VIRGINIA DEPARTMENT OF TRANSPORTATION

STRUCTURE AND BRIDGE DIVISION

INSTRUCTIONAL AND INFORMATIONAL MEMORANDUM

GENERAL SUBJECT:	NUMBER:
VDOT Modifications to the AASHTO *LRFD Bridge Design Specifications*, 8th Edition, 2017 VDOT Modifications to the AASHTO *LRFD Guide Specifications for the Design of Pedestrian Bridges*, 2009, 2015 Interims	IIM-S&B-80.6
SPECIFIC SUBJECT:	Date: October 31, 2018
	SUPERSEDES: IIM-S&B-80.5
DIVISION ADMINISTRATOR APPROVAL:	/original signed/ Kendal R. Walus, P.E. State Structure and Bridge Engineer Approved : October 31, 2018

Changes are shaded.

The AASHTO *LRFD Bridge Design Specifications*, 8th Edition, 2017, including its Errata, the AASHTO *LRFD Guide Specifications for the Design of Pedestrian Bridges,* 2009, including its 2015 Interims, and the following VDOT Modifications are effective for projects with an Advertisement date after June 11, 2019. The LRFD specifications are applicable to new construction, total bridge replacement, superstructure replacement, widening projects, etc.

Variance from the VDOT Modifications to the specifications shall require a design exception, design waiver or design approval. For complete information on and requirements of design exceptions/waivers/approvals, see Section Pre.02 of Part 1 of the Manual of the Structure and Bridge Division.

The requirements of Part 2 of the Manual of the Structure and Bridge Division shall be adhered to in conjunction with this IIM.

SECTION 1: INTRODUCTION:

Load modifiers:

Load modifiers specified below shall be used. Each condition shall be compounded when applied.

1. For fracture critical elements, η_R shall be taken as 1.05 for service and strength limit states.
2. For permanent vehicular structures which cannot be easily widened (including, but not limited to, trusses, concrete segmental boxes and bridges supported by Straddle Bents or Integral Caps, η_R shall be taken as 1.05 for strength limit states.
3. For all post-tensioned concrete superstructures, the superstructure(s) shall be taken as η_I =1.05 for service limit states. And when superstructure is post-tensioned, integral pier substructures (including but not limited to, Integral Straddle Bents, Integral Caps and pier caps) shall be designed using η_I = 1.05 for both service and strength limit states. Integral abutments shall be designed for η_I = 1.0.
4. When external tendons and/or unbonded internal tendons are used (for superstructure or substructure), elements shall be designed using η_R = 1.05 for both service and strength limit states and η_D = 1.05 for strength limit states.

For other conditions, all load modifiers (η_D, η_I , η_R and η_i) shall be 1.0 for all limit states.

Situation 1: Fracture Critical Structures				
		η_I	η_D	η_R
Sub structure	Service	1.0	1.0	1.05
	Strength	1.0	1.0	1.05
Super structure	Service	1.0	1.0	1.05
	Strength	1.0	1.0	1.05

Situation 2: Not Easily Widened Structures				
		η_I	η_D	η_R
Sub structure	Service	1.0	1.0	1.0
	Strength	1.0	1.0	1.05
Super structure	Service	1.0	1.0	1.0
	Strength	1.0	1.0	1.05

Situation 3: Post-tensioned Superstructures				
		η_I	η_D	η_R
Sub* structure	Service	1.05	1.0	1.0
	Strength	1.05	1.0	1.0
Super structure	Service	1.05	1.0	1.0
	Strength	1.0	1.0	1.0

* Only for integral pier substructures

Situation 4: Structures with tendons (External or Unbonded internal)				
		η_I	η_D	η_R
Sub structure	Service	1.0	1.0	1.05
	Strength	1.0	1.05	1.05
Super structure	Service	1.0	1.0	1.05
	Strength	1.0	1.05	1.05

All Other Structures				
		η_I	η_D	η_R
Sub structure	Service	1.0	1.0	1.0
	Strength	1.0	1.0	1.0
Super structure	Service	1.0	1.0	1.0
	Strength	1.0	1.0	1.0

Examples:

