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# Evaluation of Rumbler, Preformed Rumble Strip


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Supplemental Notes


Abstract
The Rumbler is a temporary rumble strip consisting of several plastic bumps that are six inches wide, four (to six) feet long, and between 0.15 and 0.25 inches high. They are affixed to the pavement with an adhesive. The Rumbler was installed on the northbound approach of a recently signalized intersection in rural Dodge County, WI. Vehicular speeds were measured both before and after the installation of the Rumbler to test the hypothesis that the warning would evoke an immediate driver response. In addition, noise and vibration levels interior to an automobile were recorded for both the Rumbler and a nearby conventional rumble strip. The Rumbler is much quieter than a conventional rumble strip. The Rumbler also produced considerably less vibrations in the test automobile. The quality of sound from the Rumbler is also distinctly different from a conventional rumble strip. However the Rumbler's sound is qualitatively different and louder than road noise. The Rumbler did not elicit a large behavioral response from drivers. However, the Rumbler may have had the effect of reminding drivers of the need to be alert to the signal.

## Evaluation of Rumbler, Preformed Rumble Strip

### 1. TECHNOLOGY

The Rumbler is a product of Swarco Industries (PO Box 89, Columbia TN 38402). The product consists of several plastic strips that are six inches wide, four (to six) feet long, and between 0.15 and 0.25 inches high. The plastic is a mixture primarily of polymer resins and glass beads. It comes in three solid colors; white strips were used in this evaluation. Swarco describes the Rumbler as "designed to provide a durable, cost-effective means of producing an audible, visual and vibratory warning to the motorist in areas where the motorists should be alerted to changes in their normal traffic or driving environment". Swarco further states that the Rumbler is "ideal to effectively influence driver behavior where speed reduction, advance notice of upcoming construction zones or potentially critical traffic situations need to be managed". The Rumbler is glued to the pavement in a set of lines such that a vehicle's tires would hit several strips within a short time interval. The Rumbler is advertised to produce an 80 decibel (dB) warning interior to a vehicle at speeds between 30 and 55 mph. Figure 1 shows a Rumbler being glued to a road.

Figure 1. A Strip of the Rumbler Being Glued to a Road

### 2. STUDY SITE:

The Rumbler was installed on the northbound approach of State Trunk Highway 26 at its intersection with County Trunk Highway E in Dodge County, WI. This intersection is in a rural setting about midway between the cities of Horicon and Beaver Dam. This intersection had been given a temporary signal because of increased traffic on County Trunk Highway (CTH) E owing to a bridge closure in Horicon on State Trunk Highway (STH) 33, a parallel facility. This intersection normally is two-way stop controlled, with priority given to STH 26. The intersection has unrestricted sight distances in all directions. The asphalt pavement on STH 26 was somewhat distressed. Rutting was readily apparent and there were numerous cracks, most of which had been filled with a bituminous patching material. The speed limit was 55 mph. The cycle length was 75 seconds, with two equal green phases.

In addition, a conventional rumble strip was used for comparing interior noise levels and vibration. This particular conventional rumble strip was located on the eastbound approach of STH 33 at its intersection with STH 67 between Horicon and Allenton. This is a four-way stop controlled intersection where sight distances are somewhat reduced

because of a railroad bridge. The conventional rumble strip had been cut into relatively new pavement. There were no cracks, and rutting was seen only on close inspection.

**Rumbler Location and Installation**

The Rumbler was installed 1106 feet from the stop line. The installation involved a total of 12 separate strips in 6 lines, two strips per line. Each strip was 4 feet long and was located to cover the area that a wheel would track when the vehicle is roughly centered in the lane. About 14 inches in the center of the lane was left clear. Strips were placed 7 feet apart so that motorcycles would not hit more than one strip at a time if they were not precisely centered in the lane. This spacing is somewhat greater than the recommended spacing in the product literature. The total longitudinal length of the Rumbler was therefore 35 feet. The layout of the Rumbler can be seen in Figure 2. Figure 2 is looking north; the signal is barely visible near the top, center of the picture.

The distance of the Rumbler from the stop line was determined by the placement of a pair of "signal ahead" signs that had been located 906 feet from the stop line. The intention of the Rumbler installation was to alert drivers to the signs as well as to the signal itself. The "signal ahead" signs are visible in the background of Figure 2. A special warning sign reading "rumble strip ahead" was placed about 200 feet south (upstream) of the Rumbler.

