STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISON
DEISGN BRANCH

MEMORANDUM

HWY-DB 2.6843
DATE: February 14, 2005

TO: HWY-DB, -DD, -DH, -DS, -C, -OC, -H, -K, -M, -T

FROM: HWY-D

SUBJECT: DESIGN CRITERIA FOR BRIDGES AND STRUCTURES

This memo supersedes memo HWY-DB 2.7490 dated August 13, 2002 that superseded previous HWY-DB memos 2.4915, 2.4895, 2.5065, 2.6408 and 2.94571.

- DESIGN REFERENCES
- MODIFICATIONS TO *AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS*
- MODIFICATIONS TO AASHTO *STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES AND TRAFFIC SIGNALS*
- ADDITIONAL GUIDELINES

DESIGN REFERENCES

AASHTO LRFD Bridge Design Specifications, 3rd edition (2004) including all subsequent interim revisions. This shall govern all structural designs for bridges including retaining walls, culverts, traffic barriers, catch basins, drain manholes, inlet boxes, pull boxes, and similar structures within the State's right-of-way and similar structures subject to review by the Bridge Design Section except as modified herein. The use of AASHTO *Standard Specifications for Highway Bridges*, 17th edition, shall only be allowed when checking the adequacy of existing structures designed prior to January 1997 unless the Bridge Engineer grants an exception. The Standard Specification will no longer be supported/updated by AASHTO after October 2007.

AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, 4th edition (2001) including all subsequent interim revisions. This shall govern design of structural supports for highway signs, luminaries and traffic signals including those attached to bridge structures except as modified herein.

AASHTO *Guide Specifications for Structural Design of Sound Barriers*, current edition including all subsequent interim revisions. Design for sound barrier walls shall be governed by the stricter of this guide or the latest adopted building code of the City and County of Honolulu.

Building Code of the City and County of Honolulu, latest adopted. Unless otherwise directed, this shall govern structural designs for State of Hawaii DOT buildings and other structures not covered by AASHTO guidelines and specifications. Seismic and wind requirements shall be verified prior to commencing with design.

Earthquake Retrofit Guidelines for Bridges, California Department of Transportation (Caltrans) Memo 20-4, latest version. All design for seismic retrofitting of existing bridges shall be in accordance with Caltrans seismic retrofit methodology unless otherwise directed. FHWA publication *Seismic Retrofitting Manual for Highway Bridges*, FHWA-RD-94-052, May 1995, may be referenced for supplemental information.

Standard Specifications for Tolerances for Concrete Construction and Materials (ACI 117), latest adopted. Tolerances for Concrete Construction and Materials shall conform to all requirements of ACI 117 published by the ACI except as modified herein and the project documents.

AASHTO *Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges*, October 2003 including all subsequent interim revisions. Load capacity ratings shall be computed using both the LRFR method and the alternate load factor (LF) method using this manual and as modified herein.

MODIFICATIONS TO *AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS*

1. **Load Factors and Load Combinations** [Article 3.4.1]. The effects of scour (SC) shall be considered in the design of bridges. Scour is not a load but is an extreme event that alters the geometry of the structure and foundation possibly causing structural collapse or the amplification of the effects of applied loads. Based on the 100-year flood scour depth, the following scour factors shall be applied:

   a. A scour factor of 2.00 shall be used in combination with dead loads of structure only. When scour is possible, the bridge foundation shall always be checked to ensure that the foundation depth exceeds 2.00 SC.

   b. A scour factor of 0.50 shall be used in combination with earthquake loads. When analyzing for effects due to earthquake loads, the case of zero scour depth shall also be investigated.

   If approved scour mitigation measures are implemented, the full effects of scour need not be considered.

   For design of temporary bridges, scour shall be based on a flood with an expected recurrence of at least twice the number of years the temporary bridge is expected to exist but not less than 5 years.

2. **Dead Loads** [Article 3.5.1]. The following additional dead loads shall be considered in design of new bridges and as applicable for bridge rehabilitation.

   a. Weight of future wearing surface of 25 psf from curb to curb.

   b. Future utilities load on each side of the bridge of 150 plf.

3. **Unit Weights** [Table 3.5.1-1]

   a. Concrete (Normal): 160 pcf. Use 150 pcf for the determination of the modulus of elasticity and when the material reduces the effect of another force.

   b. Concrete (Lightweight): As specified. Consult with Material Testing and Research Branch.

   c. Compacted Earth: 120 pcf minimum. Based on soil type, design may require 140 pcf. Consult with Material Testing and Research Branch or Geotechnical Engineer. Use 100 pcf when the material reduces the effect of another force.

4. **Seismic Acceleration Coefficients for Hawaii** [Figure 3.10.2-3] modified as shown on Figure 1.

