Abridgment

Shoulder Improvements on Two-Lane Roads

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An objective approach toward the development of geometric design standards has long been sought. Such an approach should link design variables to user benefits and impacts and should include economic considerations. While the relationship between shoulder design and highway safety has been extensively studied, an objective design approach has yet to be developed.

The approach outlined in this paper uses traffic volume as a measure of user exposure, traffic speed as a measure of user risk, and 1975 dollars as a common economic factor to measure costs, benefits, and eventually the net worth of shoulder improvements. The approach, as illustrated, is based on relationships between accident rate and shoulder width that are drawn from the literature (1). These relationships appear to remain consistent among various independent studies and are generally supported by the conclusions of numerous before-and-after evaluations of shoulder improvement projects conducted in various states during the last few years (2-6). The relationships shown in Figure 1 were developed by R. W. Sanderson in 1977 (7).

These relationships can be converted directly into a format that illustrates for given traffic volumes how many accidents can be expected to be prevented as shoulder widths increase (Figure 2). Plotted in this fashion, sample data show that the first 1 m (3 ft) of width over 0.6 m (2 ft) prevents the greatest number of accidents; additional width prevents diminishing numbers of accidents.

Each accident represents a societal cost; each prevented accident therefore represents a user benefit. Widely used societal cost figures (8) can be effectively linked to the relationships between travel speed and accident severity that were established by Solomon (9) and are shown in Figure 3. User benefits per prevented accident are estimated to be \$3257 at 48 km/h (30 mph) and \$5735 at 96 km/h (60 mph). Equivalent uniform annual shoulder-surfacing costs were calculated to be \$1042/km/m (\$512/mile/ft) of width, assuming 1975 cost of approximately \$5/m^2 (\$0.46/ft^2), 6 percent interest, and a 20-year service life.

For each annual average daily traffic (AADT) range shown in Figure 2, a relationship such as that depicted in Figure 4 can be constructed. This relationship depicts user benefits—for travel speeds of 48 km/h and 96 km/h—and improvement costs for shoulder widths of 0.6-3.0 m (2-10 ft). The algebraic difference between the benefits at a given travel speed and the corresponding cost for any chosen shoulder width can be plotted as the net worth of the shoulder improvement, as shown in Figure 5. The peak of the net-worth curve is reached at the shoulder width that provides the highest positive difference between benefits and costs—the optimum shoulder width.

If this procedure is repeated for each AADT range shown in Figure 2, the optimum shoulder widths for particular travel speeds may be plotted as they are shown in Figure 6. This figure indicates that for 48-km/h traffic the optimum shoulder width is 0.6 m for 0-1000 AADT, 1.9 m (6 ft) for 1000-5000 AADT, 2.4 m (8 ft) for 5000-6000 AADT, and 3.0 m for AADT over

Figure 1. Accident frequency for various traffic volume ranges versus shoulder width.

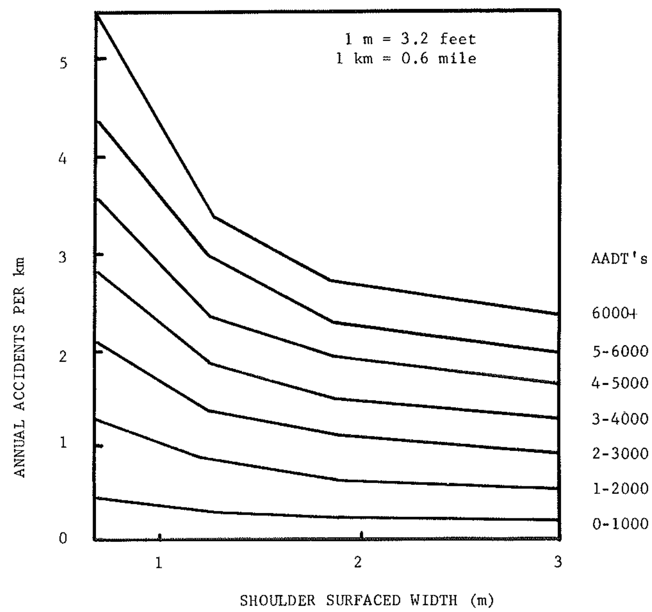


Figure 2. Expected reduction in accident frequency for various traffic volume ranges versus shoulder width.

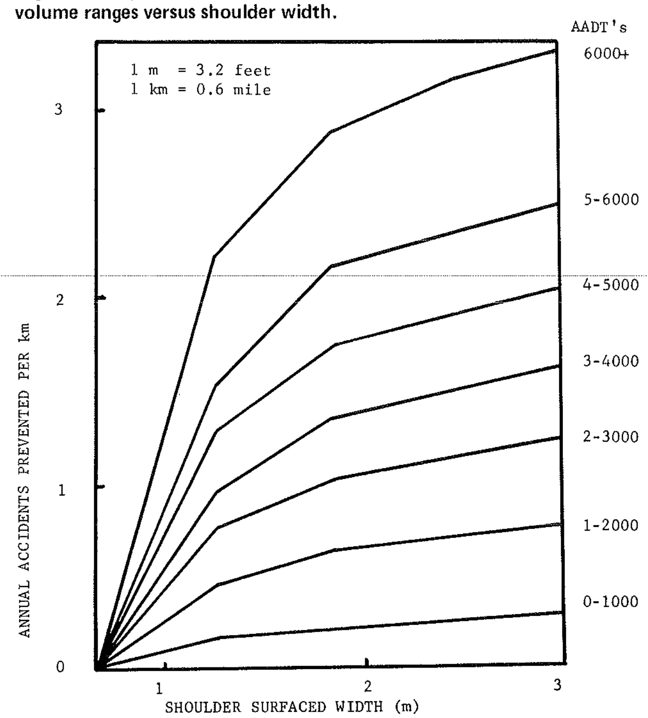


Figure 3. Accident severity versus travel speed.

