



Rumble Strip Guidelines

Background

New Hampshire's Strategic Highway Safety Plan (SHSP) – also referred to as *Driving Toward Zero - One Death is Too Many*, provides a comprehensive framework of specific goals, objectives, and strategies for reducing traffic fatalities and serious injuries in New Hampshire. Rumble strips are one of the predominant engineering strategies specified in the SHSP to reduce fatalities and serious injuries for lane departures.

These Rumble Strip Guidelines provide direction for the use of milled rumble strips on New Hampshire highways. These guidelines will be used in conjunction with the NHDOT Rumble Strip Special Details. These guidelines and plans supersede previously issued rumble strip guidance.

Purpose

Rumble strips are proven safety countermeasures which use tactile vibration and audible rumbling to alert inattentive drivers of a potential lane departure. Longitudinal rumble strips are effective in providing lane departure warnings when a vehicle drifts out of the travel lane.

Run off the road crashes, sideswipe and head-on collisions due to fatigued, inattentive or impaired drivers are a major contributor to New Hampshire's fatal and injury crashes. Rumble strips are placed as a proactive countermeasure to address lane departure resulting from driver error.

Lane departure crashes are a system-wide problem and rarely occur at the same location twice, therefore the Federal Highway Administration (FHWA) and the NHDOT recommend rumble strips be installed proactively and systemically, along stretches of roadways with particular characteristics, rather than reactively in response to particular crashes that which occurred.

Because centerline and shoulder rumble strips are recognized by FHWA as a proven low cost safety countermeasure, a project-specific cost-benefit analysis is not required for rumble strips to be eligible for Highway Safety Improvement Program (HSIP) federal funding.

Context Sensitive Design

The frequency of the sound from rumble strips is different depending upon the geometric patterns (i.e., rectangular corrugated versus sinusoidal) and the depths and widths of the rumble strips. Depending upon the pattern, some rumble strip strikes tend to cause more of an impulse noise.

Studies have shown that the noise level generated by a vehicle driving over a rectangular corrugated rumble strip is comparable to that of a heavy truck passing by on a standard pavement with no rumble strips. The noise and vibration from vehicle strikes of rectangular corrugated rumble strips are more noticeable than vehicle strikes of sinusoidal rumble strips within both the vehicle and the surrounding environment. The external and internal noise and vibration levels of a vehicle strike over a sinusoidal rumble strip are lower and may not be perceptible by heavy trucks.

To address rumble strip noise concerns, NHDOT has implemented the following strategies on Tier 2, 3 and 4 roadways which meet the minimum requirements (i.e., minimum speed limit 40 mph and minimum pavement width 28 feet) for their installation:

- Sinusoidal rumble strips will be specified on the centerlines of undivided highways with shoulders of any width in passing zones
- Sinusoidal rumble strips will be specified on the centerlines of undivided highways when one or both shoulder widths is less than 10 feet
- Shoulder rumble strips will be offset 12 inches from the white edge line to reduce the occurrence of errant strikes
- Rectangular corrugated rumble strips will be specified on the centerlines of undivided highways when both shoulder widths are greater than or equal to 10 feet
- Edge line rumble strips will only be considered in special applications
- There are many variations of the sinusoidal rumble strip pattern which have been tested for exterior noise level and their effectiveness in alerting a driver who has departed their travel lane. NHDOT has selected the pattern described below due to its reduced exterior noise while still providing adequate driver feedback for passenger cars as well as pickup trucks.

Recent research by the Minnesota Department of Transportation concludes the optimal sinusoidal design has a 14" long wavelength which varies in depth between $\frac{1}{16}$ " below the pavement surface to $\frac{1}{2}$ " below the pavement surface. This recommended sinusoidal pattern generates an internal noise above the minimum recommended levels from NCHRP Report 641 for passenger cars and pickup trucks. The internal noise generated by the rectangular corrugated rumble strip pattern is more noticeable for pickup trucks and heavy trucks. Another advantage of the sinusoidal rumble pattern is that it allows for a fully recessed pavement marking, which is anticipated to extend the service life of the roadway centerline pavement markings.

For Tier 1 Highways (Interstates, Turnpikes and divided highways), the use of rectangular corrugated rumble strips will be utilized in the shoulders for maximum safety effect for all vehicle classifications, including heavy trucks.

Rumble Strip Terminology

Rumble Strip Patterns

Rectangular Corrugated Rumble Strip

A rumble strip pattern which consists of milled rectangular shaped corrugations or grooves of a certain shape, dimension and frequency in the pavement.

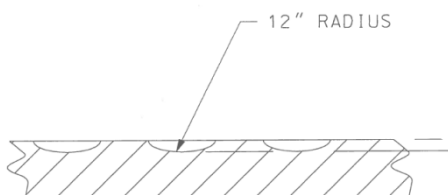


Figure 1. Rectangular Corrugated Rumble Strip – Longitudinal Section

See Rumble Strip Details and Special Provisions for additional information

Sinusoidal Rumble Strip

A rumble strip pattern which consists of a continuously-milled sine wave developed to produce less exterior noise than the rectangular corrugated rumble strip.

