February 5, 2014

MEMORANDUM

To: All Holders of the Virginia Department of Transportation’s 2008 Road and Bridge Standards

The following is a list of sheets contained in the 2008 Road and Bridge Standards that have been revised. Please add these pages to your copy of the standards. An interim standard sheet will not be required in plan assemblies for the following sheets only. Changes to these sheets will not affect the basis of payment or estimates.

<table>
<thead>
<tr>
<th>PAGE</th>
<th>REVISION</th>
</tr>
</thead>
<tbody>
<tr>
<td>803.20</td>
<td>Corrected variables in the Lr (Alt. Multi-Lane) equation, “W” to “Wn” and “m” to “M”, clarified note for Alternate Lane Method.</td>
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</tbody>
</table>

The following is a list of revised standards to the 2008 Road and Bridge Standards that require an interim standard sheet to be included in your plan assembly until the next edition of the standards is published. Please add these pages to your copy of the standards. The respective interim standard sheet number has been placed with the revised standard. The interim standard sheets are available on VDOT’s web site, on the FTP server, and in Falcon DMS for VDOT personnel. These interim standard sheets will be required in plan assemblies for Tier 1 projects advertised May 27, 2014 (Non Federally Eligible), June 10, 2014 (Federally Eligible) and later, along with Tier 2 projects advertised September 9, 2014 and later.

<table>
<thead>
<tr>
<th>PAGE</th>
<th>INTERIM</th>
<th>STANDARD</th>
<th>REVISION</th>
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<tbody>
<tr>
<td>501.01</td>
<td>IIS05_04</td>
<td>GR-HDW</td>
<td>REVISED NOTE IN DETAIL OF SPLICE JOIN REMOVING WASHER ON LAST 50’ ON RUN OFF END. ADDED L = 2” FOR BUTTON HEAD BOLT USED ON NESTED W BEAMS.</td>
</tr>
<tr>
<td>PAGE</td>
<td>INTERIM</td>
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</tr>
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<tr>
<td>501.05</td>
<td>IIS05_10</td>
<td>GR-2, 2A</td>
<td>ADDED NOTE ON WOOD POSTS 5/8” WASHER REQUIRED</td>
</tr>
<tr>
<td>501.13</td>
<td>IIS05_23</td>
<td>GR-7</td>
<td>ADDED NOTE “TRANSITION TO PROPOSED SLOPE” AND REPLACED “HINGE” WITH “TOE OF SLOPE” IN PLAN VIEW</td>
</tr>
<tr>
<td>501.17</td>
<td>IIS05_24</td>
<td>Gr-9</td>
<td>ADDED NOTE “TRANSITION TO PROPOSED SLOPE” AND REPLACED “HINGE” WITH “TOE OF SLOPE” IN BOTH PLAN VIEWS, ADJUSTED LOCATION OF SECTION B-B IN THE PLAN VIEW</td>
</tr>
<tr>
<td>501.25</td>
<td>IIS05_12</td>
<td>GR-FOA-1</td>
<td>REVISED NOTE ABOUT MC-4 TO “IF REQUIRED” IN ELEVATION VIEW, SECTION A-A AND NOTE 5 CHANGED “CARRIAGE BOLT” TO “GUARDRAIL BOLT”, NOTE 6 CHANGED “A325” TO “A449”</td>
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<tr>
<td>501.26</td>
<td>IIS05_13</td>
<td>GR-FOA-1</td>
<td>REVISED NOTE ABOUT MC-4 TO “IF REQUIRED” IN ELEVATION VIEW, SECTION A-A AND NOTE 5 CHANGED “CARRIAGE BOLT” TO “GUARDRAIL BOLT”, NOTE 6 CHANGED “A325” TO “A449”, REVISED ITEM 1 TO GUARDRAIL BOLT AND DELETED ITEM 10 IN THE MATERIALS LIST</td>
</tr>
<tr>
<td>501.28</td>
<td>IIS05_14</td>
<td>GR-FOA-2</td>
<td>SECTION A-A AND NOTE 5 CHANGED “CARRIAGE BOLT” TO “GUARDRAIL BOLT”, NOTE 7 CHANGED “A325” TO “A449”, DELETED NOTE IN ELEVATION VIEW REQUIRING COMPRESSED SPACER TUBE</td>
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<tr>
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<tr>
<td>501.29</td>
<td>IIS05_15</td>
<td>GR-FOA-2</td>
<td>SECTION A-A AND NOTE 5 CHANGED “CARRIAGE BOLT” TO “GUARDRAIL BOLT”, NOTE 7 CHANGED “A325” TO “A449”, DELETED ITEM 1 AND REVISED ITEM 8 TO GUARDRAIL BOLT IN THE MATERIALS LIST DELETE NOTE IN ELEVATION VIEW REQUIRING COMPRESSED SPACER TUBE</td>
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<tr>
<td>501.30</td>
<td>IIS05_25</td>
<td>GR-FOA-2 &amp; 4</td>
<td>DELETED W-BEAM TERMINAL CONNECTOR DETAIL, ADDED NOTE TO ITEM 8 DETAIL</td>
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<tr>
<td>501.31</td>
<td>IIS05_16</td>
<td>GR-FOA-4</td>
<td>NOTE 6 CHANGED “A325” TO “A449”, DELETED ITEM 1 AND REVISED NUMBERING OF MATERIALS LIST, DELETED NOTE 5 DELETE NOTE IN ELEVATION VIEW REQUIRING COMPRESSED SPACER TUBE ADDED NOTE FOR BOLTING END OF RUBRAIL TO POSTS</td>
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<tr>
<td>501.39</td>
<td>IIS05_08</td>
<td>GR-INS</td>
<td>REMOVED “4:1 SLOPE MAX” FROM DETAIL AT BOTTOM OF PAGE, REVISED DESIGN SPEED NOTE FOR GR-2 INSTALLATION WITH CG-3 OR CG-7 CURB</td>
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</table>

