RUMBLE STRIPS

Finding a Design for Bicycles and Motor Vehicles

DAVE BACHMAN

Dave Bachman is Bicycle and Pedestrian Program Manager, Bureau of Highway Safety and Traffic Engineering, Pennsylvania Department of Transportation, Harrisburg.

The Pennsylvania Department of Transportation (PENNDOT) researched milled rumble strip patterns that are safe and effective for bicyclists as well as motorists on nonfreeway roads—a difficult task, since the needs of each group differ. Although bicyclists want to cross the rumble strip safely and comfortably with minimal vibration, motorists want sufficient vibration and sound to warn that the vehicle is drifting from the travel lane.

Problem

Roads that are open to bicycles—the majority of the highway network—need rumble strips designed to meet the conflicting needs of motorists and bicyclists. Used mainly on urban and rural freeways, rumble strips have reduced crashes and fatalities by 20 to 50 percent.

One reason rumble strips have not been implemented on nonfreeway roads is that they can be uncomfortable for bicyclists to ride over and can cause loss of control of the bicycle—a serious safety issue. Although bicyclists usually travel on the shoulder outside of the rumble strip, they occasionally need to cross it, for example, to make a left turn or to avoid debris.

Solution

Developing a Model

After an assessment of PENNDOT's rumble strip pattern, 25 alternatives were developed and evaluated, and a simulation model was devised and validated. The simulation model indicated that 4-inch-wide (102-mm) grooves would provide the smoothest ride for bicyclists. However, the cutting head on the milling machine used by PENNDOT is a fixed diameter, which means that there is a linear relationship between width and depth of cut. Four-inch cuts would have meant an unacceptably shallow cut. Therefore, 4-inch (102-mm) grooves were not considered further. All of the patterns used the same groove length, between 16 and 17 inches (406 and 432 mm).

Testing the Rumble Strips

The five highest ranked test patterns and PENNDOT's current standard (Table 1) were installed at a test facility for field experiments. Volunteers rode four different bicycle models—mountain, touring, hybrid, and tandem—over the test rumble strip patterns at various speeds and angles (see photo, next page). Vertical acceleration (up and down movement by the bicyclist) and pitch angular acceleration (before and after rocking experienced by

TABLE 1 Rumble Strip Configurations Tested

	Rumble Strip Dimensions, inches (mm)			Performance for Bicyclists	Vehicle Sound Difference dB(A) (Rank)	
Test Pattern	Groove Width	Gap between Grooves	Groove Depth	Composite Score (Rank)	55 mph (88 km/h)	45 mph (72 km/h)
*1	7 (180)	5 (130)	0.5 (13)	0.97 (#6)	23.7 (#1)	11.6 (#2)
2	5 (130)	7 (180)	0.5 (13)	0.50 (#3)	18.5 (#2)	10.0 (#4)
3	5 (130)	7 (180)	0.375 (10)	0.12 (#2)	16.1 (#3)	6.8 (#5)
4	5 (130)	6 (150)	0.5 (13)	0.66 (#5)	16.0 (#4)	15.2 (#1)
5	5 (130)	6 (150)	0.375 (10)	0.50 (#3)	13.9 (#5)	10.9 (#3)
6	5 (130)	7 (180)	0.25 (6.3)	0.003 (#1)	13.0 (#6)	6.3 (#6)

*PENNDOT's current standard.

the bicyclist) data were collected and compared for each pattern. The bicyclists rode on an 8-inch (203-mm) white line over each pattern to measure the effect of the grooves on handling and control, and the researchers recorded the percentage of time spent off the line. The bicyclists rated the comfort and control for each pattern by marking a graphical scale from very uncomfortable to very comfortable.

Rating the Test Patterns

The researchers normalized the scores for each experiment to a scale of 0 (best) to 1 (worst) and averaged the scores to obtain composite scores (Table 1). Test Pattern 1 was clearly the worst from the bicyclist's perspective; conversely, Patterns 6 and 3 were the best and second best. Patterns 2 and 5 had the same composite score, with Pattern 2 doing better on the acceleration tests, and Pattern 5 doing better on the subjective ratings. Pattern 4 did well on the white line test but poorly on the others.

To assess each rumble strip pattern's auditory effect on inattentive or drowsy motorists, the maximum sound level in a vehicle was measured when the vehicle drove over the patterns. The difference between the maximum sound level and the ambient sound level when driving on a smooth pavement was determined (Table 1).

Vertical and pitch angular accelerations also were measured, but were not found useful. Previous research had found that rumble strips producing 4 dB(A) increases above the ambient noise can be readily detected by motorists who are awake (*1*), but there are no data indicating the sound level difference necessary to alert a drowsy motorist.

For higher speed roads, near 55 mph (88 km/h), Pattern 3 was the best balance between the competing needs of motorists and bicyclists. It was the second-best pattern for bicyclists and the third-best for motorists. Pattern 6, the best for bicyclists, was not chosen because it provided the least sound difference to motorists.

For lower speed roads, near 45 mph (72 km/h), Pattern 5—the third-best pattern for both bicyclists and motorists—was recommended. The two best patterns for bicyclists generated less than 7 dB(A) sound above the ambient level, which was not deemed to be sufficient to rouse drowsy motorists.

Application

PENNDOT will install pilot rumble strips designed from Patterns 3 and 5 on nonfreeway routes across Pennsylvania this year. Installation is only on roadways with shoulders at least 6 feet wide, so that there is sufficient room for bicyclists to travel outside of the rumble strip. If these pilot installations are well received by the bicycle community, additional installations will follow.

Volunteer bicyclist tests rumble strip pattern at various speeds and angles.

Benefits

PENNDOT's goal is to reduce crashes and fatalities by 10 percent. Run-off-the-road motor vehicle crashes on nonfreeway facilities make up a significant portion of crashes and fatalities. Although data are not yet available to estimate the reduction in crashes and fatalities due to nonfreeway rumble strips, the success of rumble strips on freeways is a good prediction of performance.

Effectively designed rumble strips also may improve bicyclist safety by providing a buffer between motor vehicles and bicycles and by reducing the number of motor vehicles infringing on the bicyclists' part of the shoulder.

Reference

1. Watts, G. R. The Development of Rumble Areas as a Driver-Alerting Device. In Supplementary Report 291, Transportation and Road Research Laboratory, 1977.

For more information contact Michael Bonini, Research Division, Pennsylvania Department of Transportation, 400 North Street, 6th Floor, Harrisburg, PA 17120-3789 (telephone 717-772-4664, email mbonini@dot.state.pa.us).

EDITOR'S NOTE: Appreciation is expressed to Ray Derr, Transportation Research Board, for his efforts in developing this article.

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, 2101 Constitution Avenue, NW, Washington, DC 20418 (telephone 202-334-2952, e-mail gjayapra@nas.edu).