The installation of the Rumbler was judged to be very straightforward. A flagging operation was needed to divert traffic from the lane. The surface of the road was inspected for condition. The road was swept clean, and two layers of contact cement were applied to the road location of each strip, and one layer was applied to the bottom of the strip. The first layer of adhesive was allowed to dry for 10 minutes before applying the second layer, which was also allowed to dry for 10 minutes before pressing the strip into place. Each strip was tamped using a tamping cart containing approximately 200 lbs. of weight. Installation of all 12 strips took about 1 ¼ hours. A representative of the manufacturer supervised the whole process of installation.

As seen in Figure 2, the surface of the road near the Rumbler was nearly free of cracks.

Figure 2. Rumbler as Installed on STH 26

**Rumbler Durability and Removal**

The Rumbler was left on the road for a little more than 7 weeks. It was observed to be intact after 5 weeks, but one of the strips had dislodged sometime before the end of the test. Otherwise, the Rumbler was in good condition.

Removal of the Rumbler was even easier than installation. A shovel jammed under an edge of a strip was sufficient to loosen it. The whole process of removing the Rumbler took about 10 minutes.

## 3. DATA COLLECTION:

The Rumbler evaluation involves three separate sets of data: vehicular speeds, interior noise levels, and vibrations. In addition, subjective observations were made as to visibility, sound and feel.

**Vehicular Speeds**

Vehicular speeds were measured both before and after the installation of the Rumbler to test the hypothesis that the warning would evoke an immediate driver response. The experimental setup is illustrated in Figure 3. Speed readings were taken with a laser gun when vehicles were 1106 (i.e., at the Rumbler), 800 and 500 feet from the stop line. The laser gun was located in an automobile that was parked on a wide gravel shoulder on the north side of CTH E, just west of the intersection. This location of the vehicle was chosen to be well clear of the path taken by vast majority of northbound vehicles.

Laser gun measurements were initiated as soon as the vehicle reached each checkpoint on the road. A vehicle was assumed to have reached a checkpoint when it obscured a traffic cone on the road's shoulder. The traffic cones were placed considerably upstream of the checkpoint to minimize the effect of parallax, as illustrated in Figure 3.

The "before" data were taken on a Wednesday between 10:40 am and 3:00 pm. The "after" data were taken on a Tuesday between 9:25 am and 2:00 pm. The weather was almost identical on both days, sunny with high temperatures in 70's. Traffic was generally light.

Only vehicles whose drivers could make an independent choice of speed were selected. These vehicles were either isolated or leading a platoon.

Speed measurements could consistently be obtained at the 800 ft checkpoint. Some data were lost at the 1106 ft checkpoint because of the long sightline and some data were lost at the 500 ft checkpoint because of the severe angle to the vehicles' path. Occasionally, the eastbound queue blocked the sightline between the laser gun and the checkpoints. The numbers of observed vehicles were 235 in the before period and 240 in the after period.

In addition to vehicle speeds, the E-W indication of the signal was recorded (the N-S indications seen by the drivers were not visible from the position of the laser gun), and the vehicle type (automobile, truck, RV) was recorded.

**Noise Levels**

Noise levels interior to an automobile were recorded for both the Rumbler and the conventional rumble strip. Measurements were taken for both devices on the same day and the same vehicle. The vehicle was a 1999 Ford Contour, a compact car belonging to the State of Wisconsin. This vehicle was selected as being typical of those owned by Wisconsin drivers. For all measurements a hand-held sound level meter was positioned at ear-height at the front passenger seat. Besides a manual reading of the peak sound levels, the actual sounds were recorded in a WAV file along with a calibration tone. Sound levels were obtained in decibels, A-weighted. The automobile was set on cruise control so that a speed of precisely 55 mph could be consistently maintained throughout the tests. Air conditioning

