

TO: All Design Section Staff
FROM: Bijan Khaleghi
DATE: July 31, 2015
SUBJECT: Buried Structures

This design memorandum supersedes the design memorandum dated May 30th, 2015.

This design memorandum defines WSDOT policy for use of buried structures for span lengths equal or greater than 20 feet. A full PS&E package including preliminary plan will be required for any buried structures with span lengths equal or greater than 20 feet. For clarity, the span length is measured from interior face to face of culvert along centerline roadway.

General Requirements:

Buried structure systems considered herein are: metal pipe, structural plate pipe, long-span structural plate, deep corrugated plate, reinforced concrete pipe, cast-in-place or precast reinforced concrete arch, box, split box, or three sided structures, elliptical structures, thermoplastic pipe, and fiberglass pipe. Buried box culverts constructed of aluminum or steel structural plate shall not be used for any types of buried structures regardless of span lengths or usage.

Design Requirements:

The design of buried structures shall be in accordance with the requirements of the current edition of AASHTO LRFD Bridge Design Specifications Section 12, unless otherwise required in the project-specific criteria. Buried structures shall be designed for a minimum service life of 75 years. The decrease in live load effect due to increase in fill depth shall be considered in both design and load rating of buried structures. The requirement of BDM Section 3.5 for inclusion of live load in Extreme Event-I load combination is applicable. The extreme event limit states include extreme event-I for seismic and extreme event-II for flood and certain hydraulic events such as scour. Foundations for buried structures shall be designed and detailed in accordance with Bridge Design, and Geotechnical Manuals.

The seismic design of buried structures with spans equal or greater than 20 feet shall conform to Chapter 13 Seismic Considerations in FHWA publication FHWA-NHI-10-034, Technical Manual for Design and Construction of Road Tunnels-Civil Elements, or equivalent methods upon approval of the Bridge Design Engineer. The seismic effects of transient racking/ovaling

deformations on culverts and pipe structures must be considered in addition to the normal load effects from dead loads of structural components, vertical and horizontal earth and water loads, and live load surcharges. The AASHTO LRFD Bridge Design Specifications Section 12.6.1 exemption from seismic loading shall not apply. The seismic design need not be considered for buried structures with span lengths of less than 20.

The ground motion attenuation as specified below shall be used for seismic design of buried structures.

Table 1: Ground Motion Attenuation with Depth

Depth to Top of Buried Structure, feet	Ratio of Ground Motion at Buried Structure Depth to Motion at Ground Surface
< 20	1.0
20 to 50	0.9
50 to 100	0.8
>100	0.7

For buried structures, with span lengths equal or greater than 20 feet, the seismic effects of potential unstable ground conditions (e.g., liquefaction, liquefaction induced settlement, landslides, and fault displacements) on the function of the buried structures shall be considered. Liquefaction, landslides, or fault displacements need not be considered if they do not cause life safety hazards. As a guideline, if the depth of fill on top of the structure is more than one-half the clear span along roadway centerline, liquefaction induced settlement or local instability are not likely to cause life safety hazards.

The above provisions are the minimum seismic design requirements for conventional buried structures. Additional provisions may be specified, on a case-by-case basis, to achieve higher seismic performance criteria for essential or critical buried structures. Where such additional requirements are specified, they shall be site or project specific and are tailored to a particular structure type.

Submittal Requirements:

The design calculations and detailed shop drawings of buried structures shall be submitted to the Bridge and Structures Office for review and approval. The submittal shall include load rating for all buried structures with span length equal or greater than 20 feet. The submittal shall include installation procedures, backfill materials, and compacting sequences. The adequacy of the buried structure for the required depth of fill shall be provided in the submittal. Final as-built plans for buried structures with a span length equal or greater than 20 feet shall be submitted to the Bridge and Structures Office for records.

The above provisions apply to buried structures composed of precast or cast-in-place concrete walls supporting the roadway embankment. Precast walls that are being supplied as part of the

culvert systems could be preapproved if they meet the WSDOT design and detailing requirement, and the preapproval procedures.

For Design-Build projects all buried structures are required to be sealed and signed by licensed Hydraulics, Geotechnical and Structural Engineers.

Background:

The main purpose of this design memorandum is to require pre-contract evaluation and design of all new non-bridge structures with spans equal or greater than 20 feet. This would require design or review by the WSDOT team (Bridge and Structures, Geotechnical, Hydraulics, etc.) of non-bridge structures such as culverts, boxes or similar, when spanning equal or greater than 20 feet. State Hydraulics Engineer and Project Engineers should be consulted for buried structure with span lengths less than 20 feet.

All buried structures shall comply with the AASHTO LRFD service life of 75 years minimum. Buried box culverts constructed of aluminum or steel structural plate shall not be used for any types of buried structures regardless of span lengths or usage. Many factors are considered in preliminary design of buried structures. Some of the more common of these are: Stream flow conditions, passage of flood debris, scour, effect of shape, width, skew, bank and pier protection, consideration of a culvert as an alternate solution, and permit requirements for navigation and stream work limitations.

General NBI requirements are that the Bridge Preservation Office has a load rating on file for every structure with span length equal or greater than 20 feet.