Structure Type		**Condition**	**Limit State**	η_I	η_D	η_R	**η_i**
Steel straddle bent with multiple beam/girders	Sub Str.	1: Yes	Service	1.0	1.0	1.05	Service = 1.05 Strength = 1.103
			Strength	1.0	1.0	1.05	
		2: Yes	Service	1.0	1.0	1.0	
			Strength	1.0	1.0	1.05	
		3: No	Service	1.0	1.0	1.0	
			Strength	1.0	1.0	1.0	
		4: No	Service	1.0	1.0	1.0	
			Strength	1.0	1.0	1.0	
		Final	**Service**	**1.0**	**1.0**	**1.05**	
			Strength	**1.0**	**1.0**	**1.103**	
	Super Str.	1: No	Service	1.0	1.0	1.0	Service = 1.0 Strength = 1.05
			Strength	1.0	1.0	1.0	
		2: Yes	Service	1.0	1.0	1.0	
			Strength	1.0	1.0	1.05	
		3: No	Service	1.0	1.0	1.0	
			Strength	1.0	1.0	1.0	
		4: No	Service	1.0	1.0	1.0	
			Strength	1.0	1.0	1.0	
		Final	**Service**	**1.0**	**1.0**	**1.0**	
			Strength	**1.0**	**1.0**	**1.05**	

Structure Type		**Condition**	**Limit State**	η_I	η_D	η_R	**η_i**
An integral concrete straddle bent with unbonded internal tendons and post-tensioned superstructure	Sub Str.	1: No	Service	1.0	1.0	1.0	Service = 1.103 Strength = 1.216
			Strength	1.0	1.0	1.0	
		2: Yes	Service	1.0	1.0	1.0	
			Strength	1.0	1.0	1.05	
		3: Yes	Service	1.05	1.0	1.0	
			Strength	1.05	1.0	1.0	
		4: Yes	Service	1.0	1.0	1.05	
			Strength	1.0	1.05	1.05	
		Final	**Service**	**1.05**	**1.0**	**1.05**	
			Strength	**1.05**	**1.05**	**1.103**	
	Super Str.	1: No	Service	1.0	1.0	1.0	Service = 1.103 Strength = 1.158
			Strength	1.0	1.0	1.0	
		2: Yes	Service	1.0	1.0	1.0	
			Strength	1.0	1.0	1.05	
		3: Yes	Service	1.05	1.0	1.0	
			Strength	1.0	1.0	1.0	
		4: Yes	Service	1.0	1.0	1.05	
			Strength	1.0	1.05	1.05	
		Final	**Service**	**1.05**	**1.0**	**1.05**	
			Strength	**1.0**	**1.05**	**1.103**	

SECTION 2: GENERAL DESIGN AND LOCATION FEATURES:

Deflections: Deflection limits as noted in Article 2.5.2.6.2 shall be adhered to.

Maximum Span Lengths: Maximum span lengths shall be limited by applicability of distribution factors for cross section types as shown in Article 4.6.2.2.2—*Distribution Factor Method for Moment and Shear* even when a refined analysis is used.

Span-to-Depth Ratios: Span to depth ratios as noted in Article 2.5.2.6.3, including Table 2.5.2.6.3-1, shall be used. For variable web depth structures, the maximum ratio between the deeper web depth and the shallower web depth shall be less than or equal to 2.0.

Drainage: See Chapter 22 of Part 2 of the Manual of the Structure and Bridge Division for guidance. Gutter flow shall be intercepted at cross slope transitions to prevent flow across the bridge deck.

SECTION 3: LOADS AND LOAD FACTORS:

Application of Vehicular Live Load:
In Article 3.6.1.3.1 - General, the following shall be added to the list of extreme force effects:

The Notional Rating Load (NRL) rating factors shall be computed under conditions required by current VDOT IIM-S&B-86. Bridge shall be designed so that the rating factors exceed 1.0. Substructures need not be checked for NRL.

Future Wearing Surface: An allowance of 15 psf minimum shall be used.

Construction Tolerances/Construction Methods: An allowance of 20 psf carried by the non-composite section of beam/girder span(s) having cast-in-place slabs shall be used. This allowance is sufficient to cover additional loads incurred by the use of stay-in-place metal forms and extra slab thickness caused by construction tolerances. The 20 psf shall be applied to the entire area of the deck not only where stay in place forms are used.