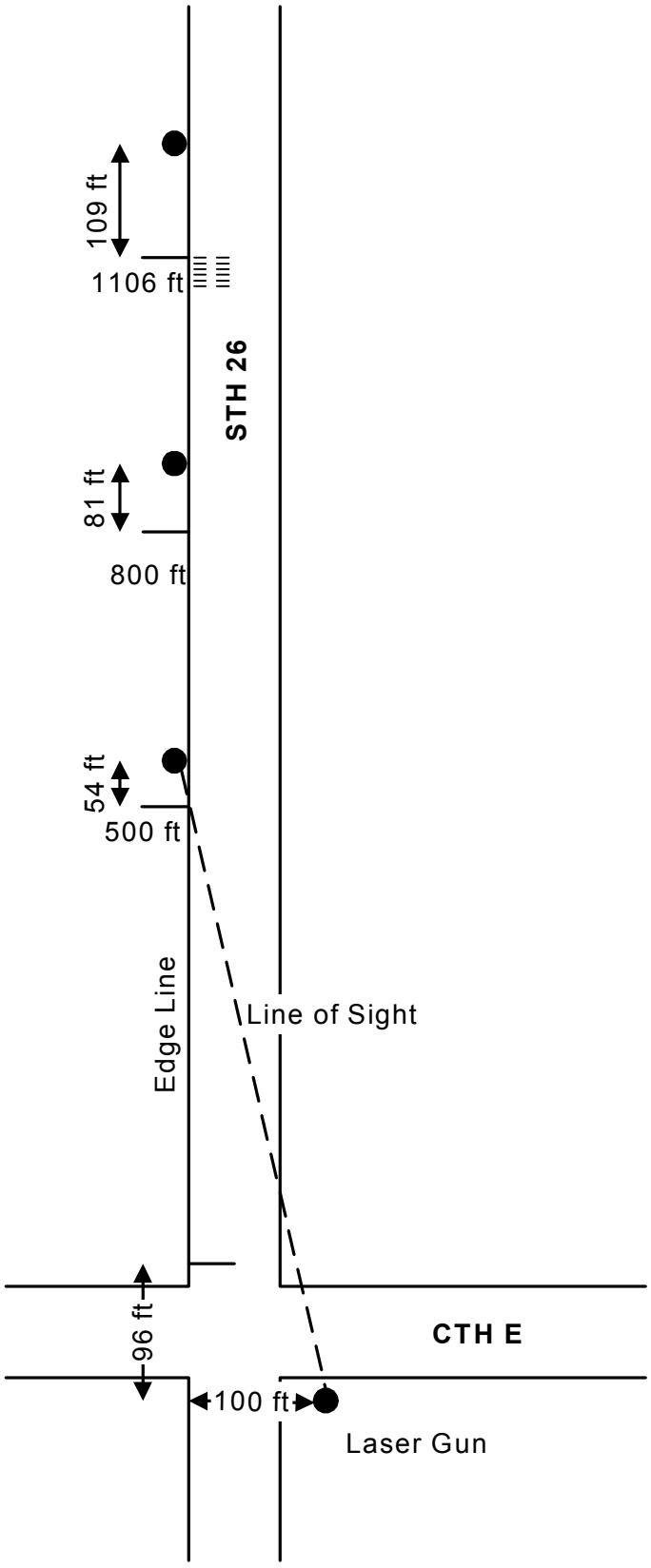


Figure 3. Speed Study Layout

was turned off and the windows were closed. The roads were dry. The sounds from the Rumbler were recorded 4 times and the sounds of the conventional rumble strip were also recorded 4 times. Two of the conventional rumble strip measurements were taken with the vehicle centered in the lane and two of measurements were taken with the vehicle well to the right of center in the lane. The latter measurements produced slightly louder sounds because there was less wear on the conventional rumble strips off center.

### Vibrations

Vibrations were measured by a single accelerometer that was mounted on upper-side of the steering column on the same 1999 Ford Contour. The accelerometer was positioned such that only vertical accelerations were obtained. Cruise control was set to precisely 55 mph. As with the sound levels, four sets of vibrations were recorded for each device. All eight sets of vibrations were recorded in the same WAV file, so that any normalization of the WAV data would not affect the relative sizes of the accelerations. The accelerations were not calibrated, so only the relative amplitudes between the two devices can be ascertained. The conventional rumble strip was twice tested with the vehicle centered in the lane and twice tested with the vehicle off-center to avoid the worn areas of the conventional rumble strip.

## 4. DATA ANALYSIS

### Vehicular Speeds and Decelerations

For each of the periods (before and after) average speeds and average deceleration rates were calculated for all vehicles. Prior to calculating the averages, speeds were adjusted from the raw data for the angle between the vehicle path and the line of sight of the laser gun. Descriptive statistics and t-tests were calculated.

### Noise

The average sound level was calculated for the Rumbler, the conventional rumble strip, and road noise at each location. Graphs of the sound amplitude v. time and amplitude v. frequency were visually inspected for a typical sample of each device and the road at each location.

### Vibrations

The relative amplitudes of the accelerations were compared between the Rumbler and the conventional rumble strip. In addition, the graphs of amplitude v. time and amplitude v. frequency were visually inspected for a typical sample of each device.

