SECTION 9: DECKS AND DECK SYSTEMS

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9.1 Scope

This Section contains guidelines to supplement provisions of Section 9 of the AASHTO LRFD Bridge Design Specifications for the design of bridge decks and deck systems of reinforced concrete, prestressed concrete, metal, or various combinations thereof.

9.4 General Design Requirements

Bridge decks minimum concrete strength f'c shall be 4.5 ksi at 28 days. Refer to Section 5, Article 5.4 (Material Properties) of these guidelines for other requirements.

To provide protection against corrosion the minimum clear cover for reinforcing steel in new deck slabs shall be 2½ inch for top reinforcement and 1 inch for the bottom reinforcement.

Only #5 or #6 bar sizes shall be used as primary reinforcement in the transverse direction and shall be spaced at 1/2-inch increments. Minimum reinforcement spacing shall be 5 inches. Maximum transverse reinforcement spacing shall be 9 inches.

Bar sizes up to #11 may be used as primary reinforcement in the longitudinal direction in slab bridges. This also applies to continuity reinforcement over piers.

All new bridge deck construction or bridge deck replacement located above an elevation of 4,000 feet, or for areas where de-icing chemicals are used, the deck reinforcement shall be epoxy coated (see section 5.4.3 for requirements covering use of epoxy coated reinforcing).

Silica-fume concrete shall be used for new deck construction located at or above an elevation of 4000 feet.

Deck protection systems shall be discussed in the Bridge Selection Report. Recommended options, other than epoxy coated reinforcing, shall be coordinated with ADOT Materials Group and shall be approved by ADOT Bridge Group.

For existing bridges, latex modified concrete overlay, silica-fume concrete overlay or a membrane system with a bonded wearing surface are alternate protection systems that may be considered. Implementation of either one of these alternatives requires coordination with ADOT Materials and Bridge Groups.

A 3/4" V-drip groove shall be located on the underside of the deck overhang for all bridges.

Bridge construction plans shall include the deck pour schedule including a plan view with joint locations, deck pour sequence, and direction of pour (see bridge construction section for more details).

For structural concrete overlay on precast deck bridges, see section 5 for design requirements.

9.5 Limit States

9.5.2 Service Limit States

Deck design is controlled by Service Limit State I. The behavior of bridge decks shall be considered elastic. Decks shall be designed by the working stress method and as stated in this section.

Allowable tensile stress in reinforcing steel, fs shall be limited to 24 ksi.

9.6 Analysis

9.6.1 Methods of Analysis

The most typical deck system used in Arizona is a cast-in-place deck slab spanning transversely over a series of girders. This type of deck shall be designed using an approximate elastic method and the criteria stated in this section.

Refined methods of analysis, such as the Finite Element Method, shall only be used for unconventional, complex structures and with prior approval from ADOT Bridge Group.

Dead load analysis shall be based on a strip method using the following simplified moment equation for both positive and negative moments:

$\frac{wS^2}{10}$, for deck slabs that are continuous over three spans or more
$\frac{wS^2}{8}$, for all other cases

where:

S = the effective span length specified in AASHTO LRFD Article 9.7.2.3
w = the uniformly distributed dead load of the slab system

The unfactored live load moments shall be obtained from AASHTO LRFD Section 4, Appendix A, Table A4-1. Negative moment values shall be based on a distance of 0.0 inch from the centerline of girder to the design section.

9.7 Concrete Deck Slabs

9.7.1 General

9.7.1.1 Minimum Depth and Cover

The thickness of new deck slabs shall be designed in 1/2" increments with the minimum thickness as follows:

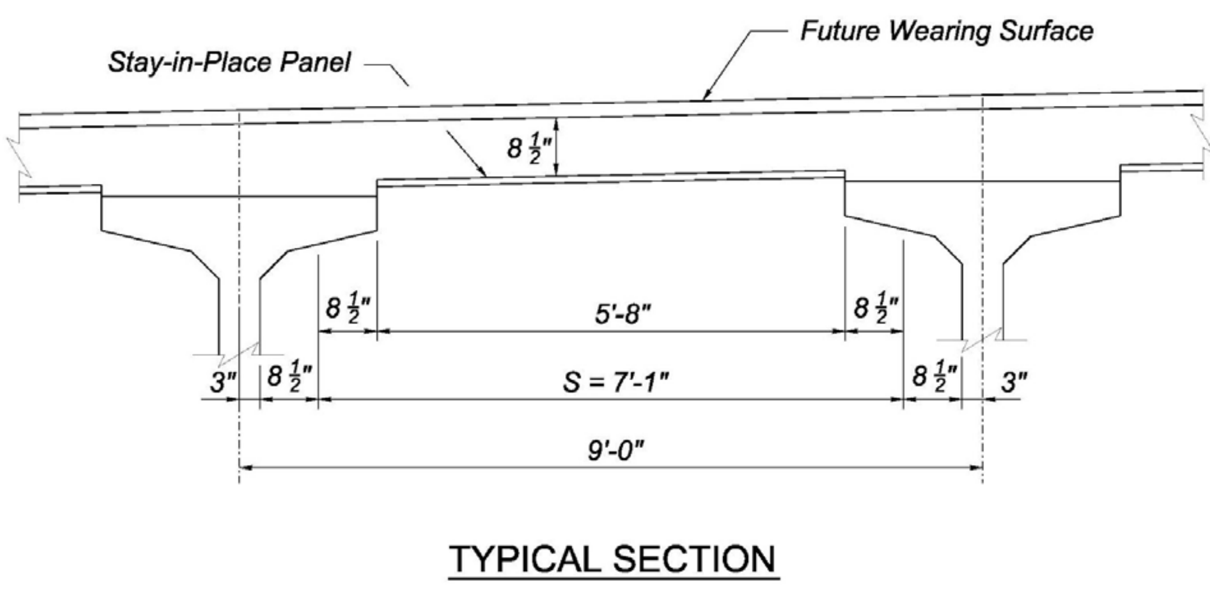
S (ft)	< 7	> 7 and ≤ 8.5	> 8.5 and ≤ 10	> 10 and ≤ 11.5	> 11.5 and ≤ 13
t (in)	8.0	8.5	9.0	9.5	10.0

where:

S = the effective span length specified in AASHTO LRFD Article 9.7.2.3
t = Minimum thickness of deck slab

Note that the slab thickness, t, includes a 1/2 inch wearing surface, which must be excluded from strength and service analysis.

Effective Span Length Example

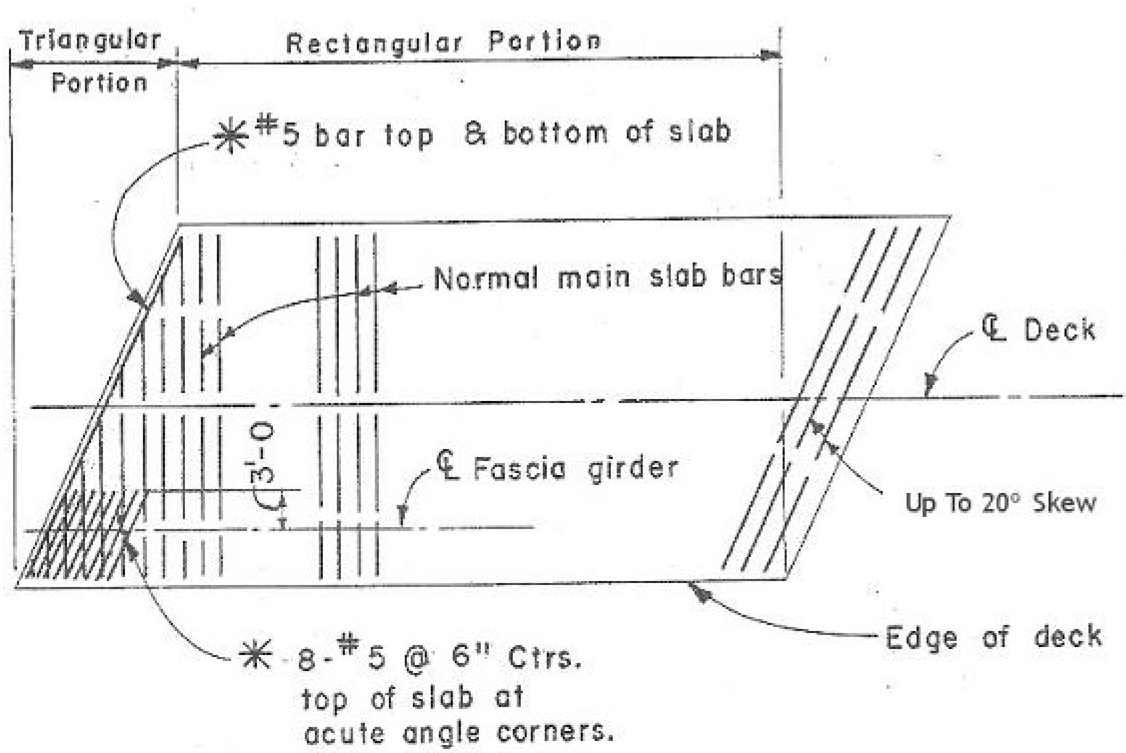


For this example with a centerline-to-centerline web spacing of 9.00 feet and a top flange width of 40 inches, clear spacing = 9-0’ – 40”/12 = 5.67 feet. The effective length is 5.67’ + (17”/12) = 7.08 feet. The resulting minimum deck slab thickness is 8.5 inches, of which 8 inches will be used in strength and service analysis.

