Index 536-001 Guardrail

Design Criteria

FDOT Design Manual (FDM), *215;* ***AASHTO Roadside Design Guide****,* 4th Edition; ***NCHRP Report 350***, Test Level 3 Criteria; ***AASHTO Manual for Assessing Safety Hardware (MASH)****,* Test Levels 2 & 3 Criteria; ***AASHTO-AGC-ARTBA Task Force 13***, A Guide to Standardized Highway Barrier Hardware

Design Assumptions and Limitations

For guardrail requirements including crash test level classification, hazard setbacks, and placement offset in relation to curb, shoulders, shoulder gutter, and the Edge of Traveled Way, see ***FDM 215.4***.

For guardrail requirements regarding Box Culverts, also see ***FDM 215.4****.*

A. General:

Index 536-001 defines guardrail segments including General Guardrail, Low-Speed Guardrail, End Treatments, and Approach Transition Connections to Rigid Barrier that will be used together to design a complete guardrail configuration on a project-specific basis.

The design of guardrail requires that certain segments and features be shown and labeled correctly in the plans, where the requirements of the Index are not violated including section geometry, adjacent pavement, and grading.

For guardrail connections to Rigid Barrier, ***Index 536-001*** applies only to newly constructed bridge Traffic Railings and Concrete Barriers or where the complete Approach Transition Connection to Rigid Barrier details shown in this Index can be installed without conflicting with existing Traffic Railings, structures, or bridge approach slabs.

For guardrail systems connecting to existing bridge Traffic Railings that conflict with ***Index 536-001*** details, use the details, layouts, and length table methodology shown in ***Indexes 536-002***, ***521-404***, and ***521-405***.

B. Shielding Hazards - Determining Begin/End Guardrail Stations:

The standard method of determining guardrail placement for shielding hazards is based on the Runout Length and the Length of Need calculation in the ***AASHTO Roadside Design Guide (RDG)***, 4th Edition.

See the FDOT 'Guardrail Length of Need (LON)' program for additional information and assistance with determining Begin/End Guardrail Stations for shielding various hazard configurations. The program is located under Design Tools on the Design Standards website.

For example guardrail configurations for shielding hazards, including ends of rigid barriers, see ***Index 536-001*** layouts and Example 1, below.

C. End Treatments:

An End Treatment segment is required for all guardrail ends where the guardrail does not transition into another barrier type (e.g. Approach or Trailing End Transition Connections to Rigid Barrier). End Treatments are divided into three types.

1. Trailing Anchorages: Place a Trailing Anchorage on the downstream ends of all guardrail runs with respect to the nearest traffic lane, except where the location is within the Clear Zone of an opposing traffic lane. Locate the end post of the Trailing Anchorage at least 25 feet downstream of any hazards being shielded.
2. Approach Terminals: Place an Approach Terminal on the approach ends of all guardrail runs, for all locations within the Clear Zone of an adjacent traffic lane.
    a. Terminal Types: Approach Terminals are defined in the Index and classified as Flared, Parallel, and Double Faced.
        i. Flared Approach Terminals: Use where raised curbs are not present and lateral clearance is available. This is the preferred option, because it provides shortest Length of Need requirement for shielding hazards and reduces driver propensity to shy away from the End Treatment under normal conditions.
        ii. Parallel Approach Terminals: Use for curbed conditions or where lateral clearance behind the End Treatment is limited.
        iii. Double Faced Approach Terminals: Use with Double Faced Guardrail segments. As an alternative, a Crash Cushion may be substituted for a Double Faced Approach Terminal as defined below.
    b. Length of End Treatment, 'LE': Predefined Approach Terminal lengths for corresponding crash Test Levels are defined in the Index and should be used in the Plans where possible. This allows for universal planning that is compatible across Approach Terminal products listed on the APL.
    c. Length of End Treatment, Custom Design Lengths: Where longitudinal space for Approach Terminals is limited, the designer may stipulate a location-specific 'Design Length' as shown on the manufacturer's APL drawings. The 'Design Length' is the shortest length of Approach Terminal required to function correctly as a crashworthy End Treatment, and it mostly consists of the proprietary segment of the Approach Terminal. When using the location-specific 'Design Length' method, the designer is responsible for ensuring the planned length accommodates the 'Design Length' as well as the midspan panel splice connection to the adjoining guardrail segment.

        In the Roadway Plan view, specify the 'Design Length' required within the Approach Terminal callout as well as make a reference to the Summary of Guardrail Note (e.g. "Design Length ≤ 25 Ft., See Summary of Guardrail Note"). In the Summary of Guardrail note, explain the Design Length

requirement per manufacturer's APL Drawing (e.g. "Device requires a Design Length ≤ 25 Ft. per the manufacturer's APL Drawing").

d. Non-Gating Terminals: Where longitudinal space is limited upstream of the re-directive portion of end terminals, a Non-Gating terminal may be used. The gating portion of a Gating Terminal is typically upstream of post 3 or 4, but a Non-Gating Terminal removes this gating portion and places the Length of Need (or Departure Line) re-directive capability at post (1), thereby saving space. When using a Non-Gating terminal, ensure that space is provided for any forward anchorage protruding from the terminal head, as seen per the APL drawings.

