Paved Shoulders

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Description

Paved shoulders play an important role in highway design, providing additional recovery space for errant vehicles and lateral support for the pavement structure (see Figure 1). The benefits of paved shoulders include reduced numbers of certain types of crashes, increased roadway capacity, reduced maintenance needs, a potential increase in pavement longevity, and improved facilities for bicyclists and other alternative road users (Souleyrette et al. 2001).

Placement

The Iowa DOT Design Manual (2004) section 3C-4 provides guidance on use of paved shoulders. It also provides guidance on retrofitting paved shoulders.

Effectiveness of Paved Shoulders in Reducing Crashes

Several studies have evaluated the impact of shoulder width and/or the provision of paved shoulders on safety. In general, these studies have indicated that wider shoulders and paved shoulders correlate to a decreased number of crashes. Table 1 summarizes the various studies where crash modification factors (CMFs) were developed. Table 2 summarizes other studies where crash reductions were found but where CMFs were not developed. Each study is also described in the following sections. As noted, one study was conducted in Iowa.

Iowa Studies

Hallmark et al. (2009) conducted a before and after crash analysis to assess the impact of adding paved shoulders. Data were collected for 220 roadway segments, including 143 sections where paved shoulders had been added since 1984 and 77 control sections with no paved shoulders. Total crashes from 1984 to 2007 were modeled by month, and the results indicated that the total number of crashes per month was lower after paved shoulders were added. The difference was statistically significant at the 95 percent level. Based on the before and after analysis, it was estimated that the presence of paved shoulders resulted in a three percent reduction in the total number of crashes. Model results

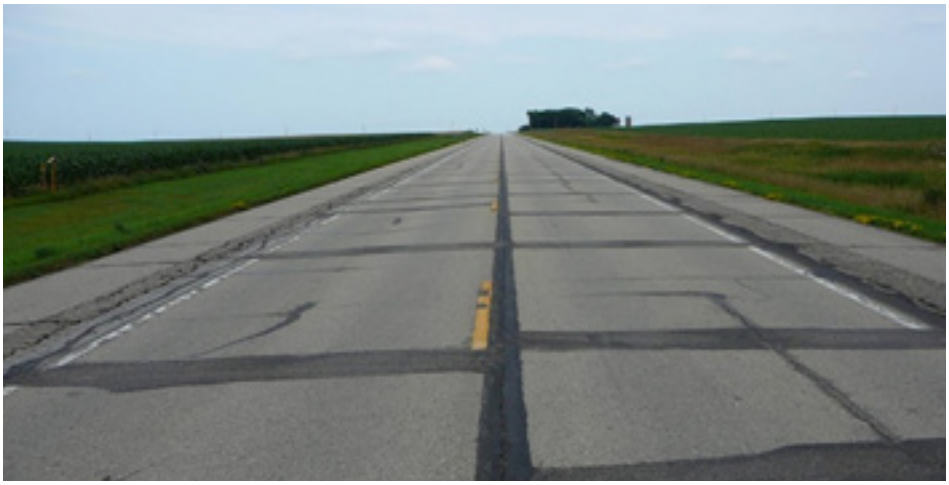

Figure 1: Two-lane highway with fully paved shoulders (Hallmark et al. 2009/2010)

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Table 1. CMFs for Shoulder Treatments

Treatment	Crash Type	CMF
Convert 2 ft turf to 8 ft paved shoulder (Zeng and Schrock 2013)	All (during winter periods)	0.67 to 0.84
	Injury (during winter periods)	0.42 to 0.60
Increase shoulder width from 0 to 10 ft (Yichuan et al. 2012)	Single-vehicle run-off-road injury on tangent sections	0.13 to 0.29
Pave 3 to 4 ft sod shoulder (Heimback et al. 1974)	All	0.81
	Injury	0.86

Table 2. Crash Impacts for Shoulder Treatments

Treatment	Sites	Crash Type	Change in Crashes
Addition of paved shoulders (Hallmark et al. 2009/2010)	143 treatment/77 control	All	-8%
		Run-off-road (ROR)	-1.3%
Each additional foot of right shoulder (Hallmark et al. 2009/2010)	143 treatment/77 control	All	-4%
Widening shoulders from 1.6 to 8.2 ft (Zegeer et al. 1981)		ROR and opposite direction	-16%
Addition of paved shoulder (Zeeger and Council 1992)		ROR, head-on, sideswipe	-3 to 6%
Addition of 8 ft paved shoulder (Zeeger and Council 1994)		Not statistically significant	-49%

also indicated a negative correlation between the presence of a divided median shoulder and the presence of rumble strips; in other words, divided median shoulders were rarely installed on the same roadway segment as rumble strips.