An allowance of 10 psf shall be applied where metal stay-in-place forms are not required, for example, prestressed concrete voided slabs, adjacent box beams, etc. which will have cast-in-place concrete slabs or asphalt overlays.

Wearing Surface: All concrete deck slabs shall be considered to have a ½" integral wearing surface which shall be included in the loads but not considered as part of the design section.

Multiple Presence Factors: When designing superstructure or substructure elements which are not capable of redistribution of load (single columns, hammerhead piers, concrete straddle bents) or are fracture critical (steel straddle bents), the multiple presence factors in Section 3.6.1.1.2 shall not be taken as less than 1.0 regardless of the number of lanes loaded on the structure for average tributary spans greater than 120 feet. For spans less than 100 feet, the multiple presence factor shall be taken as 1.2 for all configurations. For average lengths between 100 and 120 feet, the multiple presence factor shall vary linearly from 1.2 to 1.0.

Pier protection:

Pier protection or strengthening shall be provided when the edge of a permanent traffic through lane is within 30 feet of the pier. Edge of pavement, edge of roadway, edge of traveled way and edge of traffic lane are all equivalent in the context of the clarification above for the purposes of Article 3.6.5.1.

Settlements:

Total settlement shall be limited to 2 inches at each substructure unit. Post construction settlement shall be limited to 1 inch at each substructure unit. Total settlement (S_{TOT}) is defined as the arithmetic sum:

$$S_{TOT} = \text{Elastic settlement} + \text{Consolidation settlement} + \text{Secondary settlement}$$

Differential settlement at a single substructure unit shall be limited to a vertical value which does not exceed a slope of from the horizontal of 0.001 radians between as measured from the center to center of columns or of footings. The combined construction and post construction differential settlement shall not exceed 0.001 radians.

Force Effects Due to Superimposed Deformations: The design thermal movement range associated with a uniform temperature change shall be calculated using Procedure A Temperature Ranges, Table 3.12.2.1-1. The moderate climate range shall be used for steel or aluminum superstructures and cold climate range shall be used for concrete superstructures.

The full design thermal movement range associated with a uniform temperature change shall be used for joint design. 65% of the design thermal movement range associated with a uniform temperature change shall be used for non-slip expansion bearing design and the determination of superstructure forces transferred to the substructure for non-slip expansion and fixed bearings. Shrinkage shall also be considered for joint, bearing and substructure design of concrete superstructures using a shrinkage coefficient of 0.0003 except for segmentally constructed bridges which shall be estimated in accordance with Article 5.4.2.3. For typical multi-beam/girder prestressed concrete superstructures not integral with the substructure, the shrinkage coefficient can be considered to include superstructure creep effects.

See the Manual of the Structure and Bridge Division, Part 2, Chapter 15, Section 4 for specific modeling requirements and examples.

Load Factors for Uniform Temperature, TU: From Article 3.4.1 including Table 3.4.1-1, Load Combinations and Load Factors:

For deformations (e.g., joint and bearing design):
LF_{TU} = 1.2 for both strength and service load

For all other effects (e.g., temperature forces transferred to the substructure):
LF_{TU} = 0.5 for strength limit state (LS) for simplified analysis using gross moment of inertia
LF_{TU} = 1.0 for strength LS for refined analysis using partially cracked moment of inertia
LF_{TU} = 1.0 for service limit state

SECTION 5: CONCRETE STRUCTURES:

Classes of Concrete: Classes of concrete and corresponding compressive strengths shall be designated in the plans (General Notes, table of quantities and on other plans sheets as needed).

Concrete Class	General Use	Specified Compressive Strength (f'_c) (ksi)
A5	Prestressed members	5 - 10
A4	Superstructures (incl. deck slabs, integral backwalls, sidewalk rails, parapets, terminal walls, medians and median barriers); box culverts; rigid frames; reinforced substructures when needed for strength	4
A3	Reinforced substructures	3
B2	Massive or lightly reinforced substructures	2.2
C1	Massive unreinforced substructures; bag riprap	1.5
T3	Tremie seal	3

Reinforcing Steel: Structures shall be designed using Grade 60 reinforcement (deformed bars) and shall be noted on the plans.

