Rumble Strips or Not Along Wide Shoulders Designated for Bicycle Traffic?

Associate Professor Per Garder
Department of Civil & Environmental Engineering
University of Maine, Orono, Maine 04469
Phone (207)581-2177
Fax(207)581-1215

ABSTRACT

Wide paved shoulders on busy two-lane roads are sometimes designated as bicycle routes. But this shoulder may not be a safe place for bicyclists if inattentive and dozing drivers "use" it too. Preliminary estimates for a road carrying 1,000 vehicles per hour show a fatality rate substantially higher than the average rate for bicycling. To make the shoulder safe, dozing vehicle drivers have to be woken up before they infringe on the bicyclists' part of the shoulder. Continuous shoulder rumble strips have a potential to alert wandering drivers and thus reduce the number of run-off-road automobile crashes as well as enhance the safety of bicyclists and others using the shoulder. A narrow strip which leaves most of the shoulder to the bicyclists is desired. It is important that this remaining part is kept free from debris so that bicyclists are not forced to ride on the rumble area or out in traffic.

BACKGROUND

One of the most frequently cited reasons for not bicycling is fear for safety in traffic *(1).* However, increasing the perceived safety may actually be counterproductive from a safety perspective. *The subjectively experienced difficulty should not be reduced but rather increased (2)* to get fewer crashes per mile ridden. So, unless motorists and bicyclists are completely separated, neither motorists nor bicyclists should be encouraged to perceive the road as safer than it actually is. This rule is often broken, and that helps explain why partial separation e.g., bike paths that frequently intersect with streets--leads to more crashes per mile ridden than environments where bicycle and vehicular traffic share the same roadway (3). It also explains why design criteria should not be based on what bicyclists *perceive* of as safe, unless our goal is solely to increase bicycling irrespective of injury consequences.

Bicycle Crash Review

There are in the U.S. annually about *850* fatalities in motor-vehicle related crashes among bicyclists (5). This represents about 90% of all fatally injured bicyclists (6). In other words, we would almost fully solve the problem of fatalities if we managed to totally separate bicycle traffic from motor vehicle traffic. To have this as a goal would, of course, be unrealistic.

We know that nationwide about 73% of fatal motor-vehicle-related bicycle crashes happen away from intersections and 36% happen outside urban areas (5). Thus—in theory, at least-the potential number of fatalities that could be avoided if all rural roads had "safe" shoulders seems to be around 240 a year [(73%)(36%)(850)]. And some of the remaining crashes involve a driver who has dozed off. Wide paved shoulders would definitely not guarantee that these accidents were avoided.

FREQUENCY WITH WHICH DRIVERS DOZE OFF WHILE DRIVING

Reports based on police-recorded accidents give clues to how often people have accidents as a result of dozing off, but this information is most likely biased because people are not likely to report the true cause of an accident which is sleep-related. In fact, the accident may not be reported at all, especially if it doesn't involve a second party and takes place on a minor rural road. It may be possible to capture these accidents in other ways, e.g., through interview studies or with the use of questionnaires distributed among randomly chosen drivers. According to Dillman *(8),* who commonly is quoted as an expert on interview techniques, people tend to give "socially acceptable answers "in face-to-face interviews, whereas people are more apt to tell the truth if the survey is done in a way that ensures anonymity. This is probably especially true if admitting the truth may reveal embarrassing or even criminal behavior. We therefore chose to use questionnaires for collecting this data. These were distributed in the state of Maine during 1993. A total of 205 drivers participated. Below is a summary of the results. Details are presented in a separate paper (9).

The average incident rate of dozing off while driving was around once every 45,000 km (28,000 miles) among randomly selected drivers.

Fifteen (13% of those who had dozed off) reported a collision as a result of having fallen asleep. Two more reported to have woken up completely off the road-in a ditch and on a lawn, respectively-but since these incidents resulted in no damage to the vehicles, they were not considered to be accidents by the respondents. Only two of the fifteen drivers reported that they woke up prior to the collision. One woke up in a hospital. Five of the accidents were collisions with other vehicles----three involving another passenger car and two involving heavy trucks. The remaining ten were single vehicle accidents; in three cases collisions with guard rails, in two cases with trees, in one each with a snow bank, a ditch, and a telephone pole (on a sidewalk). Only five of the fifteen accidents were reported to the police.

Most of the drivers who had not had a collision stated that they were asleep only for a second or two and woke up by themselves. They seemed to think there was not a real threat of an accident.

Location When Waking Up

This analysis is to evaluate whether the driver actually infringed on the shoulder or not before waking up. If he or she did, continuous shoulder nimble strips would be fully effective if they produced enough rumble to wake up the dozing driver, and his reaction was to get back onto the traveled way before infringing on the part used by bicyclists.