In the Roadway Plan view, specify "Non-Gating" preceding the Approach Terminal callout. Additionally, add a Summary of Guardrail note explaining "Device requires a Non-Gating design per the manufacturer's APL Drawing with redirective capability at Post (1)".

3. Crash Cushions (C.C.): Where applicable, use a Crash Cushion on the approach ends of double faced guardrail as a substitute for Double Faced Approach Terminals. Crash Cushion use should be considered for locations with an expected high frequency of severe impacts, such as within the gore area of a high speed facility. Additionally, some Crash Cushions may offer reduced length and maintenance cost advantages. See Index 544-001 for additional Crash Cushion information.

D. Approach Transition Connection to Rigid Barrier (Apprh. Trans.):

Approach Transition Connection segments are required for connecting guardrail to the approach end of Rigid Barriers, including both Concrete Barrier Walls and Traffic Railings. See the Index for design options including requirements for alignment, grading, and the Length of Approach Transition, 'LA', as required per the crash Test Level selected.

The minimum length for a complete guardrail system connected to a Rigid Barrier approach is tabulated as 7¼" plus 'LA' plus 'LE'. To further minimize length, 'LA' may be replaced as described in Paragraph C.2.c above (only where needed).

When connected to Rigid Barrier, guardrail systems with a total length greater than 150 feet will generally require a taper to the corresponding ***FDM*** offset. The taper is permitted to begin at a distance of 28.13 feet for the TL-3 system and 18.75 feet for the TL-2 system, measured from the Begin/End Guardrail Station at the Rigid Barrier connection. See Example 1 below and the Index layouts for additional taper details. NOTE: The Approach Transition Connection to Rigid Barrier must remain parallel to the traffic lane prior to permitted taper location.

When connected to Rigid Barrier, guardrail systems with a total length of 150 feet or less do not require a taper to the ***FDM*** offset and may run parallel to the Rigid Barrier's shoulder line prior to any Approach Terminal Flare.

The small lateral offset difference between Rigid Barrier Shoulder Line (at the toe) and the Face of Guardrail at their connecting point may be considered negligible and ignored for plan view labeling purposes (as noted in the Index).

Per ***Specification 536,*** the Approach Transition Connection includes the Alignment Curb as shown in ***Index 536-001***. Payment for any connecting curb types begins at the end of the Alignment Curb transition (Section E-E).

For connections to existing bridge Traffic Railings that conflict with ***Index 536-001*** details, use ***Indexes 536-002***, ***521-404***, and ***521-405***.

E. Pipe Rail:

Pipe Rail segments are required where Steel Posts will be located within 4 feet of sidewalks or shared use paths in the final condition. Pipe Rail must terminate within the limits of the posts outside of End Treatment and Approach Transition segments (At least 3'-1½" outside of 'LE', 'LT', 'LA', and/or Crash Cushion segments). See the Index for details.

To provide the Contractor an option of either Timber or Steel Posts, include the Pipe Rail in the Plans with quantities assuming Steel Posts are used (Unless the design prohibits the use of Steel Posts for other reasons).

F. Rub Rail:

Place Rub rail on the median side of Double Faced Guardrail, where approaching median slopes are greater than 1:10 per the Index. Additionally, rub rail may be used where justification is provided showing that the location has a high propensity for vehicle underride or a high percentage of motorcycle traffic.

G. Deep Posts:

With approval of the District Design Engineer and where right-of-way is restricted (i.e. constrained condition), Deep Posts may be used with the slope break located at the post centerline as defined per the Slope Break Condition in the Index.

Deep Posts are only permitted for segments with a post spacing of 6'-3" or less.

H. Modified Mounts - Special Posts:

When the required post spacing results in placement of posts atop concrete structures, concrete sidewalks, or subsurface utilities, use the Special Steel Posts, Frangible Leave-Outs, or Encased Post options respectively, as defined in the Index and in ***Specification 536***.

I. Guardrail Taper Rate:

Guardrail locations will typically run parallel to traffic lanes, but certain conditions, such as a median crossover or a change in typical section, will require a change in guardrail offset. Use a linear taper (a.k.a. flare) to accommodate such changes in guardrail offsets. See the layouts in the Index as well as Example 1 below, where tapers are denoted by 'Begin/End Taper Station' callouts.

The 'Begin/End Taper Station' and offset callouts will define the linear Taper Rate for construction. For Design Speeds ≤ 45 MPH, use a maximum 1:10 Taper Rate. For Design Speeds > 45 MPH, use a maximum 1:15 Taper Rate. Where space is limited, Taper Rates may be refined by following the guidance of the RDG.

