

TO: All Design Section Staff  
FROM: Bijan Khaleghi  
DATE: February 25, 2019  
SUBJECT: Seismic Design Requirements for Bridge Retrofit, Modifications and Widening

This design memorandum provides revisions to BDM requirements for retrofit, modifications and widening of Normal, Essential and Critical bridges. BDM Section 4.3.1, 4.3.3, 4.4, 15.4.3, and 15.4.4 shall be revised as follows:

### ***4.3.1 General***

A bridge modification or widening is defined as where substructure bents are modified and new columns or piers are added, or an increase of bridge deck width or widenings to the sidewalk or barrier rails of an existing bridge resulting in significant mass increase or structural changes.

Bridge widenings in Washington State shall be designed in accordance with the requirements of the current edition of the AASHTO LRFD. The seismic design of Normal, Essential and Critical bridges shall be in accordance with the requirements of the AASHTO Seismic Guide Specifications (SGS), and WSDOT BDM.

The spectral response parameters shall be determined using USGS 2014 Seismic Hazard Maps and Site Coefficients defined in Section 4.2.3. The widening portion (new structure) shall be designed to meet current WSDOT standards for new Normal, Essential and Critical bridges. Seismic analysis is required in accordance with Section 4.3.3 and is not required for single-span bridges and bridges in SDC A. However, existing elements of single span bridges shall meet the requirements of AASHTO SGS as applicable.

### ***BDM 4.3.3 Seismic Design Requirements Bridge Widening Projects***

The Seismic Design requirements for Bridge Modifications and Widening are as follows and as illustrated in BDM Figure 4.3-1:

1. Normal bridge modification or widening projects classified as Minor Modification or Widening do not require either a seismic evaluation or a retrofit of the structure. If the conditions for Minor Modification or Widening project are met, it is anticipated that the

modified or widened structure will not draw enough additional seismic demand to significantly affect the existing sub-structure elements.

2. Seismic analysis is required for all Major Modifications and Widening projects at project scoping level in accordance with Section 4.1. A complete seismic analysis is required for Normal bridges in Seismic Design Category (SDC) B, C, and D for major modifications and widening projects as described below. A project geotechnical report (including any unstable soil or liquefaction issues) shall be available to the structural engineer for seismic analysis. Seismic analysis shall be performed for both existing and widened structures. Capacity/Demand (C/D) ratios are required for existing bridge elements including foundation.
3. The widening portion of the structure shall be designed for liquefiable soils condition in accordance to the AASHTO Seismic, and WSDOT BDM, unless soils improvement is provided to eliminate liquefaction.
4. Procedure for Normal Bridges: Seismic improvement of existing columns and crossbeams to  $C/D > 1.0$  is required. The cost of seismic improvement shall be paid for with widening project funding (not from the Retrofit Program). The seismic retrofit of the existing Normal structure shall conform to the BDM, while the newly widened portions of the bridge shall comply with the AASHTO Seismic, except for balanced stiffness criteria, which may be difficult to meet due to the existing bridge configuration. However, the designer should strive for the best balanced frame stiffness for the entire widened structure that is attainable in a cost effective manner. Major Modification and Widening Projects require the designer to determine the seismic C/D ratios of the existing bridge elements in the final widened condition.

If the C/D ratios of columns and crossbeam of the existing structure are less than 1.0, the improvement of seismically deficient elements is mandatory and the widening project shall include the improvement of existing seismically deficient bridge elements to C/D ratio of above 1.0. The C/D ratio of 1.0 is required to prevent the collapse of the bridge during the seismic event as required for life safety. Seismic improvement of the existing foundation elements (footings, pile caps, piles, and shafts to C/D ratios  $> 1.0$ ) could be deferred to the Bridge Seismic Retrofit Program.

