Topic 7-03 – Guardrail

7-03.1 Introduction

Guardrail, installed to reduce the severity of run-off-road collisions, is the most common traffic safety system found on California State Highways. Guardrail may redirect an errant vehicle and dissipate energy from the collision in some, but not for all cases depending on the sequence of events during the collision. Although guardrail is itself a fixed object, it may reduce collision severity in situations where it is determined that striking the guardrail is less severe than striking fixed objects or slopes behind the guardrail.

1. *Definition of Use*: Guardrail is used as a longitudinal rail off of the edge of pavement to shield areas of concern. It is typically installed to the right of approaching traffic, but may be installed to the left (e.g., one-way traffic roadbeds on separate alignments, ramps, or at fixed objects).
2. *CRZ Treatment*: Consideration should first be given to eliminating or minimizing conditions requiring guardrail. This may be done by flattening the embankment slope or by removing/relocating fixed objects out of the CRZ.

   Projects should eliminate or relocate solitary fixed objects found in the CRZ that cannot be made breakaway or yielding. The length-of-need for guardrail at solitary fixed object increases the exposure to the guardrail and may increase the number of collisions.

Where guardrail is to be installed on an existing highway or in conjunction with existing roadside features, the conditions relating to the roadside feature should be verified, such as slopes, clearances, dimensions, underground utilities, and material. This is especially important where connections to existing structures are proposed. Details for assembling guardrail are shown on the Standard Plans or Construction Details of Contract Plans. The layout of new guardrail shall be shown on the Contract Plans to conform to embankment and fixed object criteria.

7-03.2 Guardrail Types

The approved types of guardrail are metal beam, concrete and cable.

1. *Metal Beam Guardrail* is typical for embankment and fixed object shielding. It is made up of "W" shaped metal beam rail elements mounted on wood or plastic blocks fastened to a wood or galvanized steel posts. Additional details are shown in the Standard Plans.

   All wood posts and blocks for guardrail are pressure treated to resist decay. Line posts shall not be installed in structural pavements that would restrict movement of the posts during impact. Only one type of post, either wood or steel, should be used in a run of guardrail. Vegetation control should be considered for use around guardrail. Details for vegetation control beneath guardrail are in the Standard Plans.
2. *Concrete Barrier* is generally damage-resistant and can be used in place of metal beam guardrail to decrease maintenance worker exposure. Criteria for this use are when the guardrail is within 14 feet of the traveled way and it has been struck three or more times in any 12 consecutive months during a three-year period.

   The approved types of concrete barrier best suited for permanent guardrail installations are the Type 732B, Type 736B and the Type 60 series. For temporary or short-term installations, approved portable concrete barriers may be used, such as Temporary Railing (Type K). See Topic 7-03.6(3) for requirements on the use of Temporary Railing (Type K) as temporary guardrail.

   Justification for use of concrete barrier as guardrail that does not meet the above criteria, or is for new construction, must be based on the recommendation from the District Traffic Safety Engineer, and approved by the Headquarters Traffic Operations Liaison. Documentation for this decision must be placed in the project files.

   Concrete guardrail shall be placed a distance of 17 feet or less from the edge of traveled way (measured from the base of the barrier).

   Crash testing indicates that appurtenances on top of a concrete barrier or guardrail, except barrier markers or chain link fence, can potentially snag as vehicles roll into the barrier during impact and their hoods override the

top. Chain link fence may be attached on top of concrete barriers or guardrail if installed per the Standard Plans. Other appurtenances, such as steel sign posts or electroliers, but excluding structure columns or sign pedestals, may be placed on top of concrete guardrail based on the following restrictions to prevent snagging:

a. The top of the barrier is ramped up to 48 inches, at a minimum 4:1 slope, where the appurtenance is placed, or

b. The barrier is widened to a top and bottom width of 34 inches at minimum 20:1 taper on the approach side to provide a minimum 15 inch setback from the appurtenance.

See the Standard Plans for details for installing steel sign posts on top of Type 60 concrete barrier used as guardrail, and details of structure columns and sign pedestals enclosed by Type 60 series barriers.

Proposed appurtenances on concrete guardrail, except Standard Plans details, must be approved by the District Traffic Safety Engineer and documented in the project files.

3. *Cable Guardrail* is a high-tension three or four-strand flexible barrier. It may be recommended by the District Traffic Safety Systems Coordinator for locations that can accommodate cable deflections up to 9.5 feet. See Topic 7-04.6(3) for more details on cable barrier.

Cable guardrail must be approved by the Headquarters Traffic Operations Liaison and the Deputy District Directors for Traffic Operations and Maintenance. Documentation of the approval must be placed in the project files.

7-03.3 Guardrail Installation Criteria

When considering installation of guardrail at an embankment or a fixed object the following criteria, although not an all inclusive list, may be used as a guide:

1. *Collision History*: Based upon the run-off-road collision history, statistical experience or analysis can be used to predict if guardrail is a potential solution to reducing the severity of a collision at a particular roadway segment.
2. *Roadway Alignment*: Isolated curves on relatively straight roadway alignment may increase the risk of running off road. Also, on roads with curving alignment, curves that are sharper than expected may increase the probability for run-off-road collisions.
3. *Operating Conditions*: The location's traffic characteristics can also affect the potential for a vehicle to leave the traveled way:
   a. Volume: The higher the volume of traffic, the greater the potential for run-off-road collisions.
   b. Speed of Traffic: Higher operating speed can increase the potential for run-off-road collisions, and will affect the distance that a vehicle will traverse before the driver can regain control or bring the vehicle to a stop.
   c. Merge and Weave Areas: The potential for run-off-road or lane departure collisions may increase in the vicinity of ramp merge and diverge areas, especially those without auxiliary lanes where stopped or slowing traffic can cause abrupt lane changing and collision avoidance maneuvers.
4. *Climate Conditions*: Frequent dense fog, rain, or snow and ice conditions increase the risk of run-off-road collisions.
5. *Roadside Recovery Area*: The risk of a run-off-road vehicle colliding with an embankment or a fixed object is greater as the recovery area decreases.

The highway facility type, whether a freeway, expressway, or a conventional highway, has an impact on the analysis for installing guardrail due to the differing characteristics of these facilities. For example, the presence of driveways may prevent the installation of guardrail to shield an object within the CRZ. Funding limitations and these differing characteristics preclude firm rules for installing guardrail.

7-03.4 Guardrail at Embankment Slopes

Installing guardrail to shield embankment slopes is largely a result of analyzing the above criteria on a case by case basis and determining whether a vehicle hitting guardrail is more severe than going over an embankment slope. A tool developed for evaluating this severity, the "Equal Severity Curve" (see Figure 7-1), developed in the 1960s and updated in the early 1980s, is still applicable.

The line in Figure 7-1 represents collisions at combinations of embankment height and slope that resulted in severities generally equal to the severity of an average guardrail collision. If combina-

tions of embankment height and slope plot close to the line, the severity of an errant vehicle going over an embankment may be greater or less than the severity of striking the guardrail, so the shaded areas of the line should be regarded as a band. When the site specific embankment height and slope conditions plot above the equal severity band, the severity of colliding with the guardrail should be less than the severity of a run-off-road vehicle going over the embankment. Therefore, guardrail can be installed when the embankment height and slope plot above the band, and the criteria in Topic 7-03.3 are considered.

Although an embankment slope may not qualify for installation of guardrail based on application of Figure 7-1, the presence of fixed objects along the slope or bodies of water, school grounds, or other fixed objects at the toe of slope or beyond the CRZ, can present a greater risk to vehicle occupants or people. For this reason local site conditions need to be considered in conjunction with Figure 7-1.

Guardrail placed to shield an embankment slope should shield both directions when the embankment is within the CRZ for each direction of travel. See Figure 7-2. For more information on clear recovery zones on conventional highways see Topic 7-02.

The District Traffic Safety Engineer must approve the decision to install or not to install guardrail and the type of end treatment at an embankment slope, and the approval must be documented in the project files.

