Use of a Rumble Stripe to Reduce Maintenance and Increase Driving Safety

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•FOR MANY YEARS painted pavement markings have been necessary. The increased volume of traffic in recent years has shortened the life of paint applied by standard methods. High volume and high speed in some areas wear the paint off of the road within 30 days. A great deal of research has been done to produce better paint and reflective-bead products. Different methods of marking pavement have also been investigated, the method best known being the raised traffic markers. California has used the raised markers for many years and found them to have much better visibility and longer life than painted stripes and to produce a noise that warns a driver that he is moving outside of his traffic lane.

The main trouble with raised traffic markers is that they cannot be used in areas where snow removal is necessary because the snowplows cut them off. For the past 2 years the Utah Department of Highways has been researching the possibility of recessing a design or texture to produce the same advantages as the raised markers (1).

HISTORY

The idea of researching textured painted stripes in Utah originated when high spots or bumps were cut off of a concrete structure near Salt Lake City. The cutter used produced the design known as a No. 7 cut (Fig. 1). About a year after the stripes had been painted in this area it was noted that the paint was more visible on the areas that had been cut (Fig. 2).

At this time, Florida was experimenting with sound-on-highway by grooving to keep people more alert while driving. Obtaining sound from the texture used on the painted stripe would achieve a twofold purpose: It would enhance paint life and warn drivers that they are crossing lane lines.

From these basic ideas the first painted test stripes were developed and tried first in Georgia (Fig. 3). On the wider, deeper cuts, placed to produce noise, the paint lasted longer but lost its visibility sooner because the cuts filled with water. Researchers at Georgia Institute of Technology developed the idea that radii would reflect light better than the square corners of the No. 7 cut. The stripe was then redesigned, and the research project in Utah began in July 1967.

DESCRIPTION OF PROJECT

The first stripe in Utah, shown in Figure 4, was cut in two operations. The first operation consisted of cutting longitudinal grooves running the total length of the 15-ft painted stripe and the second consisted of cutting transverse ditches across the stripes. The groove pattern was made up of 4 grooves ¼ in. deep on 1-in. centers making the stripe 4 in. wide. The purposes of the cross cuts or drain ditches were to produce noise or rumble (thus, the name rumble stripe) and to drain the water from the stripe. They were cut in 4 different patterns. Figure 5 shows the pattern using saw cuts 2½, 3¼, and 4¼ in. wide, and Figure 6 shows the textured pattern, which is the same as that of the longitudinal grooves. They were cut ¼ in. deep at the stripe and tapered to the surface of the road 12 in. to the low side of the stripe. The longitudinally grooved stripes are referred to as type A rumble stripes.

Paper sponsored by Committee on Traffic Control Devices.

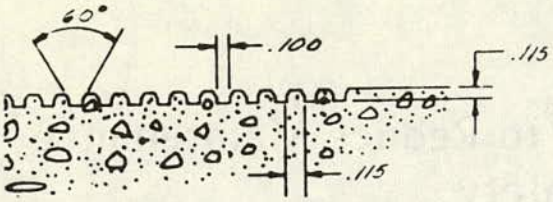


Figure 1. No. 7 cut.

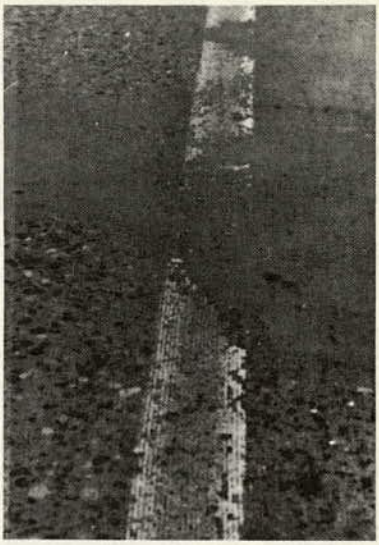


Figure 2. Painted stripe on No. 7 cut.

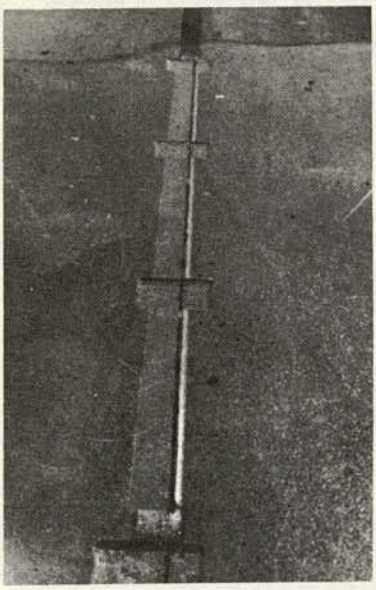


Figure 3. Painted test stripe in Georgia.

