Chapter 720 Bridges

720.01 General

The National Bridge Inspection Standards (NBIS), published in the Code of Federal Regulations (23 CFR 650, Subpart C), defines a bridge as:

> *A structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening.*

The term "bridge" as used in this chapter applies to all structures conforming to the above definition. This includes all buried structures with a structural clear span greater than 20 feet measured along the overcrossing alignment, such as concrete three-sided structures, concrete box culverts and split box culverts, and steel and aluminum structural plate, pipes, arches, and boxes.

Bridge design is the responsibility of the Washington State Department of Transportation (WSDOT) Headquarters (HQ) Bridge and Structures Office, which develops a preliminary or conceptual bridge plan for a new or modified structure in collaboration with the region. This chapter provides basic design considerations for the development of this plan. Unique staging requirements, constructability issues, and other considerations are addressed during plan development. Contact the HQ Bridge and Structures Office early in the planning stage regarding issues that might affect the planned project (see Chapter 700). See Exhibits 800-1 thru 800-3 for specialty group coordination of water crossings.

720.02 Bridge Locations

Bridge locations are chosen to conform to the alignment of the highway. Conditions that can simplify design efforts, minimize construction activities, and reduce structure costs are:

- A perpendicular crossing.
- The minimum required horizontal and vertical clearances.
- A constant bridge width (without tapered sections).
- A tangential approach alignment of sufficient length not to require superelevation on the bridge.
- A crest vertical curve profile that will facilitate drainage.
- An adequate construction staging area.

720.03 Bridge Site Design Elements

720.03(1) Structural Capacity

The structural capacity of a bridge is a measure of the structure's ability to carry vehicle loads. For new bridges, the bridge designer chooses the design load that determines the structural capacity. For existing bridges, the structural capacity is calculated to determine the "load rating" of the bridge. The load rating is used to determine whether or not a bridge is "posted" for legal weight vehicles or "restricted" for overweight permit vehicles.

720.03(1)(a) New Structures

All new structures that carry vehicular loads are designed to HL-93 notional live load in accordance with AASHTO's LRFD Bridge Design Specifications.

720.03(1)(b) Existing Structures

When the structural capacity of a bridge will be affected by the project, the Region requests a Structural Capacity Report from the Risk Reduction Engineer in the HQ Bridge and Structures Office. Permanent redistribution of traffic, introduction of median barrier, and widening or deck rehabilitation are among the triggers for evaluation of a bridge's structural capacity. The report will state:

- The structural capacity status of the structures within the project limits.
- What action, if any, is appropriate.

The Region requests the Bridge and Structures Asset Manager to provide status about whether a bridge is included in the 6-year or 20-year plans for replacement or rehabilitation under the P2 program and, if so, in which biennium the P2 project is likely to be funded.

The criteria used by the Bridge and Structures office to evaluate the structural capacity of a bridge are as follows:

1. On National Highway System (NHS) routes (including Interstate routes):
    - The operating load rating is at least 36 tons (which is equal to HS-20).
    - The bridge is not permanently posted for legal weight vehicles.
    - The bridge is not permanently restricted for vehicles requiring overweight permits.
2. On non-NHS routes:
    - The bridge is not permanently posted for legal weight vehicles.
    - The bridge is not permanently restricted for vehicles requiring overweight permits.

Include the Structural Capacity Report in the Project File (see Chapter 300).

720.03(2) Bridge Widths

The Design Manual contains multiple chapters that provide geometric cross section criteria and procedures relevant to determining design element widths. See Chapter 1230 for a guide to chapters that provide geometric cross section element widths.

While it is preferred not to alter the continuity of a roadway, there may be situations where providing a structure width more or less than the roadway approaching the structure is appropriate.

All structures on city or county routes crossing over a state highway must conform to the Local Agency Guidelines. For structures involving railroads, contact the HQ Design Office Railroad Liaison.

720.03(3) Horizontal Clearance

Horizontal clearance for structures is the distance from the edge of the traveled way to bridge piers and abutments, traffic barrier ends, or bridge end embankment slopes. Minimum distances for this clearance vary depending on the type of structure. (See Chapter 1239, Chapter 1600, and Chapter 1610 and the Bridge Design Manual for guidance on horizontal clearance.)

