VIRGINIA DEPARTMENT OF TRANSPORTATION

LOCATION AND DESIGN DIVISION

INSTRUCTIONAL AND INFORMATIONAL MEMORANDUM

GENERAL SUBJECT: Rumble Strips and Rumble Stripes	NUMBER: IIM-LD-212.6 IIM-TE-368.0
SPECIFIC SUBJECT: <u>Continuous Pattern</u>: Shoulder Rumble Strip Centerline Rumble Stripe <u>Intermittent Pattern</u>: Shoulder Rumble Strip Shoulder Rumble Stripe	DATE: May 10, 2017 SUNSET DATE: May 3, 2022 SUPERSEDES: IIM-LD-212.5
LOCATION AND DESIGN DIVISION APPROVAL: Susan H. Keen, P.E. State Location and Design Engineer Approved May 10, 2017	TRAFFIC ENGINEERING DIVISION APPROVAL: Raymond J. Khoury, P.E. State Traffic Engineer Approved May 3, 2017

Due to the number of changes, shading has been omitted.

CURRENT REVISION

- This memorandum has been rewritten to provide additional options and guidance for the applicability of Rumble Strips and Rumble Stripes, including direction on how to address common issues.

EFFECTIVE DATE

- This memorandum is effective upon receipt.

BACKGROUND

- A Roadway Departure crash is a crash that occurs after a vehicle leaves its travel lane and crosses an edge line, edge of pavement, or center line.
- Roadway Departure crashes are frequently severe and account for the majority of highway fatalities in the United States (56% of traffic fatalities in the US in 2013).

- Over half of highway fatalities in Virginia are the result of Roadway Departure crashes (almost 400 deaths and 10,000 injuries per year in Virginia).

- Rumble Strips and Stripes are one of the most effective engineering countermeasures available that reduce roadway departure crashes.

- Rumbles Strips and Stripes have a demonstrated roadway departure crash reduction of 35-50 percent. For FHWA reference documents on Roadway Departure treatments including grooved rumbles, see http://safety.fhwa.dot.gov/roadway_dept/ and http://www.cmfclearinghouse.org/.

- Rumble Strips and Rumble Stripes are cylindrical grooved patterns milled into roadway or shoulder pavement that alert drivers through detectable noise and vibration when a vehicle's wheels leave the travel lane. Rumble Stripes are similar with the exception that the pavement marking (Centerline or Edge Line) is installed within the groove.

- NCHRP Report 641 (http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_641.pdf) provides information on various state design practices and previously published evaluation studies.

POLICY FOR USE OF RUMBLE STRIPS AND RUMBLE STRIPES

- Rumble Strips and/or Stripes are to be provided on new and applicable existing roadways in accordance with this memorandum and as recommended by Design Engineer and approved by the responsible District Traffic Engineer in consultation with the Resident Engineer/Administrator.

- Per a 2013 VDOT agreement with FHWA, neither a Design Waiver (DW) nor Design Exception (DE) is required for the installation of Rumble Strip/Stripe as a retrofit project.

- Rumble Strips and/or Stripes may be implemented as a safety countermeasure device to mitigate roadway departure crashes on highways that do not have adequate shoulder or clear zone width.

- Rumble Strips and/or Stripes may be either "Continuous" or "Intermittent" and are applicable as shown in Table 1.

- Rumble Strip and/or Stripe installation on the outside (right) shoulder of Non-Controlled Access roadways shall use an "Intermittent" groove pattern to provide gaps between the milled grooves for cyclist comfort and maneuverability when transitioning from one side of the grooves to the other.

Table 1: Rumble Strip/Stripe Patterns and Applications:

Standard	Functional Classification	Roadway	Location	Pattern
RS-1	Interstate Freeway Expressway	Fully-Controlled Access – Divided (with median)	Median and/or Outside Shoulder	Continuous
RS-4 RS-5	Rural Arterial Rural Collector Rural Local	Partially- and Non-Controlled Access (with median)	Median Shoulder	
RS-3		Partially- and Non-Controlled Access – Undivided (or with flush medians)	Centerline	
RS-4 RS-5 RS-6		Partially- and Non-Controlled Access – Divided or Undivided (with or without median)	Outside Edge Line or Shoulder	Intermittent

Notes:
1) VDOT classifies a roadway segment with two-way center left lanes as a "divided roadway with flush median".
2) For information on "Fully-Controlled Access", "Partially-Controlled Access" and "Non-Controlled Access", see the AASHTO Green Book, Chapter 2.