## 5. RESULTS

### Vehicular Speeds and Decelerations

Table 1 compares average speeds between the two time periods and whether the difference is significant on a two-tailed t-test. The two-tailed test is used to affirm the hypothesis that the speeds would simply be different (either high or low). All speed measurements were included in these averages.

Table 1. Average Speeds of Vehicles both Before and After Installation of the Rumbler

| Time Period | 1106 ft | 800 ft | 500 ft |
|---|---|---|---|
| Before | 49.9 mph | 47.8 mph | 42.9 mph |
| After | 48.6 mph | 46.5 mph | 41.8 mph |
| Significant at the 0.05 Level | yes | yes | no |

Table 2 compares the changes in speed between checkpoints and reports whether the two time periods differ on the one-tailed t-test. The one-tailed test is used to affirm the hypothesis that decelerations would be greater with the Rumbler than without. Only vehicles with two valid speed measurements at adjacent checkpoints were included in these averages. Thus, the data in Table 2 cannot be directly computed from the data in Table 1.

Table 2. Average Changes in Speeds of Vehicles both Before and After Installation of the Rumbler

| Time Period | 1106 to 800 ft | 800 to 500 ft |
|---|---|---|
| Before | 2.22 mph | 6.46 mph |
| After | 1.90 mph | 6.25 mph |
| Significant at the 0.05 Level | no | no |

The only differences seen between the two periods are slightly higher speeds during the before period at 1106 and 800 feet. Two possible explanations for these differences are the "rumble strip ahead" sign and the appearance of the strips on the road. It is likely that some drivers are slowing in response to visual clues.

The mix of vehicles and the distribution of signal indications were essentially identical between the two test periods.

**Noise**

Peak sound levels averaged 77.3 dBA for the Rumbler and averaged 85.0 dBA for the conventional rumble strip. This sound level is slightly lower than advertised in the product literature.. Sounds from the Rumbler were noticeably above the road noise for about 0.7 second and the sounds from the conventional rumble strip were noticeably above the road noise for about 0.5 second. A narrower spacing between strips, as suggested in the product literature, should produce higher sound levels. If the spacing is adjusted to make the rumbler active for the same 0.5 seconds as the conventional rumble strip, acoustic theory suggests that the sound level would increase by about 1.5 decibels. For the Rumbler, dominant frequencies were between 60 and 1000 Hz (±3 dB). For the conventional rumble strip, the dominant frequencies were between 50 and 170 Hz (±3 dB). Overall, the Rumbler sound was whiter than the conventional rumble strip, although not as white as the road noise at either location.

**Vibrations**

The accelerations of the steering column v. time are shown in Figure 4. All eight tests are shown in this figure, with the four Rumbler tests on the left and the four conventional rumble strip tests on the right. The peak near the center is a partially recorded test and should be ignored. As seen in Figure 4, peak accelerations from the Rumbler were slightly more than half those from the conventional rumble strip. It is interesting to note that some accelerations due to patched cracks in the pavement exceed 50% of those produced by the Rumbler.

