

TO: All Design Section Staff  
FROM: Bijan Khaleghi  
DATE: June 10, 2016  
SUBJECT: Seismic Design Requirements for Bridge Modifications and Widening

This design memorandum provides design guidance for modifications and widening of WSDOT bridges in seismic regions. Owners specified seismic design requirements shall be used for modifications and widening of essential or critical bridges.

A bridge 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 Bridge Design Specifications. The seismic design shall be in accordance with the requirements of the AASHTO Guide Specifications for LRFD Seismic Bridge Design (AASHTO SGS), and WSDOT Bridge Design Manual (BDM). The widening portion (new structure) shall be designed to meet current WSDOT standards for new bridges. Seismic analysis 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.

Bridge widening projects are classified according to the scope of work as either minor or major widening projects.

### **Minor Modification and Widening Projects**

A bridge widening project is classified as a minor widening project if all of the following conditions are met:

- Substructure bents are not modified and no new columns or piers are added, while abutments may be widened to accommodate the increase of bridge deck width.
- The net superstructure mass increase is equal or less than 10% of the original superstructure mass.
- Fixity conditions of the foundations are unchanged.
- There are no major changes of the seismicity of the bridge site that can increase seismic hazard levels or reduce seismic performance of the structure since the initial screening or most recent seismic retrofit.

- No change in live load use of the bridge

### **Major Modifications and Widening Projects**

A bridge widening project is classified as a major Widening project if any of the following conditions is met:

- Substructure bents are modified and new columns or piers are added, excepting abutments, which may be widened to accommodate the increase of bridge deck width.
- The net superstructure mass increase is more than 20% of the original superstructure mass.
- Fixity conditions of the foundations are changed.
- There are major changes of the seismicity of the bridge site that can increase seismic hazard levels or reduce seismic performance of the structure since the initial screening or most recent seismic retrofit.
- Change in live load use of the bridge

Major changes in seismicity include, but are not limited to, the following: near fault effect, significant liquefaction potential, or lateral spreading. If there are concerns about changes to the Seismic Design Response Spectrum at the bridge site, about a previous retrofit to the existing bridge, or an unusual imbalance of mass distribution resulting from the structure widening, the designer should consult the WSDOT Bridge and Structures Office.

### **Seismic Design Guidance:**

The Seismic Design for Bridge Modifications and Widening are as follows:

1. Bridge widening projects classified as Minor Widening projects do not require either a seismic evaluation or a retrofit of the structure. If the conditions for Minor Widenings are met, it is anticipated that the widened/modified structure will not draw enough additional seismic demand to significantly affect the existing sub-structure elements.
2. If the net superstructure mass increase is between 10% to 20% of the original superstructure mass, and if all the other bulleted criteria listed for Minor Widenings are met, then the "Do No Harm" policy and professional judgment could be used upon approval of the Bridge Design Engineer. The "Do No Harm" policy requires the designer to compare the C/D ratios of the existing bridge elements in the before widening condition to those of the after widening condition. If the C/D ratios are not decreased, the widening can be designed and constructed without retrofitting existing deficient bridge elements. Elements of the existing structure with C/D ratios made worse by the widening/modification work shall be retrofitted to restore their C/D ratios to before-widening values, at a minimum. Foundation elements with seismic deficiencies (C/D

ratios made worse by the widening/modification work) shall be deferred to the Seismic Retrofit Program for rehabilitation.

3. Seismic analysis is required for all Major Modifications and Widening at project scoping level. A complete seismic analysis is required for 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.
4. The widening portion of the structure shall be designed for liquefiable soils condition in accordance to the AASHTO SGS, and WSDOT BDM, unless soils improvement is provided to eliminate liquefaction.
5. 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 structure shall conform to the BDM, while the newly widened portions of the bridge shall comply with the AASHTO SGS, 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 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 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 as part of the widening project funding. 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-

### **Scoping for Bridge Widening and Liquefaction Mitigation**

The Region project manager should contact the Bridge Office for bridge widening and retaining wall scoping assistance before project funding commitments are made to the legislature and the public. The Bridge Office will work with the Geotechnical Office to assess the potential for liquefaction or other seismic hazards that could affect the cost of the proposed structures. The initial evaluation design time and associated costs for the Geotechnical and Bridge Offices shall be considered at the scoping phase.