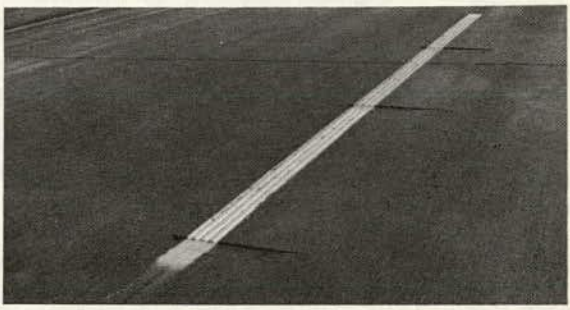


Figure 4. Type A rumble stripe.

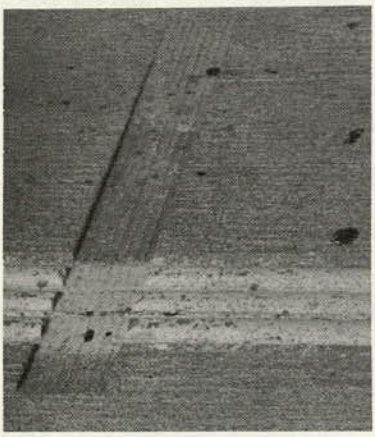


Figure 5. Pattern using saw cuts 2½, 3¼, and 4¼ in. wide.

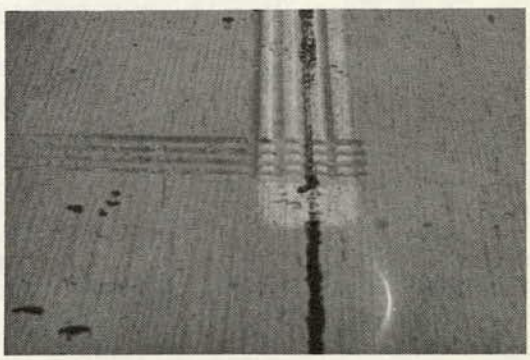


Figure 6. Textured pattern 4 in. wide.

Figure 7. Type B rumble stripe 5 in. wide and 7½ ft long.

After the project had been under way for a year and a half, the Utah Division Office of the U.S. Bureau of Public Roads suggested that other designs be tried because very little rumble had resulted from the type A stripes. The design had 1-in. grooves as did the type A stripes, but instead of running longitudinally the grooves were cut transverse to the flow of traffic, as shown in Figure 7. It was hoped that they would drain themselves of water so that the stripe could be cut in one operation. There were two variations of this stripe, one 5 in. wide with only 7½ ft of the 15-ft painted stripe textured and the other (Fig. 8) 8½ in. wide with the total 15 ft of the stripe textured. Only 2 wide stripes were cut. Cost is a large factor in cutting stripes in concrete, and it was hoped that texturing only part of the painted stripe would produce adequate visibility and noise. This transversely grooved stripe is referred to as type B rumble stripe.

LOCATION OF PROJECT

The location of the test sections is shown in Figure 9. No test stripes were cut on the bridge deck to avoid weakening it. The location was selected for several reasons. The roadway has a horizontal curve, and traffic tends to cross over the lane stripes in a curve. The area has on and off ramps that also increase the chance that traffic will cross over the stripes. The 3 lanes of traffic in both directions made it possible to stagger the type A rumble stripe and standard painted stripe from one skip line to another every 1,000 ft.

The type B strips were cut on the inside skip line of the northbound lane just north of the area where type A stripes were cut so that a close comparison could be made.

CONSTRUCTION

Type A stripes were cut during November 1967 with a concrete planer (Fig. 10)

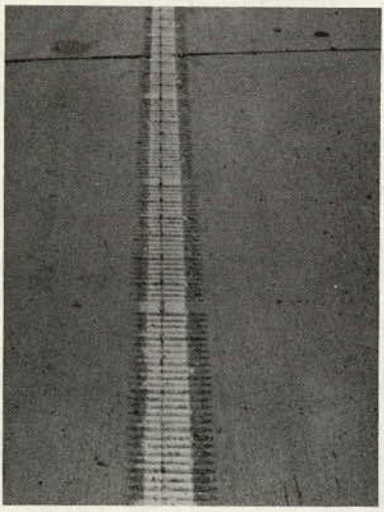


Figure 8. Type B rumble stripe 8½ in. wide and 15 ft long.