- Rumble Strips and Rumble Stripes are <u>not</u> appropriate for bridge decks, ramp gore areas, surface drainage structures, railroad crossings, marked crosswalks, intersection areas, or other areas identified by the responsible District Traffic Engineer in consultation with the Resident Engineer/Administrator.

- As with any project that increases impervious area, the Environmental Division shall be consulted when adding shoulder pavement with Rumble Strips or Rumble Stripes to determine if a Programmatic Categorical Exclusion (PCE) will be required.

CRITERIA FOR DETERMINING USE OF RUMBLE STRIPS AND RUMBLE STRIPES

- Rumble Strips are appropriate for rural interstates and may be appropriate for urban interstates.

- Rumble Strips or Stripes are appropriate for new rural freeway, expressway, arterial, collector, and local roadway segments that are being constructed or for existing segments, particularly those being resurfaced or reconstructed, and those with adequate pavement condition for mill in place installation.

- Rumble Strips or Stripes may be appropriate for other urban roadway classifications where studies indicate a history or potential of roadway departure crashes.

- The responsible District Traffic Engineer will verify that Rumble Strips/Stripes are an appropriate measure through an engineering study and consultation with the Resident Engineer/Administrator, District Maintenance Engineer, and District Materials Engineer. The following factors should be considered when determining and prioritizing roadways for Rumble Strip/Stripe installation:

  - History of Roadway Departure crashes for the past 3-5 years or potential for future crashes.
  - Roadway geometry (horizontal alignment, lane and shoulder widths, roadway access, roadside design) and continuity along a route corridor or segment.
  - Traffic volumes (AADT) and percent heavy vehicles.
  - Design Speed / Posted Speed.
  - Pavement conditions (depth and existing quality).
  - Roadway Functional Classification / type of facility.
  - Adjacent land use.
  - Traffic Control Devices present or planned.

- In general, if resources are limited, first priority should be given to higher-speed routes with higher traffic volumes and a history of, or potential for, Roadway Departure crashes.

POLICY FOR RUMBLE STRIP/STRIPE FOR TRAVEL LANE & PAVED SHOULDER WIDTHS

- When evaluating travel lanes and paved shoulders for the application of centerline and/or shoulder Rumble Strips/Stripes, the following items shall be considered:

  - Minimum of 4-inch travel lane pavement depth and sufficient condition determined by the District Materials Engineer to effectively accept the milling process without raveling or deteriorating. Otherwise, the travel lane should be upgraded prior to milling. See the most recent Road and Bridge Specifications Section 315 for other pavement considerations.
  - Minimum of 2-inch shoulder pavement depth and sufficient condition determined by the District Materials Engineer to effectively accept the milling process without raveling or deteriorating. Otherwise, the shoulder pavement should be upgraded prior to milling.
  - For Fully-Controlled Access roadways the location of the Shoulder Rumble Strip is set by Standard RS-1.
  - For Partially- and Non-Controlled Access roadways, the location of Shoulder Rumble Strips/Stripes will depend on the width of the paved shoulder. The Design Engineer, in consultation with the responsible District Traffic Engineer and the Resident Engineer/Administrator, has discretion for the installation of Centerline Rumble Stripes and the lateral placement of Shoulder Rumble Strips/Stripes to abate noise concerns and to provide accommodations for non-motorized users as shown in Figure 1 and as follows:

- On divided highways, travel lanes shall be 11.0 feet or wider measured from center of markings where median (left) or shoulder (right) Rumble Strips/Stripes are installed. Median (left) paved shoulder widths 1.0 foot or wider left of the travel lane edge line will accommodate a RS-4 Rumble Stripe. Median paved shoulder widths 2.0 feet or wider will accommodate a RS-5 Rumble Strip.

- For two-lane undivided highways, the through travel lane widths shall be greater than 9.0 feet when centerline Rumble Stripes (RS-3) are installed without shoulder Rumble Strips/Stripes. Travel lane widths shall be greater than 11.5 feet where centerline Rumble Stripes are installed with shoulder Rumble Strips/Stripes, as shown in Table 2. On two-lane undivided roadways with less than 25 feet of total pavement width, Rumble Stripes (RS-4) may be placed on both sides of the road with 1-foot shoulders in lieu of placing centerline Rumble Stripes (RS-3). The decision on which rumble groove – centerline or shoulder – to install on such roadways may be guided by the history of Roadside Departure characteristics.