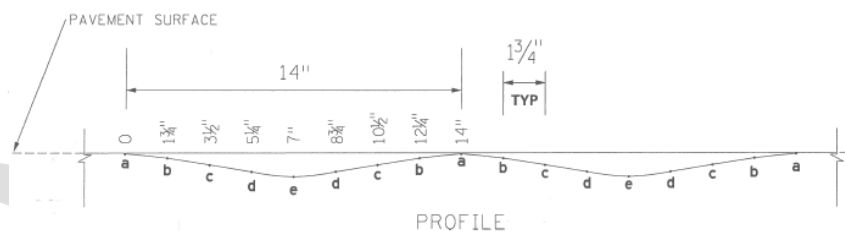


Figure 2. Sinusoidal Rumble Strip - Longitudinal Section

See Rumble Strip Details and Special Provisions for additional information

Rumble Strip Locations

Centerline Rumble Strips (CRS)

Rumble strips milled directly under the centerline on undivided highways.

Shoulder Rumble Strips (SRS)

Rumble strips milled in the shoulder of divided and undivided highways, offset a fixed distance from the edge line.

Edge Line Rumble Strips (ERS)

Rumble strips milled under the edge line and extending into the shoulder of divided and undivided highways.

Layout

Replacement of Existing Installations

Document the existing rumble strip layout, including CRS and SRS gaps for major drives. Revise layout, gaps and rumble strip pattern (i.e., corrugated or sinusoidal) and consider installation of SRS as necessary to meet these Guidelines.

New Installations and Replacement of Existing Installations

The types and limits of the rumble strips, including gaps in CRS and SRS for major drives, will be conveyed via straight-line diagrams, annotated aerial photos or other methods in the contract documents. The contractor shall lay out the limits of the rumble strips on the roadway and NHDOT will verify the layout meets these Guidelines. Language will be included in the Prosecution of Work to require proper time notification for review of rumble strip layout prior to milling.

Public Outreach

For new rumble strip installations on Tier 2, 3, 4 highways, written correspondence to public officials in each municipality is required and a Public Informational or Public Officials Meeting will be offered. Public Informational Meetings may include multiple municipalities.

For replacement of existing rumble strip installations on Tier 2, 3, 4 highways, outreach will be via a letter notifying the municipality of the scope of the project and the intent to reinstall the rumble strips.

Public outreach is not required for rumble strip installations on Tier 1 highways.

The intent of the public outreach is to advise the municipality of the planned rumble strip installation, develop community understanding and acknowledgement and solicit local input on extents of installations, major drives and any particular areas of concern, especially sensitive noise receptors, etc.

Documentation

Any deviation from these Rumble Strip Guidelines will be documented.

Rumble Strips on Divided Highways (Tier 1)

Shoulder Rumble Strips (SRS)

Shoulder rumble strips will be installed on all Tier 1 Interstate and Turnpike Highways and similar Limited Access divided highways.

Right Side Shoulders

- Depth will be 1/2 inch
- Width will be 16 inches
- Location will be 30 inches from the outside of the edge line
- SRS will not be installed on bridge decks
- Terminate SRS 30 feet before at-grade bridges and begin SRS 30 feet after to eliminate conflicts with at-grade approach slabs
- Install SRS on fill-over bridge structures

Ramp starting and stopping locations

Off ramps: Terminate SRS when the shoulder either gets narrower than 6 feet or at the beginning of the concrete nose

Mainline: Begin at beginning of pavement marking gore for the off ramp
Terminate at end of pavement marking gore for on ramp

On ramps: Begin at end of the concrete nose as long as the shoulder is wider than 6 feet throughout the length of the acceleration lane

At cloverleaf interchanges that have high volume and the acceleration lane is also the deceleration lane, consideration should be given to start the SRS 500 feet to 1000 feet beyond the off ramp nose

If the ramp continues as a multi-lane roadway beyond the nose, consideration should be given during the design phase to extend SRS beyond the nose.

Left Side Shoulders (Median side)

- Depth will be 1/2 inch
- Width will be 16 inches
- Location will be 6 inch from the outside of the edge line or 30 inches from the outside of the edge line for shoulders 10 feet and wider
- SRS will be installed in shoulders with and without guardrail
- Under special circumstances, the location may be directly beneath the edge line with the remaining 10 inches extending into the shoulder area.

Median Crossovers (Starting and Stopping locations)

- Terminate SRS 130 feet before and begin SRS 50 feet after.

Rumble Strips on Undivided Highways (Tier 2, 3, 4)

Centerline Rumble Strips (CRS)

Centerline rumble strips will be installed on undivided highways with the following characteristics:

Posted speed limit of 40 mph or greater

Pavement width of 28 feet or greater

Pavement surface in good condition

Minimum wearing course depth and pavement condition will be evaluated by the Bureau of Materials & Research, Pavement Management Section.