### **Background:**

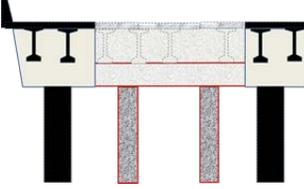
WSDOT Geotechnical Design Manual, Design Manual will be modified to conform to the provisions of this memorandum. Appendix-A provides an illustration of the Seismic Design Criteria for Bridge Modifications and Widening as was described above. Revisions to BDM Section 4.3 for Seismic Design and Retrofit, and Section 15.4.3 for Structural Design Requirements for Design-Build Contracts are shown in Appendix B.

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

cc: Mark Gaines, Bridge Construction – 47354  
Craig Boone, Bridge and Structures – 47340

## Appendix-A: Seismic Design Criteria for Bridge Modifications and Widening

Modifications or Widening	Alterations	Seismic Design Guidance	Illustration
<b>Minor Modifications</b> <ul style="list-style-type: none"> <li>Deck Rehabilitations</li> <li>Traffic Barrier Replacements</li> <li>sidewalk addition/rehabilitation</li> <li>No change in LL use</li> </ul>	<ul style="list-style-type: none"> <li>Superstructure mass increase is less than 10%</li> <li>Fixity conditions are not changed</li> </ul>	<ul style="list-style-type: none"> <li>Do not Require seismic evaluation</li> <li>Do not require retrofit of the structure</li> </ul>	
<b>Major Modifications</b> Minor Modifications PLUS <ul style="list-style-type: none"> <li>Replacing/adding girder and slab</li> <li>Change in LL use</li> </ul>	<ul style="list-style-type: none"> <li>Superstructure mass increase between 10% to 20% and/or</li> <li>Fixity conditions are changed</li> </ul>	<ul style="list-style-type: none"> <li>Seismic evaluation of the structure is required.</li> <li>Do-No-Harm is required for substructure.</li> <li>Do-No-Harm is required for foundation.</li> </ul>	
<b>Major Widening – Case 1</b> Minor Modifications PLUS <ul style="list-style-type: none"> <li>Superstructure or Bent Widening</li> </ul>	<ul style="list-style-type: none"> <li>Superstructure mass increase is more than &gt; 20% and/or</li> <li>Substructure/bents modified and/or</li> <li>Fixity conditions are changed</li> </ul>	<ul style="list-style-type: none"> <li>Seismic evaluation of the structure is required.</li> <li>C/D ratio of equal or greater than 1.0 is required for substructure.</li> <li>Do-No-Harm could be used for Foundation.</li> </ul>	
<b>Major Widening – Case 2</b> <ul style="list-style-type: none"> <li>widening on one side</li> </ul>	<ul style="list-style-type: none"> <li>Substructure or bents are modified. Columns are added on one side.</li> </ul>	<ul style="list-style-type: none"> <li>Seismic evaluation of the structure is required.</li> <li>C/D ratio of equal or greater than 1.0 is required for substructure.</li> <li>Do-No-Harm could be used for Foundation.</li> </ul>	

<p><b>Major Widening – Case 3</b></p> <ul style="list-style-type: none"><li>widening on both sides</li></ul>	<ul style="list-style-type: none"><li>Substructure or bents are modified. Columns are added on both sides.</li></ul>	<ul style="list-style-type: none"><li>Seismic evaluation of the structure is required.</li><li>C/D ratio of equal or greater than 1.0 is required for substructure.</li><li>Do-No-Harm could be used for Foundation.</li></ul>	
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## **Appendix B: Revisions to BDM Section 4.3 for Seismic Design and Retrofit, and Section 15.4.3 for Structural Design Requirements for Design-Build Contracts**

### **4.3 Seismic Design Requirements for Bridge Modifications and Widening Projects**

#### **4.3.1 General**

A bridge 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 Bridge Design Specifications. The seismic design shall be in accordance with the requirements of the AASHTO Guide Specifications for LRFD Seismic Bridge Design (AASHTO SGS), and WSDOT Bridge Design Manual (BDM). The widening portion (new structure) shall be designed to meet current WSDOT standards for new bridges. Seismic analysis 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.

