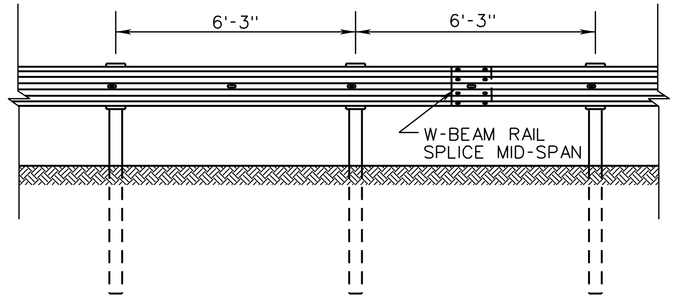
TRAFFIC DIRECTION FOR RAIL LAP AS SHOWN

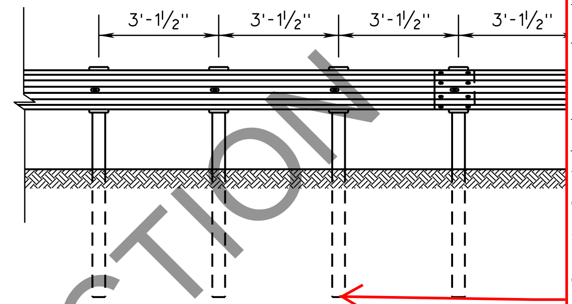
(SEE NOTE 7)



GR-MGS1

(6'-3" POST SPACING)

MIN. DISTANCE FROM FACE OF RAIL TO FIXED OBJECT = 60"



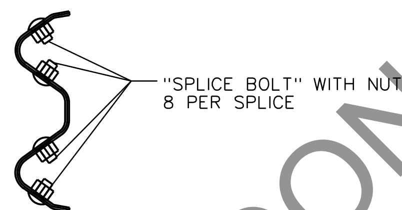
GR-MGS1A

(3'-1½" POST SPACING)

MIN. DISTANCE FROM FACE OF RAIL TO FIXED OBJE

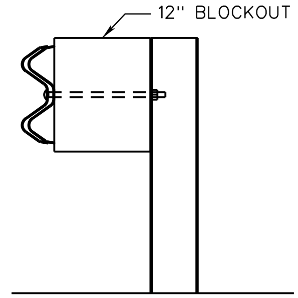
Note: The 1/2 post s
version of the MGS
to be evaluated to M
1/4 and 1/2 post spa
were evaluated unde
NCHRP 350. NDOR
currently considerin
funding MASH eval
of 1/2 post spacing.
a high likelihood of
performing well. Ho
as it has not been ev
to MASH, we canno
the working width v
shown. That said, th
number is likely in t
correct ballpark if n
conservative.

Guidance for MGS installed on curves has not been fully developed. Previous research has shown that curved guardrail impacts may be more severe. MwRSF did the research below on large radii at intersections - http://mwrsf.unl.edu/researchhub/files/Report288/TRP-03-296-14.pdf. George Mason currently has NCHRP project 22-29A to investigate this issue on superelevated curves, but the results are not complete. To date their crash testing has met mixed results.



SPLICE DETAIL

RAIL SPLICE SHALL BE PLACED MID-SPAN FOR STANDARD POST SPACING (6'-3")



* OPTIONAL GR-MGS1A METHOD USING NESTED RAIL WITH 6'-3" POST SPACING.

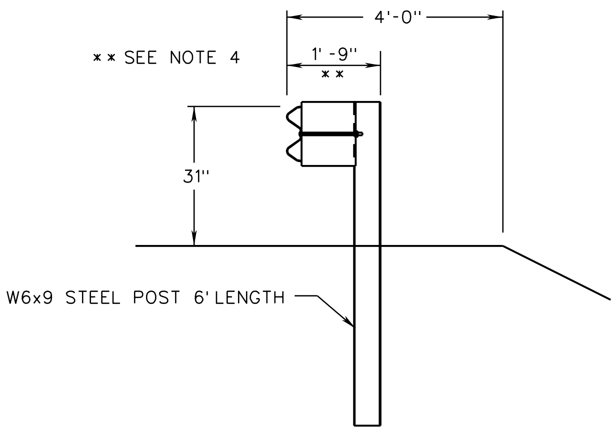
Nested guardrail with standard post spacing will not provide similar reductions in deflection to reduced psot spacing.

NOTES:

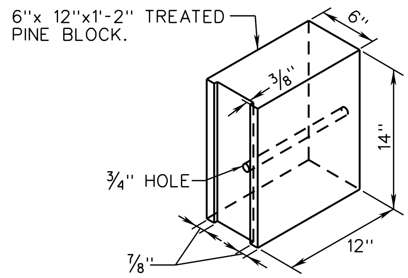
1. GUARDRAIL LOCATIONS SHOWN ON PLANS ARE APPROXIMATE ONLY AND CAN BE ADJUSTED DURING CONSTRUCTION IF AND AS DIRECTED BY THE ENGINEER.
2. FOR DETAILS OF POST AND BLOCKOUTS SEE SHEET NO. 506.__.
3. FOR DETAILS OF RAIL ELEMENT AND ASSOCIATED HARDWARE SEE SHEETS 501.01 AND 501.02.
4. RAIL ELEMENTS WITH RADII LESS THAN OR EQUAL TO 150 FEET SHALL BE SHOP CURVED AND PAID FOR AS RADIAL GR-MGS1, OR 1A.
5. ALL GR-MGS1 AND GR-MGS1A RAIL SHALL BE MAINTAINED AT A HEIGHT OF 30" MIN - 32" MAX AS MEASURED PER STANDARD GR-INS.
6. ALL GUARDRAIL POSTS SHALL BE SET PLUMB. POST SHALL NOT BE SET WITH A VARIATION OF MORE THAN ⅛" PER FOOT FROM VERTICAL. W-BEAM, BLOCKOUTS, AND POSTS SHALL BE SET AND ALIGNED WITHOUT ALTERATION OR FORCE, AS PER SECTION 505 OF THE SPECIFICATIONS.
7. ALL W-BEAM RAILS SHALL BE LAPPED IN THE DI OF VEHICULAR TRAVEL FOR THE FINISHED ROAD
8. THE OPTIONAL GR-MGS1A METHOD OF NESTING T SHALL BE APPROVED BY THE ENGINEER PRIOR INSTALLATION.

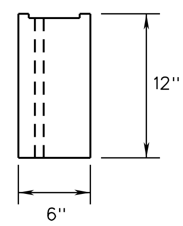
Minimum height may be lower than 30" and still meet MASH, but we would prefer maintaining the height as much as possible like you have shown.

