Report No. CDOT-DTD-R-2001-8
Interim Report

CENTERLINE RUMBLE STRIPS

William (Skip) Outcalt

August 2001

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH BRANCH

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views of the Colorado Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CDOT-DTD-R-2001-8		

4. Title and Subtitle	5. Report Date
Centerline Rumble Strips	August 2001
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
William (Skip) Outcalt, E/PS Tech II	CDOT-DTD-R-2001-8

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Colorado Department of Transportation 4201 East Arkansas Avenue Denver, Colorado 80222	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Colorado Department of Transportation 4201 East Arkansas Avenue Denver, Colorado 80222	Final Report August 2001
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report presents an evaluation of centerline rumble strips on a two-lane mountain highway. Accident data before and after construction is given to demonstrate the improvement in safety. Visual evaluations of the effects of the rumble strips on the condition of the pavement and center line striping are given.

Implementation

Center line rumble strips are recommended for installation on two-lane highways where there is a history of crossover (head-on and sideswipe from opposite directions) type accidents.

17. Key Words	18. Distribution Statement
head-on accidents, sideswipe accidents, crossover accidents, lane divider, safety	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	15	

CENTERLINE RUMBLE STRIPS

by

William (Skip) Outcalt, E/PS Tech II

Report No. CDOT-DTD-R-2001-8

Sponsored by the
Colorado Department of Transportation
In Cooperation with the
U. S. Department of Transportation
Federal Highway Administration

August 2001

Colorado Department of Transportation
Research Branch
4201 E. Arkansas Avenue
Denver, CO 80222
303-757-9506

ACKNOWLEDGEMENTS

Special thanks are hereby expressed to:

The study panel members: Dave Price, CDOT DTD, Dave Jessup, CDOT Safety and Traffic, and Jeff Kullman, CDOT Region 1.

Thanks to Bryan Allery, CDOT Traffic and Safety for help in collecting accident data.

EXECUTIVE SUMMARY

Several states are installing centerline rumble strips on high-speed two-lane highways in an effort to reduce the number and severity of head-on accidents and opposite direction sideswipe accidents. In 1996, Colorado installed 17 miles of centerline rumble strips on a winding, two lane mountain highway for evaluation.

Comparison of traffic records for similar 44-month periods before and after the installation shows the following:

- Head-on accidents decreased from 18 to 14.
- Sideswipe from opposite directions decreased from 24 to 18.
- Average daily traffic (ADT) increased from 4007 in 1992 to 5661 in 1999.
- Average ADT for the 44-month period before construction was 4628, for the same time span and the same months after construction it was 5463.

Several positive comments were received from the public. During the four-year evaluation there was no noticeable effect on the pavement due to moisture and only a slight increase in the apparent wear on the paint stripe that may have been due to the rumble strips. One remaining question, and a possible topic for a future study, is the effect of centerline rumble strips on motorcyclists and high-speed bicyclists.

Implementation Statement

The results of this study clearly demonstrated the effectiveness of centerline rumble strips in reducing accidents involving vehicles traveling in opposite directions on two-lane highways. Therefore, in areas with a history of that type of accidents, their use is highly recommended. Because of the potential of increased danger to motorcyclists and bicyclists, however, centerline rumble strips should not be indiscriminately used; they should be limited to areas that have experienced high numbers of head-on and/or cross-over type accidents.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

Shoulder rumble strips have shown their effectiveness in reducing run-off-the-road accidents. Centerline rumble strips had not been used in Colorado before this study. However, Delaware, Maryland, and Washington have used milled rumble strips along the centerline of two-lane roadways to help reduce crossover and head-on crashes. One site in Delaware had six crossover fatalities in the three years prior to strip installation. During the first year after the installation of centerline rumble strips there were zero fatalities on the same stretch of roadway. While this is not a statistically valid comparison, it does show a pattern of improvement.

2.0 BACKGROUND

From Boulder to Nederland, for approximately 20 miles through Boulder Canyon, SH 119 is a narrow, winding, two-lane highway that has a history of head-on and sideswipe accidents due to vehicles crossing the centerline. During the spring of 1996, the CDOT Region 4 Residency in Boulder hired a contractor to grind rumble strips along the centerline of the roadway in the no passing zones. They hoped to reduce traffic accidents caused by vehicles crossing over the centerline. The CDOT Research Branch was asked to monitor construction of the rumble strips and evaluate their effectiveness.

3.0 OBJECTIVES OF THE STUDY

The objectives of this study were:

- Evaluate the effectiveness of centerline rumble strips by comparing accident data before and after construction.
- Determine if there were any detrimental effects on the existing pavement caused by the rumble strips.

The effectiveness of the centerline rumble strips will be based mainly on the reduction in the number of accidents involving vehicles crossing from one lane to the other over the centerline. Installation costs, maintenance costs, and the effects of the rumble strips on the life of the pavement are also important.