Table 2: Rumble Strip/Stripe Installation for Two- Lane Undivided Roadways

Total Width (ft)	Travel Lane Width (ft) Note 1	Paved Shoulder Width (ft)	RS-3	RS-4	RS-5	RS-6	Pavement Wedge
20-24	9 - 12	0-1	Note 2	Note 2			Preferred
25	10 - 11.5	1 - 2.5	✓	Note 3			Preferred
26	11.5 - 12	1 - 2	✓	Note 3		Note 4	Preferred
27 - 30	11.5 -12	1.5 - 3.5	✓	Note 3		Note 4	Preferred
31 - 33	11.5 -12	3.5 - 5	✓	✓			Preferred
≥ 34	≥ 11.5	≥ 5	✓	✓	Note 5		Optional

Notes:
1) Travel lane widths are measured from center of centerline to outside edge of the edge line.
2) When less than 25 feet of total pavement width is available, RS-3 *or* RS-4 (9-inch rumble stripes) may be installed at the direction of the responsible District Traffic Engineer based on the crash experience of the subject roadway segment.
3) RS-4 may be installed when the paved shoulder is between 1'-0" and 1'-6" or ≥ 3'-6".
4) RS-6 may be installed when the paved shoulder is between 1'-6" and 3'-6".
5) RS-5 may be installed when paved shoulder is ≥ 5'-6".

- On Non-Access Controlled highways where bicycle accommodations are provided, a minimum of 4 feet of pavement should be provided outside (to the right) of the milled Rumble Strip or Stripe if no other obstacles are present adjacent the travel lane, such as a barrier. A minimum of 5 feet of paved shoulder outside of the groove is preferred where obstacles exist adjacent the travel lane. RS-4 and RS-5 are applicable for such wider paved shoulders (i.e., $\geq$ 4.5 feet and $\geq$ 5.5 feet, respectively). Additional graded shoulder width may also be necessary if horse and buggy traffic is present or expected.

- On Non-Access Controlled highways, where the outside (right) paved shoulder is between 1.0 feet and 1.5 feet or is greater than 3.5 feet, a RS-4 edge line Rumble Stripe may be installed. Where these minimal shoulder widths exist, cyclists are expected to occupy the travel lane. The 3.5-foot wide and wider shoulders with Rumble Stripes provide early audible warning of errant vehicles and offer cyclists the option of cycling on 3 feet or more of paved surface to the outside of the grooved rumbles.

- On Non-Access Controlled highways, where the paved outside (right) shoulders are between 1.5 feet and 3.5 feet wide, RS-6 places the Rumble Strip on the outside edge of the pavement to maximize the available area for cyclists between the grooves and the travel lane.

- On Non-Access Controlled highways with variable outside paved shoulder widths less than 3.5 feet, the Design Engineer should coordinate with the jurisdiction and the District Bicycle and Pedestrian Coordinator to determine expected non-motorized use and to define the preferred standard, RS-4 or RS-6. The selected standard and design should consider continuity of the shoulder rumble groove offset between major intersections/interchanges, physical and jurisdiction boundaries, and anticipated users. Installation of Rumble Strips/Stripes on short segments of roadway, such as paving project limits less than one mile, are acceptable and encouraged but should be designed in anticipation of a consistent cross-section and Rumble Strip/Stripe standard with future projects along a corridor. A corridor Rumble Strip/Stripe plan should be developed to establish short, medium, and long term designs for various segments of each route.

- Additional graded shoulder width to provide at least 4 feet of vehicle recovery area outside of the edge line is preferred. This decision will be made at the joint discretion of the responsible District Traffic Engineer, Resident Engineer/Administrator, District Materials Engineer, and the Design Engineer.

- An offset of at least 36 inches (measured from the outside right edge) is required for installation of milled grooves adjacent to fixed objects/barriers to accommodate the installation equipment. Locations with less than 36-inch offset shall be documented in each contract to be omitted from installation.