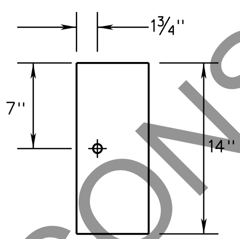
SPECIFICATION REFERENCE	MIDWEST GUARDRAIL SYSTEM (STANDARD AND REDUCED POST SPACING)	VDOT ROAD AND BRIDGE STANDARDS	
221 236 505	VIRGINIA DEPARTMENT OF TRANSPORTATION	REVISION DATE	SHEET 1 OF 2 506.__



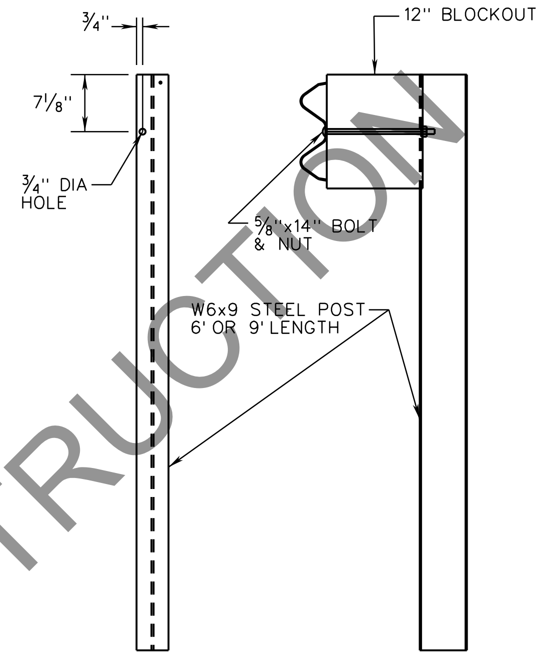
STANDARD INSTALLATION
6' STEEL POST



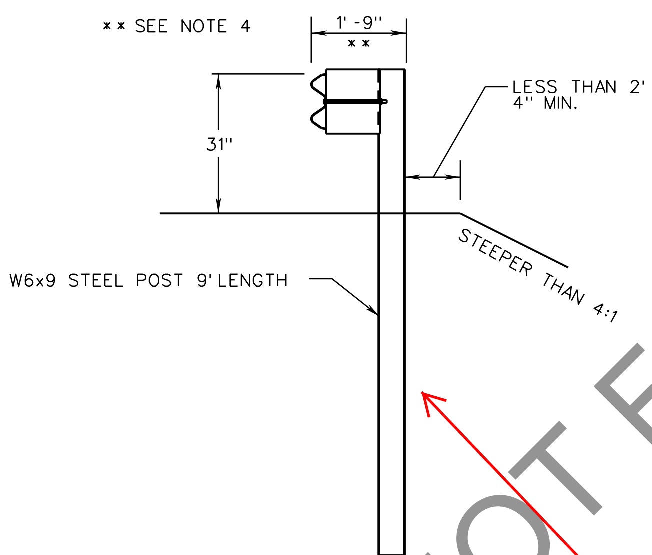




6" WIDE ROUTED
WOOD BLOCKOUT



STEEL POST

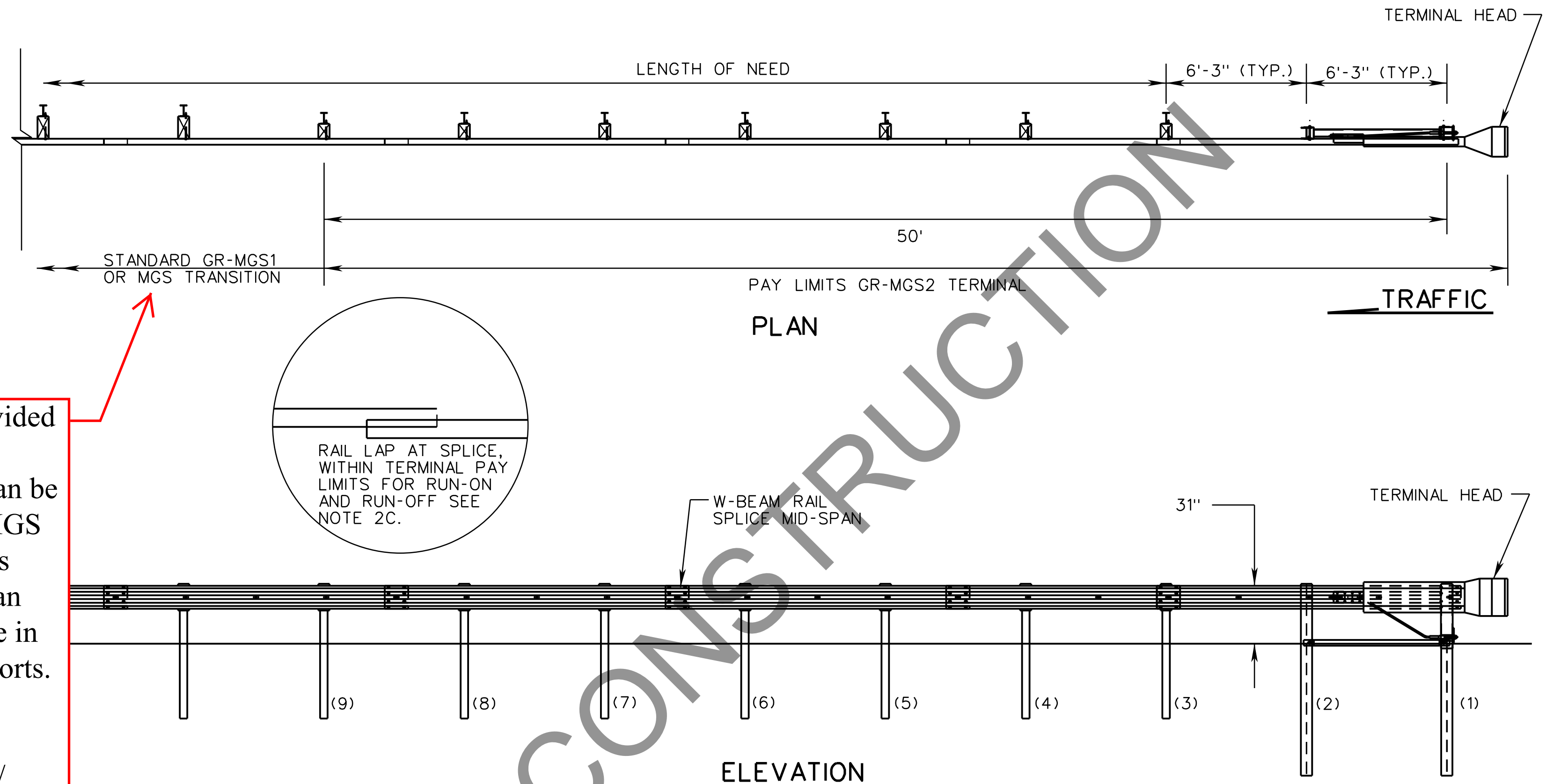


GUARDRAIL INSTALLATION
SITES REQUIRING 9'
GUARDRAIL POSTS

NOTES:

1. ALL BOLTS, NUTS, WASHERS, AND OTHER STEEL ITEMS ARE TO BE GALVANIZED.
2. BLOCKOUTS OTHER THAN SHOWN SHALL BE A VDOT APPROVED PRODUCT MEETING MASH TESTING CRITERIA. BLOCKOUTS SHALL BE FROM THE VDOT APPROVED PRODUCTS LIST. APPROVED BLOCKOUTS MAY BE INTERCHANGED ON ANY ONE PROJECT WITH THE RESTRICTION THAT THE SAME TYPE OF BLOCKOUT MUST BE USED IN ANY SINGLE RUN OF GUARDRAIL.
3. WOOD BLOCKOUTS SHALL BE TREATED WITH A WOOD PRESERVATIVE IN ACCORDANCE WITH THE SPECIFICATIONS.
4. DIMENSION MAY VARY PLUS OR MINUS 1/4" DUE TO MANUFACTURING TOLERANCES IN GUARDRAIL COMPONENTS.

