# 2.6 HYDRAULIC DESIGN FOR STRUCTURES OVER WATERWAYS

## 2.6.1 GENERAL

This policy addresses design criteria for the hydraulic design of new bridges and bridge widenings over waterways. The criteria cover Hydraulic Design Flood, Scour Design Flood, Scour (Design) Check Flood, and scour conditions for foundation design.

## 2.6.2 POLICY

The hydraulic design of structures over waterways shall meet the following criteria and be in accordance with AASHTO-CA BDS. Scour analysis and scour countermeasure design shall follow the Federal Highway Administration (FHWA) guidance contained in the 2012 Hydraulic Engineering Circular (HEC) 18, 2012 HEC-20, and 2009 HEC-23, and TechBriefs FHWA-HIF-19-007 and FHWA-HIF-23-048.

### 2.6.2.1 Flood Frequencies for Design

- The minimum Hydraulic Design Flood Frequency is the 50-year flood.
- For the Scour Design Flood; the discharge creating the deepest scour corresponding to frequencies up to the 100-year flood.
- For the Scour (Design) Check Flood; the discharge creating the deepest scour corresponding to frequencies up to the 200-year flood.

### 2.6.2.2 Waterway Conveyance

The waterway opening at a bridge shall be designed to convey the greater of the following:

- 50-year flood plus a minimum of 2 feet of freeboard
- 100-year flood (Base Flood) without freeboard

### 2.6.2.3 Scour Conditions for Foundation Design

Scour estimation shall be based on HEC-18 and HEC-23.

Potential channel migration effects at a bridge site shall be considered for all abutment and pier foundations.

With regard to the bridge scour design provided herein, and in the AASHTO-CA BDS, the bridge abutment shall be defined to include the components fully or partially supported by the abutment foundation, such as the bridge end, abutment wall, and wing walls.

Earth retaining systems supporting the approach fill side slopes that are not critical to the bridge stability are not considered part of the bridge abutment. Earth retaining systems critical to bridge stability shall be designed to meet the same scour design requirements as for abutments.

#### 2.6.2.3.1 Piers

The design of piers shall ignore the presence and function of scour countermeasures, and the streambed material above the scour elevation is assumed to have been removed.

Shallow foundations of piers supported on soil or erodible rock shall be located so that the top of the footing is below the scour elevation determined for the Scour Design and Scour (Design) Check Floods. Shallow foundations of piers supported on rock highly resistant to scour may be placed directly on or embedded into cleaned rock formations.

Piers supported on pile groups shall be located so that the bottom of the pile cap is below the scour elevation determined for the Scour Design Flood and shall satisfy the Extreme Event II limit state for scour conditions determined for the Scour (Design) Check Flood.

#### 2.6.2.3.2 Abutments

Shallow foundations of abutments supported on soil or erodible rock shall be located so that the top of the footing is below the scour elevation determined for the Scour Design and Scour (Design) Check Floods. The presence and function of scour countermeasures shall be ignored. Shallow foundations supported on rock highly resistant to scour may be placed directly on or embedded into cleaned rock formations.

For abutments supported on deep foundations, the presence and function of scour countermeasures shall not be considered, and the streambed material above the scour elevation is assumed to have been removed (except as noted below). The foundations shall be located so that the bottom of the pile cap is below the scour elevation determined for the Scour Design Flood and shall satisfy the Extreme Event II limit state for scour conditions determined for the Scour (Design) Check Flood. However, the abutment foundation may be designed assuming the soil protected by the scour countermeasure remains in place under all limit states, except the Extreme Event II limit state for the Scour (Design) Check Flood, if the following criteria are satisfied:

- The current or projected annualized average daily traffic (AADT) multiplied by the detour length is less than or equal to 10,000 vehicle-miles, and the AADT is less than or equal to 2000 vehicles. The detour route shall not include scour-critical bridges.
- The scour countermeasure is properly designed as described in HEC-23 and TechBrief FHWA-HIF-23-048.

## 2.6.2.4 Sea Level Rise

New bridges and bridge widenings, where affected, shall consider impact scenarios from Sea Level Rise (SLR) following the latest *State of California Sea Level Rise Guidance* and satisfy the requirements of the California Coastal Commission and any other agency as required.

Refer to Section 2.6.2.5 for SLR that coincides with tsunami events.

## 2.6.2.5 Tsunami

New bridges and bridge widenings, where affected, shall consider the effects of tsunami hazards.

Tsunami Hazard evaluations shall include the effect of scour and SLR. Structural assessments shall assume the following based on the *AASHTO Guide Specifications for Bridges Subject to Tsunami Effects (*AASHTO Guide Specifications).

- SLR = 1.5 ft for bridge widenings
- SLR = 3.5 ft for new bridges

In lieu of the probabilistic tsunami event specified in the AASHTO Guide Specifications, the wave velocity and elevation shall be based on the 975-year return interval inundation mapping compiled by Honk Kie Thio.  The Tsunami Inundation Portal tool can be found through the University of California, Los Angeles Natural Hazards Risk and Resiliency Research Center (NHR3) at:

http://ec2-35-167-122-9.us-west-2.compute.amazonaws.com/tsunamis/new

The scour depth shall be based on the Colorado State University (CSU) equation found in Section 8 of the AASHTO Guide Specifications.

## 2.6.3 REFERENCES

*References listed were used to develop this STP. Use the latest versions that have been adopted by Caltrans.*


1. AASHTO (2022), *AASHTO Guide Specifications for Bridges Subject to Tsunami Effects*, 1st Edition, American Association of State Highway and Transportation Officials, Washington, D.C.

2. AASHTO (2017), A*ASHTO LRFD Bridge Design Specifications*, 8th Edition, American Association of State Highway and Transportation Officials, Washington, D.C. (LRFD)

3. CA Ocean Protection Council (2024), *State of California Sea Level Rise Guidance,* CA Ocean Protection Council and CA Ocean Science Trust, CA.

4. Caltrans (2019), *California Amendments to AASHTO LRFD Bridge Design Specifications, 8th Edition*, California Department of Transportation, Sacramento, CA. (AASHTO-CA BDS)

5. Caltrans (2017), Bridge Memo to Designers 16-1 *Hydraulic Design for Structures Over Waterways*, California Department of Transportation, Sacramento, CA.

6. FHWA (2023), *Hydraulic Considerations for Abutments on Deep Foundations and Bridge Embankment Protection*, Technical Brief (TechBrief) - Publication No. FHWA-HIF-23-048, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.

7. FHWA (2023), *National Bridge Inspection Standards, 23 Code of Federal Regulations (CFR)*, Part 650, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.

8. FHWA (2018), *Hydraulic Considerations for Shallow Abutment Foundations*, Technical Brief (TechBrief) - Publication No. FHWA-HIF-19-007, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.

9. FHWA (2012), *Evaluating Scour at Bridges*, 5th Edition, Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. (HEC-18)

10. FHWA (2012), *Stream Stability at Highway Structures*, 4th Edition, Publication No. FHWA-HIF-12-004, Hydraulic Engineering Circular No. 20, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. (HEC-20)

11. FHWA (2009), *Bridge Scour and Stream Instability Countermeasures: Experience, Selection and Design Guidance*, 3rd Edition, Publication No. FHWA-NHI-09-111, Hydraulic Engineering Circular No. 23, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. (HEC-23)