

# **Synthesis of Best Practices for the Implementation of Centreline and Shoulder Rumble Strips**

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## **Abstract**

Road and traffic professionals have used rumble strips for many years. More recently, highway authorities have adopted a more systematic application of rumble strips along shoulders. Shoulder rumble strips are warning devices intended to alert drivers that they are leaving (or have left) the travelled way and that a steering correction is needed to return to the travelled way.

Even more recent in the use of rumble strips is the implementation of rumble strips along the centreline of undivided roads. Few jurisdictions in North America have implemented centreline rumble strips in test situations to date. Like shoulder rumble strips, centreline rumble strips are warning devices intended to alert drivers that they are leaving the travelled way and that a steering correction is required to return to the travelled way. However, centreline rumble strips are intended to alert drivers that they have crossed the centre of the road and are travelling in the opposing traffic lanes.

In Canada, a number of Provinces have developed guidelines and policies for the implementation of shoulder rumble strips. Other Provinces wish to commence to apply shoulder and centreline rumble strips, however, they lack experience and require guidance based on other jurisdictions' results of such applications.

Currently, there are some inconsistencies in the terminology used by Canadian highway agencies in describing the dimensions and design parameters for shoulder rumble strips. There are also

discrepancies in the dimensions adopted. There is a need to harmonize the practice and identify the most effective design, taking into consideration all vehicles including trucks, bicycles and motorcycles. There is also a need to identify solutions for noise impact.

This paper will describe the best practices for the implementation of shoulder and centreline rumble strips based on in-depth information search, including the review of the results of an extensive practice survey and experimental testing completed by others throughout North America. This includes traffic noise measurements along rumble strips, and bicycle and truck safety and effectiveness when traversing rumble strips.

## **Résumé**

Les zones d'alerte sont utilisées depuis nombre d'années par les experts de la route et de la circulation. Toutefois, les administrations routières procèdent depuis peu à une application plus systématique des zones d'alerte sur les accotements. Ces zones sont des systèmes destinés à prévenir les conducteurs qu'ils quittent (ou ont quitté) la chaussée et qu'ils doivent rectifier leur trajectoire pour revenir sur la route fréquentée. L'aménagement de zones d'alerte le long de la ligne médiane des routes à chaussée unique est encore plus récente. À ce jour, seules quelques administrations en Amérique du Nord ont mis à l'essai des zones d'alerte installées sur la ligne médiane. Tout comme les zones d'alerte sur l'accotement, les zones d'alerte sur la ligne médiane servent à prévenir les conducteurs qu'ils dévient de la route fréquentée et qu'ils doivent rectifier leur trajectoire. Cependant, elles sont destinées à avertir les conducteurs qu'ils ont traversé le centre de la route et qu'ils conduisent en sens inverse de la circulation.

Au Canada, certaines provinces ont élaboré des lignes directrices et des politiques pour l'aménagement de zones d'alerte sur l'accotement. D'autres provinces souhaiteraient installer des zones

d'alerte sur l'accotement et sur la ligne médiane mais manquent d'expérience et requièrent l'expertise des autres administrations à cet égard.

Présentement, la terminologie utilisée au sein des organismes canadiens de la voirie pour décrire les dimensions et les paramètres de conception des zones d'alerte sur l'accotement n'est pas uniforme. Il existe également des différences quant aux dimensions adoptées. Il importe d'harmoniser les pratiques et d'identifier la conception la plus efficace, en prenant en considération tous les véhicules, y compris les camions, les bicyclettes et les motos. Il importe également de trouver des solutions aux problèmes du bruit.

Ce rapport fera état des pratiques optimales concernant l'aménagement des zones d'alerte sur l'accotement et sur la ligne médiane basées sur des recherches approfondies, notamment sur l'examen des résultats d'un sondage d'envergure sur les pratiques et les essais expérimentaux d'autres administrations en Amérique du Nord. Le rapport traitera des mesures du bruit de la circulation le long des zones d'alerte ainsi que de l'efficacité et de la sécurité des zones d'alerte pour les vélos et les camions.

## **Introduction**

This paper presents some of the findings of the project undertaken by **iTRANS Consulting Inc.** for the Transportation Association of Canada (TAC). TAC will publish a document named '*Synthesis of Best Practices for the Implementation of Shoulder and Centreline Rumble Strips*' in the Fall 2001. This synthesis will provide highway agencies and other professionals with a summary of current practices.

In the past decade, six Canadian provinces (Alberta, Ontario, British Columbia, Saskatchewan, and New Brunswick) have started to implement rumble strips on rural freeways and highways in an attempt to reduce single vehicle run-off-the-road collisions. The Synthesis contains design parameters applied in Canada, supported by guidelines for their

application and maintenance and a set of values for consideration by future users. Cost-effectiveness of rumble strips was exemplified by means of real-life costs and expected benefits in terms of the reduction in target collisions.