Precast walls that are being supplied as part of the culvert systems could be preapproved similar to other preapproved wall systems if they meet the WSDOT design and detailing procedures.

For Design-Build projects all reports and plan sheets for buried structures are required to be sealed and signed by licensed Hydraulics, Geotechnical and Structural Engineers (with civil PE license).

If you have any questions regarding this policy memorandum, please contact Tony.Allen@wsdot.wa.gov, Harvey.Coffman@wsdot.wa.gov, Richard.Zeldenrust@wsdot.wa.gov, or Bijan Khaleghi@wsdot.wa.gov at 705-7181.

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

BDM Revisions:

Chapter 8 Walls and Buried Structures

Contents

BDM section 8.3 shall be modified as follows:

8.3 Miscellaneous ~~Underground~~ Buried Structures

8.3.1 General

Miscellaneous buried structures consist of metal pipe, structural plate pipe, long-span structural plate, deep corrugated plate, reinforced concrete pipe, cast-in-place reinforced concrete and precast concrete arch, box and elliptical structures, thermoplastic pipe, and fiberglass pipe. All buried structures shall comply with the current edition of the AASHTO LRFD Specifications for minimum service life of 75 years.

The requirement of this chapter applies to buried structures with span lengths equal or greater than 20 feet. A full PS&E package including preliminary plan will be required for any buried structures with span lengths equal or greater than 20 feet. For clarity, the span length is measured from interior face to face of culvert along the skew.

General NBI requirements are that the Bridge Preservation Office has a load rating on file for every structure with span lengths equal or greater than 20 feet.

A. General Requirements

Buried structure systems considered herein are: metal pipe, structural plate pipe, long-span structural plate, deep corrugated plate, reinforced concrete pipe, cast-in-place reinforced concrete and precast concrete arch, box and elliptical structures, thermoplastic pipe, and fiberglass pipe. Buried box culverts constructed of aluminum or steel structural plate shall not be used for any types of buried structures regardless of span lengths or usage.

B. Design Requirements

The design of buried structures shall be in accordance with the requirements of the current edition of AASHTO LRFD Bridge Design Specifications Section 12, unless otherwise required in the project-specific criteria. Buried structures shall be designed for a minimum service life of 75 years. The decrease in live load effect due to increase in fill depth shall be considered in both design and load rating of buried structures. The requirement of BDM Section 3.5 for inclusion of live load in Extreme Event-I load combination is applicable. The extreme event limit states include extreme event-I for seismic and extreme event-II for flood and certain hydraulic events. Foundations for buried structures shall be designed and detailed in accordance with Bridge Design, and Geotechnical Manuals.

The seismic design of buried structures with spans equal or greater than 20 feet shall conform to Chapter 13 Seismic Considerations in FHWA publication FHWA-NHI-10-034, Technical Manual for Design and Construction of Road Tunnels-Civil Elements, or equivalent methods upon approval of the Bridge Design Engineer. The seismic effects of transient racking/ovaling deformations on culverts and pipe structures must be considered in addition to the normal load effects from dead loads of structural components, vertical and horizontal earth and water loads, and live load surcharges. The AASHTO LRFD Bridge Design Specifications Section 12.6.1 exemption from seismic loading shall not apply. The seismic design need not be considered for buried structures with span lengths of less than 20.

The ground motion attenuation as specified below shall be used for seismic design of buried structures.

Attenuation with Depth

Depth to Top of Buried Structure, feet	Ratio of Ground Motion at Buried Structure Depth to Motion at Ground Surface
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For buried structures, with span lengths equal or greater than 20 feet, the seismic effects of potential unstable ground conditions (e.g., liquefaction, liquefaction induced settlement, landslides, and fault displacements) on the function of the buried structures shall be considered, except liquefaction need not be considered if the liquefaction, landslides, or fault displacements do not cause life safety hazards. As a guideline, if the depth of fill on top of the structure is more than one-half the clear span along roadway centerline, liquefaction induced settlement or local instability are not likely to cause life safety hazards.

The above provisions are the minimum seismic design requirements for conventional buried structures. Additional provisions may be specified, on a case-by-case basis, to achieve higher seismic performance criteria for essential or critical buried structures. Where such additional requirements are specified, they shall be site or project specific and are tailored to a particular structure type.

C. Submittal Requirements

The design calculations and detailed shop drawings of buried structures shall be submitted to the Bridge and Structures Office for review and approval. The submittal shall include load rating for all buried structures with span length equal or greater than 20 feet. The submittal shall include installation procedures, backfill materials, and compacting sequences. The adequacy of the buried structure for the required depth of fill

shall be provided in the submittal. Final as-built plans shall be submitted to the Bridge and Structures Office for records.

The above provisions apply to buried structures composed of precast or Cast-in-place concrete walls supporting the roadway embankment. Precast walls that are being supplied as part of the culvert systems could be preapproved if they meet the WSDOT design and detailing requirement, and the preapproval procedures.

For Design-Build projects all buried structures are required to be sealed and signed by licensed Hydraulics, Geotechnical and Structural Engineers.