H7 Bridges

H7.1 Introduction

This section identifies the appropriate roadside safety treatment for bridges and bridge-related features. In particular, this section focuses primarily on bridgerails and bridge approach rail transitions. The term "bridgerail" is used throughout this section in the broadest sense to cover all types of bridge barriers, from post mounted barriers to concrete barriers.

In general, bridgerails are required along each edge of a bridge to delineate the edge of the bridge and to reduce the consequences of vehicles leaving the travelled roadway. It is important that the right bridgerail is selected to provide the appropriate level of protection. In the selection process, the following factors are considered:

- design speed
- shoulder width
- traffic volume (AADT)
- percentage of trucks
- highway type, curvature and grade
- height of bridge, and
- the type of occupancy under the bridge.

In general, bridge approach rail transitions are required at the end of bridgerails:

- to provide a safe transition connection between the rigid bridgerail and the more flexible approach rail, and
- to protect traffic from head-on collisions with the ends of the bridgerail.

H7.2 Selection of Performance Levels for Bridgerails and Approach Rail Transitions on New Bridge Structures

INFTRA adopted a new design standard for the design of bridgerails in November 2000. This standard requires the designer to choose one of three Performance Levels: PL-1, PL-2, or PL-3. Factors affecting the selection of the required bridgerail Performance Level (PL) include:
1) AADT and percent of truck traffic
2) design speed
3) highway type, curvature and grade
4) height of bridge and
5) type of occupancy under the bridge.

These three Performance Levels were originally defined in the *AASHTO 1989 Guide Specifications for Bridge Railings*. This barrier Performance Level system was eventually introduced into the *Canadian Highway Bridge Design Code* in the 2000 edition of CAN/CSA-S6. The 2006 edition of CAN/CSA-S6 also uses the Performance Level rating system.

Whereas CAN/CSA-S6 uses Performance Levels to rate the safety performance of bridgerails, roadside barriers are rated based on Test Levels as defined in *NCHRP Report 350.* The equivalency between Performance Levels and Test Levels has been documented by the Federal Highway Administration (FHWA) under *NCHRP Project 22-8* as well as in the Bridge Code Commentary for CAN/CSA-S6-06. The equivalency between Performance Levels and Test Levels is shown in **Table H7.1.**

TABLE H7.1 Equivalency between Performance Level and Test Level

Performance Level (PL)	Test Level (TL)
PL-1	TL-2
PL-2	TL-4
PL-3	TL-5

The current *Canadian Highway Bridge Design Code (CAN/CSA-S6-06)* is to be used to select the appropriate bridgerail performance level on new bridge structures. The performance level for the approach rail transition should match that of the bridgerail, unless otherwise approved by INFTRA.

H7.3 INFTRA Bridgerail and Approach Rail Transition Standard Drawings

Since year 2000, INFTRA has used crash-test based standard bridgerails that meet the requirements for Performance Levels PL-1, PL-2, and PL-3. Standard crash-test based approach rail transitions have also been adopted. Standard drawings for these crash-test based bridgerails and approach rail transitions are listed in **Table H7.2**. The Department has mandated the use of crash-test based bridgerail and approach rail transition systems on all new construction projects.

TABLE H7.2
Standard Bridgerail and Approach Rail Transition Drawings

Drawing No.	Title	Application/ Transition Type
S-1642-00	PL-2 (TL-4) Double Tube Type Bridgerail - Bridgerail Details (Sheet 1 of 2)	Preferred bridgerail for most applications.
S-1643-00	PL-2 (TL-4) Double Tube Type Bridgerail - Approach Rail Transition Details (Sheet 2 of 2)	14 m long Thrie Beam Approach Rail Transition PL-2 (TL-4) and Strong Post Approach Rail (TL-3).
S-1648-00	PL-2 (TL-4) Thrie Beam on Curb Bridgerail - Bridgerail Details (Sheet 1 of 2)	Bridgerail for use on short bridges < 20 m long.
S-1649-00	PL-2 (TL-4) Thrie Beam on Curb Bridgerail - Approach Rail Transition Details (Sheet 2 of 2)	14.3 m long Thrie Beam Approach Rail Transition PL-2 (TL-4) c/w transition curb and Strong Post Approach Rail (TL-3).
S-1650-00	PL-2 (TL-4) Single Slope Concrete Bridge Barrier - Barrier Details (Sheet 1 of 2)	Bridgerail for use in urban areas where aesthetics is important.
S-1651-00	PL-2 (TL-4) Single Slope Concrete Bridge Barrier - Approach Rail Transition Details (Sheet 2 of 2)	14 m long Thrie Beam Approach Rail Transition PL-2 (TL-4) and Strong Post Approach Rail (TL-3).
S-1652-00	PL-1 (TL-2) Thrie Beam Bridgerail	Bridgerail for use on local roads. 5.7 m long Thrie Beam Approach Rail Transition PL-1 (TL-2).
S-1653-00	PL-1 (TL-2) Low Height Thrie Beam Bridgerail	Bridgerail for use on local roads with clear roadway < 9 m. 5.7 m long Thrie Beam Approach Rail Transition PL-1 (TL-2).

