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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.

Bridge design is the responsibility of the Washington State Department of Transportation (WSDOT) Headquarters (HQ) Bridge and Structures Office, which develops a preliminary 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, constructibility 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). A Project File (PF) is required for all bridge construction projects.

720.02 References

(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

(2) Design Guidance

Bridge Design Manual, M 23-50, WSDOT

Geotechnical Design Manual, M 46-03, WSDOT

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

LRFD Bridge Design Specifications, 4th Edition, Washington DC, AASHTO, 2007

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

(3) Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

Manual for Railway Engineering, American Railway Engineering and Maintenance of Way Association (AREMA), 2006

720.03 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.

720.04 Bridge Site Design Elements

(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.

(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*.

(b) Existing Structures

When the Structural Capacity column of a design matrix applies to the project, request a Structural Capacity Report from the Risk Reduction Engineer in the HQ Bridge and Structures Office. The report will state:

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

Include the Structural Capacity Report in the Design Documentation Package (DDP).

The considerations used 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.

(2) Bridge Widths for Structures

(a) New Structures

Full design level widths are provided on all new structures (see Chapter 1140). All structures on city or county routes crossing over a state highway must conform to the *Local Agency Guidelines*. Use local city or county adopted and applied criteria when their minimum width exceeds state criteria.

(b) Existing Structures

For guidance on existing structures, see the design matrices in Chapter 1100.

(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. The *Bridge Design Manual* provides guidance on horizontal clearance.

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

(4) Medians

For multilane highways, the minimum median widths for new bridges are as shown in Chapters 1130 and 1140. An open area between two bridges is undesirable when the two roadways are separated by a median width of 26 feet or less. The preferred treatment is to provide a new single structure that spans the area between the roadways. When this is impracticable, consider widening the two bridges on the median sides to reduce the open area to 6 inches. When neither option is practicable, consider installing netting or other elements to enclose the area between the bridges. Consideration and analysis of all site factors are necessary if installation of netting or other elements is proposed. Document this evaluation in the Design Documentation Package and obtain the approval of the State Design Engineer.

(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.

Construction of new bridges and the reconstruction or widening of existing structures often require 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 accidents to occur by hitting this lower construction stage falsework is increased.

(a) Vertical Falsework Clearance for Bridges Over Highways

1. On all routes that require a 16-foot-6-inch vertical clearance, maintain the 16-foot-6-inch clearance for falsework vertical clearance.
 - On structures that currently have less than a 16-foot-6-inch 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.

(b) Minimum Clearance for New Structures

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

1. Bridge Over a Roadway

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

2. 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.

3. Pedestrian Bridge Over a Roadway

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

Project Type	Vertical Clearance	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	> 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	> 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	> 23.5 ft	[2]
	< 23.5 ft	[4][5]
Existing Bridge	> 22.5 ft	[2]
	< 22.5 ft	[4][5]
Pedestrian Bridge Over Roadway		
New Bridge	> 17.5 ft	[2]
Existing Bridge	17.5 ft	[6]
<p>Notes:</p> <p>[1] Applies to all bridge vertical clearances over highways and under highways at interchanges.</p> <p>[2] No documentation required.</p> <p>[3] Document to Design Documentation Package.</p> <p>[4] Approved deviation required.</p> <p>[5] Requires written agreement between railroad company and WSDOT and approval via petition from the WUTC.</p> <p>[6] Maintain 17.5-ft clearance.</p> <p>[7] Coordinate railroad clearance with the HQ Design Office Railroad Liaison.</p>		

Bridge Vertical Clearances
Exhibit 720-1

(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 720.04(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 720-1 for bridge vertical clearances.)

1. 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 deviation 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 deviation 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 deviation request is required.

2. Bridge Over a Railroad Track

For an existing structure over a railroad track, 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.

(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.

(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.

(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 Services Division 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 Services Division, evaluates bridge-widening projects involving liquefiable soils and recommends appropriate liquefaction mitigation. The following guidance is intended to assist designers in making project decisions that balance project risks with project and program budget realities.

(a) Design Decision Considerations

The following design decision guidance is generally in order of the complexity of project decision making, starting with the most straightforward through the most complex.

1. New bridges will be designed to current seismic and liquefaction standards.
2. Bridge widening that does not require new substructure (a new column) does not require consideration of liquefaction mitigation.

3. Widening that involves any new substructure will require a settlement and lateral loading analysis by the HQ Bridge and Structures Office in collaboration with the HQ Geotechnical Services Division. Each analysis will be unique to the conditions at that particular bridge site.
 - a. If a bridge has less than 15 years of its service life remaining, no liquefaction mitigation is necessary according to FHWA guidelines.
 - b. If the HQ Geotechnical Services Division analysis demonstrates that the differential settlement induced by liquefaction between the existing bridge and the widened portion will not create forces great enough to cause collapse of the existing bridge, and if lateral loading and movement caused by the liquefaction is minimal, liquefaction mitigation may not be necessary. The decision must be endorsed by the State Geotechnical Engineer, the State Bridge Engineer and the Regional Administrator. The decision and rationale are to be included in the Design Documentation Package.
 - c. If the HQ Geotechnical Services Division analysis demonstrates that the differential settlement induced by liquefaction or the lateral loading and movement will be substantial and these movements will result in the collapse of the existing and widened portion of the bridge, additional analysis and documentation are necessary for the project to proceed. A preliminary design and estimate of the mitigation necessary to prevent collapse needs to be performed. Consider alternative designs that eliminate or reduce the need for the widening.