External issues such as noise to adjacent areas and shared use of shoulders by cyclists are included in the synthesis. Research needs were identified and those will be listed in the paper. The use of temporary and raised rumble strips does not form part of this synthesis.

## **Shoulder Rumble Strips**

### **Definition**

Quoting the Ontario Ministry of Transportation Directive PLNG-B-004, 2000: "A shoulder rumble strip is a grooved formation installed within the paved shoulder or partially paved shoulder on a highway. The intention of shoulder rumble strips is to provide the motorist with both an audible and tactile warning that the vehicle has partially or completely departed the travelled way of a highway. An audible warning to the motorist is produced by noise generated by the vehicle tires passing over the shoulder rumble strip. A tactile warning to the motorist is provided by the vibration induced in the vehicle by the shoulder rumble strip. An encounter with shoulder rumble strips is expected to alert an inattentive motorist to steer the vehicle back onto the travelled way of the highway."

### **Types**

There are three basic types of shoulder rumble strips in use in North America: rolled, milled, and raised. The application methodology and use in different climates varies among the three types of shoulder rumble strips. Key findings are summarized below:

Rolled-in or milled-in rumble strips may be installed on new, reconstructed, or rehabilitated pavement during the construction of the pavement.

The milled-in method has been found to be more accurate and is becoming less expensive to install than the rolled-in method.

The milled-in method of rumble strip application is recommended for all types of implementation strategies on new or existing pavement.

Raised rumble strips are suitable in Canada on a temporary basis in work zones where their use is restricted to seasons where there is no snow.

Discontinuities in the rumble strip pattern (intermittent rumble strips) may be used, where required, to facilitate the movement of bicycles to and from the shoulder, and at intersections with residential or commercial driveways and side roads.

### Design Dimensions

Currently provinces and cities in Canada apply varied dimensions for shoulder rumble strips. This synthesis identifies a range of design dimensions for their use, as summarized below:

<b>Distance from Travelled Way</b>	<b>0 – 200 mm</b>
<b>Length of Intermittent Pattern</b>	<b>Approximately 4 m</b>
<b>Width of Intermittent Pattern</b>	<b>300 mm typical 500 mm heavy trucks</b>
<b>Number of Strips per Pattern</b>	<b>12 strips</b>
<b>Spacing Between Patterns</b>	<b>4 m</b>
<b>Strip Shape</b>	<b>Rounded</b>
<b>Strip Width</b>	<b>300 mm typical 500 mm heavy trucks</b>
<b>Spacing Between Strips</b>	<b>150 ± 40 mm</b>
<b>Strip Depth</b>	<b>8 ± 2 mm</b>
<b>Strip Length</b>	<b>150 ± 25 mm</b>

Modifications to these design parameters are provided when the shoulders are marked as cycling routes or used by cyclists. Design guidelines are listed for when partial-paved shoulders are provided.

There is a concern regarding the acceptable increase in noise from rumble strips to the surrounding environment. Therefore, a balance is required between installing effective rumble strips and minimizing noise impacts. Studies show that rumble

strips terminated 200 m away from residential or urban areas produce tolerable noise impacts on residences. At an offset of 500 m the noise from rumble strips is negligible.

There is also a concern regarding the appropriate dimensions for rumble strips to effectively alert drivers inside their vehicles, particularly truck drivers. The rumble strip depth and width values are crucial to the effectiveness of rumble strips. The testing of a number of optional combinations provided a good insight in the effectiveness of the sound and tactile impacts of the rumble strips.

### Application

Shoulder rumble strips can be considered for installation on two-lane and multi-lane highways. Shoulder rumble strips have been applied in the following locations:

On two-lane and multi-lane highways with partially or fully paved shoulders where 200 mm of paved shoulder can be maintained between the outside edge of the rumble strip and the edge of pavement

On multi-lane highways on the median shoulder where 200 mm of paved shoulder can be maintained between the outside edge of the rumble strip and the edge of pavement or physical constraint such as a barrier

In interchange areas on a selective basis, based on collision-prone locations

In the above noted locations, even when scheduled for rehabilitation, if a benefit / cost analysis shows that the installation is cost effective

Shoulder rumble strips are not used in a number of locations, such as, bridge decks and overpass structures.

In the special circumstances when cyclists are present, or there are intersections with side roads, commercial driveways, and residential driveways, shoulder rumble strips are interrupted.

## **Maintenance**

Once shoulder rumble strips are installed, standard annual road maintenance is sufficient. The installation of shoulder rumble strips in new or well-maintained pavement does not alter the rate of deterioration of the pavement. Concerns regarding debris collecting in the rumble strip or water and ice collecting in the rumble strip during the freeze / thaw weather periods are for the most part unfounded. Rumble strips are self-cleaning as the vibration of vehicles travelling over the rumble strips breaks down and knocks out water, ice, or debris that may collect in the groove.