Drawing No.	Title	Application/ Transition Type
S-1681-07	PL-3 (TL-5) Bridgerail to Modified Thrie Beam Transition Details	8.2 m long Modified Thrie Beam Approach Rail Transition PL-2 (TL-4).
S-1700-06	PL-2 (TL-4) Combination Barrier - Bridgerail Details (Sheet 1 of 2)	Bridgerail for use on urban bridges with 4.2 m widened outside lane for cyclists.
S-1701-06	PL-2 (TL-4) Combination Barrier - Barrier End Details (Sheet 2 of 2)	Connects to single slope concrete road barrier.
S-1702-06	PL-3 (TL-5) Double Tube Type Bridgerail - Bridgerail Details (Sheet 1 of 4)	Bridgerail for use when high AADT with heavy truck volumes and/or high structure requires a PL-3 (TL-5) bridgerail.
S-1703-06	PL-3 (TL-5) Double Tube Type Bridgerail - Barrier End Details (Sheet 2 of 4)	N/A
S-1704-06	PL-3 (TL-5) Double Tube Type Bridgerail - Concrete Barrier Details (Sheet 3 of 4)	N/A
S-1705-06	PL-3 (TL-5) Double Tube Type Bridgerail - Approach Rail Transition Details (Sheet 4 of 4)	14 m long Thrie-Beam Approach Rail Transition PL-2 (TL-4) and Strong Post Approach Rail (TL-3).

These drawings are applicable for new bridge construction as well as bridgerail and curb replacement projects. On these drawings the performance level of the approach rail transition has been selected to be consistent with that of the corresponding bridgerail. With Department approval, an alternative approach rail transition can be substituted provided it meets the same Performance Level/Test Level requirements.

At the end of the standard approach rail transition, the approach rail continues on with either a Weak Post W-Beam, Strong Post W-Beam, or Modified Thrie Beam Guardrail as prescribed on INFTRA standard traffic control drawings TEB 3.16a, TEB 3.16b, and TEB 3.17a. These drawings are summarized in **Table H7.3.**

When Modified Thrie Beam Guardrail is used for the bridge approach rail, as per traffic control drawings TEB 3.16a and TEB 3.17a, the approach rail transition shown in standard drawing S-1681-07 should be used.

The Length of Need (LON) of the entire length of the bridge approach rail at each corner of the bridge, including the transition at the interface of the bridgerail, is determined by locating the interception line as shown on standard drawings TEB 3.16a, 3.16b, and 3.17a. Designers should refer to **Table H3.12** for runout length based on design speed and traffic volume. In this case, the top of fill line is treated as the beginning of the hazard; the lateral offset to the hazard is taken to be the full clear zone distance from the edge of the travel lane. The barrier flare rate is determined in accordance with **Table H.5.4**.

Note that INFTRA standard drawings are revised, deleted or added from time to time. The latest standard drawings available from the INFTRA website should always be used.

TABLE H7.3
Typical INFTRA Bridge Approach Rail General Layout Drawings

Drawing No.	Title
TEB 3.16a	Typical Strong Post W-Beam or Modified Thrie Beam Guardrail Placement at Bridge Approaches (Two-Lane Highway)
TEB 3.16b	Typical W-Beam Weak Post Guardrail Placement at Bridge Approaches (Two-Lane Highway)
TEB 3.17a	Typical Strong Post W-Beam or Modified Thrie Beam Guardrail Placement at Bridge Approaches (Four-Lane Divided Highway)

H7.4 Upgrading of Existing Bridgerails

Background

In INFTRA's existing bridge inventory there is a considerable length of existing bridgerail that was designed to the standards of the day. The types of bridgerails in this inventory vary from timber bridgerails to bridgerails that meet the crash test requirements of CAN/CSA-S6-06. **Table H.7.4** summarizes the common types of bridgerails used by INFTRA prior to 2000.

Several opportunities for improving the bridgerails listed in **Table H.7.4** have been identified as a result of research and development in the area of roadside safety over the last few decades. This knowledge base continues to expand yearly as more research is published and as additional crash testing and computer simulations are carried out. Some of the opportunities for improving bridgerails installed prior to year 2000 include:

- Strengthening the bridgerail to the appropriate Performance Level as required by CAN/CSA-S6-06. This may be done by:
  1) adding new rails, and posts if required, in front of the existing bridgerail, and
  2) improving anchorage of the bridgerail to the bridge deck, and
  3) strengthening the rail and/or posts.
- Increasing the bridgerail height to meet the requirements of the desired Performance Level. Required minimum bridgerail heights are provided in CAN/CSA-S6-06.
- Removing or shielding of bridgerail appurtenances that have the potential for causing vehicle snagging.
- Eliminating safety curbs. Safety curbs can have a detrimental effect on bridgerail-vehicle interaction. As the compressed suspension of an errant vehicle rebounds after impacting a safety curb, it causes the vehicle to launch into the bridgerail and potentially vault over.

These opportunities for improvement as well as others are discussed in more detail later in this section.

