



**Washington State
Department of Transportation**

Bridge and Structures Office

DESIGN MEMORANDUM

TO: All Design Staff
FROM: Bijan Khaleghi
DATE: July 31, 2012
SUBJECT: Seismic Design of Underground Structures

The purpose of this memorandum is to clarify the seismic design requirement for underground structures. This memorandum supersedes the BDM Section 8.2.1 in its entirety.

Miscellaneous underground structures consist of box culverts, precast reinforced concrete three-sided structures, detention vaults, and metal pipe arches. Where miscellaneous underground structures pass under or support roadways and other structures, they shall be designed for seismic effects as follows:

- Seismic effects need not be considered for structures with span lengths of 20 feet or less.
- Seismic effects shall be considered for structures with span lengths more than 20 feet. The potential effects of unstable ground conditions (e.g., liquefaction, liquefaction induced settlement, landslides, ground motion attenuation with depth, and fault displacements) on the function of the underground structures shall be considered. The AASHTO LRFD Bridge Design Specifications Section 12.6.1 exemption from seismic loading shall not apply.

As with any structure, a geotechnical soils report with loading or pressure diagrams, settlement criteria, and ground water levels will be needed from the Materials Laboratory Geotechnical Office in order to complete the design. The requirement of BDM Section 3.5 for inclusion of live load in Extreme Event-I load combination is applicable.

In addition to the AASHTO LRFD Bridge Design Specifications, the FHWA Publication No. FHWA-NHI-09-010 dated November 2008 “Technical Manual for Design and Construction of Road Tunnels Civil Elements” may also be used as a design specification reference for the seismic design requirement.

Background:

The current BDM 8.2.1 states that the seismic design criteria do not control the design of underground structures unless the peak ground acceleration exceeds 0.3g, where g is the acceleration due to gravity. This memorandum provides more detailed guidelines for the design of underground structures. The seismic design of tunnel structures is referred to the FHWA Technical Manual for Design and Construction of Road Tunnels Civil Elements.

If you have any questions regarding these issues, please contact Bijan Khaleghi at 360-705-7181 (KhalegB@wsdot.wa.gov).

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BDM 8.2 Miscellaneous Underground Structures

8.2.1 General

Miscellaneous underground structures consist of box culverts, precast reinforced concrete three-sided structures, detention vaults, and metal pipe arches, and tunnels.

~~Generally, the seismic design criteria does not control the design of underground structures unless the peak ground acceleration exceeds $0.3g$, where g is the acceleration due to gravity.~~ This is because the structures are supported on all sides by soil and rock, and move as a unit with the adjacent soil. See reference by Miller and Constantino (1994). As with any structure, a geotechnical soils report with loading or pressure diagrams, settlement criteria, and ground water levels will be needed from the Materials Laboratory Geotechnical Services Branch in order to complete the design.

Where miscellaneous underground structures pass under or support roadways and other structures, they shall be designed for seismic effects as follows:

- Seismic effects need not be considered for structures with span lengths of 20 feet or less.
- Seismic effects shall be considered for structures with span lengths more than 20 feet.
The potential effects of unstable ground conditions (e.g., liquefaction, liquefaction induced settlement, landslides, ground motion attenuation with depth, and fault displacements) on the function of the underground structures shall be considered. The AASHTO LRFD Bridge Design Specifications Section 12.6.1 exemption from seismic loading shall not apply.

As with any structure, a geotechnical soils report with loading or pressure diagrams, settlement criteria, and ground water levels will be needed from the Materials Laboratory Geotechnical Office in order to complete the design. The requirement of BDM Section 3.5 for inclusion of live load in Extreme Event-I load combination is applicable.

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