If you have any questions or comments regarding this revision, please contact Chuck Patterson P.E., at (804) 786-1805, of the Standards and Special Design Section.

Sincerely,

Signature on File ______________________ Date: February 5, 2014

B. A. Thrasher, P.E.
State Location & Design Engineer
Section Thru Rail Element and W Beam Back-Up Plate

Detail of Splice Joint

Detail of Standard Washer

Notes:
All hardware is to be galvanized in accordance with the specifications.

The guardrail and median barrier components depicted in ARTBA Technical Bulletin Number 2668 may be substituted if interchangeable with the standards for guardrail (GR) or median barrier (MB) and approved by the engineer.

Detailed Guardrail Hardware

Reference Specification

Virginia Department of Transportation
CONCRETE POST

POST MAY BE HOT ROLLED OR WELDED.

SOUTHERN PINE

ROUND WOOD POST

6X8 WOOD POST

ROUND WOOD POST

STANDARD BLOCKED-OUT W-BEAM GUARDRAIL
(STRONG POST SYSTEM, POST AND BLOCKOUT DETAILS)

VIRGINIA DEPARTMENT OF TRANSPORTATION

NOTE:
1. ALL BOLTS, NUTS, WASHERS, AND OTHER STEEL ITEMS ARE TO BE GALVANIZED.

2. ALTERNATE TYPE POSTS AND BLOCKOUT MAY BE INTERCHANGED ON ANY ONE PROJECT WITH THE RESTRICTION THAT THE SAME TYPE OF POST AND BLOCKOUT MUST BE USED IN ANY SINGLE RUN OF GUARDRAIL.

3. FOR DETAILS OF GUARDRAIL ELEMENT SPLICE JOINT, HARDWARE, ETC. SEE SHEET NOS. 501.01 AND 501.02.

4. THE GUARDRAIL AND MEDIAN BARRIER COMPONENTS DEPICTED IN A.R.T.B.A. TECHNICAL BULLETIN NUMBER 268B MAY BE SUBSTITUTED IF INTERCHANGEABLE WITH THE STANDARDS FOR GUARDRAIL (GR) OR MEDIAN BARRIER (MB) AND APPROVED BY THE ENGINEER.

5. DRIVE NAIL ON BOTH SIDES WITHIN 2" OF THE TOP OR BOTTOM OF BLOCKOUT AFTER ¾" x 18 BOLT IS INSTALLED.
NOTES:


2. THE AREA IMMEDIATELY BEHIND AND BEYOND THE TERMINAL SHOULD BE TRAVERSABLE (3:1 OR FLATTER) 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 UN-SHIELDED ROADSIDES.

3. FOR NEW CONSTRUCTION, RECONSTRUCTION, AND 3R WORK, THE 10:1 SLOPE GRADING MUST EXTEND A MINIMUM OF 5'-0" BEHIND THE END POST.