For structures involving railroads, contact the HQ Design Office Railroad Liaison.

720.03(4) Bridge Medians

Designs for bridges on divided multilane highways often include the decision to join parallel bridges as one or build them as independent structures. There are several factors in this decision, such as in new corridor construction, phased construction of corridors, and the general median width of the divided highway. This section covers some common design considerations related to bridge medians.

Advances in crash barriers and their applications have resulted in an expanded set of choices for bridge medians on divided highways.

Modern barrier designs and applications have allowed for longer runs of traffic barrier, different barrier types, and bullnose guardrail designs for shielding the gap between parallel structures. These tools have reduced collisions with abrupt bridge ends as well as shielded the opening between bridges.

Some highway corridors are initially planned as multilane divided highways but may be developed in logical, affordable phases and individual projects. This could result in an initial phase where a corridor may open as a two-lane rural highway used by both travel directions. A later phase could convert the facility to a divided highway, bringing with it the need for median separation. Consider the long-range plans when determining median widths for bridges. The photos in Exhibit 720-1 show a completed multilane highway where two separate bridges were ultimately constructed years apart and a new corridor underway where one bridge is now built.

Joining two structures may not be the most cost-effective or sustainable solution for all projects. Coordinate with the Bridge and Structures Office and the local Maintenance Office when discussing options and concerns. For bridges on parallel horizontal and vertical alignments, practical considerations for joining two structures as one include, but are not limited to:

- Phased development where one structure exists and another is planned.
- Old and new structure types and compatibility (with phased corridor construction).
- Median width.
- Median barrier treatment options.
- Environmental contexts and regulations.
- Seismic conditions and load ratings.
- Bridge maintenance and inspection techniques: accessibility options and equipment for terrain in specific contexts. An open area between structures may be needed for bridge inspection.
- Skew angles and/or curvature of waterways or roadways beneath the structures.
- Economics.
- Historical/aesthetic value of existing bridges to remain in place.

If structures will not be joined, evaluate the median as described here:

When there is a median gap between bridges of 6 inches or more, the Region PEO will evaluate whether or not the median gap needs to be screened. Address the potential for pedestrians on the bridge and if closing the median gap to less than 6 inches, or installing fencing, netting, or other elements to enclose the area between the bridges would be beneficial. Document this evaluation in the Basis of Design and Alternatives Comparison Table.

Exhibit 720-1 Phased Development of Multilane Divided Highways

720.03(5) Vertical Clearance

Vertical clearance is the critical height under a structure that will accommodate vehicular and rail traffic based on its design characteristics. This height is the least height available from the lower roadway surface (including usable shoulders) or the plane of the top of the rails to the bottom of the bridge. Usable shoulders are the design shoulders for the roadway and do not include paved widened areas that may exist under the structure.

In addition to the following vertical clearance guidance, consider whether the corridor experiences overheight loads. Consider a vertical clearance such that it will not create a new "low point" in the corridor.

720.03(5)(a) Vertical Falsework Clearance for Bridges Over Highways

Construction of new bridges and the reconstruction or widening of existing structures often requires the erection of falsework across the traveled way of a highway. The erection of this falsework can reduce the vertical clearance for vehicles to pass under the work area. The potential for collisions to occur by hitting this lower construction stage falsework is increased.

1. On all routes that require a 16.5-foot vertical clearance, maintain this same clearance for falsework vertical clearance.
    - On structures that currently have less than a 16.5-foot vertical clearance for the falsework envelope, maintain existing clearance.
    - On new structures, maintain the falsework vertical clearance at least to those of the minimum vertical clearances referenced below.
2. Any variance from the above must be approved by the Regional Administrator or designee in writing and made a part of the Project File.

720.03(5)(b) Minimum Clearance for New Structures

For new structures, the minimum vertical clearances are as follows:

i Bridge Over a Roadway

The minimum vertical clearance for a bridge over a roadway is 16.5 feet.

