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5.3 Haunches

5.3.1 General

For continuous welded plate girder (CWPG) and rolled steel beam (RSB) bridges, haunch design is directly related to lengths of shear studs that are welded to the top flanges of the girders or beams. When designing the haunches for steel bridges the designer should consult Bureau policy for shear studs [BDM 5.5.1.4.1.8] in addition to the haunch policies in following articles.

5.3.1.1 Policy overview

For pretensioned prestressed concrete beam (PPCB), continuous welded plate girder (CWPG), and rolled steel beam (RSB) bridges the Bureau typically uses a variable concrete haunch thickness at each beam or girder to fit the roadway surface to the top profiles of the beams or girders. The design haunch is used in determining the beam or girder seat elevations and the estimated deck concrete quantity.

The designer should set haunch thicknesses inside the minimum design limit at edge of beam or girder and maximum design limit at centerline of beam or girder, with consideration of shear steel, so that the contractor will have tolerances for both upward and downward adjustments in the field.

In the field the contractor will set the beams or girders on the bearings at the beam seats and will survey the tops of beams or girders at the intervals given on the “Slab Haunch Data Details” sheet [BSB SS 1066] or, for RSB bridges, the “Beam Line Haunch Data” standard sheet selected for the bridge length [BSB SS 5264, 5267, etc.]. Then the contractor can subtract the survey elevations from the beam line haunch elevations given on the sheet to determine the haunch thicknesses for setting the deck forms.

If limits given on the plans for haunch are exceeded in the field, the Resident Construction Engineer (RCE) may reset the profile grade to adjust to the differing as-built conditions. If the grade adjustment is not practical for a PPCB bridge, thick haunches may be reinforced with additional bars so that the beam stirrups are extended a minimum of 2.5 inches into the deck. If the grade adjustment is not practical for a CWPG or RSB bridge, the Bureau will address the haunch problem on a case-by-case basis.

5.3.1.2 Design information

Reserved

5.3.1.3 Definitions

Reserved

5.3.1.4 Abbreviations and notation

CWPG, continuous welded plate girder
PPCB, pretensioned prestressed concrete beam
RCE, Resident Construction Engineer
RSB, rolled steel beam

5.3.1.5 References

Reserved

5.3.2 PPCB bridges

NOTE: The haunch design for the three-span PPCB standard bridges [H-standards] is based on an 8.00-inch thick deck with a cover of 2.50 inches to the top transverse reinforcement. The haunch design in the BDM articles below is based on an 8.50-inch deck with 2.75 inches of cover to the top reinforcement. Designers should refer to the January 1, 2023, BDM release as needed to design haunches for H-standard bridges until such time as the H-standards are updated for the new deck thickness and top cover requirements [BDM Preface].

5.3.2.1 Analysis and design

The maximum and minimum field and design limits allowed for haunches are given in Table 5.3.2.1-1.

Table 5.3.2.1-1. Maximum and minimum haunch thickness

Beam Location	**Field Limits**	**Design Limits**
Maximum at or near center of span, centerline of beam flange	3.5 inches	3.0 inches
Maximum at or near beam ends, centerline of beam flange	4.0 inches	3.5 inches
Minimum anywhere along beam, edge of beam flange	-0.5 inch (i.e. 0.5-inch embedment)	0.0 inches

The maximum and minimum haunch limits in Table 5.3.2.1-1 may, however, be controlled by shear steel heights. The required clearance and embedment of the shear steel with respect to the deck is given in Table 5.3.2.1-2. For A through D beams, standard shear reinforcement extends 4.5 inches above the top flange, and for BTB through BTE beams, shear reinforcement extends 5 inches above the top flange.

Table 5.3.2.1-2. Required shear steel clearance and embedment in the deck

Criteria	**Field Limits**	**Design Limits**
Minimum shear steel embedment into deck (may control maximum haunch)	2.5 inches	3.0 inches
Minimum shear steel clearance from top of deck (may control minimum haunch)	2.75 inches	3.25 inches

As shown in the tables above the design limits shall be within 0.5 inch of the field limits. Haunches shall be designed to stay within the design limits in order to allow for some haunch adjustment in the field. The maximum and minimum limits for the haunch thickness may vary along the beam. The variation of the maximum and minimum field haunch limits shall be shown in the plans.