Note: The MGS adjacent to slope has been tested at the slope-break-point of 2:1 slope with 9' posts. 8' posts were tested with the face of race at the SBP of a 2:1 slope, thus 8' posts would be allowed at the SBP as well. MwRSF also recently successfully tested 6' posts at the SBP of a 6:1 slope. However, we only recommend this installation when adequate soil strength can be maintained.



MwRSF has provided guidance on how close terminals can be installed to the MGS upstream stiffness transition. You can find this guidance in the following reports.
1. http://mwrsf.unl.edu/researchhub/files/Report38/TRP-03-210-10.pdf
2. http://mwrsf.unl.edu/researchhub/files/Report295/TRP-03-291-14.pdf

NOT FOR CONSTRUCTION

...NT END TERMINAL (GR-MGS2) SHALL BE A VDOT APPROVED PRODUCT ...NG MASH TESTING CRITERIA. ANY TERMINAL USED FOR THE GR-MGS2 SHALL ...OM THE VDOT APPROVED PRODUCTS LIST.

...ERMINALS SHALL BE INSTALLED ACCORDING TO THE MANUFACTURER'S ...LATION INSTRUCTIONS AND THE FOLLOWING VDOT REQUIREMENTS:

...LL STANDARD GR-MGS2 TERMINALS (SIMILAR TO AS SHOWN ABOVE) ...SHALL BE INSTALLED WITHOUT AN OFFSET.

...DIRECTION OF THE REFLECTIVE TAPE ON THE TERMINAL HEAD SHALL CONFORM TO MUTCD APPLICATION FOR DIAGONAL STRIPES ON OBJECT MARKERS AND BRIDGE END PANELS. (SEE NOTE 4)

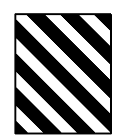
C. DO NOT CHANGE THE LAPPING OF TERMINAL FOR ANY INSTALLATIONS. INSTALL AS SHOWN IN THE MANUFACTURER'S INSTALLATION INSTRUCTIONS REGARDLESS OF ADJACENT TRAFFIC DIRECTION. (SEE DETAIL THIS SHEET)

D. HEIGHT MEASURED AT TOP OF W-BEAM IS 30" MIN. - 32" MAX.

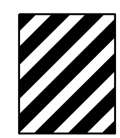
3. THIS DRAWING IS REPRESENTATIONAL ONLY. DETAILS, DIMENSIONS, QUANTITIES, AND OTHER INFORMATION NOT SHOWN WILL VARY FOR EACH MANUFACTURER. SEE INDIVIDUAL MANUFACTURER'S PLANS FOR THIS INFORMATION.

4. FLUORESCENT PRISMATIC LENS YELLOW SHEETING SHALL BE USED ON THE REFLECTIVE MARKERS. ALL REFLECTIVE SHEETING IS TO BE IN ACCORDANCE WITH SECTION 701 OF THE ROAD AND BRIDGE SPECIFICATIONS. STRIPES SHALL SLOPE DOWN TOWARD THE SIDE OF THE OBSTRUCTION ON WHICH TRAFFIC IS TO PASS.

COLOR:
FIELD - YELLOW (REFLECTORIZED)
MESSAGE - BLACK STRIPES (NON-REFLECTORIZED)

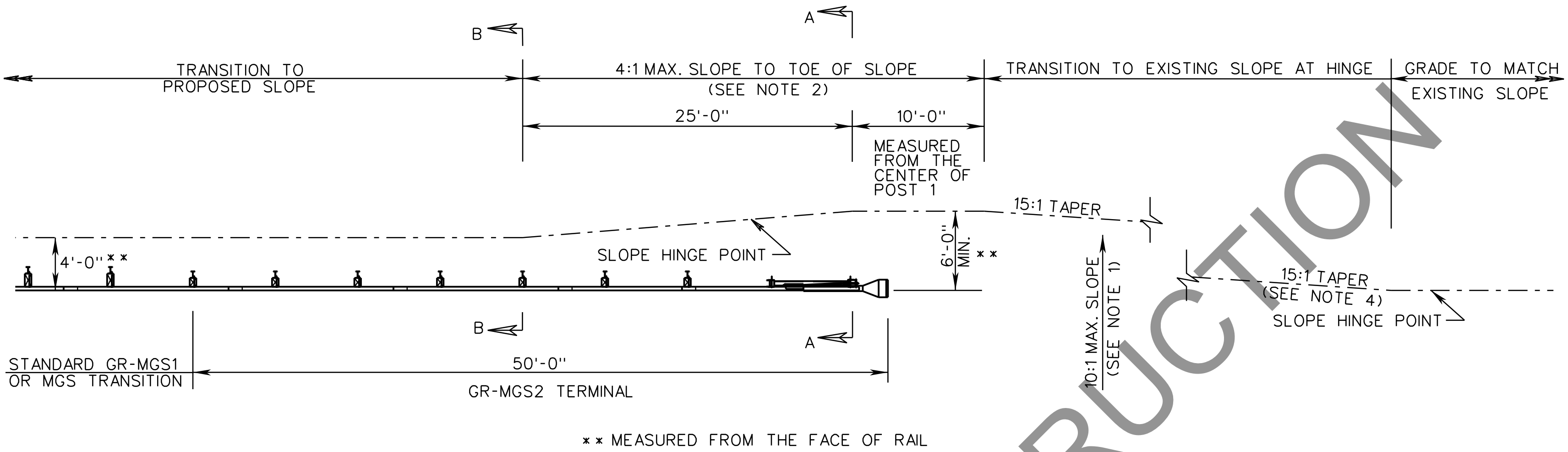


THROUGH ROADWAY MARKER POSITION LEFT OF TRAFFIC

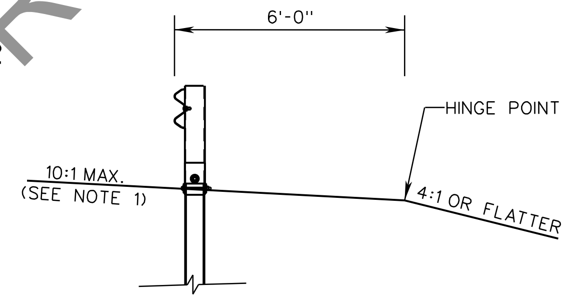


THROUGH ROADWAY MARKER POSITION RIGHT OF TRAFFIC

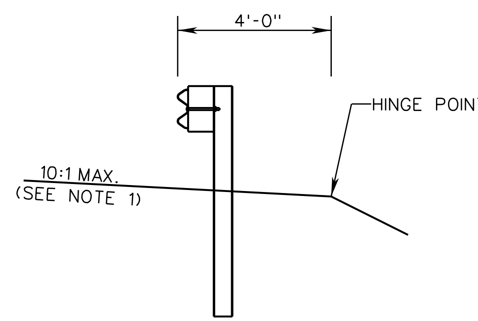
SPECIFICATION REFERENCE	MIDWEST GUARDRAIL SYSTEM	VDOT ROAD AND BRIDGE STANDARDS	
221 236 505	(TANGENT END TERMINAL) VIRGINIA DEPARTMENT OF TRANSPORTATION	REVISION DATE	SHEET 1 OF 3 506.__



