EVALUATION OF EXPERIMENTAL RUMBLE STRIPS

FINAL REPORT
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standard, specification or regulation."

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ABSTRACT

This report was prepared to provide the results of evaluations conducted upon twenty-six roadways where rumble strips were installed experimentally in Louisiana between August 1982 and September 1984. Situated randomly throughout Louisiana, construction of these coarse-textured, exposed sandstone aggregate rumble strips was accomplished by district maintenance forces using conventional asphalt distributing equipment.

The purpose of this project was to develop a supplement to typical traffic control devices, such as signs or signalization, where a substantial reduction in speed is required to divert driver inattentiveness towards a potentially hazardous intersection or situation. It was hoped that the audible and tactile stimuli provided by the designated intermittent pattern of the coarse-textured, exposed sandstone aggregate rumble strips would increase driver reaction time, thereby creating the reduction in speed necessary to reinforce or augment standard visual traffic control devices.

This report addresses installation techniques/problems, relative aggregate durability, aggregate loss determinations, possible rejuvenation procedures and analyzes historical accident statistics prior to and after installation.

INTRODUCTION

During the late 1970's, the Louisiana Department of Transportation and Development (LADOTD), herein after called the Department, recognized the existence of many intersections with relatively low traffic volumes with apparently good alignment and visibility but which had unexpectedly high accident rates. These conditions did not warrant costly corrective measures, such as signalization, to augment existing traffic control devices. Frequent violation of these devices, usually nothing more that STOP signs, dictated that an alternative be developed.

A poll of other states resulted in acquisition of several promising methods utilizing delineators or coarse-textured aggregates placed in a series of intermittent intervals, i.e. "rumble strips." One report (1)* stated that rumble strips provided audible and tactile stimuli to alert drivers to potentially hazardous intersections or situations and tended to increase driver reaction time, whereas existing visual stimuli was otherwise largely ineffective.

Based upon the findings and recommendations of that and related reports (2), the Department's Research and Development Section, now the Louisiana Transportation Research Center (LTRC), developed tentative installation procedures and a typical rumble strip configuration (Appendix) for applications in Louisiana. In October 1979, with the assistance of district maintenance forces, four coarse-textured, exposed sandstone aggregate rumble strips were installed in low density rural environments for preliminary evaluation purposes. After one-year of satisfactory performance, the proposal for this project was developed and approved by the FHWA for experimental installation on a statewide basis.

*Underlined numbers in parenthesis refer to list of references.

subsequently, twenty-six rumble strip areas were installed throughout Louisiana for evaluation purposes. This report presents the performance characteristics of those evaluations conducted between 1982 and 1986 by LTRC.

METHODOLOGY

TYPICAL RUMBLE STRIP CONFIGURATION

Figure 1 depicts a typical rumble strip layout for applications in Louisiana. It was developed by the Louisiana Transportation Research Center (LTRC) based upon a review of studies conducted by others (1, 2). An example is enclosed in the Appendix with a sample of instruction to a District Traffic Operations Engineer used to facilitate installation by District Maintenance Crews. Further enclosed (Appendix) is early intradepartmental correspondence reflecting the emphasis the Department placed upon the need to provide a viable solution to development of policies with regards to use and application of rumble strips on Louisiana Highways. Absence of such a policy mandated installation applications on a trial or experimental basis only. This report is an evolution of those early inquiries and presents the findings acquired from twenty-six experimental rumble strips installed variously throughout Louisiana between 1982 and 1984.

TYPICAL RUMBLE STRIP CONFIGURATION

SITE SELECTION

In December 1980, the Department sent a memorandum to each of its nine District Traffic Operations Engineers requesting that they designate five tentative intersections for installation of rumble strips on an experimental basis. These locations were to be restricted to two lane asphaltic concrete or bituminous surfaces treatment roadways. Needs were to be based upon previous traffic studies, accident occurrences or other conditions that indicated a need to warn motorists of an approaching stop condition. Site locations and descriptions were then forwarded to the Louisiana Transportation Research Center for monitoring and for performance evaluation purposes.