Life-Cycle Benefit-Cost Analysis:

A life-cycle benefit-cost analysis procedure has been developed to improve the performance of this existing bridgerail hardware in a cost effective manner. This procedure takes into account both vehicle collision costs and bridgerail upgrading costs. A technical summary of this analysis procedure, including examples, is provided in **Appendix C**.

When a decision is made to upgrade a bridgerail, the approach rail transition and approach guardrail should be upgraded at the same time.

TABLE H.7.4
Common Bridgerail types in Existing INFTRA Inventory

Bridgerail Type	Description of Bridgerail
Timber Bridgerail	Timber rail bridgerail on either timber or steel posts. This bridgerail is typically found on short span bridges on low volume local roads or land accesses.
Lattice Panel Bridgerail	Steel lattice panel type bridgerail originally provided on steel trusses. It is typically found on low volume highways or local roads. Some of these bridgerails have been upgraded by adding a tube rail in front of the lattice panels.
Vertical Bar/ Horizontal Rail Bridgerail on Safety Curb	Most common type of bridgerail used by INFTRA on major bridges in the 1950s and 1960s. The bridgerail is mounted on either steel or concrete posts. The bridgerail ties into vertical concrete parapets at the bridge abutments.
Double Tube Bridgerail on Safety Curb	Standard bridgerail used by INFTRA on major bridges from the 1970s to the 1990s. The bridgerail consists of double steel tube rails mounted on steel tube posts. The steel tube rails are sloped down to the top of the safety curb at the bridge abutments.
Single Layer Deep Beam (W-Beam) Bridgerail on Participating Curb	Most common type of bridgerail used by INFTRA on standard bridges in the 1950s to 1970s. The bridgerail is mounted on either steel or timber posts.
Single/Double Layer Deep Beam (W-Beam) Bridgerail on Safety Curb	Bridgerail used by INFTRA in the 1950s and 1960s on some types of prestressed concrete girder bridges. The bridgerail is mounted on steel posts. Some of the bridgerails have been upgraded by adding a second layer of W-Beam to the rail.
Double Tube Bridgerail on Participating Curb	Bridgerail used by INFTRA on standard bridges in the 1980s and 1990s. The bridgerail consists of double steel tube rails mounted on steel tube posts. The steel tube rails are sloped down to the ground at the bridge abutments.
Double Layer Deep Beam (W-Beam) Bridgerail on Participating Curb	Bridgerail used by INFTRA on standard bridges less than 9 metres wide in the 1980s and 1990s. The bridgerail is mounted on steel posts.

Upgrading of Existing Bridgerails

Like any other roadside design problem, the primary objective in the upgrading of bridgerails is to reduce the overall severity of the roadside hazard. For bridges, the hazard is the height of the bridge deck above the ground below.

There are two basic requirements that must be met for the severity of the bridgerail to be minimized:

1. Containment of vehicles for the appropriate Performance Level (no gating of errant vehicles); and
2. Maintaining a smooth profile and continuity in the bridgerail (to prevent vehicle snagging).

In many cases it may not be feasible to upgrade a bridgerail to conform to a crash-tested bridgerail system, and the bridgerail upgrading details will need to be determined on a site specific basis. Section C12.1 of the CAN/CSA-S6-06 Commentary states that the retrofitting of barriers on existing bridges is not covered by Section 12 of CAN/CSA-S6-06 . Reasonable bridgerail upgrading results can, however, be achieved by modifying or incorporating concepts and features from crash-tested bridgerails. The intent is to improve the crash test performance of the bridgerail so that a performance level closer to the requirements of CAN/CSA-S6-06 is achieved in a cost effective manner based on life-cycle benefit-cost analysis.

General guidelines for bridgerail upgrades include:

- The capacity of bridgerails with inadequate strength can be increased by placing a retrofit tube rail in front of the existing bridgerail and connecting it to the existing bridgerail posts with collapsible steel tubes such as shown on standard drawings S-1750-07 to S-1752-07. The collapsible steel tubes limit the maximum collision load applied to the existing posts and allow the retrofit rail to distribute the collision load to several posts.
- Bridgerails with inadequate height and on safety curbs can have their effective heights increased by placing a retrofit rail in front of them and in line with the roadway face of the safety curb. This allows the effective bridgerail height to be measured from the top of the bridge deck rather than from the top of the safety curb.
- Bridgerails with discontinuous railings should have the discontinuous rail ends connected together to prevent them from acting as spears in the event of a vehicle collision with the bridgerail.
- Bridgerails with rail spacings and post setbacks that are not in accordance with the *AASHTO LRFD Bridge Specifications Section 13 – Appendix A* may cause unacceptable snagging during vehicle collisions with the bridgerail. The snagging potential of an existing bridgerail may be reduced by placing a retrofit rail in front of the existing bridgerail.