## **Benefit / Cost**

The benefit of installing shoulder rumble strips is the reduction in run-off-the-road collisions. Many American states have completed before / after collision analyses to determine the reduction in this type of collision due to the installation of shoulder rumble strips. A 30% reduction in run-off-the-road collisions, resulting in a collision modification factor (CMF) of 0.70, is adopted in the TAC Synthesis.

The results of the benefit / cost analysis example using most recent costs at two different Canadian provinces showed that the benefits of installing shoulder rumble strips in terms of the collision cost savings far outweigh the cost of installation, even at low AADT volumes, on a 2-lane rural highway. Implementation costs diminishes with greater number of applications for longer sections of road.

## **Centreline Rumble Strips**

### **Types**

Typically, two types of centreline rumble strips are installed: milled or raised. Key findings on these two types of rumble strips are summarized below:

The milled-in method of centreline rumble strip application has been successfully applied on new and existing pavement.

Raised centreline rumble strips are not appropriate for application in Canada due to winter weather conditions.

Centreline rumble strips are mostly applied in no-passing zones on undivided highways.

Continuous centreline rumble strips are applied on undivided highways as mitigation measures, if the local agency identifies a history of head-on or side-swipe collisions and a benefit / cost analysis shows that the implementation of centreline rumble strips is cost effective.

## **Design Dimensions**

Design dimensions for centreline rumble strips, based on a review of current North American practices, are summarized below:

The following dimensions for continuous milled-in centreline rumble strips are typically used:

<b>Strip Shape</b>	<b>Rounded</b>
<b>Strip Width</b>	<b>300 mm within painted lines</b>
<b>Spacing Between Strips</b>	<b>300 mm</b>
<b>Strip Depth</b>	<b>8 ± 2 mm</b>
<b>Strip Length</b>	<b>175 ± 25 mm</b>

Centreline rumble strips should be placed in the centre of the road within the centreline pavement markings.

Similar to shoulder rumble strips, the noise increase to the surrounding environment from rumble strips requires attention.

## **Application**

Unlike the use of shoulder rumble strips, centreline rumble strip application is best limited to the following areas until further research is completed.

Centreline rumble strips are appropriate for use in the following locations:

On two-lane and four-lane undivided roads in no-passing zones,

On horizontal curves with high collision history or low radius curves,

On climbing or passing lanes with no-passing zones.

Centreline rumble strips are not appropriate for use in locations, such as, within 200 m of a residential or urban area, on bridge decks, in passing zones on two-lane roads, and across the intersections of a road or commercial entrance.

### **Maintenance**

Maintenance issues specific to centreline rumble strips currently are not identified. Standard annual highway maintenance practices outlined for shoulder rumble strips may be followed for centreline rumble strips.

### **Benefit / Cost**

Limited cost information is currently available regarding the installation of centreline rumble strips. In 2000, Alberta is the only province in Canada to install centreline rumble strips on a highway.

Currently, limited data is available on the effectiveness of centreline rumble strips in reducing head-on and side-swipe collisions. Two states, Arizona and Colorado, apply centreline rumble strips in no-passing and passing zones. Although before / after studies have not been completed to date, the installation of centreline rumble strips is believed to have cut down “ill-advised” passing and dangerous “peeking out” behaviour (1).

The state of Minnesota undertook two separate applications of centreline rumble strips, one in 1995 and one in 1996. Each location consisted of a 2-lane rural road with a posted speed limit of 55 mph (89 km/h). A review of 3-year before and after collision data along these sections of road revealed that the number of head-on collisions was not reduced after the installation of centreline rumble strips (2). Pennsylvania and Delaware have implemented centreline rumble strips along with other

countermeasures in no-passing zone areas and they have realized a reduction in collisions; however, a number of factors may have contributed to this reduction (3).

### **Additional Research Needs**

The following issues are identified for future studies:

Rumble strips effectiveness at urban applications where lower travel speeds prevail. Currently, tests have been carried out at sites where travel speeds range from 80 km/h to 120 km/h

Safety and cost effectiveness of centerline rumble strips on different road classes

Safety performance of motorcycles at curves with centerline rumble strips

Positioning of shoulder rumble strips at very narrow shoulders

Safety and cost effectiveness of rumble strips at work zones.

### **References**

1. Russell, E., Stokes, R., and Rys, M., “Guidelines for Centerline Rumble Strips on Two-Lane Rural Highways – Draft Report”, Kansas State University, K-TRAN Project Number KSU (00)-1, April 12, 2000.
2. Mailed Material from David Engstom, Metro Division Studies Engineer, Minnesota Department of Transportation, Minnesota, November 16, 2000.
3. Stutts, Jane C., NCHRP Synthesis 287, “Sleep Deprivation Countermeasures for Motorist Safety”, TRB, 2000.