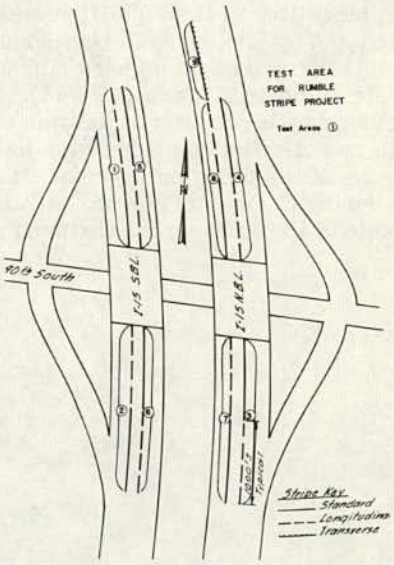


Figure 9. Location of test area and test sections near Salt Lake City.

Figure 10. Concrete planer.

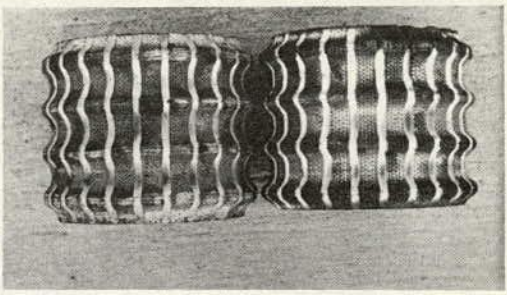


Figure 11. Diamond-studded cutters.

equipped with diamond-studded cutters (Fig. 11). This machine, normally used to plane high spots from concrete surfaces, is very bulky and was hard to adapt to the cutting. Fifteen ft of texturing was cut followed by a 25-ft skip and then another 15 ft of texturing. This cycle continued for about 1,000 ft on one skip line then changed to the other lane line and continued for about 1,000 ft. The cross cuts or drain ditches were always placed on the low side of the stripe.

Type B rumble stripes were cut in April 1969 by the same equipment but the cutters were mounted to cut 90 deg to the flow of traffic instead of parallel to it (Fig. 12). Stripes were painted in the test area about 6 months prior to the cutting of the transverse stripes. Twenty-three of the stripes were textured 7½ ft long and 5 in. wide, and 2 stripes were cut 8 in. wide over the entire 15-ft length. These 2 stripes were added because it was thought that a wider cut would drain better and a longer stripe would be more visible. After the stripes were cut, they were thoroughly cleaned and painted the next day.

FINDINGS

Visibility

Until the cutting of the type B stripes, the only means of evaluation was by visual inspection and by photographs (1). Photographs and visual comparison showed that 4 to 5 rumble stripes could be seen during wet night conditions when only one standard painted stripe could be seen (Fig. 13). During a storm a film of water covers the road and eliminates the reflective qualities of a painted stripe. Texturing breaks this surface film and allows the beads in the paint to reflect light as shown in Figure 14.

Patterns of the different types of stripes were cut in wood, and pictures were taken of them during the day and night. At times during the day when the sun casts a shadow on one side of the texture, the textured stripes are not as bright as the standard painted

Figure 12. Transverse cutter.

Figure 13. Rumble stripe (left) at night.

Figure 14. Rumble stripe (right) in rain during day.

stripes. They are bright enough, however, to be seen adequately (Fig. 15). At nighttime the textured stripes are almost always more visible than are the standard stripes (Fig. 16). The visual inspection and photographs show that the advantage of texturing a painted stripe is greatest during very critical times such as at night during wet weather.

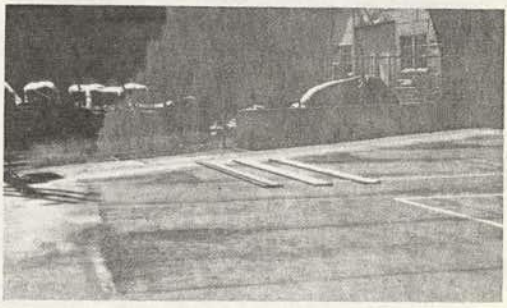
Just after the type B rumble stripes were cut, the Colorado Division of Highways issued a report (2) on a bead study in which an electronic photocell device was used to measure the reflectivity of stripes during night conditions. Colorado made this device available to Utah for possible adaptation to this study. The photocell device was used for about 2 months during which 2 sets of readings were taken on that test section. Since then, Utah has acquired parts and built a photocell device.

