Washington State Department of Transportation

Memorandum

TO: All Design Section Staff

FROM: Bijan Khaleghi

DATE: April 10, 2009

SUBJECT: AASHTO Guide Specifications for LRFD Seismic Bridge Design Amendments

This design memorandum is an amendment to AASHTO Guide Specifications for LRFD Seismic Bridge Design and revisions 1st edition, 2009. WSDOT requires all new bridges and bridge widenings to be designed in accordance with the requirements of the AASHTO Guide Specifications and WSDOT amendments.

The following items summarize WSDOT's additional requirements and deviations from the AASHTO Guide Specifications for LRFD Seismic Bridge Design:

Article	Subject	WSDOT Requirements
3.3	Earthquake Resisting Systems (ERS) Requirements for SDCs C and D	WSDOT Global Seismic Design Strategies: Type 1: Ductile Substructure with Essentially Elastic Superstructure. This category is permissible. Type 2: Essentially Elastic Substructure with a Ductile Superstructure. This category is not permissible. Type 3: Elastic Superstructure and Substructure with a Fusing Mechanism Between The Two. This category is permissible with Bridge Design Engineer's approval. Foundations in all SDCs could be designed for the minimum of the linear elastic forces or the capacity protection forces. If foundations are designed for elastic forces, no inelastic deformation is anticipated, but minimum detailing is required according to the bridge seismic design category. Shear design shall be based on 1.2 times elastic shear force and nominal material strengths shall be used.
3.3	Earthquake Resisting Systems (ERS)	Figure 3.3-1a: Permissible Earthquake Resisting System (ERS), see attachment.

	Requirements for SDCs C and D	• Types 1 and 3 are permissible. • Types 2, 4 & 5 are permissible with Bridge Design Engineer's approval. • Type 6 is not Permissible. Figure 3.3-1b: Permissible Earthquake Resisting Elements (ERE), see attachment. • Types 1, 2, 7, 8, 9, 10 &14 are permissible ERE. • Types 3, 5, 6, 11, 12 are permissible ERE with Bridge Design Engineer's approval. • Types 4 &13 are not permissible. Figure 3.3-2: Permissible Earthquake Resisting Elements that require Owner's Approval (ERE), see attachment. • Types 1 & 2 are permissible ERE with Bridge Design Engineer's approval. • Types 6 & 8 are not Permissible for Non-liquefied configuration and Permissible with Bridge Design Engineer's approval for liquefied configuration • Types 3, 4, 5, 7 & 9 are not Permissible. Figure 3.3-3: Earthquake Resisting Elements that are not Recommended for New Bridges • Types 1, 2, 3, & 4 are not Permissible. Permissible ERS and ERE systems with Bridge Design Engineer's approval are applicable to all projects regardless of contracting methods.
3.4	Seismic Ground Shaking Hazard	The procedure used to determine the ground shaking hazard for site class F, critical or essential bridges shall be based on the WSDOT Geotechnical Engineer recommendations.
3.5	Selection of Seismic Design Category (SDCs)	Pushover Analysis shall be used to determine displacement capacity for both SDCs C and D.

3.6	Temporary and Staged Construction	Design response spectra for temporary and staged construction bridges may be reduced by a factor of not more than 2.5. However, it shall be clear in the contract document that structure is designed for reduced response spectra.
3.7	Load and Resistance Factors	Use load factor of 0.0 for live load.
4.1.2 4.1.3	Balanced Stiffness SDCs D Balanced Frame Geometry SDCs D	Balanced stiffness requirements and balanced frame geometry requirement shall be satisfied for bridges in both SDCs C and D. Deviation from balanced stiffness and balanced frame geometry requirements shall be approved by Bridge Design Engineer.
4.2	Selection of Analysis Procedure to Determine Seismic Demand	Analysis Procedures: Procedure 1 (Equivalent Static Analysis) shall not be used. Procedure 2 (Elastic Dynamic Analysis) shall be used for all regular bridges with 2 through 6 spans. Procedure 3 (Nonlinear Time History) may be used where applicable. The time histories of input acceleration used to describe the earthquake loads shall be selected in consultation with WSDOT Geotechnical Engineer and Bridge Design Engineer.
4.9	Member Ductility Requirement for SDCs D	In-ground hinging for drilled shaft and pile foundations may be considered for liquefied configuration with WSDOT Bridge Design Engineer approval.
4.11.2	Plastic Hinging Forces	Revise Figure 4.11.2-1, see attachment.
4.12.3	Minimum Support Length Requirements Seismic Design Category D	For single-span bridges, the support length shall be 150% of the empirical support length, N, specified by Equation 4.12.2-1
4.13.1	Longitudinal Restrainers	Longitudinal restrainers shall be provided at the expansions between superstructure segments. Restrainers shall be designed for a force calculated as the acceleration coefficient, As, as specified in Eq.3.4.1-1, times the permanent load of the lighter of the two adjoining spans or parts of the structure. Restrainers shall be detailed in accordance with the requirements of WSDOT BDM Section 4.3.5.