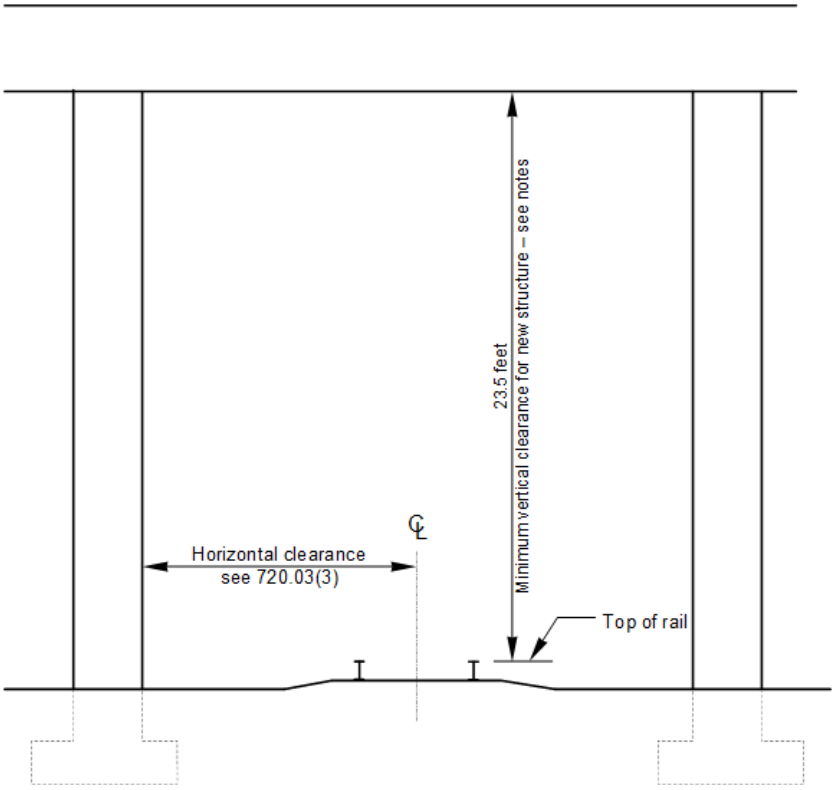
ii Bridge Over a Railroad Track

The minimum vertical clearance for a bridge over a railroad track is 23.5 feet (see Exhibit 720-2). A lesser clearance may be negotiated with the railroad company based on certain operational characteristics of the rail line; however, any clearance less than 22.5 feet requires the approval of the Washington State Utilities and Transportation Commission (WUTC) per WAC 480-60. Vertical clearance is provided for the width of the railroad clearance envelope. Coordinate railroad clearance issues with the HQ Design Office Railroad Liaison.

iii Pedestrian Bridge Over a Roadway

The minimum vertical clearance for a pedestrian bridge over a roadway is 17.5 feet.

Exhibit 720-2 Highway Structure Over Railroad



Notes:

- Use 22.5-foot vertical clearance for existing structures.
- Lesser vertical clearance may be negotiated (see 720.03(5)).
- Increase horizontal clearance when the track is curved.
- Coordinate railroad clearance issues with the HQ Design Office Railroad Liaison.

iv Water Crossing Structures

When determining the vertical clearance beneath a bridge or inside a buried structure, there are two elements that must be considered. The first is 100 Year Design Freeboard (Freeboard), and the second is Maintenance Clearance.

Freeboard is related to the hydraulic capacity of the structure and is required by state and federal guidance. Typically, all bridges and buried structures are required to have a minimum of 1-3 feet of Freeboard above the 100-year water surface elevation (see WSDOT Hydraulics Manual). The State Hydraulics Engineer determines the Freeboard, and it is documented in the Preliminary/Final Hydraulic Design Report (PHD/FHD). Approval from the State Hydraulics Engineer is required for any vertical clearance that is less than Freeboard.

Maintenance Clearance is the distance from the highest ground elevation within the horizontal limits of the Hydraulic Width to the controlling top elevation. The State Hydraulics Engineer determines the Hydraulic Width, and it is documented in the PHD/FHD. Providing Maintenance Clearance beyond the minimum Freeboard is beneficial for required monitoring and inspections, as well as any maintenance activities that may be required during the life of the structure. Generally, these activities include staff walking through the culvert, taking measurements and photographs, but could also involve the use of machinery within the structure limits. Clearances above the minimums provided below are allowed and may be desirable based on an analysis of the project's contextual needs.