The typical procedure for designing the haunch is as follows:

1.) To start, set the minimum design haunch at 0.5 inch at centerline of beam but not less than 0.0 inch at edge of top flange after cross slope is considered.
2.) Once the minimum is set, the haunch thickness can be checked along the entire beam line.

3.) Check the minimum and maximum haunches based on shear steel heights. When checking the maximum haunch, the designer need not consider any cross slope or superelevation that increases the haunch at the edge of the deck.
4.) Modify the bridge seat elevations as necessary to attempt to fit within the haunch limits.

If the haunch at the centerline of the beam flange exceeds the maximum design limits because of beam camber and grade considerations, the designer has the following two options. Option 1 is the preferred option when the maximum haunch is at midspan, and Option 2 is the preferred option when the maximum haunch is at the beam ends.

Option (1) Provide additional 5a3 and #6 longitudinal bars with the deck reinforcing to adequately reinforce the haunch where it exceeds 2.0 inches as shown in Figure 5.3.2.1.

This option is preferred at midspan because the additional 5a3 bars can be rotated from vertical to allow for some variation in the haunch thickness since actual beam camber can differ from predicted camber. The additional 5a3 and #6 longitudinal bars also help to reinforce the haunch and ensure composite action at midspan where it is most important. [An example of a case where the haunch at midspan may exceed the haunch at the beam ends is for a 2 span PPCB bridge that has a relatively steep crest vertical curve over a relatively short vertical curve length (e.g. Hoover Street over I-35 in Polk County)]

Option (2) Adjust the length of the beam shear reinforcement in the required areas to extend a minimum of 3.0 inches into the bottom of the bridge deck. For this option, the Bureau prefers that the beam shear reinforcement details be symmetrical. It is preferable to use 0.5-inch increments in the height adjustment rather than a uniform variation. The minimum design limit for shear steel design clearance from the top of the deck shall be 3.75 inches. This will minimize interference of the shear reinforcement with the top layer of reinforcement in the deck. Provide additional 5a3 and #6 longitudinal bars, similar to Option 1, in order to adequately reinforce haunches exceeding 3.0 inches.

This option is preferred at the beam ends where the effect of camber is minimal and the depth of haunch should be subject to minimal variation since it depends primarily on the accuracy of the beam seat elevations.

In cases where the haunch weight exceeds the average haunch weight assumed in the standard beam design, it may be necessary to check the beam design is adequate.

If, after the adjustments, the haunch limits appear not to work for the project, the designer shall consult with the supervising Unit Leader.

