CHAPTER 2
DESIGN DATA

2-1 Variations from Current AASHTO LRFD StandardBridge Design-Specifications and Interims

Article 3.35 Dead Permanent Loads

For all bridge floors, except those on movable spans, the design dead load shall include an additional 20 30 lbs/ft^2 (1.0 4 kN/m^2) for future bituminous wearing surface. For movable spans and other unusual type spans, use 8 lbs/ft^2 (0.4 kN/m^2) for future wearing surface.

Article 3.5 Overload Provisions

Disregard the overload provisions for working stress design.

Article 3.76 Highway Live Loads

For all highways regardless of truck traffic, the minimum live load, designated as HL-93, shall consist of a combination of be the design truck or design tandem coincident with the design lane load. Design for the HL-93 loading that results in maximum force effects. HS20 (MS18). -See Section 2-24. For continuous spans, determine the maximum negative moment between points of contraflexure and the reaction at interior piers by positioning two trucks 50 feet apart as specified in the LRFD Specifications.

Provide adequate clearance to avert design for vehicle collision and rail waycar collision with structures. Discuss situations where sufficient clearance cannot be provided with the State Bridge Design Engineer. See the paragraph in this chapter for variations to Article 3.6.5.2., as well as Section 7-11 and 7-12 of this manual.
For all HS20 (MS18) loads, include a special loading consisting of 2 axles only, spaced 4'-0" (1.2 m) apart with 24,000 lbs (107 kN) on each axle. See Figure 2-1. This specialIn general the HL-93 design tandem loading may controls for relatively short simple spans (37 feet (11.3 m) and less). The HS20 (MS18)HL-93 design truck controls for simple spans in excess of 37 feet (11.310.7 m). See Figure 2-2. For continuous spans, the special loading should be investigated for spans up to 40 feet (12.2 m). Design for this special loading if resulting stresses are greater than those for HS20 (MS18) loading. The distribution factor for the fraction of wheel load to any

~~stringer is to be the same as used for present specification loads. The lane loading remains the same as for the HS20 (MS18) loading.~~

Article 3.6.4 **Braking force**

Take the braking force, BR, as 5% of the design truck plus lane load or 5% of the design tandem plus lane load.

Article 3.6.5.2 **Vehicle and Railcar~~way~~ Collision with Structures**

Abutments and piers within distances less than 30 ft. to the edge of roadway shall be protected with a concrete barrier and approach guardrail in lieu of being designed for the equivalent static force of 400 kips. Abutments and Piers within 25'-0 of the centerline of a track must be protected by a crashwall. See Section 7-11 and 7-12.

Article ~~3.23~~4.6.2 **~~Distribution of Loads to Stringers, Longitudinal Beams, and Floor Beams~~Approximate Methods of Analysis**

~~For superstructure design, disregard the 25% allowable stress increase in outside stringers under sidewalks. For substructure design, calculate reactions using simple beam distribution for loads in all positions. Keep the truck within its design traffic lane. For width of design traffic lane, see Figure 2-3.~~

~~For exterior beams and stringers located at the gutter line or beneath the curb, distribute the live load according to the AASHTO Standard Specifications.~~

Design the exterior beams and stringers to have at least as much capacity as interior beams and stringers.

Article 4.6.3 **Refined Methods of Analysis**

When a refined method of analysis is used, a table of live load distribution factors for maximum~~extreme~~ force effects in each span shall be provided in the plans to aid in future analyses for permit issuance and bridge rating.

~~**Article 3.25.1**~~ ~~**Distribution of Wheel Loads on Timber Flooring: Transverse Flooring**~~

~~Normal to the direction of span for plank floor distribution = 12" (305 mm), instead of "width of plank".~~

Article 9.7.2 **Empirical Design: Concrete Decks**

In general, empirical design of concrete decks shall not be permitted.

