Product Evaluation
on

ATM Removable Rumble Strips
Report No. 2003-1

Reporting on Work Plan 2001-R-2
Final Report

State of Vermont
Agency of Transportation
Materials and Research

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16. Abstract

In the past few years Vermont has joined several other states in the implementation of rumble strips along the shoulders of the interstate highway system. These can be created in one of two ways; either milling or rolling grooves in the pavement or by adding material on top of the pavement creating a raised ridge.

For the purpose of this study, a temporary preformed rumble strip material was evaluated. The proprietary product, Advance Traffic Markings (ATM) Removable Rumble Strips, was evaluated to determine its effectiveness in alerting motorists and reducing traffic speeds in a construction work zone. The rumble strips were placed in conjunction with the agency's standard sign package used in construction work zones.

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Introduction

Making highways safe is an ongoing process for transportation agencies worldwide. With the innovation of new products and processes, technologies enhancing driver's safety have been employed in various applications on our highway transportation systems. In the past few years Vermont has joined several other states in the implementation of rumble strips along the shoulders of the interstate highway system. Rumble strips, a device used to create an audible, tactile, and visual effect to gain the attention of drivers, are typically created one of two ways; milling or rolling grooves in the pavement or by adding material on top of the pavement creating a raised ridge. This traffic-calming device can be utilized in both a temporary or permanent application.

For the purpose of this study, a temporary preformed rumble strip material was evaluated. The proprietary product, Advance Traffic Markings (ATM) Removable Rumble Strips, was evaluated to determine its effectiveness in alerting motorists and reducing traffic speeds in a construction work zone. The rumble strips were placed in conjunction with the agency's standard sign package used in construction work zones.

Product Description

ATM Removable Rumble Strips, manufactured by Advance Traffic Markings of Roanoke Rapids, NC, are surface-mounted rumble strips designed to be placed on top of the pavement. The material is produced from polymers, pigments and process aids into a preformed material with a pre-applied, high tack polymeric adhesive. The product is produced in a variety of colors and is supplied in 4"x 90' rolls. Manufactured in a 150 mils thickness, these strips can be doubled to a total thickness of 300 mils to intensify the tactile (vibration) effect.

Material Costs

At the time of installation, the cost of the product was $6.00 per linear foot. The amount of material needed for this demonstration project was three rolls at $540 per roll for a total of $1620. For the purpose of this study, the material and installation was provided at no cost to the agency.

Project Location

Selected for its limited site distance, rural character, and lack of nearby homes, ATM Removable Rumble Strips were placed on the Warren BHF 013-4(27)S bridge deck replacement project on Vermont Route 100. The construction project required a one-lane closure along with a traffic signal and accompanying sign package. The rumble strips were placed in the southbound lane only, where the roadway alignment - located on an inclining horizontal curve - created limited visibility of the construction site and traffic signal. In 2000, the estimated annual average daily traffic (AADT) volume in this area was 1200.

Test Site Configuration

The test site was laid out in accordance to the manufacturer's recommendation as shown in Figure 1. The rumble strips, placed in three separate groups of 10, were evenly spaced 20 inches center to center. Each group was located 20-50 feet before a construction warning sign to help aid in gaining the motorist attention to the adjacent temporary warning sign.