SITE PREPARATION REQUIREMENTS FOR GR-MGS2



SECTION A-A



SECTION B-B

NOTES:

1. THE CROSS SLOPE OF THE GRADE APPROACHING THE GUARDRAIL TERMINAL, AND ADJACENT TO FOR ITS FULL LENGTH, MUST BE A MAXIMUM OF 10:1. IF THE EXISTING GRADE IS FLAT OR IS A POSITIVE SLOPE DUE TO THE SUPERELEVATION OF THE ROADWAY PAVEMENT, THE MINIMUM OFFSET FROM THE FACE OF RAIL TO THE HINGE POINT, AS SHOWN, IS REQUIRED.

2. THE AREA IMMEDIATELY BEHIND AND BEYOND THE TERMINAL SHALL BE TRAVERSABLE AND FREE FROM FIXED OBJECTS. IF A CLEAR RUN OUT IS NOT ATTAINABLE THIS AREA SHALL AT LEAST BE SIMILAR IN CHARACTER TO THE UPSTREAM UNSHIELDED ROADSIDE AREAS.

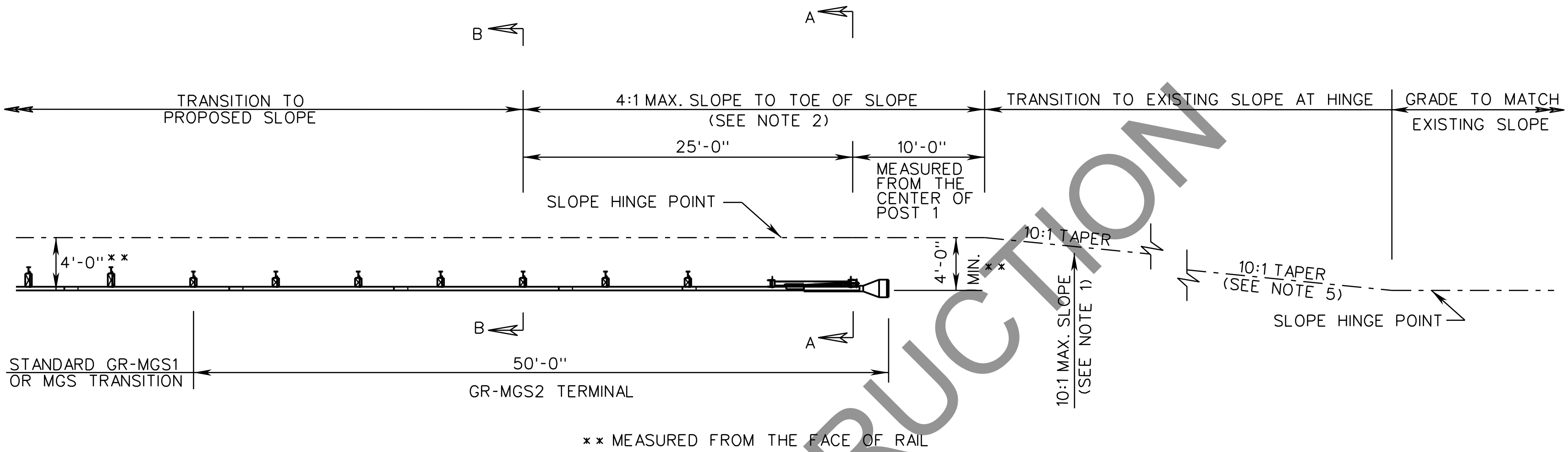
3. FOR NEW CONSTRUCTION AND RECONSTRUCTION, THE 10:1 SLOPE GRADING SHALL EXTEND A MINIMUM OF 6'-0" MEASURED FROM THE FACE OF RAIL.

4. FOR PROPRIETARY GUARDRAIL TERMINALS, THE MANUFACTURER'S SITE PREPARATION REQUIREMENTS TAKE PRECEDENCE OVER THIS STANDARD IF ADDITIONAL GRADING IS REQUIRED.

MIDWEST GUARDRAIL SYSTEM
(TANGENT END TERMINAL)

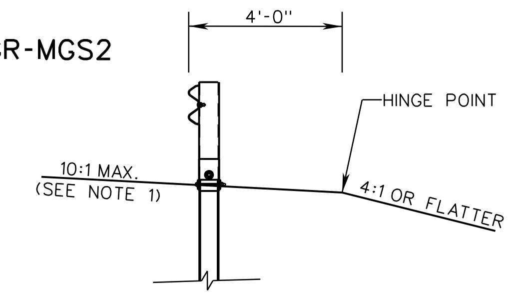
VIRGINIA DEPARTMENT OF TRANSPORTATION

SPECIFICATION REFERENCE
221
236
505



LIMITED USE SITE PREPARATION REQUIREMENTS FOR GR-MGS2

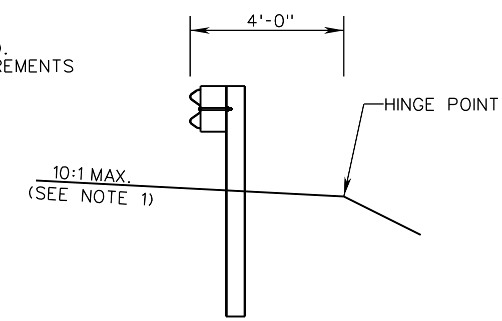
NOT FOR USE ON INTERSTATES, FREEWAYS, OR NEW CONSTRUCTION.



