reviews the attachment details and submits these to the designer for comment. The Utilities Team will notify the utility company of needed revisions. Once all changes have been made, the Utilities Team will approve the utility-attachment details and process the Utility Agreement.
3. Plans Incorporation. The Utilities Team will submit the approved utility-attachment details to the designer for incorporation into the final contract plans.



CROSS SECTION OF MULTI-BEAM BRIDGE

Figure 404-1A

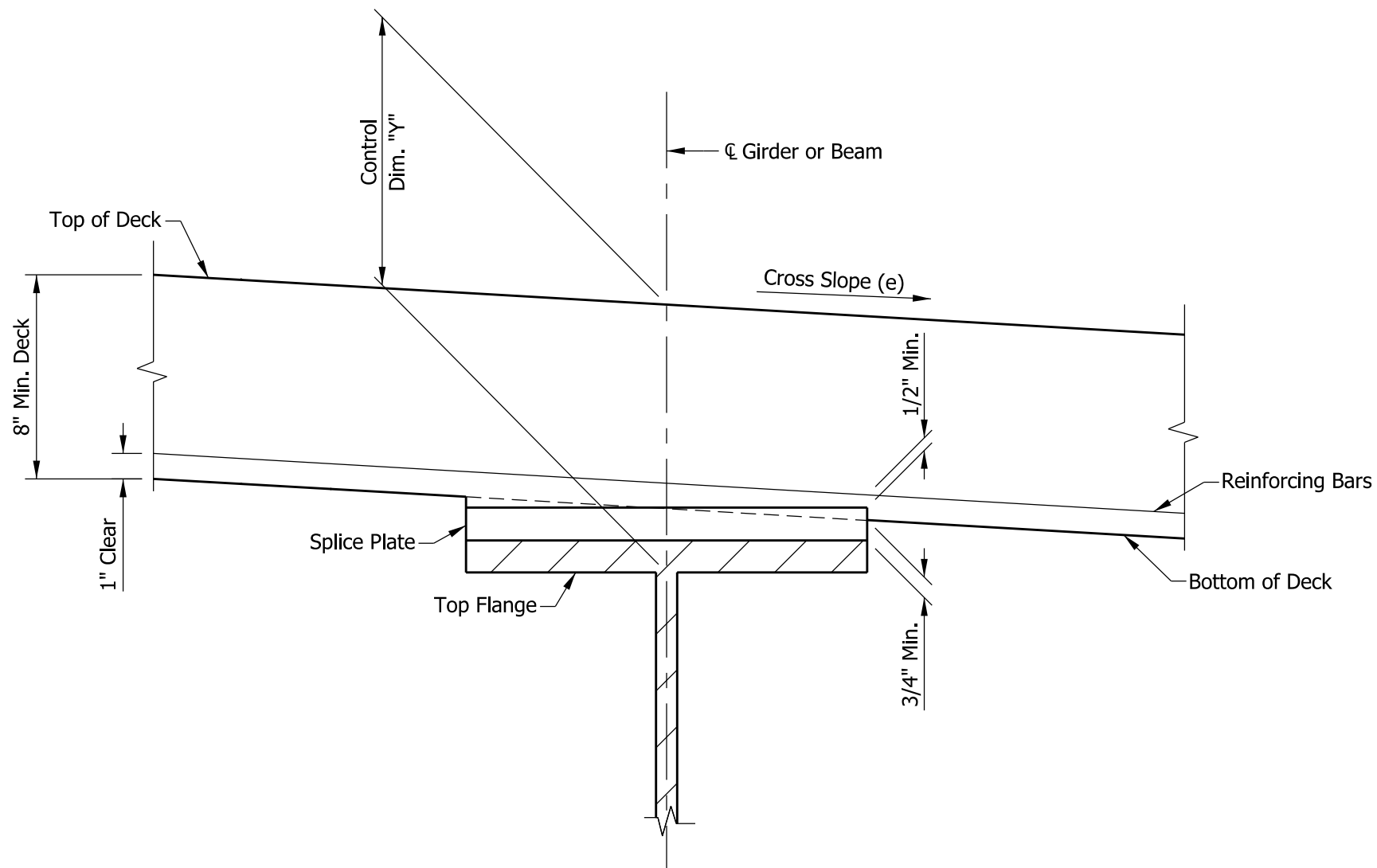




*Note: 10'-0" spacing pattern may begin at left support or may be centered in span.*

