

RUMBLE STRIP DESIGN CHARACTERISTICS ON WAYSIDE NOISE

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1 Introduction

Rumble strips are a traffic safety measure designed to help drivers that are either distracted, sleepy or not paying attention, and as a result unintentionally stray off their lane. Rumble strips do this by generating noise inside the vehicle cabin. Noise is generated when the vehicles pass over irregularities created in the rolling surface of the road. The noise generated inside the cabin of the vehicle is intentional; in the sense that the higher noise levels generated from the rumble strips are desirable to be effective in alerting drivers. However, the use of rumble strips also generates increased noise level in the outside environment (wayside) when compared to pass-by of vehicles on a section of road without the rumble strips.

This paper reviews milled rumble strip design characteristics, with respect to exterior noise levels for automobiles. Overall noise levels, frequency spectra and tonal characteristics are considered with respect to rumble strip design.

2 Strip Design Characteristics

Although the optimum design dimensions for milled rumble strips depend on operating conditions, two key dimensions that have been noted in the literature to create the greatest effect on the vehicle alerting sound and vibration inside the vehicle: depth and width, where longitudinal to the road. Although several documents can be found about the design of rumble strips, not many review and take into consideration the wayside noise generated by traffic passing over the rumble strips.

Of the five milled rumble strips designs that were used for testing of exterior noise levels, there are three design characteristics that are the focus of this paper, with respect to their impact on overall noise level, frequency spectra and tonal characteristics:

- a) Width of strip
- b) Distance between strips
- c) Straight versus angled strip

Within construction tolerances, we expect that the rumble strips tested had the same relative depth.

3 Methodology

Milled rumble strips were installed in the section of Highway 58A in Welland, Ontario. All of the rumble strips designs are located at the edge of the shoulder on the north side of the highway.

Four light vehicles were used in the test, and included a Subaru Forrester, Ford C-Max, Chevrolet Volt and Toyota

Camry. Vehicles were running on the north shoulder of the highway, in order that measurement locations could be taken in the center of the road. This meant that the testing was conducted without other traffic on the highway to ensure that the results would not be affected by extraneous traffic.

Vehicle test runs were conducted to achieve 80 km/h over the rumble strips. Exterior noise measurements were done following the guidelines of AASHTO standard TP 98-13 [2], which defines that measurements are to be taken:

- 7.5 m away from the center of the travel lane; and
- 1.5 m above the roadway plane.

We note that the number of vehicle test runs do not comply with the minimum test run requirements in the standard, and as such the testing is not in full compliance with the AASHTO standard for data analysis.

4 Results

The following rumble strip groups are defined for the purpose of assessing rumble strip design characteristics. One rumble strip design was used as a control, and others with varying characteristics were compared to its results.

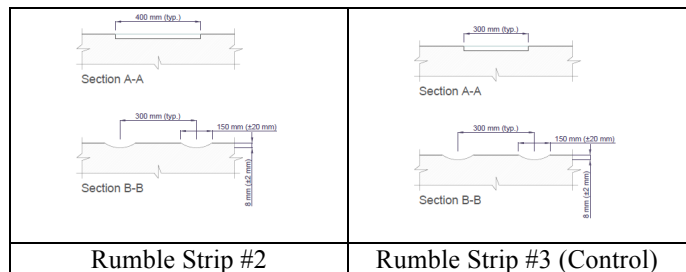


Figure 1 - Width of Strip

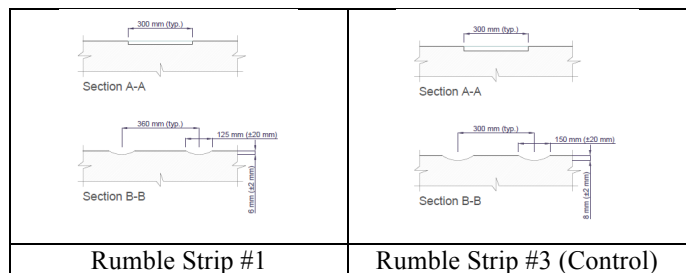


Figure 2 - Distance between Strips

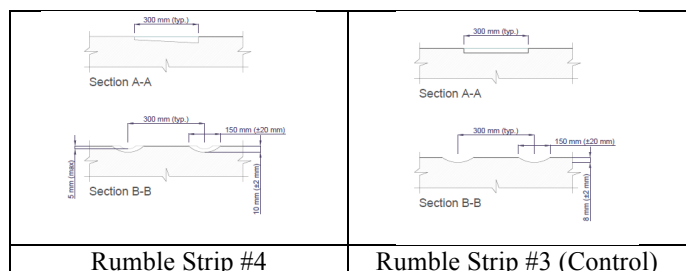


Figure 3 - Straight versus Angled Strip

The overall noise level change of the strip types compared to the control strip are provided in Table 1.