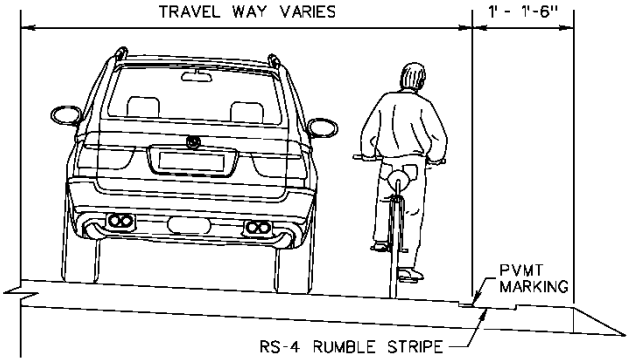
- For new construction or paving projects with shoulders 4 feet wide or less, a Pavement Shoulder Wedge should be installed in accordance with IIM-MD-002 and VDOT Special Provision SP315-000320-00. Pavement Shoulder Wedge is optional but encouraged for shoulder pavement construction and maintenance projects where the shoulder is greater than 4 feet. For Non-Access Controlled highways, adding Shoulder Pavement Wedge to shoulder construction and maintenance contracts is strongly encouraged to enhance pavement edge preservation and to promote safer recovery for motorists and non-motorized users where rutting has occurred.

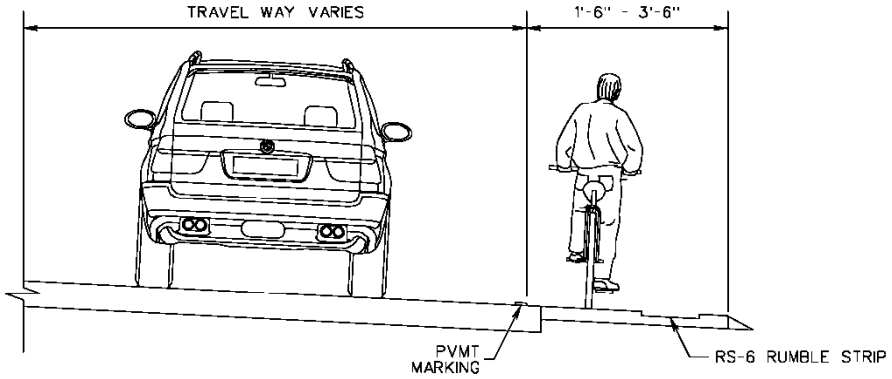
- Rumble Strips/Stripes shall not be installed:

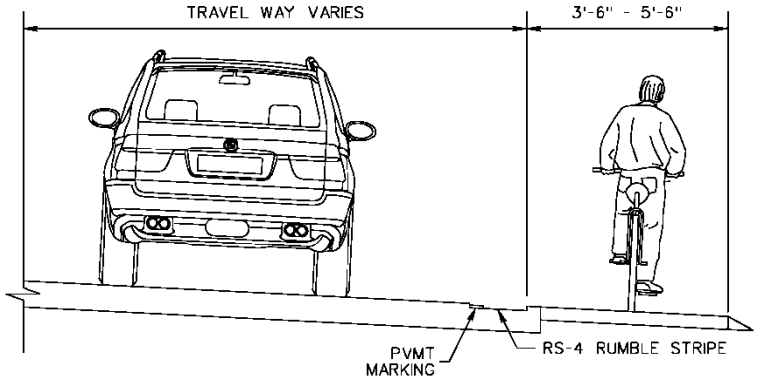
  - within limits of bridges, physical gore areas, or median cross-overs;
  - within limits of public roadways, commercial entrances, marked crosswalks, and railroad crossings as directed by the Design Engineer per the standard;
  - within the limits of bridge drainage aprons, two-way left turn lanes (designated as divided roadway with flush median), or special design shoulder slot inlets;
  - on subdivision streets; or,
  - on unmarked roadway pavement segments.

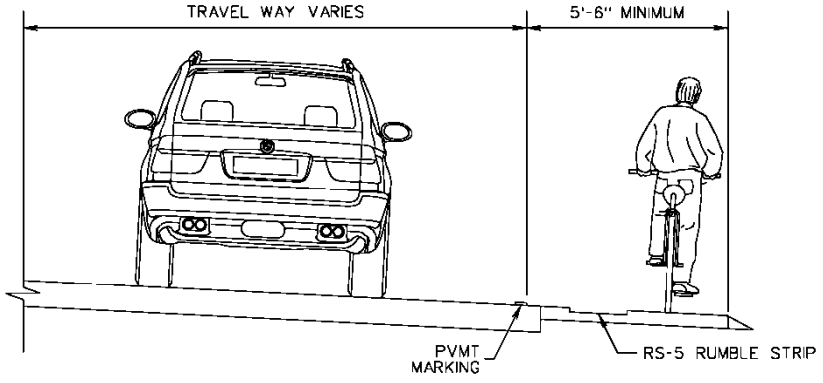
Figure 1: Shoulder Rumble Strip/Stripe Options on Partially- and Non-Controlled Access Roadways