4. FOR PROPRIETARY GUARDRAIL TERMINALS, THE MANUFACTURER'S SITE PREPARATION REQUIREMENTS TAKE PRIORITY OVER THIS STANDARD.
NOTES:

1. The cross slope of the grade approaching the guardrail terminal, and adjacent to for its full length, must be 10:1. If the existing grade is flat or is a positive slope due to the super-elevation of the roadway pavement, the minimum offset from behind the post 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. For new construction and reconstruction the 10:1 slope grading must extend a minimum of 5'-0" behind the end post.

4. For 3R work the grading should be as close as possible to the new construction with slope extending a minimum of 2'-0" behind the blocked out post. From the hinge point tie the graded slope into the existing ditch slope to cover the foundation tubes and soil plates without extending this slope beyond the ditch bottom. Use #21B aggregate, or other suitable material as approved by the engineer, at roadway shoulders.

5. The taper for new construction will be 15:1. For 3R work the minimum allowable taper is 10:1.

6. For proprietary guardrail terminals the manufacturer's site preparation requirements take precedence over this standard.
NEW BRIDGES - ATTACHMENTS
ONE WAY TRAFFIC - RUN-ON, 2-GR-FOA-1, TYPE I
- RUN-OFF, 2-GR-FOA-1, TYPE II
TWO WAY TRAFFIC - RUN-ON, 4-GR-FOA-1, TYPE I
EXISTING BRIDGE ATTACHMENTS AS SHOWN ON PLANS.

SECTION A-A
SECTION B-B
SECTION C-C

ELEVATION

SEE SHEET 3 OF 3 FOR RUBRAIL BLOCKOUT DETAILS.

NOTE:
1. FIXED OBJECTS MAY CONSIST OF BRIDGE RAILS, ABUTMENTS, PIERS, RETAINING WALLS, OR OTHER FLAT-SURFACED STRUCTURES WITH VERTICAL FACE.
2. BRIDGE RAIL ENDS AND BRIDGE PARAPETS MUST BE OF ADEQUATE STRENGTH TO ACCEPT FULL IMPACT LOADING.
3. GUARDRAIL COMPONENTS SHALL BE IN ACCORDANCE WITH VDOT ROAD AND BRIDGE STANDARDS.
4. POSTS 1, 2, 3, 4, AND 5 REQUIRE AN ADDITIONAL HOLE TO ATTACH BLOCKS AND/OR RUBRAIL. RUBRAIL IS NOT BOLTED TO POSTS 2 AND 4.
5. BOTTOM WOOD BLOCKS LOCATED ON POSTS 1 THROUGH 4 ARE CENTER DRILLED AND SECURED WITH ¾" GUARDRAIL BOLTS (LENGTH AS REQUIRED).
6. APPROPRIATE LENGTH ¾" DIAMETER ASTM A449 HEX BOLTS WITH WASHERS MUST BE USED WITH THRU DRILLED HOLES AND A ¾" BEARING PLATE ON THE BACK SIDE OF THE BRIDGE PARAPET OR TERMINAL WALL.
7. DRIVE NAIL WITHIN 2" OF THE TOP OR BOTTOM OF THE BLOCKOUT AFTER ¾" X 18 BOLT IS INSTALLED.
8. SEE SHEET 3 OF 3 FOR RUBRAIL BLOCKOUT DETAILS.
1. Fixed objects may consist of bridge rails, abutments, piers, retaining walls, or other flat surfaced structures with vertical face.

2. Bridge rail ends and bridge parapets must be of adequate strength to accept full impact loading.

3. Guardrail components shall be in accordance with VDOT road and bridge standards.

4. Posts 1, 2, 3, 4, and 5 require an additional hole to attach blocks and/or rubrail. Rubrail is not bolted to posts 2 and 4.

5. Bottom wood blocks located on posts 1 through 4 are center drilled and secured with \( \frac{3}{4} \)" guardrail bolts (length as required).

6. Appropriate length \( \frac{3}{4} \)" diameter ASTM A449 hex bolts with washers must be used with thru drilled holes and a \( \frac{3}{8} \)" bearing plate on the back side of the bridge parapet or terminal wall.