Figure 7-1: Equal Severity Curve

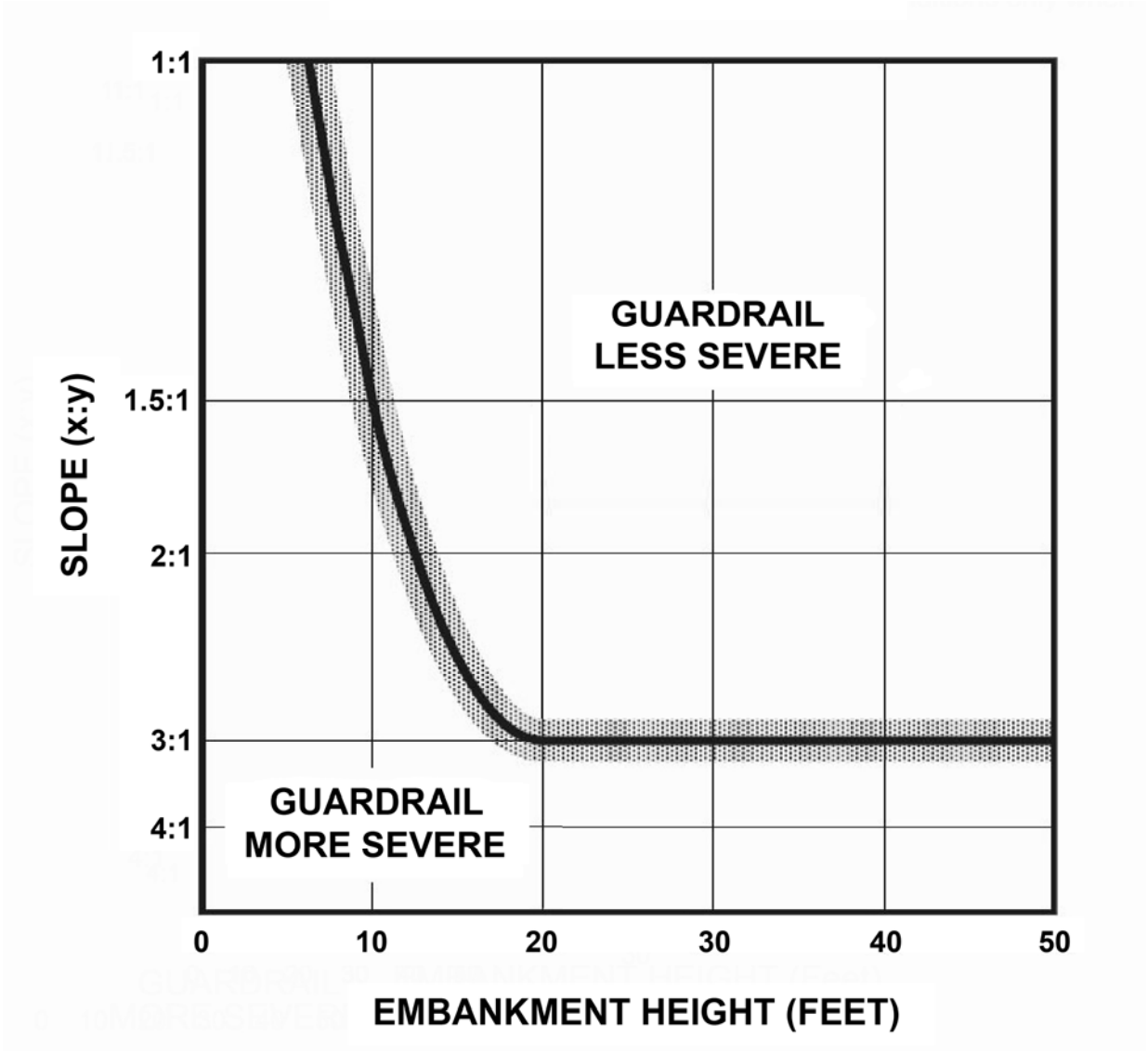


Figure 7-2: Railing at Fixed Objects or Embankment Installations

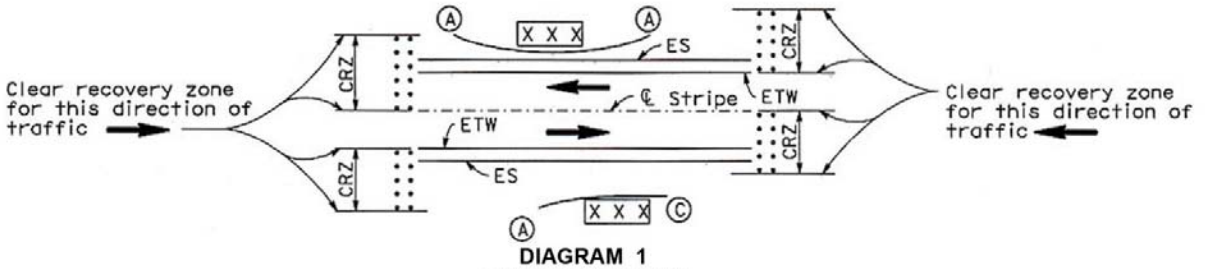


DIAGRAM 1
TWO-WAY HIGHWAY

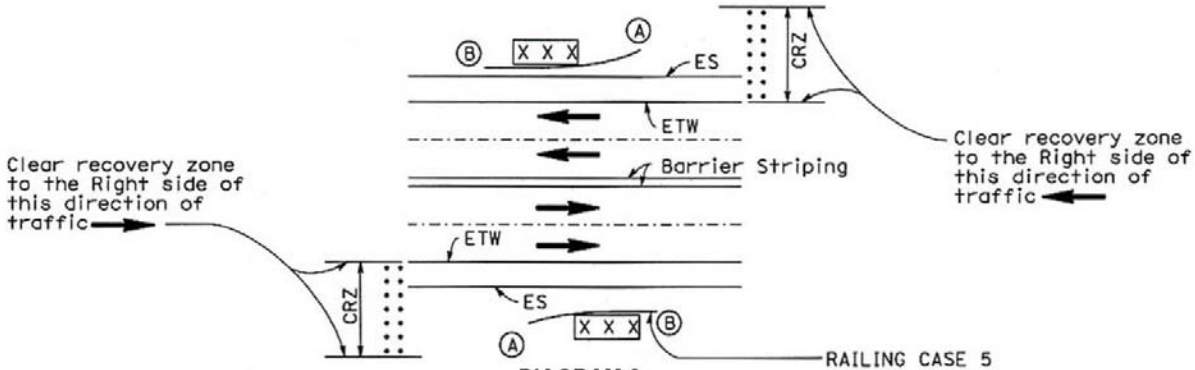


DIAGRAM 2
TWO-WAY MULTILANE HIGHWAY
WITH BARRIER STRIPING

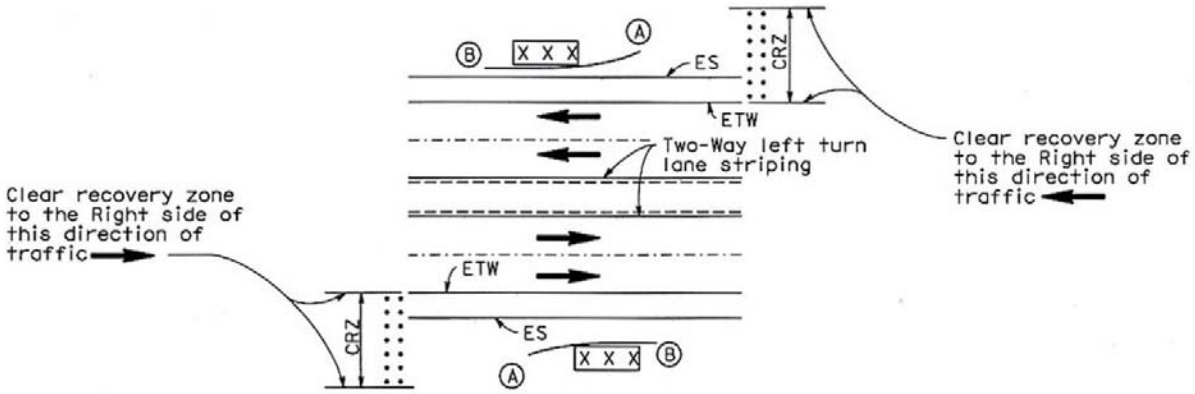


DIAGRAM 3
TWO-WAY MULTILANE HIGHWAY WITH
TWO-WAY LEFT TURN LANE STRIPING

LEGEND

Ⓐ Caltrans approved end treatment, buried post end anchor, or crash cushion. If located outside of the CRZ, an approved end anchor, buried post end anchor, or crash cushion may not be necessary.

Ⓑ Railing end anchor assembly

X X X Fixed object(s) or non-recoverable embankment slope

7-03.5 Guardrail at Fixed Objects

Guardrail should be considered at all fixed objects that are accessible to traffic and within the CRZ, whether to the left or right of traffic. Guardrail may also be considered at fixed objects located beyond the CRZ when such objects occupy an otherwise clear recovery area.

Metal beam guardrail with standard post size and spacing may be placed as far as possible from the edge of pavement, but no closer than 48 inches from the face of the rail to the object. This clearance between the guardrail and the fixed object is necessary since guardrail deflects up to 36 inches during impact. The extra 12 inches is to allow for those instances where a guardrail post would intrude into the 36-inch clearance. Guardrail that is to be installed between 48 inches and 27 inches from a fixed object shall be constructed according to "Strengthened Railing Sections for Fixed Object" detail of the Standard Plans. See Topic 7-03.6(5)(c) for discussion of this detail. If guardrail is to be installed less than 27 inches from a fixed object, concrete barrier is to be used. See Topic 7-03.2 for allowable types of concrete barrier to be used as guardrail. Where there is a row of structure columns with less than 26 feet in-between each column, the strengthened railing section detail should be continued between the columns. Where the column spacing exceeds 26 feet, a new detail may be started.

As mentioned in the introduction, guardrail redirects and dissipates the energy generated by an errant vehicle in most situations. However, it is unlikely to prevent or reduce injury in all potential collision scenarios. Placement of guardrail, itself a fixed object, may also increase the probability of a vehicle colliding with the guardrail. For this reason, fixed objects such as individual electrical controller cabinets, signal poles, lighting standards, utility poles or trees are typically not shielded by guardrail. (See the memo dated 12/01/03, Placement of Traffic Controller Cabinets, available on the Traffic Safety Devices webpage, for further discussion on installation of traffic control cabinets.) Guardrail shall be placed at the following fixed objects within the CRZ that are not shielded by other traffic safety systems:

1. Overhead sign posts,
2. Structure piers, columns, and abutments, and
3. Exposed ends of walls.

See Standard Plans for additional details where walls are above the height of guardrail.

When evaluating placement of guardrail to shield rows of trees within the CRZ that have trunks 4 inches or greater in diameter, consult with the District Traffic Safety Engineer. More emphasis should be given to those trees spaced 100 feet apart or less.

In medians or roadway separations that are less than 100 feet wide and traversable by vehicles, structure piers or columns should be shielded with guardrail with appropriate end terminals and/or crash cushions if not otherwise shielded.

Guardrail placed to shield a fixed object on a two-way highway should shield both directions when the object is within the CRZ for each direction of travel. See Figure 7-3: Railing at Structures, Diagram 6, for illustration of CRZ on multilane highway structure with asymmetrical roadway layout. For more information on clear zones on conventional highways see Topic 7-02.

Guardrail placed to shield a fixed object on a two-way multilane highway with a two-way, left turn lane, should protect adjacent traffic if the fixed object is within the CRZ.

The District Traffic Safety Engineer must approve the decision to install or not to install guardrail and the type of end treatment at a fixed object and the approval must be documented in the project files.

7-03.6 Guardrail Design Considerations

This topic addresses site-specific considerations involved in designing a guardrail layout. It discusses the length of guardrail needed to shield an area of concern, as well as the lateral placement relative to the area of concern. It also covers uses of guardrail at structures and drainage features, and addresses appropriate cross slopes. It discusses end treatments and transitions to structures, gaps in guardrail installations, and concludes with various other design details.