MATERIALS EVALUATED

While this memorandum was being circulated, the Research and Development Section (now LTRC) reviewed analyses of rumble strips installed by other states (1, 2). From these findings they developed a modified rumble strip configuration, specifications for aggregate gradations, established a source of supply and developed installation techniques and procedures (Appendix). These guidelines were implemented by installation of four experimental rumble strips in the Chase District in 1979. Composed of cationic asphalt emulsion and coarse, exposed aggregate surfaces with an intermittent pattern, the strips were found to be effective in producing a series of changes in sensation rather than a single stimuli as would a continuous rumble strip. Based upon these installations, the best available aggregate appeared to be 3/4" (nominal size) washed sandstone. Each District was then instructed to order 120 tons of aggregate, enough to complete five installations using the proposed configuration, and to plan for installation on an experimental basis at the earliest convenience by their respective maintenance forces. Twenty-six installations were completed and provided the basis for these evaluations.

FIELD INSTALLATION

Field installation of the coarse, exposed aggregate rumble strips was accomplished by each district's maintenance forces utilizing conventional asphalt distributing equipment. The intermittent pattern was measured and masked off using ordinary brown wrapping paper (Figure 2) to protect the

centerline markings and provide a square leading edge.

Cationic asphalt was then applied at a rate of approximately 0.45 gal./sq. yd. to provide a slurry slightly heavier than is normally used for surface treatment applications (Figure 3).

This heavier slurry was to provide for better adhesion to the larger 3/4" (nominal size) aggregate being used. Application was accomplished with either hand-wand distributors (Figure 2) or with conventional asphalt spray bar distributing equipment (Figure 4). There has been no discernable difference noted in rumble strips relative to the method of application. On many locations, where the asphalt sprayer bar displayed a uniform rate of delivery, the brown wrapping paper was eliminated and the operator controlled the application at start and finish marks indicated on the existing pavement. Utilizing this method, depending upon the temperature and consistency of the emulsion, and the slope of the roadway, some run-off onto the shoulder was noticed occasionally.

On eleven of the rumble areas, an experimental polymerized asphalt was used in lieu of conventional cationic emulsion. The addition of polymers to the asphalt creates a chemical reaction that is to strengthen the cohesion of the binder and impart a elastomeric characteristic that enhances the binders. Unlike conventional cationics, researchers noted a more rapid, pliable "set" that permitted opening the rumble areas to traffic in almost half the time required by the former method. Applied directly on HMAC as well as plant mix seal coat surface treatments alike, comparative evaluations are being conducted to determine the effectiveness of this material for future applications.

Coarse, washed sandstone of the following approximate gradations were distributed:

1" - 100% passing
3/4" - 20% to 60% passing
5/8" - 0% to 10% passing

This washed 3/4" (nominal size) exposed aggregate was chosen based upon the favorable results from the four experimental rumble strips installed in the Chase District during 1979. Although most of the aggregate was applied using spreader boxes, at least one district was successful in spreading and distributing it manually (Figure 5).

After application by either method, stiff push brooms were used to spread the aggregate uniformly to eliminate "bald spots" (Figure 6).

Application of excessive thicknesses always contributed to rapid loss of aggregate once opened to traffic, with approximately 5-10% being strewn onto the shoulder or into the opposite lane overnight

(figure 7). Experience can be utilized in the application of future installations to maximize coverage and minimize waste. Distribution of aggregate with excessive fines or contamination should be avoided. Stockpiles of materials should be maintained on paved areas wherever possible and used as soon after receipt from the quarry as is practical.

Rolling of the rumble strips was accomplished using either steel wheel or pneumatic rollers (Figure

8) depending upon the district. While both have met with success, the pneumatic roller is preferred. Large steel wheel rollers should be emptied of ballast. Even where using small portable steel wheel rollers, fracturing of the aggregate, which may reduce the effectiveness of the rumble strips, has been noted. Generally, six to eight overlapping passes appeared to give adequate penetration into the roadway. Rolling should be reduced significantly when using polymerized cationic as its more rapid "set" and tackiness tends to retain the aggregate more readily.

Traffic should be kept off the freshly compacted rumble strips as long as practical. Due to the close proximity of busy intersections, it has been necessary to open several "bands" or strips to traffic almost immediately because of the excessive length of the construction train. The use of a flagman is recommended to keep speeds down and to give the emulsion time to set-up. This process is facilitate when using the polymerized asphalt, as it gets tacky and resilient within 10 to 20 minutes, depending upon temperature and humidity, and has more elasticity to insure maximum aggregate retention.