SECTION A-A

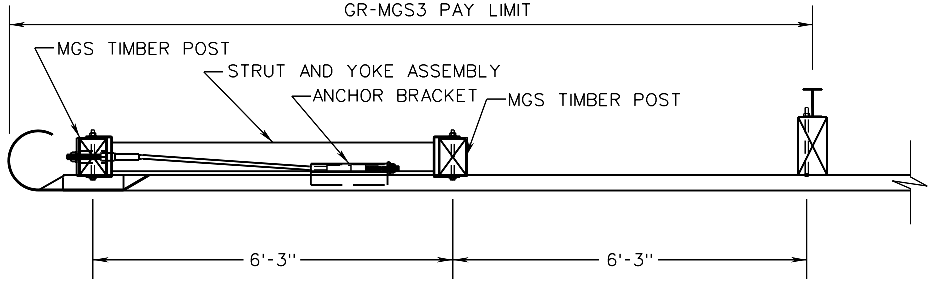
NOTES:

1. THE CROSS SLOPE OF THE GRADE APPROACHING THE GUARDRAIL TERMINAL, AND ADJACENT TO FOR ITS FULL LENGTH, MUST BE A MAXIMUM OF 10:1. IF THE EXISTING GRADE IS FLAT OR IS A POSITIVE SLOPE DUE TO THE SUPERELEVATION OF THE ROADWAY PAVEMENT, THE MINIMUM OFFSET FROM THE FACE OF RAIL TO THE HINGE POINT, AS SHOWN, IS REQUIRED.
2. THE AREA IMMEDIATELY BEHIND AND BEYOND THE TERMINAL SHOULD BE TRAVERSABLE AND FREE FROM FIXED OBJECTS. IF A CLEAR RUN OUT IS NOT ATTAINABLE THIS AREA SHOULD AT LEAST BE SIMILAR IN CHARACTER TO THE UPSTREAM UNSHIELDED ROADSIDE AREAS.
3. NOT FOR USE ON INTERSTATES, FREEWAYS, OR NEW CONSTRUCTION. MAY BE USED ON LOWER CLASSIFICATION ROADWAYS WHEN UPGRADING EXISTING TERMINALS WITH SITE LIMITATIONS (WHEN APPROVED BY THE ENGINEER). OR WHEN SPECIFIED IN THE PLANS FOR 3R WORK THAT CANNOT CONFORM TO THE SITE PREPERATION REQUIREMENTS ON PAGE 506.__.
4. FOR LIMITED APPLICATIONS AS DESCRIBED IN NOTE 3, THE GRADING SHOULD BE AS CLOSE AS POSSIBLE TO THE SITE PREPARATION REQUIREMENTS ON PAGE 506.__. THE SLOPE SHALL EXTEND A MINIMUM OF 4'-0" FROM THE FACE OF RAIL AND GRADING SHALL CONFORM TO THE DETAILS ABOVE. USE 21B AGGREGATE, OR OTHER SUITABLE MATERIAL AS APPROVED BY THE ENGINEER.

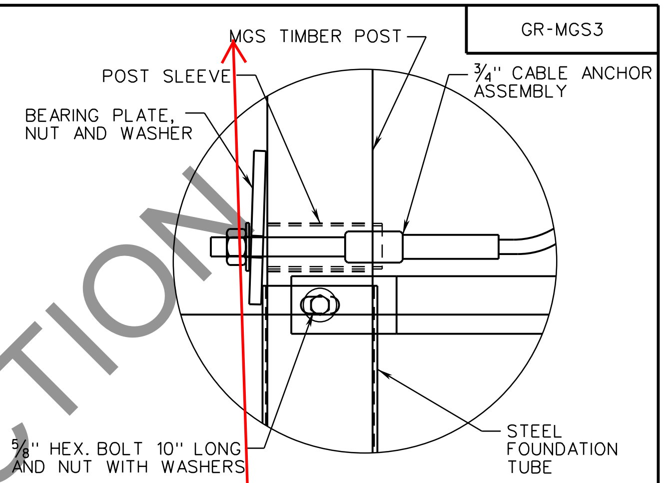


SECTION B-B

SPECIFICATION REFERENCE	MIDWEST GUARDRAIL SYSTEM	VDOT ROAD AND BRIDGE STANDARDS	
221 236 505	(TANGENT END TERMINAL) VIRGINIA DEPARTMENT OF TRANSPORTATION	REVISION DATE	SHEET 3 OF 3 506.__

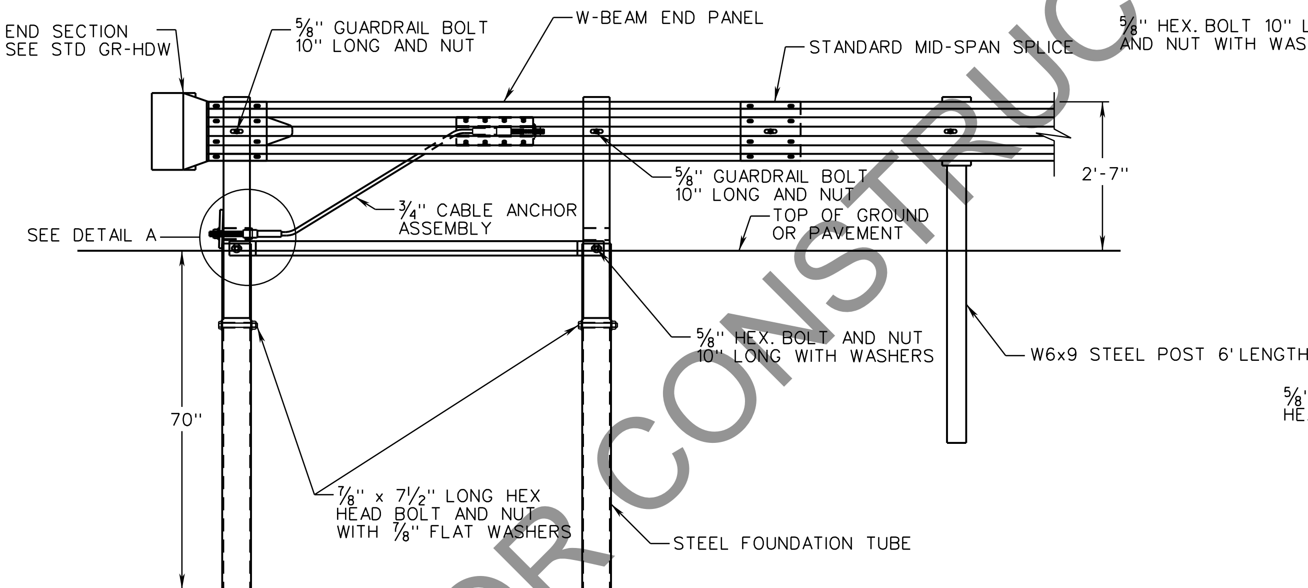


PLAN

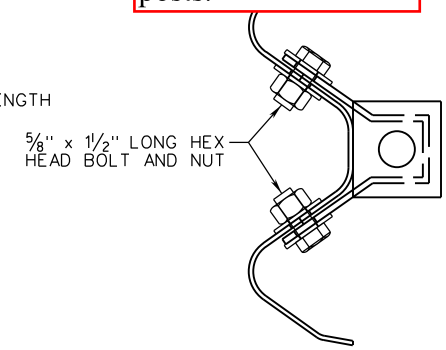


DETAIL A

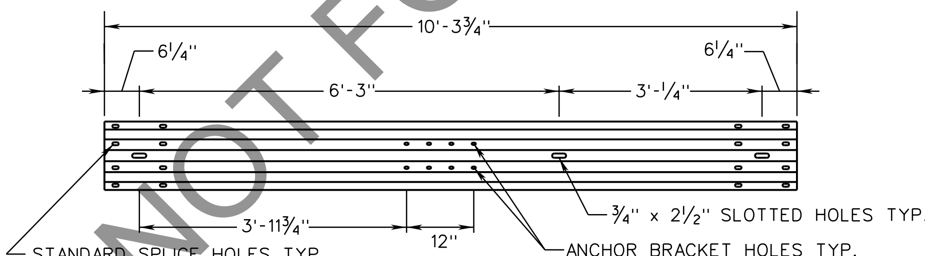
These are typically referred to as BCT posts.