4.0 LOCATION OF THE PROJECT

Figure 1. State Highway 119 in Boulder Canyon winds through Forest Service land.

The centerline rumble strip site is located in Boulder Canyon on SH 119 from Milepost (MP) 23, just east of Nederland, to MP 40, about two miles west of Boulder. This is a winding stretch of two-lane highway that has limited site distance and a double yellow "no passing" center stripe for most of its length (Figure 1). In the 17-mile stretch through the canyon, centerline rumble strips were placed at all no passing locations except through intersections. In areas where sufficient sight distance allowed safe passing, no rumble strip was installed.

5.0 RUMBLE STRIP INSTALLATION

CDOT contracted with Surface Preparation Technologies, Inc. to install the centerline rumble strips using the machine shown in Figure 2. To grind the rumble strips, the operator drives the self-contained machine along the centerline of the roadway. A compact diamond grinder mounted across the front of the vehicle is automatically raised and lowered to cut the rumble strip grooves at the desired spacing and depth. Centerline rumble strips are similar to those used on shoulders. The 12-inch-wide grinder makes grooves that are 12-inches long (measured perpendicular to the roadway), and 7-inches across separated by 5-inch flats (Figure3). The

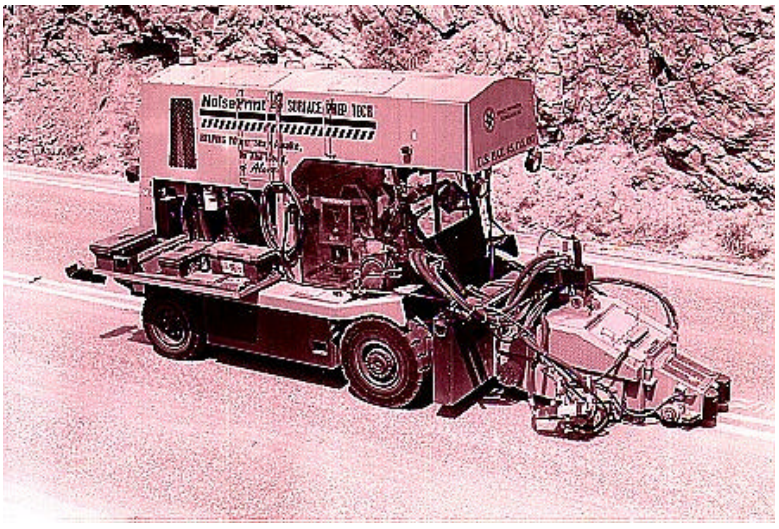

Figure 2. The machine that grinds the rumble strips

grinding machine moves at a relatively high rate of speed - about 1-1/4 miles per hour. The rapid installation means less danger to the equipment and operators and less inconvenience to the public.

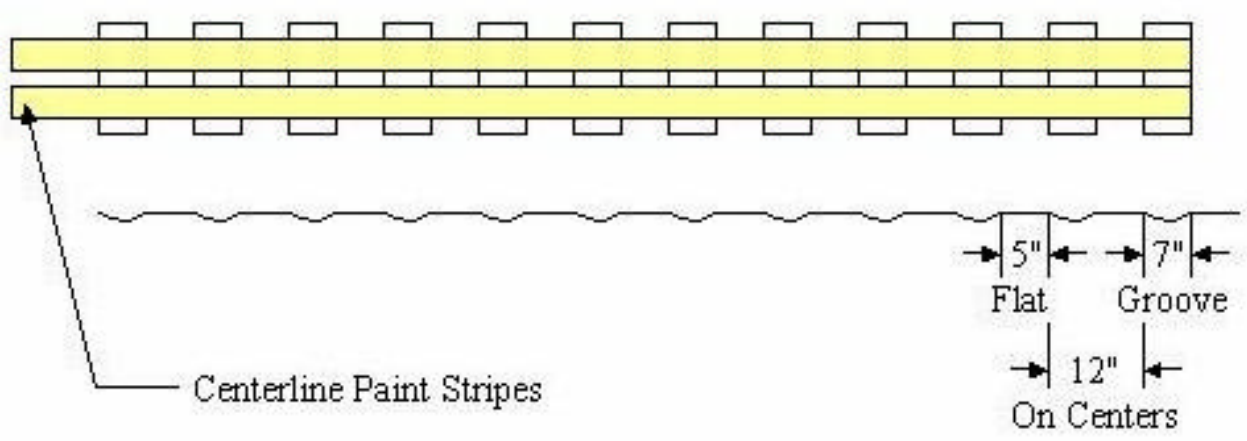

Figure 3. A drawing of the centerline rumble strips.

5.1 Cost

This project had several variables that made cost data unavailable. However, the same company did another project in 1998: Shoulder rumble strips installed using the same equipment cost $0.87 per linear foot. This cost included the grinding and all traffic control and replacement of pavement marking materials.