FIELD EVALUATION

Evaluation of completed rumble strip installations consisted of visual inspection of the overall condition and effectiveness of the exposed aggregate surfacing. Of primary consideration was the retention of aggregate, especially in proximity of the wheelpaths. Other areas of concern were the cause of excessive "bald spots" and "bleeding" of the cationic emulsion that literally engulfed the aggregate. In general, periodic overall visual inspection was conducted to determine the cause of any condition that might create a loss of the audible or tactile stimuli, thereby reducing the effectiveness of the rumble strips as a supplemental traffic control.

Secondly, in order to make a more definite aggregate loss determination, a photo-box utilizing a 35 mm camera with a remote flash unit was employed. At each site, five locations were selected at random in alternating wheelpaths throughout the section. Using a template oversprayed with paint to identify and locate each selected test spot, the photo-box was used to photo-document the exposed aggregate with a superimposed grid pattern. These slides were taken initially after a two-week "wearing-in" period following installation and then annually during the anniversary month. These were then compared in order to establish the loss rate of nominal large size aggregate. Table 2 (Appendix) provides the results of those determinations made at each site.

DATA ANALYSIS

Factors given consideration were site specific historical and statistical data such as traffic volume, alignment, sight obstructions and public reaction to the improvements. It was decided that these historical parameters did little to establish whether rumble strips reduced the type and/or severity of accidents. In summation, only specific accident report data were extracted for the final analysis. Results of those findings are presented in Table 1 (Appendix).

A comparison of accident report statistics would seem to indicate that, after installation of coarse, exposed aggregate rumble strips, there was a slight reduction in both the quantity and severity of accidents at potentially hazardous intersections. Accident reports indicated that 58.6% of all the accidents occurred prior to installation. A paired t-test for the before/after distributions for all sites indicates a significant reduction in accidents at a 95% confidence level. Also, a chi-square test on these same distributions find that the null hypothesis (there is no significant reduction) can be rejected at a 94% confidence level. However, most of the accidents evaluated were property damage only.

Analysis of the severity of accidents indicates there were no fatality accidents in the after period, as opposed to 2.6% in the before period. While injury accidents remained virtually unchanged, 20.3% versus 19.7%, accidents involving property damage only (PDO) dropped from 35.5% to 21.7%.

Analysis of the time-of-day in which accidents were most likely to occur demonstrated that two-thirds of all accidents were during daylight hours. Daylight accidents dropped from 33.6% to 28.9% in the after period while nighttime accidents were reduced more significantly by 50%... or from 25.0% in the before period to 12.5% in the after period. A paired t-test for the nighttime (before/after) distributions for all sites found a significant reduction in accidents at a 95% confidence level. This would tend to suggest that the audible and tactile stimuli of the coarse, exposed aggregate was effective in alerting drivers to potentially hazardous intersections during periods of reduced visibility. This theory is reinforced by the distribution of inclement weather accidents with 60.6% in the before period versus 39.4% in the after period.

CONCLUSIONS

1. A comparison of accident report statistics indicates that, after installation of coarse, exposed aggregate rumble strips, there is a slight reduction in both the quantity and severity of accidents at potentially hazardous intersections. Accident reports that covered a four-year period, two-years before and two-years after installation, demonstrated that 58.6% of all the accidents occurred prior to installation. A paired t-test for the before/after distributions for all sites rejects the null hypothesis, that there is no significant reduction in accidents, at a 95% confidence level. Also, a chi-square test on these same distributions rejects the null hypothesis at a 94% confidence level. However, most of the accidents evaluated were property damage only.

2. Analysis of the severity of accidents indicate there were no fatality accidents in the after period, as opposed to 2.6% in the before period. While injury accidents remained virtually unchanged, 20.3% versus 19.7%, accidents involving property damage only (PDO) dropped from 35.5% to 21.7%. Sites that were subsequently improved by eliminating sight obstructions, shoulder widening, turn lanes, signalization, etc., were not included due to the possible bias those safety improvements might have introduced.

3. Analysis of the time-of-day in which accidents were most likely to occur demonstrated that two-thirds of all accidents were during daylight hours. Daylight accidents dropped from 33.6% to 28.9% in the after period while nighttime accidents were reduced more significantly by 50%... or from 25.0% in the before period to 12.5% in the after period. A paired t-test for the nighttime (before/after) distributions for all sites found a significant reduction in accidents at a 95% confidence level. This would tend to suggest that the audible and tactile stimuli of the coarse, exposed aggregate was effective in alerting drivers to potentially hazardous intersections during periods of reduced visibility. This theory is reinforced by the distribution of inclement weather accidents with 60.6% in the before period versus 39.4% in the after period.