In 62% of the incidents the driver didn't wake up until after he or she had left the traveled lane. In three out of four of these cases, the driver had drifted off to the right.

Rate of Dozing Off and Drifting Onto Shoulders of 2-lane Roads in the Daytime

Our best estimate of how often a random Maine driver leaves the traveled way as a result of falling asleep

and drifts off onto either of the shoulders before waking up is about once every 206,000 km [(45,000)/(.80)/(.44)/(.62)] (once every 128,000 miles). This rate assumes that the road is lacking devices for waking the driver back up before infringing onto the shoulder. With such devices, these situations could practically be eliminated.

ANALYSIS OF SLEEP-RELATED FATAL ACCIDENTS

Of the fatal accidents on Maine's Interstate system from 1989 to 1993, 42% (33/79) were caused by a driver *definitely* or *very probably* having fallen asleep. The investigating officers have for these accidents either indicated "driver apparently fell asleep" or noted that the driver or a passenger said that the driver had fallen asleep. The 79 fatal accidents actually killed 94 people; 45 of them died in sleep-related accidents. Table 1 shows what time of day these sleep-related fatal accidents occurred.

Table 1 Time of day for fatal sleep-related accident on Maine's interstate system

					morning		afternoon			evening	
Time	0-2	2-4	4-6	6-8	8-10	10-12	12-2	2-4	4-6	6-8	8-10 10-12
No. of accidents:	4	0	4	1	2	2	5	8	1	3	2 1

Table 2 shows that most fatal sleep-related accidents happen in the summertime. Again, if people ride bicycles from may to October (typical in Maine) the frequency should be adjusted towards higher values per mile.

Table 2 Month of fatal sleep-related accident on Maine's interstate system

Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
No. of acc:	0	3	2	1	5	5	8	3	1	2	1	1

THE RISK OF A SLEEP-RELATED BICYCLE CRASH ON ROADS WITH CONTINUOUS SMOOTH PAVEMENT WITHOUT SEPARATION OF TRAVELED WAY AND SHOULDER

… Severe injury and fatal bicycle crashes typically involve a motor vehicle traveling at more than minimum speed. Along a road with paved shoulders, such collisions can occur if the bicyclist leaves the paved shoulder, for example, to swerve around a pothole. More often such a collision is the result of a motorist infringing onto the shoulder. The shoulder infringement can also be an involuntary movement resulting from the driver going too fast to control the vehicle, being inattentive, or having dozed off. Below is a risk estimate for this last type of crash. This estimate gives, of course, only a fraction of the total risk that a bicyclist is subjected to.

Let us assume that a bicyclist rides on a paved shoulder with high quality pavement and no separating continuous shoulder rumble strips along a busy road for one hour; that he travels about 16 km (10 miles); and is passed by about 1,000 vehicles. The likelihood of someone dozing off over this section would be about 7.8%, using the estimate that drivers fall asleep once every 206,000 km in the daytime on two-lane roads. In-depth interviews with a limited number of drivers having fallen asleep and gone off the road indicate that often the vehicle travels for quite a long distance before leaving the paved roadway. The angle with which the car goes off the road is another argument for this. According to the Illinois Division

of Highways, the average angle for run-off-road accidents is 3 degrees *(12).* This means that a car travels just over 45 meters (150 ft) on the shoulder, if the shoulder is 2.5 meters (8 ft) wide, before hitting the pavement edge. A 1.8 meter (6 ft) wide car will in average occupy 50% of the width of the shoulder over these 45 meters. With these assumptions, and assuming that 3 out of 4 drivers veer to the right, we get a risk around 1 in 12,000 {(0.078)(150/52,800)(3/4)(0.5)} that the bicyclist will be hit from behind by a dozing driver. And the chance that the injuries would be fatal is high.

What is the likelihood that such a collision would prove fatal? A German study *(13)* shows that the probability of death for a pedestrian hit by a car is closely related to the collision speed of the passenger car. It gave the following relationships between collision speed and death probability: 20 km/h (12 mph)=10%, 30 km/h (19 mph)=20%, 50 km/h (31 mph)=60%, 80 km/h (50 mph)=98%. A study of death probabilities among Maine bicyclists supports similar death rates among bicyclists (7). Motorists dozing off on rural roads normally continue with high speeds after dozing off. A 50% chance that the injuries prove fatal seems rather conservative.

The example above has illustrated the risk of riding on the shoulder of a two-lane road In some states bicycling is allowed on Interstate shoulders. Here the risk of a fatal sleep-related crash is almost four times higher than on a two-lane road carrying the same traffic volume. A separating device becomes a necessity.