Readings were taken in the test area at the 9 sections shown in Figure 9.

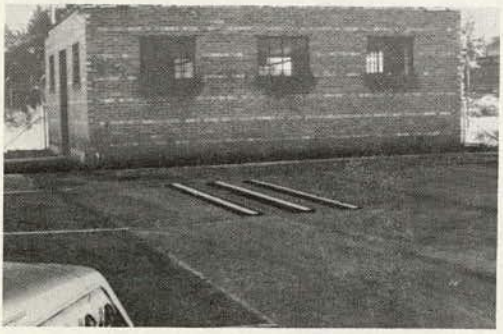
Test sections 1 through 8 are 2,000 ft long and contain both standard painted stripes and type A rumble stripes. Test section 9 is 1,000 ft long and contains only type B rumble stripes.

The first readings were taken 3 days after type B stripes were cut. Sections 5, 6, 7, 8, and 9 were all painted the day before the readings were taken. Sections 1, 2, 3, and 4 were painted 6 months before the first readings were taken and were painted again the day after they were taken. The age of the painted stripes in all test sections at the time of the second reading was 1 month, and at the time of the third reading, 4 months. The relative numbers obtained are based on an average number registered on

Sun on left, type B on left, type A on right.



Sun on left, type B on left, type A on right.



Sun on right, type B in center, type A on right.

Figure 15. Standard painted strip, type B rumble stripe, and type A rumble stripe during day.

Dry

Dry

Wet

Figure 16. Standard painted and rumble stripes at night during dry and wet conditions (type B on right, type A on left, and standard in center).

a voltmeter for 20 stripes in each test section. A brief summary of the readings that have been taken to date is given in Table 1. The photocell evaluation of the stripes is still being tested and it is thought that further calibrations and adjustments will improve the performance of the photocell device; however, the readings obtained so far indicate a close correlation with visual observations:

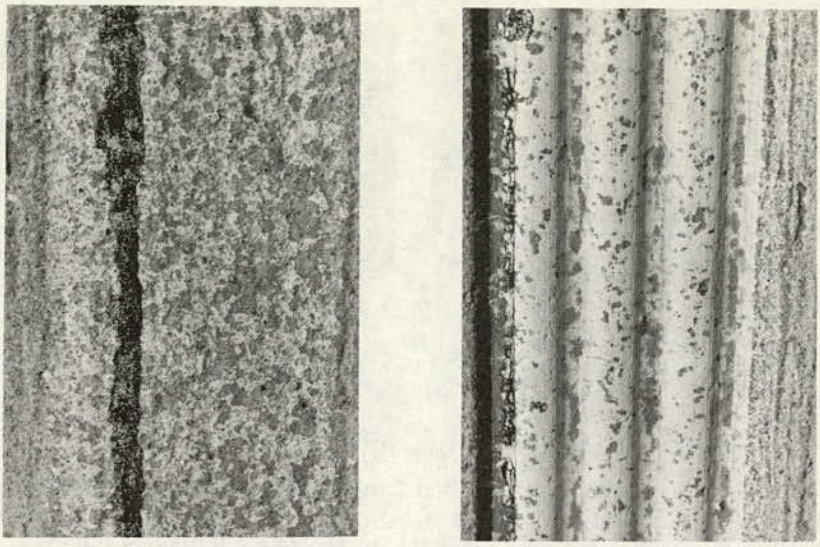
TABLE 1

RATINGS OF RUMBLE STRIPES IN RELATIONSHIP TO PAINTED STRIPES

Age of Paint	Type of Stripe	Rating[a] (percent)
New	Type A rumble stripe	+8
	Type B rumble stripe, 5 in. by 7½ ft	+15
	Type B rumble stripe, 8 in. by 15 ft	+31
1 month	Type A rumble stripe	+3
	Type B rumble stripe, 5 in. by 7½ ft	+7
	Type B rumble stripe, 8 in. by 15 ft	+43
4 months	Type A rumble stripe	-2
	Type B rumble stripe, 5 in. by 7½ ft	-8
	Type B rumble stripe, 8 in. by 15 ft	+57
6 months	Type A rumble stripe	+35

[a]Plus indicates that the rumble stripe is better, and minus indicates that it is worse than the standard painted stripe.