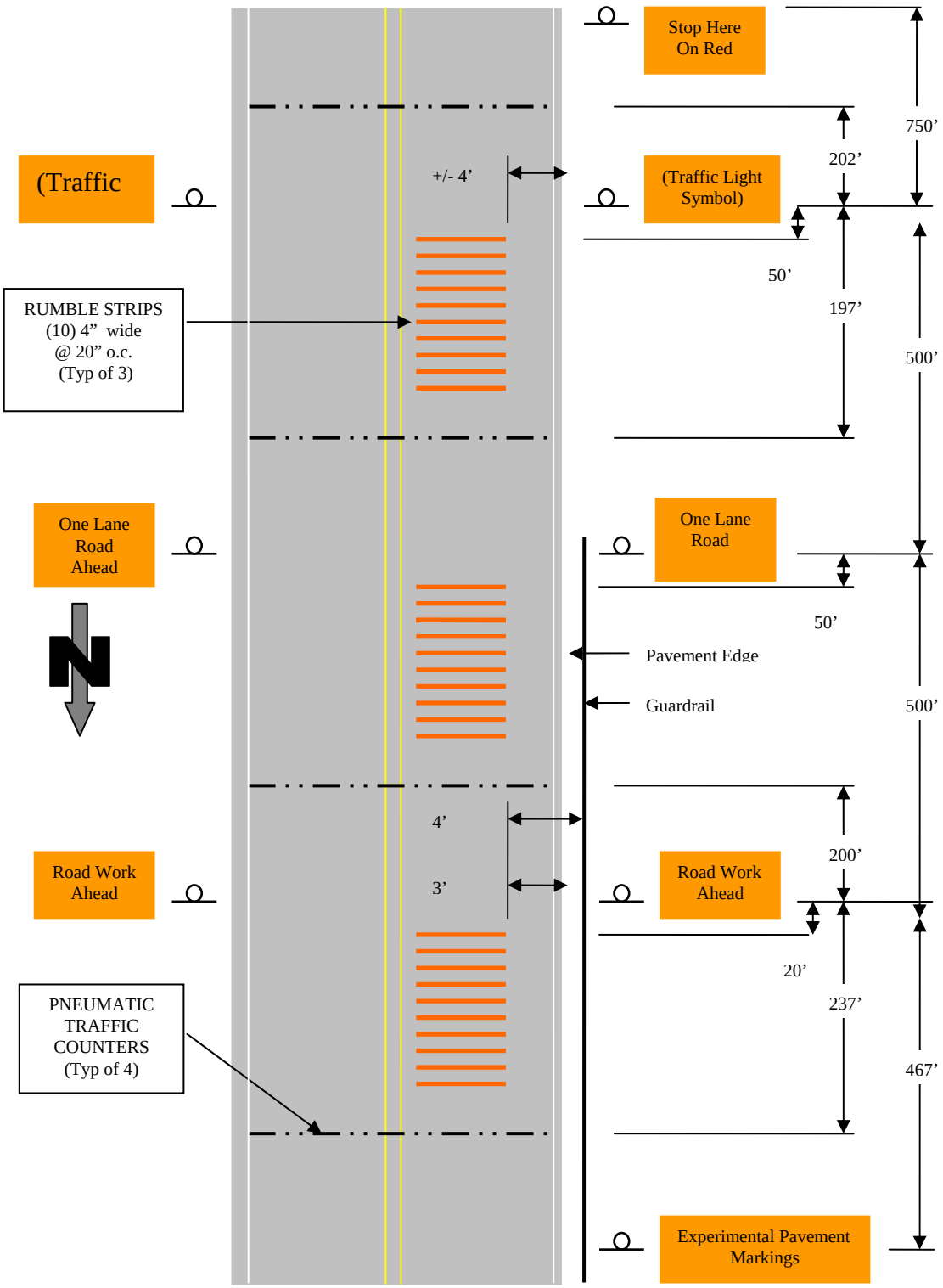

Figure 1. Actual Test Site Layout – Warren, VT.

Recognizing that the travel-way is used by bicyclists, the rumble strips were cut into eight foot lengths and placed a minimum three feet from the pavement edge providing an unobstructed passage way. In the event a bicyclist crossed a rumble strip, only a single layer of material (0.150 inch) was placed to generate a minimum "bump." In addition, a sign was placed approximately 470 feet prior to the first set of rumble strips reading "Experimental Pavement Markings," to inform motorist and bicyclists of the test site area.

Data Collection

The effectiveness of the temporary rumble strips was evaluated on data collected from pneumatic tube counters and subjective observations. Pneumatic tube counters were placed on the project to collect information before and after the motorist passed over each test set group. A total of four counters collected information for a period of days before, immediately after, and one month after the product's installation. The counters were setup to collect vehicular speed, volume, and vehicle classification.

To evaluate the audible and tactile (vibrating) effectiveness, subjective observations were made. Since vehicle size can affect this measurement, these parameters were evaluated in a passenger car, a pickup truck, and a two-axle, state maintenance dump truck. These observations were made after a first-time pass over the strips in each vehicle type.

The durability of the rumble strips was also evaluated based on the condition of the product, including its ability to stay intact to the pavement surface over the duration of its time in-place. Installation and removal of the strips were also observed to evaluate the efforts involved in these processes.