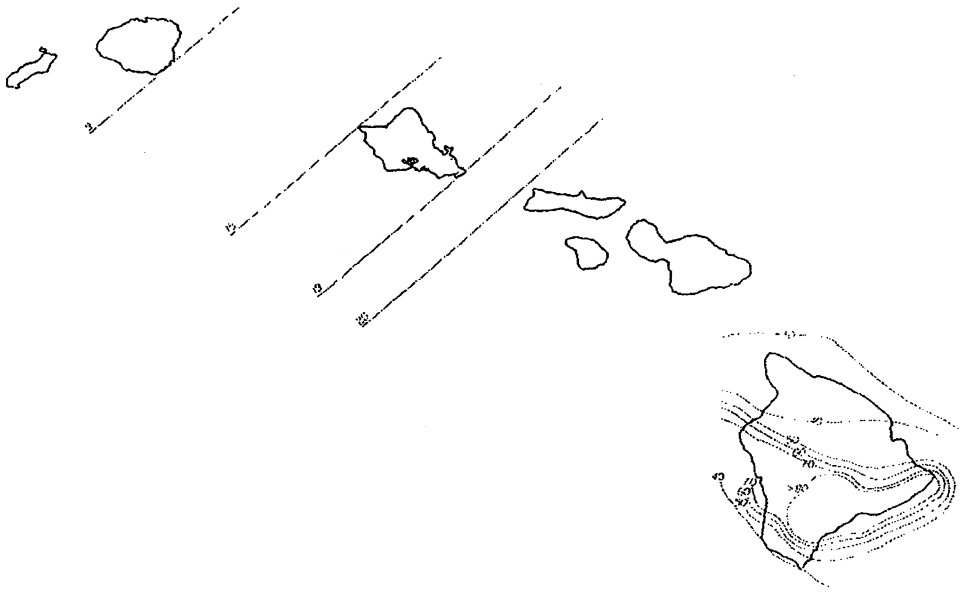

Figure 1 - Seismic Acceleration Coefficients for Hawaii

5. **Importance Categories** [Article 3.10.3]. Unless otherwise directed, classification for design of bridges shall conform to the following importance categories:

   a. Critical Bridges: All new vehicular bridges not including temporary bridges.

   b. Essential Bridges: Bridges to be seismically retrofitted.

   c. Other Bridges: Pedestrian bridges and temporary bridges.

6. **Temporary Bridges and Stage Construction** [Article 3.10.10]. The seismic acceleration coefficients to be used for design of temporary bridges and bridges constructed in stages and expected to carry traffic and/or pass over routes that carry traffic shall not be less than 75 percent of the modified values for Hawaii shown in Figure 1.

7. **Temperature Range** [Article 3.12.2]. Concrete superstructures shall be designed using [Article 3.12.2.2] Procedure B with a temperature range of 60 degrees Fahrenheit.

8. **Shrinkage** [Article 5.4.2.3.3]. Concrete shrinkage strain shall be in accordance with Equation 5.4.2.3.3-1 but not be less than 0.0003.

9. **Tension Stresses** [Article 5.9.4.2.2] in prestressed concrete. No tension stresses are allowed in precompressed tensile zone after all losses have occurred except when computing load capacity ratings at the operating level and for legal and permit loads.

10. **Concrete Cover** [Article 5.12.3]. The following changes shall be made to this article.

    a. Cover to ties and stirrups shall not be less than 1.5 inches except cover for stirrups in webs of precast prestressed girders may be 1.25 inches.

    b. Cover for main reinforcing steel shall be in accordance with Table 5.12.3-1 and as modified herein. Cover for main reinforcing steel shall be adjusted where minimum cover for ties and stirrups govern.

    c. Cover for the top deck slab reinforcing steel measured perpendicular to the concrete surface shall be 2 inches with a tolerance of ..... –0 in., and +3/8 in. This tolerance shall be noted on the plans and/or special provisions. Alternatively, a concrete cover for the top deck reinforcing steel of 2.5 inches may be used with no special notation on the plans or special provisions.

    d. Cover for the bottom layer reinforcing steel of cast-in-place or precast concrete slabs shall not be less than 1.5 inches for No. 11 bars and smaller.

11. **Shear in Footings** [Article 5.13.3.6]. Minimum shear reinforcement for Seismic Zones 2, 3 and 4.

    a. Column footings. Vertical No. 5 bars at 12 inches spacing in each direction in a band between "d" of the footing from the face of the column and 6 inches maximum from the column reinforcement. Shear bars shall be hooked around the top and bottom reinforcement mat in the footing. The top hook shall be 135 degrees minimum and the bottom 90 degrees.

    b. Wall-type bridge footings including bridge abutments. Vertical No. 5 bars at 12 inches spacing in the direction perpendicular to the wall face and No. 5 bars at 24 inches spacing in the direction parallel to the wall face in the band between "d" of the footing from the face of the wall and 6 inches maximum from the column or abutment vertical reinforcement. Shear bars shall be hooked around the top and bottom reinforcement mat in the footing. The top hook shall be 135 degrees minimum and the bottom 90 degrees.