PAVED SHOULDER WIDTH	RUMBLE STRIP(E)
0' - 1'	NONE
> 1' - 1.5'	RS-4 RUMBLE STRIPE
> 1.5' - 3.5'	RS-6 RUMBLE STRIP
> 3.5' - 5.5'	RS-4 RUMBLE STRIPE
> 5.5'	RS-5 RUMBLE STRIP OR RS-4 RUMBLE STRIPE









CONTINUOUS GROOVE SHOULDER RUMBLE STRIP, STANDARD RS-1

- For Rural Roadways with Fully-Controlled Access, Continuous Groove Shoulder Rumble Strip Standard RS-1 is to be specified for Outside (Right) and Median (Left) Paved Mainline Shoulders.

- Based on crash history and engineering judgement, RS-1 may be installed along acceleration/deceleration lanes and ramp lanes at the discretion of the responsible District Traffic Engineer in consultation with the Resident Engineer/Administrator.

- Continuous Groove Shoulder Rumble Strip shall be milled into asphalt concrete pavements as shown on the section views in Standard RS-1, and as follows:

  - 7 inches wide by 16 inches across by ½ inch deep with 12-inch leading edge spacing.

  - 6-inch positive offset from the outside edge line or 5-inch positive offset from the median edge line.

  - The groove shall be a minimum of 4 inches from surface course pavement joints as shown in RS-1 with the joint between the edge line and groove. The joint may be placed outside of the groove as directed by the Design Engineer.

- RS-1 cut into existing pavements shall be coated with liquid asphalt emulsion following VDOT Specifications and Special Provisions. Emulsion coating of new/resurfaced asphalt pavements is not required but may be specified at the discretion of the District Materials Engineer.

CENTERLINE RUMBLE STRIPE, STANDARD RS-3

- For New and Existing Undivided Partially and Non-Access Controlled Roadways, Centerline Rumble Stripe (CLRS), Standard RS-3, is to be specified by the Design Engineer and/or responsible District Traffic Engineer (in consultation with the Resident Engineer/Administrator) based on the following:

  - Speed limit ≥ 45 mph.
  - Through travel lane widths for undivided highways when installed alone or with shoulder rumble grooves, as shown in Table 2. For multi-lane undivided roadways, the center lane shall be ≥ 11.5 feet from crown to center of skip lane marking.
  - Pavement depths and condition.
  - Adjacent land-uses with noise sensitive areas shall be considered as provided below under noise concerns.

- For existing roadways, first priority when considering installation of CLRS should be given to routes with a speed limit ≥ 55 mph, higher traffic volumes, and a history of Roadway Departure crashes that involved crossing the centerline.

- CLRS grooves shall be milled into asphalt concrete pavements as shown on the section and plan views in Standard RS-3 and as follows:

  - 7 inches by 16 inches across by 3/8 inch deep, and spaced 12 inches apart from leading edge to leading edge in No-Passing Zones.
  - The 16-inch length accommodates installation of raised pavement markers following the preferred PM-8 Type C configuration.
  - CLRS may only be installed in Passing Zones when directed by the responsible District Traffic Engineer (in consultation with the Resident Engineer/Administrator) based on evaluation of traffic crash types and patterns. When CLRS are installed in existing Passing Zones, the groove spacing may be increased to 24 inches and/or, alternatively, only placed on the skip line segments. The contract documents should be specific about the chosen design and locations.

- CLRS grooves milled into existing pavements shall be coated with liquid asphalt emulsion following VDOT Specifications and Special Provisions. However, following Specifications in Sections 315, 512 and 704, additional maintenance of traffic and cure time will be necessary prior to installing pavement markings. Exceptions to the coating of CLRS milled into existing pavements must be approved by the District Materials Engineer and provided in the project contract. Emulsion coating of new/resurfaced asphalt pavements is not required but may be specified and applied at the discretion of the Design Engineer.

