Washington State Department of Transportation

Memorandum

TO: All Design Section Staff

FROM: Bijan Khaleghi

DATE: November 14, 2008

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 approved in 2008 by the AASHTO Highway Subcommittee on Bridges and Structures. Revisions include 2008 Ballot Items 74, 75 and 76. WSDOT requires all new bridges, bridge widenings, and retaining walls to be designed in accordance with the requirements of the AASHTO Guide Specifications, revisions and WSDOT amendments.

The AASHTO Guide Specifications for LRFD Seismic Bridge Design and Ballot Items could be downloaded from the following web sites:
http://bridges.transportation.org/sites/bridges/docs/Seismic%20Guide%20Specification%20Ballot.pdf

http://bridges.transportation.org/sites/bridges/docs/2008%20Ballot%20Item%2074.pdf

http://bridges.transportation.org/sites/bridges/docs/2008%20Ballot%20Item%2075.pdf

http://bridges.transportation.org/sites/bridges/docs/2008%20Ballot%20Item%2076.pdf

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 SDC C & 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.

3.3	Earthquake Resisting Systems (ERS) Requirements for SDC C & D	Figure 3.3-1a: Permissible Earthquake Resisting System (ERS), see attachment. • 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 (SDC)	Pushover Analysis shall be used to determine displacement capacity for both SDC C & 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 Requirements Balanced Frame Geometry Requirement	Balanced stiffness requirements and balanced frame geometry requirement shall be satisfied for bridges in both SDC C & 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 SDC C and 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

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.
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 SDC B, C & 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.
8.6.7	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 SDC B, C, & D.
8.8.10	Development length for Column Bars Extended into Oversized Pile Shafts for SDC C & 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.
8.9	Requirements for Capacity Protected members	Add paragraphs as follows: For SDC 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 pile and drilled shaft may be designed for the forces determined using Nonlinear Static Procedure (pushover analysis). Forces determined at the displacement demand obtained from a linear dynamic response analysis may be used to designed piles and drilled shafts. Where in-

		ground plastic hinging is part of ERS, the confined concrete core should be limited to a maximum compressive strain of 0.008 and the member ductility demand shall be limited to 4. The point of maximum moment shall be identified based on a moment diagram for the column-shaft configuration. The expected plastic hinge zone shall extend 3D above and below the point of maximum moment. The plastic hinge zone shall be designated as the "No-splice" zone and the transverse steel for shear and confinement shall be provided accordingly.
8.10	Superstructure Capacity design for Integral Bent Caps for Longitudinal direction for SDC B, C & 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 SDC B, C & D	Non-Integral Bent Caps shall not be used for continuous concrete bridges in SDC B, C & D.

Background:

This design memorandum describes WSDOT's amendments to AASHTO Guide Specifications for LRFD Seismic Bridge Design and revisions approved in 2008 by the AASHTO Highway Subcommittee on Bridges and Structures based on the WSDOT design and construction requirements. This memorandum supersedes design memorandum issued on February 18, 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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