J. Median Crossover Guardrail - Double Faced:

When using an Approach Transition Connection to Rigid Barrier, use a Crossover Guardrail layout if the following conditions apply:

1. The end of an opposing lane's concrete Rigid Barrier is within the Clear Zone, aligned laterally across the median (typical with a bridge configuration).
2. The guardrail system is within the Clear Zone of the opposing lane's traffic
3. The guardrail system, including the End Treatment, will be designed for the minimum length.

NOTE: For guardrail systems only meeting the above criteria of (1.) and (2.) and that will be designed to continue beyond the minimum length, a basic Double Faced Guardrail segment would be required.

This Crossover Guardrail layout includes a taper segment, which reduces the Length of Need required for shielding the opposing lane's concrete railing while also using Double Faced Guardrail to shield the opposing lane's traffic. See the layouts in the Index as well as Example 1 below, for more details.

When measuring the length of a Crossover Guardrail layout, tabulate the entire run of guardrail, including the length of the Approach Transition Connection, as Double Face Guardrail. See Example 3 below for an example layout showing measurement limits.

K. Reduced Post Spacing and/or Nested W-Beam Segments:

Where hazards must be located closer than 5 feet behind the Face of Guardrail, Reduced Post Spacing may be used to decrease the required Setback Distance (the anticipated deflection distance of an impacted guardrail system). See ***FDM***, Table 215.4.2., for the decreased required Setback Distance per each Reduced Post Spacing.

Provide Reduced Post Spacing along the entire portion of the hazard(s) requiring a decreased Setback Distance. Place a minimum Reduced Post Spacing segment length of 25'-0" total, and begin the Reduced Post Spacing segment a minimum of 12'-6" upstream of the hazard(s) being shielded (relative to the direction of traffic receiving shielding).

Per ***FDM***, Table 15.4.2, further reduction of the required Setback Distance may be achieved through Nested W-Beam panel segments (doubling of W-Beam panels per location). Nested W-Beam is not permitted outside of Reduced Post Spacing segments. Plans labeling of Nested W-Beam is not required where already shown in the Index (i.e. within the Approach Transition Connection to Rigid Barrier).

Separate guardrail length tabulations are not required for Reduced Post Spacing and/or Nested W-Beam segments.

L. Additional Offset Blocks:

Instead of the default single Offset Block, use either two or three Offset Blocks such that the resulting post placement, moved farther behind the Face of Guardrail, will avoid a post conflict with an obstacle (e.g. sidewalks, gutter, underground utilities, concrete drainage structures, or other permanent obstacles).

Each additional Offset Block will move the post 7.5 inches further behind the Face of Guardrail. When considering Setback Distances to hazards per ***FDM***, Table 215.4.2, add 7.5 inches to the required Setback Distance for each additional Offset Block used.

Do not use additional Offset Blocks in Approach Terminal or Trailing Anchorage segments.

M. CRT Segments:

Where a guardrail segment will connect with a perpendicular guardrail segment (e.g. rounding into side streets or driveways), design the guardrail segment following the requirements of the corresponding CRT layout as shown in the Index. Ensure that the Clear Area shown is not violated.

N. Slope Guards:

Where no other wall or structure is used to delineate the abutment's drop-off, place Slope Guards between bridge approaches as shown in the Index layouts, and label them per the examples shown below in Example 1. End Treatments are not required.

NOTE: Slope Guards are intended to deter maintenance vehicles from traveling beyond the slope edge; Slope Guards are not considered crashworthy for roadway vehicles.

Include Slope Guards as individual guardrail length entries in the Summary of Guardrail table. Assume the guardrail type to be the same as the majority of adjacent guardrail used (typically General TL-3 or Low-Speed TL-2). Include the Approximate Station and length for each Slope Guard entry, and label each a "Slope Guard" in the Design Notes column.

Plan Content Requirements

For the Plans sheets listed below, show the guardrail system to scale, including a depiction of the post, offset block, and panel type in its design location.

A. Typical Sections

Design and label the 'Lateral Offset' from the Face of Curb or Edge of Traffic Lane as it corresponds to the Guardrail Sections sheet in the Index.

Meet the offset requirements of the ***FDM*** and the adjacent grading requirements as shown in the Index.

B. Cross Sections

Meet the offset requirements of the ***FDM*** and the adjacent grading requirements as shown in the Index.

C. Roadway Plan

Begin/End Station and Offset: Label the Station and Offset (From the Station Reference, Centerline or Baseline) for the Face of Guardrail at the locations with corresponding Begin/End Stations shown in the Index, including the following:

1. Begin/End GR. Stations label the limits of the guardrail length measurement, generally located at centerline of Post (1) in End Treatments and/or at the Terminal Connector splice of an Approach Transition Connection segment. See the Index layouts for details.

   If Low-Speed (TL-2) guardrail is required, change this label to "Begin/End TL-2 GR."