1. *Guardrail Length of Need*: The length of need is the total length of a guardrail and portion of the end terminal needed to shield an area of concern by containing or redirecting an errant vehicle. The length of need begins at the point where an end terminal can redirect a vehicle or functions as a re-directive, non-gating device. Non-gating end treatments are capable of redirecting a vehicle impacting the nose or the

side of the system along the systems entire length. Gating end treatments allow a vehicle impacting the nose or the side of the system near the nose to pass through the device. For gating end treatments, the length of need will usually start 12 feet-6 inches from the impact head. Nearly all errant vehicles that run off road do so at angles of less than 25 degrees. The majority of run-off-road collisions occur at departure angles between 10 and 15 degrees, with 12.5 degrees typically used to determine if guardrail shields an object.

Guardrail approaching fixed objects and having a clearance of four feet or less from the face of rail to the objects should typically have a minimum length of 25 feet preceding the object exclusive of an approved end treatment.

The length of need will vary depending upon site conditions and the guardrail layout. As the setback to a fixed object increases, so will the length of need required to shield that object. Likewise, for locations with multiple objects within the CRZ, such as a bridge approach rail on an embankment with trees, the length of need to be considered should be sufficient to shield the approach rail, embankment, and the other fixed objects.

Figure 7-4, Position of Guardrail at Fixed Objects, illustrates how additional guardrail is needed to shield an area extending back from the edge of the roadbed on a one-way road. Figure 7-4 also illustrates how the length of a guardrail installation may be reduced where there is a wider clear recovery area between the edge of the shoulder and the fixed object.

Where fixed objects are added behind existing guardrail, care should be taken that all fixed objects are within the area shielded by the guardrail. Fixed objects shall not be allowed behind breakaway anchors.

> The District Traffic Safety Engineer must approve the length-of-need for embankment and fixed object guardrail for all installations and the approval must be documented in the project files.

2. *Guardrail Placement and Position*: For illustrations of guardrail at structure approaches in the following applications, see Figure 7-3. Structure approaches apply to the ends of bridge railings, parapets exposed to approaching traffic, curb, sidewalk and dike. Where guardrail is needed at structure approaches or concrete barrier, transition railing (Type WB) of the Standard Plans should be used unless site conditions support use of a crash cushion system. Refer to Topic 7-6 for more information on crash cushions. If curb or bridge barrier without a vertical face is present, refer to Structures XS Sheets (Barriers and Railings) for connection details. Where a curb or sidewalk is present, traffic is one-way and approach speeds are 45 mph or less, the connection details in Figures 7-5a and 7-5b may be used. See Note 1 of Figure 7-5b for design requirement from Headquarters Geotechnical Services.

   a. *Two-Way Conventional Highway*: When the roadbed width across the structure is less than 40 feet, approach guardrail should be placed on both sides of the roadbed at each end of the structure. When the roadbed width is 40 feet or more, guardrail should be placed only to the right of approaching traffic. A roadbed is that portion of highway extending from curb line to curb line or edge of shoulder line to edge of shoulder line. Divided highways are considered to have two roadbeds.

   b. *Multi-Lane Highways with Separate Structures*: Guardrail should be placed to the right and left of approaching traffic. Railings, guardrail, and bridge railing should not be placed transversely across the median or separation openings between adjacent or parallel structures. Protection should be provided by bridge approach guardrail with adequate length and an appropriate typical layout. Details regarding guardrail typical layouts are contained in the Standard Plans.

   c. *Multi-Lane Freeways or Expressways with Decked Medians*: When the bridge clear width is less than 60 feet, guardrail should be placed on both sides of the structure. When the bridge clear width is 60 feet or more, guardrail should be placed only to the right of approaching traffic.

Figure 7-3: Railing at Structures

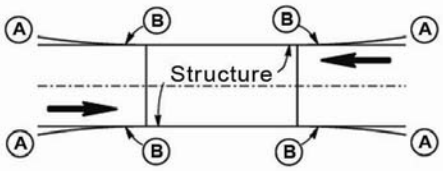


DIAGRAM 4
TWO-WAY HIGHWAY STRUCTURE ROADBED
WIDTH LESS THAN 40 FEET

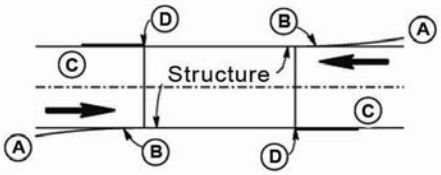


DIAGRAM 5
TWO-WAY HIGHWAY STRUCTURE ROADBED
WIDTH EQUAL TO OR GREATER
THAN 40 FEET

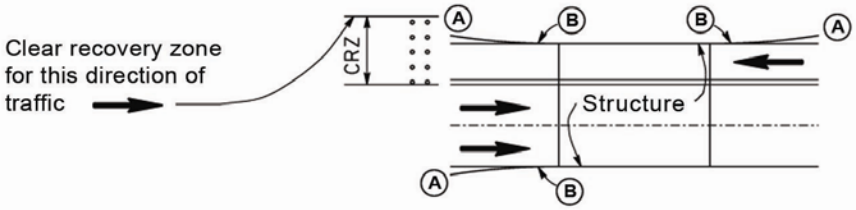


DIAGRAM 6
MULTILANE HIGHWAY WITH
ASYMMETRICAL ROADWAY LAYOUT

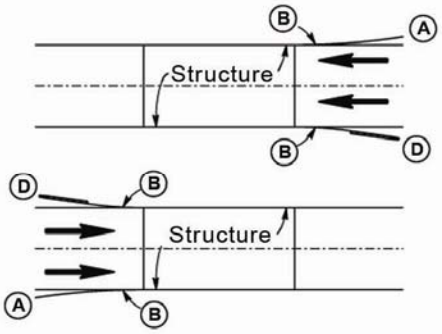


DIAGRAM 7
MULTILANE HIGHWAY WITH SEPARATE
STRUCTURE FOR EACH DIRECTION OF TRAVEL

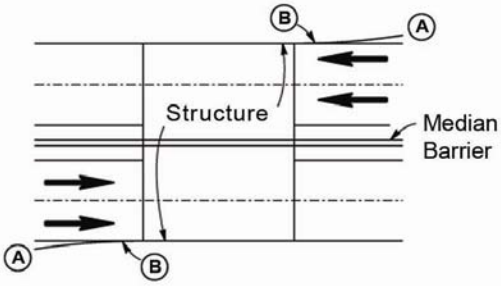


DIAGRAM 8
MULTILANE HIGHWAY WITH
DECKED MEDIAN ON STRUCTURE

LEGEND

- (A) Caltrans approved end treatment, buried post end anchor, or crash cushion
- (B) Transition railing with anchorage to structure
- (C) Railing end anchor assembly
- (D) Positive anchorage to structure

