MARYLAND DEPARTMENT OF TRANSPORTATION STATE HIGHWAY ADMINISTRATION	Office of Structures ***Guidelines and Procedures Memorandum***	DESIGN Number: D-18-53(4) Date: 03-16-2018
	Prestressed Concrete	Approval:

The following guidelines and procedures relate to the design of bridges containing prestressed concrete and shall be used in conjunction with the AASHTO LRFD Bridge Design Specifications.

Concrete for Prestressed Girders and Slabs

The minimum 28-day compressive concrete strength specified for all prestressed concrete girders and slabs shall be 8000 psi. The designers shall use 7000 psi for all design calculations. The minimum compressive strength at the transfer of prestress shall be 5800 psi.

The use of lightweight concrete in prestressed concrete elements is prohibited.

Use Self Consolidating Concrete (SCC) for all prestressed concrete girders and slabs.

Prestressing Strands

Use bright ½" diameter 7-wire low relaxation strands for all prestressed concrete girders and slabs. The minimum center-to-center spacing of all strands shall be 2".

Strands shall be placed either straight or harped. Based on the recommendations of the PCI manual (PCI 3.3.2.2.2), the slope of harped strands shall not exceed 9 degrees. Hold down forces at any single harping point shall not exceed 48 kips. In most cases, approximately 12 strands or less can be harped at one point to meet this provision. If more than 48 kips of hold down force is needed for all of the harped strands, the strands that are to be harped shall grouped into multiple harping points that are separated by a minimum of 5 feet.

Debonding any strands in prestressed concrete girders and slabs is prohibited.

For the final design of all prestressed concrete girders and slabs, the refined time-dependent losses in AASHTO-LRFD 5.9.5.4 shall be calculated in lieu of the approximate time-dependent losses in AASHTO-LRFD 5.9.5.3. The following assumptions shall be made:

1. Relative humidity (H) = 75% for Districts 1 and 2, 70% for Baltimore City and Districts 3, 4, 5, 6, and 7
2. Age at Transfer (t_i) = 1 day
3. Age at deck placement (t_d) = 28 days
4. Final Age (t_f) = 36,525 days (100 years)

Mild Reinforcement

For prestressed concrete slabs, only #5 or #6 sized bars can be utilized for the design. For prestressed concrete girders with span lengths less than 150 feet, only #4 or #5 sized bars can be utilized for the design. A note shall be added to the plans to allow a contractor to substitute #3 or #4 bars for the required bars as long as the spacing of the bars is adjusted to match the area of steel per foot of girder.

The minimum center to center spacing of any mild reinforcement bars within prestressed concrete girders and slabs shall be 3".

Minimum clear cover for all mild reinforcing steel shall meet the following:

TYPE OF ELEMENT	LOCATION	CLEAR COVER
Prestressed concrete slabs	Entire perimeter	2"
Prestressed concrete girders	At the bottom of bottom flange	2 ½"
	Around the web and top flange	1 ¼", if #4 bars are used 1 1/8", if #5 bars are used
	Everywhere else	2"

When determining the final shear resistance for all prestressed concrete girders and slabs, the general procedure in AASHTO-LRFD 5.8.3.4.2 shall be calculated in lieu of the simplified procedure in AASHTO-LRFD 5.8.3.4.3.

If the maximum bar size (#5) at the minimum spacing (3") is utilized in the design of some prestressed girders, it may be impossible to conform to the provision in AASHTO-LRFD 5.10.10 for the pretensioned end anchorage zones. If this is the case, the area of reinforcement for end anchorage shall be calculated using all stirrups within a distance of "h" (in lieu of h/4 from AASHTO-LRFD) from the end of the girder, where "h" is the depth of the girder. In all cases, the stirrup reinforcement for prestressed girders shall be spaced at 3" for a distance of "h" from the end of the beam.

Diaphragms

For prestressed concrete girders with a span length between 50 and 100 feet, a single diaphragm shall be place at the midspan of the girders. For prestressed concrete girders with a span length greater than 100 feet, three diaphragms shall be placed at the quarter points of the girders. All diaphragms shall be oriented to be parallel with the centerline of bearing.

The plans shall show cast-in-place concrete details for these elements. At the request of the contractor or if accelerated bridge construction methods are required, the use of precast concrete diaphragms can be utilized. The use of steel diaphragms on prestressed girders is prohibited.

Making spans continuous for live loads

In new multiple span prestressed girders and slabs, the superstructure elements may be connected together to make them continuous for superimposed dead loads and live loads. The girders or slabs and the non-composite dead loads shall be designed and constructed as simply supported beams.

To make the connection between simply supported beams the provision of AASHTO-LRFD 5.14.1.4 will be used. Reinforcement bars (in lieu of the strands or any other system) shall be used to make the connection at the bottom of the girders over the pier as specified in AASHTO-LRFD 5.14.1.4.9b. The age of the girder or slab when continuity is established shall be assumed to be 28 days. Thus, the assumptions in AASHTO-LRFD 5.14.1.4.4 cannot be applied and a positive restraint moment must be calculated using the following assumptions:

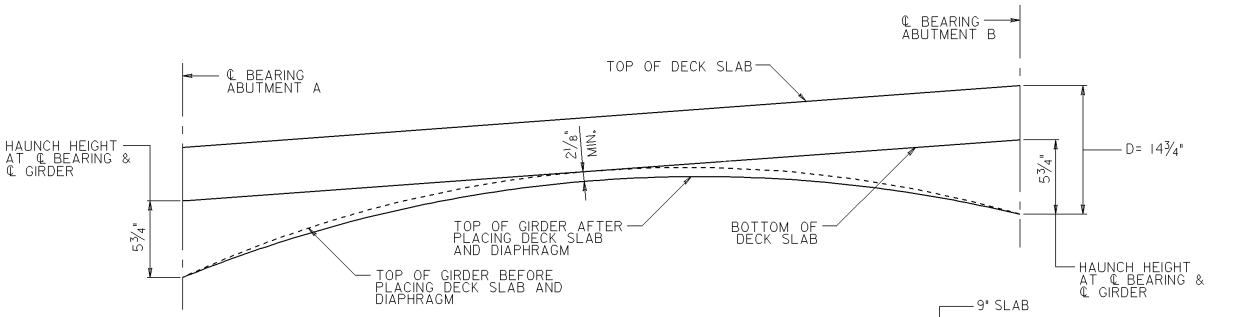
1. Girder concrete ultimate creep coefficient = 2.4
2. Girder concrete ultimate shrinkage = 750 microstrands
3. Deck concrete ultimate shrinkage = 550 microstrands
4. Time between tensioning of strand and prestress transfer = 1 day
5. Time between prestress transfer and establishment of continuity = 28 days
6. Time between prestress transfer and placement of deck = 31 days
7. The restraining effect of the slab reinforcement on shrinkage will not be considered.

For in-house designs, there is a post processor portion of Merlin-Dash that designs this connection using these assumptions as default settings.

Camber and Haunch Depth

Camber calculations for prestressed girders and slabs shall not include the effects of future wearing surfaces.

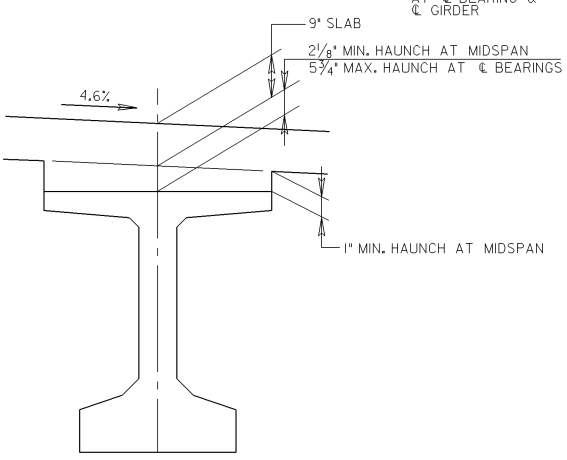
Since the camber calculations for concrete girders assume a minimum concrete strength, the camber values may be different from actual girder. If the concrete strength of the girder is higher than the minimum strength, the girder will achieve less camber. To account for differences in the camber, the haunch depth of the girder (the distance between the top of girder and bottom of deck) will vary along the length of the girder. Using the theoretical camber values, the vertical profile of the bridge, and the cross slope of the roadway, designers should determine the haunch depth at the centerline of the support bearings to achieve a 1" minimum haunch at mid-span of the girder on the outside edge of the flange. This 1" minimum haunch should be calculated assuming that the deck and diaphragms have already been poured and the girders have deflected from their full weight. See sketch below.



CAMBER DIAGRAM
SCALE: NONE

NOTES FOR CAMBER:

1. "D" IS MEASURED FROM THE TOP OF DECK SLAB TO TOP OF GIRDER AT ℄ BEARINGS.
2. SUPERIMPOSED DEAD LOAD (S.D.L.) INCLUDES THE EFFECTS OF THE CONCRETE PARAPET. IT DOES NOT INCLUDE THE EFFECT OF THE FUTURE WEARING SURFACE.
3. CAMBER DUE TO PRESTRESS FORCE PLUS DECK SLAB DEAD LOAD TO BE CHECKED IN THE FIELD PRIOR TO PLACEMENT OF DECK SLAB FORMS. FINISHED GRADE ELEVATIONS SHALL BE OBTAINED BY ADJUSTING THE HAUNCH DEPTH OF THE DECK SLAB TO ACCOMMODATE ANY DIFFERENCE BETWEEN THE PROPOSED AND ACTUAL CAMBER AND DEFLECTIONS.
4. PRESTRESS CAMBER AND DEAD LOAD DEFLECTION DATA SHOWN ARE THEORETICAL AND WILL VARY DEPENDING ON CONCRETE STRENGTH, STORAGE TIME, VARIBLE PRESTRESSING CONDITIONS, ETC.
5. THE CAMBER AND DEAD LOAD DEFLECTION DATA SHOWN ARE THE THEORETICAL VALUES FOR THE ENTIRE BRIDGE DECK SLAB AFTER ALL STAGES OF CONSTRUCTION.
6. GIRDER DEFLECTIONS SHALL BE CHECKED AFTER DECK SLAB POURS AND THE SCREED SETTINGS FOR SUBSEQUENT POURS SHALL BE MODIFIED AS REQUIRED SUBJECT TO THE APPROVAL OF THE ENGINEER.
7. VERTICAL CURVE CAMBER WILL BE HANDLED BY VARYING THE HAUNCH DEPTH.
8. THE HAUNCH DEPTH WILL VARY OVER THE TOP FLANGE DUE TO THE CROSS SLOPE IN THE DECK. THE HAUNCH DEPTH SHALL BE NO LESS THAN 1" AT THE EDGE OF THE TOP FLANGE.



GIRDER SECTION
SCALE: NONE

When designing the girder, a 1" haunch depth shall be used to determine the section properties of the composite girder. The maximum haunch depth shall be used when determining its uniform weight over the length of the beam.