2. Begin/End Taper Stations label the offset Face of Guardrail locations for the start and end of linear tapers (e.g. for a change in typical section or for a Crossover Taper segment). The Guardrail Taper Rate requirements above will govern these transitions.

3. Begin/End CRT(8, 16, 24, or 32) Ft. R. Station labels the starting point for the Controlled Release Terminal (CRT) System and the radius, 'R'.

4. Begin/End Pipe Rail Stations label the limits of Pipe Rail length measurement, generally located at centerline of the Terminal Posts.

5. Begin/End Rub Rail Stations label the limits of Single-Sided Rub Rail length measurement, generally located at centerline of the Terminal Posts. NOTE: This is not depicted in the Index.

   For Double Face Guardrail, place labels pointing to Face of Guardrail on the side requiring the Rub Rail.

6. Begin/End Double-Sided Rub Rail Stations label the limits of Double-Sided Rub Rail length measurement, generally located at centerline of the Terminal Posts. NOTE: This is not depicted in the Index.

7. Begin/End Half Sp. Stations label the limits of Reduced Post Spacing at 3'-1½". The overall length of this segment must be a multiple of 6'-3".
8. Begin/End Quarter Sp. Stations label the limits of Reduced Post Spacing at 1'-6¾". The overall length of this segment must be a multiple of 6'-3".
9. Begin/End Nested W-Beam Stations label the limits of Nested (or doubled) W-Beam panels

Label the Station and Offset at the Face of Guardrail for the following guardrail end features:

1. TL-2 Flared Terminal
2. TL-2 Parallel Terminal
3. TL-2 Dbl. Faced Terminal
4. TL-3 Flared Terminal
5. TL-3 Parallel Terminal
6. TL-3 Dbl. Faced Terminal
7. C.C.
8. Trailing Anchor.
9. CRT End Treatment
10. TL-2 Apprh. Trans.
11. TL-3 Apprh. Trans.

NOTE: The above labels may be included with the Begin/End Guardrail Station callouts.

Label the Station and Offset at the Face of Guardrail for the following guardrail miscellaneous features:

1. Encased Post
2. Special Steel Post
3. Frangible Leave-Out
4. Deep Post
5. Two Offset Blocks
6. Three Offset Blocks
7. GR. Slope Guard

D. Summary of Guardrail Table:

Tabulate the individual Pay Items as defined in the Basis of Estimates Manual (***BOE***) and ***Specification 536***. Produce the Summary of Guardrail table and include it in the Plans. The Department's CADD tools, including the Design and Computation Manager and Linked Data Manager, may be used to assist in populating the table. See the CADD Production Support Office website for details.

The location call-outs of guardrail segments will be listed as Station to Station, but the length of the corresponding segments must be measured along the centerline of the panels and include the effect of curvature. See Example 2 and Example 3 below for geometry details.

For guardrail measurement, the total length of a guardrail run must equal the basic guardrail length (General or Low-Speed Guardrail) at a multiple of 6'-3", plus the applicable End Treatment length(s) and Approach Transition Connection length.

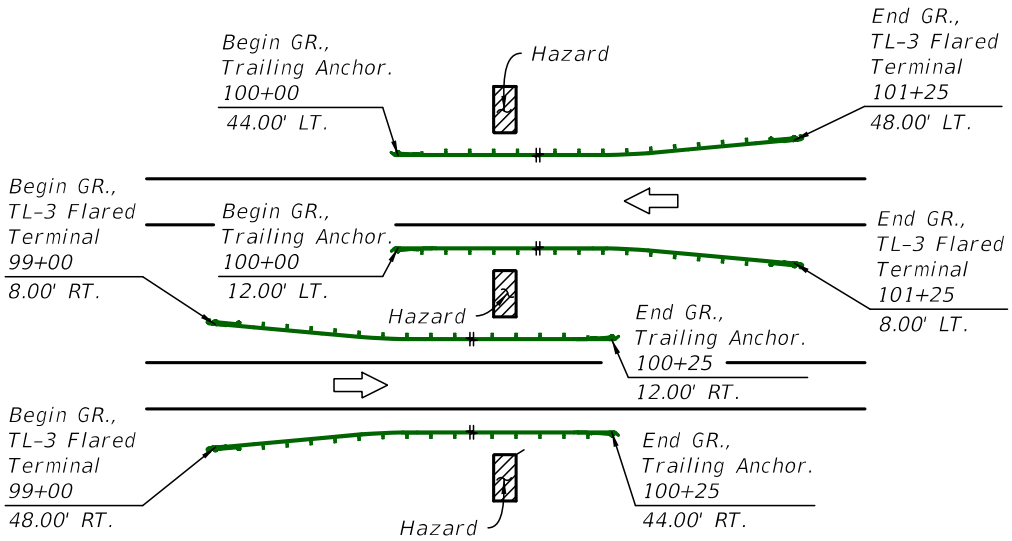
Per ***Specification 536***, Guardrail is measured end-to-end, including the full lengths of the adjoining Approach Terminals, Trailing Anchorages, and Transition Connections to Rigid Barrier. Additional Pay Items, which cover costs over-and-above that of Guardrail, are required as applicable for these End Treatments and Approach Transition Connections to Rigid Barrier. For the Guardrail end locations using Crash Cushions, see Index 544-001. See Example 2 and Example 3 below for callout details.

