Section 20 - Deck and Approach Slabs

20.1 High Performance Concrete (HPC) Deck Slabs

1. New construction or the replacement of existing deck slabs of bridge structures that are on the State Highway System shall be based on the construction of a one course deck slab with HPC. HPC is defined as concrete that meets special combinations of performance and uniformity requirements that cannot always be achieved through routine use of conventional constituents and normal placing, mixing and curing practices. The Table below establishes the levels of desired performance for HPC deck slabs.

   Sidewalks, parapets and curb lines on bridges shall also be detailed to be constructed with HPC.

   An HPC element may be further defined as that which is designed to give optimized performance characteristics for a given set of loads, usage and exposure conditions consistent with the requirements of cost, service life and durability.

2. HPC for deck slabs, sidewalks, parapets and curb lines shall consist of the same properties as Class A concrete with the added stipulation that a pozzalonic material is to be included in the mix design.

3. The Designer should familiarize himself with the following performance requirements and test methods that are to be followed for the HPC mix design development. Refer to the *NJDOT Standard Specifications for Roadway and Bridge Construction*.

Performance Characteristic	**Standard Test Method**
Scaling Resistance (X=visual rating of the surface after 50 cycles)	ASTM C 672
Freeze-Thaw Durability (x=relative dynamic modulus of elasticity after 300 cycles)	ASTM T 161 ASTM C 666 Proc. A
Chloride Permeability (x=coulombs)	AASHTO T 277 ASTM C 1202
56 Day Compressive Strength (Design Compressive Strength)	AASHTO T 22 ASTM C 39

   Note: All tests to be performed on concrete samples that are moist or submersion cured for 56 days.

4. With the construction of an HPC deck slab, provision of a concrete overlay protective system is not warranted.

20.2 Design Criteria

1. Refer to Subsection 20.5 herein for concrete cover requirements and detailing guidance.

Provision of a 1½ inch bottom reinforcement cover must be accounted for in bridge structures that are located in a marine environment.

2. The use of either permanent stay in place (S.I.P.) forms or conventional removable timber forms is permitted for deck slab construction.

   For construction over electrified railroad tracks, S.I.P. forms shall always be used.

3. To account for the use of S.I.P. forms, the Concrete Deck Slab Design Table 20.1 in this Section assume that an extra 3/8 inch thickness of concrete is added to the dead load of the slab.

   When the S.I.P. ribs cannot be aligned with the bottom main reinforcement steel, and the forms must be dropped to achieve the 1 inch bottom reinforcement cover, Subsection 20.5 herein, for additional dead load considerations, should be referred to.

4. Section 3 of this Manual should be referred to for stipulations to the *AASHTO LRFD Bridge Design Specifications* that concern design of concrete deck slabs. Otherwise, the criteria of Subsection 9.7 of the *AASHTO LRFD Bridge Design Specifications* shall be followed.

5. One-half (1/2) inch shall be deducted from the actual deck slab thickness in the design calculations as an allowance for depth of sawcut grooved finishing and wear.

6. The superstructure design for bridges shall include a 25 psf provision for future maintenance overlay potential.

7. The deck overhang shall be designed according to the provisions of Subsection A13.4 of the LRFD Specifications except that the nominal traffic barrier resistance to the transverse load, R_w, need not exceed 120% of F_t as specified in LRFD Table A13.2-1 for the respective test levels.

20.3 Concrete Deck Surface and Overlay Protective System

1. Newly constructed decks shall be one-course HPC deck slabs. The concrete deck surface shall be saw cut in accordance with NJDOT Standard Specifications and Construction Details. If overlay system is deemed necessary, HMA overlay system shall be used with the approval of the Manager, Structural Engineering.

2. If any of the concrete bridge slabs are located in areas of significant adverse geometrics (see Subsection 20.9 herein), which could preclude machine finishing of the concrete deck surface, then opinions from construction forces regarding machine finishing capabilities in such cases should be obtained.

3. Assume that the effective slab depth is taken from the bottom of the slab to the center of the top main reinforcement steel.

4. For a precast deck system or a prefabricated superstructure and deck system, HMA overlay is permitted.

20.4 Corrosion Protected Reinforcement In Deck Slabs

1. All concrete deck slab reinforcement steel shall be corrosion protected. Use of epoxy coated, galvanized reinforcement steel is permitted. However, use of stainless steel or stainless steel clad reinforcement is permitted only with the approval of the Manager, Structural Engineering and specified in the Special

Provisions. When epoxy coated reinforcement is planned, the top and bottom layers of rebars in structural deck slabs shall be epoxy coated. These bars include transverse bars, longitudinal distribution bars, corner, skew and header bars.