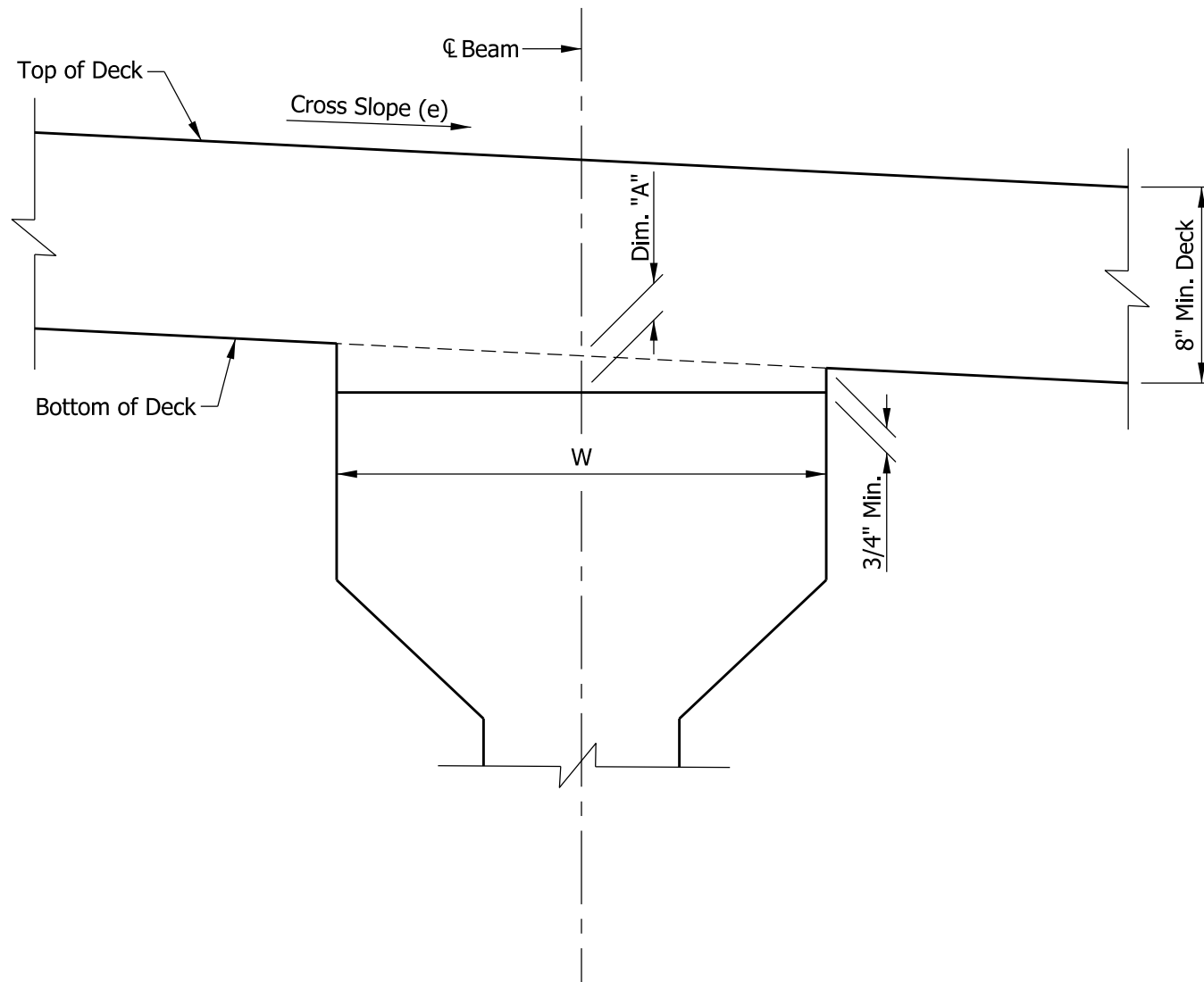
## PLAN OF SCREEDS

Figure 404-2A



## FILLET DIMENSIONS FOR STEEL BEAM

Figure 404-2B

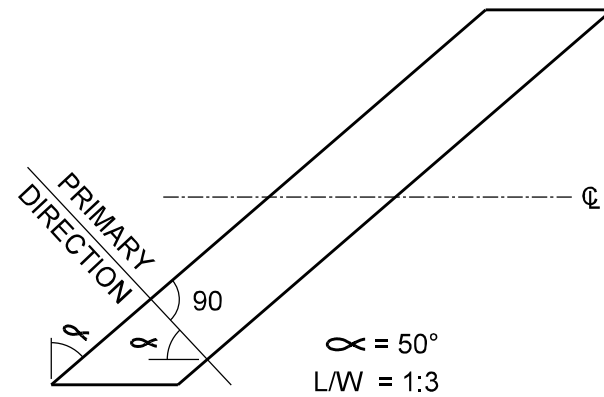
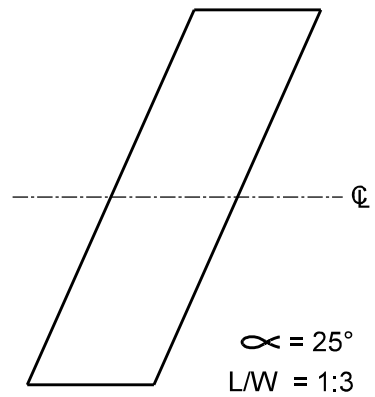
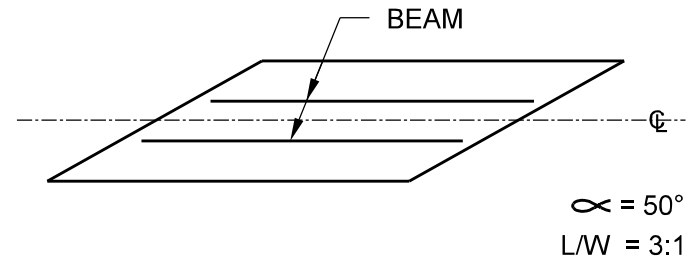
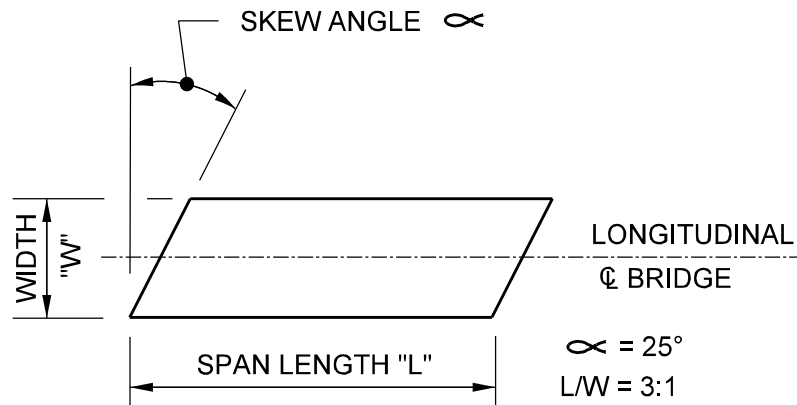


## FILLET DIMENSION FOR PRE-STRESSED BEAMS

Figure 404-2C

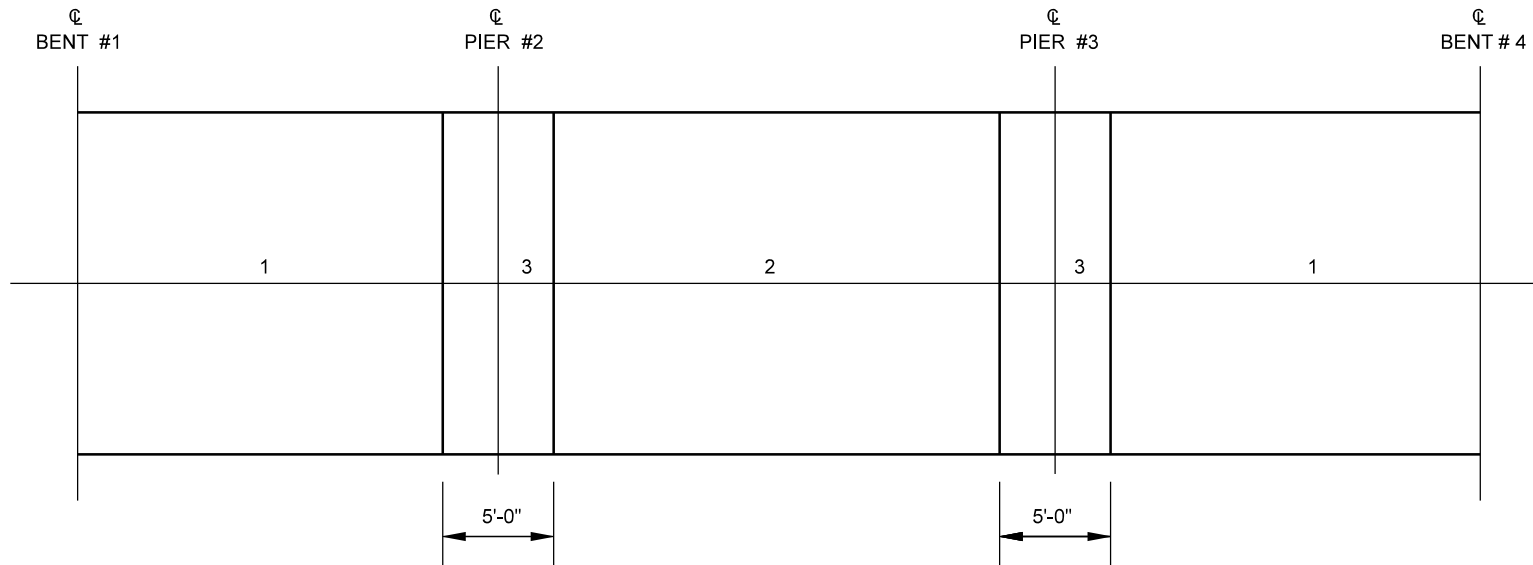
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**PRECAST DECK PANELS ON BRIDGE WITH SAG VERTICAL CURVE**  
**Figure 404-2D**



COMBINATION OF SKEW ANGLE AND SPAN LENGTH/BRIDGE WIDTH RATIO

Figure 404-2E



*The following note, revised as necessary, should be shown on the plans for a continuous prestressed concrete I-beam, bulb-T, or box beam structure in which the composite slab over the interior supports is designed for the live load:*

POUR NUMBERS INDICATE SEQUENCE OF POURS, POURS OVER INTERIOR SUPPORTS SHALL BE MADE LAST TO REDUCE THE EFFECT OF THE SLAB DEAD LOAD IN THE NEGATIVE MOMENT AREA. POUR #3 WILL INCLUDE THE DIAPHRAGM AT THE SUPPORT AND SHALL BE HELD TO A 5'-0" LENGTH. INTERIOR DIAPHRAGMS WILL BE POURED BEFORE SLAB IS POURED. ALL POUR SEQUENCES AND PROCEDURES SHALL BE SUBMITTED IN ACCORDANCE WITH SECTION 704.04 OF THE STANDARD SPECIFICATIONS.

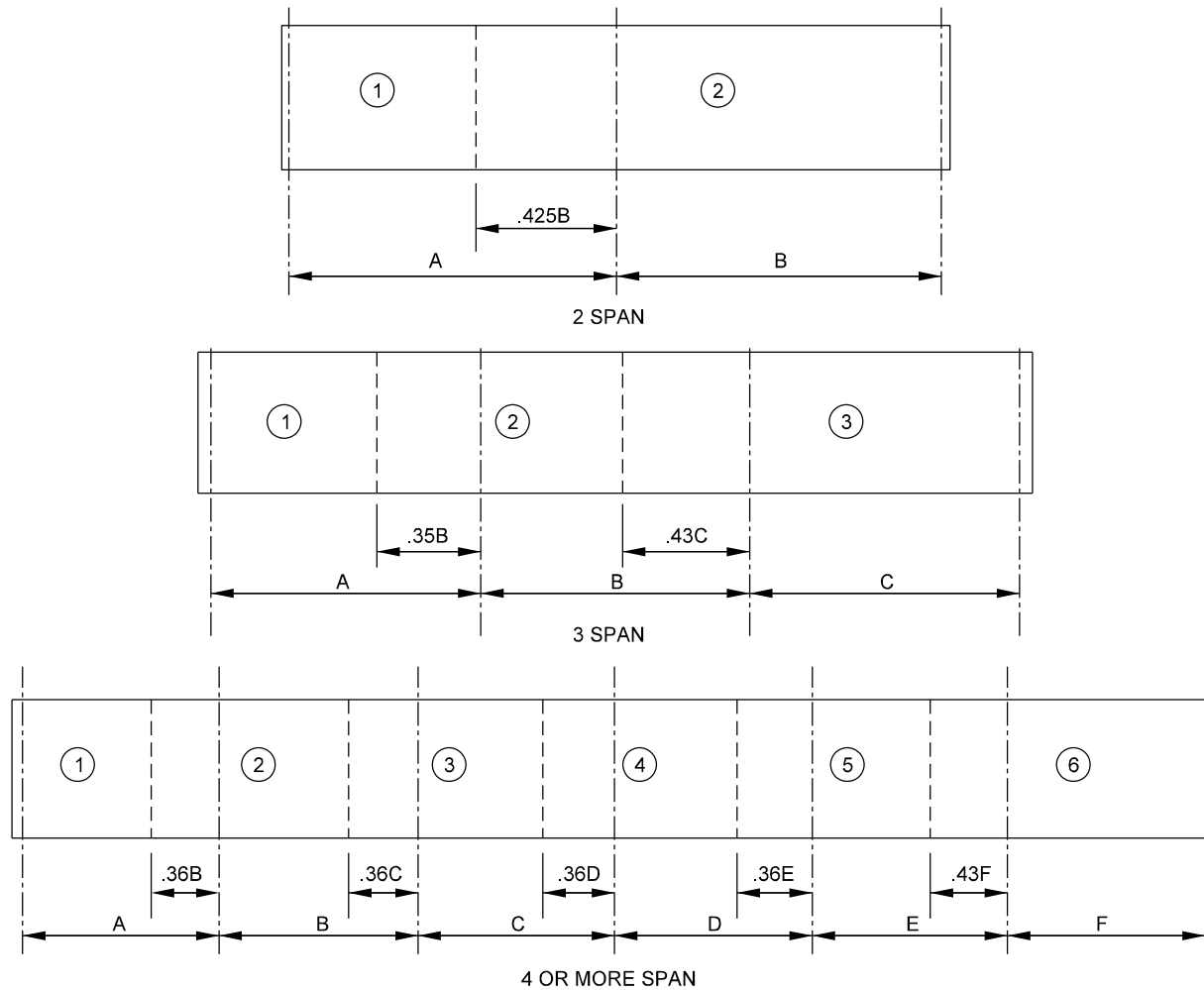
*If a continuous pour is allowable in accordance with the criteria provided in 404-2.06(02), the following note should also be included on the plans:*

AS AN ALTERNATE, THE CONTRACTOR MAY ELECT TO POUR THE DECK AND DIAPHRAGMS AS ONE CONTINUOUS POUR FROM ONE END TO THE OTHER. THIS WILL BE ALLOWED PROVIDED THE FOLLOWING CRITERIA IS MET:

- THE MINIMUM REQUIRED POUR RATE SHALL BE \_\_\_\_ CYS/HR.
- EACH SPAN (DECK + PRIOR PIER DIAPHRAGM) SHALL BE COMPLETED WITHIN 3 1/2 HRS FROM THE TIME THE CONCRETE WITHIN THAT SPAN IS DISCHARGED.