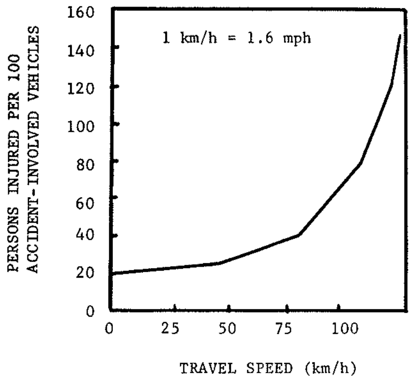
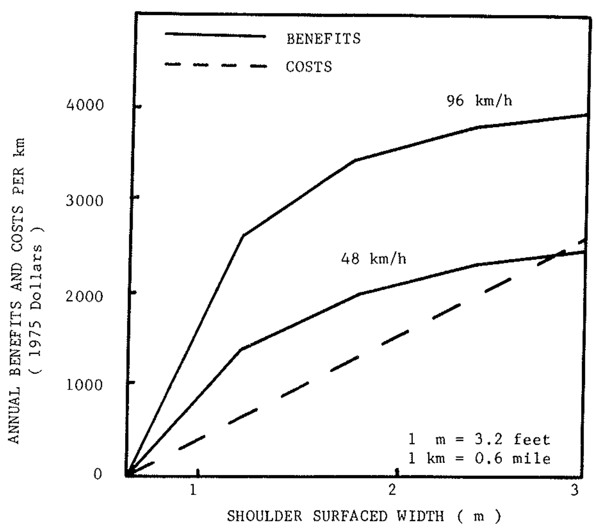


Figure 4. Annual safety benefits and equivalent uniform annual improvement costs for two travel speeds versus shoulder width (AADT 1000-2000).



6000. For 96-km/h traffic, the optimum width is 3.0 m for highways that have AADT over 3000.

While the greatest need for improved data is generally to eliminate certain apparent assumptions in this approach and is particularly acute for roads that have low volumes (especially AADT under 400), it is thought that such objective techniques can now be used to guide the judgment of engineers who will continue to work toward the improvement of geometric standards.

Figure 5. Net worth of shoulder widening per kilometer improved versus shoulder width (AADT 1000-2000).

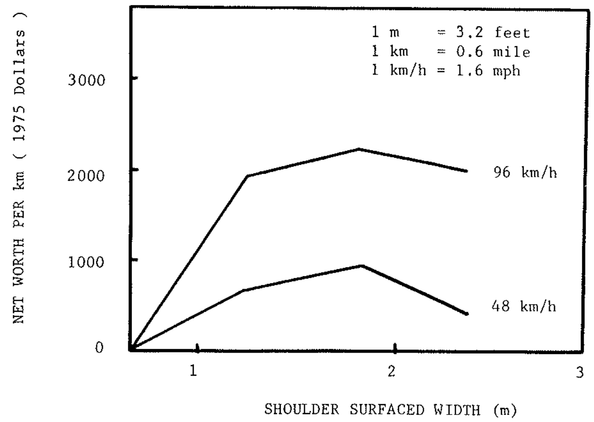
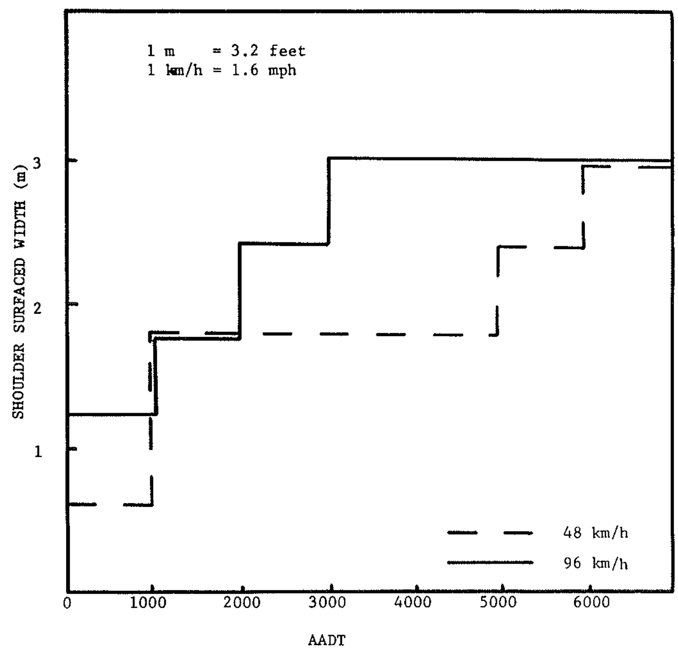


Figure 6. Optimum shoulder widths for various traffic volumes and travel speeds.



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