In culverts, where the top slab is used as a riding surface, both layers of the top slab reinforcement steel shall be corrosion protected.

2. When galvanized reinforcement is considered, both the top and bottom mat layers shall be galvanized. In addition, chairs, tie wires, nuts, bolts, washers, other devices and miscellaneous hardware that is to be used to support, position or fasten the galvanized reinforcement shall be galvanized. Plastic chairs or plastic coated metal hardware, in lieu of galvanized components may be used.

20.5 Deck Slab Design and Construction Detailing

1. The criteria indicated in the following Table is based on a 2½ inch top cover, a 1 inch bottom cover and placement of rebars perpendicular to traffic with concrete strength of f'_c = 4000 psi and reinforcement steel tensile strength of f_y = 60 ksi. The Table has been prepared in order to establish uniformity in design and details. However, a Designer may develop other deck slab configurations. Calculations shall be included in the design folder.
2. The selection of beam spacings cannot be standardized since this is dependent on beam type selection. Generally, beam spacings of 8 to 10 feet are preferred. The basis for the selection of beam spacings shall include consideration of the necessity of future deck replacement and the maintenance of traffic associated with a deck replacement.
3. The main reinforcement shall be placed normal to the stringers regardless of the skew of the deck slabs. The bars shall be straight, continuous, and of the same size and spacing in both the top and bottom of the slab.

Table 20.1 Concrete Deck Slab Design

Span ft	Actual Slab Thickness in	Main Rebar Top and Bottom	Long. Dist. Rebar Top and Bottom	Additional Top Main Rebar in Overhang with 2'-10" Parapet	Additional Top Main Rebar in Overhang with 2'-8" Parapet & Sidewalk
4'-3" to 5'-3"	8 ¼	# 16 @ 12"	# 13 @ 12"	# 19 @ 12"	#19 @ 12"
5'-4" to 6'-3"	8 ½	# 16 @ 11"	# 13 @ 11"	# 19 @ 11"	#16 @ 11"
6'-4" to 7'-3"	8 ½	# 16 @ 9"	# 13 @ 9"	# 16 @ 9"	#13 @ 9"
7'-4" to 8'-3"	9	# 16 @ 8 ½"	# 13 @ 8 ½"	# 13 @ 8 ½"	#13 @ 17"
8'-4" to 9'-3"	9 ½	# 16 @ 8 ½"	# 13 @ 8 ½"	# 13 @ 8 ½"	#13 @ 17"
9'-4" to 9'-10"	10	# 16 @ 8"	# 13 @ 8"	# 13 @ 24"	None
9'-11" to 10'-6"	10	# 19 @ 10"	# 16 @ 10"	# 13 @ 69"	None
10'-7" to 11'-2"	10 ½	# 19 @ 9 ½"	# 16 @ 9 ½"	None	None
11'-3" to 11'-10"	10 ½	# 19 @ 8 ¼"	# 16 @ 9"	None	None
11'-11" to 12'-6"	10 ¾	# 19 @ 8 ¼"	# 16 @ 9"	None	None
12'-7" to 13'-2"	10 ¾	# 19 @ 7 ½"	# 16 @ 8 ½"	None	None

Notes for the above Table:

a. Design is based upon the criteria specified in Appendix A4 of the LRFD Specifications.

b. Span dimensions shall be based on the distance that is the center to center of girders.

4. Designers should locate stud shear connectors to avoid conflicts with the main bottom reinforcement steel spacing. This is due to the fact that there is little room for field adjustment when the main reinforcement steel must match the rib spacing. Shop drawings for S.I.P. forms should be checked accordingly.

5. For continuous beam spans additional corrosion protected longitudinal reinforcement steel shall be provided over the interior supports.

6. The main reinforcement steel pattern in the acute corners of skewed slabs and in the deck slabs of curved girder bridges shall be given special consideration. In the acute corners of skewed slabs, a portion of the main reinforcement may have to be placed in a fanned arrangement extending into the corner of the deck slab. On curved girder bridges, the main reinforcement steel should generally be placed radially.
7. When the main reinforcement will not be aligned with the S.I.P. ribs, a 1 inch thickness of concrete shall be added to the dead load of the slab. This is in lieu of the 3/8 inch thickness of concrete that is specified in Subsection 20.2.3.