#### **4.3.2 Bridge Widening Project Classification**

Bridge widening projects are classified according to the scope of work as either minor or major widening projects.

##### **A. Minor Modification and Widening Projects**

A bridge widening project is classified as a minor widening project if all of the following conditions are met:

- Substructure bents are not modified and no new columns or piers are added, while abutments may be widened to accommodate the increase of bridge deck width.
- The net superstructure mass increase is equal or less than 10% of the original superstructure mass.
- Fixity conditions of the foundations are unchanged.
- There are no major changes of the seismicity of the bridge site that can increase seismic hazard levels or reduce seismic performance of the structure since the initial screening or most recent seismic retrofit.
- No change in live load use of the bridge

## **B. Major Modifications and Widening Projects**

A bridge widening project is classified as a major widening project if any of the following conditions is met:

- Substructure bents are modified and new columns or piers are added, excepting abutments, which may be widened to accommodate the increase of bridge deck width.
- The net superstructure mass increase is more than 20% of the original superstructure mass.
- Fixity conditions of the foundations are changed.
- There are major changes of the seismicity of the bridge site that can increase seismic hazard levels or reduce seismic performance of the structure since the initial screening or most recent seismic retrofit.
- Change in live load use of the bridge

Major changes in seismicity include, but are not limited to, the following: near fault effect, significant liquefaction potential, or lateral spreading. If there are concerns about changes to the Seismic Design Response Spectrum at the bridge site, about a previous retrofit to the existing bridge, or an unusual imbalance of mass distribution resulting from the structure widening, the designer should consult the WSDOT Bridge and Structures Office.

### ***4.3.3 Seismic Design Guidance:***

The Seismic Design guidance for Bridge Modifications and Widening are as follows:

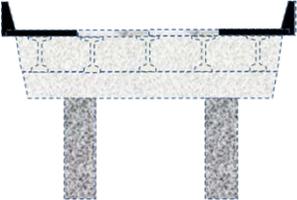
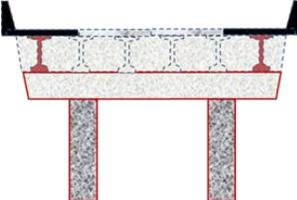
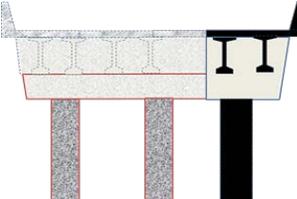
1. Bridge widening projects classified as Minor Widening projects do not require either a seismic evaluation or a retrofit of the structure. If the conditions for Minor Widening project are met, it is anticipated that the widened/modified structure will not draw enough additional seismic demand to significantly affect the existing substructure elements.
2. If the net superstructure mass increase is between 10% to 20% of the original superstructure mass, and if all the other bulleted criteria listed for Minor Widening projects are met, then the "Do No Harm" policy and professional judgment could be used upon approval of the Bridge Design Engineer. The "Do No Harm" policy requires the designer to compare the C/D ratios of the existing bridge elements in the before widening condition to those of the after widening condition. If the C/D ratios are not decreased, the widening can be designed and constructed without retrofitting existing deficient bridge elements. Elements of the existing structure with C/D ratios made worse by the widening/modification work shall be retrofitted to restore their C/D ratios to before-widening values, at a minimum. Foundation elements with

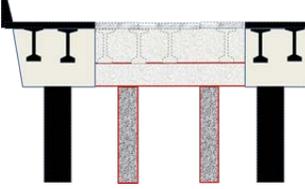
- seismic deficiencies (C/D ratios made worse by the widening/modification work) shall be deferred to the Seismic Retrofit Program for rehabilitation.
3. Seismic analysis is required for all Major Modifications and Widening projects at project scoping level. A complete seismic analysis is required for 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.
  4. The widening portion of the structure shall be designed for liquefiable soils condition in accordance to the AASHTO SGS, and WSDOT BDM, unless soils improvement is provided to eliminate liquefaction.
  5. 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 structure shall conform to the BDM, while the newly widened portions of the bridge shall comply with the AASHTO SGS, 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 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 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 as part of the widening project funding. 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.