INFTRA Standard Drawings for Upgrading Bridgerails

Standard bridgerail upgrading drawings have been developed for the following types of bridgerails:

1. Vertical Bar/Horizontal Rail Type Bridgerail (refer to standard drawings S-1750-07 to S-1752-07)
2. Single/Double Layer Deep Beam Bridgerail on Participating/Safety Curb (refer to standard drawing S-1720-07 in **Appendix D3**)

These standard drawings are available on the INFTRA website. Standard bridgerail upgrading drawings have not been developed for the other common bridgerail types used by INFTRA prior to year 2000 either because these bridgerails are used only on low traffic volume roads where upgrading is rarely economically justified, or, because the performance of the existing bridgerail types are sufficiently adequate so that upgrading is rarely economically justified even at higher traffic volumes.

H7.5 Upgrading of Existing Approach Rail Transitions

Background

In INFTRA's existing bridge inventory there is a considerable amount of existing bridge approach rail transitions that were designed to the standards of the day. The types of approach rail transitions in this inventory vary from approach rail transitions that are unconnected to the ends of the bridgerail, to approach rail transitions that meet the crash test requirements of Section 12 of CAN/CSA-S6-06 . **Table H7.5** summarizes the common types of approach rail transitions used by INFTRA prior to 2000.

TABLE H7.5
Approach Rail Transitions for Common Bridgerail Types in the Existing INFTRA Inventory.

Bridgerail Type	Description of Approach Rail Transition
Timber Bridgerail	Timber bridgerails do not typically have approach rails or approach rail transitions.
Lattice Panel Bridgerail	Steel lattice panel bridgerails do not typically have approach rails or approach rail transitions.
Vertical Bar/ Horizontal Rail Bridgerail on Safety Curb	The approach rails are typically not connected to the bridgerail and the ends of the bridgerails and safety curbs are largely unprotected from vehicle collisions.
Double Tube Bridgerail on Safety Curb	The approach rails are typically connected to the bridgerail and additional approach rail posts are added to provide a transition in stiffness between the bridgerail and approach rails. The ends of the safety curb are transitioned to a reduced width at the bridge abutments.
Single Layer W-Beam Bridgerail on Participating Curb	The approach rails are not typically connected to the bridgerail. The ends of the bridgerails and participating curbs are largely unprotected from vehicle collisions.
Single/Double Layer W-Beam Bridgerail on Safety Curb	The approach rails are not typically connected to the bridgerail. The ends of the bridgerails and safety curbs are largely unprotected from vehicle collisions.
Double Tube Bridgerail on Participating Curb	The approach rails are typically connected to the bridgerail and additional approach rail posts are added to provide a transition in stiffness between the bridgerail and approach rails. The ends of the participating curb are partially protected from vehicle collisions.
Double Layer W-Beam Bridgerail on Participating Curb	The W-Beam approach rail is typically continuous with the W-Beam bridgerail. The ends of the participating curb are partially protected from vehicle collisions.

Similar to bridgerails installed prior to year 2000, several opportunities for improving the approach rail transitions listed in **Table H7.5** have been identified as a result of an increase in research and development in the area of roadside safety over the last few decades. Some of the opportunities for improving approach rail transitions installed prior to year 2000 include:

- Connecting the approach rail to the bridgerail.

- Gradually increasing the stiffness of the approach rail in the direction approaching the bridgerail, to prevent pocketing of vehicles at the end of the bridgerail.
- Aligning the approach rail with the bridgerail curb to avoid wheel snagging on the end of the curb. In lieu of this, a steel channel rub rail can be added such as shown on standard drawing S-1713-07 in **Appendix D3**.
- Aligning the approach rail with the top of the bridgerail to avoid snagging of vehicles on the top end of the bridgerail.
- Increasing the height of the approach rail to meet the requirements of the desired Performance Level.

These opportunities for improvement as well as others are discussed in more detail later in this section.

<u>Life-Cycle Benefit-Cost Analysis:</u>

Similar to the upgrading of bridgerails, the decision for upgrading the approach rail transition is based on a life-cycle benefit-cost analysis procedure. A technical summary of this procedure, including examples, is provided in **Appendix D**.

<u>Upgrading of Existing Approach Rail Transitions</u>

Like any other roadside design problem, the primary objective in the design of approach rail transitions is to reduce the overall severity of the roadside hazard. For bridges, the hazard is generally the end of the bridgerail, curb end, wing wall, and/or embankment below the bridge.

The need to upgrade existing bridge approach rail transitions may be present even when it has been determined that the adjacent bridgerail does not need to be upgraded. This need can be attributed to the severity of a vehicle collision with the end of the bridgerail.

There are three basic requirements that must be met for the severity of the approach rail transition to be minimized:

1. Containment of vehicles for the appropriate Performance Level (no gating of errant vehicles).
2. A gradual transition in barrier stiffness between the approach rail and the bridgerail itself (to prevent vehicle pocketing).
3. A smooth profile in the transition (to prevent vehicle snagging).

Since bridgerails are generally rigid and anchored to the bridge deck, post-mounted approach rail systems such as W-Beam, Thrie Beam, and Box Beam barriers are transitioned to the bridgerail using an approach rail transition that allows for a gradual increase in barrier stiffness. This is achieved by stiffening the rail element and reducing the post spacing on the approach rail as it approaches the bridgerail. On the leaving end of bridges where the flow of traffic is unidirectional, such as on divided highways, a bridgerail can be terminated without a transition, provided there are no other hazards beyond the bridge. In situations when an approach rail is required for a bridge on a divided highway, a gradual transition in barrier stiffness is only applied to the corners of the bridge on the approaching end. For two-way undivided traffic flow, however, approach rail transitions at all four corners of the bridge must be used due to the possibility of cross centreline collisions.