Payment

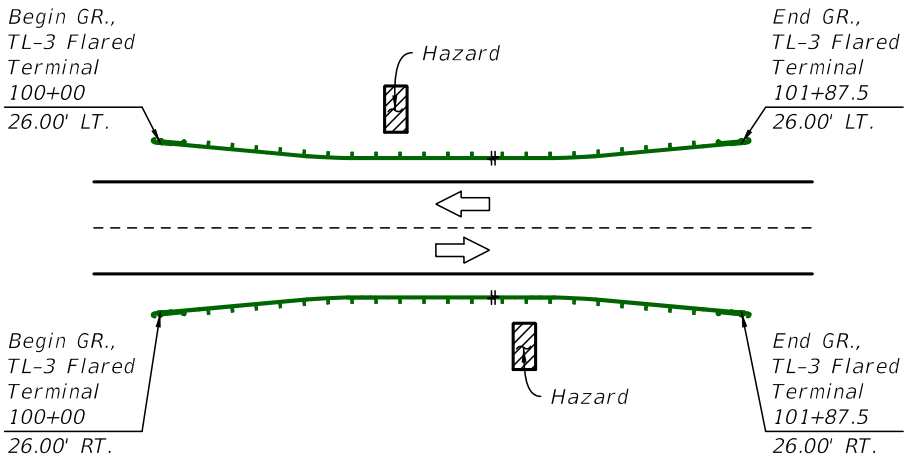
Item number	Item Description	Unit Measure
536-1-XXX	Guardrail	LF
536-5-XXX	Rub Rail	LF
536-6-XXX	Pipe Rail	LF
536-7-XXX	Special Guardrail Post	EA
536-8-XXX	Bridge Anchorage Assembly / Approach Trans. Connection to Rigid Barrier	EA
536-73-XXX	Removal of Existing Guardrail	LF
536-85-XXX	Guardrail End Treatment	EA

EXAMPLES

Example 1 Basic Layouts for Shielding Hazards (1 of 3)

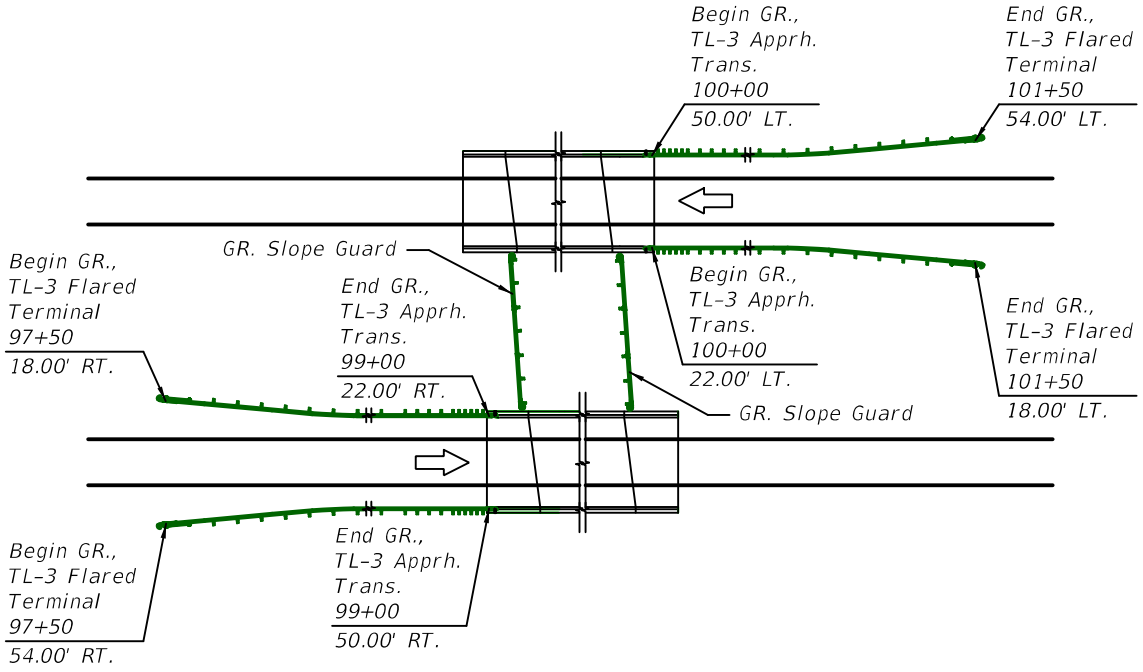


TYPICAL HAZARD SHIELDING EXAMPLE: ROADSIDE AND MEDIAN BACK OF GUARDRAIL OUTSIDE OF OPPOSING LANE'S CLEAR ZONE ('LON' Program Part 'A')