Figure 7-4: Position of Guardrail at Fixed Objects

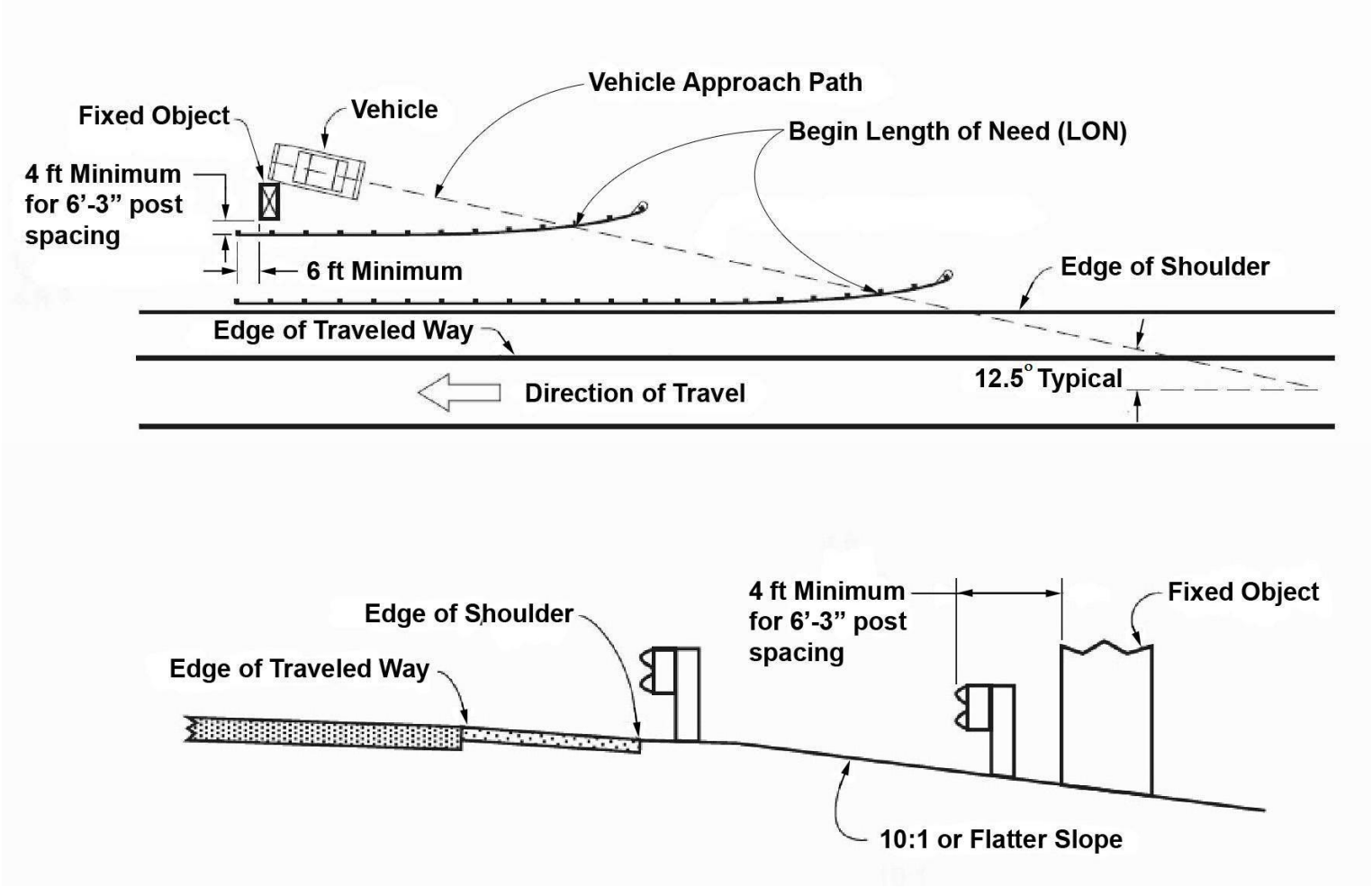


Figure 7-5a: Guardrail Connection to Bridge Curbs

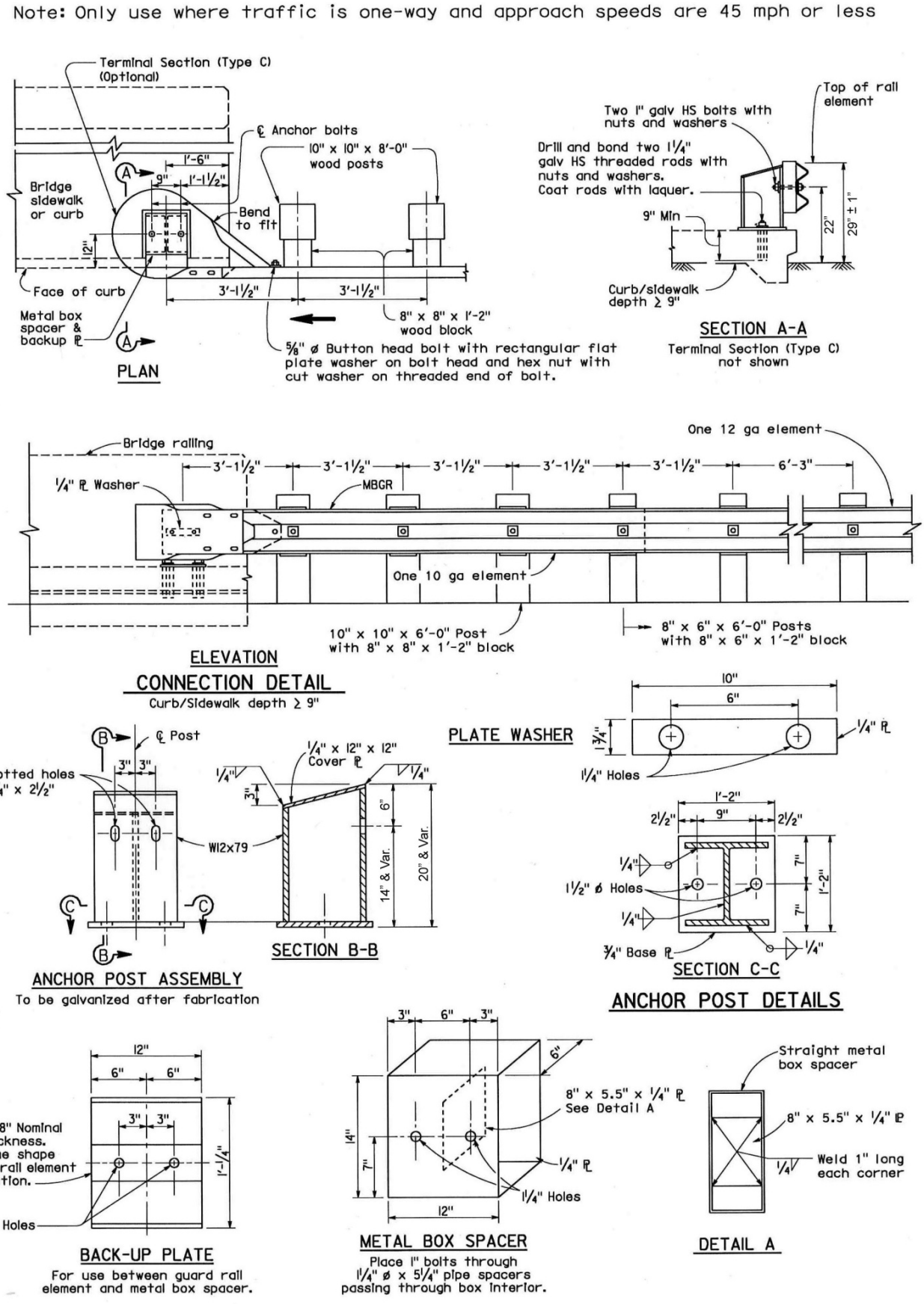
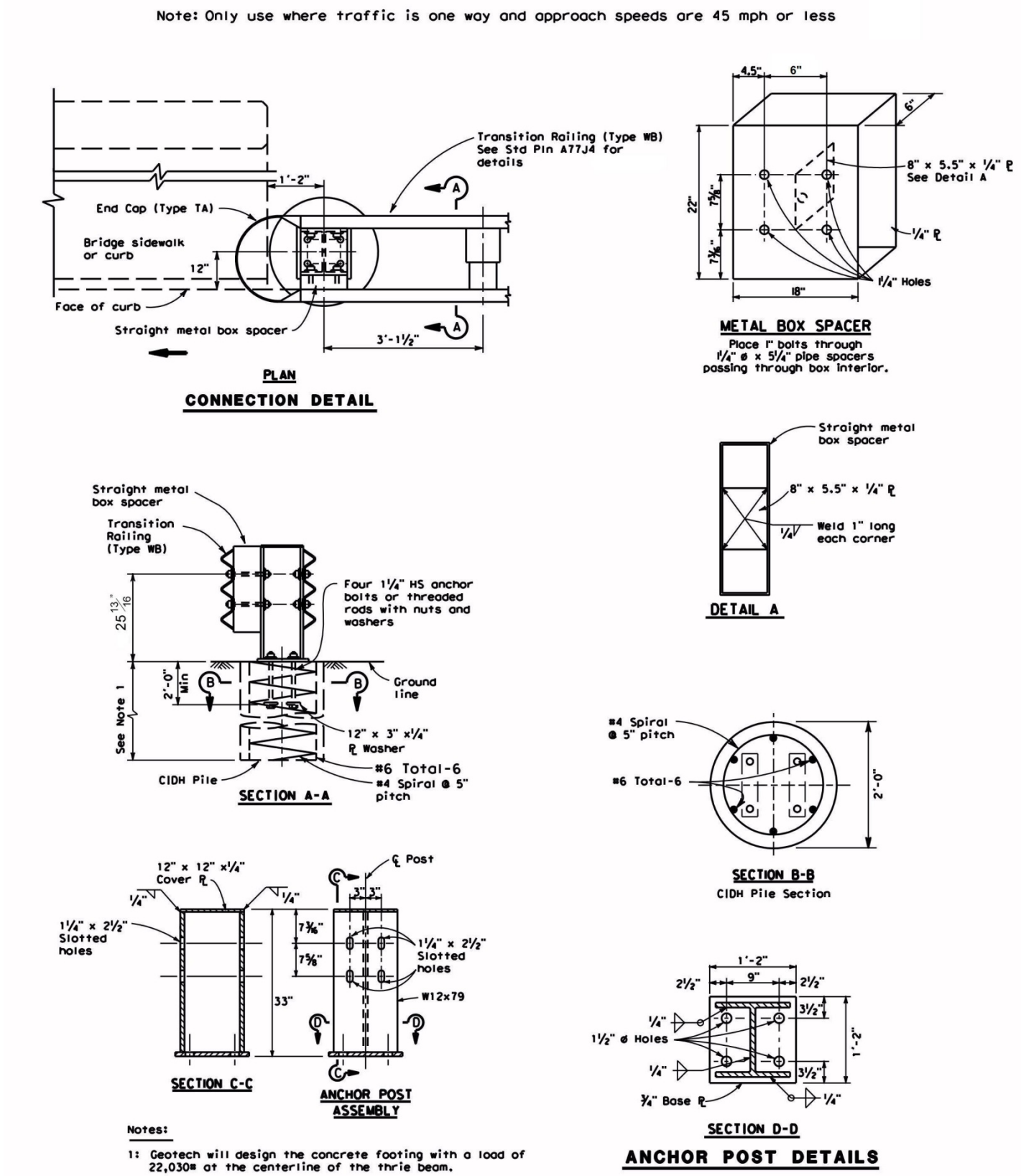


Figure 7-5b: Guardrail Connections to Anchor Posts



Notes:

1: Geotech will design the concrete footing with a load of 22,030# at the centerline of the thrie beam.

d. Curb and Dike: To prevent a vehicle from vaulting over standard guardrail when it is used in conjunction with a 4-inch high curb or dike, the guardrail face should be on a vertical line with the curb face or on a line no more than two inches behind the flow line of the dike.

A curb or dike greater than 2 inches in height, ditches, and drainage structures shall not be placed in front of standard guardrail. When the height of dike is reduced due to installation of guardrail, consult with the district hydraulics engineer regarding hydraulic capacity. If a dike is required in front of the guardrail, Type C dike may be used. Where high dike or curb is needed for drainage and guardrail is recommended, the modified guardrail and dike detail in Figure 7-6 may be used.

> Use of the details in Figure 7-6 must be approved by the Headquarters Traffic Operations Liaison.

e. Cross Slopes: **The cross slope from edge of shoulder to guardrail shall be 10:1 or flatter, except when conforming to the cross slope of the roadway.** A discussion of trajectory is in Traffic Bulletin No. 15, "Method for Checking the Integrity of Cable and Beam Barriers".

> Possible vehicle trajectory must be checked, and documented in the project files, when guardrail placement is proposed behind a slope steeper than 10:1.

3. Guardrail Anchorage, Transitions and Approach End Treatment: Guardrail functions as a tension member, much like a bowstring, redirecting the errant vehicle away from the obstacle. Thus it is necessary that both ends of all guardrail installations be anchored. Concrete guardrail shall be anchored to prevent movement. Type 732B and 736B are anchored by continuous footings; Type 60 series requires a 10-foot long footing at each end; Temporary Railing (Type K) is anchored by 1-inch diameter dowels for temporary and long-term use. See the Standard Plans for staking details.