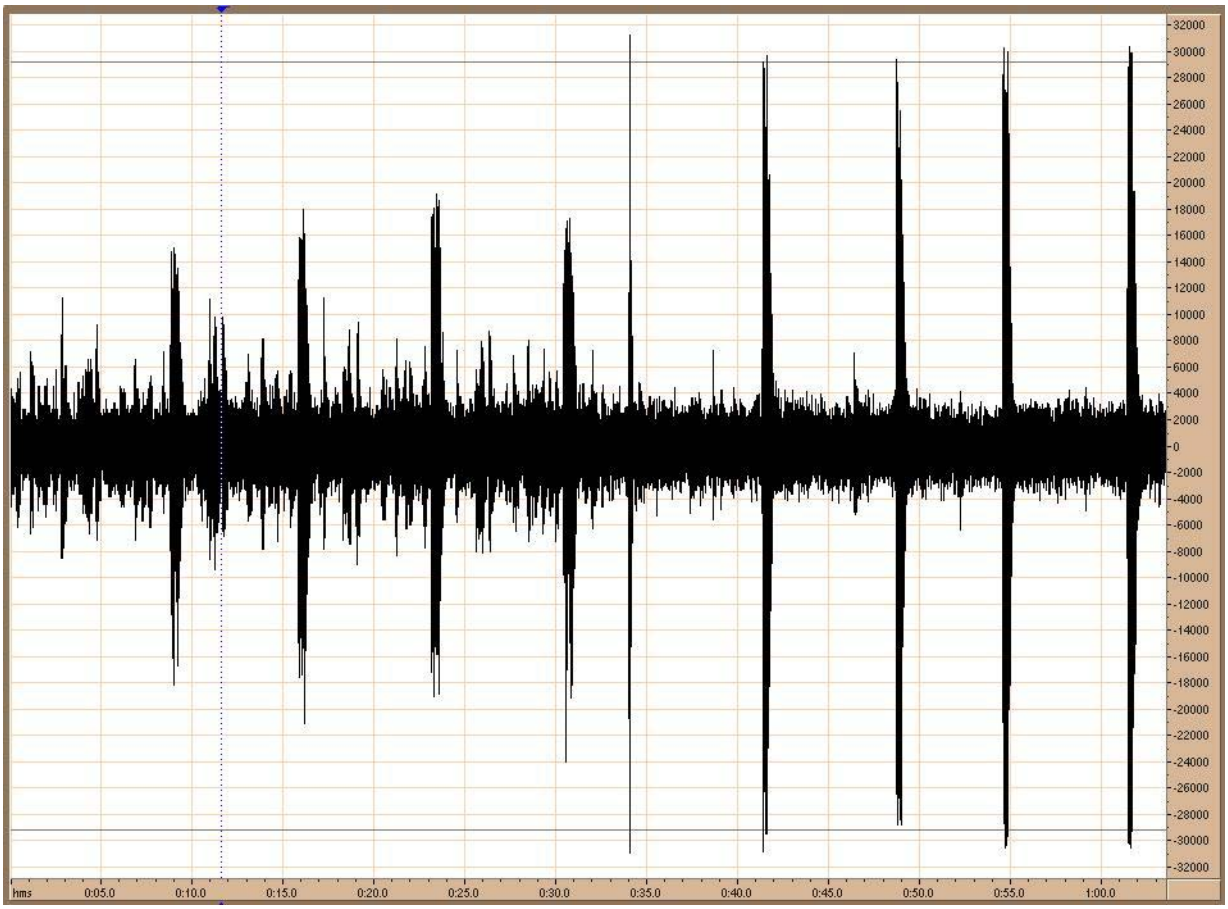


Figure 4. Accelerations v Time for the Rumble and Conventional Rumble Strip on an Arbitrary Scale

Frequencies of accelerations peaked sharply at about 250 Hz for the Rumbler; which seemed to be a natural resonance frequency for the steering column. The conventional rumble strip had a flatter peak at about 250 Hz. Both devices had strong accelerations below 60 Hz.

**Subjective Observations**

The Rumbler was more visible than the conventional rumble strip, allowing motorcyclists ample opportunity to see it and adjust their path.

The qualitative nature of the sounds from the Rumbler were different from those of the conventional rumble strip. For the Rumbler quiet intervals were clearly distinguishable from the sounds of the tires hitting each strip. The sounds from the conventional rumble strip were continuous and at a nearly constant level.

As seen in Figure 2, the strips were not perfectly aligned when installed. However, the strips amply covered the normal track of wheels from both automobiles and trucks.

Although the Rumbler is clearly visible at a few hundred feet, its does not look like an obstacle and may not be readily recognized by drivers as a traffic calming device. However, the rumble may have had the effect of reminding drivers of the need to be alert to the signal.

**Collisions**

No collisions were reported for the intersection during the study period.

## 6. CONCLUSIONS

The Rumbler is much quieter than a conventional rumble strip.. The Rumbler also produced considerably less vibrations in the test automobile. The quality of sound from the Rumbler is also distinctly different from a conventional rumble strip. However the Rumbler's sound is qualitatively different and louder than road noise.

Installation and removal of the Rumbler were easy. There is a concern as to the strength and durability of the adhesive used to affix the Rumbler to the pavement, because not all strips remained in place for the full 7-week test period.

The Rumbler did not elicit a large behavioral response from drivers. This lack a response is not by itself a criticism of the Rumbler, because other traffic calming devices were not tested at the same location. The combination of warning signs and the Rumber caused a small, statistically significant slowing of vehicles.

## 7. RECOMMENDATIONS

The Rumbler should only be used as a supplemental device for alerting drivers to an approaching hazard. The maximum period of installation should be limited to 4 weeks, unless frequent inspection of the device can be preformed after this initial period.