EDGE LINE RUMBLE STRIPE – STANDARDS RS-4

- On non-interstate/freeway/expressway roadways, Standard RS-4 Rumble Stripes are the preferred Roadway Departure safety countermeasure. In addition to providing maximum warning to the driver, Rumble Stripes also extend the life and visibility of edge line pavement markings.

- For New and Existing Divided and Undivided Non-Access Controlled roadways, Edge Line Shoulder Rumble Stripes, Standard RS-4, is to be specified by the Design Engineer and/or responsible District Traffic Engineer (in consultation with the Resident Engineer/Administrator) based on the following:

  - Speed limit $\geq$ 45 mph.
  - Through Travel Lane Widths $\geq$ 11.5 feet when installed with centerline Rumble Stripes on undivided roadways.
  - Milled with continuous grooves on divided roadway median (left) side paved shoulders $\geq$ 1.0 feet.
  - Paved outside (right) shoulder widths between 1 and 1.5 feet or $\geq$ 3.5 feet (see Figure 1 and Table 2).
  - Additional graded shoulder width may also be necessary if horse and buggy traffic is present or expected.
  - Pavement depths and condition.
  - Adjacent land-uses. Noise sensitive areas shall be considered as provided below under noise concerns.

- Edge line Rumble Stripe grooves shall be milled into asphalt concrete pavements as shown on the section and plan views in Standard RS-4 and as follows:

  - 7 inches by 9 inches across by 3/8-inch deep, spaced 12 inches apart, leading edge to leading edge.
  - The groove shall a minimum of 4 inches from surface course pavement joints with the joint outside of the groove as directed by the Design Engineer.
  - Intermittent 15-foot gap provided between each 45-foot section of Rumble Stripe grooves on the outside (right) shoulder. The layout should attempt to align gaps to align with residential driveways, so the length of the grooved sections may vary according to the Design Engineer's design.

- RS-4 grooves milled into existing pavements shall be coated with liquid asphalt emulsion following VDOT Specifications Sections 315, 512 and 704 and Special Provisions. However, additional maintenance of traffic and cure time will be necessary prior to installing pavement markings. Emulsion coating of new/resurfaced asphalt pavements is not required but may be specified and applied at the discretion of the Design Engineer.

EDGE LINE SHOULDER RUMBLE STRIP, STANDARD RS-5

- Edge Line Shoulder Rumble Strip, Standard RS-5, should be specified for paved shoulders on appropriate higher classification (such as principle arterials), Partially-Controlled and Non-Controlled Access roadways based on the following:

  - Speed limit ≥ 45 mph.
  - Lane widths ≥ 11 feet on divided roadways and ≥ 11.5 feet when installed with centerline Rumble Stripes on undivided roadways.
  - Milled with continuous grooves on divided roadway median (left) side paved shoulders ≥ 2.0 feet.
  - If there is a potential for cyclists on the roadway, RS-5 is only recommended where at least 5.5 feet of right shoulder pavement width is available (see Figure 1 and Table 2). A 5-foot paved shoulder outside of the groove is desirable, particularly if adjacent obstructions are present such as guardrail. If less than 5.5 feet of paved shoulder width is available, RS-4 (shoulder width ≥ 3.5 feet) or RS-6 (1.5 feet ≤ shoulder width < 3.5 feet) are recommended to minimize potential impacts to cyclists.
  - Additional graded shoulder width may also be necessary if horse and buggy traffic is present or expected.
  - Pavement depths and condition.
  - Adjacent land-uses. Noise sensitive areas shall be considered as provided below under noise concerns.

- Edge Line Shoulder Rumble Strip, RS-5, shall be milled into asphalt concrete pavements as follows:

  - 7 inches by 9 inches across by 3/8 inch deep, spaced 12 inches apart from leading edge to leading edge.
  - The groove shall be a minimum of 4 inches from surface course pavement joints as shown in RS-5 with the joint between the edge line and groove. The joint may be placed outside of the groove as directed by the Design Engineer.
  - Intermittent 15-foot gap provided between each 45-foot section of Rumble Strip grooves on the outside (right) shoulder. The layout should attempt to align gaps in groove sections with residential driveways, so the length of the grooved section may vary based on the Design Engineer's design.

- RS-5 milled into existing pavements shall be coated with liquid asphalt emulsion following VDOT Specifications Sections 310, 315, 512 and 704 and Special Provisions. Emulsion coating of new/resurfaced asphalt pavements is not required but may be specified and applied at the discretion of the District Materials Engineer.