Product Installation

On June 5, 2001, ATM Removable Rumble Strips (product code: 19-690, Batch #: 1-0997) were placed on the southbound lane of Vermont Route 100 in Warren, VT. Orange rumble strips were selected for this study to coincide with the standard color used in construction work zones. The overall condition of the aged bituminous concrete surface was well intact. Before installing the strips, a moisture bag test was performed on the shoulder of the road near one of the proposed test group locations. The test involved securely taping a piece of black plastic along all its edges to the pavement surface in a sunny location. After 20 minutes the bag was removed and the underside was inspected. No condensation was evident and the placement of the rumble strips commenced.

The installation of the three groups of rumble strips took place between 12:00-3:00pm with the ambient air temperature averaging 57^{o} F. Beginning with the most southerly test group, each section was installed in the same manner. The site was laid out and marked, incorporating 10 strips, with a 16 inch spacing between each strip and then the area was swept clean.

The material was cut into eight-foot strips, positioned, and tamped down using a tamper cart with 200 pounds of weight as shown in Figures 2 and 3. A minimum of three full passes (back and fourth) was made over the length of the strip. Care was taken ensuring that each pass was longitudinal to the strip, with no twisting motion over the material. Traffic was allowed to pass over the rumble strips immediately after placement.

Figure 2. Placing the rumble strips.

Figure 3. Tamping the rumble strips.

Unlike the two southerly test groups, the northern group was located only 20 feet, rather than 50 feet, from the construction work zone sign due to significant cracking of the pavement. The purpose of the relocation was to avoid the possibility of failure due to any movement of the pavement structure. In the most southerly group area a minor transverse crack was unavoidable and therefore required on test strip to be placed perpendicularly over the crack as seen in Figure 4.

Figure 4. Placing strip over minor crack at most southern test group.

Field Data

Vehicular Classification

During the product evaluation period there was no significant change in the types of vehicles passing through the project area. The majority of the traffic volume was generated by passenger cars (including motorcycles and pickup trucks), making up 90% or more of the vehicles. Single unit trucks and tractor trailer trucks made up 5% of the volume collectively during each data collection period. Details of the vehicular make-up during each collection period are shown in Table 1.

Vehicular Classification VT Route 100 - Warren, VT			
	Before Installation	After Installation	One-Month After Installation
Passenger Cars	94%	91%	90%
Single Unit Trucks	5%	5%	3%
Tractor Trailer Trks	0%	0%	2%
Unidentified (Error)	1%	4%	5%

Table 1. Vehicular Classification in Test Area.

Speed Statistics

Pneumatic tube counters placed within the project area collected data at three independent time intervals. One variable collected was the speed of the vehicles before and after they passed over the rumble strips. This information was recorded and statistical data computed. Data was collected for four consecutive days before the product's installation and six consecutive days both immediately after and one-month after their placement. All the counters continued to collect information throughout these periods except for the one located between the 1500 and 2000 foot location. This counter collected information for only the first 2 ½ days. The speed statistics are presented in Tables 2 and 3.

From this data we can conclude the average speed of the vehicles decreased over the duration of the project and the percentage of vehicles in the 10 MPH pace increased. The 85^{th} percentile speed shown in Figure 5, the speed typically used in traffic analysis and usually represents the speed that most people travel, decreased at all the data collection points after one-month, as seen in Figure 6. The percentage of vehicles travelling over 55 MPH continued to decrease over the course of the project at all the test site groups as seen in Figure 7.

Speed Statistics (First Two Sites)			
	Before Installation	After Installation	One Month After Installation
	2000 FEET FROM PROJECT		
Average Speed - All Vehicles (MPH)	53	55	49
Number of Vehicles > 55 MPH	741	1333	609
% Vehicles > 55 MPH	34.54%	33.84%	13.93%
10 MPH Pace Speed	51-60	46-55	46-55
Number of Vehicles in Pace	1152	2174	2782
% of Vehicles in Pace	53.69%	55.18%	63.64%
15th Percentile Speed (MPH)	45	46	42
50th Percentile Speed (MPH)	52	52	48
85th Percentile Speed (MPH)	58	59	54
95th Percentile Speed (MPH)	63	67	58
	1500 FEET FROM PROJECT		
Average Speed - All Vehicles (MPH)	51	50	50
Number of Vehicles > 55 MPH	537	724	232
% Vehicles > 55 MPH	25.19%	18.49%	13.43%
10 MPH Pace Speed	46-55	46-55	46-55
Number of Vehicles in Pace	1210	2300	1110
% of Vehicles in Pace	56.76%	58.75%	64.25%
15th Percentile Speed (MPH)	43	42	42
50th Percentile Speed (MPH)	51	48	48
85th Percentile Speed (MPH)	57	56	54
95th Percentile Speed (MPH)	61	59	59