   This extra 5/8 inch thickness of concrete will account for the additional dead load that results from dropping the S.I.P. forms.

   Dropping the forms may be needed to achieve the minimum 1 inch bottom rebar cover. A 2 inch nominal form depth shall be assumed. Deeper forms will require additional dead load consideration.
8. When the extra thickness or the dead load is added, the Table 20.1 within this Section is no longer valid. The designer shall develop an independent slab design. The working drawings shall be checked carefully to verify that the intended result is acceptable.
9. In deck slab corners where the acute angle is 65° or less, 7-#16 bars by 15'-0" long shall be placed directly under the top layer of bars. They should be detailed in a fanned arrangement. This reinforcement shall also be corrosion protected; such as, epoxy coated, galvanized or stainless steel.

20.6 Deck Joints

1. Refer to Section 21 of this Manual for the design of transverse and longitudinal joints in deck slabs.
2. Shear locks, as specified in Subsection 24.15 of this Manual, shall be provided with the structural steel work when a longitudinal expansion joint is located in the roadway area.
3. See Guide Sheet Plate 3.8-1 for details of longitudinal joints.

20.7 Haunches On Stringer Bridges

1. All steel stringer bridges with monolithic deck slabs shall be provided with a haunch over each stringer that is to be placed monolithic with the deck slab. The haunch minimum is to be measured from the top of the steel flange to the theoretical bottom of the bottom slab at the center of the web. A deeper haunch may be required when the top flange exceeds 16 inches in width. This is to allow for deck slab cross slopes.
2. The minimum haunch dimension depth shall be one (1) inch and is to be located at the centerline of the span. It shall be calculated to include all factors such as roadway profile, architectural camber, camber for future overlay, camber for future utilities, deck cross slopes, etc.
3. For simple span welded steel girder bridges, the depth of the haunch at the centerline of bearings shall be the minimum depth, that is computed in 2. above, plus the difference in thickness between the maximum and minimum top flange plates.

4. Haunches of fascia beams of multispan bridges shall be set so that the top of the webs of fascia beams in adjacent spans line up.
5. The depth of the haunches shall be labeled on the plans only at the centerline of bearings. The depth of the haunch at the centerline of bearing is necessary on the plans to enable the Contractor to verify the concrete seat elevations. The depth of the haunch at other locations along the span will be computed by the Contractor after the superstructure steel has been erected.
6. Haunches that are greater than 4 inches shall be reinforced with U-stirrups. The minimum reinforcement shall be #16 stirrups at 12 inches.
7. Where field splices in the stringers are shown on the plans or permitted in the Specifications, the haunch shall be a minimum depth of 1 inch over the splice plate. A 1 inch minimum clear cover shall be maintained between the main steel reinforcement and the bolts.

20.8 Concrete Placing Sequence

1. A concrete deck slab placing sequence shall be shown on the plans for deck slabs supported by trusses, arches, continuous and cantilevered design. Other types of structures, such as single span curved girder bridges, may also require special deck placement sequences. The Designer shall evaluate unique situations and provide proper guidance on the plans.
2. Details of keyed transverse construction joints for a deck placing sequence should be developed and shown on the plans.

   The transverse construction joint shall be designed as an edge beam. For skewed spans, a skewed-stepped arrangement may be required because of the use of permanent steel stay in place forms.
3. In the construction of Integral Abutment deck slabs, if girder continuity is provided, a deck placing sequence should be detailed for spans greater than 100 feet.

20.9 Machine Finishing for Concrete Deck Surface

1. The following criteria could preclude the use of machine finishing of bridge deck slabs:
   a. The bridge is on a curve of less than 250 feet radius.
   b. The acute skew angle is less than 40 degrees.
   c. The cross slope is variable.
   d. Variable width occurs with non-parallel machine support rails.
   e. Variable width is due to internal variable width lane with grade breaks at the edges of this lane.
   f. Only one structure is in the contract and/or the length is less than 60 feet and curb to curb distance is 24 feet or less.
   g. Staging of construction is such that machine finisher overhang will interfere with active vehicular traffic lanes.
2. It shall be the responsibility of the Structural Design Engineer to show the following note on deck slab plans where the above conditions could conceivably preclude the use of machine finishing:

"Note: Machine finishing of deck slab shall not be required."