Some structure elements require Corrosion Resistance Reinforcing (CRR) steel. For the type of CRR to be used and location(s), see current IIM-S&B-81. Design shall be based on a yield strength of 60 ksi for all types of CRR except for the box culverts and rigid frames where a yield strength of 75 ksi may be used.

Galvanized reinforcing steel (except for use with prestressed piles) and epoxy-coated reinforcing steel (except where designated in prestressed beams with CFRP strands) shall not be used.

Control of Cracking by Distribution Reinforcement: Class 2 exposure condition shall only be used for segmental concrete box girders.

Column Reinforcement: Circular columns are to be designed as tied columns. However, the confinement steel shall be spirals (#3 reinforcing bars minimum) or welded wire fabric. The pitch of the spiral shall be taken as the required spacing for ties.

Minimum Concrete Cover: The following minimum cover (inches) shall be provided for reinforcement:

Location	Normal Condition	Corrosive Environment(1)	Marine(2)
Pier caps, bridge seats and backwalls:			
Principal reinforcement	2 ¾	3 ¾	4
Stirrups and ties	2 ¼	3 ¼	3 ½
Pier caps, bridge seats and backwalls (at open joint locations):			
Principal reinforcement	3 ¾	3 ¾	4
Stirrups and ties	3 ¼	3 ¼	3 ½
Footings and pier columns:			
Principal reinforcement	3	4	4
Stirrups and ties	2 ½	3 ½	3 ½
Cast-in-place deck slabs:			
Top reinforcement(3)	2 ½	2 ½	2 ½
Bottom reinforcement	1 ¼	1 ¼	2
Precast and cast-in-place slab spans:			
Top reinforcement(3)	2 ½	2 ½	2 ½
Bottom reinforcement	2	2	3
Prestressed slabs and box beams:			
Top steel	1 ¾	2 ¾	2 ¾
Stirrups and ties	1 ⅛	1 ⅛	1 ⅛
Reinforcement concrete box culverts and rigid frames with more than 2 ft. fill over top of slab:			
Top slab – top reinforcement	1 ½	2 ½	3
Top slab – bottom reinforcement	1 ½	2 ½	3
Inside walls and bottom slab top mat	1 ½	2 ½	3
Outside walls and bottom slab bottom mat	1 ½	2 ½	3
Reinforcement concrete box culverts and rigid frames with less than 2 ft. fill over top of slab:			
Top slab – top reinforcement	2 ½	2 ½	3
Top slab – bottom reinforcement	2	2 ½	3
Inside walls and bottom slab top mat	1 ½	2 ½	3
Outside walls and bottom slab bottom mat	1 ½	2 ½	3
Rails, rail posts, curbs and parapets:			
Principal reinforcement	1 ½	1 ½	1 ½
Stirrups, ties and spirals	1	1	1
Concrete piles cast against and/or permanently exposed to earth (not applicable for prestressed concrete):	3	3	3
Drilled shafts:			
Principal reinforcement	4	5	5
Ties and spirals	3 ½	4 ½	4 ½
All other components not indicated above:			
Principal reinforcement	2 ½	3 ½	3 ½
Stirrups and ties	2	3	3

(1) Corrosive environment affects cover where concrete surface is in permanent contact with corrosive soil.
(2) Marine includes all locations with direct exposure to brackish and salt water.
(3) Includes ½ inch monolithic (integral) wearing surface.

Strength of Prestressed Members:

Concrete strengths from 5 to 10 ksi may be used.

Strengths greater than 10 ksi require a design waiver approved by the State Structure and Bridge Engineer.

Maximum strength of lightweight concrete shall be limited to 8 ksi. Strengths between 8 ksi and 10 ksi require a design waiver approved by the State Structure and Bridge Engineer.

Spacing of Strands: The spacing of strands shall be 2 inches c-c minimum for strands up to 0.6 inches in diameter.

Prestress Loss: Gains due to elastic deformations shall not be used to determine total prestress losses.

Post-tensioned Structures: Structures requiring post-tensioning (using ducts and grouting or flexible filler) shall not be used without a design waiver approved by the State Structure and Bridge Engineer. Exempt are prestressed voided concrete slabs with transverse ties (Manual of the Structure and Bridge Division, Part 5, PSS-series) or prestressed concrete boxes with transverse ties.