(b) Deferring Liquefaction Mitigation

1. Consideration of Deferment

If an alternative design concept is not feasible given the constraints of the project or program, consideration may be given to defer the liquefaction mitigation. Project-related structural retrofits that are deferred because of scope-related issues, are to be considered for implementation through the WSDOT seismic retrofit program. The operating characteristics of the roadway and overall estimated cost of the liquefaction mitigation is typically considered in making that decision.

2. Deferment Requires Approval

A decision to defer the mitigation to the seismic retrofit program is made by the WSDOT Chief Engineer after reviewing and considering the alternatives. The decision is to be included in the Design Documentation Package.

A memo from the Chief Engineer will be provided to the structural designer of record documenting the agency's decision to defer the mitigation work to the WSDOT seismic retrofit program. A copy of the memo is to be included in the Design Documentation Package (DDP) and the contract general notes.

(7) Pedestrian and Bicycle Facilities

When pedestrians or bicyclists are anticipated on bridges, provide facilities consistent with guidance in Chapters 1020 and 1025.

(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 Engineer, may decide to omit bridge approach slabs.

(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.

(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 720-3 illustrates the factors taken into consideration and the experts involved in the process.

(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, semi-open concrete masonry, and rubble stone.

(12) Slope Protection at Watercrossings

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.

(13) Protective Screening for Highway Structures

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

Protective screening might reduce the number of incidents, but will not stop a determined individual. Enforcement provides the most effective deterrent.

Installation of protective screening 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, that are subject to damage.

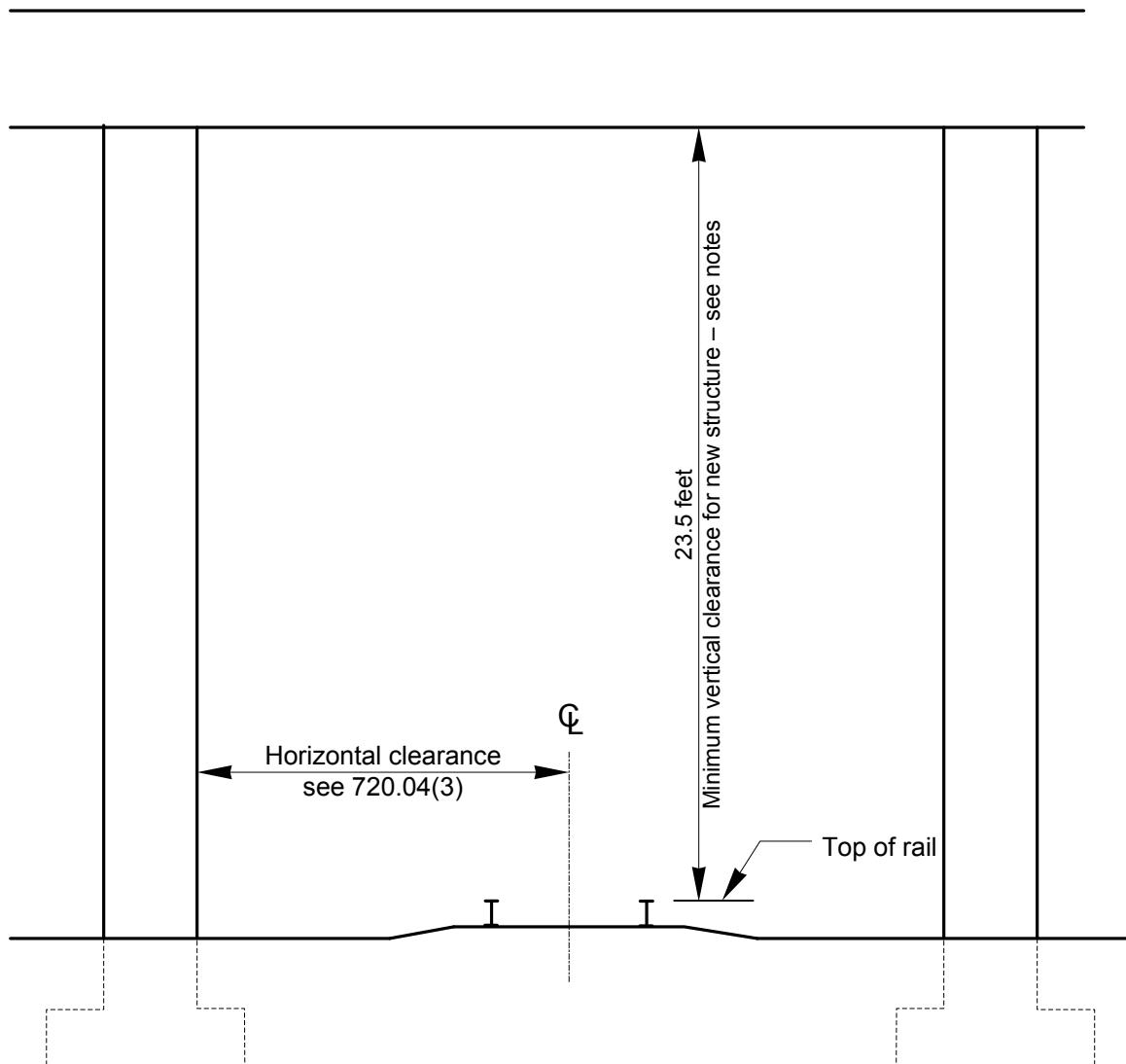
In most cases, the installation of a protective screen on a new structure can be postponed until there are indications of need.