The following general guidelines apply to all bridge approach rail transitions:

- Install a rub rail beneath the guardrail, where necessary, to mitigate wheel snagging when transitioning a post supported approach rail to a concrete bridgerail, or to a bridgerail on a concrete curb.

- For approach rail transitions approaching a bridgerail with a concrete end parapet, the top of the parapet should not extend above the top of the approach rail transition by more than 50 mm. Concrete end parapets that are higher than the top of the approach rail transition should be reduced in height by tapering vertically at a maximum slope of 8(H):1(V).
- For concrete roadside barriers approaching the end of a bridgerail with a concrete end parapet, the concrete roadside barrier should be transitioned in height with a maximum slope of 8(H):1(V) to match the height and profile of the end parapet.
- The face of the approach rail transition should be smooth. Projections from the face of the barrier should be avoided wherever possible, and in any case limited to 25 mm.
- For bridgerails on concrete safety curbs, the profile of the approach rail transition should be matched to the profile of the bridgerail to maintain a smooth transition. In this situation a cast-in-place concrete curb extension, such as shown in standard drawing S-1711-07 in **Appendix D3**, should be used. If the face of the approach rail transition is aligned flush with the bridgerail curb, use a steel channel rub rail as shown in standard drawings S-1713-07 and S-1716-07 in **Appendix D3**. A channel rub rail should also be used when the gap under the approach rail transition is greater than 300 mm or if the curb end is not sufficiently flared.
- Lapping guardrail panels in the direction of traffic flow. For bi-directional traffic flow, the direction of overlap is based on the direction of traffic flow closest to the barrier.
- Using button head bolts to fasten guardrail panels at splices and at post locations. The dome-shaped bolt heads should always be positioned on the traffic side of the barrier.

<u>INFTRA Standard Drawings for Upgrading Approach Rail Transitions</u>

Standard approach rail transition upgrading drawings have been developed for the following types of bridgerails:

1. Vertical Bar/Horizontal Rail Type Bridgerail (refer to standard drawings S-1711-07 to S-1715-07 in **Appendix D3**)
2. 850 mm Double Tube Bridgerail on Safety Curb (refer to standard drawings S-1716-07 to S-1719-07 in **Appendix D3**)
3. Single Layer/Double Layer Deep Beam Bridgerail on Participating/Safety Curb (refer to standard drawing S-1720-07 in **Appendix D3**)

These standard drawings are available on the INFTRA website and are also provided in **Appendix D**. Standard approach rail transition drawings have not been developed for other types of approach rail transitions installed prior to year 2000 because these transitions are used only on low traffic volume roads where upgrading is rarely economically justified.

<u>Upgrading Warrant Charts</u>

To assist in the decision of when to upgrade a bridge approach rail transition, Warrant Charts in **Appendix D1.2** have been developed for the approach rail transition upgrades presented in standard drawings S-1711-07 to S-1720-07 in **Appendix D3**. These Warrant Charts are based on the detailed life-cycle benefit-cost analysis procedure presented in **Appendix D1.1** and the assumptions stated therein.

H7.6 Bridge Piers, Abutments, Wing Walls, and Retaining Walls

Bridge piers, abutments, wing walls and retaining walls are considered hazards when located within the Desirable Clear Zone. The Standard INFTRA practice is to position these structures outside the Clear Zone.

When this cannot be accomplished due to site specific constraints, there are several risks that should be carefully evaluated. These are:

- The probability that the structure will cause serious injury to vehicle occupants when struck.
- The likelihood of either an errant vehicle or the structure itself sustaining significant damage and costly repairs.
- The risk of an impacting vehicle striking the structure and compromising its structural integrity.

The standard practice is to achieve barrier free designs by placing bridge piers, abutments, wing walls and retaining walls outside the Clear Zone . However, in the rare occasion where a structure needs to be located within the Desirable Clear Zone, it will be necessary to shield the structure with an appropriate barrier system.

When retaining walls are required, the following guidelines should be followed:

<u>Guidelines for Retaining Walls Outside or Along the Edge of the Clear Zone</u>

- The walls should be vertical faced or slightly sloped back into the backfill.
- The retaining wall ends should flare back in accordance with the Flare Rate Table in **Section H5.4.2**, and be buried in the backslope.
- Precast facing panels should be backed by well compacted backfill and be readily replaceable or economically repairable.