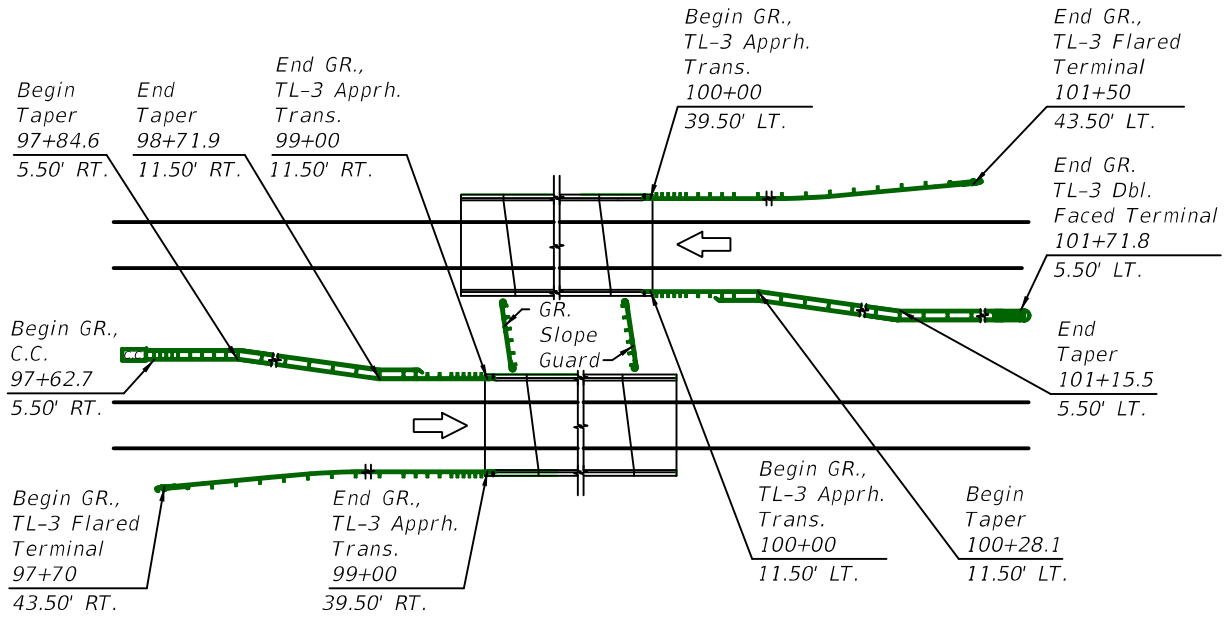


TYPICAL HAZARD SHIELDING EXAMPLE: 2-LANE, 2-WAY ROAD HAZARD OR GUARDRAIL END WITHIN OPPOSING LANE'S CLEAR ZONE ('LON' Program Parts 'A' & 'B')

Example 1 Basic Layouts for Shielding Hazards (2 of 3)