7. See Sheet 3 of 3 for rubrail blockout details.

### Item Material/Specifications/Notes

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( \frac{3}{4} )&quot; x 10&quot; long guardrail bolt &amp; recessed nut</td>
</tr>
<tr>
<td>2</td>
<td>Std. W6x8.5 or W6x9 steel post</td>
</tr>
<tr>
<td>3</td>
<td>Std. 6&quot;x14&quot; lg treated pine block or recycled material</td>
</tr>
<tr>
<td>4</td>
<td>Standard W-beam rail</td>
</tr>
<tr>
<td>5</td>
<td>( \frac{3}{4} )&quot; x 2&quot; long guardrail bolt &amp; recessed nut (see standard CR-HDW)</td>
</tr>
<tr>
<td>6</td>
<td>Rectangular plate washer (see Std. GR-HDW)</td>
</tr>
<tr>
<td>7</td>
<td>Bent plate rubrail (see Sheet 3 of 3)</td>
</tr>
<tr>
<td>8</td>
<td>C6 x 82 rubrail (see Sheet 3 of 3)</td>
</tr>
<tr>
<td>9</td>
<td>W8 x 13 x 7'-6&quot; long steel post with standard 6&quot;x8&quot;x14&quot; long treated pine block or recycled material</td>
</tr>
</tbody>
</table>
W-Beam Guardrail - Fixed Object Attachment

For Use Between Safety Shape and Guardrail (Wood Posts)

NOTES:
1. Fixed objects may consist of safety shaped bridge parapets or concrete barriers.
2. Bridge rail ends and bridge parapets must be of adequate strength to accept full impact loading.
3. Guardrail components shall be in accordance with VDOT road and bridge standards.
4. Posts 1, 2, 3, 4, and 5 require an additional hole to attach lower blocks and/or rubber. Rubrail is not bolted to posts 2 and 4.
5. Bottom wood blocks located on posts 1 through 4 are centered drilled and secured with ¾" guardrail bolts. (Length as required).
6. Rubrail must be twisted 35° between section C-C and D-D. Shop fabrication may be required. Right hand and left hand twists will be necessary.
7. Appropriate length ¼" ASTM A449 hex bolts with washers must be used with thru drilled holes and a ½" bearing plate on the back side of the bridge parapet or concrete barrier.
8. Drive nail within 2" of the top or bottom of blockout after ¾" x 18 bolt is installed.

SECTION A-A

SECTION B-B

SECTION C-C

SECTION D-D

ELEVATION

PLAN

Steel spacer tube
5" i.d. x 9" long, schedule 40, galv. pipe

Concrete barrier
Bridge parapet or safety-shape

New bridge - attachments
One-way traffic-run-on, 2-GR-FOA-2, Type I
- Run-off, 2-GR-FOA-2, Type I
Two-way traffic-run-on, 4-GR-FOA-2, Type I

Existing bridge attachments as shown on plans.

Washer for ½" bolt

Item | Material/Specifications/Notes
--- | ---
1 | ¾" x 18" LG. GUARDRAIL BOLT AND RECESSED NUT
2 | STANDARD 6" x 8" WOOD POST AND BLOCK.
3 | STANDARD W-BEAM TERMINAL CONNECTOR
4 | STANDARD W-BEAM RAIL
5 | ¾" x 2" LONG GUARDRAIL BOLT AND RECESSED NUT (SEE STANDARD GR-HDW)
6 | RECTANGULAR PLATE WASHER (SEE STANDARD GR-HDW)
7 | BENT PLATE RUBRAIL (SEE SHEET 3 OF 3)
8 | C6 x 8.2 RUBRAIL (SEE SHEET 3 OF 3)
9 | 8" x 8" x 7½" 6" LONG WOOD POST AND 8" x 8" x 14" LONG TREATED PINE BLOCK OR RECYCLED MATERIAL
10 | WOOD BLOCKOUT FOR RUBRAIL (SEE SHEET 3 OF 3)
11 | WASHER FOR ½" BOLT
### Notes:
1. Fixed objects may consist of safety shaped bridge parapets or concrete barriers.
2. Bridge rail ends and bridge parapets must be of adequate strength to accept full impact loading.
3. Guardrail components shall be in accordance with VDOT road and bridge standards.
4. Posts 1, 2, 3, 4, and 5 require an additional hole to attach lower blocks and/or rubrail. Rubrail is not bolted to posts 2 and 4.
5. Bottom wood blocks, located on posts 1 through 4, are center drilled and secured with ¾" guardrail bolts. (Length as required).
6. Rubrail must be twisted 35° between sections C-C and D-D. Shop fabrication may be required. Right hand and left hand twists will be necessary.
7. Appropriate length ¾" ASTM A449 hex bolts with washers must be used with thru drilled holes and a ¾" bearing plate on the back side of the bridge parapet or concrete barrier.
8. See sheet 3 of 3 for rubrail blockout details.