Article ~~4.5.15~~10.7.1 **Driven Piles: Spacing, Clearances, and Embedment**

Center-to-center spacing for 12 inch (305 mm) prestressed concrete piles shall not be ~~spaced~~ less than 2'-9" (840 mm) ~~center to center~~ in footings. In general, embed pile heads into concrete as follows:

Embedment - Type of Pile
(Dimension to be measured at centerline of pile)

Type of Structure	~~Timber~~	Steel HP	Steel Pipe	12" (305 mm) Prestressed Concrete	Prestressed Concrete Larger Than 12" (305 mm)
Abuts. & Ret. Walls	~~9" (230 mm)~~	9" (230 mm)	12" (300 mm)	9" (230 mm)	12" (300 mm)
End Bent & Bent Caps	~~12" (300 mm)~~	12" (300 mm)	~~12~~9" (300 mm)	12" (300 mm)	12" (300 mm)
Integral End Bents		24"	24"	24"	24"
Pile Footings	~~9" (230 mm)~~	9" (230 mm)	12" (300 mm)	9" (230 mm)	12" (300 mm)

NOTE: Special cases, including Seismic Performance ~~Category B~~Zone 2 or vessel impact analyses, may require more embedment.

~~**Article 4.6.6.2.2**~~ ~~**Drilled Shafts: Splices**~~

~~Splices of longitudinal reinforcing steel in drilled piers do not need to be staggered, and may occur in the same horizontal plane. However, minimum reinforcement spacing must be maintained.~~

~~**Article 4.6.6.2.5**~~ ~~**Drilled Shafts: Reinforcement and Reinforcement Cover**~~

~~Reinforcement and reinforcement cover for drilled piers shall be as described in Section 7-7.~~

Articles 8.15.5.7 and 8.16.6.7 — **Special Provisions for Slabs of Box Culverts**

Service Load Design - Shear stress v_c shall be computed by AASHTO Equation 8-14, but v_c need not be taken less than $0.95\sqrt{f'_c}$ $(0.08\sqrt{f'_c})$ for single cell or multicell box culverts.

Load Factor Design - Shear strength V_c shall be computed by AASHTO Equation 8-59, but V_c need not be taken less than $2\sqrt{f'_c}\,bd$ $(0.017\sqrt{f'_c}\,bd)$ for single cell or multicell box culverts.

Article 8.17.2.1.35.7.3.4 — **Distribution of Reinforcement Steel: Flexural Tension ReinforcementCrack Control by Distribution of Reinforcement**

The maximum spacing requirements of d/6 shall not apply to caps of end bents or multi-column piers.

Article 9.15.2.15.9.4.1 — **Allowable Stresses: Temporary Stresses Before Losses Due to Creep and Shrinkage**

Tension in other areasAreas other than the precompressed tensile zone,

- For girders, box beams, and cored slabs: 200 psi 0.2 ksi (1.4 38 MPa) or 30.0.0948 $\sqrt{f'_{ci}}$ (ksi) (0.25 $\sqrt{f'_{ci}}$) at end.

Article 9.15.2.25.9.4.2 — **Allowable Stresses: Stress at Service Load Limit State After Losses Have Occurred**

Tension in the Precompressed Tensile Zone,

- For bBox beams and cored slabs at all sites: 0 psi (0 MPa) at mid span
- For gGirders at Corrosive corrosive Sitessites: 0 psi (0 MPa)
- For pPrestressed concrete panels at Corrosive corrosive Sitessites: 0 psi (0 MPa)

For other girders and panels, the tension is limited to 60.19 $\sqrt{f'_c}$ (ksi) (0.45 $\sqrt{f'_c}$ MPa).

Article 10.20.16.6.1.3.1 — **Diaphragms and Cross Frames: GeneralTransverse Connection Plates**

For intermediate diaphragms on rolled beams used in simple spans, the vertical ~~transverse stiffener~~connector plate need not be rigidly connected to top and bottom flanges. There shall be a 4 inch (100 mm) gap between both the top and bottom flanges and the vertical stiffener. See Figures 6-103, 6-104 and 6-105 for details.

Article ~~10.24.3.2~~6.13.2.3 **~~Fasteners (Rivets and Bolts)~~Bolts, Nuts, and Washers~~: Washer Requirements~~**

All high strength bolts shall have a hardened washer under the element turned in tightening.