For each water crossing location, evaluate and document the type of activities that will be conducted in collaboration with Region Maintenance, Bridge Preservation, ESO/Stream Restoration Biologists, and other key stakeholders. Additionally, site specific considerations must be evaluated in order to determine the appropriate Maintenance Clearance. See Design Instructions - Vertical Clearance Considerations for additional information and considerations when determining the preferred vertical clearance.

In general, when no large objects are placed beneath the structure, use 6 feet as the initial Maintenance Clearance target. Design Instructions - Vertical Clearance Considerations

Large objects, including boulders and large woody debris, under or inside water crossing structures are not allowed unless approved by the State Hydraulics Engineer. When large objects are approved to be placed beneath the structure, provide 10 feet minimum Maintenance Clearance.

The ARA for Development approves vertical clearance where greater than or equal to the Freeboard and does not otherwise require a Design Analysis.

720.03(5)(c) Minimum Clearance for Existing Structures

The criteria used to evaluate the vertical clearance for existing structures depend on the work being done on or under that structure. When evaluating an existing structure on the Interstate System, see Section 720.03(5)(e), Coordination. This guidance applies to bridge clearances over state highways and under state highways at interchanges. For state highways over local roads and streets, city or county vertical clearance requirements may be used as minimum design criteria. (See Exhibit 720-3 for bridge vertical clearances.)

i Bridge Over a Roadway

For a project that will widen an existing structure over a highway or where the highway will be widened under an existing structure, the vertical clearance can be as little as 16.0 feet on the Interstate System or other freeways or 15.5 feet on nonfreeway routes. An approved design analysis is required for clearance less than 16.0 feet on Interstate routes or other freeways and 15.5 feet on nonfreeway routes.

For a planned resurfacing of the highway under an existing bridge, if the clearance will be less than 16.0 feet on the Interstate System or other freeways and 15.5 feet on nonfreeway routes, evaluate the following options and include in a design analysis request:

- Pavement removal and replacement
- Roadway excavation and reconstruction to lower the roadway profile
- Providing a new bridge with the required vertical clearance

Reducing roadway paving and surfacing thickness under the bridge to achieve the minimum vertical clearance can cause accelerated deterioration of the highway and is not recommended. Elimination of the planned resurfacing in the immediate area of the bridge might be a short-term solution if recommended by the Region Materials Engineer (RME). Solutions that include milling the existing surface followed by overlay or inlay must be approved by the RME to ensure adequate pavement structure is provided.

For other projects that include an existing bridge where no widening is proposed on or under the bridge, and the project does not affect vertical clearance, the clearance can be as little as 14.5 feet. For these projects, document the clearance in the Design Documentation Package. For an existing bridge with less than a 14.5-foot vertical clearance, an approved design analysis request is required.

ii Bridge Over a Railroad Track

For an existing structure over a railroad track (see Exhibit 720-2), the vertical clearance can be as little as 22.5 feet. A lesser clearance can be used with the agreement of the railroad company and the approval of the Washington State Utilities and Transportation Commission. Coordinate railroad clearance issues with the HQ Design Office Railroad Liaison.

Exhibit 720-3 Bridge Vertical Clearances

Project Type	Vertical Clearance [8]	Documentation Requirement (see notes)
Interstate and Other Freeways [1]		
New Bridge	> 16.5 ft	[2]
Widening Over or Under Existing Bridge	> 16 ft	[2]
	< 16 ft	[4]
Resurfacing Under Existing Bridge (See Section 1120.02(5) Vertical clearance)	> 16 ft	[2]
	< 16 ft	[4]
Other With No Change to Vertical Clearance	> 14.5 ft	[3]
	< 14.5 ft	[4]
Nonfreeway Routes		
New Bridge	> 16.5 ft	[2]
Widening Over or Under Existing Bridge	> 15.5 ft	[2]
	< 15.5 ft	[4]
Resurfacing Under Existing Bridge (See Section 1120.02(5) Vertical clearance)	> 15.5 ft	[2]
	< 15.5 ft	[4]
Other With No Change to Vertical Clearance	> 14.5 ft	[3]
	< 14.5 ft	[4]
Bridge Over Railroad Tracks [7]		
New Bridge (as measured from top of rail)	> 23.5 ft < 23.5 ft	[2] [4][5]
Existing Bridge (as measured from top of rail)	> 22.5 ft < 22.5 ft	[2] [4][5]
Pedestrian Bridge Over Roadway		
New Bridge	> 17.5 ft	[2]
Existing Bridge	17.5 ft	[6]
Water Crossing Structures		
Water Crossing Structures		
Water Crossings without boulders and LWD	≥ 6 ft [10]	[3][9]
Water Crossings with boulders and LWD	≥ 10 ft [10]	[3][9]