<u>Guidelines for Retaining Walls Within the Clear Zone:</u>

- In a restricted environment such as tight urban situations or rehabilitation projects, there may be a requirement for retaining walls to be located within the Clear Zone.
- Retaining walls can incorporate the profile of crash-tested barriers in the lower portion of the wall. These profiles include the vertical face, Single Slope or F-shape profiles. These walls can effectively function as traffic barriers provided that the facing maintains a smooth profile, has no snagging points, and does not suffer damaging deformation or become unstable when impacted by an errant vehicle.
- When the wall is used as a roadside barrier, it should be placed at the shy line offset or the shoulder's edge, whichever is greater. However, the distance from the edge of the travelled lane should not be more than 4 m, to reduce the likelihood of an errant vehicle hitting the wall at a high angle.
- The preferred retaining wall end treatment should flare back in accordance with the Flare Rate Table in **Section H5.4.2**, and be buried in the backslope. Alternatively, the approach end of a retaining wall can be tapered down to match the height of the approach guardrail transition and be shielded with an appropriate end treatment.
- Where the top of the wall is exposed to approaching traffic, there should be no abrupt change in height. For any portion of the wall less than 1.6 m in height, the slope of the top of the wall should not be steeper than 8(H):1(V).

- Placement of external precast or Extruded Concrete Barriers directly in front of Mechanically Stabilized Earth (MSE) walls may not be compatible with durability and long term settlement issues of the MSE wall, and is discouraged.
- The Zone of Intrusion effect shall be considered for any obstacles (such as corners of box abutments or lamp posts) placed behind the tops of the walls.

<u>Guidelines for Retaining Walls with Roadway(s) Running Along the Top of the Wall:</u>

- A rigid bridgerail meeting the requirements of the bridge code (CAN/CSA-S6-06) shall be provided along the tops of the retaining walls, complete with any necessary foundation footings and hardware required to distribute the barrier collision forces to the tops of the retaining walls.
- The retaining wall shall be designed to fully resist the barrier load applied to the bridgerail consistent with the performance level rating of the barrier.
- Semi-rigid and flexible barriers with an appropriate deflection allowance behind the barriers may be considered for rural situations with lower AADT, if they can be justified by economic considerations, and approved as design exceptions. In such cases, the retaining walls shall be designed to resist the soil pressures resulting from the barrier loads consistent with the performance level rating of the barrier.

H7.7 Underpasses

Unless dictated otherwise by significant constraints, all new underpasses should be designed so that barrier systems are not required between the travel lane on the underpassing roadway and the structure. This can be accomplished by ensuring the structure piers or abutments are placed outside the Clear Zone of the underpassing roadway. Barriers must be provided whenever it is necessary for the structure piers or abutments to be offset from the travelled underpass roadway by less than the Clear Zone distance, such as for narrow urban road cross sections. In these cases, place the barrier with due consideration for the various factors presented in **Section H5.4**, such as the shy line offset and Zone of Intrusion.

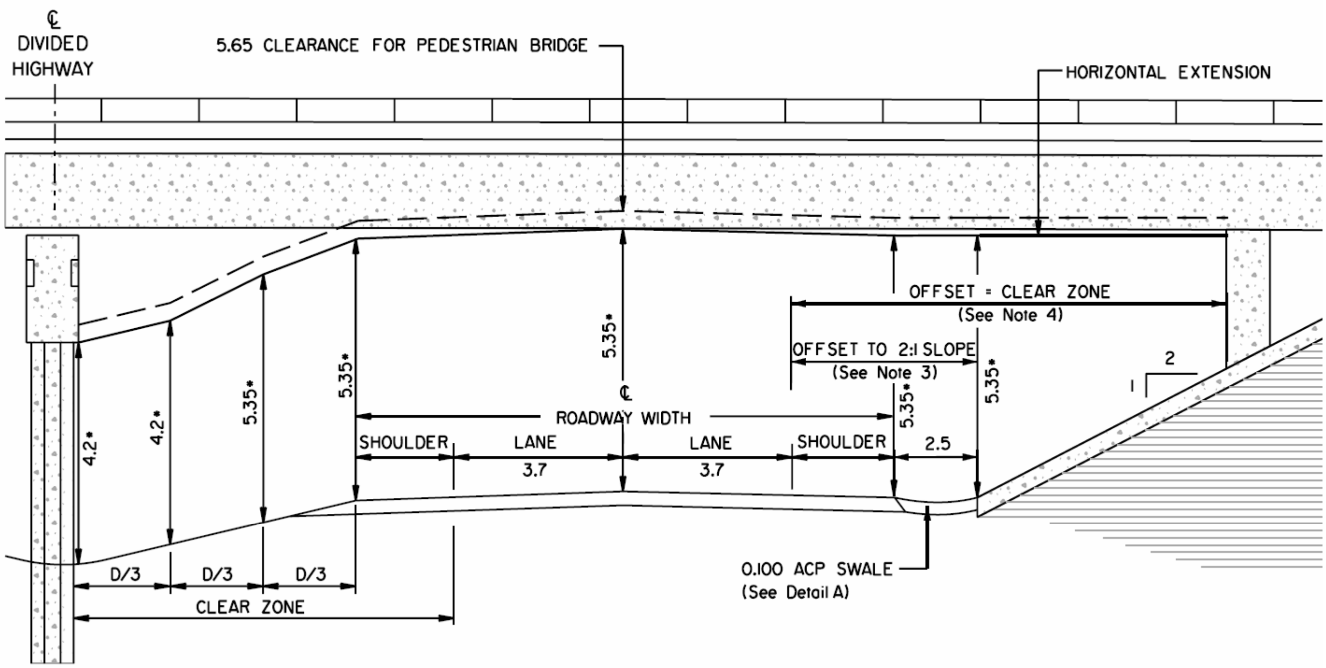
The use of a 2:1 headslope in the clear zone under bridges as shown in Figure H7.1 has been adopted as a normal practice by the department after more than 30 years of satisfactory in-service experience with this cross-section. The choice of a 2:1 headslope without barriers for the limited length of the bridge is considered less hazardous to the road user than the installation of a longer roadside barrier system which is itself a hazard, would be located closer to the travel lane and would cause snow-drifting.