12. **Test Level Selection Criteria** [Article 13.7.2] for traffic railings. Also refer to memo HWY-TD 2.2822, *Statewide Policy for Permanent Highway Safety Hardware*, dated March 1, 1999. Unless otherwise directed, all traffic railings shall conform to the following test levels:

    a. TL-2 (Test Level Two) – For design speed of 45 mph or less.

    b. TL-4 (Test Level Four) – For design speed greater than 45 mph.

    c. For unusual conditions, such as high truck volume roadways, higher test level criteria may be warranted.

MODIFICATIONS TO AASHTO *STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES AND TRAFFIC SIGNALS*

Note: For manufacturer designed support structures, all affected design parameters contained herein shall be noted on the construction plans.

1. **Basic Wind Speed** [Article 3.8.2] to determine the design wind pressure shall be 105 mph. For unusual or differing exposure conditions, the basic wind speed should be increased using rational procedures and sound engineering judgment. Alternatively, the design wind pressure may be increased by using a higher Wind Importance Factor [Table 3-2] corresponding to a recurrence interval of at least one level greater than recommended.

2. **Wind Importance Factor** [Article 3.8.3] noted in Table 3-2 used to determine the design wind pressures shall be based on the following recurrence intervals:

    a. For overhead cantilevered sign structures: 100 years

    b. For traffic signal structures: 50 years

    c. For luminaire support structures: 25 years
    (Except use 50 years when luminaire mounted on a traffic signal structure.)

    d. For temporary support structures 10 years

3. **Height and Exposure Factor** [Article 3.8.4]. For sign and luminaire support structures on bridges, the height and exposure factor shall be determined based on the maximum height they are above the surrounding ground. For severe exposure conditions such as along the coastline, the factor shall be increased based on the latest ASCE Standard No. 7, *Minimum Design Loads for Buildings and Other Structures*.

4. **Fatigue Importance Factors** [Article 11.6] noted in Table 11-1 for overhead cantilevered sign and traffic signal structures shall be based on Fatigue Category I.

Luminaire support structures with round cross sections under 50 feet and roadside sign structures do not need to be designed for fatigue.

5. **Galloping** [Article 11.7.1]. Overhead cantilevered sign and traffic signal support structures shall be designed for galloping-induced cyclic loads unless approved vibration mitigation devices are installed.

6. **Vortex Shedding** [Article 11.7.2]. Non-tapered lighting structures shall be designed to resist vortex shedding-induced loads including cantilevered mast arms and lighting structures that have tapers less than 0.14 in/ft.

7. **Natural Wind Gust** [Article 11.7.3]. Overhead cantilevered sign, traffic signal, and high-level lighting support structures shall be designed to resist an equivalent static natural wind gust pressure. For unusual or differing exposure conditions, the equivalent static natural wind gust pressure should be increased using references noted in the specifications.

8. **Truck-Induced Gust** [Article 11.7.4]. Overhead cantilevered sign and traffic signal support structures shall be designed to resist an equivalent static truck gust pressure range based on a truck speed of 20 mph over the posted speed.

ADDITIONAL GUIDELINES

1. **Approach Slabs.** Approach slabs shall be provided on all new bridges unless otherwise directed. If an existing bridge is being widened and it has an approach slab, slabs shall be provided at widening.

   a. Length of approach slab shall be such that influence of live load on slab does not impose lateral earth pressure on the abutments. A Geotechnical Engineer or the Material Testing and Research Branch shall determine the length.

   b. Slabs shall be designed to span simply supported. Center of support at approach end shall be based on centerline of bearing of thickened edge. Width of thickened edge shall be determined based on the given soil parameters.

2. **Design of Covers for Junction Boxes, Handholes, and Other Gaps, Holes, or Cavities ("Boxes") in Concrete Guardrails.**

   a. It is preferred that all "boxes" be located on the opposite side of the traffic face of concrete guardrails.

   b. If not possible to locate on opposite side, then try to locate "boxes" above the minimum guardrail height but not less than 32 inches above the roadway or shoulder surface.

c. If the "boxes" must be located under 32 inches or under the minimum guardrail height, then the covers for the "boxes" shall be designed for a linear transverse force acting parallel to the roadway surface and applied anywhere along the vertical face of the cover. The minimum linear load shall be as follows:

1) For TL-2: 8 klf (27 kips maximum total)
2) For TL-3 & TL-4: 16 klf (54 kips maximum total)

d. The concrete guardrail around the "boxes" shall be appropriately designed to account for their presence.

e. The above design loads are not in-lieu of any wheel loads that may be applied to the covers for the "boxes". The covers shall also be designed for wheel loads and wheel impact if applicable.