Table 2. Speed Statistics for ATM Temporary Rumble Strips. First Two Sites, Vermont Route 100 – Warren, VT

Speed Statistics (Second Two Sites)			
	Before Installation	After Installation	One Month After Installation
1000 FEET FROM PROJECT			
Average Speed - All Vehicles	47	46	43
Number of Vehicles > 55 MPH	180	247	168
% Vehicles > 55 MPH	8.52%	6.34%	3.93%
10 MPH Pace Speed	41-50	41-50	41-50
Number of Vehicles in Pace	1224	2268	2520
% of Vehicles in Pace	57.92%	58.21%	58.90%
15th Percentile Speed (MPH)	40	37	36
50th Percentile Speed (MPH)	46	43	43
85th Percentile Speed (MPH)	53	51	49
95th Percentile Speed (MPH)	57	57	54
500 FEET FROM PROJECT			
Average Speed - All Vehicles (MPH)	44	43	43
Number of Vehicles > 55 MPH	82	151	115
% Vehicles > 55 MPH	3.83%	4.02%	2.66%
10 MPH Pace Speed	41-50	36-45	41-50
Number of Vehicles in Pace	1191	2160	2464
% of Vehicles in Pace	55.68%	57.48%	57.10%
15th Percentile Speed (MPH)	36	33	36
50th Percentile Speed (MPH)	43	41	42
85th Percentile Speed (MPH)	49	47	48
95th Percentile Speed (MPH)	54	53	53

Table 3. Speed Statistics for ATM Temporary Rumble Strips.
Second Two Sites
Vermont Route 100 – Warren, VT