20.10 Approach Slabs

1. Approach slabs are required for all bridges on the State Highway System. This shall also apply to the reconstruction of such bridges.
2. For bridge structures not on the State Highway System, if either of the following conditions exist, provision of approach slabs shall not be considered.
   a. When the projected Average Daily Traffic (ADT) is less than 2000 vehicles.
   b. When the Average Daily Heavy Truck Traffic is less than 5% of the ADT.
3. For bridge widening or rehabilitation projects, provision of approach slabs shall be subject to the approval of the Manager, Structural Engineering.
4. Refer to NJDOT Standard Roadway Construction-Traffic Control-Bridge Construction Details for standard approach slab details for constructing approach slabs at existing bridges.

   Design circumstances that vary form the standard plans may require revisions.

   For bridge widening or bridges on new alignments, may require 45′ long approach slabs with other details being the same. The Manager of Structural Engineering should be consulted for approach slab details.
5. To facilitate an estimation of material quantity that is needed to construct the slabs, a Designer may provide a Table that lists the needed concrete, reinforcement steel and sawcut grooving quantities.
6. Refer to Subsection 17.2.7 for approach slab design assumptions.

20.11 Medians

1. Unless precluded by profile and geometric considerations, the median area between parallel bridges shall be "decked over" when the width between curb lines is 30 feet or less. See Guide Sheet Plate 3.6.3.
2. When the median width is greater than 30 feet, cost estimates shall be made for the alternative of "decking over" vs. "open well design".
3. Decking over is preferred in all cases for safety reasons when the extra construction cost is relatively insignificant.
4. Live load design for the median area shall be similar to the bridge deck slab live load design.

20.12 Parapets, Barriers and Sidewalks

1. Provide 3/16″ open deflection joints in parapets at intervals not exceeding 20 feet. Contraction joints at the midpoint between the open joints shall also be provided.
2. Contraction joints shall be provided in sidewalks at the locations of the 3/16″ open parapet deflection joints.
3. Provide 3/16″ open deflection joints in median barriers at intervals not exceeding 15 feet. There shall be no contraction joints between the open joints and no contraction joints located below the open deflection joints (refer to Bridge Construction Details).

4. Full depth joints shall be provided in parapets, median barriers and sidewalks at locations of transverse deck joints and at a distance not exceeding 20 feet. The full depth joint opening width shall equal the transverse deck joint opening width. (See Bridge Construction Details).

5. All reinforcement steel in parapets, median barriers and sidewalks shall be corrosion protected.

6. Refer to Bridge Construction Details for additional reinforcement that is required to prevent concrete cracking in the overhang portion of the deck slab.

20.13 Alternative Deck Slab Systems

1. Subsection 9.8 of the *AASHTO LRFD Bridge Design Specifications* provides criteria on the design of Metal Decks. Criteria is provided for the use of open, filled and partially filled and unfilled grid decks that are composite with a reinforced concrete deck slab.

   Designers are advised that use of metal deck systems must include a fatigue analysis. This analysis should address the installation of the metal deck onto the bridge framing.

2. An example of an unfilled grid deck that is composite with the concrete deck slab is the Exodermic bridge deck system.

   a. The Exodermic system is comprised of an unfilled steel grid, typically 3 inches to 5.2 inches deep, with a 3.5 inch to 5.2 inch reinforced concrete slab on top of the grid.

   b. A portion of the grid extends into the reinforced concrete slab. This creates the composite action.

   c. An exodermic deck system can provide a lighter element to a bridge structure without sacrificing stiffness and strength.

3. Orthotropic Deck systems shall be designed on a project to project basis.

   a. Orthotropic decks are lightweight and can be easily integrated with an existing bridge superstructure.

   b. Orthotropic decks may be used to reduce the bridge dead weight and to eliminate deck joints.

   c. Orthotropic decks consist of steel deck plates that are stiffened by longitudinal ribs and may be of two basic types:

      - With torsionally stiff closed ribs
      - With torsionally soft open ribs

4. The above metal deck systems as well as other prefabricated elements and systems may be evaluated for use in deck replacement projects as well as an overall element of a bridge structure.

5. Such prefabricated deck systems may be used where rapid deployment is a consideration. Concerns for traffic disruption and getting a bridge back into service as quickly as possible can play into the decision making with their use.

6. Use of precast concrete deck panels and prefabricated concrete deck slabs that are built into girder systems may also be considered when rapid deployment is an issue.