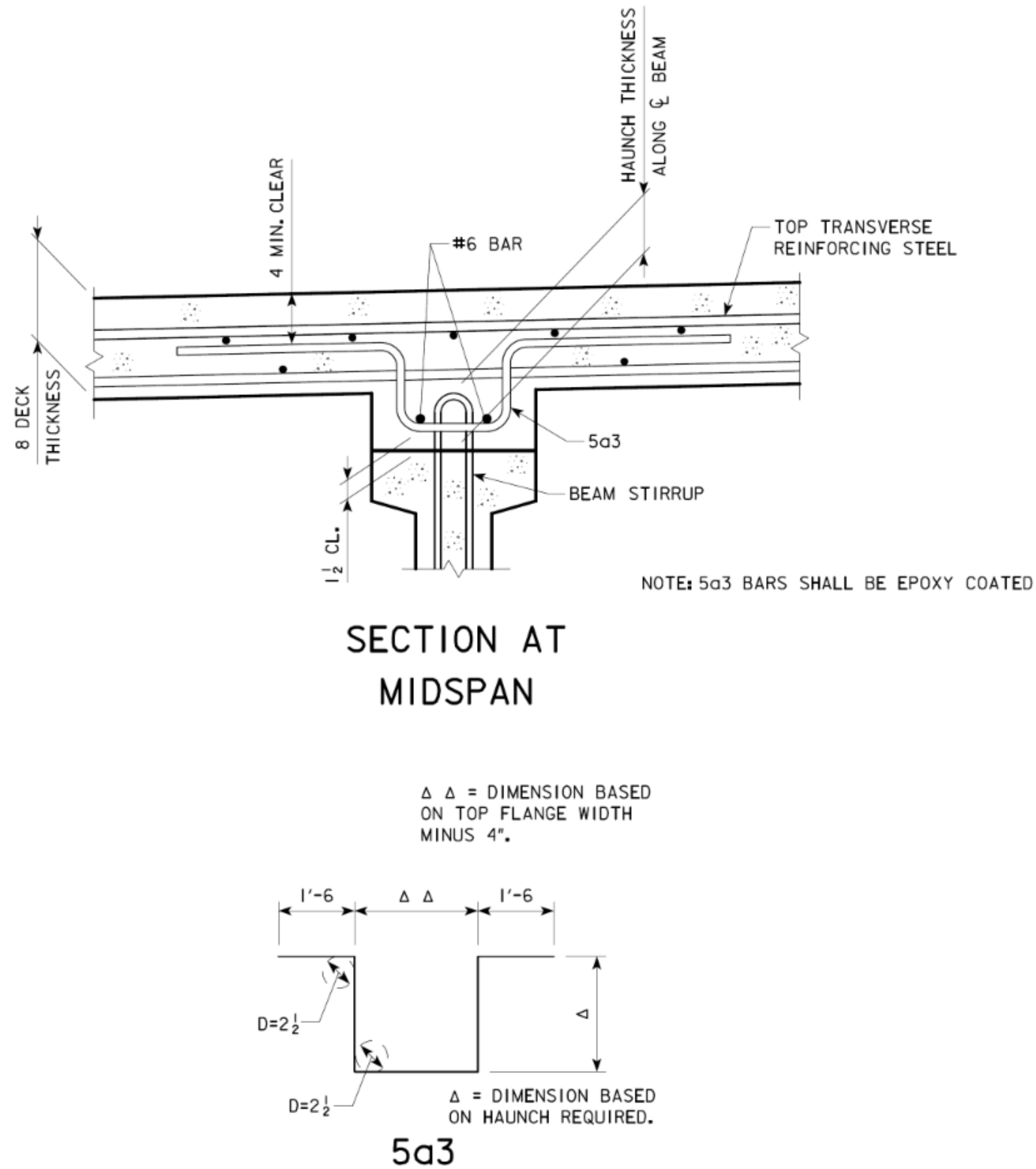


Figure 5.3.2.1. Option 1 reinforcement for thick haunches at midspan
[Note: The deck thickness in the figure is outdated.]

5.3.2.2 Detailing

The designer should provide the following information and haunch details for interior beams on the plans [BSB SS 1065]:

- "Beam Camber Data",
- "Slab Thickness at Beams (T)", and
- "Slab Thickness Details".

In addition, the designer shall provide a plan sheet titled "Slab Haunch Data Details" [BSB SS 1066]. The purpose of the sheet is to provide beam line haunch elevations convenient for the contractor to use in setting field haunch. The designer determines the elevations by taking each beam line slab elevation, subtracting the deck thickness, and adding the theoretical immediate and long-term dead load deflection for the deck and diaphragms. In the field the contractor determines each haunch thickness by subtracting the surveyed top of beam elevation from the beam line haunch elevation on the plan sheet.

The “Slab Haunch Data Details” sheet includes the following:

- “Table of Beam Line Slab Haunch Elevations”;
- “Miscellaneous Data Table” for immediate and long term deflections of the slab and diaphragms, cross slope adjustments, and allowable field haunch;
- A note for “Haunch Locations”; and
- “Haunch Detail”.