### Item | Material/Specifications/Notes
--- | ---
1 | Std. W6 x 8.5 or W6 x 9 steel post w/ Std. 6" x 6" x 14" LG treated pine block or recycled material
2 | Standard W-Beam Terminal Connector
3 | Standard W-Beam Rail
4 | ¾" x 2" long guardrail bolt and recessed nut (see standard GR-4H)
5 | Rectangular plate washer (see standard GR-HDW)
6 | Bent plate rubrail (see sheet 3 of 3)
7 | C6 x 8.2 rubrail (see sheet 3 of 3)
8 | ¾" x 10" long guardrail bolt and recessed nut (see sheet 3 of 3)
9 | Wood blockout for rubrail (see sheet 3 of 3)
10 | W8 x 13 x 7¾" LG steel post w/ std. 6" x 8" x 14" LG treated pine block or recycled material

### W-Beam Guardrail - Fixed Object Attachment
For use with safety shape - (steel posts)

Virginia Department of Transportation

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A copy of the original sealed and signed drawing is on file in the Central Office.

**Road and Bridge Standards**

**Revision Date:** 01/14

**Sheet:** 2 of 3
W-BEAM GUARDRAIL - FIXED OBJECT ATTACHMENT

RUBRAIL AND HARDWARE DETAILS

1. CAN BE FIELD CUT AND BENT USING HEAT. IF SHOP CUT AND BENT, RIGHT HAND OR LEFT HAND MUST BE SPECIFIED DEPENDING ON WHICH SIDE OF THE ROADWAY THE TRANSITION IS USED.

2. CONNECTOR TERMINAL.

A COPY OF THE ORIGINAL SEALED AND SIGNED DRAWING IS ON FILE IN THE CENTRAL OFFICE.
**TYPE I**
- Two run-on sections (with 2 rubrails shown)

**TYPE II**
- One run-on section (with 1 rubrail retained)
- One run-off section (with 1 rubrail removed)

**TYPE III**
- Two run-off sections (with 2 rubrails removed)

### Materials/Specifications/Notes

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rectangular plate washer (see standard GR-HDW)</td>
</tr>
<tr>
<td>2</td>
<td>Bent plate rubrail (see sheet 2 of 2)</td>
</tr>
<tr>
<td>3</td>
<td>Wood blockout for rubrail (see sheet 2 of 2)</td>
</tr>
<tr>
<td>4</td>
<td>5/8&quot; x 10&quot; long guardrail bolt and recessed nut</td>
</tr>
</tbody>
</table>

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**Notes:**

1. All guardrail posts are to be steel.
2. All guardrail components are to be in accordance with VDOT Road and Bridge Standards.
3. Posts 1, 2, 3, 4 and 5 require an additional hole to attach lower blocks and/or rubrail. Rubrail is not bolted to posts 2 and 4.
4. Bottom wood blocks located on posts 1 through 4 are to be drilled and secured with ¾" guardrail bolts (length as required).
5. Appropriate length ¾" ASTM A449 hex bolts with washers are to be used with holes drilled through the concrete median barrier attaching the W-beam terminal connectors on each side. Bolts to project no more than ½" beyond nuts. Use lock washers under nuts.
**TABLE I**

<table>
<thead>
<tr>
<th>Total Shoulder Width (S)</th>
<th>Paved Shoulder Width (P)</th>
<th>Offset From Edge of Pavement to Face of Guardrail (O)</th>
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<tbody>
<tr>
<td>1'</td>
<td>12'</td>
<td>14'</td>
</tr>
<tr>
<td>15'</td>
<td>3', 4', or 10'</td>
<td>12'</td>
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<tr>
<td>13'</td>
<td>3'</td>
<td>10'</td>
</tr>
<tr>
<td>11'</td>
<td>3'</td>
<td>8'</td>
</tr>
<tr>
<td>8' (MED.)</td>
<td>3' or 4'</td>
<td>5'</td>
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</table>

**TABLE II**

<table>
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<tr>
<th>Total Shoulder Width (S)</th>
<th>Paved Shoulder Width (P)</th>
<th>Offset From Edge of Pavement to Face of Guardrail (O)</th>
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<tbody>
<tr>
<td>17'</td>
<td>12'</td>
<td>14'</td>
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<tr>
<td>15'</td>
<td>6' or 10'</td>
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<td>13'</td>
<td>8'</td>
<td>10'</td>
</tr>
<tr>
<td>11'</td>
<td>0, 3', 4', or 6'</td>
<td>8'</td>
</tr>
<tr>
<td>9'</td>
<td>0, 3' or 4'</td>
<td>6'</td>
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<tr>
<td>8'</td>
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<td>7'</td>
<td>2'</td>
<td>4'</td>
</tr>
<tr>
<td>5'</td>
<td>0</td>
<td>2'</td>
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**GUARDRAIL LOCATION ON RECOVERABLE SLOPE**