5. Procedure for Essential/Critical Bridges: The initial goal is to conduct the seismic design effort so the composite structure (existing bridge and widening) meet requirements of the two-level seismic design (FEE and SEE) described in BDM Section 4.1. This includes the superstructure, substructure and foundation elements of the composite structure. Retrofitting or strengthening of the existing structure may be necessary to achieve this. Depending on the year the bridge was constructed, type of foundation and capacity of the soils during a seismic event, it may become expensive to meet this goal. If the Engineer determines it is cost-prohibitive to meet the two-level

design criteria, the Bridge Design Engineer may approve deviations. Examples of potential deviations include:

- a. Meeting two-level design criteria for the widened portion, but only achieving Normal bridge criteria for the existing bridge.
  - b. Meeting two-level design criteria for the above-ground portions of the composite structure, but not achieving this for the below-ground portions (foundations).
  - c. Performing a two-level design, but requiring deviations from the displacement ductility demand limits identified in BDM Section 4.1.
  - d. Only achieving Normal (no collapse) criteria for the composite structure.
6. The first step in retrofitting a bridge is to analyze the existing structure to identify seismically deficient elements. The initial analysis consists of generating capacity/demand ratios for all relevant bridge components. Seismic displacement and force demands shall be determined using the multi-mode spectral analysis of Section 5.4.2.2 (at a minimum). Prescriptive requirements, such as support length, shall be considered a demand and shall be included in the analysis. Seismic capacities shall be determined in accordance with the requirements of the Seismic Retrofitting Manual. Displacement capacities shall be determined by the Method D2 – Structure Capacity/Demand (Pushover) Method of Section 5.6.

#### ***BDM 4.4 Seismic Retrofit of Existing Bridges***

##### ***4.4.1 Seismic Analysis Requirements***

The seismic retrofit of Normal, Essential and Critical bridges shall be in accordance with the requirements of the AASHTO SGS, and WSDOT BDM. For Essential and Critical Bridges, the seismic design required for Normal bridges shall be performed and adequacy of the existing foundation for lower level seismic demand shall be investigated. A summary of C/D ratios for all elements shall be provided. With the approval of the State Bridge and Structures, Bridge Design and Geotechnical Engineers the retrofit of foundation elements with seismic deficiencies could be deferred to the Seismic Retrofit Program.

#### ***BDM 15.4.3 Seismic Design Requirements for Bridge Modifications and Widening Projects***

##### ***A. Seismic Analysis Policy***

The Seismic Analysis Policy for Bridge Modifications and Widening Projects shall conform to Sections 4.3.1, 4.3.2, 4.3.3, and 4.3.4.

Specific seismic requirements for widenings of Essential and Critical bridges are provided in RFP Section 2.13.

## ***BDM 15.4.4. Seismic Analysis Requirements***

### ***A. Seismic Analysis Requirements***

The multi-mode spectral analysis of Seismic Retrofitting Manual Section 5.4.2.2 (as a minimum) shall be used to determine the seismic displacement and force demands to identify seismically deficient elements of the existing structure. Prescriptive requirements, such as support length, shall be considered mandatory and shall be included in the analysis. Seismic capacities shall be determined in accordance with the requirements of the Seismic Retrofitting Manual. Displacement capacities shall be determined by the Method D2 – Structure Capacity/Demand (Pushover) Method of Seismic Retrofitting Manual Section 5.6.

The seismic retrofit of Normal, Essential and Critical bridges shall be in accordance with the requirements of the AASHTO SGS, and WSDOT BDM. Specific requirements for the seismic retrofit of Essential and Critical bridges are provided in RFP Section 2.13.

### **Background:**

The BDM requirement for retrofit of existing foundation does not adequately address the foundation retrofit requirement and two-level seismic analysis for Essential and Critical bridges. This memorandum addresses the BDM inconsistency for foundation retrofit requirement and two-level seismic analysis for Normal, Essential and Critical bridges.

The concept here is that WSDOT does preliminary analysis and design of widenings to determine the most cost-effective approach. The level of retrofitting we want to require is then included in RFP 2.13 as contractual requirements for the retrofit.

If you have any questions regarding this policy memorandum, please contact [Tony.Allen@wsdot.wa.gov](mailto:Tony.Allen@wsdot.wa.gov) or (360) 709-5450, [Bijan.Khaleghi@wsdot.wa.gov](mailto:Bijan.Khaleghi@wsdot.wa.gov) at 705-7181.

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