## TYPICAL POUR DIAGRAM (Continuous Prestressed Concrete Beams)

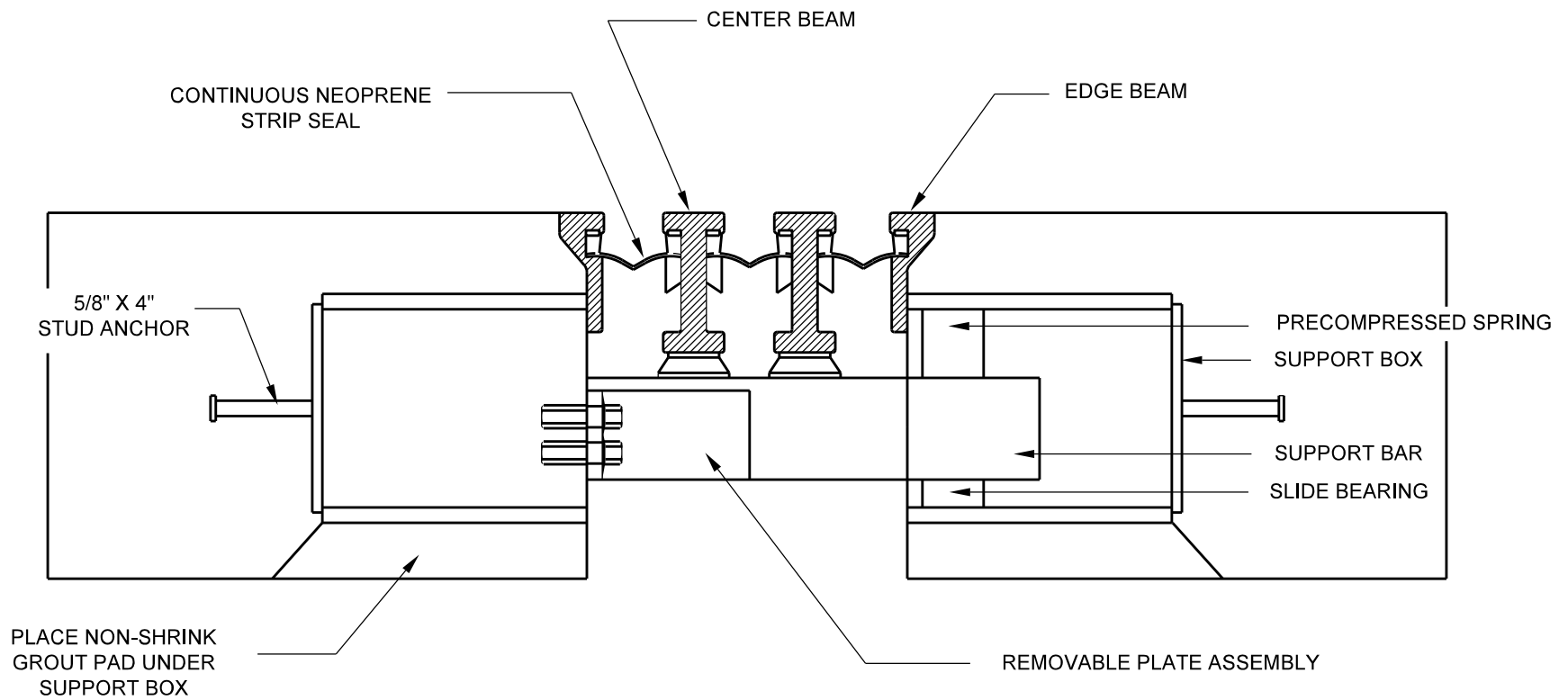
Figure 404-2F



*Note: Pour numbers indicate sequence of pours. Avoid placing construction joints at same location as the beam or girder splice.*

