

## CHAPTER 2—STRUCTURAL DESIGN

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## 2.1—SCOPE

### 2.1.1—Specifications

The following shall replace *A2.1.1*.

The structural design of movable bridges shall conform to the requirements of the latest editions of *AASHTO LRFD Movable Highway Bridge Design Specifications* including all applicable interim changes, *provisions in LADOTD BDEM, Part II, Volume 2*, the latest editions of *AASHTO LRFD Bridge Design Specifications* including all applicable interim changes, and provisions in *LADOTD BDEM, Part II, Volume 1*, except as modified or supplemented herein.

Construction specifications shall be the latest edition of *Louisiana Standard Specifications for Roads and Bridges (Standard Specifications)*. *Standard Specifications* are subject to amendment whenever necessary by supplemental specifications and special provisions to specific contracts. In the absence of specific information in *Standard Specifications*, follow the latest edition of *AASHTO LRFD Bridge Construction Specifications*.

### 2.1.2—Bridge Types

#### 2.1.2.1—General

The following shall replace *A2.1.2.1*.

Movable bridges shall be of the following types, unless otherwise specified by LADOTD:

- bascule span bridges,
- swing span bridges,
- vertical lift bridges,
- removable span bridges, or
- pontoon bridges.

#### 2.1.2.2—Contract Documents

The following shall supplement *A2.1.2.2*.

Refer to *LADOTD BDEM, Part II, Volume 1*.

#### C2.1.2.1

Pontoon bridges are only allowed with special permission from the Bridge Design Engineer Administrator.

### **2.1.2.3—Prohibited Structure Types**

The following shall replace A2.1.2.3.

Pin-connected trusses and permanent cable-operated bascule, vertical lift, or swing span bridges shall not be used for movable spans.

## **2.3—NOTATION**

The following shall supplement A2.3.

WA = water load, stream pressure or wave force (lb.) (2.4.2.3).

## **2.4—LOADS, LOAD FACTORS, AND COMBINATIONS**

### **2.4.1—General Provisions and Limit States**

#### **2.4.1.1—Live Load and Dead Load**

The following shall supplement A2.4.1.1.

In addition to *AASHTO LRFD Bridge Design Specifications*, required live load and dead load criteria shall be as specified in *LADOTD BDEM, Part II, Volume 1*. Future wearing surface shall not be included in the movable bridge design.

#### **2.4.1.2—Dynamic Load Allowance**

##### **2.4.1.2.4—End Floor beams**

The following shall supplement A2.4.1.2.4.

The live load deflection of end floor beams shall be limited to ¼ in.

#### **2.4.1.3—Wind Loads**

##### **2.4.1.3.1—General**

The following shall supplement A2.4.1.3.1.

Refer to *LADOTD BDEM, Part II, Volume 1, D3.8*.

#### **2.4.1.5—Fatigue Limit Truck**

The following shall supplement A2.4.1.5.

Refer to *LADOTD BDEM, Part II, Volume 1, D3.6.1.4*.

#### **2.4.1.9—Strength and Rigidity of Structural Machinery Supports**

The following shall supplement the 2<sup>nd</sup> paragraph of A2.4.1.9.

The loads specified in A5.7, D5.7, A7.4, and D7.4 for the overload limit state shall include the dynamic load allowance (DAM), as specified in A2.4.1.2.3.

### **2.4.2—Bridge-Type Specific Provisions**

#### **2.4.2.2—Application of Fixed Bridge Load Combinations**

The following shall replace the 1<sup>st</sup> sentence of A2.4.2.2.

The load combinations, specified in *Table 3.4.1-1* of *AASHTO LRFD Bridge Design Specifications*, as amended by *LADOTD BDEM, Part II, Volume 1*, for all applicable limit states, shall apply to movable bridges, as follows, using the resistance factors specified therein:

#### **2.4.2.3—Movable Bridge-Specific Load Combination-Strength Limit State**

The following shall supplement A2.4.2.3.

Load combinations for pontoon bridge structures:

- Strength P-I—Load combination related to structure in any open or closed position and dynamic effects of operating machinery.
- Strength P-II—Load combination related to structure in open or closed position and effects of operating machinery, wind, and wave or current forces.
- Strength P-III—Load combination related to structure in any open or closed position and effects of wind and wave or current

#### **C2.4.2.3**

The following shall supplement AC.2.4.2.3.