Table 1 – Rumble Strip Change in Overall Sound Level

Group	Control Strip dBA Level	Strip Type dBA Level	Difference[Δ in dB]
Width of Strip	86.4	86.9	0.5
Distance Between Strips	86.4	91.9	5.5
Straight versus Angled Strip	86.4	84.0	-2.4

Figure 4 shows the frequency spectra of the control strip compared to the strips with varying characteristics.

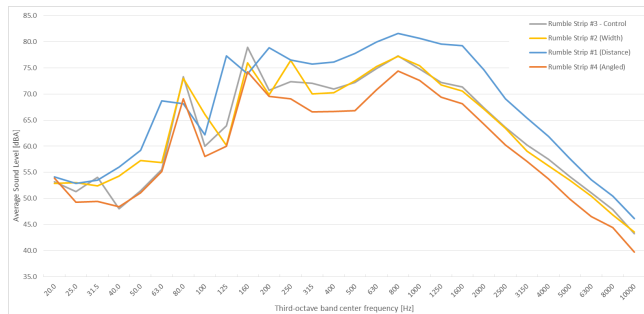


Figure 4 - Rumble Strip Change in Frequency Spectra

Table 2 compiles the tonal characteristics¹ of the control strip, and the changes in tonality with respect to the rumble strip design.

Table 2 – Rumble Strip Change in Tonal Quality

Group	Control Tonal Components [Hz]	Strip Type Tonal Components [Hz]
Width of Strip	80, 160	80, 160, 250
Distance Between Strips	80, 160	none
Straight versus Angled Strip	80, 160	80

5 Conclusion

Tests on milled rumble strips were conducted on Highway 58A in Welland, Ontario. The tests were conducted following as basis the AASHTO standard TP 98-13. The results presented in this paper were grouped in order to assess the change in wayside noise levels due to changes in rumble strip design.

The results shows that in terms of overall sound pressure level the following characteristics seem to affect the

¹ A tonal components was defined to exist when the sound pressure level for a third-octave band exceeded simultaneously the level of the adjacent bands by more than 5 dB

resultant wayside sound level in order of decreasing importance:

- An increase of the distance between strips seems to have a direct effect on the sound level, with an increase of 5.5 dB when distance between rumble strips is changed from 300 mm to 360 mm;
- An increase of the width of the rumble strip has marginal to no effect on the noise level, with an increase of only 0.5 dB; and
- An angled² design seems to have a reduction of the sound level. It cannot be determined if it is the angled design that makes it quieter, or if this is a consequence of having the smaller longitudinal width of the rumble strips facing the measurement location.

For the tonal quality of noise, in terms of the presence of tonal components, it seems that an increase of the distance between rumble strips reduces tonal components, while an increase of the width will have the opposite effect.

The angled strip² design has a small mitigating effect on the presence of tonal components. As stated for the sound levels assessment above, it cannot be determined from this investigation whether this is a consequence of the angled design, or the fact the longitudinal width facing the measurement location is smaller.

References

- [1] Amec Foster Wheeler, “Rumble Strips Noise Study”, October 2014
- [2] AASHTO standard TP 98-13 - Standard Method of Test for Determining the Influence of Road Surfaces on Vehicle Noise Using the Statistical Isolated Pass-By (SIP)
- [3] Federal Highway Administration, "Technical Advisory - Center Line Rumble Strips, T 5040.40, Revision 1," FHWA, November 7, 2011.
- [4] NCHRP 641 – National Cooperative highway Research Program Report #641, “Guidance for the Design and Application of Shoulder and Centerline Rumble Strips”.

² It should be noted that in the case of the angled design the sound levels were only evaluated on one side – the side with a smaller longitudinal width.