9.7.1.3 Skewed Decks

For skew angles less than or equal to 20 degrees, the primary reinforcement shall be placed parallel to the skew. For skew angles greater than 20 degrees the reinforcing shall be placed perpendicular to the main supporting members. The effects of the skew shall be accounted for by providing additional short bars at the deck corners as shown in the figure below. Truss bars shall not be used.

Skewed Girder Bridges



* Use for skew angles of 20° or more at each skewed corner.

9.7.3 Traditional Design

9.7.3.2 Distribution Reinforcement

Distribution reinforcement shall be calculated in accordance with AASHTO LRFD Article 9.7.3.2. The required reinforcement shall be placed in the secondary direction throughout the effective span length between girders in the bottom of the slab.

9.7.4 Stay-in-Place Formwork

9.7.4.1 General

Use of stay-in-place (SIP) formwork shall be investigated for each bridge site during preliminary design and a discussion of this issue shall be included in the Bridge Selection Report. Use of a SIP formwork system may be considered for the following situations:

- When bridges span high traffic volume roadways, deep canyons, perennial streams or canals.
- Where removal of conventional formwork would be difficult or hazardous.

When a SIP formwork system is selected, the contract documents shall include conceptual design and connection details for the SIP system. The contractor shall submit all SIP formwork design calculations and connection details to the design engineer for approval. Shop drawings for the girders including the location of inserts and the SIP formwork, shall be submitted concurrently for review and approval.

9.7.4.2 Steel Formwork

Steel formwork is the preferred stay-in-place formwork for bridge deck construction. The design engineer shall assume an additional 15 psf of dead load due to the weight of the forms and the concrete in the flutes. SIP formwork flutes shall only be filled with structural concrete. The use of foam or polystyrene in the flutes is not allowed.

Steel formwork shall not be considered to be composite with the concrete deck slab. The construction plans shall state the assumed additional weight that the deck, girder and substructure have been designed for due to this method of construction.

Stay-in-place metal forms for cast-in-place concrete decks are considered a falsework system. The additional concrete in the metal flutes shall not be included in the deck concrete quantities and the following note shall be included in the plans when stay-in-place forms are allowed to be used:

No additional payment will be made for the stay-in-place metal forms and the additional concrete placed in the flutes, the cost being considered as included in the contract unit price for deck concrete quantities.

The steel formwork shall be galvanized for corrosion protection.

9.7.4.3 Concrete Formwork

Precast stay-in-place concrete panels used with a cast-in-place concrete topping to create a final composite deck are another form of formwork for deck construction. The panels are designed to span transversely between the girders and are usually prestressed. A full discussion justifying the use of precast concrete deck panels over steel formwork, including all design and construction parameters, shall be included in the Bridge Selection Report before final approval can be considered.

9.8 Deck Overhang Design

The deck overhang shall be designed in accordance with AASHTO LRFD Section 13, Appendix A, Article A13.4. For Design Case 1, the deck shall be designed to resist both the axial force and the bending moments due to the dead load and the horizontal railings impact load. The vertical wheel load shall not be applied simultaneously with these loads. The net tensile strain in the extreme tension steel in the overhang reinforcing for Design Case 1, Extreme Event Load Combination II limit state, shall not exceed 0.025.

For Design Case 3 both the strength and service limit states shall be investigated. For the Service Limit State, the design live load distribution shall be determined using AASHTO LRFD Table 4.6.2.1.3-1.

When traffic barriers are located at the edge of the deck, the minimum slab thickness of the overhang shall be as shown on the barrier standard drawings. Deck reinforcement resisting overhang loadings shall be fully developed at the section under consideration. Reinforcing steel larger than #5 bars may require hooks at the edge of the deck for development length.

Concrete barriers continuous over intermediate supports such as piers shall have a 1/2 inch open joint filled with bituminous joint filler. The joint shall extend from the top of the barrier to within 10 inches of the deck surface with reinforcing below this level made continuous.

The values in the following table shall be used for the design of the deck overhang in conjunction with ADOT Bridge Group Standard Drawings (SD) for concrete barriers. Refer to AASHTO LRFD Section 13, Appendix A13, for definition of the symbols contained in the table.

Barrier Type	M_b	R_w	M_c	M_w	Top rail M_p	Bottom rail M_p	Post M_p	Weight
SD 1.10 38” Single Slope Bridge Concrete Barrier	0	97.38 k	11.29 [a]	35.18	--	--	--	0.457 klf
SD 1.11 42” Single Slope Bridge Concrete Barrier	0	205.6 k	18.65 [b]	78.13	--	--	--	0.574 klf
SD 1.12 Combination Predestrail-Traffic Bridge Railing	0	--	12.69 [d]	57.40 [e]	9.80	9.80 [f]	15.03	0.675 klf

a. M_c = 18.10 at open joints
b. M_c = 19.17 at open joints

c. Assumes 10-inch curb height at parapet
d. M_c = 15.39 at open joints
e. M_w = 47.70 at open joints
f. When fence is omitted
g. Excluding widewalk weight