6.0 ACCIDENT DATA

Accident data was collected comparing similar periods from before construction and after construction: Before construction from July 1, 1992 to March 1, 1996 – after construction from July 1, 1996 to March 1, 2000. The periods selected represent the same length of time and the same months of the year to prevent bias due to seasonal variations in weather and traffic.

Within the 17-mile project limits of the centerline rumble strips there were 18 head-on accidents and 24 sideswipe accidents by vehicles going opposite directions - a total of 42 cross-over accidents during a 44-month period before construction. During a similar 44-month period after construction there were 14 head-on and 18 sideswipe accidents; a total of 32 cross-over accidents. The average ADT was 4628 for the 44-period before construction; average ADT increased to 5463 for the period after construction. Note that these figures are averages for the entire 44-month periods.

Accident reports from the two periods show a decrease of 34% in head-on accidents, and a 36.5% decrease in sideswipe accidents in spite of a considerable increase in the ADT for t he highway. Table 1 shows the accident rates for both types of accidents for both periods.

Table 1. Accident Data.

Time Period -->	7/1/92- 3/1/96 (44 months) Before construction	7/1/96-3/1/2000 (44 months) After construction	Percent change
Head-on accidents	18	14	
Head-on accidents per million vehicles	2.91	1.92	-34%
Sideswipe opposite direction	24	18	
Sideswipe accidents per million vehicles	3.88	2.46	-36.5%
Average ADT	4628	5463	+18%

7.0 FIELD EVALUATIONS

Since the construction of the centerline rumble strips, CDOT Research personnel have performed visual field evaluations annually. They looked at pavement distress, pavement marking conditions, and debris build-up within the rumble strips. The sound levels generated by the rumble strips were evaluated subjectively to see if there was a noticeable reduction caused by sand in the grooves.

During the winter, the grooves in the strip tend to collect some of the sand that is applied during snowstorms (Figure 4). The sand does not completely fill the grooves, however, it does obscure

Figure 4. Sand collects in the bottoms of the rumble strip grooves.

the part of the paint stripe at the bottom of the grooves. The level of sound generated when a vehicle drives in the rumble strip does not seem to be affected by the sand. The action of traffic eventually clears most of the sand out of the grooves.

Before the installation of the rumble strips, there were concerns about water standing in the grooves: Would it increase the rate of deterioration of the pavement at the grooves? Sand accumulated in the grooves tends to stay damp in cool weather, but by the time the rest of the surface of the pavement is dry there is no standing water in the grooves. Air movement caused

by passing traffic dries the grooves fairly rapidly. There does not appear to be any deterioration in the asphalt at the bottom of the grooves.

Another question associated with centerline rumble strips was the increase in noise levels but, since the highway is through US Forest Service land for most of its length, noise was not a problem. There are very few homes near the highway after the first 2-3 miles and only one complaint was received by CDOT about noise levels. One property owner wrote to say that he felt the rumble strips had a positive effect. While they raised the noise level slightly, they seemed to make driving in the area safer. He also thought that as his neighbors got used to the sound caused by traffic on the rumble strips, they would notice it less. Centerline rumble strips were received so well that they have been installed on the high volume parts of US 6 and SH 119 near the gaming areas of Central City and Black Hawk.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Based on accident data for similar 44-month periods before and after construction, centerline rumble strips are an effective way to reduce cross-over accidents in an area where there is a history of this type of accident. For this test section the data shows a statistically significant decline in number of cross-over type accidents in the area where the rumble strips were installed. The number of head-on accidents per million vehicles declined 34% while the sideswipe accident per million vehicles declined 36.5%. When the 18% increase in average ADT is added, the reductions become even more impressive.

The only drawbacks associated with centerline rumble strips are the potential of increased danger to motorcyclists and bicyclists, increased noise, and increased wear on the pavement marking stripes. There is considerable interest in the use of centerline rumble strips and several states and other agencies are performing evaluations at the time this is being written.

Additional research needs to be done concerning motorcycles and high-speed bicycles. There is not enough data available at this time to evaluate the effects of centerline rumble strips on motorcycles and bicycles.

The centerline rumble strip does have an effect on the life of the yellow centerline stripe. Field reviews show that the paint wears off on the flats between the grooves of the rumble strip more quickly than on sections of pavement where there is no rumble strip.

The rumble strips do not appear to have a detrimental effect on the life of the pavement. In the five years since they were installed, there is no indication of accelerated deterioration of the pavement in the area of the rumble strips.

There does not appear to be any reduction in the effectiveness of the rumble strips caused by the accumulation of sand and debris in the grooves during the winter. The driver and passenger made subjective evaluations as a vehicle was intentionally driven over the rumble strips. The rumble strips functioned very well under these circumstances with no apparent reduction in sound and vibration level inside the vehicle.