ELEVATION



ANCHOR BRACKET BOLT DETAIL

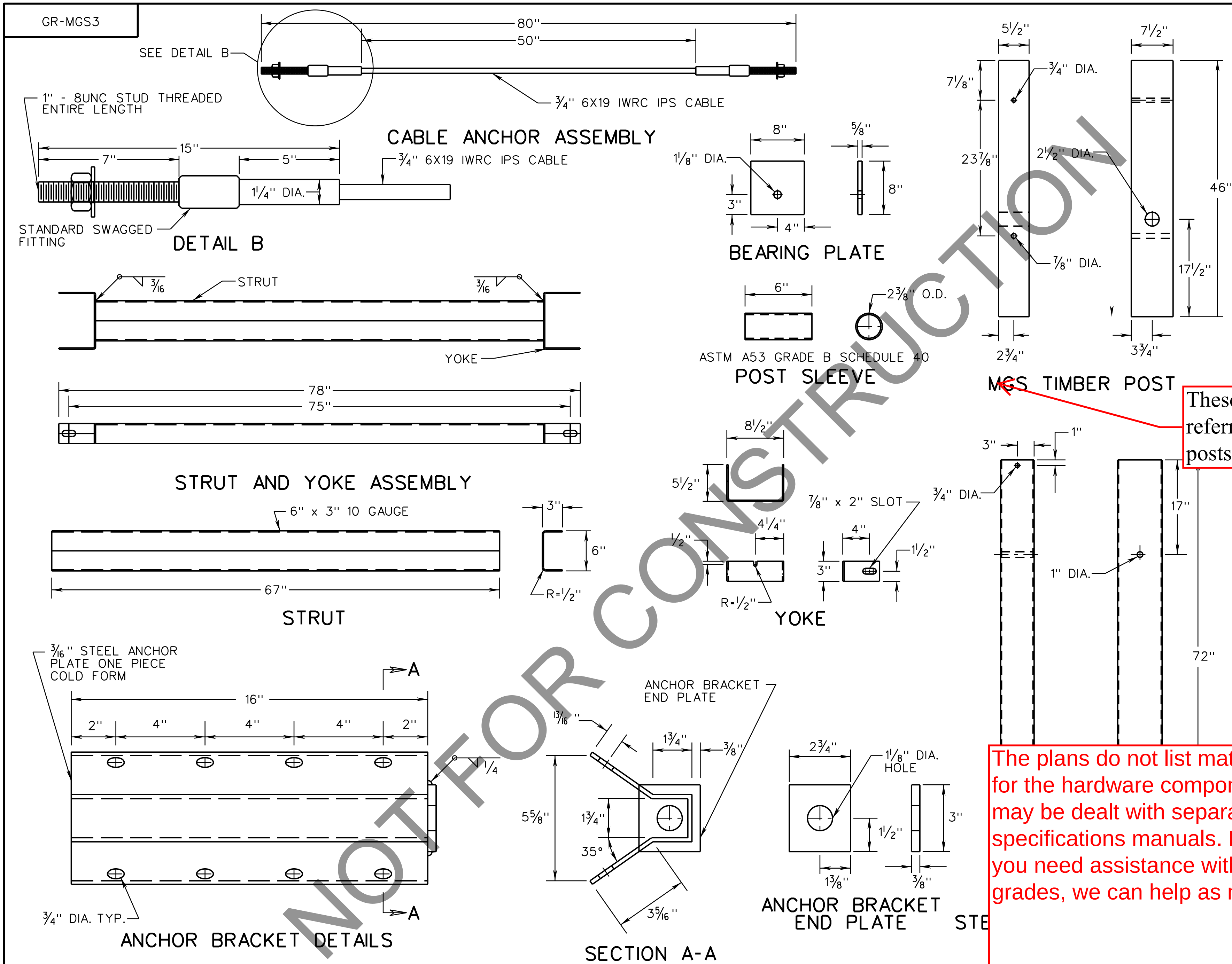


W BEAM END PANEL DETAIL

NOTES:

1. USE OF THIS TRAILING END ANCHORAGE IS RESTRICTED TO RUN-OFF CONDITIONS ON DIVIDED HIGHWAYS.
2. STEEL POST, BLOCKOUT, AND SPLICE SHALL BE IN ACCORDNCE WITH THE GR-MGS1 STANDARD AND LOCATED AS SHOWN IN THE DETAILS ABOVE.

SPECIFICATION REFERENCE	MIDWEST GUARDRAIL SYSTEM	VDOT ROAD AND BRIDGE STANDARDS	
221 236 505	(TRAILING END ANCHORAGE) VIRGINIA DEPARTMENT OF TRANSPORTATION	REVISION DATE	SHEET 1 OF 2 506.__



These are typically referred to as BCT posts.

The plans do not list material grades for the hardware components. These may be dealt with separately in your specifications manuals. However, if you need assistance with material grades, we can help as needed.