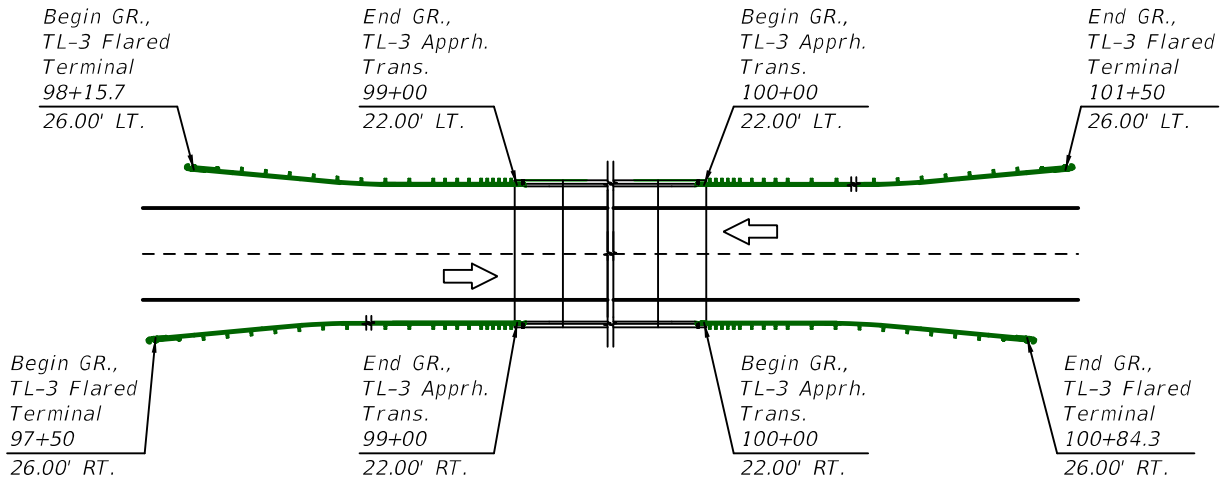


BRIDGE RAILING SHIELDING EXAMPLE:
OPPOSING LANE'S CONCRETE RAILING OUTSIDE OF CLEAR ZONE

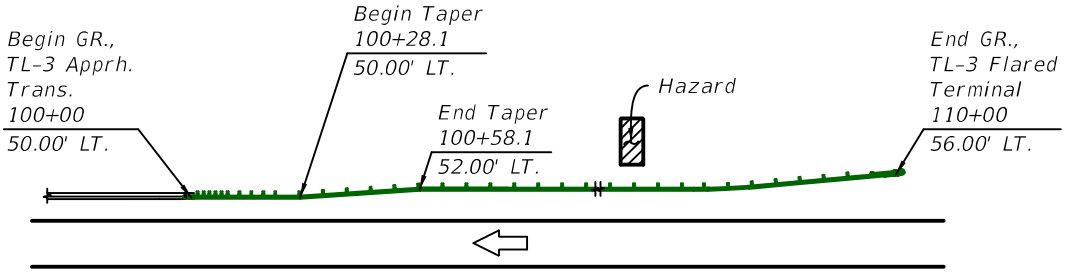


BRIDGE RAILING SHIELDING EXAMPLE: 'CROSSOVER GUARDRAIL'
OPPOSING LANE'S CONCRETE RAILING WITHIN CLEAR ZONE
('LON' Program Part 'C' or 'D')

Example 1 Basic Layouts for Shielding Hazards (3 of 3)

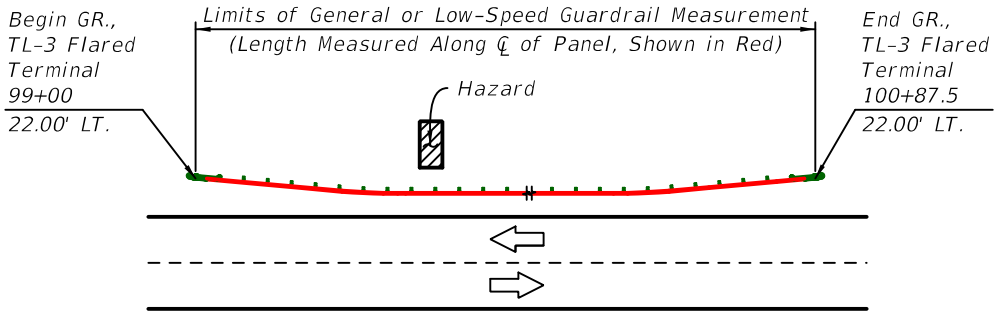


BRIDGE RAILING SHIELDING EXAMPLE: 2-WAY, 2-LANE ROAD CONCRETE RAILING WITHIN OPPOSING LANES' CLEAR ZONE (Min. Length Guardrail Shown)

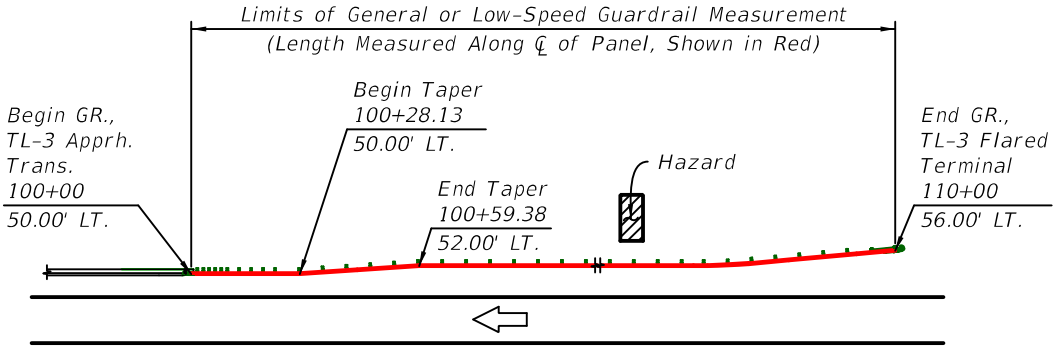


TAPER TO DIFFERING GUARDRAIL OFFSET EXAMPLE: (Where General or Low-Speed guardrail run has a different offset from the Approach Transition Connection)

Example 2 Guardrail Length (LF) Measurements (1 of 2)