For Precast Segmental and Cast-in-Place Post-tensioned Segmental boxes, the tensile stress limit at service limit states, due to permanent loads only, shall be 0 ksi (no tension). This limitation shall apply to all portions of superstructure not replaceable by conventional means.

Post-tensioned straddle bents shall not allow concrete tension under service limits.

SECTION 6: STEEL STRUCTURES:

The requirements of Chapter 11 of Part 2 of the VDOT's Manual of the Structure and Bridge Division shall be adhered to.

SECTION 9: DECKS AND DECK SYSTEMS:

Deck Design: Cast-in-place concrete deck slabs supported on beams/girders (steel or prestressed concrete) shall be designed by the strip method. Crack control shall not be applied for deck slab design including deck slab extensions. The maximum spacing of primary reinforcement shall not exceed the slab depth minus ½" wearing surface. Bars larger than #5 shall not be used for transverse reinforcement. Distribution bars shall be limited to #4 bars except in the negative moment areas where the maximum bar size shall be limited to #6 bars.

The empirical method for deck slab design shall not be used.

Cantilever Deck Slab Design: If all of the following requirements are met, the cantilever deck slab shall be detailed with additional #5 bars between the transverse bars in the top layer. This is the minimum requirement of reinforcement with or without additional analysis. The bars shall extend past the exterior beam/girder with the development length extending past the contraflexure point in the slab.

- beam/girder spacing is less than or equal 12'-0"
- cantilever length is less than or equal to 0.3 x beam/girder spacing
- railing/parapet type (if any on the cantilever) is an approved VDOT crash tested system
- additional loads (i.e. soundwall, utilities, etc.) are not added to the cantilever except for fencing as shown in BPF-series standards.

If any of the above requirements is not met, the cantilever deck slab shall be designed in accordance with AASHTO LRFD A13.4 with the revisions described in "Decks supporting concrete parapet railings" and "Decks supporting Post-and-Beam railings".

For the VDOT approved Kansas Corral rails: The deck overhang may be designed with the method described in "Decks supporting concrete parapet railings" (section below).

Decks supporting concrete parapet railings: For Design Case 1 in AASHTO LRFD A13.4.1, the deck overhang shall be designed to resist the combined effects of tensile force T and moment M_s, and other applicable forces at the inside face of the parapet or the gutter line, as specified as follows:

For an interior parapet segment

$$T = \frac{1.2F_t}{L_t + 2H}$$

$$M_s = \frac{1.2F_t H}{L_t + 2H}$$

For an end parapet segment

$$T = \frac{1.2F_t}{L_t + H}$$

$$M_s = \frac{1.2F_t H}{L_t + H}$$

F_t = transverse force specified in Table A13.2-1 (kips) of AASHTO LRFD
L_t = longitudinal length of distribution of impact force F_t (ft)
H = height of wall (ft)
T = tensile force per unit of deck length (kip/ft)
M_s = design moment in the deck overhang due to F_t (kip-ft/ft), not greater than 110% of the average of M_c of the bridge railing/parapet, M_{c_ave}
M_c = resistance of the parapet about an axis parallel to the longitudinal axis of the bridge (kip-ft/ft)
$L_t + 2H$ = Distribution length for interior parapet section at the gutter line
$L_t + H$ = Distribution length for end parapet section at the gutter line

The following design values may be used to design the deck overhang.

Railing Type (Test Level)	**T (kip/ft)**		**M_{c_ave} (kip-ft/ft)**		**M_s (kip-ft/ft)**	
	Interior	End	Interior	End	Interior	End
32” F-shape (TL-3)	6.9	9.7	12.5	12.5	13.8	13.8
42” F-shape (TL-5)	10.0	13.0	21.6	21.6	23.8	23.8
CPSR (TL-4)	8.6	11.8	15.4	15.4	16.9	16.9

At the sections other than the gutter line in the deck overhang, T and M_s may be distributed over a length which equals the distribution length at the gutter line plus 2*(distance from the gutter line)*tan(30^o) for an interior parapet segment, and the distribution length at the gutter line plus the distance from the gutter line*tan(30^o) for an end parapet segment.