## TYPICAL POUR DIAGRAMS (Continuous Steel Beams or Plate Girders)

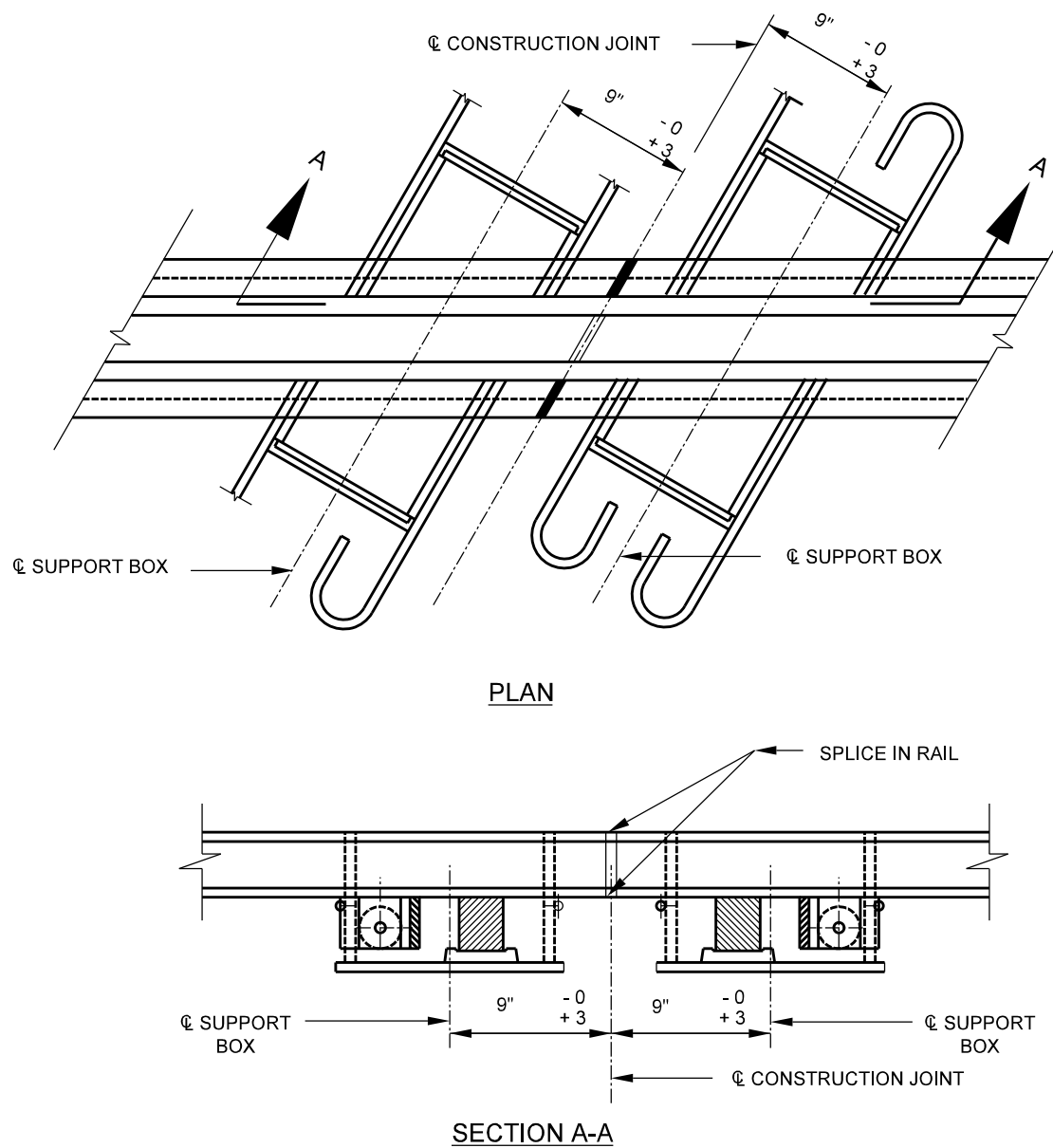
Figure 404-2G



## MODULAR EXPANSION JOINT

Figure 404-2H



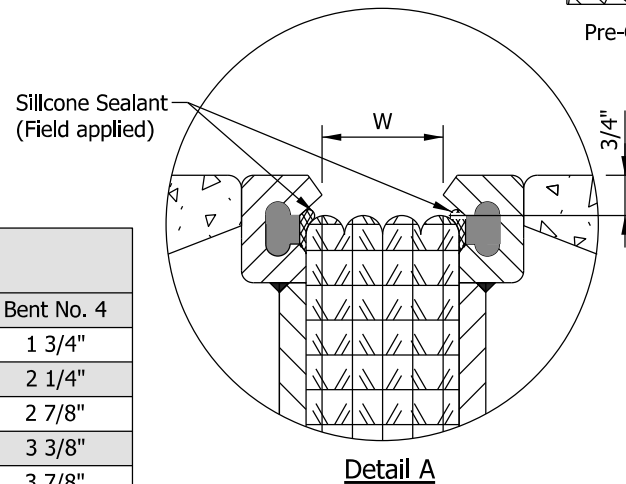
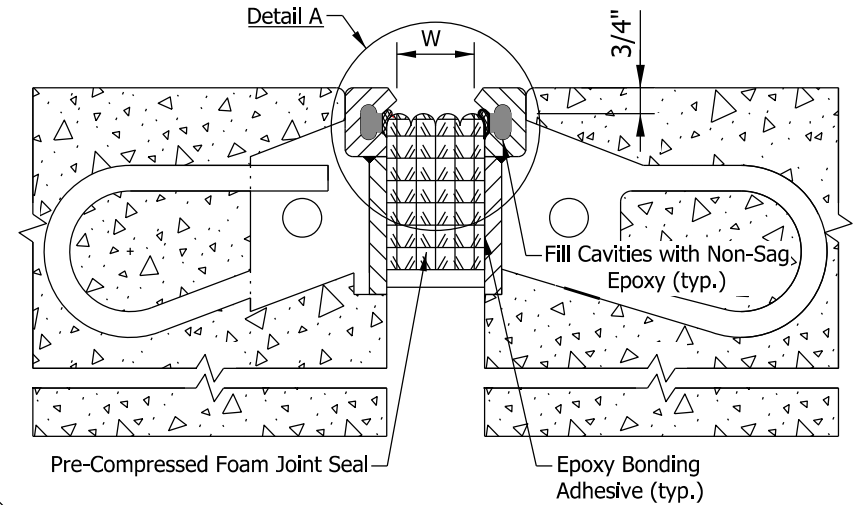
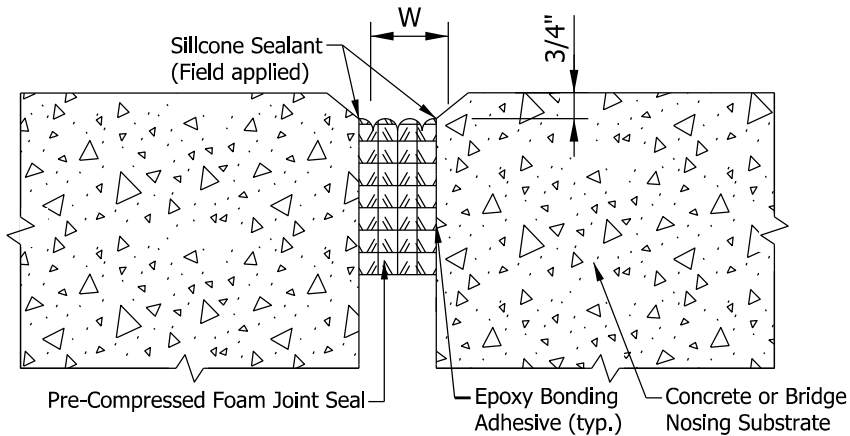


Where modular joints are placed in the roadway, the following will apply:

1. The CL of the support box will not be less than 9" nor more than 1'-0" from the construction joint.
2. The elastomeric seal will be one piece across the roadway width and will not be spliced at the construction joint.
3. Where practical, a modular joint should be a one-piece rail across the roadway width.

## MODULAR EXPANSION JOINT (Field Splice)

Figure 404-2 I



JOINT SETTING TABLE Dimension "W" (in.)		
Temp. (°F)	Bent No. 1	Bent No. 4
80	2 3/8"	1 3/4"
60 (Mean Joint Opening)	2 1/2"	2 1/4"
40	2 3/4"	2 7/8"
20	2 7/8"	3 3/8"
0	3 1/8"	3 7/8"
Total Movement Range	3/4"	2 1/8"
Tributary Expansion Length	100'-0"	300'-0"

Notes:

1. Movements include LRFD strength load case factor.
2. Example based on concrete superstructure.

**Example 1**  
**RETROFIT UNARMORED DETAIL**

JOINT SETTING TABLE Dimension "W" (in.)		
Temp. (°F)	Bent No. 1	Bent No. 4
120	1 1 1/2"	1 1/4"
100	1 3/4"	1 5/8"
80	1 7/8"	2"
60 (Mean Joint Opening)	2"	2 1/4"
40	2 1/4"	2 5/8"
20	2 3/8"	3"
0	2 5/8"	3 3/8"
-30	2 7/8"	4"
Total Movement Range	1 3/8"	2 3/4"
Tributary Expansion Length	100'-0"	200'-0"

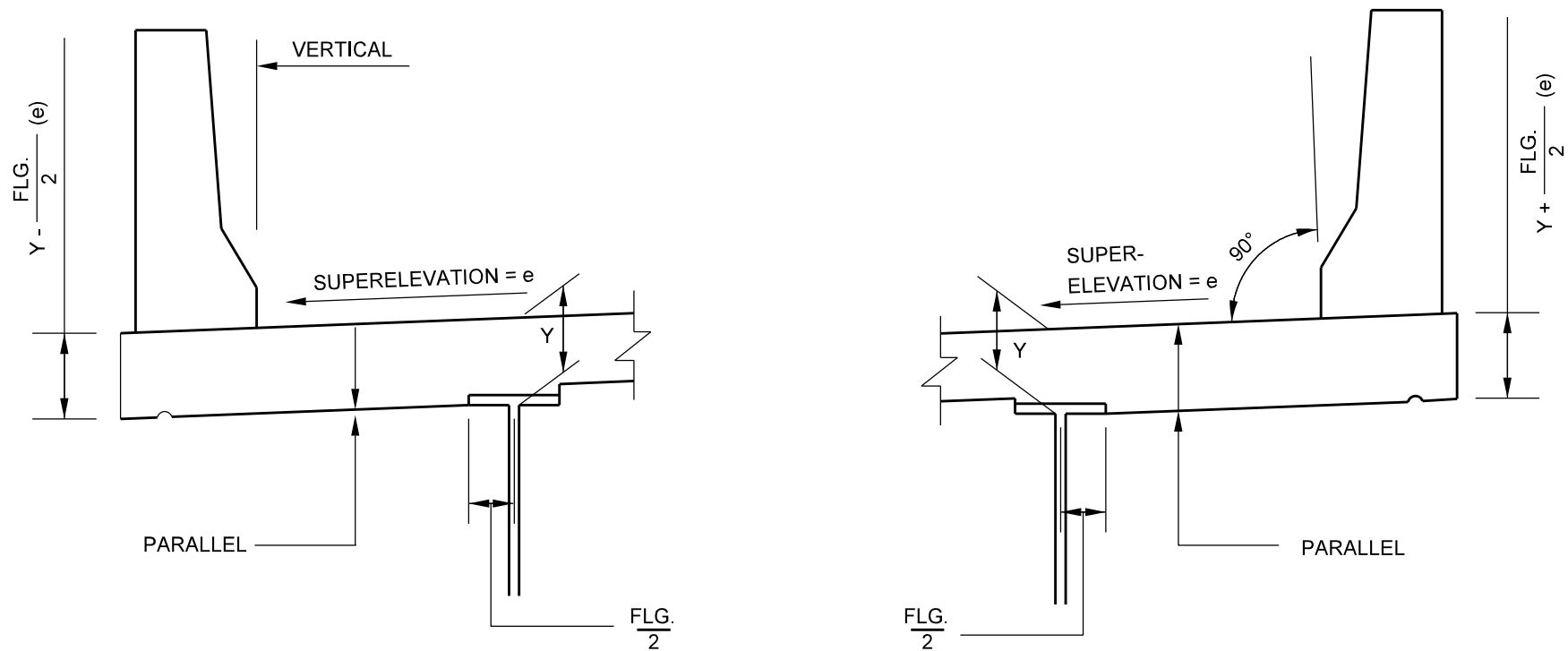
Notes:

1. Movements include LRFD strength load case factor.
2. Example based on steel superstructure.

**Example 2**  
**EXPANSION JOINT, SS, RETROFIT DETAIL**

## PRE-COMPRESSED FOAM JOINT

**Figure 404-2J**  
[New Apr. 2021]

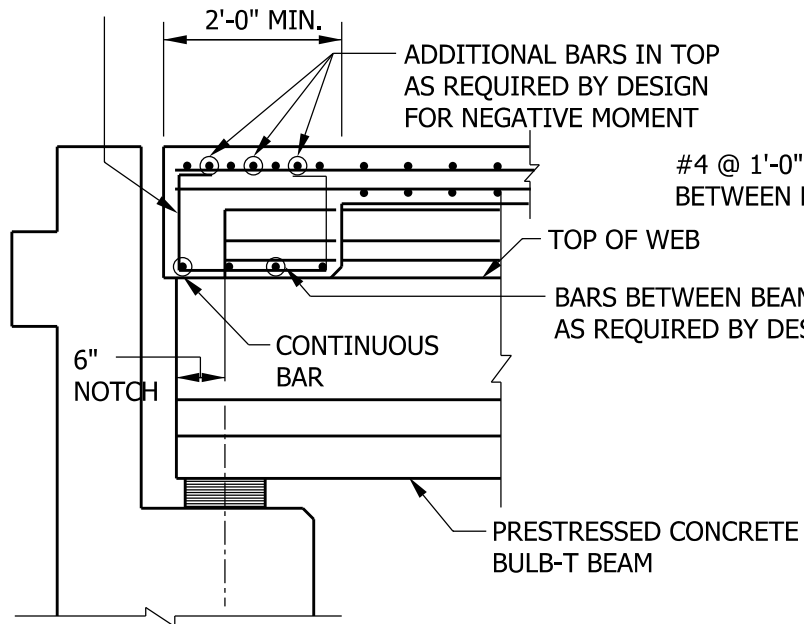


Y = CONTROL DIMENSION (in.)  
 FLG. = FLANGE WIDTH (in.)  
 e = SUPERELEVATION RATE ( % )