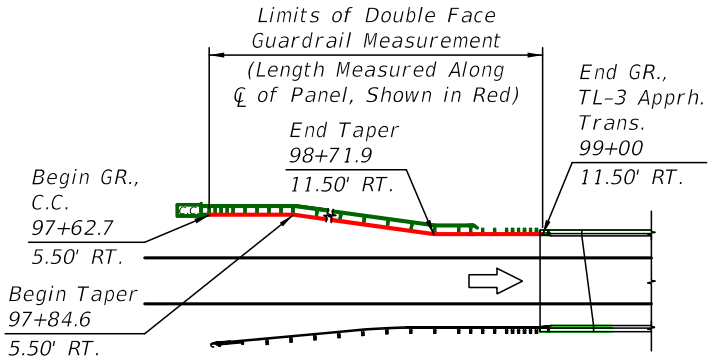


GUARDRAIL LENGTH MEASUREMENT EXAMPLE:
END TREATMENTS AND BASIC RUN
Include End Treatment lengths added as the basic connecting guardrail type, such as General or Low-Speed Guardrail (End Treatment Pay Items consider costs as over-and-above basic guardrail)

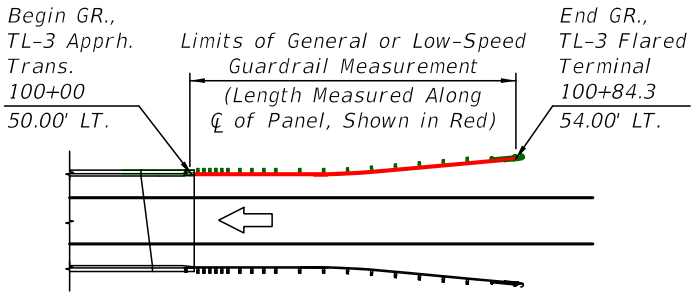


GUARDRAIL LENGTH MEASUREMENT EXAMPLE:
APPROACH TRANSITION CONNECTION, BASIC RUN, & END TREATMENT
Include End Treatment and Approach Transition Connection lengths added as the basic connecting guardrail type, such as General or Low-Speed Guardrail (End Treatment and Approach Transition Connection Pay Items consider costs as over-and-above basic guardrail)

Example 2 Guardrail Length (LF) Measurements (2 of 2)

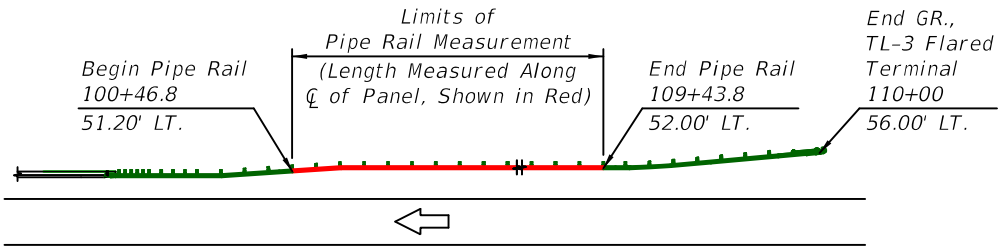


GUARDRAIL LENGTH MEASUREMENT EXAMPLE:
'GUARDRAIL CROSSOVER' APPROACH TRANSITION CONNECTION
Tabulate the layout as Double Face Guardrail, including the Approach Transition. (Measure to Begin/End GR. as shown at Post (1) per Index 544-001; the Design Length of Crash Cushions per the APL Drawing is not included)

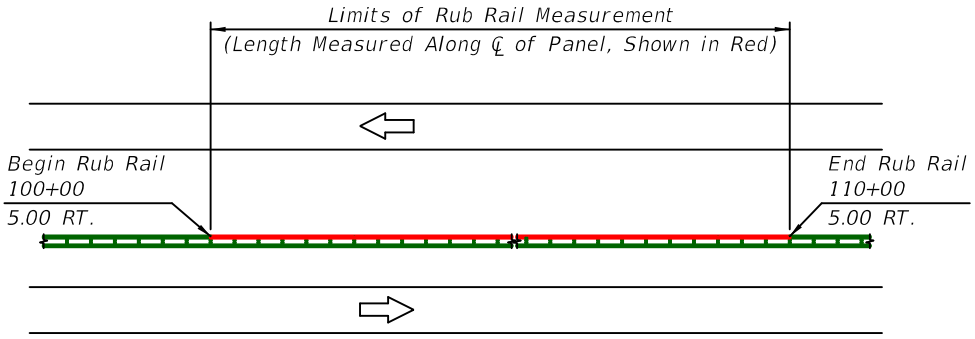


GUARDRAIL LENGTH MEASUREMENT EXAMPLE:
APPROACH TRANSITION CONNECTION AND END TREATMENT ONLY
Tabulate the End Treatment and Approach Transition lengths as basic W-Beam General Guardrail. (End Treatment and Approach Transition Connection Pay Items consider costs as over-and-above basic guardrail)

Example 3 Miscellaneous Pay Item Length (LF) Measurements



PIPE RAIL LENGTH MEASUREMENT EXAMPLE



RUB RAIL LENGTH MEASUREMENT EXAMPLE