SHOULDER EDGE RUMBLE STRIPS, STANDARD RS-6

- On roadways with paved outside (right) shoulder width between 1 and 3.5 feet , Standard RS-6 is appropriate on Partially-Controlled and Non-Controlled Access roadways based on the following:

  - Speed limit ≥ 45 mph.
  - Lane widths ≥ 11 feet on divided roadways and ≥ 11.5 feet when installed with centerline rumble stripes on undivided roadways.
  - Milled in conjunction with RS-4 or RS-5 continuous grooves specified for divided roadway median (left) side paved shoulders ≥ 1.0 feet.
  - A minimum of 3 inches shall be provided to the edge of pavement for new construction or paving projects. Adding a Pavement Shoulder Wedge (IIM-MD-002) is preferred and strongly encouraged when RS-6 is installed to ensure the integrity of the pavement edge. The layout should provide a single offset dimension from the edge line for variable shoulder widths between 1.5 and 3.5 feet such that the Rumble Strips do not encroach on the 3-inch minimum offset for the length of the project. On a given route the same rumble groove offset should be maintained for visual and functional continuity.
  - Pavement depths and condition.
  - Adjacent land-uses. Although fewer encroachments than the other Rumble Strip/Stripe designs are expected, noise sensitive areas shall be considered as provided below under noise concerns.

- Shoulder edge Rumble Strips, RS-6, shall be milled as follows:

  - 7 inches by 9 inches across by 3/8 inch deep, spaced 12 inches apart from leading edge to leading edge.
  - Intermittent 15-foot gap provided between each 45-foot section of Rumble Strip grooves on the outside (right) shoulder. The layout should attempt to align gaps in groove sections with residential driveways, so the length of the grooved rumble strip sections may vary according to the Design Engineer's design.
  - Shoulder edge Rumble Strips, RS-6, milled into existing pavements shall be coated with liquid asphalt emulsion following VDOT Specifications Sections 310, 315, 512 and 704 and Special Provisions. Emulsion coating of new/resurfaced asphalt pavements is not required but may be specified and applied at the discretion of the District Materials Engineer.

DESIGN CONSIDERATIONS FOR CYCLISTS

- A number of provisions have been incorporated in this guidance to better accommodate cyclists, including:

- Works from the premise that bicycles may be present on any Non-Controlled Access roadway and therefore builds in bicycle considerations into all shoulder Rumble Strip/Stripe options (except the RS-1). Since bicycle considerations are built in, it is no longer required, but is good practice, to seek the concurrence of the VDOT District Pedestrian and Bicycle Coordinator before a Rumble Strip or Rumble Stripe project is installed.
- Specifies that all Non-Access Controlled outside (right) shoulder / edge line Rumble Strip/Stripe options are Intermittent, to accommodate cyclist maneuverability between the travel lane and paved or unpaved shoulder.
- Increases the standard gap length for Intermittent Rumble Strips/Stripes from 12 to 15 feet long for every 45-foot section of rumble grooves.
- Includes the RS-6 directive to place Rumble Strip on the outside edge of pavement when the available shoulder width is between 1.5 and 3.5 feet, to maximize the shoulder width provided for cyclists. This improves upon the previous practice of placing rumble grooves in the middle of available narrow shoulder space, thereby creating an uneven surface where many cyclists prefer to ride when limited shoulder space is available.
- Makes the RS-4 standard the preferred treatment on Non-Access Control highways with paved shoulders between 1 and 1.5 feet wide or > 5 feet in width. This maximizes the number of roadways with a minimum 4-foot-wide paved shoulder for cyclists and will provide audible warning for cyclists when a motorist encroaches into the shoulder. Previously, when the RS-5 was used, some of the paved shoulder space was taken up by the buffer between the pavement marking edge line and Rumble Strip.
- Reduces the depth of the Rumble Strip from ½-inch to 3/8-inch deep grooves for all Rumble Strip/Stripe standards except the RS-1.