## DECK OVERHANG TREATMENTS (Superelevated Structures)

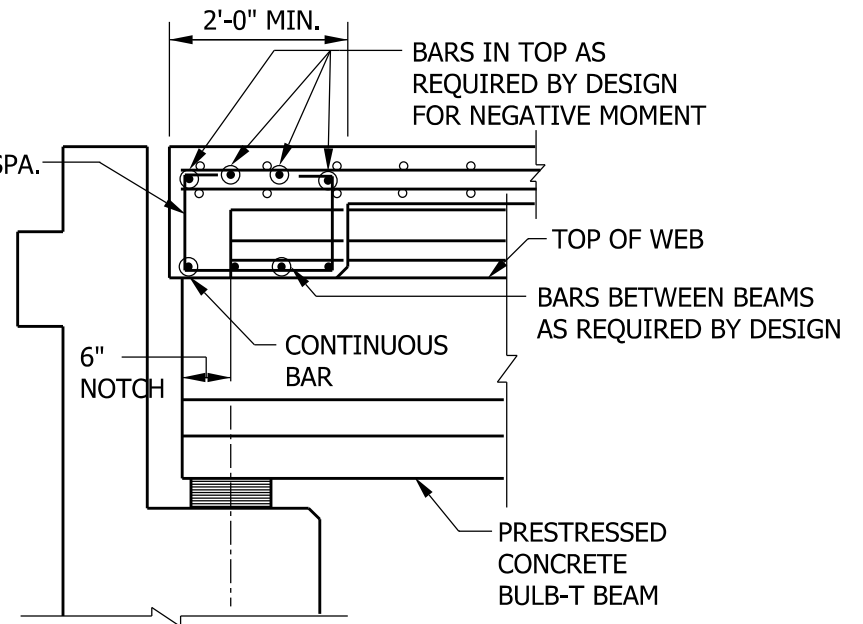
Figure 404-3A

#4 @ 1'-0" MAX. SPA.  
BETWEEN BEAMS



SKEW 25° OR LESS

NOTE: ALL REINFORCING STEEL  
SHALL BE EPOXY COATED.

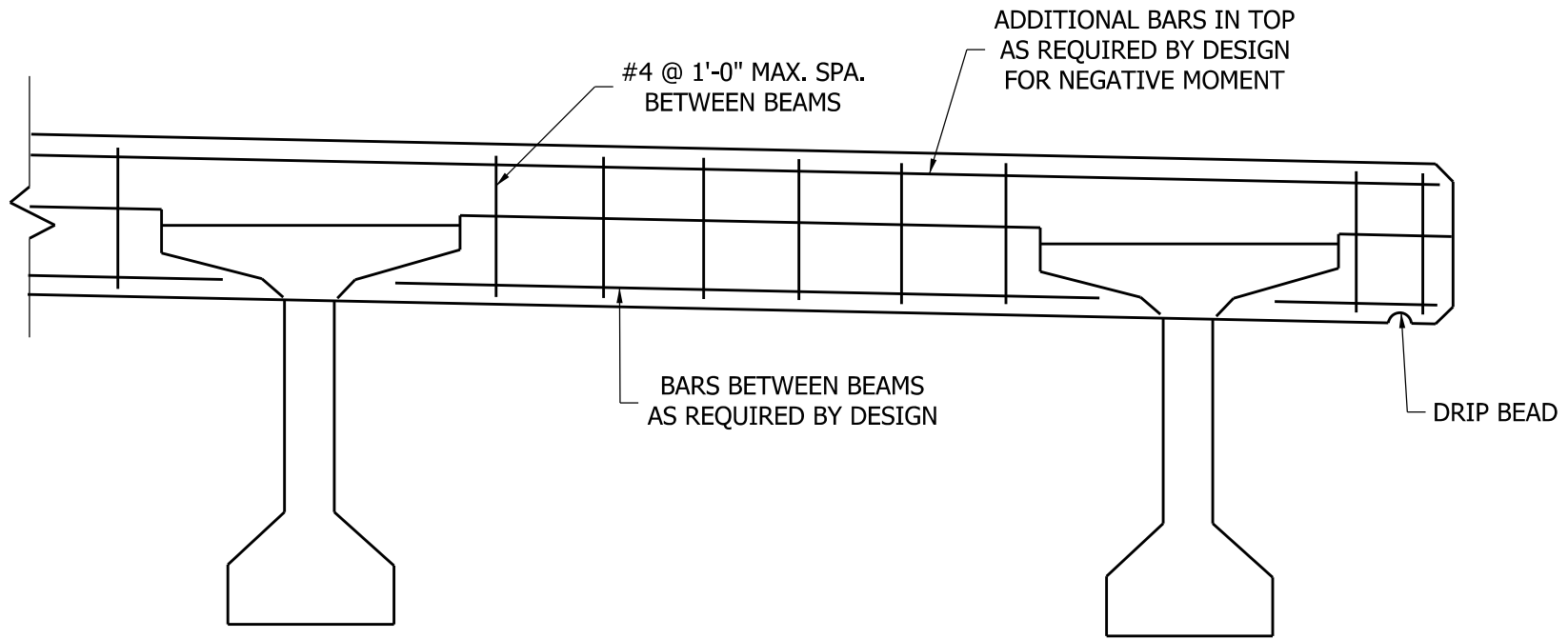


SKEW OVER 25°

## SUGGESTED TRANSVERSE EDGE BEAM DETAILS (For Bulb-Tee Beams)

Figure 404-3B  
(Page 1 of 2)

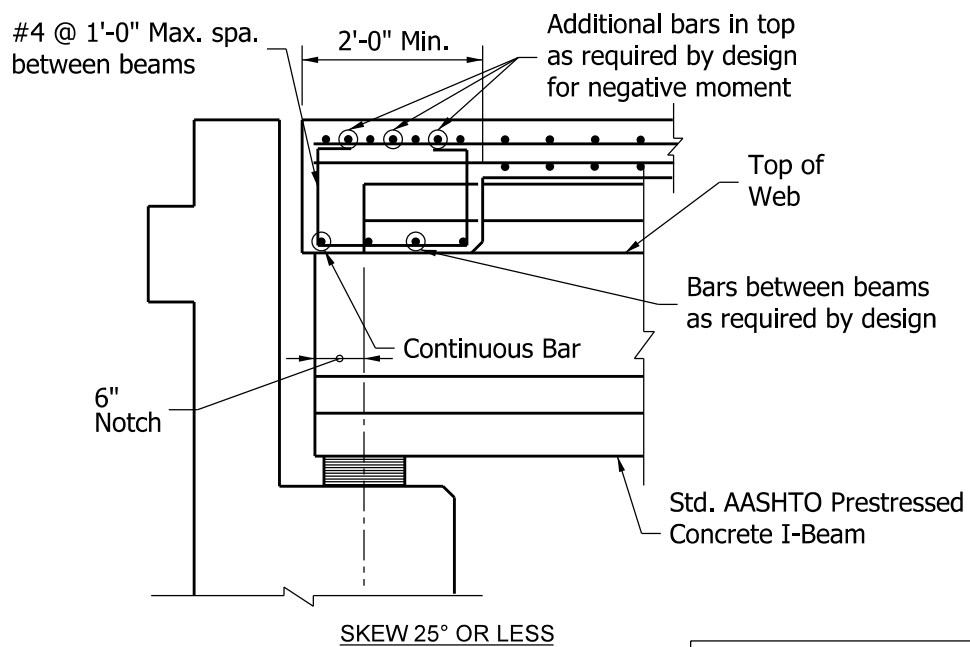
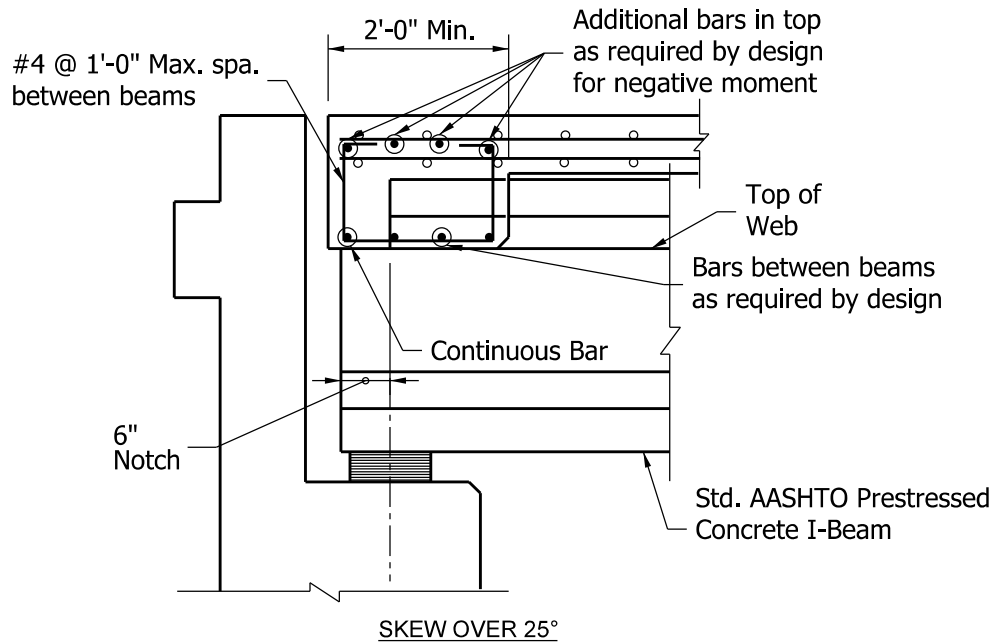
NOTE: ALL REINFORCING STEEL  
SHALL BE EPOXY COATED.



NOTE:  
THE EDGE BEAM SHALL EXTEND  
FROM COPING TO COPING.