3. **Concrete Box Culvert Fillets.** Fillets are required at the top corners. Bottom fillets are recommended if water will "sit" for an extended period of time at the wall construction joint. Otherwise, bottom fillets are optional.

4. **Load Capacity Ratings** for all bridges shall comply with both the Load and Resistance Factor Rating (LRFR) and the alternate Load Factor (LF) Methods of the AASHTO *Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges.*

a. Load rating factors for each bridge element shall be computed and shown on the structural drawings following the structural notes for all new, replaced and rehabilitated bridge projects.

b. Modifications for prestressed concrete members shall be as follows:

1) Inventory level – no tension allowed in concrete.

2) Operating level – tension of $0.19(f_c')^{1/2}$ allowed in concrete where f_c' expressed in ksi units.

5. **Vertical Clearances for Separation Structures**

a. Over Interstate Highways. 16'-6" minimum over the entire roadway width including the usable width of the shoulders.

b. Over Other State Highways. 15'-6" minimum over the entire roadway width including the usable width of the shoulders.

c. Under Pedestrian Bridges. 17'-6" minimum over the entire roadway width including the usable width of the shoulders.

d. Under Sign Structures and Light Fixtures. Clearance shall be a minimum of one foot greater than specified in 5a, 5b and 5c.

e. For resurfacing projects under an existing bridge, the clearance shall be verified. If the clearance will be less than the minimum required vertical clearance, the existing clearances shall be maintained or improved.

6. **Bridge Endposts/Guardrail Transitions – Trailing End on Divided Highways**

a. For fill slopes at trailing end of bridges greater than 3H:1V, provide guardrail transition similar to approach end unless otherwise directed.

b. For fill slopes at trailing end of bridges equal to or less than 3H:1V, no guardrail transition required at trailing end unless an obstruction or obstacle occurs within 25'-0" from the end of the bridge within the minimum recommended clear zone.

c. For cut slopes at trailing end of bridges, decision for guardrail requirement shall be based on likelihood of impact and site specific circumstances.

7. **Additional Structural Notes**

a. **Bottom fillets of girder stems** for concrete box girders are optional unless required to satisfy stresses by design. If bottom fillets are shown on the plans, a note should be added that they are not required by design. Top fillets for girder stems are required.

b. **Falsework traffic openings** (widths and heights), if required, shall be indicated on the plans and in the specifications.

c. **Design of falsework** shall consider any increased or readjusted loads caused by prestressing, post-tensioning, or secondary forces imposed during construction. The design engineer shall indicate these loads on the plans.

8. **Seismic Retrofitting of Existing Bridges**. Unless otherwise directed, procedures for designs for seismic retrofitting of existing bridges shall be in accordance with Caltrans *Earthquake Retrofit Guidelines for Bridges*. In addition FHWA publication *Seismic Retrofitting Manual for Highway Bridges*, FHWA-RD-94-052, May 1995, may be referenced for supplemental information.

9. **Retrofitting of Existing Overhead Sign Structures.** The retrofitting philosophy shall be "no collapse". Retrofitting of existing footings or other items that may have an impact on traffic should be minimized. Any item whose failure may be a safety concern shall be upgraded and designed in accordance with the latest *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

10. **Required Data for Consultant Designed or Design-Build Bridge or Structurally Related Projects.** The following items are essential for construction and effective maintenance of the structures and shall be submitted to the Bridge Design Section.

    a. Design calculations for all structural items including bridges, buildings, retaining walls, culverts, manholes, sign structures, etc. Any diagrams used in the calculations shall be submitted. If computer inputs/outputs are included, computer software User's Manual or adequate description of inputs/outputs shall be submitted.

    b. Calculations of estimated quantities for structural items.

    c. Load Capacity Ratings for all bridges using both the LRFR and the alternate LF methods.

    d. All reports, e.g. basis of designs, engineering reports, major structures reports, soils investigation reports, etc.

11. **Review of Structural Documents Prepared by Consultants.** To assure better quality submittal documents, all structural plans and calculations shall be reviewed by a licensed structural engineer other than the designer prior to each submittal to the State. Initials of the reviewer shall be placed on each sheet of the plans and calculations, or a signed letter accompanying the submittal stating that the signee, a licensed structural engineer other than the designer, had conducted a thorough review. Failure to do this will be grounds for rejection and no review will be conducted by the Bridge Design Section until this criteria is met. No extension of design time will be allowed for noncompliance.

If there are any questions, contact the Bridge Design Engineer of the Highways Division, Design Branch, Bridge Section.

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