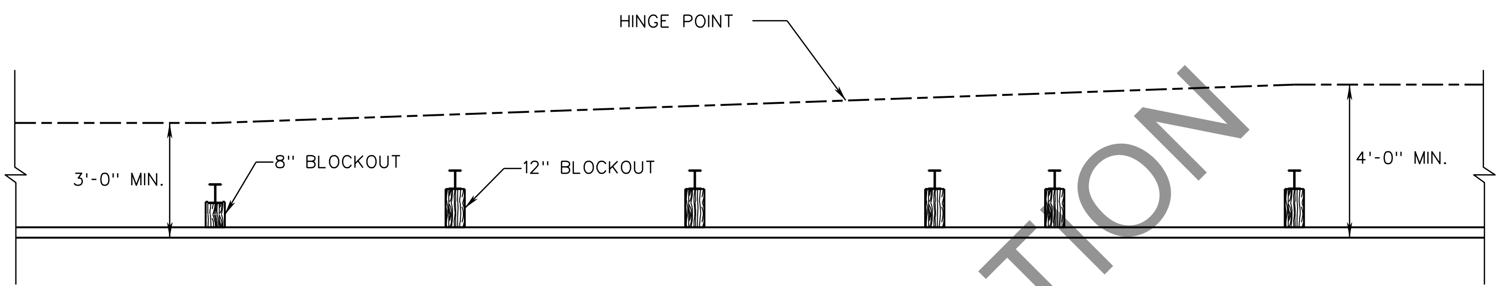
VDOT
ROAD AND BRIDGE STANDARDS

SHEET 2 OF 2 | REVISION DATE

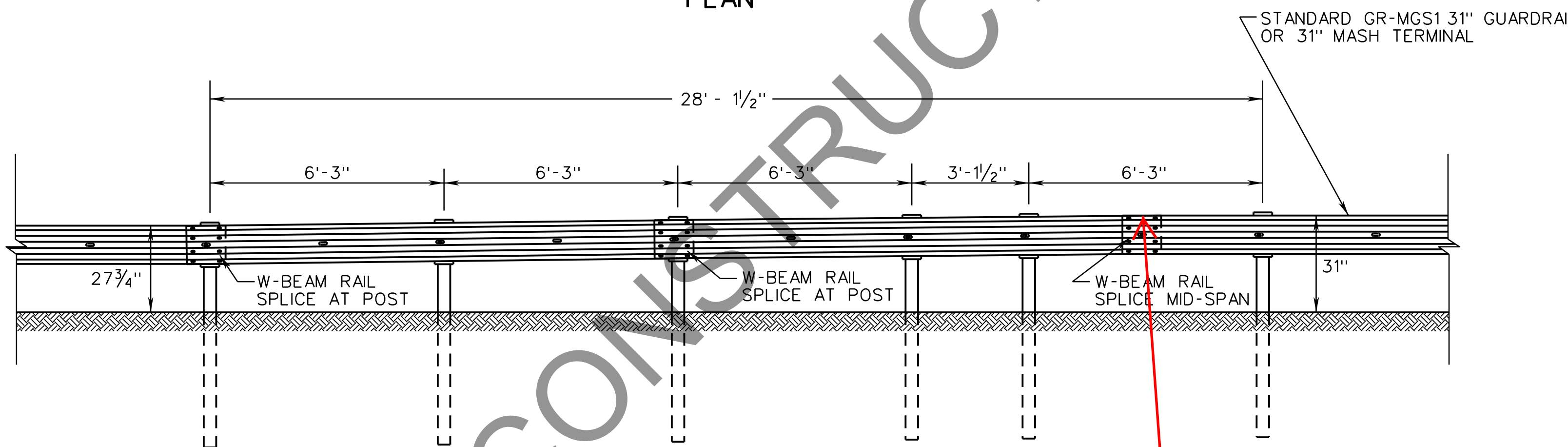
506.__

MIDWEST GUARDRAIL SYSTEM
(TRAILING END ANCHORAGE)

VIRGINIA DEPARTMENT OF TRANSPORTATION



PLAN

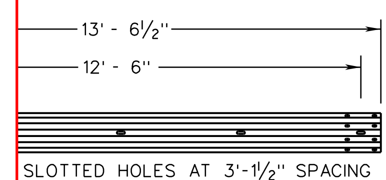


ELEVATION

We don't typically recommend altering the splice locations within the height transition. We just completed guidance on this for a report that is going to be final soon. I attached the relevant section of the report.

NOTES:

1. TRANSITIONS FROM 31" GR-MGS1 TO 27¾" GR-2 SHALL BE ACCOMPLISHED WITH 2 STANDARD 12½ FOOT SECTIONS OF W-BEAM.
2. POSTS, BLOCKOUTS, AND SPLICES SHALL BE IN ACCORDNCE WITH THE GR-MGS1 STANDARD AND LOCATED AS SHOWN IN THE DETAILS ABOVE.
3. STANDARD 6 FOOT POSTS SHALL BE USED UNLESS OTHERWISE NOTED ON PLANS
4. STANDARD GR-MGS1 TRANSITION SHALL BE PAID FOR AS EACH COMPLETE IN PLACE
5. END TERMINAL SHALL BE A VDOT APPROVED PRODUCT MEETING MASH TESTING CR



NDARD 12½ FOOT
-BEAM SECTION

SPECIFICATION REFERENCE	MIDWEST GUARDRAIL SYSTEM (TRANSITION FROM MGS 31" HEIGHT TO GR-2 27¾" HEIGHT) VIRGINIA DEPARTMENT OF TRANSPORTATION	VDOT ROAD AND BRIDGE STANDARDS	
221 236 505		REVISION DATE	SHEET 1 OF 1
			506.__

3. Anchor damage or disengagement would require replacement. For the end shoe bracket, it may only require installation of new mounting bolts if the bracket is undamaged. The blockout mounting bracket could be replaced using the two unused anchor holes if one of the anchors is damaged or becomes disengaged.

12.5 Integration with Other Barrier Systems

The guardrail to PCB transition system developed herein focused on the MGS guardrail system and the 12.5-ft (3.81-m) long, F-shape PCBs that were developed through the Midwest States Pooled Fund Program. While the transition was designed specifically for these two barrier systems, there may be a desire to integrate this transition using other barrier systems, including existing G4(1C) W-beam guardrail or alternative PCB designs.

Because a majority of the guardrail currently on the highway system consists of the G4(1S) guardrail, there will likely be a need to attach the G4(1C) guardrail to a PCB transition. Two issues must be addressed to transition the G4(1S) system to the MGS guardrail. They related to differences in rail height and splice location. Previous guidance has been given to raise rail height from the G4(1S) to the MGS over a distance of 25 ft to 50 ft (7.62 m to 15.21 m). Several options exist to reposition the rail splices from the posts to the mid span locations by including omitting a post or use of ½ post spacing. Three layout options are proposed, but each requires a slightly different layout depending on the preferred splice repositioning method. In addition, each guardrail to PCB transition option requires a slightly different connection point to the nested MGS guardrail to provide a short length of standard MGS prior to the beginning of the guardrail to PCB transition. The three recommended G4(1S) to MGS transitions are detailed below.

1. Omitted Post Option – The transition between the rail splice locations for the G4(1S) to MGS transition can be accomplished through omission of a post after the rail height transition is completed, as shown in Figure 107. Recent research has shown that the

omission of a single post in the MGS and creation of a 12.5 ft (3.81 m) unsupported span is acceptable under MASH TL-3 impact conditions [15]. As such, it is recommended that the splice repositioning can occur following the rail height transition through omission of the post at the first splice following the height transition. This option creates a 9 ft – 4½ in. (2.86 m) span between G4(1S) spacing and MGS spacing. MGS attachment to the nested MGS may begin at the first splice following the splice repositioning.

2. Half-Post Spacing in MGS Option – A second option for transitioning from G4(1S) to MGS consists of adding an additional post following the rail height transition, as shown in Figure 108. For this transition, a post at ½-post spacing is added after the second post following the rail height repositioning, and standard MGS begins after that point. Attachment of the MGS to the nested rail that begins the guardrail to PCB transition may begin after one 12.5-ft (3.81-m) long section of standard MGS following the splice repositioning.
3. Half-Post Spacing in G4(1S) Option – A third option for transitioning from G4(1S) to MGS consists of adding an additional post prior to the rail height repositioning, as shown in Figure 109. For this transition, a post at ½-post spacing is added after the final post in the G4(1S) prior to the rail height repositioning, and standard MGS post spacing begins after that point. Attachment of the MGS to the nested rail that begins the guardrail to PCB transition may begin after one 12.5-ft (3.81-m) long section of standard MGS following the rail height repositioning.