#### ***4.3.4 Scoping for Bridge Widening and Liquefaction Mitigation:***

The Region project manager should contact the Bridge Office for bridge widening and retaining wall scoping assistance before project funding commitments are made to the legislature and the public. The Bridge Office will work with the Geotechnical Office to assess the potential for liquefaction or other seismic hazards that could affect the cost of the proposed structures. The initial evaluation design time and associated costs for the Geotechnical and Bridge Offices shall be considered at the scoping phase.

**Figure 4.3-1: Seismic Design Criteria for Bridge Modifications and Widening**

Modifications or Widening	Alterations	Seismic Design Guidance	Illustration
<p><b>Minor Modifications</b></p> <ul style="list-style-type: none"> <li>• Deck Rehabilitations</li> <li>• Traffic Barrier Replacements</li> <li>• sidewalk addition/rehabilitation</li> <li>• No change in LL use</li> </ul>	<ul style="list-style-type: none"> <li>• Superstructure mass increase is less than 10%</li> <li>• Fixity conditions are not changed</li> </ul>	<ul style="list-style-type: none"> <li>• Do not Require seismic evaluation</li> <li>• Do not require retrofit of the structure</li> </ul>	
<p><b>Major Modifications</b> Minor Modifications PLUS</p> <ul style="list-style-type: none"> <li>• Replacing/adding girder and slab</li> <li>• Change in LL use</li> </ul>	<ul style="list-style-type: none"> <li>• Superstructure mass increase between 10% to 20% and/or</li> <li>• Fixity conditions are changed</li> </ul>	<ul style="list-style-type: none"> <li>• Seismic evaluation of the structure is required.</li> <li>• Do-No-Harm is required for substructure.</li> <li>• Do-No-Harm is required for foundation.</li> </ul>	
<p><b>Major Widening – Case 1</b> Minor Modifications PLUS</p> <ul style="list-style-type: none"> <li>• Superstructure or Bent Widening</li> </ul>	<ul style="list-style-type: none"> <li>• Superstructure mass increase is more than &gt; 20% and/or</li> <li>• Substructure/bents modified and/or</li> <li>• Fixity conditions are changed</li> </ul>	<ul style="list-style-type: none"> <li>• Seismic evaluation of the structure is required.</li> <li>• C/D ratio of equal or greater than 1.0 is required for substructure.</li> <li>• Do-No-Harm could be used for Foundation.</li> </ul>	
<p><b>Major Widening – Case 2</b></p> <ul style="list-style-type: none"> <li>• widening on one side</li> </ul>	<ul style="list-style-type: none"> <li>• Substructure or bents are modified. Columns are added on one side.</li> </ul>	<ul style="list-style-type: none"> <li>• Seismic evaluation of the structure is required.</li> <li>• C/D ratio of equal or greater than 1.0 is required for substructure.</li> <li>• Do-No-Harm could be used for Foundation.</li> </ul>	

<p><b>Major Widening – Case 3</b></p> <ul style="list-style-type: none"> <li>widening on both sides</li> </ul>	<ul style="list-style-type: none"> <li>Substructure or bents are modified. Columns are added on both sides.</li> </ul>	<ul style="list-style-type: none"> <li>Seismic evaluation of the structure is required.</li> <li>C/D ratio of equal or greater than 1.0 is required for substructure.</li> <li>Do-No-Harm could be used for Foundation.</li> </ul>	
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***Structural Design Requirements for Design-Build Contracts***

***Chapter 15***

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

**A. Seismic Analysis and Retrofit Policy**

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