NOISE CONCERNS

- Noise concerns are more commonly associated with RS-3 (Centerline Rumble Stripe), RS-4 (Intermittent Shoulder Rumble Stripe), and to a lesser extent RS-5 (Intermittent Shoulder Rumble Strip). To minimize the opportunity for RS encroachments along the portions of a roadway corridor that have adjacent sensitive land uses situated within 250 feet of the travel way, the Design Engineer, in consultation with the responsible District Traffic Engineer and Resident Engineer/Administrator may adjust the installation based on engineering judgement as follows:

  - Omit the centerline Rumble Stripes (RS-3) in areas with sensitive noise receptors, particularly in passing zones.
  - Increase centerline Rumble Stripe (RS-3) spacing to 24-inch centers and/or only place within the limits of the passing zone skip lines.
  - Omit the RS-4, RS-5, or RS-6 Shoulder Rumble Strips/Stripes in areas with sensitive noise receptors.

- Concerns about noise pollution may arise when a Rumble Strip/Stripe project is installed at a location that did not previously have rumble grooves, especially in areas with residences, parks, or certain businesses. Three characteristics of noise are important to assessing the subjective community responses: intensity, frequency, and varying characteristics over time. Intensity is the measure of energy magnitude and is directly related to pressure. Pressure levels, sensed over wide ranges, are expressed in logarithmic scale units called decibels (dB). Frequency measures the tonal qualities of sound. People are more sensitive to sounds in middle to high frequencies. Studies have shown that the ambient noise decibel level generated by vehicles driving over ½-inch rumble grooves is comparable to that of a truck passing by on the travel lane, particularly at distances greater than 250 feet away. However, the noise from rumble grooves may be more noticeable as the public is more accustomed to truck noise, the frequency of the sound is different and rumble grooves tend to produce more short term impulse noise. Studies also indicate that the depth of the groove changes the noise level. So, the depth for all Rumble Strip/Stripe standards, except the RS-1, have been reduced to 3/8-inch deep grooves, which will result in a lower sound level compared to installations constructed prior to this version of the IIM.

METHOD OF SHOWING RUMBLE STRIPS/STRIPES IN THE PLAN ASSEMBLY

- Projects requiring the use of Rumble Strips/Stripes shall indicate the begin and end stations on the plan view for median, centerline, and outside shoulder locations. The limits shall include the Rumble Strip/Stripe standard to be used.

SUMMARIZATION AND PAYMENT

- Quantities for Rumble Strips and Rumble Stripes are to be shown in the Pavement Summary.

- Quantities will be shown as linear feet of “Rumble Strip” or “Rumble Stripe” regardless of type of application (continuous/intermittent/centerline) or method of pavement marking (strip or stripe). Measurement is to include the length of application, measured longitudinally along the edge of pavement in the field and paid for in linear feet of shoulder where actually placed and accepted (excluding test site).

- Deductions are to be taken for bridge decks, acceleration/deceleration lanes, gore areas, intersections, driveways, crossovers, surface drainage structures, and other sections where the Rumble Strips or Rumble Stripes are not to be installed.

- For Intermittent outside (right) Shoulder Rumble Strips (RS – 4, 5, and 6), there is to be no deduction in measurement for the 15-foot gap between the 45-foot grooved sections, except as noted above.

- When Rumble Strips/Stripes are installed in existing asphalt concrete pavement, the entire Rumble Strip/Stripe area shall be coated with Liquid Asphalt Coating. This coating shall be measured and paid for in square yards, estimated as follows:

  - For 16-inch groove – Pay area shall be 20 inches (0.556 yd.) times the length of Rumble Strip/Stripe application, measured longitudinally along the edge of pavement.

  - For 9-inch groove – Pay area shall be 11 inches (0.306 yd.) times the length of Rumble Strip/Stripe application, measured longitudinally along the edge of pavement.

- Overspray shall not extend more than 2 inches beyond the width of cut and/or shall not come in contact with pavement markings.

- The following pay items have been established (applicable to Continuous Shoulder, Intermittent Shoulder, and Centerline applications):

Pay Item	Pay Unit	Item Code
Rumble Strip (Asphalt)	Lin. Ft.	10700
Rumble Stripe (Asphalt)	Lin. Ft.	10700
Liquid Asphalt Coating (Rumble Strip/Stripe)	S.Y.	10701
Rumble Strip (Concrete)	Lin. Ft.	10702

SPECIFICATIONS

- The most recent, as revised with Special Provisions, Road and Bridge Specifications shall be used for Rumble Strip/Stripe installation and is available at: http://www.virginiadot.org/business/const/spec-default.asp

- Changes or additions to the most recent Road and Bridge Specifications and Special Provisions shall be included in contracts as project specific Special Provisions.