## SUGGESTED TRANSVERSE EDGE BEAM DETAILS (For Bulb-Tee Beams)

Figure 404-3B  
(Page 2 of 2)



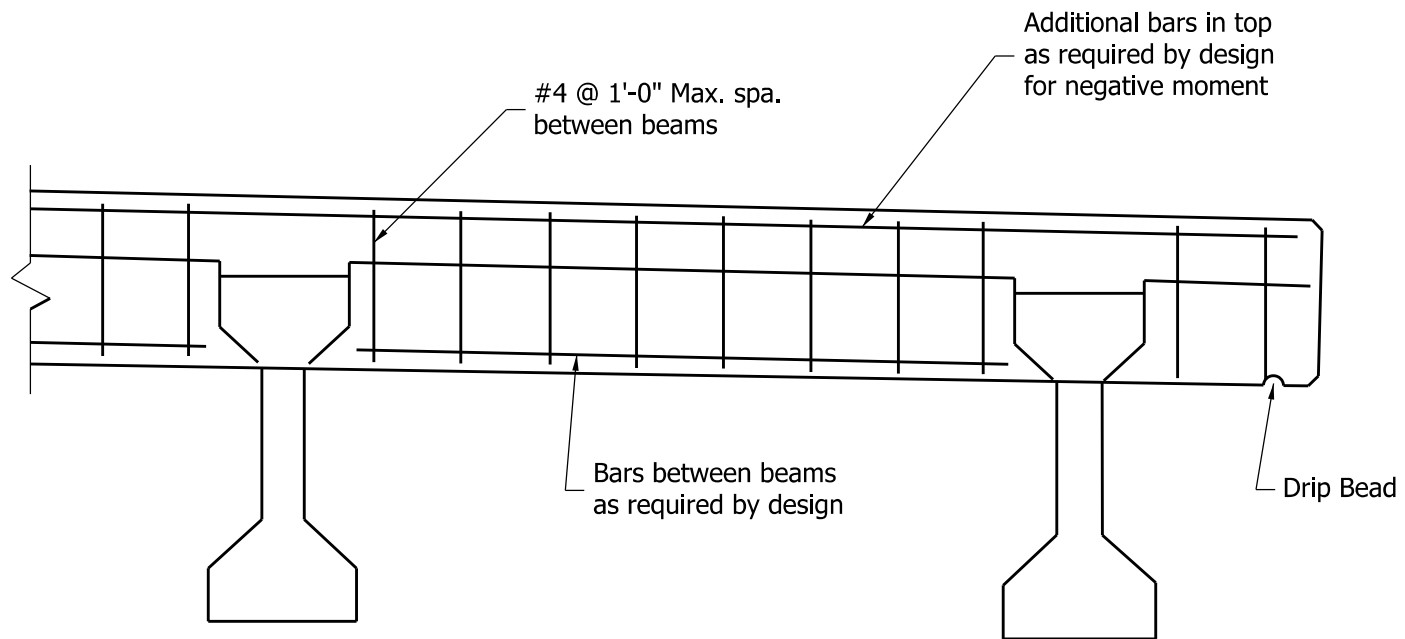
NOTE: All reinforcing steel shall be epoxy coated.

## SUGGESTED TRANSVERSE EDGE BEAM DETAILS (For AASHTO I-Beam)

Figure 404-3C  
(Page 1 of 2)

NOTE: The edge beam shall extend from coping to coping.

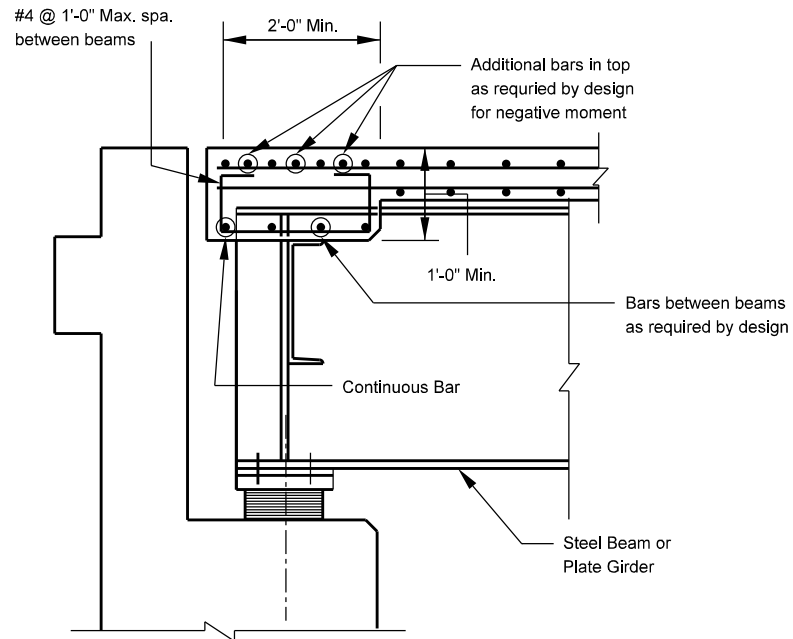
NOTE: All reinforcing steel shall be epoxy coated.



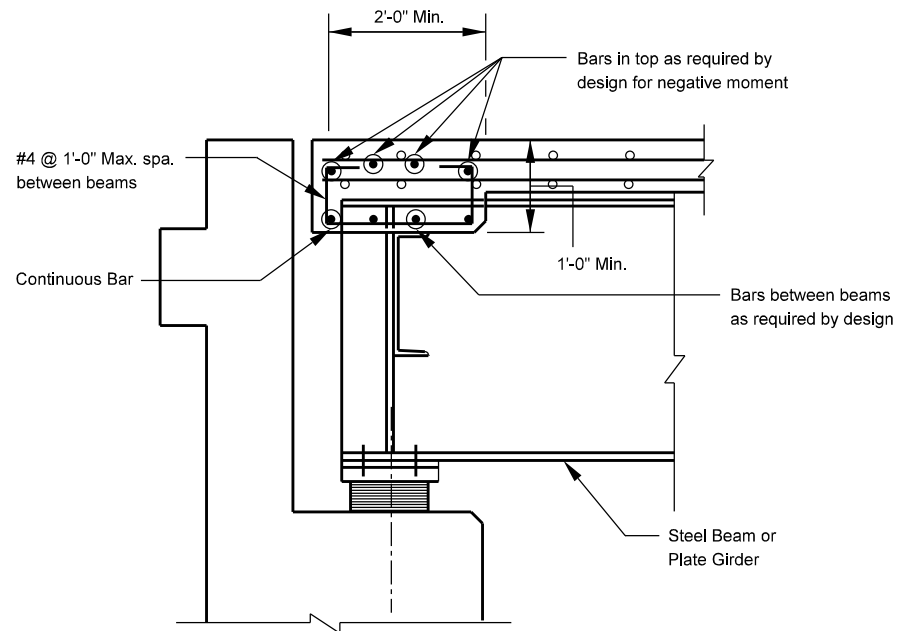
### SUGGESTED TRANSVERSE EDGE BEAM DETAILS (For AASHTO I-Beam)

Figure 404-3C  
(Page 2 of 2)

NOTE: All reinforcing steel shall be epoxy coated.



SKEW 25° OR LESS



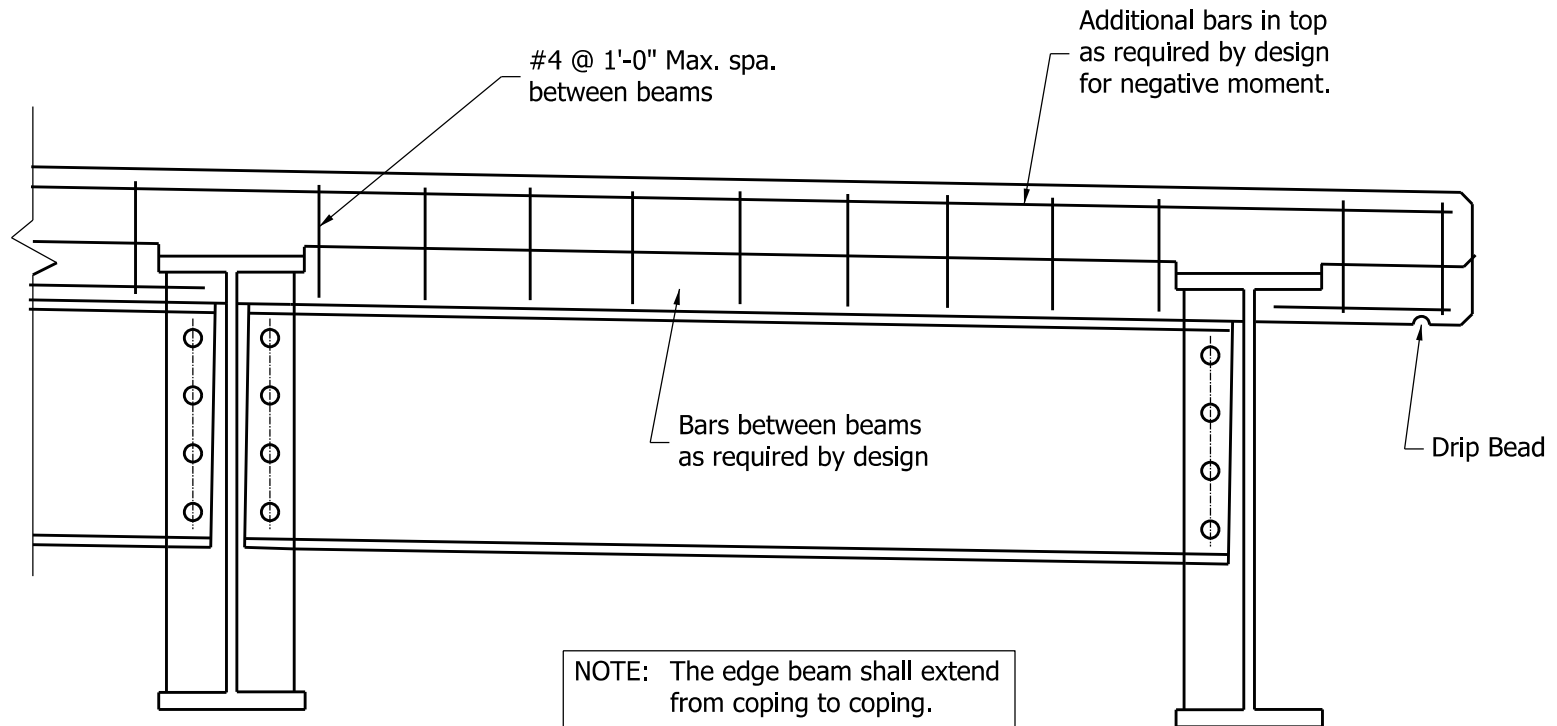
SKEW OVER 25°

## SUGGESTED TRANSVERSE EDGE BEAM DETAILS (For Steel Plate Girder)

Figure 404-3D  
(Page 1 of 2)