Type CA Cable Anchor Assembly (non-breakaway) shown in the Standard Plans can be used only where the end of a guardrail installation cannot be impacted by an approaching vehicle. A non-breakaway anchor should be used to add intermediate anchorage where there is an abrupt change in the alignment of the guardrail, such as when the guardrail is continued down an intersecting road or if there is an area of concern on the side slope that would cause a more severe collision than impacting the guardrail**.** If there is no area of concern on the side slope, then a breakaway anchor with drilled posts set in a foundation should be used for intermediate anchorage.

Guardrail approaching structures is anchored to, or near the structure. In general, guardrail may be anchored to structure railings that are designated barrier railings. Guardrail shall not be anchored to structure columns or abutments unless detailed in the Standard Plans, as holes drilled for anchor bolts can compromise the integrity of earthquake reinforcement. Where existing masonry and lightly reinforced concrete walls are involved, an independent anchor shall be used. Connections may be made to new installations of concrete barrier.

Type 60 series and Temporary Railing (Type K) should be supported by a 4-inch thick asphalt or concrete pad that begins from the edge of the pavement and extends 12 inches beyond the back edge of the concrete guardrail. If the pad cannot be extended 12 inches beyond the back edge of concrete guardrail, other measures should be used to prevent soil erosion. Pavement should extend to the footing of the Type 732B and 736B barriers.

a. Approach End Treatments: The order of preference for approach end treatments is as follows:

i. Bury the end of the guardrail in a non-traversable slope. It may be necessary to extend a guardrail installation a reasonable distance to reach a cut section where a buried end anchor can be used. A minimum height of 28 inches to the top of guardrail is to be maintained to minimize vaulting.

ii. Extend the end of the guardrail at a 20:1 or flatter flare (for concrete), or a 15:1 or flatter flare (for metal beam guardrail), to a point outside the CRZ.

iii. Install an approved end treatment at the approach end of the guardrail.

For more information on which end treatments are approved for use on California State highways and for assistance in choosing an appropriate system, contact

your District Traffic Safety Systems Coordinator.

b. Trailing End Anchorage: The End Anchor Assembly (Type SFT) is intended for use on the trailing end of guardrail installations that are outside the CRZ of opposing traffic. See Figure 7-2.

c. Transitions to Structures: Transitions are required for metal beam guardrail approaching connections to structures. Metal beam guardrail is a semi-rigid barrier and must be gradually stiffened as it approaches connections to, or at rigid objects such as bridge railings, retaining walls, abutment walls, or other structure supports. Stiffening smoothly redirects an impacting vehicle away from the rigid object and shall be accomplished by using the Metal Beam Guardrailing Transition Railing (Type WB) of the Standard Plans.

4. Gaps Between Guardrail Installations: Gaps of less than 200 feet between guardrail installations, or between the end of cut slopes and the beginning of guardrail, should be avoided. Where such a gap is essential for maintenance purposes, removable rail elements can be installed. For additional information on rail panels, consult the District Safety Systems Coordinator.

A gap for maintenance use may be left at the departing end of embankment guardrail on one way roadbeds, or two-way roadbeds where the departure end is outside of the CRZ. Where there is recovery area between the edge of the traveled way and the edge of an embankment, the guardrail should be installed near the edge of the embankment, preserving the recovery opportunity.

5. Design Details: There are a number of factors that must be taken into consideration when installing guardrail.

a. Restricted Horizontal Clearance to Hinge Point: Where embankment width between the edge of shoulder and hinge point is less than 3 feet, there is not sufficient soil to support a standard length guardrail post. If there is at least 2 feet of this embankment width but less than 3 feet, and standard metal beam guardrail is to be installed, a 7-foot long, 8-inch x 8-inch wood post or a 7-foot long steel post should be used. See Figure 7-7, Guardrail on Standard and Narrow Embankments. This design may also be used where embankment material is non-cohesive. If there is less than 2 feet between the hinge point and the edge of shoulder, the concrete beam detail in Figure 7-8 may be used. Another potential option where there is less than 2 feet between the hinge point and the edge of shoulder is use of a 2-foot diameter cast-in-drilled-hole pile (CIDH) to support a W6x9 steel post. Use of the CIDH detail should be limited to no more than six consecutive posts. Details for these alternate designs are shown in Figure 7-7.

> Use of CIDH piles for guardrail must be approved by the Headquarters Traffic Operations Liaison.

b. Restricted Post Embedment Depth or Placement: When it is necessary to continue a roadside guardrail across a shallow cover box culvert or pipe culvert full embedment of the guardrail post(s) may not be possible due to the shallow soil cover. Posts located in an overside drain are undesirable and are therefore often set back behind the drain with multiple blocks. The use of more than two blocks can cause guardrail rotational problems and should be avoided. One or two posts located directly over the culvert or drain may be eliminated and the rail element spanning the gap doubled to provide the necessary stability. Design details are shown in Figure 7-9, Long Span Nested Guardrail. Long Span Nested Guardrail should not be used in transition areas.

An alternative design to Figure 7-9 is the special post footing shown in Figure 7-10. This detail may be used only where standard embedment of railing post is restricted by underground facilities, such as drainage structures, utilities, footing of walls, columns, etc., and more than three consecutive posts with this design shall not be used.

> Use of Figure 7-10 must be approved by the Headquarters Traffic Operations Liaison.

c. Strengthened Rail Sections: Topic 7-03.5 discusses application of the strengthened railing sections detail where guardrail is installed less than 4 feet from a fixed object. This detail uses reduced post spacing of 37½ inches and larger posts and blocks to transition from the standard post spac-

ing and size. The wood posts are 10-inches x 10-inches x 8 feet long with 8-inch x 8-inch blocks. The alternate steel posts are a W6x15 section and the block-outs are 8-inch x 8-inch wood or plastic blocks. All steel parts are to be galvanized. Details of the "Strengthened Railing Section for Fixed Objects" are shown in the Standard Plans.

d. *Adjusting Rail Height*: All standard posts have holes for adjusting the rail-height for an overlay to be placed on the shoulder. The adjustable post had three predrilled holes per the 1995, 1997 and 1999 Standard Plans and has two holes per the 2004, 2006 and 2010 Standard Plans, which allow the rail element and block to be raised when an overlay is placed on the shoulder. Details of the components are shown in the Standard Plans. See Figures 7-11a and 7-11b for installation details. **Pavement overlays that impact the effective height of rail elements shall include the required action from Table 7-4 for metal beam guardrail.**

e. *Adjusting Rail Curvature*: Guardrail can be installed on curving alignment without special fabrication where the radius of curvature is more than 150 feet. Where the radius of curvature is 150 feet or less, down to a minimum radius of 5 feet, the rail elements require shop rolling to the required radius. Installations of guardrail with specially fabricated components should be held to a minimum to reduce the need to stockpile special components for maintenance. Also, where special components are not stockpiled, the delay in ordering and receiving replacements unnecessarily extends the exposure for traffic. The rail elements for guardrail are available in two lengths: 12.5 feet and 25 feet. The longer elements create problems for later maintenance work because trucks with longer beds are required to haul the rail elements.

f. *Guardrail Delineation*: Galvanized steel guardrail provides some supplemental value as a delineation device. Where necessary, this delineation ability can be enhanced with reflective delineation devices as described in the California MUTCD. Reflective delineation devices used on guardrail installations should provide optimum visibility. Guardrail located more than 12 feet from the roadbed should not have reflective delineation devices

Table 7-4: Railing and Barrier Restoration Practice

Existing Railing or Barrier	Standard Height (in)	Tolerance (in)	Required Action
Metal Beam Guardrail	29	+1 -1¼	Raise block and rail using additional hole(s) in post. If out of tolerance: - Add rub rail if top of rail is above 30" - Reconstruct if top of rail is below 27-¾"
Metal Beam Barrier	30	N/A	Should be upgraded per policy to current standards. If not, contact the Headquarters Traffic Operations Liaison.
Thrie Beam	32	-3	Reconstruct if top rail is below 29"
Type 50	32	-3	Remove and install Type 60 Barrier if height, not including glare extension or cap, is below 29".
Type 60	36	-7	Remove and install new Type 60 Barrier.
All Other Barriers	N/A	N/A	Consult Bridge Barrier & Railing Specialist – Division of Engineering Services.
Crash Cushions	N/A	N/A	Remove, raise pad to grade and replace cushion all per manufacturer.

installed. Guardrail intruding on the roadbed, such as at approaches to narrow bridges, warrants additional delineation treatment as described in the California MUTCD.

g. Aesthetic Metal Guardrail Treatment: Weathered steel or ungalvanized steel is allowed only where rainfall is less than 8 inches per year and there is no salt in the area. Additionally, all new and existing installations of weathering steel or ungalvanized steel guardrail or median barrier shall be examined annually to determine their conditions. Those installations showing signs of advanced deterioration shall be replaced as soon as possible. Advanced deterioration is defined as visible tubercular rust signs. Replacement parts shall be galvanized.

h. Use of Steel Posts and Plastic Blocks in Fire Prone Areas: All new and replacement metal beam guardrail shall be specified with steel posts and plastic blocks if the surrounding environment contains potential fuel for wildfires. This restriction does not apply to transitions to bridge rails or concrete barriers. Wood posts have the following disadvantages in fire prone areas:

- Guardrail with wood posts and blocks is destroyed or damaged by fire and remains impaired until it is replaced.
- After a fire, burned areas renew their fuel loads in 5 to 15 years, depending on the species of vegetation.
- Repeat area fires result in additional expenditures of resources by Maintenance to replace burned guardrail.
- Installing wood posts and blocks adds to an area's total fuel load.

Guardrail in roadside areas with no proximate fuel sources may use wood or steel posts. However, guardrail post and block type should be consistent in a single installation or run. Consult with the District Maintenance Engineer to determine if a project site is in an area containing flammable vegetation that requires use of steel posts and plastic blocks for guardrail

i. Thrie Beam Barrier Used as Guardrail: Thrie Beam Barrier may be used as guardrail only in special situations where additional height of rail is needed. Refer to Topic 7-04.5 for more details.

j. Pullouts: Pullouts have many safety benefits and should be kept where appropriate. At pullouts, guardrail may be routed around the perimeter of the pullout.