Deflections due to permanent loads applied after the deck has hardened, such as deflections due to barrier rail loads, are normally excluded from the above computations since these loads do not typically produce much additional deflection on the composite deck-beam system. Additionally, deflections are typically determined for the interior beams only and are assumed to be similar for the exterior beams when the bridge and beam spacing layouts follow the standard sheets. In relatively complex PPCB bridges, the designer may need to provide separate details for one or more beams if the deflections are expected to vary among the beams. The use of closure pours as described in BDM 5.2.4.1.2 may be a scenario where the deflections among the different beams will not be similar and would require separate details for beams adjacent to the closure pour. The designer shall discuss the presentation of the information for these scenarios with the supervising Unit Leader. The designer shall not rely on field personnel to adjust deflections based on the tributary load to the beams. The designer shall specifically note in the plans that deflections shown in the plans were based on actual slab and diaphragm loads and shall not be adjusted in the field.

5.3.3 CWPG bridges

5.3.3.1 Analysis and design [AASHTO-LRFD 6.10.10.1.4]

Because camber can be cut into the web of a continuous welded plate girder (CWPG), the haunch can be relatively constant, and the design range is limited accordingly. For haunch design, the haunch thickness shall be 0-inch minimum measured at edge of flange and 2-inches maximum measured at centerline of girder.

The maximum and minimum haunch limits may, however, be controlled by shear stud heights. The minimum shear stud clearance from top of deck is 2.75 inches, which may control minimum haunch, and the minimum shear stud embedment into the deck is 2.0 inches [AASHTO-LRFD 6.10.10.1.4], which may control maximum haunch.

To start, set the minimum design haunch at 0.5 inch at centerline of girder but not less than 0.0 inch at edge of the top flange after cross slope is considered. During construction the contractor then will have 0.5-inch tolerance for minimum haunch.

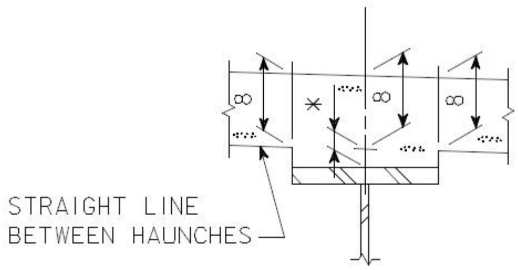
Once the minimum is set, the haunch thickness can be checked along the entire girder line. Changes in thickness of the top flange will affect shear studs, and therefore the changes need to be considered with respect to the haunch thickness shown on the plans.

Check the minimum and maximum haunches based on shear stud heights. The maximum haunch should not exceed 2.0 inches so that the contractor has 1.5-inch tolerance for maximum haunch in the field. Modify the bridge seat elevations, girder camber, and shear stud heights as necessary to fit within the haunch limits. If the haunch limits appear not to work for the project, the designer shall consult with the supervising Unit Leader.

5.3.3.2 Detailing

For typical CWPG bridges the designer should provide the following information and haunch details for interior girders on the plans. (See the example drawing in the commentary [BDM C5.3.3.2] and Figure 5.3.3.2.)

- “Beam Camber and Blocking Diagram”
- ”Deflection Diagram”
- A table containing the following information:
  - Deflections due to concrete only (slab + haunch)
  - Total dead load deflection (slab + haunch + structural steel)
  - Top flange plate thickness, excluding bolted field splice plate thickness
  - Concrete haunch thickness, excluding top flange plate thickness and bolted field splice plate thickness



TYP. DECK & HAUNCH DETAIL

* CONCRETE HAUNCH DIMENSION MEASURED BETWEEN BOTTOM OF SLAB AND TOP OF TOP FLANGE PLATE.

THE MAXIMUM EMBEDMENT OF THE EDGE OF THE TOP FLANGE IN THE DECK SHALL BE $\frac{1}{2}$ INCH. SHEAR STUDS ARE TO HAVE A MINIMUM PENETRATION OF 2 INCHES INTO THE DECK AND BE AT LEAST $2\frac{1}{2}$ INCHES CLEAR OF THE TOP OF THE DECK. THESE REQUIREMENTS WERE USED IN SETTING THE MAXIMUM AND MINIMUM ALLOWABLE FIELD HAUNCH VALUES SHOWN IN THE “MISCELLANEOUS DATA TABLE” SHOWN ELSEWHERE ON THESE PLANS.

Figure 5.3.3.2. Typical slab and haunch detail and note [BSB SS 4305, 4308, 4309, and 4310] [Note: The deck thickness in the figure is outdated.]