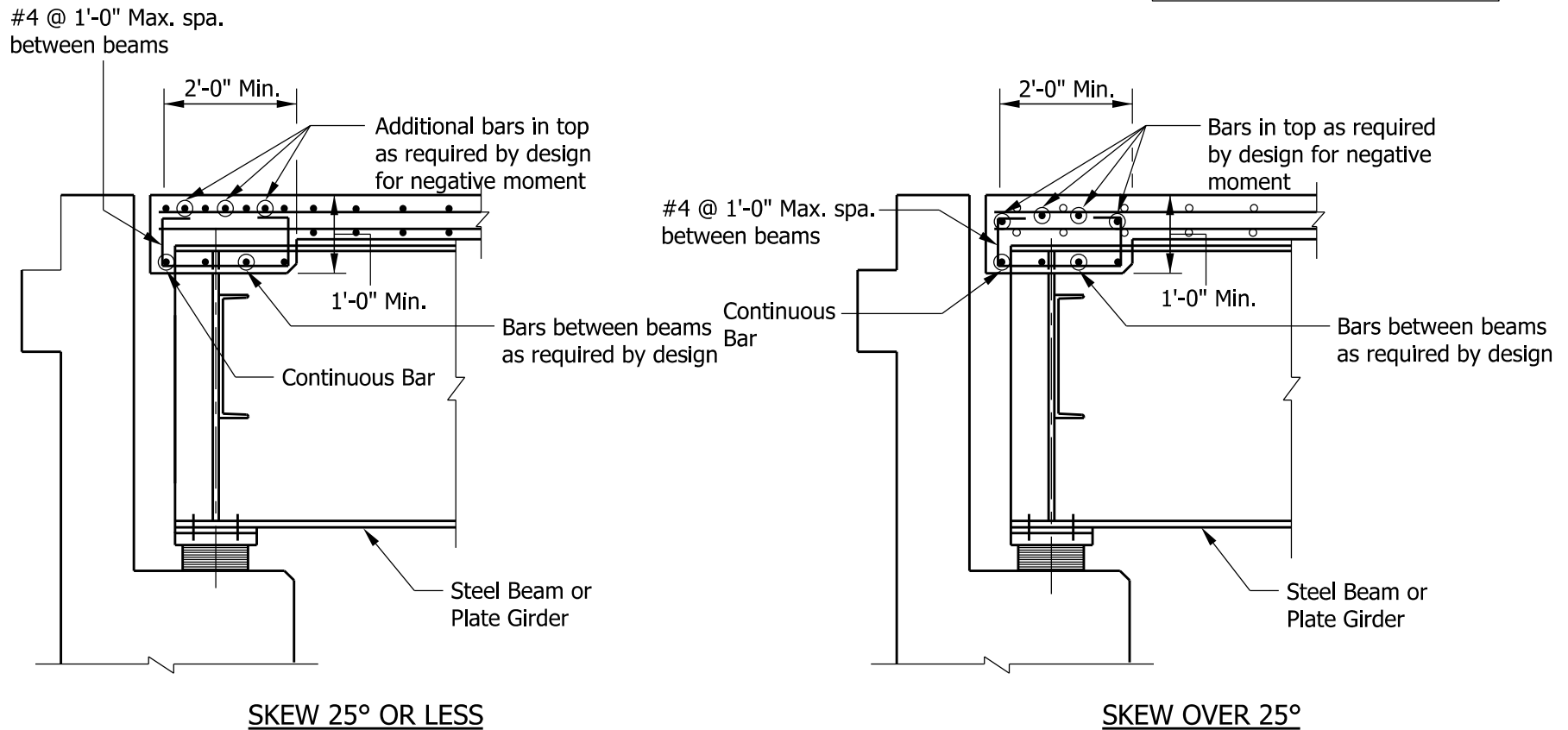
NOTE: All reinforcing steel shall be epoxy coated.



## SUGGESTED TRANSVERSE EDGE BEAM DETAILS (For Steel Plate Girder)

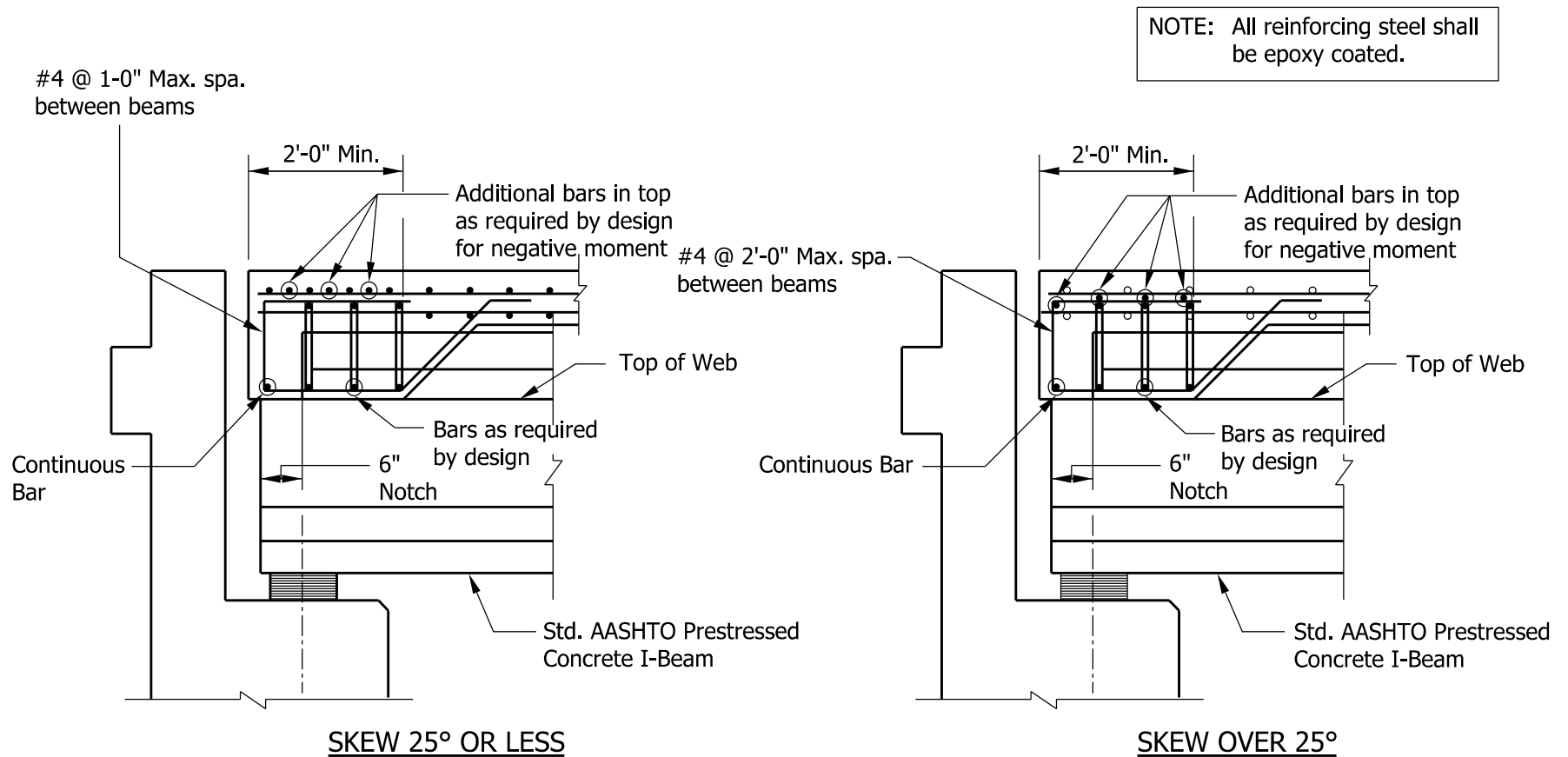
Figure 404-3D  
(Page 2 of 2)

NOTE: All reinforcing steel shall be epoxy coated.