If the above criteria are met for installation of CRS, the CRS pattern will be as follows;

- Sinusoidal rumble strips will be specified on the centerlines of undivided highways when one or both shoulder widths is less than 10 feet
- Rectangular corrugated rumble strips will be specified on the centerlines of undivided highways when both shoulder widths are greater than or equal to 10 feet
- Sinusoidal rumble strips will be specified on the centerlines of undivided highways in all passing zones
- Sinusoidal CRS may be used instead of rectangular corrugated CRS in areas where an excessive number of gaps for major drives and/or the number of short distances between passing zones result in lack of or inefficient CRS placement.

The sinusoidal centerline rumble strip will be 12 inches wide, with a 14 inch long wavelength which varies in depth from $\frac{1}{16}$ inch below the pavement surface to $\frac{1}{2}$ inch below the pavement surface. See details and specifications for additional information.

The rectangular corrugated rumble strip will be 12 inches wide with a 12 inch cycle length, maximum $\frac{1}{2}$ inch below the pavement surface and 7 inches long parallel to centerline (resulting in 5 inches of unmilled pavement between corrugations). See details and specifications for additional information.

Centerline Rumble Strips (CRS) (cont.)

Centerline rumble strips will be discontinued at

Two-Way Left Turn Lanes

Bridge Decks

- Terminate CRS 30 feet before at-grade bridges and begin CRS 30 feet after to eliminate conflicts with at-grade approach slabs

Intersections with no turn lanes or painted islands - starting and stopping locations:

- Terminate CRS where radius point of side road meets mainline highway edge of pavement
- Begin CRS where radius point of side road meets mainline highway edge of pavement

Intersections with left turn lanes - starting and stopping locations:

- Terminate CRS where radius point of side road meets mainline highway edge of pavement
- Begin CRS where radius point of side road meets mainline highway edge of pavement

Intersections with raised islands - starting and stopping locations:

- When approaching an island and at the point where the double yellow lines diverge, the CRS will continue along the right double/single yellow line and terminate at the beginning of the raised island and/or begin at the end of the raised island

Intersections with Painted Medians - starting and stopping locations:

- At the point where the painted median starts (yellow lines diverge), CRS will only continue along the *left* yellow line(s) and terminate where radius point of side road meets mainline highway edge of pavement

At major drives, use the guidelines noted above for side roads (CRS will not be interrupted for low-volume drives).

Rumble Strips on Undivided Highways (Tier 2, 3, 4)

Shoulder Rumble Strips (SRS)

Shoulder rumble strips will be installed on undivided highways with these characteristics:

Posted speed limit of 40 mph or greater.

Paved shoulder minimum width 6 feet (7 feet minimum with guardrail or curb)

Pavement surface in good condition

Minimum wearing course depth and pavement condition will be evaluated by the Bureau of Materials & Research, Pavement Management Section.

Shoulder rumble strips will be of rectangular corrugated pattern. The shoulder rumble strips will be 12 inches wide with 12 inch cycle length, maximum $\frac{1}{2}$ inch below the pavement surface and 7 inches long parallel to centerline (resulting in 5 inch unmilled pavement between corrugations). See details and specifications for additional information.

Shoulder rumble strips will be offset 12 inches from the white edge line. Provide a minimum 4 feet (5 feet adjacent to guardrail or curb) clear area from edge of rumble strip to edge of pavement.

Shoulder rumble strips will have one 12 foot gap every 60 feet (48 feet rumble strip plus 12 feet gap) for bicyclists. Side road or major drive breaks may satisfy this requirement.

Shoulder rumble strips (SRS) will be discontinued at

Bridge Decks

- Terminate SRS 30 feet before at-grade bridges and begin SRS 30 feet after to eliminate conflicts with at-grade approach slabs

Intersections and major drives – starting and stopping locations:

- Where no right turn lane exists - terminate SRS 300 feet before pavement radius of the side road
- Where right turn lanes exist – terminate at the beginning of the edge line taper of the turn lane
- Where no left turn lane exists but there is a heavy left turn volume, terminate SRS 300 feet before the pavement radius of the side road
- Begin SRS 150 feet after the radius of the side road

Shoulder Rumble Strips (SRS) (cont.)

- If the highway has on and off ramps, terminate SRS at the edge line taper point

At major drives, use the guidelines noted above for side roads. (SRS will not be interrupted for low-volume drives).

Edge Line Rumble Strips (ERS)

Edge line rumble strips require the approval of the Executive Office.

Contact the Bureau of Highway Design, Safety Section for additional criteria and details on edge line rumble strips.

DRAFT

References

New Hampshire Strategic Highway Safety Plan, Driving Toward Zero, 2017 – 2021

https://www.nh.gov/dot/projects/documents/nhdot_strategic_highway_safety_plan_2017_2021.pdf

NHDOT Highway Tiers – Definitions

https://www.nh.gov/dot/org/projectdevelopment/planning/amps/documents/tier_definitions.pdf

NHDOT Tiers map

<http://nh.maps.arcgis.com/apps/webappviewer/index.html?id=1d83377ccf4d4236bb11f3de2b82eab5>

Research References

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