Decks supporting Post-and-Beam railings: the deck overhang shall be designed in accordance with the AASHTO LRFD A13.4.3.

Designer shall consider additional loads on the cantilever or blister. Examples include fencing, soundwall attachments, supports for sign structures, etc.

Integral Wearing Surface: The ½” integral wearing surface shall not be included in the computation of section properties of composite beams/girders or for deck slab design, however, it shall be used in the computation of dead loads.

SECTION 10: FOUNDATIONS:

Spacing of Piles:

Concrete piles: Not less than 3 x diameter or side dimension of the piles.
Not greater than 10’-0” for piles within a row.

Steel H- piles: As friction piles: Not less than 3.5 x nominal size of the piles.
As bearing piles: Not less than 2’-6”.
Not greater than 10’-0” for piles within a row.

Timber piles: Not less than 2'-6".
Not greater than 10'-0" for piles within a row.

Edge Distance of Piles: The distance from the side of any pile to the nearest edge of the footing shall not be less than 9".

Driving Tolerance of Piles: Driving tolerance(s) for piles shall be considered when determining shear at the critical section.

Driving Tolerances for Steel and Concrete Piles *		
Pile Location/Condition	**Tolerance for Single Pile**	**Direction**
For elements supported by a single row of piles (plumb, battered or staggered). Includes but is not limited to bent caps, full integral abutments and abutments behind MSE walls.	± 3"	About long axis of footing
Footings for column piers	± 6"	About both major axes
Footings for abutments, retaining walls and piers except as noted above.	± 6"	About long axis of footing

* For driving tolerances of timber piles and other information, see VDOT *Road and Bridge Specifications*, Section 403 and Table IV-1.

Projection (Embedment) of Piles in Caps/Footings:

Pile type	**Minimum projection (embedment)**
Cast-in-place or precast concrete piles (including cylinder piles and drilled shafts)	6" into concrete with reinforcement projecting to obtain development as required by the design 18" for prestressed concrete piles with CFRP strands
Steel H-piles	12" into footings
Steel H-piles: when subjected to intermittent uplift (under any loading conditions) in areas subject to uplift under seismic load	18" into footing unless other methods of anchoring the pile to the footing are provided 18" plus a positive method of anchoring the pile to the footing
Timber piles	12" into footings

Minimum Footing Depth: Minimum footing depth shall be 3'-0".

Pile Bents: Cast-in-place piles shall not be used in pile bents or in soils which may induce shell collapse during driving.

Collision Walls: For details and requirements, see the Manual of the Structure and Bridge Division, Part 2, Chapter 6.

SECTION 11: ABUTMENTS, PIERS, AND WALLS:

Temperature and Shrinkage Forces Transferred to Substructure: Temperature and shrinkage forces where applicable shall be computed taking into account fixity, bearing type and pier stiffness.

For non-slip expansion and fixed bearings, the maximum superstructure movement at each substructure unit for force determination is as follows:

$$\Delta_O = (0.65 \times \Delta_T) + (\text{shrinkage}) = 0.65 \times (\alpha \times T_R \times L_{exp}) + (L_{exp} \times 0.0003)$$

where: Δ_O = maximum horizontal displacement of the superstructure, in.
$\Delta_T = \alpha \times T_R \times L_{exp}$ = the design thermal movement range, in.
α = coefficient of thermal expansion, in./in./°F
T_R = temperature range, °F (See Section 3 modifications)
L_{exp} = expansion length, in.

Uniform Temperature, TU, and Shrinkage, SH, are summed in the equation for Δ_O above. The force effects of both can be considered together because load factors for TU (all other effects) and SH are the same in both the strength and service limit states. Load factors are not shown in the equation for Δ_O above, but are applied to the force effects derived from the maximum horizontal displacement of the superstructure, Δ_O. Note that the load factors for force effects for both Uniform Temperature, TU, and Shrinkage, SH, in the strength limit state depend on whether I_g or $I_{effective}$ was used to derive forces.

Typical pier and abutment software apply load factors to derived forces internally. Designers shall ensure that the appropriate load factors are used in abutment and pier software programs for TU and SH. Designers must apply the appropriate load factors for the load combination limit state to the derived forces in any hand computations.