## SUGGESTED ALTERNATE TRANSVERSE EDGE BEAM DETAILS (For Steel Plate Girder)

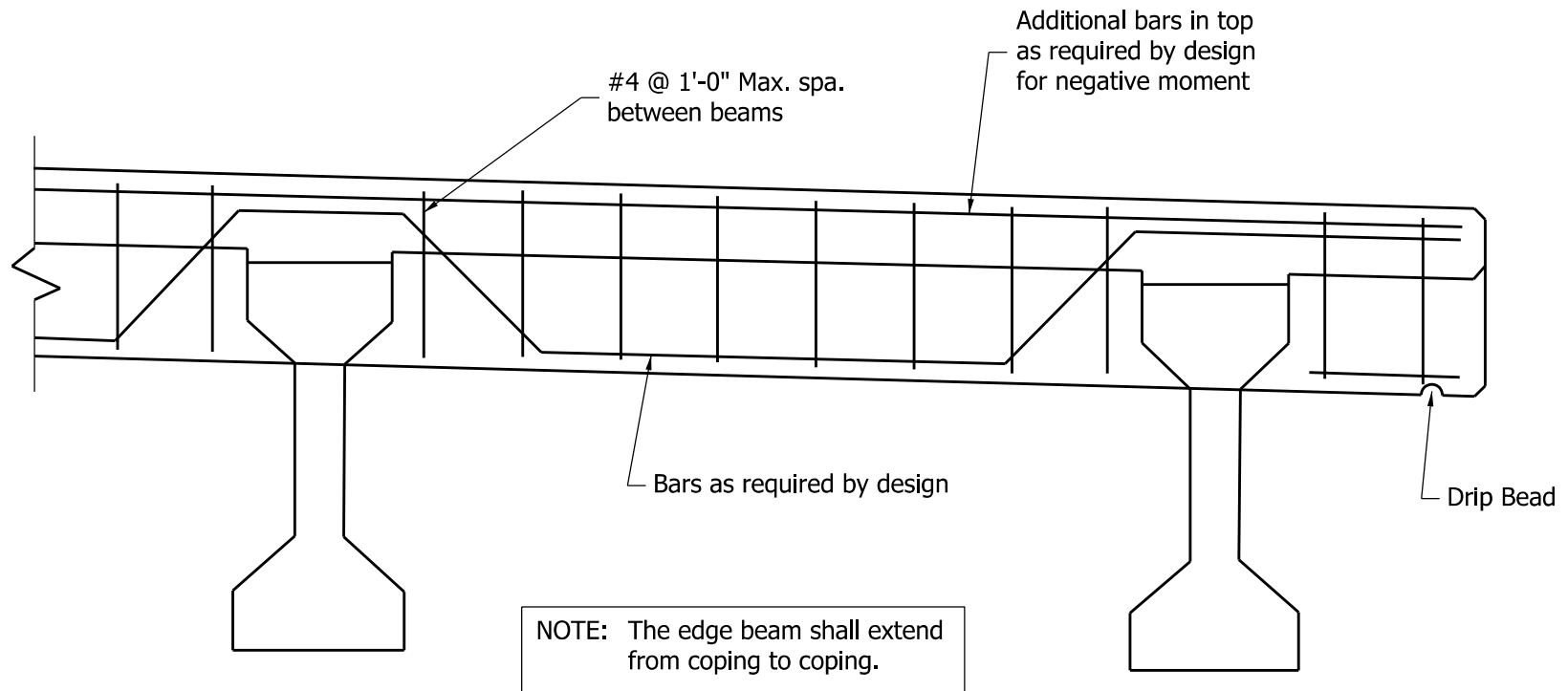
Figure 404-3E



## SUGGESTED ALTERNATE TRANSVERSE EDGE BEAM DETAILS (For Bulb-Tee Beam, AASHTO I-Beam, and Steel Plate Girder)

Figure 404-3F  
(Page 1 of 2)

NOTE: All reinforcing steel shall be epoxy coated.



**SUGGESTED ALTERNATE TRANSVERSE EDGE BEAM DETAILS**  
(For Bulb-Tee Beam, AASHTO I-Beam, or Steel Plate Girder)

Figure 404-3F  
(Page 2 of 2)

This figure deleted.

## **BRIDGE-RAILING LEVEL EQUIVALENCY**

**Figure 404-4A**

<b>Railing Type</b>	TS-1 *	TX **	FC	PS-1	PF-1	FT	TF-2
<b>Test Level</b>	NCHRP 350 TL-2	NCHRP 350 TL-2	MASH TL-3	MASH TL-3	MASH TL-3	MASH TL-5	MASH TL-5
<b>Height Designation</b>	Common	Pedestrian	Common	Pedestrian	Pedestrian	Truck	Truck
<b>Mounting Location</b>	Side-mounted to bridge deck coping	Atop sidewalk. (5 ft min. width), or flush with bridge deck	Flush with bridge deck	Atop sidewalk (5 ft min. width)	Flush with bridge deck	Flush with bridge deck	Flush with bridge deck
<b>Railing Elements</b>	Thrie-beam with steel posts	Concrete	Concrete, shape F	2 steel tubes with steel posts on concrete parapet	2 steel tubes with steel posts on concrete parapet	Concrete, shape F	2 steel tubes with steel posts on concrete parapet
<b>Total Height</b>	2'-9"	3'-6"	2'-9"	3'-6"	3'-6"	3'-9"	4'-2"
<b>Standard Drawings</b>	Recurring Plan Detail	706-BRTX	706-BRSF	706-BRPP	706-BRPP	706-BRSF	706-BRTF

\* Bridge railing type TS-1 may be used only on a local public agency collector or local road.  
Details for the bridge railing and transition are shown in INDOT Recurring Plan Detail 706-B-140d.

\*\* Bridge railing type TX may be used only on a local public agency road.

## BRIDGE RAILING TYPES

**Figure 404-4B**

Bridge Railing Type	Bridge Railing		Bridge Railing Transition		Guardrail Transition	
	Pay Items	Pay Units	Pay Items	Pay Units	Pay Items	Pay Units
TS-1	Railing, Steel, TS-1	LFT	none	n/a	Guardrail Transition, TGS-1	EACH
TX	Railing, Concrete, TX Reinforcing Bars, Epoxy Coated	CYS LBS	Concrete Bridge Railing Transition, TTX Reinforcing Bars, Epoxy Coated	EACH LBS	MGS Guardrail Transition* (with or without curb)	EACH

### NCHRP 350 Test Level 2 Bridge Railing

FC	Railing, Concrete, FC Reinforcing Bars, Epoxy Coated	CYS LBS	Concrete Bridge Railing Transition, TFC * Reinforcing Bars, Epoxy Coated	EACH LBS	MGS Guardrail Transition* (with or without curb)	EACH
PF-1	Railing, Concrete, PF-1 Railing, Steel, PF-1 Reinforcing Bars, Epoxy Coated	CYS LFT LBS	Concrete Bridge Railing Transition, TPF-1 Reinforcing Bars, Epoxy Coated	EACH LBS	MGS Guardrail Transition* (with or without curb)	EACH
PS-1	Railing, Concrete, PS-1 Railing, Steel, PS-1 Reinforcing Bars, Epoxy Coated	CYS LFT LBS	Concrete Bridge Railing Transition, TPS-1 Reinforcing Bars, Epoxy Coated	EACH LBS	MGS Guardrail Transition* (with or without curb)	EACH

### MASH Test Level 3 Bridge Railing

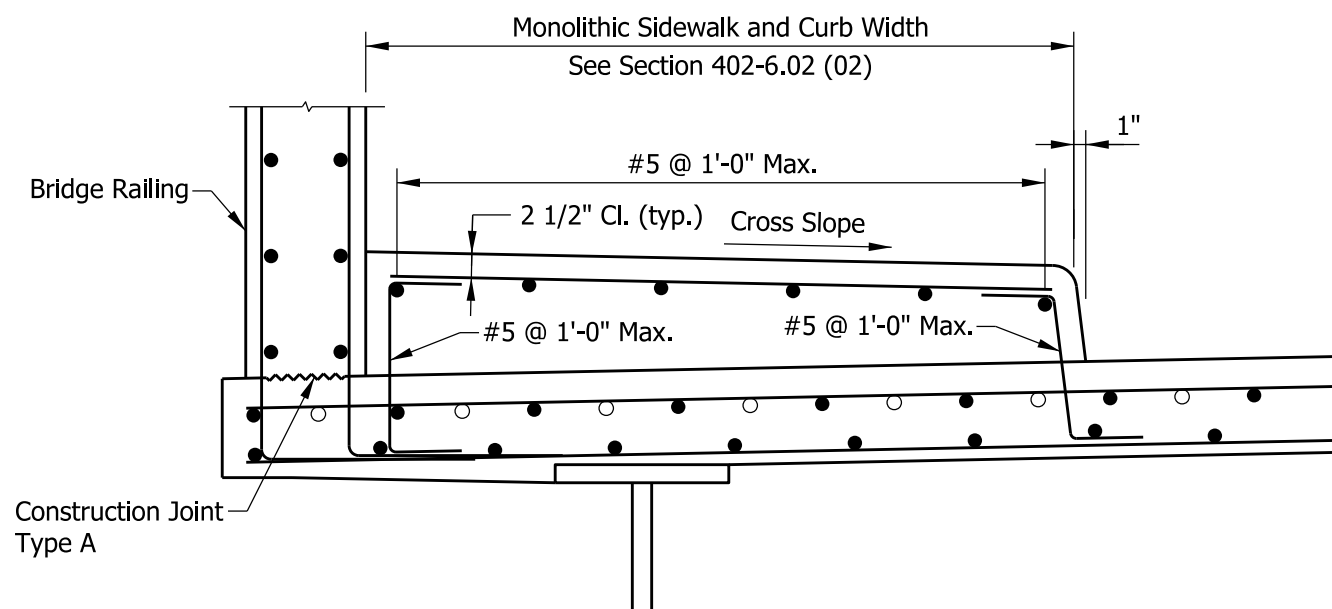
FT	Railing, Concrete, FT Reinforcing Bars, Epoxy Coated	CYS LBS	Concrete Bridge Railing Transition, TFT Reinforcing Bars, Epoxy Coated	EACH LBS	MGS Guardrail Transition* (with or without curb)	EACH
TF-2	Railing, Concrete, TF-2 Railing, Steel, TF-2 Reinforcing Bars, Epoxy Coated	CYS LFT LBS	Concrete Bridge Railing Transition, TTF-2 Reinforcing Bars, Epoxy Coated	EACH LBS	MGS Guardrail Transition* (with or without curb)	EACH

### MASH Test Level 5 Bridge Railing

\* Guardrail Transition Type TGB may be used to address site-specific constraints. Coordination with Standards and Policy Division required.

## BRIDGE RAILING SUMMARY

Figure 404-4C



## TYPICAL REINFORCEMENT IN BRIDGE SIDEWALK

Figure 404-4D