Other National Studies

Heimbach et al. (1974) compared crash rates for rural two-lane highways with paved shoulders to crash rates for highways with grass or unstabilized shoulders. The authors found that crash rates were significantly lower on roadways with paved shoulders.

A study by Turner et al. (1981) reviewed crash rates for three types of rural highways with traffic volumes from 1,000 to 7,000 vehicles per day (vpd): two-lane highways with and without paved shoulders and four-lane undivided without paved shoulders. The study concluded that full-width paved shoulders are effective in reducing crashes, particularly run-off-road crashes. In a similar study, Rogness et al. (1982) found that using full-width paved shoulders was effective in reducing the total number of crashes on rural two-lane roads.

The width that paved shoulders add to the roadway also provides crash reduction benefits. An important study of shoulder width was National Cooperative Highway Research Program Report 197 (Roy Jorgensen Associates 1978), which analyzed the relationship between highway design features and safety. Different linear regression models were developed based on traffic volume, curve radius, and shoulder type (paved, unpaved, or no shoulder). The study reported that there was no significant difference between 22- and 24-foot-wide pavements, but these wider pavements had lower crash rates than 22-, 20-, and 18-foot-wide pavements. In general, crash rate decreased as shoulder width increased, except on roadways with an average daily traffic (ADT) volume of less than 1,000 or greater than 5,000 vpd. Additionally, paved shoulders had a lower crash rate than unpaved shoulders.

Zegeer et al. (1981) found similar results during a comparative analysis of shoulders on Kentucky state primary, state secondary, and rural two-lane roads. Only paved or dense-graded shoulders were considered shoulders because grass and soil are not suitable for driving. The authors found that run-off-road and opposite-direction crash rates decreased as shoulder

width increased. The reduction in crash rate depended on the amount of shoulder widening; based on the results of the study, widening the shoulders on a rural two-lane roadway from 1.6 to 8.2 feet reduced run-off-road and opposite-direction crashes by 16 percent. Souleyrette et al. (2001) cited a Minnesota Department of Transportation study (Preston 1979) that found similar results: using at least 4-foot-wide paved shoulders can reduce crashes by up to 15 percent.

Harwood et al. (2000) also found that wider shoulders tended to have fewer crashes on rural two-lane highways. Using a 6-foot-wide paved shoulder as a base value, the authors determined the accident modification factor (AMF) of an 8-foot-wide paved shoulder under different traffic volumes, or the crash increase that could be expected if 8-foot shoulders were used instead of 6-foot shoulders. An AMF greater than 1.0 would indicate that more crashes were expected for the 8 foot shoulder than for the 6 foot shoulder. The authors found that the AMF for an 8-foot-wide paved shoulder is 0.98 for 400 vpd and 0.87 for more than 2,000 vpd, with the AMF varying linearly between the two vpd values. For a roadway with no shoulders, the AMF is 1.10 for 400 vpd and 1.50 for more than 2,000 vpd, with the AMF varying linearly between those vpd values. While the authors did not explain the difference between paved and gravel shoulders, the study also found that turf shoulders performed worse than paved or gravel shoulders, with an AMF of 1.11.

A study by Zeeger and Council (1992) generally found that increasing shoulder width can help reduce several types of crashes, including run-off-road, head-on, and sideswipe crashes. Additionally, the number of crashes can be further reduced by 3 to 6 percent when the shoulders are paved. In a later study by Zegeer and Council (1994), it was found that adding an 8-foot-wide paved shoulder may reduce related crashes by up to 49 percent.

However, not all studies have concluded that paved shoulders offer a significant safety benefit. For example, Abboud (2001) evaluated roadway segments where 2- and 4-foot-wide paved shoulders had been installed, but the author did not find a statistically significant decrease in crashes due to the installation of the paved shoulders.

Advantages

- Paved shoulders may decrease shoulder maintenance
- Paved shoulders provide lateral support for pavement
- Paved shoulders benefit not only motor vehicle operators but also other road users such as bicyclists and Amish horse and buggy drivers

Disadvantages

Installation cost

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