6. Typical Layouts: Guardrail typical layouts are designed to place the ends of guardrail installations away from approaching traffic and provide a smooth transition. Placement is controlled by such factors as embankment width, distance between roadways, clear roadside width, and the design of the guardrail itself. The layouts shown in the Standard Plans are both general and typical. They are most applicable to new construction; however, any installation may require some modification to fit special circumstances.

Deviations from guardrail typical layouts must be approved by the District Traffic Safety Engineer and documented in the project files.

a. Embankment Layouts:

The Type 11 Layout series are used to shield embankment slopes where guardrail is recommended.

Layout Types 11A, 11B and 11C are used where guardrail is recommended to shield embankment slopes only for adjacent traffic, using an allowable end treatment. See Topic 7-03.6(3)(a) for information about allowable guardrail end treatments.

Layout Types 11D through 11L illustrate combinations of allowable end treatments used at the approach and trailing ends of guardrail to shield embankment slopes.

b. Structure Approach and Departure Layouts:

The Type 12 Layout series are used to shield the approach or departure ends of structures with an allowable end treatment.

Layout Types 12A, 12B and 12C illustrate allowable end treatments used at structure approaches, to the right or left of traffic.

Layout Type 12D is used where continuous guardrail is installed between structures. Layout Type 12E is used to the left of approaching traffic at the end of each structure on multilane freeways or expressways.

Layout Types 12AA, 12BB and 12CC illustrate allowable end treatments used at structure departures.

Layout Type 12DD is used where guardrail is recommended to shield embankment slopes only for adjacent traffic.

c. *Fixed Object Layouts*:

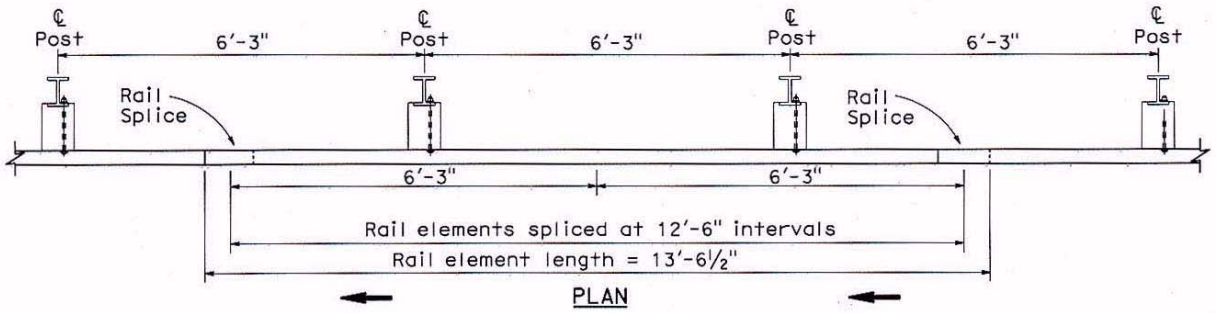
The Type 14, 15 and 16 Layout series are used to shield fixed objects.

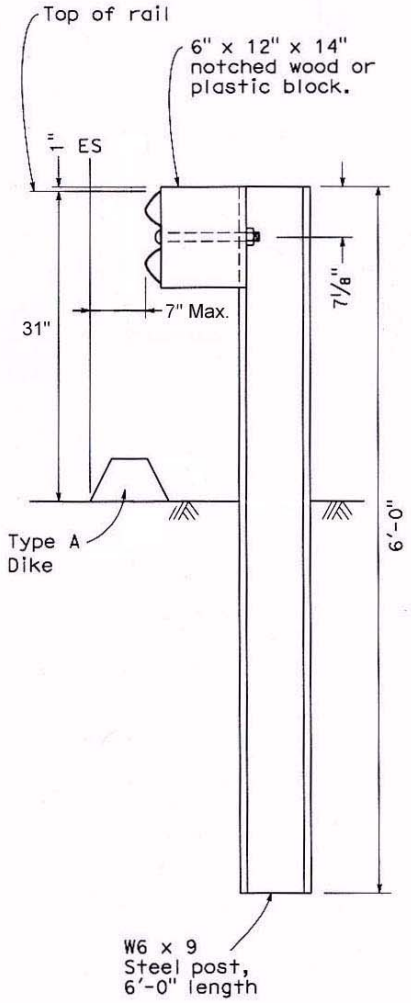
Layout Type 14A is used to shield fixed objects between separated roadbeds in two-way traffic and Layout Type 15A is used to shield objects between separated roadbeds in one-way traffic, using allowable end treatments.

Layout Types 16A, 16B and 16C are used to shield fixed objects only for adjacent traffic, using allowable end treatments.

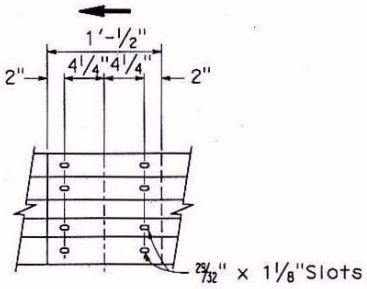
Layout Types 16D through 16L illustrate combinations of allowable end treatments used at the approach and trailing ends of guardrail to shield fixed objects.

Figure 7-6: Modified Guardrail Installation with Type A Dike or 6 inch Curb





TYPICAL STEEL LINE POST INSTALLATION



ELEVATION

RAIL ELEMENT SPLICE DETAIL

a) Connect the overlapped end of the rail elements with ⅝" ø x 1⅜" button head oval shoulder splice bolts inserted into the 29/32" x 1⅛" slots and bolted together with ⅝" ø recessed hex nuts. Recess of hex nut points toward rail element. A total of 8 bolts and nuts are to be used at each rail splice connection.

b) The ends of the rail elements are to be overlapped in the direction of traffic (see details).

c) Where end cap is to be attached to the end of a rail element, a total of 4 of the above described splice bolts and nuts are to be used.