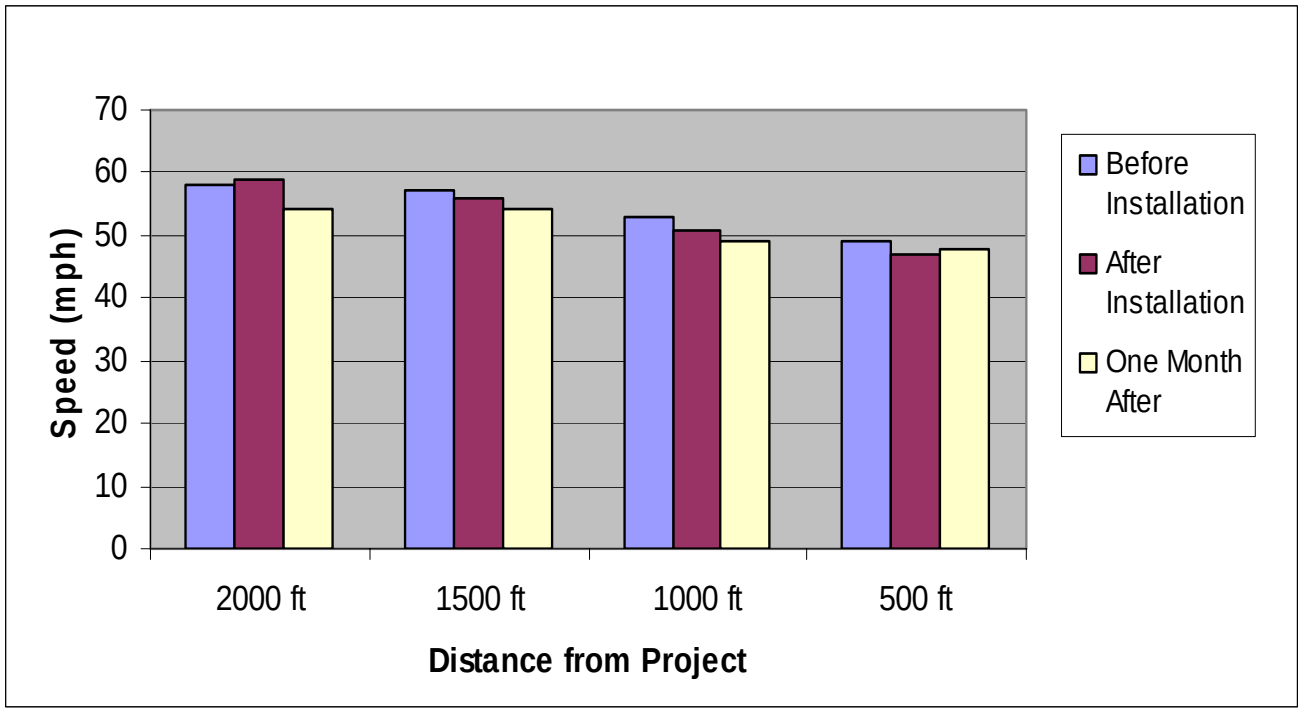

Figure 5. 85th Percentile Speed

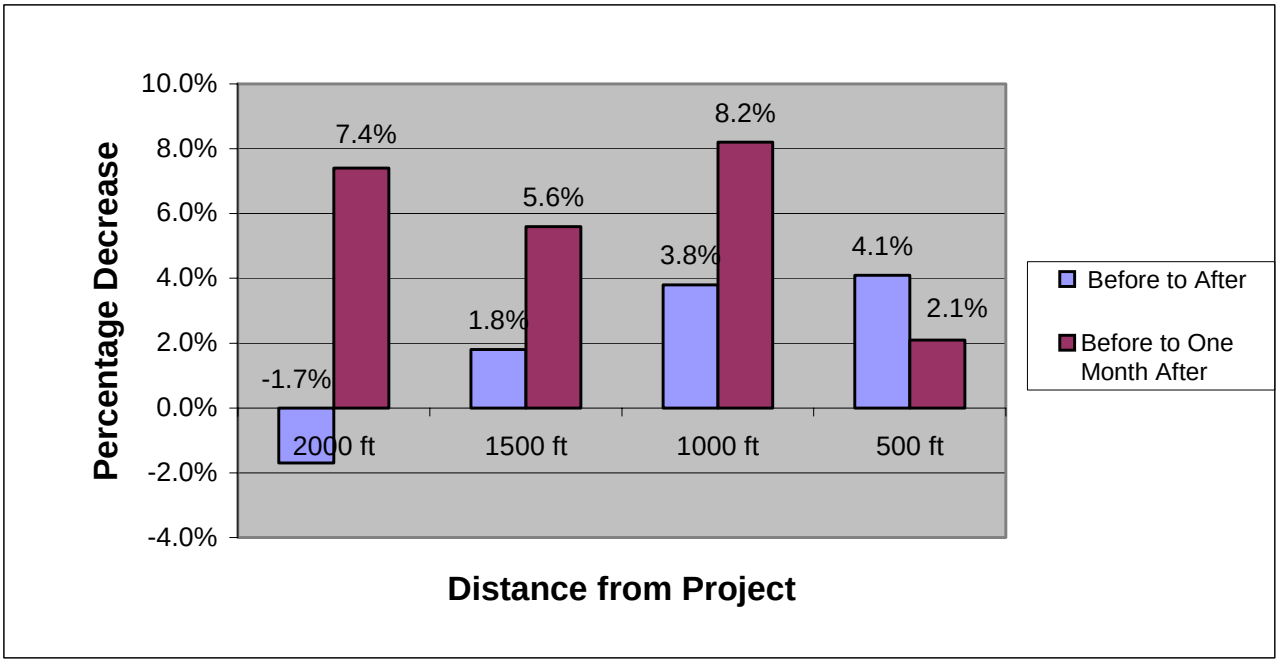

Figure 6. Percentage Decrease in the 85th Percentile Speed.