Article 14.~~3~~7 **Material Properties ~~(See - Discuss with TKK)~~**

When designing elastomeric bearings, the shear modulus shall be 110 psi (0.76 MPa) for 50 durometer hardness and 160 psi (1.10 MPa) for 60 durometer hardness. Use Method A when designing elastomeric pads and steel reinforced elastomeric bearings.

Article 14.~~5~~6.3.2 **~~Bending~~ Force Effects Resulting from Restraint of Movement at the Bearing: Moment**

The moment transferred by elastomeric bearings need not be considered in the design of bridge substructures or superstructures.

2-2 Culverts and Buried Structures

Design culverts and buried structures in accordance with AASHTO Standard Specifications for Highway Bridges.

Articles 8.15.5.7 and 8.16.6.7 **Special Provisions for Slabs of Box Culverts**

- Service Load Design - Shear stress v_c shall be computed by AASHTO Equation 8-14, but v_c need not be taken less than $0.95\sqrt{f'_c}$ $(0.08\sqrt{f'_c})$ for single cell or multicell box culverts.

- Load Factor Design - Shear strength V_c shall be computed by AASHTO Equation 8-59, but V_c need not be taken less than $2\sqrt{f'_c}$ bd ($0.017\sqrt{f'_c}$ bd) for single cell or multicell box culverts.

~~2-2~~2-3 Live Loads

Minimum design live load shall be ~~HS20~~ HL-93 (MS18) ~~or alternate loading~~ unless otherwise instructed by the ~~Unit Head~~State Bridge Design Engineer.

~~2-3~~2-4 Permanent~~Dead~~ Loads

An additional permanent (dead) load must be included in the design when using metal stay-in-place deck forms. This additional ~~dead~~permanent load will consist of 3 lbs/ft^2 (0.145 kN/m^2) for the weight of the metal form plus the weight of concrete in the valleys of the forms which shall be ~~taken as~~taken as the weight of 1 inch (25 mm) additional concrete over the deck area formed. For wide girder spacings, consideration should be given to increasing this weight due to the possible use of deeper stay-in-place forms.

When prestressed concrete panels are used for prestressed concrete girder spans, girders shall be designed for additional ~~dead~~permanent loads due to the possible use of metal stay-in-place forms.

For steel beams and girders, an additional ~~dead~~permanent load of 10 lbs/ft^2 (0.48 kN/m^2) shall be included in the non-composite ~~dead~~permanent load for the stress check due to the temporary construction loading. ~~This loading is included in both the Composite I-Beam and Composite Plate Girder computer programs.~~ When the computer program Merlin-Dash is used for the design, the composite beam should be designed, and the deflections computed without the construction load, see Section 2-6~~5~~. The non-composite stresses should then be checked with the construction load added and a 1.5 load factor applied for all applicable strength limit states ~~as a~~ (Load Type 2 in LFD).

Superimposed ~~dead~~permanent loads such as barrier rails, medians and any ~~dead~~permanent load which would be applied after the deck is cast shall be distributed equally to all beams for bridges up to 44 feet (13.4 m) in width. In the case of bridges over 44 feet (13.4 m) wide, these loads shall be distributed equally to the first three beams adjacent to the loads.

Weights of various types of rails are as follows,

- One bar metal rail: 10 lbs/ft (0.15 kN/m)
- One bar metal rail with 1'-6" (457 mm) concrete parapet: 235 lbs/ft (3.43 kN/m)

- Two bar metal rail with 2'-6" (760 mm) concrete parapet: 455 lbs/ft (6.64 kN/m)
- Three bar metal rail: 25 lbs/ft (0.36 kN/m)
- Concrete barrier rail: 406 lbs/ft (5.92 kN/m) for 2'-8" (813 mm) section
- Concrete median barrier: 414 lbs/ft (6.04 kN/m)

Concrete weight for foundation seal design shall be based on 140 lbs/ft^3 (22.0 kN/m^3).