Notes:

[1] Applies to all bridge vertical clearances over highways and under highways at interchanges.
[2] No documentation required.
[3] Document to Design Documentation Package.
[4] Approved design analysis required.
[5] Requires written agreement between railroad company and WSDOT and approval via petition from the WUTC.
[6] Maintain 17.5-ft clearance.
[7] Coordinate railroad clearance with the HQ Design Office Railroad Liaison.
[8] See Section 720.03(5).
[9] Approved by the ARA for Development.
[10] See Section 720.03(5)(b)iv for information on how determine the vertical clearance.

720.03(5)(d) Signing

Low-clearance warning signs are necessary when the vertical clearance of an existing bridge is less than 15 feet 3 inches. Refer to the *Manual on Uniform Traffic Control Devices* and the *Traffic Manual* for other requirements for low-clearance signing.

720.03(5)(e) Coordination

The Interstate System is used by the Department of Defense (DOD) for the conveyance of military traffic. The Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) represents the DOD in public highway matters. The MTMCTEA has an inventory of vertical clearance deficiencies over the Interstate System in Washington State. Contact the MTMCTEA, through the Federal Highway Administration (FHWA), if either of the following changes is proposed to these bridges:

- A project would create a new deficiency of less than a 16.0-foot vertical clearance over an Interstate highway.
- The vertical clearance over the Interstate is already deficient (less than 16.0 feet) and a change (increase or decrease) to vertical clearance is proposed.

Coordination with MTMCTEA is required for these changes on all rural Interstate highways and for one Interstate route through each urban area.

720.03(6) Liquefaction Impact Considerations

To determine the amount of settlement and the potential for the soil to flow laterally during the design level earthquake due to liquefaction, an analysis performed by the HQ Geotechnical Office is needed for each bridge project site location. The information collected is used by bridge engineers to determine the bridge's capability to withstand the movement and loading in a seismic event and to explore other foundation mitigation options not necessitating total bridge replacement.

The HQ Bridge and Structures Office, in collaboration with the HQ Geotechnical Office, evaluates bridge-widening projects involving liquefiable soils and recommends appropriate liquefaction mitigation.

See the Bridge Design Manual LRFD for further information.

720.03(7) Pedestrian and Bicycle Facilities

When pedestrians or bicyclists are anticipated on bridges, provide facilities consistent with guidance in Chapter 1510, Chapter 1515, and Chapter 1520.

Evolving programs and technologies such as incident response, personal cell phones, and ITS cameras have further reduced the probability of motorists becoming pedestrians. Investigate other methods of treatment such as pedestrian scale signing or other low-cost safety improvement measures. Document decisions in the Basis of Design.

720.03(8) Bridge Approach Slab

Bridge approach slabs are reinforced concrete pavement installed across the full width of the bridge ends. They provide a stable transition from normal roadway cross section to the bridge ends, and they compensate for differential expansion and contraction of the bridge and the roadway.

Bridge approach slabs are provided on all new bridges. If an existing bridge is being widened and it has an approach slab, slabs are required on the widenings.

The region, with the concurrence of the State Geotechnical Engineer and the State Bridge Design Engineer, may decide to omit bridge approach slabs. Document decisions in the DDP.

720.03(9) Traffic Barrier End Treatment

Plans for new bridge construction and bridge traffic barrier modifications include provisions for the connection of bridge traffic barriers to the longitudinal barrier approaching and departing the bridge. Indicate the preferred longitudinal barrier type and connection during the review of the bridge preliminary plan.

720.03(10) Bridge End Embankments

The design of embankment slopes at bridge ends depends on several factors. The width of the embankment is determined not only by the width of the roadway, but also by the presence of traffic barriers, curbs, and sidewalks, all of which create the need for additional widening. Examples of the additional widening required for these conditions are shown in the Standard Plans.

The end slope is determined by combining the recommendations of several technical experts within WSDOT. Exhibit 720-4 illustrates the factors taken into consideration and the experts involved in the process.