With respect to the load combinations required for pontoon bridges, Load Case P-I deals with the structure in the open or closed position, including dynamic effects resulting from the acceleration of the span for stopping or starting. Load Case P-II deals with the structure in the open or closed position with dead load in combination with wind and wave loads or current caused by a 20-year wind storm. The 20-year wind storm conditions should be used to make operational decisions for closing the bridge to traffic to ensure safety of the traveling public. The maximum safe wind load condition for traffic on the pontoon shall be included in the O&M manuals. Load Case P-III

forces.

Considering only one damage condition and location at any one time, pontoon structures shall also be designed for at least the following:

1. Collision: Apply a 10 kip horizontal collision load as a service load to the pontoon exterior walls. Apply a 30 kip collision load as a factored load to the pontoon exterior walls. Apply collision forces to an area no greater than 1 ft. x 1 ft.
2. Flooding of any two adjacent exterior cells along the length of the pontoon.
3. Flooding of all cells across the width of the pontoon.
4. Loss of mooring cable or component.

deals with the structure in the open or closed position with dead load in combination with wind and wave loads or current caused by a 100-year wind storm.

The following table shall replace *Table 2.4.2.3-1*.

**Table 2.4.2.3-1—Movable Bridge-Specific Load Combinations**

Load Combination	$D_o$	$D_{CW}$	$L_s$	$L_C$	$L_{CW}$	$W_o$	$DAD$	$M_o$	$WA^*$
Bascule and Vertical Lift Bridges									
Strength BV-I	1.55	0	N/A	N/A	0	0	1.55	1.55	N/A
Strength BV-II	1.25	0	N/A	N/A	0	1.25	1.25	1.25	N/A
Strength BV-III	0	1.25	N/A	N/A	1.40	0	0	0	N/A
Swing Bridges									
Strength S-I	1.55	N/A	0	0	N/A	0	1.55	1.55	N/A
Strength S-II	1.35	N/A	1.75	0	N/A	0	0	0	N/A
Strength S-III	1.35	N/A	0	1.75	N/A	0	0	0	N/A
Strength S-IV	1.25	N/A	0	0	N/A	1.25	1.25	1.25	N/A
Strength S-V	1.25	N/A	1.40	0	N/A	1.25	0	0	N/A
Strength S-VI	1.25	N/A	0	1.40	N/A	1.25	0	0	N/A
Pontoon Bridges									
Strength P-I	1.55	N/A	N/A	N/A	N/A	N/A	1.55	1.55	0
Strength P-II	1.25	N/A	N/A	N/A	N/A	1.25	1.25	1.25	1.00
Strength P-III	0.90	N/A	N/A	N/A	N/A	1.25	N/A	N/A	1.00

\*WA = water load, stream pressure or wave force (lb.)

## **2.5—MOVABLE BRIDGE DESIGN FEATURES AND REQUIREMENTS**

### **2.5.1—Movable Bridge Specific Design Features and Requirements**

The following shall supplement A2.5.1.

#### **Pontoon Bridges**

##### ***Main Roadway Flotation:***

Main roadway flotation shall require welded steel construction, having marine external coating with magnesium anodes on external surfaces below water line.

##### ***Pontoon Swing Arm:***

Flexible-moment attachment to rear face of pontoon shall be allowed if variance in water levels is small, i.e. less than 1 ft. per 20 ft. swing arm length. Use rigid-moment attachment to rear face of pontoon with vertical sleeve on pivot pile for all other cases. Swing arm shall be designed to remain above water line at all times. Electrical, hydraulic, and utility lines shall be placed on cable tray along walkway on top of swing arm.

##### ***Pontoon Apron:***

Apron pivot hinges on roadway structure/bent and locks on pontoon shall be designed for wind and current loads, assuming the swing arm provides no resistance. Apron shall be designed to raise high enough so it does not encroach on horizontal clearance of span. Maximum ramp slope-to-level differential shall be limited to 1:12 without ballast adjustment. Roadway barrier interfaces shall be designed for 1:10 slope differential to allow for live load flotation shifts.

