Chapter 1

General Design Information

Section 1.03 – Loads and Load Factors

Introduction

This section defines the loads and load factors to be used in structural analysis and design. The loads and load factors from the *AASHTO LRFD Bridge Design Specification* will be used unless noted.

Load Modifying Factors

The following load modifying factors (η_i) will be used for all structures designed under the LRFD Specifications unless noted below.

Ductility - η_D

All bridges and box culverts will use $\eta_D = 1.0$.

Redundancy - η_R

Structural components whose failure is expected to cause the collapse of the bridge are considered fracture-critical and are deemed as non-redundant. These components may include pin and hanger systems, tension members in trusses, floorbeams, two-girder system bridges, and simple span metal pier caps.

The typical girder bridges and box culverts designed by the Bridge Program have multiple loads paths and, therefore, will use $\eta_R = 1.0$. For structures without multiple load paths, consult with Bridge Program Staff for the appropriate value of η_R

Operational Importance - η_I

The importance of a structure will depend on many factors, which may include:

- Roadway Classification
- Feature Intersected
- Span Lengths
- Number of Spans
- Structure Length
- Detour Length
- ADT and Percent Trucks
- Defense Route
- Seismic Classification

For all girder bridges and box culvert designs, use $\eta_I = 1.0$. The Design Squad Leader should consider the above mentioned factors and if they feel the new structure should be considered operationally important, they should discuss the use of a larger factor with the Bridge Program Staff.

Load Factors

The following load factors (γ) will be used for structures designed under the LRFD Specifications.

- γ_{EQ} shall be assumed as 0.5 for Extreme Event I Load Combination
- γ_{SE} & γ_{TG} shall be taken as follows:
  - 0.0 for strength and extreme event limit states
  - 1.0 for service limit states if live load is not considered
  - 0.5 for service limit states with live load

Multiple Presence Factors

Apply multiple presence factors as noted in the LRFD specification.

Design Vehicular Live Load

All new bridges and culverts including culvert extensions, which carry traffic on Interstates & Ramps, US, and State highways, will be designed for HL93 loading using the LRFD Design Code.

All new Local and Off-System bridges and culverts including culvert extensions will be designed for HL93 loading using the LRFD Design Code.

For rehabilitations and widenings, the design vehicle should match that truck for which the structure was originally designed. For older structures designed by LFD or ASD, the minimum design load should be HS20.

The truck platooning affect due to frequent closures of Interstate 80 in Wyoming has been shown to significantly increase the live load affects to bridges ("Assessment and Evaluations of I-80 Truck Loads and Their Load Effects – FHWA-WY-17/02F (Phase 1) WY-20/05F (Phase 2)

For new bridges located on mainline Interstate 80 and mainline Interstate 25 from intersection of Interstate 80 in Cheyenne to the Colorado State Line, the following live load criteria shall be applied:

For Strength I Limit State: HL93 loading with optional "lowboy" tandem pair loading per article C3.6.1.3.1 of the LRFD specifications with increased live load factor γ_{LL} equal to 2.0.

For Service II Limit State: : HL93 loading with optional "lowboy" tandem pair loading per article C3.6.1.3.1 of the LRFD specifications with increased live load factor γ_{LL} equal to 1.45.

For Service III Limit State: : HL93 loading with optional "lowboy" tandem pair loading per article C3.6.1.3.1 of the LRFD specifications with increased live load factor γ_{LL} equal to 1.0.

Pedestrian Load

All new bridges with sidewalks will be designed assuming that the sidewalk may be removed in the future. Therefore, the vehicular live load (HL-93) will be placed assuming 1'-8" wide curbs, and no pedestrian live load will be applied. The weight of the sidewalk(s) will be included as a superimposed dead load.

Dynamic Load Allowance

The Dynamic Allowance shall be applied only to the design truck or design tandem.

Vehicular Collision Force

The 600 kip load as specified in Article 3.6.5shall be applied to all structures not meeting the requirements of Article 3.6.5.1 and the functional classification of the roadway being crossed is not a local rural or urban roadway.

In lieu of designing for the collision force, the following strategies may be used in accordance with Article 3.6.5:

1. Reinforced concrete pier components that have 3 foot thick minimum dimension and 30 square feet cross sectional area.

2. Pier protection is provided in accordance with the following: 42" high MASH crash tested rigid TL-5 barrier located such that the top of the barrier is 3.25 feet or more from the face of the pier component being protected.

The magnitude of the load may be reduced based on the following criteria:

- Posted Speed Limit
- Number of Highway Access Points adjacent to Bridge
- Lane Width
- Horizontal Curve Radius
- Lanes in One Direction
- Grade Approaching the Pier System
- Engineering judgment based on site specific data

Article C3.6.5.1 shall be used to determine the probability of collapse in justifying any reduction in collision force. Any reduction of the collision force must be approved by the Bridge Program Staff. The strategy for applying the collision force shall be documented in the Structure Selection Report.

Columns placed behind retaining walls do not need to be designed with the collision force.

Stream Pressure

The design high water elevation and velocity for the purposes of stream pressure calculations shall be based on Q_{100}.
For structures where the pier is aligned with the stream flow the lateral stream pressure applied to the side of the pier will be based on an angle of 5° to allow for a change in the direction of flow over the life of the structure.

The stream flow pressure distribution shall be rectangular. In cases where the corresponding top of water elevation is above the low beam elevation, stream flow loading on the superstructure will be investigated. The pressure acting on the superstructure shall be a uniform distribution.