Unit weights for lightweight concrete are as follows,

- Unreinforced lightweight concrete: 115 lbs/ft^3 (18.0 kN/m^3)
- Reinforced lightweight concrete: 120 lbs/ft^3 (18.8 kN/m^3)

2-5 Non-Composite Permanent ~~Dead Load~~ Deflections for Steel Bridges

Non-composite permanent (i.e., dead load) deflections for steel bridges shall be computed in accordance with the North Carolina State University research report titled *Development of a Simplified Procedure to Predict Dead Load Deflections of Skewed and Non-skewed Steel Plate Girders*. This research recommends procedures for modifying non-composite dead load deflections based on a single girder line (SGL) analysis. These procedures are the Simplified procedure (SP), the Alternative Simplified procedure (ASP), and the Single Girder Line Straight Line (SGLSL) procedure. Use the appropriate procedures to modify the SGL predicted non-composite dead load deflections of steel bridges that meet all of the following criteria:

1. Span Length $\leq$ 250 feet
2. Girder Spacing $\leq$ 11.5 feet
3. $\dfrac{\text{Girder Spacing}}{\text{Span}} \leq 0.10$

Non-composite dead load deflections for bridges that do not meet the above criteria will require a more refined analysis that accounts for the stiffness of the entire structure, such as a 3-D finite element analysis.

A more detailed summary of the development and application of the SP, ASP, and SGLSL procedures and an Excel spreadsheet that utilizes these procedures are available via the Differential Deflection link on the Structure Design Unit Homepage.

~~2-4~~2-6 Friction Force

The force effects caused by an expansion bearing sliding on its bearing plate on the supporting substructure element must be included in the design of the structure. These forces are determined by multiplying the coefficient of friction by the total permanent~~dead~~ load reaction on the bearing. For steel on steel, use a coefficient of 0.30, and for stainless steel on teflon, use a coefficient of 0.10. For elastomeric bearings, the force required to deform the elastomeric pad is found by using the following equation:

$$F = \frac{\text{(Shear Modulus) x (Contact Area) x (Deflection Due to Temperature)}}{\text{Thickness (Effective Rubber)}}$$

~~2-5~~2-7 Temperature

Provision shall be made for stresses and movements resulting from variations in temperature.

The range of temperature shall generally be as follows,

- Steel Structures: 0°F to 120°F (-18°C to 50°C)
- Concrete Structures: 20°F to 100°F (-6°C to 38°C)
- Assumed normal fabrication and erection temperature: 60°F (16°C)

For temperature ranges for expansion joints and bearings, see Chapter 6.

~~2-6~~2-8 Earth Pressures

Earth pressures on structures such as retaining walls and wing walls which retain fills shall be determined using Rankines' Formula. In special cases good engineering judgment will be required in determining the most suitable design method. In no case shall a structure be designed for less than an equivalent fluid pressure of 40 lbs/ft^3 (6.3 kN/m^3).

~~2-7~~2-9 Differential Settlement

When differential settlement needs to be addressed by the Structure Design Unit, the ~~Soils and Foundation Section~~Geotechnical Engineering Unit will indicate the amount of differential settlement in the Foundation Recommendation. If no differential settlement is specified in the recommendation, then the differential settlement has been considered by the ~~Soils and Foundation Section~~Geotechnical Engineering Unit in their foundation design. Generally, the ~~Soils and Foundation Section~~Geotechnical Engineering Unit will consider differential settlement in their foundation design if it is less than 1 inch (25 mm) over a period of time. If the differential settlement is greater than 1 inch (25 mm) over a period of time or if the structure is particularly sensitive to settlement, then the Structure Design Unit must consider the specified settlement in the bent design.

~~2-8~~2-10 Dynamic (Seismic) Loads

All structures must be designed in accordance with the seismic requirements of the ~~Standard Specifications for Seismic Design of Highway Bridges~~AASHTO LRFD Bridge Design Specifications. ~~To determine if a structure is to be designed for Seismic Performance Category Zone A 1 or B2, see Figure 2-4.~~

~~The Soils and Foundation SectionGeotechnical Engineering Unit will specify on the Foundation Recommendation the Soil Profile Type as defined in the AASHTO Standard SpecificationsLRFD Bridge Design Specifications. For preliminary design only, a North Carolina Site Coefficient Map showing soil profile type is shown in Figure 2-5.~~