720.03(11) Bridge Slope Protection

Slope protection provides a protective and aesthetic surface for exposed slopes under bridges. Slope protection is normally provided under:

- Structures over state highways.
- Structures within an interchange.
- Structures over other public roads unless requested otherwise by the public agency.
- Railroad overcrossings if requested by the railroad.

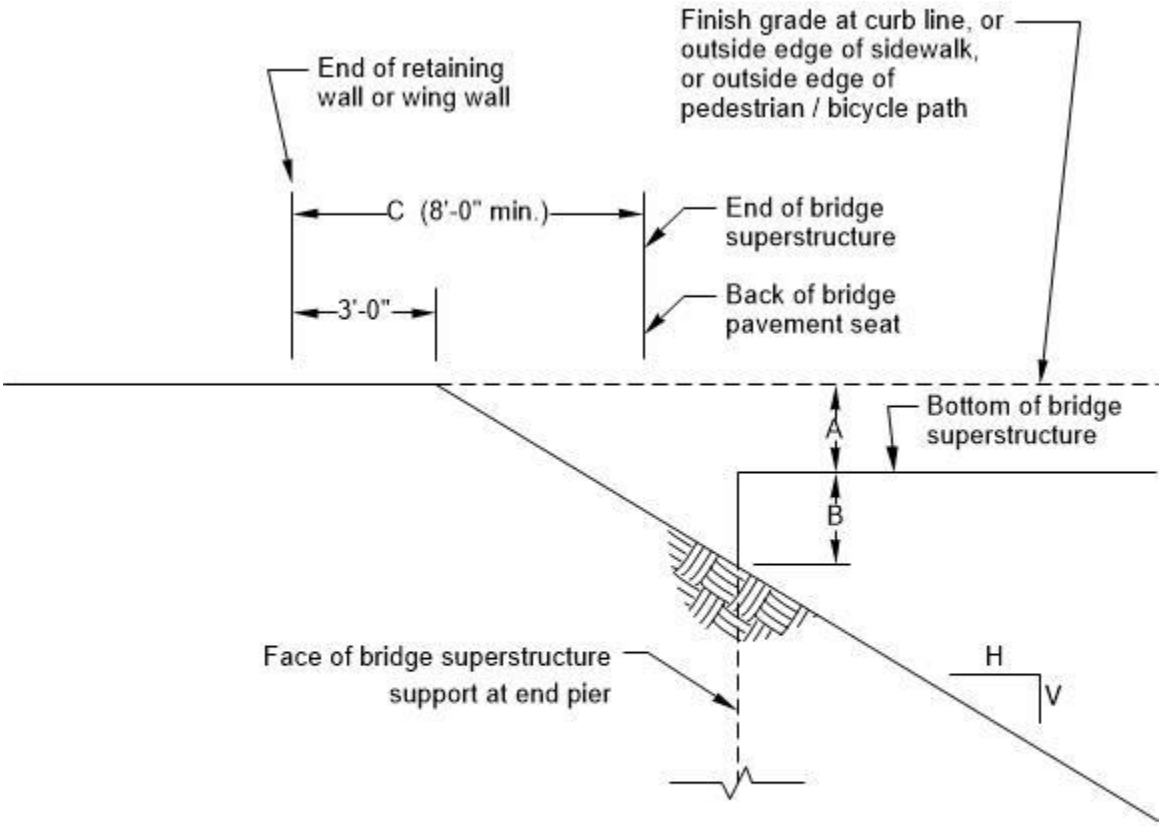
Slope protection is usually not provided under pedestrian structures.

The type of slope protection is selected at the bridge preliminary plan stage. Typical slope protection types are concrete slope protection, and rubble stone.

720.03(12) Slope Protection at Water Crossings

The HQ Hydraulics Section determines the slope protection requirements for structures that cross waterways. The type, limits, and quantity of slope protection are shown on the bridge preliminary plan.