**SHOULDER RECOVERABLE AREA**

**SLOPE**

- **SLOPE 10:1 OR FLATTER**
- **SLOPE STEEPER THAN 10:1 BUT NO STEEPER THAN 6:1**
- **SLOPE STEEPER THAN 10:1**

**MEASURING GUARDRAIL HEIGHT ON FRONT SLOPE RELATIVE TO SHOULDER HINGE POINT**

**GR-INS**

**ASPHALT CURB SECTION**

**W-BEAM GUARDRAIL INSTALLATION CRITERIA**

**REFERENCES**

- **SPECIFICATION REFERENCE**
  - W-BEAM GUARDRAIL INSTALLATION CRITERIA
- **ROAD AND BRIDGE STANDARDS**
  - REFERENCES SHEET 6 OF 9
  - VIRGINIA DEPARTMENT OF TRANSPORTATION

**NOTE**

- A COPY OF THE ORIGINAL SEALED AND SIGNED DRAWING IS ON FILE IN THE CENTRAL OFFICE.
**RELATIVE GRADIENTS**

<table>
<thead>
<tr>
<th>DESIGN SPEED V0 MPH</th>
<th>MAXIMUM RELATIVE GRADIENT (rg)</th>
<th>MIN. TRANSITION LENGTH IN FEET (2 SECOND RULE)</th>
<th>MAXIMUM RELATIVE GRADIENT (rg)</th>
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<tr>
<td></td>
<td>12' LANE</td>
<td>16' LANE</td>
<td>18' LANE</td>
</tr>
<tr>
<td>20</td>
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<td>59</td>
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<td>80</td>
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<td>235</td>
<td>0.39</td>
</tr>
</tbody>
</table>

**DEFINITIONS**

- **A** - Front overhang of design vehicle from appropriate table.
- **bw** - Adjustment factor from table.
- **C** - Laterally clearance of design vehicle from appropriate table.
- **E** - Super-elevation rate from appropriate table.
- **e_d** - Design super-elevation rate, percent.
- **e_w** - Normal cross slope rate, percent.
- **F_a** - Calculated width of overhang for design vehicle.
- **L** - Wheelbase of design vehicle from appropriate table.
- **Lr** - Length of super-elevation runoff section.
- **L_t** - Length of tangent runoff section.
- **M** - Multiple lane factor.
- **N** - Number of lanes.
- **n** - Number of lanes rotated (from table).
- **n_r** - Number of lanes rotated (from table).
- **P** - Pavement width.
- **P_w** - Pavement width.
- **R** - Radius of curve.
- **W** - Pavement width.
- **W_c** - Calculated total curve width.
- **W_n** - Width of lane.
- **W_e** - Calculated extra width allowance.
- **U** - Calculated track width of design vehicle.
- **V** - Design velocity.
- **V_0** - Design velocity.
- **w** - Calculated widening.
- **W** - Width of lane.
- **W** - Width of lane.

**FORMULAS USED TO CALCULATE SUPER-ELEVATION RUNOFF (Lr) AND CROWN RUNOUT (L_t)**

<table>
<thead>
<tr>
<th>NO WIDENING REQUIRED</th>
<th>WIDENING REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lr = b_w(W_n/E/rg)</td>
<td>Lr = b_wC n_r (W_n + W/N)/rg</td>
</tr>
<tr>
<td>Lr = M(E/W_n/E/rg)</td>
<td>(ALT. MULTI-LANE)</td>
</tr>
<tr>
<td>Lr = M(E/W_n/E/rg)</td>
<td>(ALT. MULTI-LANE)</td>
</tr>
</tbody>
</table>

FOR SOLVED PROBLEMS USING THIS METHODOLOGY FOR Lr SEE THE EXAMPLES ON PAGE 803.22

**NOTE:** An alternate method for multi-lane roadways for four lane undivided pavements (48') the Lr is 1.5 times (M=1.5) the corresponding length for two lane highways; and for six lane undivided pavements (72), the Lr is two times (M=2) the corresponding length for two lane highways.