In addition, the designer shall provide a plan sheet titled “Slab Haunch Data Details” [BSB SS 1066] with the following:

- “Table of Beam Line Slab Haunch Elevations”;
- “Miscellaneous Data Table” for deflections of the slab and haunch, cross slope adjustments, and allowable field haunch;
- A note for “Haunch Locations”; and
- “Haunch Detail”.

In relatively complex CWPG bridges, the designer may need to provide the deflection, girder fabrication, and theoretical haunch information in special tables and details. The designer shall discuss presentation of the information with the supervising Unit Leader.

5.3.4 RSB bridges

NOTE: The haunch design for the three-span rolled beam standard bridges [RS-standards] are based on an 8.00-inch thick deck with a cover of 2.50 inches to the top transverse reinforcement. The BDM articles below will not be updated for the new 8.50-inch deck thickness and 2.75-inch top cover requirements until the RS-standards have been updated [BDM Preface]. The designer shall discuss custom RSB designs with the Bridge Project Development Engineer.

5.3.4.1 Analysis and design [AASHTO-LRFD 6.10.10.1.4]

For a three-span rolled beam standard bridge the designer shall determine rolled beam haunch with respect to the dead load deflections given on the appropriate standard plan sheet [BSB RS40-061-10 to RS40-070-10].

The designer should stay at least 0.5 inch within the maximum haunch of 3.5 inches at centerline of beam and -0.5 inch at edge of beam. These field limits will be given for the contractor in a note on the plans.

The maximum and minimum haunch limits may, however, be controlled by shear stud heights. The minimum shear stud clearance from top of deck is 2.5 inches, which may control minimum haunch, and the minimum shear stud embedment into the deck is 2.0 inches [AASHTO-LRFD 6.10.10.1.4], which may control maximum haunch.

To start, set the minimum design haunch at 0.5 inch at centerline of beam but not less than 0.0 inch at edge of the top flange after cross slope is considered. During construction the contractor then will have 0.5-inch tolerance for minimum haunch.

Once the minimum is set, the haunch thickness can be checked along the entire beam line. Changes in beam depth will affect shear studs, and therefore the changes need to be considered with respect to the haunch thickness shown on the plans.

Check the minimum and maximum haunches based on shear stud heights. The maximum haunch should not exceed 3.0 inches so that the contractor has 0.5-inch tolerance for maximum haunch in the field. Modify the bridge seat elevations and shear stud heights as necessary to fit within the haunch limits.

If these modifications do not position the haunch within limits, consider camber but generally camber a beam only if the maximum haunch is greater than 2 inches. Rolled beams can be cambered at the mill by cold cambering or at the fabrication shop by cold or heat cambering in accordance with the standard specifications [IDOT SS 2408.02, K].

If the haunch limits appear not to work for the project, the designer shall consult with the supervising Unit Leader.

5.3.4.2 Detailing

For a three-span rolled beam standard bridge the designer should provide the following camber and haunch information on the plans with a standard “Misc. Details” sheet selected for bridge length [BSB SS 5252-5261]:

- “Beam Camber and Blocking Diagram”
- ”Deflection Diagram”
- “Typ. Slab & Haunch Detail”.
- A table containing the following information:
    - Deflections due to concrete only (slab + haunch)
    - Total dead load deflection (slab + haunch + structural steel)
    - Top flange plate thickness, excluding bolted field splice plate thickness
    - Concrete haunch thickness, excluding top flange plate thickness and bolted field splice plate thickness

The “Dead Load Deflection Diagram” is provided as a standard “Beam Deflections” sheet to be selected for bridge length [BSB RS40-061-10 to RS40-070-10].

In addition, the designer shall provide a plan sheet titled “Beam Line Haunch Data” [BSB SS 5264, 5267, etc.]. The sheet shall include the following:

- “Table of Beam Line Haunch Elevations”,
- “Miscellaneous Data Table”, and

- “Haunch Detail”.

Haunch locations are shown on the “Slab Elevations” sheet [BSB SS 5262 or 5263, 5265 or 5266, etc.] and need not be redrawn on the “Beam Line Haunch Data” sheet.