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

720.05 Documentation

For the list of documents required to be preserved in the Design Documentation Package and the Project File, see the Design Documentation Checklist:

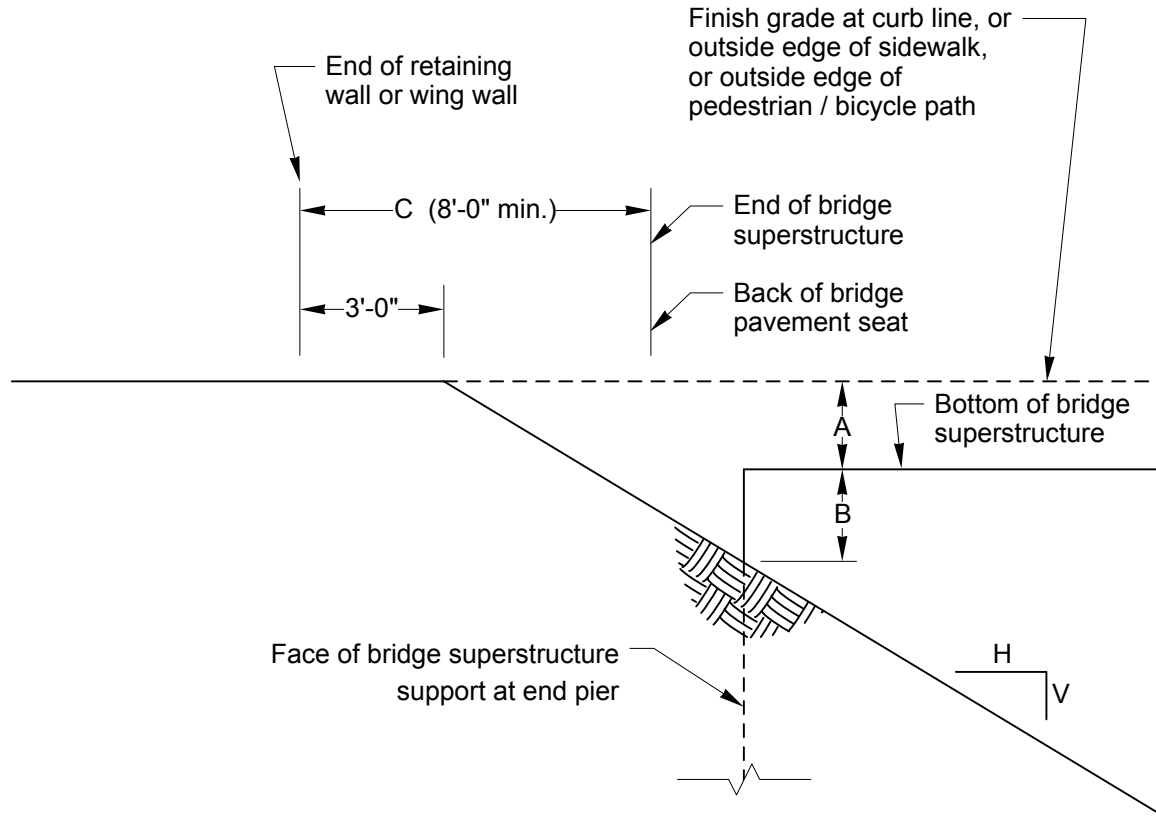
🔗 www.wsdot.wa.gov/design/projectdev/

**Notes:**

- Use 22.5-foot vertical clearance for existing structures.
- Lesser vertical clearance may be negotiated (see 720.04(5)).
- Increase horizontal clearance when the track is curved.
- Coordinate railroad clearance issues with the HQ Design Office Railroad Liaison.

Highway Structure Over Railroad

Exhibit 720-2



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

Embankment Slope at Bridge Ends

Exhibit 720-3