If the highway is to be widened within the service life of the structure, consider providing a structure that would allow for barrier-free operation at all stages of the structure's life. The design should consider the service life of the interchange (not just the structure), staging considerations and economic factors.

This guideline applies to all underpassing roadways including major highways, ramps, collector-distributor roads, and minor highways.

The clearance requirements for roadway and railway underpasses are illustrated in **Figures H7.1, H7.2** and **H7.3**.

FIGURE H7.1 Typical Details of Highway Grade Separation



Notes:

1. Abutment slopes are normally 2:1 however flatter slopes may be used for stability and/or roadside safety.

2. Where traffic barriers are not installed, shoulder rumble strips are desirable.

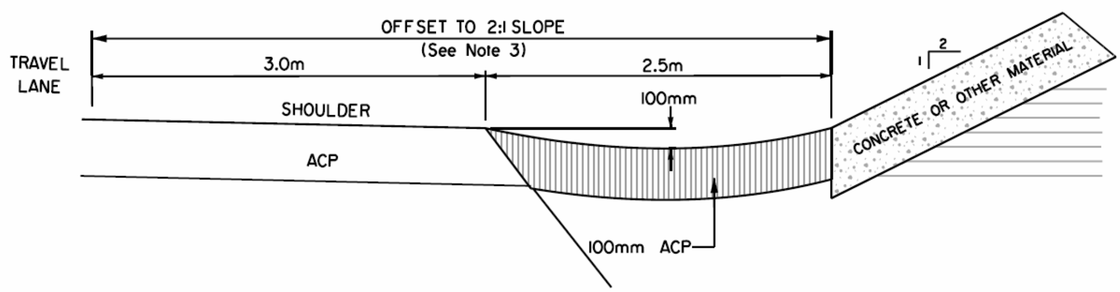
3. Barrier is normally required if pier is located within the clear zone. An unprotected 2:1 backslope within the clear zone is generally acceptable especially if a suitable offset from the travel lane is provided. A suitable minimum offset for an unprotected 2:1 backslope for any given speed is one half of the clear zone. Refer to Table H3.1 for clear zone distances.

4. Normally the bridge abutment will be located at the top of the headslope which is outside the clear zone and the abutment is sized to provide good aesthetics and balance to the depth and span length of the superstructure.

5. Barrier protection around median piers is generally provided if warranted by clear zone guidelines.

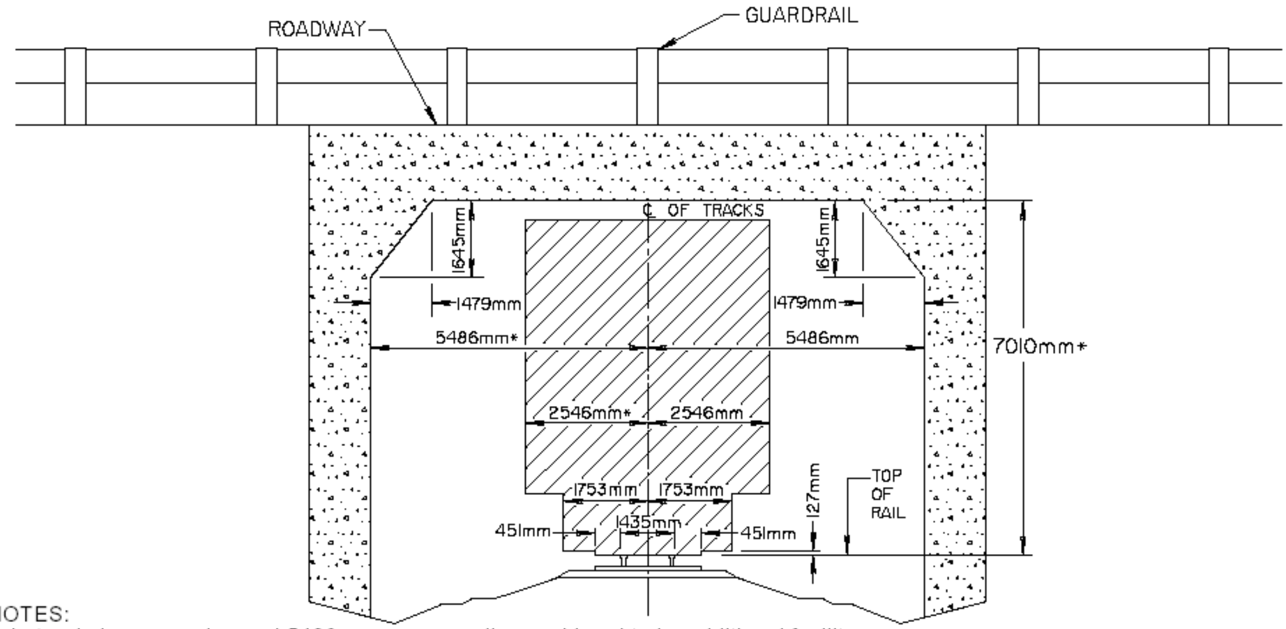
6. The standard vertical clearance for pedestrian bridges is 5.65 m over the roadway surface.
   * For design vertical clearance, add 0.05 m for construction tolerance.