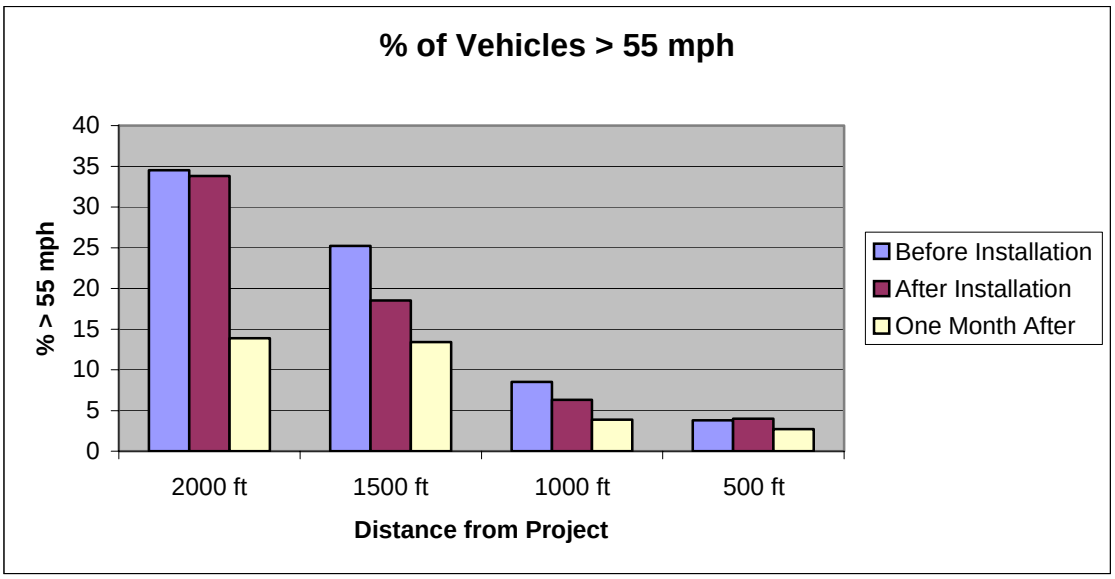

Figure 7. Percentage of Vehicles over 55 MPH.

Product Performance

Audible and Tactile Effect

To further evaluate the performance of the rumble strips, subjective observations were made of audible and tactile effects to drivers in different vehicles, in this case, a passenger car, a pick-up truck, and a state maintenance, two-axle, dump truck. Drivers familiar with the daily operation of each vehicle type were asked if there were any noticeable effects, either audible or tactile, after passing over the rumble strips for the first time.

Both passenger vehicle and pick-up truck drivers reported some sensory reaction including both sound and vibratory effects. The driver and passenger of the dump truck reported no detectable sound or "rumble" effect after passing over the test site at a moderately slow speed. In addition, the audible effect of the rumble strips were very noticeable to pedestrians in the vicinity of the test site area.

Durability

Routine investigations of the test site area revealed the product remained intact, with no material loss or damage, over its four-month service life. The most northerly test strip group, with one strip placed over a transverse crack, remained unaffected by the minor road surface deterioration.

Product Removal

On October 2, 2001, the temporary rumble strips were removed. The removal of the material required no special tools or equipment, only a rigid flat-tip tool. Each strip was pried up on its

narrow end with a flat-tip screwdriver as shown in Figure 8, after which it was slowly pulled up along its length, coming up in full-length strips as shown in Figure 9.

All 30 rumble strips were removed in full-length pieces with little effort. The road, as seen in Figure 10, exhibited no damage as the result of the temporary rumble strip application. The time required to remove all the test strips was less than one hour.

Figure 8. Prying-up the material.

Figure 9. Removing the rumble strips.

Figure 10. After the rumble strips removal.

Summary

Temporary rumble strips have been documented as an effective tool for reducing the speed of traffic in various applications. Two independent studies conducted by the Kansas Department of Transportation in 1999 (KDOT) and Texas Transportation Institute (TTI) in 2000, evaluated the performance of Advance Traffic Markings removable rumble strips in a construction zone application and maintenance activity zone respectively. In both evaluations, orange was selected as the color for the strips to provide a visual warning in addition to an audible and tactile effect.

In the Kansas study it was concluded that the "audible and tactile effects of the strips were weak … in comparison with … standard asphalt rumble strips. However, the orange removable rumble strips were found to have a significant effect on vehicular speeds, attributable to their high visibility" (Meyer, 36). Since the Kansas study revealed the 0.125 inch thickness limited the effectiveness of the rumble effect, TTI incorporated a double thickness of the material for their evaluation. This study also concluded speed reductions of about 1 to 2 miles per hour resulting from the rumble strips application. The researchers of the TTI study recommended that temporary "portable rumble strips should not be used at rural maintenance work zones" but rather in long-term work zones and they should not be placed in residential areas were noise may be of concern (Fontaine et al, 67).

Similar to the data collected for TTI, this study detailed in this report revealed that the average speed of all the vehicles declined 1 mile per hour after the immediate placement of the rumble strips, and the average 85^{th} percentile speed declined 2 miles per hour. Additional data collected one-month after their placement continued to show a decline in speed travelling through the work zone and the number of vehicles travelling over 55 miles per hour also continued to decrease. The long-term decrease may be attributed in part to the placement of the rumble strips, but the public's awareness of the ongoing construction project may have influenced some drivers' behaviors that typically travel through the project area as well.