1. When freshly painted, both type A and type B stripes show up better at night.
2. Type A stripes, type B stripes 5 in. wide, and standard stripes at age 1 month have very few differences at night during dry weather. The similarities appear to be caused by dirt and debris in the textured stripes making them less visible, although the amount of debris does not collect to the point of making their visibility poor. After a certain amount of debris has collected, it is removed by air turbulence.
3. Differences begin to appear when the paint on the standard



Standard painted Type A rumble

Figure 17. Standard painted stripe and type A rumble stripe after 5 months of wear.

stripe begins to wear off, in about 6 months, and then the textured stripe performs much better.

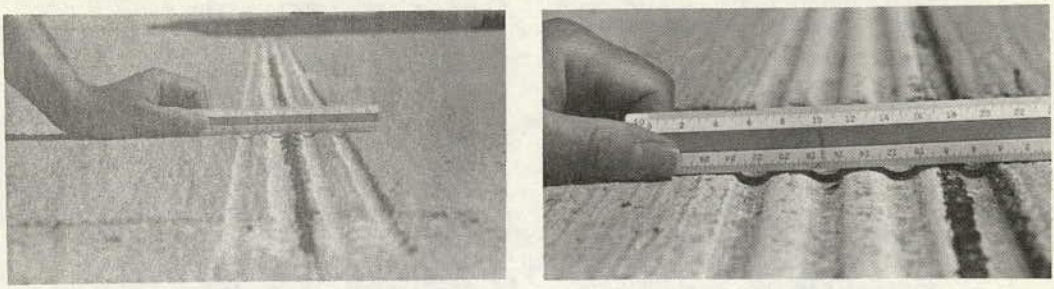
4. The 2 type B stripes 8 in. wide and 15 ft long show up much better both by visual inspection and on the photocell device.

Durability

Figure 17 shows a comparison of a standard painted stripe and a type A rumble stripe after 5 months of wear. Because of the addition of more test stripes and repainting of the test sections, no determination has been made of exactly how much paint life can be obtained from any of the textured stripes. Type A and B stripes cut in March 1969 were still in good condition in August, and so were standard stripes painted at the same time. It was expected that winter use would indicate a bigger difference in the stripes. Visual observations, photographs, and readings of the photocell indicate that the paint on the textured stripes will last much longer, but exactly how much will not be known until further research is completed.

Figure 18. Continuous type B rumble stripe cut in plastic concrete near Ogden.

Figure 19. Joint filler being forced out of seam.



Level Recessed

Figure 20. Top of grooves of type A rumble stripe level with road surface and recessed slightly.

RUMBLE EFFECT

Little or nor rumble noise was obtained from any of the drain ditches cut into the type A stripes. Type B stripes produce a zip or buzz that is noticeable in most passenger automobiles that traverse it. Figure 18 shows a continuous type B stripe that was cut in fresh concrete near Ogden, Utah. The sound effect of this stripe is good.

Where the longitudinal joints in the concrete have been filled with joint filler and a stripe is painted over it, as shown in Figure 19, some of the filler is forced out of the joint during the summer months, reducing the effectiveness of the stripe. This can be avoided by offsetting the seam or joint at the time of construction.

Some of the grooves of the type A stripes were cut so that the tops were actually a slight distance below the top of the road surface (Fig. 20). The slightly recessed stripes seem to be wearing longer.

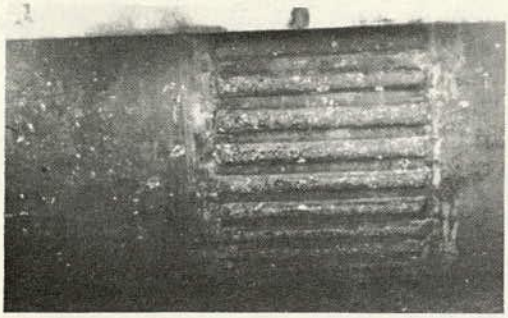
APPLICATIONS

This research indicates that texturing of painted stripes has some definite advantages. Most problems were found to be surmountable; however, a big problem was that no equipment has been designed specifically to cut any type of textured stripe.