7. D = (Clear zone - shoulder width).



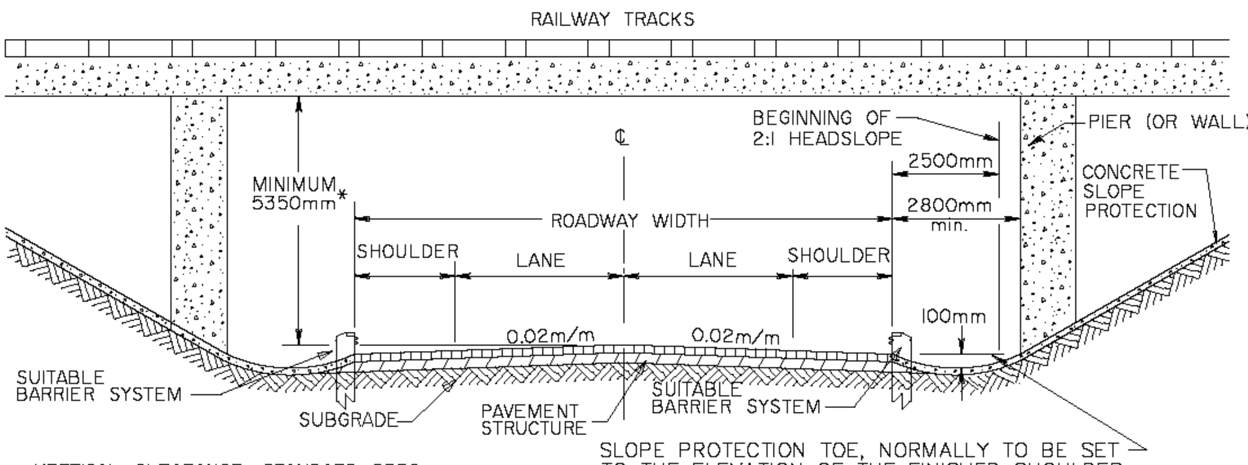
DETAIL A - SWALE

FIGURE H7.2 Minimum Clearance Requirements For Railway Overpass



* NOTES:
1. Lateral clearances beyond 5486mm are normally considered to be additional facility.
2. 2546mm is the absolute minimum lateral clearance from a safety perspective.
3. The 'standard' vertical and horizontal clearance dimensions of 7010mm and 5486mm respectively apply to cost-share projects. For non cost-share projects, smalller clearances may be negotiated with the railway.

FIGURE H7.3 Minimum Clearance Requirements For Railway Underpass and Grade Separations (See Typical Details on Figure H7.1)



* VERTICAL CLEARANCE: STANDARD 5350mm
LOCAL (SPECIAL CASE) 4750mm
ABSOLUTE MINIMUM 4150mm = Maximum height of standard truck (see Figure D-56)

NOTES:
1. The horizontal clearances shown here are minimum values that are normally used only in retrofit or constrained environments. On new construction or unconstrained projects, the layout and dimensions shown in figure H7.1 are normally used.
2. The clearance box used on special routes may exceed the dimensions shown here, for example on the high load corridor (where the clearance box is normally 9m wide x 9m high). On log haul routes the vertical clearance should provide for all permitted load sizes.
3. Rounding depth and relative elevation of shoulder and toe of slope protection may vary approximately 150mm.
4. A construction tolerance of 50mm on the vertical clearance is generally allowed for.

H7.8 References

The following documents were used during the development of this section:

Alberta Infrastructure and Transportation,
Guidelines for Upgrading of Existing Bridgerails/Approach Rail Transitions,
Edmonton, AB, 2003

Alberta Infrastructure and Transportation,
Highway Geometric Design Guide,
Edmonton, AB, 1999

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Edmonton, AB, 2003

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Edmonton, AB, 2003

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Traffic Control Standards Manual,
Edmonton, AB, 1995

American Association of State Highway and Transportation Officials,
A Guide to Standardized Highway Barrier Hardware 1995

American Association of State Highway and Transportation Officials,
LRFD Bridge Specifications Section 13 - Appendix A

American Association of State Highway and Transportation Officials,
Roadside Design Guide 2002,
Washington, DC, 2002.

Canadian Highway Bridge Design Code (CAN/CSA-S6-06)

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