For slip expansion bearings, the maximum superstructure movement at each substructure unit for force determination need not be taken larger than the deformation corresponding to first slip using the extreme values of the friction coefficient between the sliding surfaces. Designers are cautioned that friction values often vary with compression stress, since slip velocity is low, coefficient of friction values used to initiate slip shall correspond to DL, even when the load combination includes both DL and LL.

Expansion and Contraction Joints: Expansion and contraction joints are not required for abutments and conventional retaining walls which have the required shrinkage and temperature reinforcement in Article 5.10.6 and a length not greater than 100 feet.

Substructure: Substructures shall be self-supporting under all service life conditions including superstructure replacement. Superstructure shall not participate in the stability or strength of the substructure. Three (3) sided precast rigid frames are exempt from the self-supporting requirement.

SECTION 13: RAILINGS:

Crash tested parapets/rails shall be used on all projects. See Chapter 25 of Part 2 of the Manual of the Structure and Bridge Division for additional information.

The minimum height of a pedestrian and/or bicycle railing shall not be less than 54" measured from the top of the walkway/riding surface. See also Chapter 6 (Geometrics), Chapter 25 (Parapets, Railing, etc.) and Chapter 30 (Pedestrian Fencing) of Part 2 of the Manual of the Structure and Bridge Division.

The designer shall consider the use of open rails/parapets for structures over bodies of water in accordance with the Commonwealth Transportation Board resolution dated July 20, 1995.

For the timber initiative, FHWA crash tested timber rail shall be used.

SECTION 14: JOINTS AND BEARINGS:

Steel Reinforced Elastomeric Bearings: Steel reinforced elastomeric pads shall be designed by Method A, Article 14.7.6. For expansion bearings, the maximum total shear deformation of the bearing, Δ_S, shall be calculated as follows with shrinkage where applicable in the service limit state:

$$\Delta_S = LF_{TU} \times (0.65 \times \Delta_T) + LF_{SH} \times (\text{shrinkage}) + LF_{ED} \times (ED)$$
$$= 1.2 \times (0.65 \times \alpha \times T_R \times L_{exp}) + 1.0 \times (L_{exp} \times 0.0003) + 1.0 \times (ED)$$

where: Δ_S = maximum total shear deformation of the bearing, in.
LF_{TU} = Load Factor from Table 3.4.1-1 for temperature deformation = 1.2
LF_{SH} = Load Factor from Table 3.4.1-1 for shrinkage = 1.0
LF_{ED} = Load Factor for expansion due to dead load deflection = 1.0
$\Delta_T = \alpha \times T_R \times L_{exp}$ = the design thermal movement range, in.
α = coefficient of thermal expansion, in./in./°F
T_R = temperature range, °F (See Section 3 modifications)
L_{exp} = expansion length, in.
ED = Expansion due to dead load deflection. ED may be only considered for expansion bearings at the abutments. ED may be ignored if jacking the superstructure and resetting the bearings are included in the plans. This is of particular concern in long span steel structures with high cambers. ED may be estimated with the equations on Page 7-70 and 7-71 of the Manual of Steel Construction, Volume II, 9th Edition, 1992.

From Eq. 14.7.6.3.4-1, $h_{rt} \geq 2 \times \Delta_S$

where: h_{rt} = total elastomer thickness, in.

SECTION 15: DESIGN OF SOUND BARRIERS:

AASHTO *Guide Specifications for Structural Design of Sound Barriers*, 1989 with 1992 and 2002 Interims shall be used in place of Section 15 for design of sound barriers.

AASHTO *LRFD Guide Specifications for the Design of Pedestrian Bridges*, 2009, 2015 Interims.

Pedestrian and Multi-Use Bridges: A dead load wearing surface of 12 psf shall be added for pedestrian bridges wider than 12 feet between handrails if it is anticipated that the bridge could be overlaid in the future.

Fracture Critical Member (FCM): FCM requirements in Article 4.2 shall not be waived.

Number of Panels in a Truss: The number of panels in a truss is limited to 16.

CC: Assistant State Structure and Bridge Engineers
District Structure and Bridge Engineers
FHWA: Bridge Section