Figure 7-7: Guardrail on Standard and Narrow Embankments

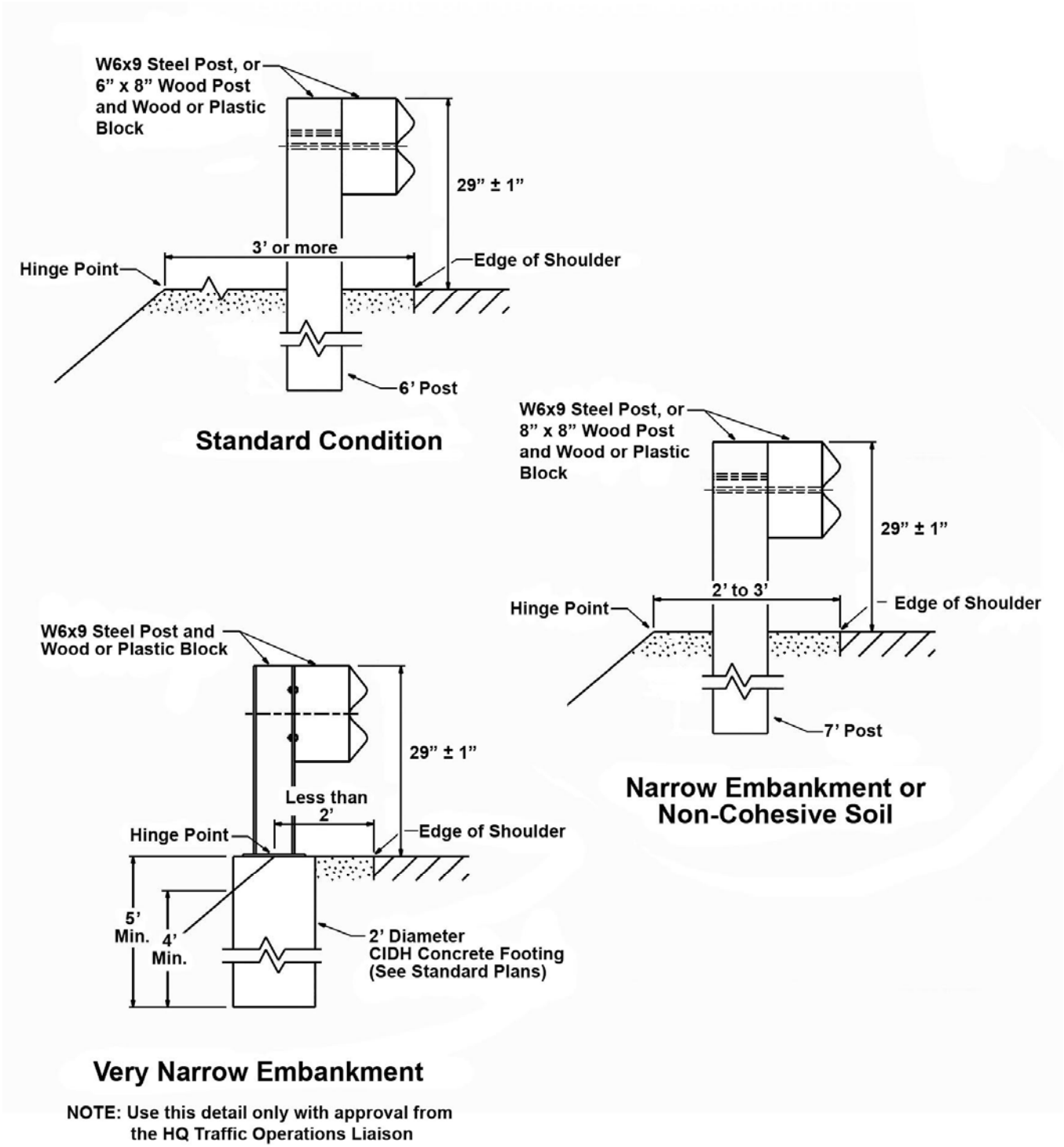
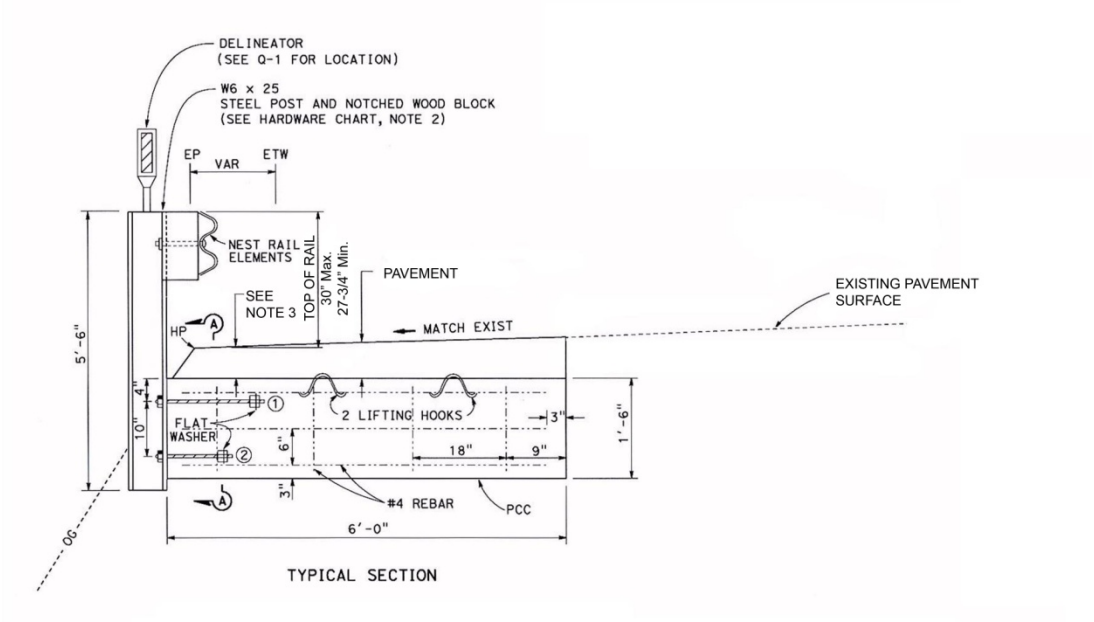
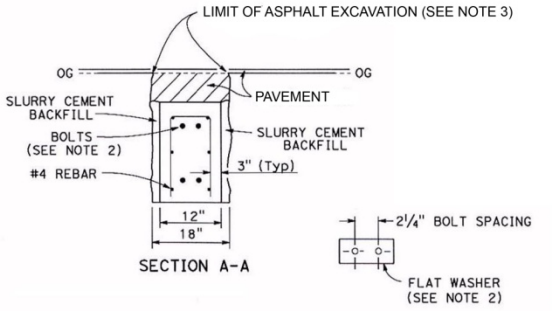
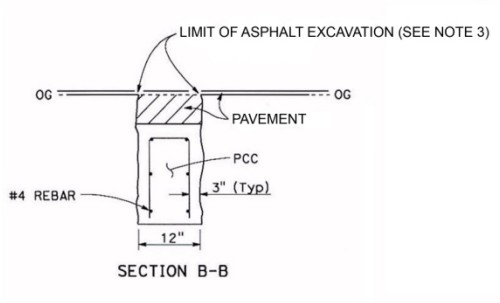
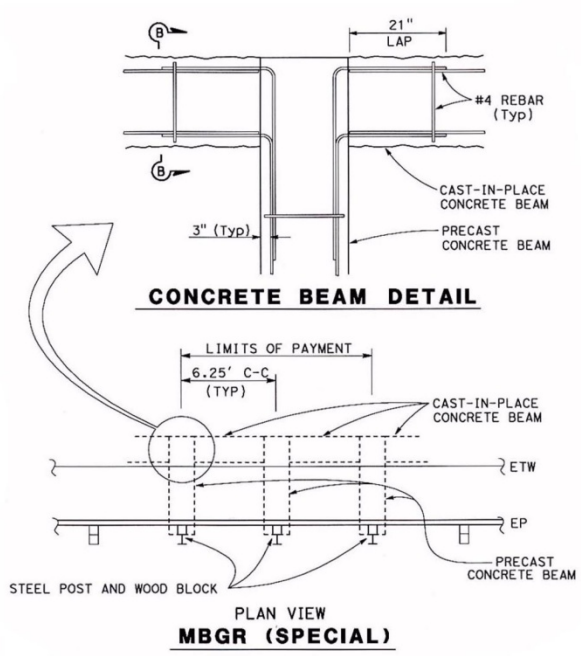


Figure 7-8: Guardrail Concrete Beam on Narrow Embankments









HARDWARE CHART FOR PRECAST CONCRETE BEAM

CASE	STEEL POST	WOOD BLOCK	①	②	BOLT SPACING
PRECAST BEAM	W6 x 25	6" x 8" x 1'-2"	2 EA ¾" DIA x 1'-6" HS BOLTS (THREADED BOTH ENDS) WITH 3 EA HEX NUTS AND 3" x 7" x ¼" FLAT WASHER	2 EA ⅝" DIA x 1' HS BOLTS (THREADED BOTH ENDS) WITH 3 EA HEX NUTS AND 2" X 7" X ¼" FLAT WASHER	2¼"

NOTES:

1. 12" Min. AT EP. CONCRETE BEAM MUST BE BELOW PAVEMENT LAYER.
2. SEE HARDWARE CHART FOR DIMENSIONS.
3. FOR CONCRETE PAVEMENT, REMOVE EXISTING PAVEMENT UP TO TRANSVERSE JOINT USING DETAILS IN STD PLAN P8 AND STANDARD SPECIFICATIONS FOR INDIVIDUAL SLAB REPLACEMENT.

LEGEND

= COLD PLANE AC PAVEMENT

Figure 7-9: Long Span Nested Guardrail

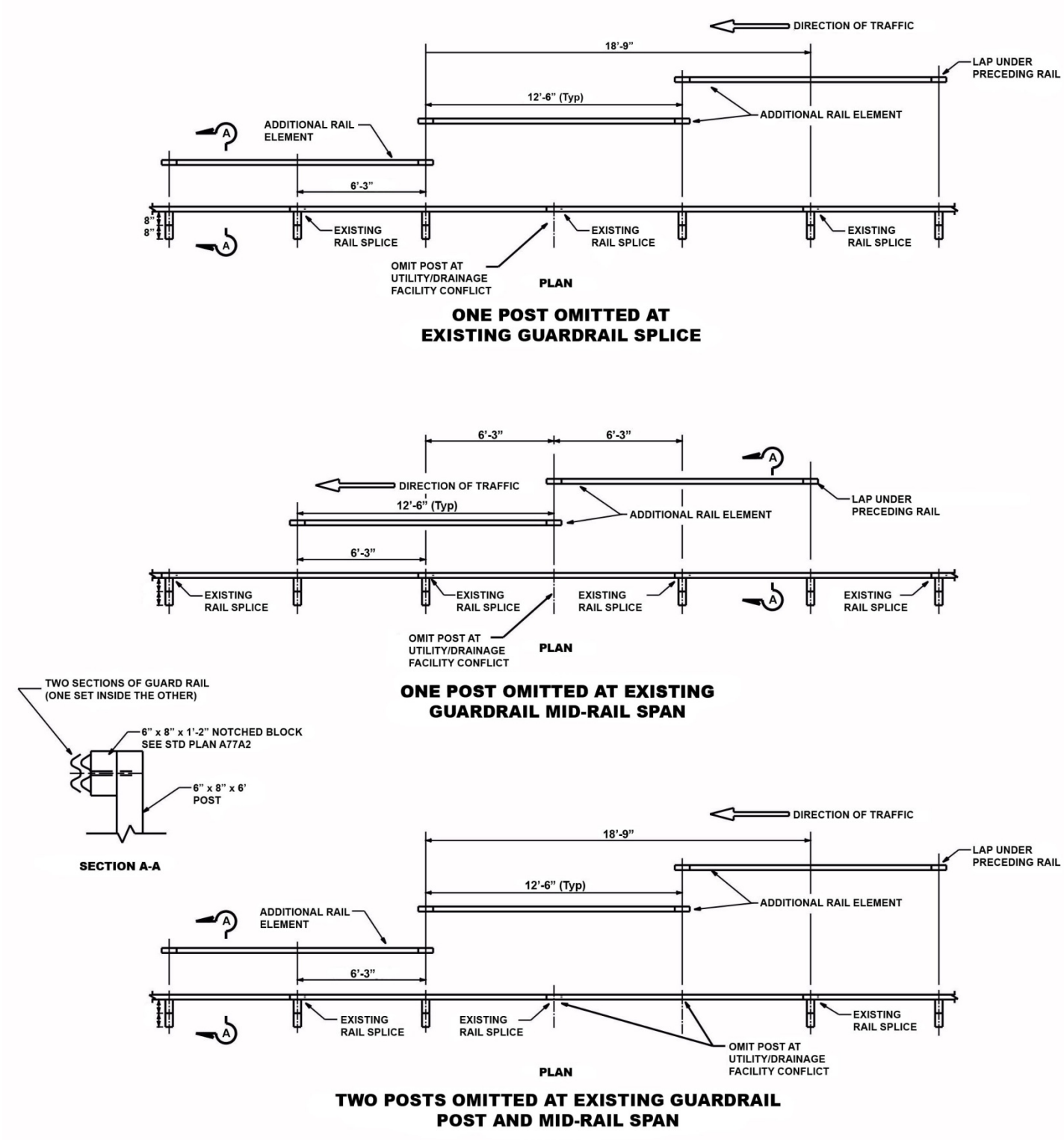
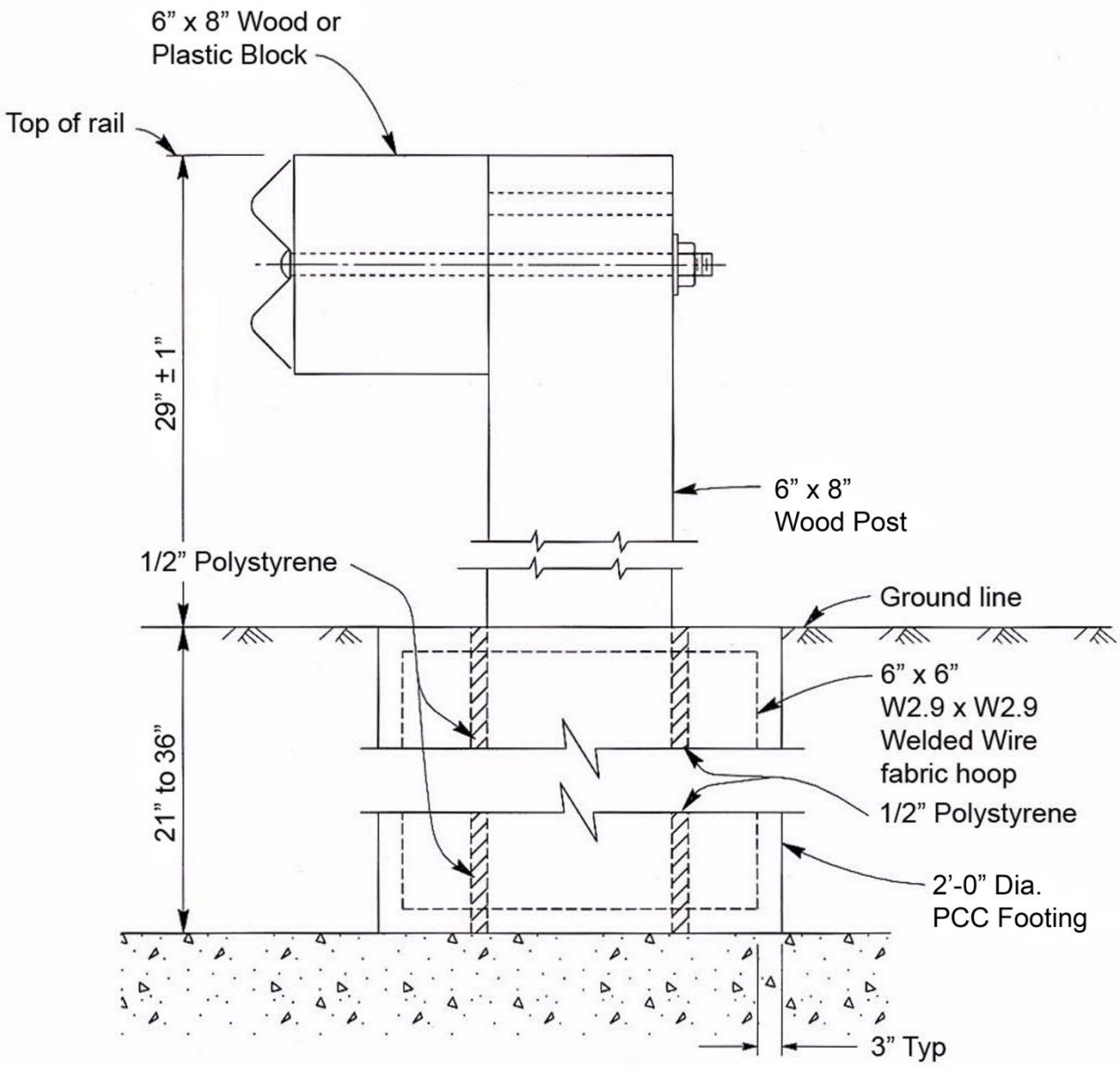