4. Rumble strips of coarse, exposed aggregate were readily installed by district maintenance crews utilizing only conventional asphalt distributing equipment. Relatively inexperienced crews were

able to accomplish installation within 3-4 hours. When polymerized additives were used in the emulsion, the roadway was opened to traffic almost immediately.

5. Aggregate loss throughout the evaluation period was considered negligible. Of more concern was a condition wherein the emulsion experienced softening and a condition referred to as "bleeding" developed. Although not common, this condition literally engulfs the aggregate in proximity of the wheelpaths, thereby diminishing the audible and tactile stimulus somewhat.

RECOMMENDATIONS

1. It is recommended that the Louisiana Department of Transportation and Development (LADOTD) adopt a policy concerning the application and use of coarse, exposed aggregate rumble strips for intersections wherein conventional traffic controls devices have proven largely ineffective by high accident frequency, and yet, do not provide justification for more costly corrective measures.

2. It is recommended that this policy provide guidelines for district traffic, safety and maintenance engineers to utilize in the event that procedures outlined in the Louisiana Manual of Uniform Traffic Control Devices (LAMUTCD) fail to reduce high accident frequency at certain potentially hazardous intersections.

3. In the event that such a policy and/or specifications be developed then the recommendation to place "Experimental Surface Area Ahead" signs should not be considered. Instead, it is suggested that a more poignant message, such as "Prepare To Stop-Hazardous Intersection" be followed by a simple "Stop Ahead" midway between the approaching rumble strips (or area) and the intersections' "Stop" sign. It was felt that the motoring public did not always recognize the significance of the "Experimental Surface Area Ahead" signs.

4. It is recommended, that only polymerized cationic asphalt and pneumatic rollers be considered for installation in order to facilitate construction, minimize exposure to traffic, reduce road/lane closure time and increase the longevity of the rumble strips, thereby reducing future maintenance costs.

5. Since 1980, all accident report data on the master file was considered to be reliable, whereas

many reports previous to that were questionable upon close examination. It is recommended that accident statistics be recalled prior to consideration of rumble strips installation to reinforce the recommendation by demonstrating the ineffectiveness of present traffic control devices. It is further recommended that subsequent accident reports be monitored to measure the effectiveness of future applications and reinforce the findings of this report.

TABLE 2

EVAULATION OF EXPERIMENTAL RUMBLE STRIPS

Aggregate Loss Determinations
(Initial Versus Two-Years After Installation)

SITE	LOCATION	INITIAL	2 YEARS	% RET.	% LOSS
#1	Alexandria	230	229	100%	0%
#2	Alexandria	238	234	98%	2%
#3	Hammond	221	215	97%	3%
#4	Archie	241	240	100%	0%
#5	Jonesville	236	234	99%	1%
#6	Newellton	221	217	98%	2%
#7	Elton	172	171	99%	1%
#8	Elton	190	188	99%	1%
#9	Baton Rouge	131	113	86%	14%
#10	Labadieville	168	156	93%	7%
#11	Plattenville	188	127	68%	32%
#12	Iowa	152	152	100%	0%
#13	Iowa	180	180	100%	0%
#14	Fields	170	170	100%	0%
#15	Roanoke	182	151	83%	17%
#16	Roanoke	168	141	84%	16%

#17	Ville Platte	190	187	98%	2%
#18	Nuba	183	177	97%	3%
#19	Nuba	171	167	98%	2%
#20	Ruston	138	130	94%	6%
#21	Cheniere	154	147	95%	5%

TABLE 2 (Continued)

EVAULATION OF EXPERIMENTAL RUMBLE STRIPS

Aggregate Loss Determinations
(Initial Versus Two-Years After Installation)

SITE	LOCATION	INITIAL	2 YEARS	% RET.	% LOSS
#22	Cheniere	130	125	96%	4%
#23	Monroe	289	284	98%	2%
#24	Monroe	231	228	99%	1%
#25	Mer Rouge	268	268	100%	0%
#26	Mer Rouge	195	195	100%	0%

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LIST OF REFERENCES

[1] Mark L. Kermit and T. C. Hein, "Effects of Rumble Strips on Traffic Control and Driver Behavior," Proceedings, Highway Research Board, Vol. 41, (1962), pp. 469-482.

[2] John T. Capelli, Audible Roadway Delineators, New York; Report NYSDOT-ERD-73-SR 14, May 1973.