		Restrainers may be omitted for SDCs C and D where the available seat width exceeds the calculated support length specified in Eq. 1 (using 2 times seismic displacement instead of 1.65 as required in Eq. 4.12.3-1). $N=(4+\mathbf{2.0}\Delta_{eq})(1+0.00025S^2) \geq$ 24 in. (1) Omitting restrainers for liquefiable sites shall be based on the WSDOT Bridge Design Engineer's approval. Longitudinal restrainers shall not be used at the end piers (abutments).
5.2	Abutments	Diaphragm Abutment type shown in Figure 5.2.3.2-1 shall not be used for WSDOT bridges. With WSDOT Bridge Design Engineer approval, the abutment may be considered and designed as part of earthquake resisting system (ERS) in the longitudinal direction of a straight bridge with little or no skew and with a continuous deck. Longitudinal passive soil pressure shall be less than 50% of the value obtained using the procedure given in Article 5.2.3.3. Participation of wingwall in transverse direction may not be considered in the seismic design of bridges.
5.3	Foundation - general	The required foundation modeling method (FMM) and the requirements for estimation of foundation springs for spread footings, pile foundations, and drilled shafts shall be based on the WSDOT Geotechnical Engineer's recommendations.
5.6.2	Figure 5.6.2-1	The horizontal axis label of Figure 5.6.2-1 for both (a) Circular Sections and (b) Rectangular sections shall be Axial Load Ratio $\frac{P}{f'_{ce}\ A_g}$
5.6.3	I_{eff} for Box Girder Superstructure	Gross moment of inertia shall be used for box girder superstructure modeling.
6.3.9	Foundation Rocking	Foundation rocking shall not be used for the design of WSDOT bridges.
C6.5	Drilled Shafts	The scale factor for P-y curves for large diameter shafts shall not be used for WSDOT bridges. Unless

		approved by WSDOT Geotechnical Engineer and Bridge Design Engineer.
6.7.1	Longitudinal Direction Requirements	Case 2: Earthquake Resisting System (ERS) with abutment contribution may be used provided that the mobilized longitudinal passive pressure is less than the 0.50 of the value obtained using procedure given in Article 5.2. 3.3.
6.8	Liquefaction Design Requirements	Soil liquefaction assessment shall be based on the WSDOT Geotechnical Engineer's recommendation and GDM Section 6.4.2.8.
8.4.1	Reinforcing Steel	Only ASTM A 706 reinforcing steel shall be used. Deformed welded wire fabric may be used with Bridge Design Engineer's approval. Wire rope or strands for spirals, and high strength bars with yield strength in excess of 75 ksi shall not be used for design purposes.
8.5	Plastic Moment Capacity for Ductile Concrete Members for SDCs B, C and D	The overstrength magnifier of 1.2 for ASTM A 706 reinforcement shall be applied to column plastic hinging moment to determine force demand for capacity protected members connected to a hinging member.
8.6.1	Shear Demand and Capacity	The shear reinforcement outside plastic hinge region need not exceed the required shear reinforcement inside the plastic hinge region.
8.6.7	Interlocking Bar Size	Same bar sizes may be used inside and outside of interlocking spirals.
8.8.2	Minimum Longitudinal Reinforcement	Minimum longitudinal reinforcement of 1% shall be used for columns in SDCs B, C, and D.
8.8.10	Development length for Column Bars Extended into Oversized Pile Shafts for SDCs C and D	Extending column bars into oversized shaft shall be based on either a staggered manner as described in Article 8.8.2, or per current BDM practice based on TRAC Report WA-RD 417.1 "Non Contact Lap Splice in Bridge Column-Shaft Connections" and Design Memo "Column-Shaft connection Design and Detailing Recommendation" dated as July 18, 2008. Same size column-shaft is not permissible unless approved by Bridge Design Engineer.