The blockout depth may be converted from the 8-in. deep G4(1S) blockouts to the 12-in. deep MGS blockouts at whatever point is convenient.

Finally, the guardrail to PCB transition that was tested and evaluated herein used a common 12.5-ft (3.81-m) long, F-shape PCB that is used by a majority of the Pooled Fund states in the

Midwest. However, there may be potential to use this transition system with alternative PCBs if some basic criteria are met.

1. The reinforcement in alternative PCB designs would need to provide equal or greater barrier capacity to that provided by the PCBs used in this research.
2. Alternative PCB segment connections must have comparable or greater structural capacity and torsional rigidity about the longitudinal barrier axis when compared to the as-tested PCB.
3. Alternative barrier geometry may affect the performance of the system. As such, barrier height should be maintained at 32 in. (813 mm) to maintain a similar or less risk for wheel snag. Differences the barrier face geometry, such as New Jersey and single-slope barriers, may be acceptable, but they are not recommended at this time without further study. There are concerns that the difference in face geometry may affect vehicle interaction with the PCB in the overlapped barrier region. Thus, it may require revised connection hardware for the W-beam end shoe and blockouts.
4. The PCB segments with alternative lengths could potentially be used but are not recommended without further study due to concerns for potential differences in the PCB deflection and stiffness.
5. Any alternative PCB should have similar mass per unit length to the as-tested PCB system to provide similar inertial resistance, stiffness, and dynamic deflections.
6. Finally, it is recommended that any alternative PCB should meet MASH TL-3. It is also recommended that any alternative PCB have similar MASH TL-3 dynamic deflections to the as-tested PCB. Significantly increased or decreased dynamic deflections may adversely affect the performance of the guardrail to PCB transition system.

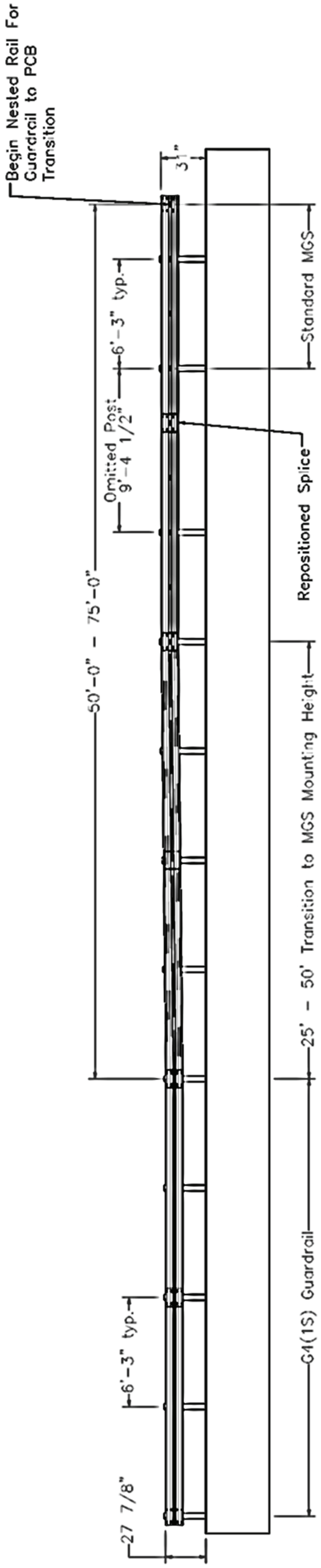


Figure 107. Schematic for Transitioning G4(1S) to MGS Prior to Guardrail to PCB Transition, Omitted Post Option

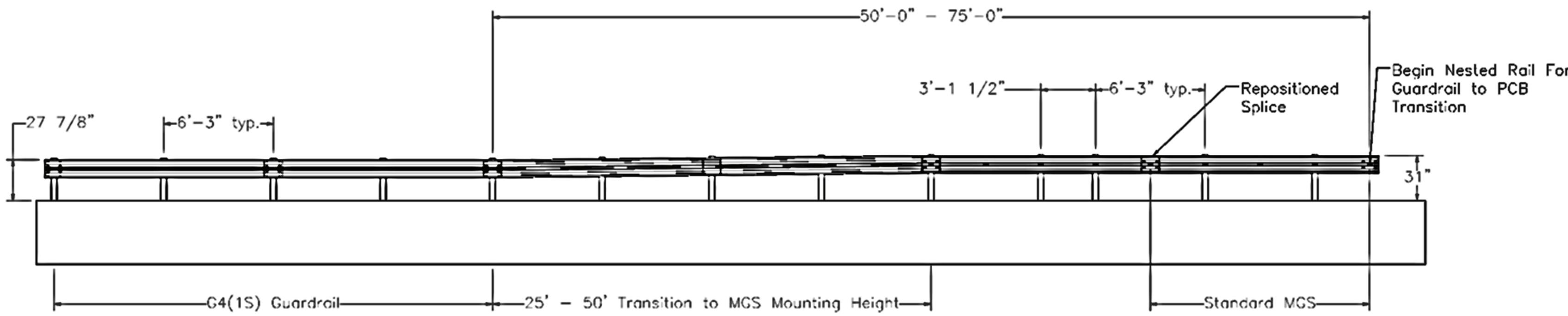


Figure 108. Schematic for Transitioning between G4(1S) and MGS Prior to Guardrail to PCB Transition, Half-Post Spacing in MGS Option

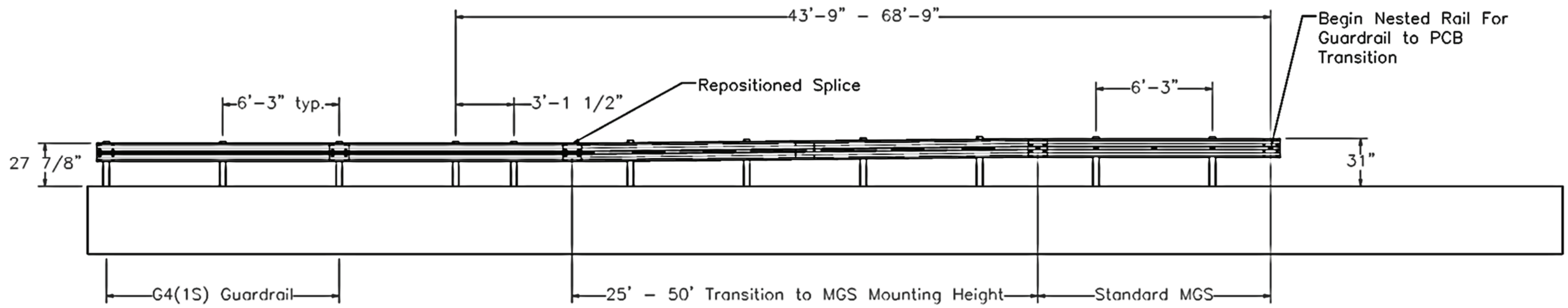


Figure 109. Schematic for Transitioning between G4(1S) and MGS Prior to Guardrail to PCB Transition, Half-Post Spacing in G4(1S) Option