##### ***Anchorage/Piles for Swing Arm & Breasting/Sheave Clusters:***

Personnel roadway access to swing arm pivot pile and swing arm access walkway shall be provided. If operator control is located on pontoon (operator rides pontoon), access walkway to breasting pile is required. Pivot

pile(s) and sheave pile(s) shall be rigid and have minimal deflection. Breasting pile(s) should be used to allow for impact movement and recovery. Cushioning fenders for pontoon contact points shall be provided.

### ***Operator Controls***

Extent of controls, automation, and permissives to be established by Design Engineer based on location and frequency of projected openings.

### ***Movable Barriers, Gates, & Traffic Lights***

Movable barriers are not required if aprons extend more than 8 ft. above roadway surface when in full up position and at an angle greater than 45°. Traffic gates are required in front of aprons and traffic lights are required in front of traffic gates. Apron pontoon areas and apron roadway surfaces shall be illuminated.

### ***Mechanical System and Design Basis***

Mechanical and electrical equipment shall be housed in a protected environment suitable for equipment being contained, behind a locked gate to prevent tampering, and shall be accessible from the roadway deck.

### ***Wind and Current Loadings on Vertical Freeboard Spaces***

Locks, couplings, and piles shall be designed to hold against load case P-III conditions at 90° angles applied to all exposed vertical surfaces between pivot pile and far apron anchorage. Mechanical operating system shall be designed for full swing open, full closed, and hold position against case P-III load conditions in 200 percent of the allowed opening time.

Pontoon bridges shall be designed considering both high water and low water conditions.

### **2.5.1.1—Bascule Span Bridges**

#### ***2.5.1.1.4 Floors and Floor Fastenings***

The following shall supplement A2.5.1.1.4.

Refer to *LADOTD Standard Plans* for standard steel grid flooring details.

### **2.5.1.2—Swing Span Bridges**

The following shall supplement A2.5.1.2.

The end reactions provided for the swing span shall satisfy the following:

- No negative reactions from any live load conditions.

Refer to A6.8.2.4 and D6.8.2.4 for end lifts.

#### ***2.5.1.2.2—Rim Bearing***

The following shall replace A2.5.1.2.2.

Rim bearing type swing span bridges are not allowed.

#### ***2.5.1.2.3—Combined Bearing***

The following shall replace A2.5.1.2.3.

Combined bearing type swing span bridges are not allowed.

#### ***2.5.1.2.4—Rim Girders***

The following shall replace A2.5.1.2.4.

Rim bearing type swing span bridges are not allowed.

#### **2.5.1.2.5—Shear Over Center**

#### **C2.5.1.2.5**

A2.5.1.2.5 shall be deleted.

The shear over center article only applies to rim bearing swing spans. For rim bearing bridges, the center truss panel is designed to be strong enough to resist vibrations and end wind forces when the bridge is open, but weak enough to prevent full continuous girder action across the drum bearings. The middle panel chords are designed to be strong enough to provide for full bending moments due to continuity, but the middle web members are designed so that they only act as braces for the middle posts when the span is open. In this condition, the middle web members cannot carry shears, due to a continuous action. This article is deleted, since rim bearing type swing spans are not allowed.

#### **2.5.1.2.6—Reaction Due to Temperature**

The following shall replace the 1<sup>st</sup> paragraph of A2.5.1.2.6.

Provision shall be made for an end reaction due to a temperature differential between the top and bottom chords of 60<sup>0</sup>F.

## REFERENCES

*AASHTO LRFD Bridge Construction Specifications*, Latest Edition, American Association of State Highway and Transportation Officials, Washington D.C.

*AASHTO LRFD Bridge Design Specifications*, Latest Edition, American Association of State Highway and Transportation Officials, Washington D.C.

*AASHTO LRFD Movable Highway Bridge Design Specification*, Latest Edition, American Association of State Highway and Transportation Officials, Washington D.C.

*AASHTO Standard Specifications for Movable Highway Bridges*, 5<sup>th</sup> Edition, MHB 5, American Association of State Highway and Transportation Officials, Washington D.C., 1988.

*Louisiana Standard Specifications for Roads and Bridges*, Latest Edition, State of Louisiana Department of Transportation and Development, Baton Rouge, LA.