Ice Loads

The friction angle φ_f between the pier nose and the ice is defined by the following equation.

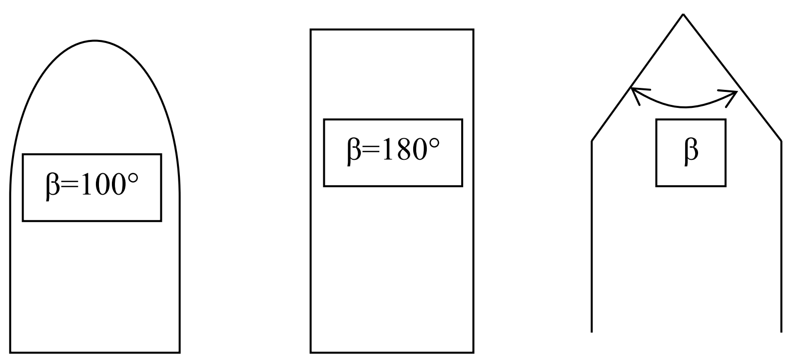
$$\varphi_f = \tan^{-1} \mu$$

However, the coefficient of friction μ cannot be established with great certainty. The Alberta Research Council uses $\mu = 0.18$ and the Alyeska Pipeline Co uses $\mu = 0.10$.

For most design cases $\varphi_f = 0.0$ (which is conservative) should be used unless the loads become unrealistic in which case the following values should be $\mu = 0.10$ and $\varphi_f = 5.7°$.

Changing the nose geometry β will have a bigger effect than changing φ_f.

β is defined as follows:



Note when $\beta = 180$ $F_t = 0.15F$

Seismic Loads

The seismic loads and analysis shall be based on the *AASHTO Guide Specification for LRFD Seismic Bridge Design.*

If the route that the structure is on services an emergency facility (hospital, fire station, etc.) or a major transportation facility and the detour for the emergency facility is greater than one mile the structure should be classified as critical. If the structure carries utilities (water, gas, and power) and these utilities would be considered essential in the case of an earthquake or other emergency, the structure should be considered critical. All bridges that are classified as critical will be considered Important for η_I purposes.

Dead Loads

All structures whose deck slab will be exposed to traffic will be designed for a future wearing surface (fws) of 25 psf. All structures whose deck slab will have an asphalt wearing surface placed during original construction do not need to be designed for any additional future wearing surface.

All new girder structures will be designed for an additional dead load of 15 psf to account for the use of stay in place (SIP) deck forms. The SIP load is assumed to act on the girder bays only, no permanent deck forming on the deck cantilevers.

The following unit weights should be used when determining dead loads:

Material	Unit Weight (kcf)
Concrete	0.150
Steel	0.490
Soil	0.120 (unless noted in Geology Report)
Wood	0.050
Asphalt	0.145
Water	0.0624

For **RAILING DEAD LOADS**, the use of the following table is suggested.

Railing Type	Dead Load (plf)	Approximate Center of Gravity
Steel Bridge Rail (TL-3) (TL3BRGRAIL NCHRP 350)	35	8" from FF curb
Steel Bridge Rail (TL-4) (TL4BRGRAIL NCHRP 350)	45	8" from FF curb
Steel Bridge Rail (TL-4) (TL4BRGRAIL MASH)	70	5” from FF curb
Corrugated Beam Type Railing	40	7" from FF curb
Concrete Bridge Barrier Rail	372	11" from FF rail
Standard Pedestrian Railing	40	4" from RF sidewalk
Pedestrian Safety Railing	35	5" from RF sidewalk

The front face curb or sidewalk thickness for new structures and rehabilitation projects should be 6” for TL-3 and TL-4 NCHRP 350 railing, and 9” for TL-4 MASH type railing.

For girder structures, the weight of diaphragms, splices, stiffeners, etc., should be included as part of the applied dead load. For steel structures, this can be approximated by using 40 plf for interior girders and 20 plf for exterior girders.

Distribution of deck loads will be in accordance to the following based on the structure type.

Non-composite structures - Use tributary area for distribution of stage 1 loads (DC). For bridges without sidewalks, distribute stage 2 loads (DC & DW) equally to all girders. For bridges with sidewalks, distribute stage 2 loads (DC & DW) by transverse continuous beam.

Composite structures - Use tributary area for distribution of stage 1 loads (DC). For bridges without sidewalks, distribute stage 2 loads (DC & DW) equally to all girders.

For bridges with sidewalks, distribute stage 2 loads (DC & DW) by transverse continuous beam.

Temperature Ranges

All of Wyoming is assumed to be in the cold climate region.

The base construction temperature for bridge structures is 60 degrees Fahrenheit. The base construction temperature is the assumed temperature at which the structure is initially built. All temperature related movements should be determined based on the difference between the base temperature and the limits of the temperature ranges listed below.

The Following temperature ranges and load factors will be used in the design of steel and concrete structures.

Steel Girder Bridges

- Base Temperature Range = -30° F to 120° F
- Bearing and Expansion Joint Design
  - Temperature Range = -50° F to 130° F
  - This range incorporates the 1.2 load factor

Concrete Girder Bridges

- Base Temperature Range = 15° F to 95° F
- Bearing and Expansion Joint Design
  - Temperature Range = 5° F to 105° F
  - This range incorporates the 1.2 load factor