Overall, the ATM removable rumble strips aided in producing a minimal reduction in traffic speeds within a construction zone area. Since the majority of the traffic consisted of passenger cars, it is assumed that the combination of visual, audible, and tactile effects contributed to the drivers' response. As concluded in the TTI study, the noise generated by traffic travelling over the strips is quite noticeable to people outside of vehicles, hence, making the application of this product in a residential area for any length of time undesirable.

References

Fontaine, Michael D., Carlson, Paul J., Hawkins, Jr., H. Gene. *"Evaluation of Traffic Control Devices for Rural High-Speed Maintenance Work Zones: Second Year Activities and Final Recommendations."* Report FHWA/TX-01/1879-2. Texas Transportation Institute, College Station, TX. October 2000.

Meyer, Eric. *"Evaluation of Orange Removable Rumble Strips for Highway Work Zones."* Transportation Research Record 1715. Paper No. 00-1496. TRB, Washington, D.C. 2000. pp 36-42.

Appendix A

TA 564 Rev 2/01

Prepared By: Theresa C. Gilman
Date: February 26, 2001
Sheet 1 of 2

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH

PRODUCT EVALUATION

Work Plan # 2001-R-2

Product ATM Rumble Strips

Manufacturer Advance Traffic Markings
P.O. Box H
Roanoke Rapids, NC 27870

Distributor Advance Traffic Markings
P.O. Box H
Roanoke Rapids, NC 27870

Evaluation Requested by New Product Committee Date February 2001

Date Evaluation Required Spring/Summer 2001

Date Product Information Received October 2000

Date and Quantity of Samples Received To be received at time of construction. (See attached letter).

Purpose of Evaluation To determine the durability and effectiveness of a temporary rumble strip in a construction zone.

Proposed Test or Evaluation Procedures See attached

Proposal Discussed with New Products Committee Projected Work Days Required 10 days

Investigation to be conducted by Materials and Research personnel

Proposed Start Date Spring/Summer 2001 Estimated Completion Date Fall 2001

Approval/Disapproval by Materials and Research Engineer Robert Cauley

Date 8 Mar 2001 Comments

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Proposed Test or Evaluation Procedures

Warren BHF 013-4 (27) S, scheduled for construction in 2001, is a bridge deck replacement project, which includes a one-lane closure during construction. A temporary traffic signal accompanied with proper signage is planned for this project. The addition of "orange" rumble stripes are anticipated to aid in warning motorist via color and vibration, of up coming construction. Placement of these markings will be in the southbound lane only where the roadway alignment is on a horizontal curve and visibility of the construction site is limited.

The layout of the temporary rumble strips will be determined at time of construction. A possible configuration may resemble New York's guide for Temporary Rumble Strips for Construction Zones (see attached). This layout may vary in the number and spacing of strips, depending on the site and further review.

In recognition of the fact that this travel-way is used by bicycles, the rumble strips will be placed such that there is a gap of at least 3 feet between the edge of the rumble strips and the edge of the pavement, to allow for safe passage of bicycles.

ATM Removable Rumble Strips have been evaluated in several states, including a study published in a Transportation Research Record report from Kansas DOT. Based on methods of evaluations previously used, the following would be a proposed evaluation procedure:

- Installation will be monitored to determine ease and time required for the application of the product.
- Working in conjunction with the Agency's Traffic Research Section, pneumatic tube counters will be placed in the southbound lane in a minimum of four locations (before rumble strips and after all three sets of strips). These tubes will be placed after the installation of the traffic signal and appropriate signage. Data to be collected with these tubes will include speed, vehicle classification, and volume.

  Data with the pneumatic tubes will be collected on two separate days, both before and after the rumble strips are installed. Based on the data collected, a correlation analysis will compare the effectiveness of the rumble strips with respect to speed and possibly vehicle type, depending on the data sample size.
- Subjective observations may also be made of the noise and vibration provided by these strips. Since vehicle size can effect this measurement, it may be beneficial to observe these parameters in a passenger car, a heavy-duty truck and a state maintenance truck.
- The rumble strips will remain for the duration of the project to further evaluate the product's durability.

Research & Development staff, Traffic Research staff and temporary personnel will gather the data associated with this project.

A report will be written including the results of the data collected above.