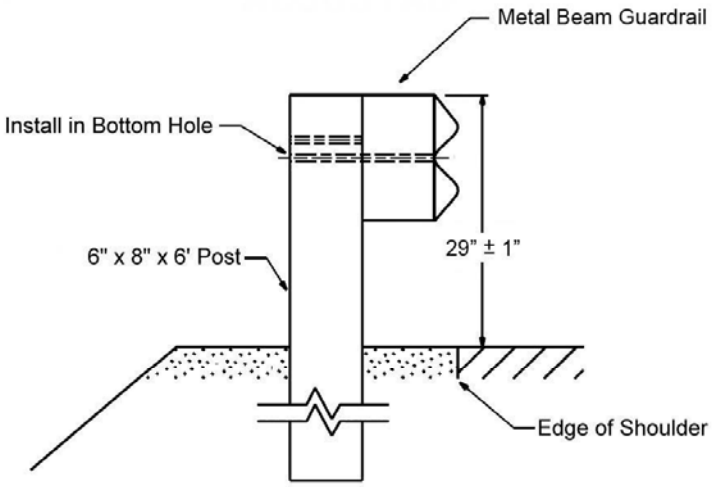
Figure 7-10: Special Post Footing Detail



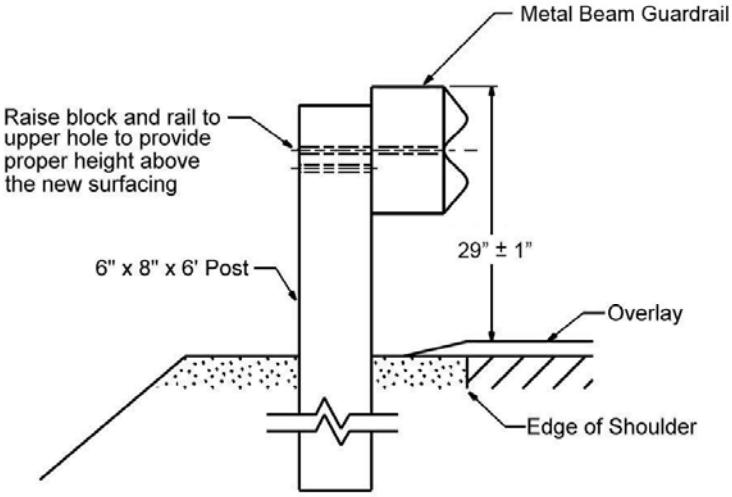
Form socket in concrete to receive 6” x 8” post or place concrete around 6” x 8” post wrapped with one layer of 1/2” thick expanded polystyrene foam sheeting. Do not nail polystyrene to post. Post to be centered in concrete footing.

NOTE: Use this detail only by approval of HQ Traffic Operation Liaison

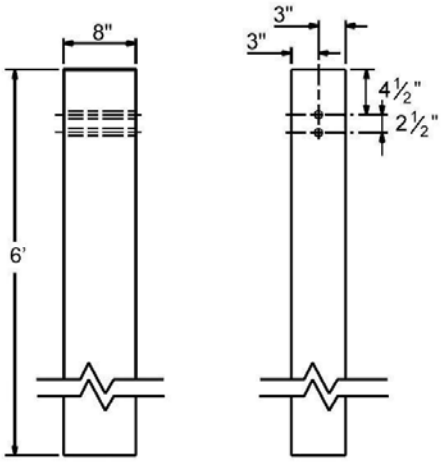
Figure 7-11a: Adjustable Height Guardrail (2 Hole Post)



Initial Installation



Adjusted Rail Height

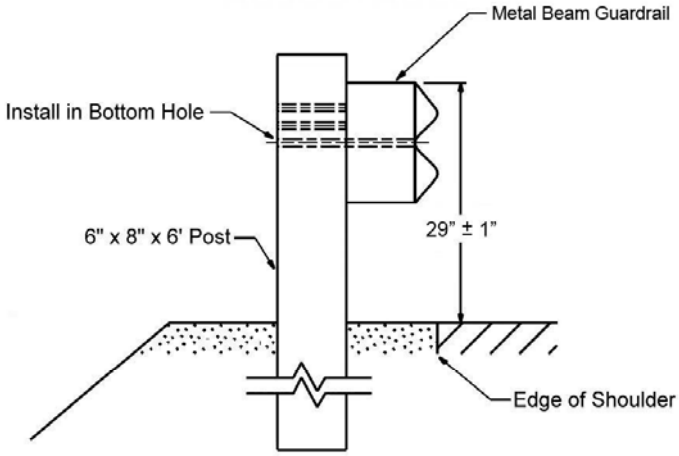


2-Hole Post Detail

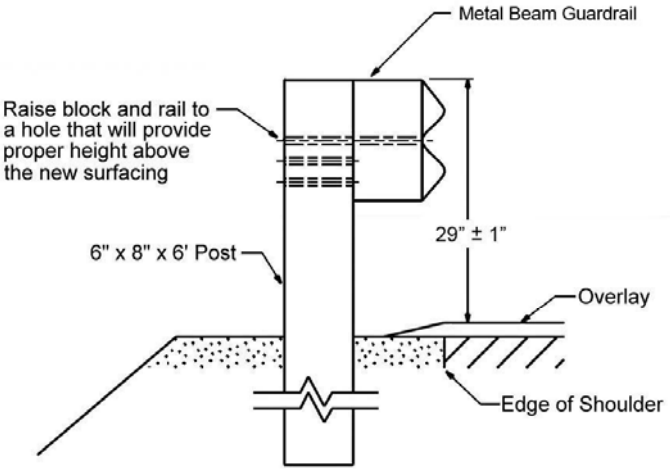
NOTES:

1. All holes in wood posts and blocks shall be ¾" diameter ±1/16"
2. For additional details, see Standard Plans.

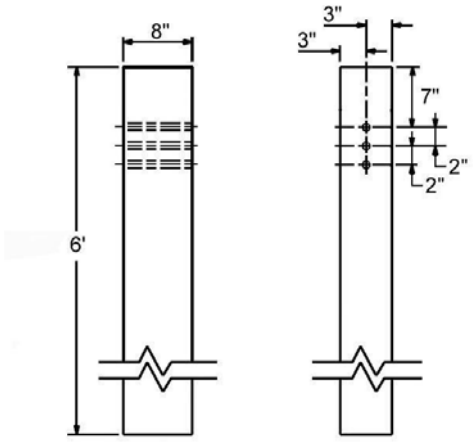
Figure 7-11b: Adjustable Height Guardrail (3 Hole Post)



Initial Installation



Adjusted Rail Height



3-Hole Post Detail

NOTES:

1. All holes in wood posts and blocks shall be ¾" diameter ±1/16"
2. For additional details, see Standard Plans.