Adverse Effects of Continuous Shoulder Rumble Strips

[One] problem reported with continuous shoulder rumble strips is the risk that a motorcyclist or bicyclist can have an accident as a result of a wheel getting caught at the edge of a rumble strip which may interfere with the steering of the bike. This problem was recently echoed by an NCHRP Synthesis Report on the use of rumble strips to enhance safety (15*).* However, no accident data seem to support this fear. Motorcyclists have for years been traveling along Interstates with continuous shoulder rumble strips without accident problems. And, a test by Massachusetts State Police on the Mass Turnpike (16) showed that there were no maneuverability problems for motorcycles traversing the milled-in strip [18 cm (7") longitudinal cut with circle segment profile, spaced at 30 cm (12") with 41 cm (16") transversal width, and a depth of 13 mm (1/2") to 16 mm (5/8"), and typically removed about 10 cm (4") from the shoulder line].

The author, together with 20 students and staff (age varying from 16 to 65), have tested what it is like to ride a bicycle across and along milled-in rumble strips-both ground-in 18 cm (7") long, 13 mm (1/2") deep circular ones, and narrower rectangular ones 13 mm (1/2") deep. Several types of bicycles were used, including narrow wheel road racing bikes. **Not a single rider reported any tendency to lose control at any speed or any angle even when not holding on to the handlebars.** But every rider reported that riding on the rumble strips was annoying. My conclusion is that **there is absolutely no danger if a bicyclist by mistake gets into the rumble area, or has to swerve into it to pass broken glass.**

CONCLUSIONS

… calculations show that the accident risk on paved shoulders of busy roads is several times higher than that of average bicycling, if the shoulder isn't separated from the traveled lane by a device that wakes up the dozing driver. The most efficient device is probably a continuous shoulder rumble strip.

REFERENCES

1. *The National Bicycling and Walking Study: Final Report.* Publication No. FHWA-PD-94-.023. U.S. Department of Transportation, Washington D.C., 1994.

2. J. Steenberg. Local Prevention of Accidental Road Traffic Deaths. *Accident Analysis* &

Prevention Volume 26, Number 1, pp 1-9, February 1994.

3. P. Garder, L. Leden & T. Thedeen. Safety Implications of Bike Paths at Signalized Interections. *AccidentAnalysis & Prevention* Volume 26, No.4, pp 429-439, 1994.

4. C.V. Zegeer and F.M. Council. Safety Effects of Cross-Section Design. In: *Compendium of Safety Effectiveness of Highway Design Features.* McLean, VA. Federal Highway Administration, 1991.

5. *FARS 90. Fatal Accident Reporting System 1990.* National Highway Traffic Safety Administration, U.S. Department of Transportation, DOT HS 807 794, December 1991.

6. J. F. Kraus, D. Fife, and C. Conroy. Incidence, Severitry, and Outcomes of Brain Injuries Involving Bicycles. *American Journal of Public Health* 77:76-78, 1987.

7. P. Garder. Bicycle Accidents in Maine: An Analysis. Presented at the 73rd Annual Meeting of TRB in 3anuary 1994. Accepted for publication in *Transportation Research Record* (manuscript no.940328).

8. D. A. Diliman. *Mail and Telephone Surveys: The Total Design Method. John* Willey and Sons, New York, N.Y., 1978.

9. P. Garder and J. Alexander. Fatigue Related Accidents and Continuous Rumble Strips. Paper submitted to TRB Committee on Traffic Control Devices (A3A02) for presentation at the 74th Annual Meeting of TRB in January 1995.

10. *Selected Highway Comparisons* by *Functional Class 1990-1992.* State of Maine. Maine *Department of Transportation*. April 1993.

11. Institute of Transportation Engineers. *Traffic Engineering Handbook,* 4th Edition, Prentice Hall, New Jersey, 1992.

12. *Portland Cement Concrete Shoulders.* Illinois Divisions of Highways, Research and Development Report No.27. July 1970.

13. W. Teichgraber. Die Bedeutung der Geschwindigkeit fur die Verkehrssicherheit. Zeitschrift fur *Verkehrssicherheit* 2. Heft, II Quartal 1983.

14. C. Komanoff, C. Roelofs, J. Orcutt, and B. Ketcham. Environmental Benefits of Bicycling and Walking in the United States. *Transportation Research Record 1405. TRB,* National Research Council, Washington D.C., 1993 pp.7-12.

15. Use of Rumble Strips to Enhance Safety. NCHRP Synthesis 191, Transportation Research Board Washington, D.C. 1993.

16. Telephone information by J. D. Johnson, Product Manager of Surface Preparation Technologies, Mechanicsburg, PA. July 1994