Exhibit 720-4 Embankment Slope at Bridge Ends



Bridge End Elevation

Applies to retaining wall or wing wall (or combination) extending beyond bridge superstructure (barrier omitted for clarity)

Legend

A = Superstructure depth: recommended by HQ Bridge and Structures Office

B = Vertical clearance from bottom of superstructure to embankment: recommended by Bridge Preservation Engineer

C = Distance from end of retaining wall or wing wall to back of pavement seat: recommended by HQ Bridge and Structures Office

H & V = Embankment slope: recommended by Geotechnical Engineer

720.03(13) Bridge Fence

The Washington State Patrol (WSP) classifies the throwing of an object from a highway structure as an assault, not an accident or collision. Therefore, records of these assaults are not contained in WSDOT's crash databases. Contact the Region Traffic Engineer, RME's office and the WSP for the history of reported incidents.

Bridge fence might reduce the number of incidents, but will not stop a determined individual at that location, or deter them from moving to other locations in the area. Enforcement provides the most effective deterrent and is typically the first approach used.

Installing bridge fence is analyzed on a case-by-case basis at the following locations:

- On existing structures where there is a history of multiple incidents of objects being dropped or thrown and where enforcement has not changed the situation.
- On new structures near schools, playgrounds, or areas frequently used by children not accompanied by adults.
- In urban areas on new structures used by pedestrians where surveillance by local law enforcement personnel is not likely.
- On new structures with walkways where experience on similar structures within a 1 mile radius indicates a need.
- On private property structures, such as buildings or power stations, subject to damage.

In most cases, installing bridge fence on a new structure can be postponed until there are indications of need.

Submit all proposals to install bridge fence on structures to the State Design Engineer, for approval. Contact the HQ Bridge and Structures Office for approval to attach bridge fence to structures and for specific design and mounting details.

720.03(14) Contractor Supplied Designs for Buried Structures

When utilizing a contractor supplied design for a buried structure in a design-bid-build Contract (see WSDOT Bridge Design Manual 8.3.3.A), provide for sufficient time from award to any construction windows to allow for design, review, and fabrication of the Buried Structure (typically up to 6 months). Determine any restrictions to be placed on the contractor in their selection of buried structure, headwall, wingwall, vehicle barrier, and fall protection types. Include sufficient information in the contract documents so that the contractor can properly execute the design (see Plans Preparation Manual 700.06(2)).

720.04 Coordination with US Coast Guard for Existing Bridges

Existing bridges crossing navigable waters occasionally require construction or maintenance activities that impact navigation channels governed by USCG permits. For fixed span bridges, this may include construction or maintenance activities that infringe upon the horizontal and vertical navigation opening defined in the USCG permit. For movable bridges, in addition to the above, this may also include adjustments to existing bridge opening operating notice and process as defined in current regulations.

Because these impacts are temporary and are limited to the duration of the construction or maintenance activity, they do not affect or change the actual USCG bridge permit. However, such temporary adjustments still require coordination with the US Coast Guard early in the project design schedule.

The primary responsibility for this contact and coordination lies with the Region Design Project Office. The scope of such coordination varies depending on the extent of the infringement into the defined horizontal or vertical navigation clearance opening, the extent of the change to the bridge operation notice or process as defined in current regulation, and the duration of the construction or maintenance activity.

This coordination activity may require the Design Project Office to conduct a survey of waterway users or to perform other background information tasks requested by the US Coast Guard. Projects with more extensive impacts may lie outside the approval authority of the local USCG Commander and may require review and action by US Coast Guard HQ in Washington, DC. In all cases, the earlier in the design process that the Region Design Project Office initiates these coordination efforts, the more likely the USCG can complete their regulatory process without impacting the project schedule.

720.05 Documentation

Refer to Chapter 300 for design documentation requirements.

720.06 References

720.06(1) Federal/State Laws and Codes

23 CFR Part 650, Subpart C – National Bridge Inspection Standards

Washington Administrative Code (WAC) 480-60*, Railroad companies – Clearances

*Note: railroads may have stricter clearances than what is required in law and each railroad should be consulted as early as possible as to allowable clearances.

720.06(2) Design Guidance

Bridge Design Manual LRFD, M 23-50, WSDOT

Geotechnical Design Manual, M 46-03, WSDOT

Local Agency Guidelines (LAG), M 36-63, WSDOT

LRFD Bridge Design Specifications, AASHTO, Current Edition

Hydraulics Manual, M 22-03, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-10, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

Traffic Manual, M 51-02, WSDOT

720.06(3) Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition

Manual for Railway Engineering, American Railway Engineering and Maintenance-of-Way Association (AREMA)