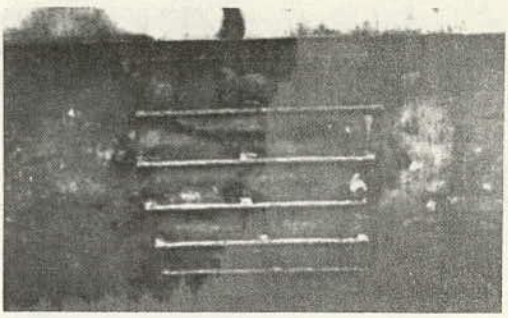
Equipment similar to that shown in Figure 21 has been used to cut 5,000 ft of type A rumble stripes for the highway department in the Salt Lake area. The stripes were cut in areas on the concrete-surfaced freeway where it is difficult to maintain painted stripes. Cost of cutting type A stripes with this machine, excluding painting, ranges from 30 to 40 cents per cut foot. At the present time there is no economical equipment for cutting type B stripes in old pavement. Several hundred feet of continuous type B stripes were cut in fresh concrete near Ogden (Fig. 18) by joint efforts of the highway department and the paving contractor. The operation is not yet to the point of absolute success, but enough progress had been made to show that texturing can be placed with relative ease in plastic concrete.

Figure 21. Stripe-cutting equipment.

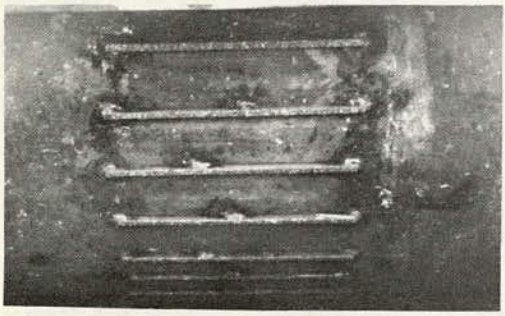
In an attempt to place transverse grooves in asphalt, a vibratory roller was altered slightly by removing the rear roller and tack-welding rods 10 in. long by 1 in. wide by ¼ in. deep onto the center of the roller at 1¼-in. centers. This particular design did not work as anticipated, so about half of the original rods were replaced by various other rods at different centers. Four basic designs of 10-in. bars were placed on the wheel (Fig. 22): 1 by ¼ in. at 1½-in. centers; ¼ by ¼-in. at 1½-in. centers; ¼-in. round at 2-in. centers; and 1 by ¼ in. at 3-in. centers.



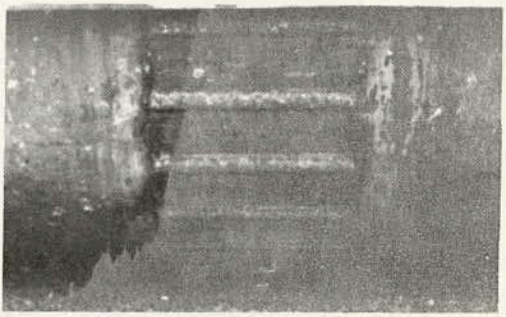
1 by ¼ in. at 1½-in. centers



¼-in. round at 2-in. centers



¼ by ¼ in. at 1½-in. centers



1 by ¼ in. at 3-in. centers

Figure 22. Four designs of 10-in. bars placed on wheel to cut transverse grooves.

The best results were obtained by the ¼-in. round bars at 2-in. centers, but the direction of the roller was hard to control and it was not heavy enough to produce the desired groove depth. Additional research is needed to produce an acceptable method.

SUMMARY AND RECOMMENDATIONS

Improvements are needed in traffic marking for directional control of traffic and in areas where snow-removal equipment operates. Textured painted stripes produce the following advantages:

1. Visibility is increased during critical conditions such as when it is dark and wet.
2. Paint life is increased.
3. A zip or buzz noise can be heard when the vehicle crosses over the type B rumble stripe and serves to warn the driver that he has entered another lane.

Research is still continuing to determine the best design for a rumble stripe. This will depend on factors such as durability and cost. The advantage of the type B stripe is that it produces a noise; the disadvantage is that it cannot be cut economically with available equipment.

Recessing the grooves slightly (1/16 in.) will increase paint life. When joint seal is used, the longitudinal concrete joint should be offset from the painted stripe.

It is felt that a recessed, textured, painted stripe produces a traveled way that is safer than that produced by the standard painted stripe.

ACKNOWLEDGMENT

The opinions, findings, and conclusions expressed in this paper are those of the author and not necessarily those of the U.S. Bureau of Public Roads.

REFERENCES

1. Fairmond, Kenneth D. Use of Rumble Stripe to Reduce Maintenance and Increase Driving Safety. Utah State Dept. of Highways, Salt Lake City, Interim Report, 1968.
2. Reflective Traffic Bead Study. Colorado Div. of Highways, Denver, 3rd Interim Report, July 1969.