8.8.12	Lateral Confinement for Oversized Pile Shaft for SDCs C and D	The requirement of this article for shaft lateral reinforcement may be replaced with the recommendations of July 18, 2008 Design Memorandum.
8.9	Requirements for Capacity Protected members	Add paragraphs as follows: For SDCs C and D where liquefaction is identified, with Bridge Design Engineer's approval, pile and drilled shaft in-ground plastic hinging may be considered as an ERE. The bridges should be analyzed and designed in both nonliquefied configuration and liquefied configuration in accordance with Article 6.8. In nonliquefied configuration, the capacity protected members shall be designed in accordance with the requirements of Article 4.11. The pile and drilled shaft shall be designed for a flexural expected nominal capacity equal to 1.25 times the moment demand generated by the overstrength column plastic hinge moment. Plastic hinges shall only be permitted at locations in columns where they can be readily inspected and/or repaired. In liquefied configuration, the capacity protected members shall be designed in accordance with the requirements of Article 4.11 except the pile and drilled shaft shall be designed for a flexural expected nominal capacity equal to 1.0 times the moment demand generated by the overstrength column plastic hinge moment.
8.10	Superstructure Capacity design for Integral Bent Caps for Longitudinal direction for SDCs B, C and D	The effective width for open soffit girder-deck superstructure as specified in Article 8.10 shall be used instead of current WSDOT practice based on the tributary number of girders per column. The requirement of Article 8.11 for eccentricity between the plastic hinge location and CG of bent cap applies.
8.12	Superstructure Design for Non-Integral Bent Caps for SDCs C & D	Non-Integral Bent Caps shall not be used for continuous concrete bridges in SDCs B, C and D.
C 8.13	Joint Design for SDCs C and D	Add commentary as follows: Additional joint reinforcement specified in Article 8.13.4.2 for integral bent cap and Article 8.13.5.1 for nonintegral bent cap is based on the tests by Priestley (1996) and Sritharan (2005) for certain standard joint

		as shown in Figure C8.13.1-1 and Figure 8.13.4.2-1-2 using the external strut force transfer method. The column longitudinal bars for these joint shall be extended into the cap beam as close as practically possible to the deck for integral bent cap and top of cap beam for nonintegral bent cap. The joint reinforcement shall be placed within a distance of 0.5 Dc from the column surface. Consequently, these specifications only applicable to the joints that closely match the geometry of test joints and can be detailed as shown in Figure 8.13.4.2-1-1 to 3 and Figure 8.13.5.1.1-1 to 2. Bent cap beams not satisfying these joint geometry and detail requirements shall be designed based upon the strut and tie provisions of the AASHTO LRFD Bridge Design Specifications.
8.15	Column Shear Key Design for SDCs C and D	Add paragraphs as follows: The column hinge shall be designed in accordance with Article 5.8.4 provisions for shear friction of the AASHTO LRFD Bridge Design Specifications using the nominal material strength properties. The design procedure and hinge detail per TRAC Report WA-RD 220.1 titled "Moment-Reducing Hinge Details for the Based of Bridge Columns" should be used. The thickness of the expansion joint filler shall allow the maximum column rotation without crushing the edge of the column concrete against the cap beam or footing.

Background:

This design memorandum describes WSDOT's amendments to AASHTO Guide Specifications for LRFD Seismic Bridge Design 1st edition, 2009 based on the WSDOT design and construction requirements. This memorandum supersedes design memorandum issued on November 14, 2008.

If you have any questions regarding these issues, please contact Bijan Khaleghi at 705-7181 or Chyuan-Shen Lee at 705-7441.

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