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.CTIVENESS OF ALTERNATIVE SKID REDUCTION MEASURES

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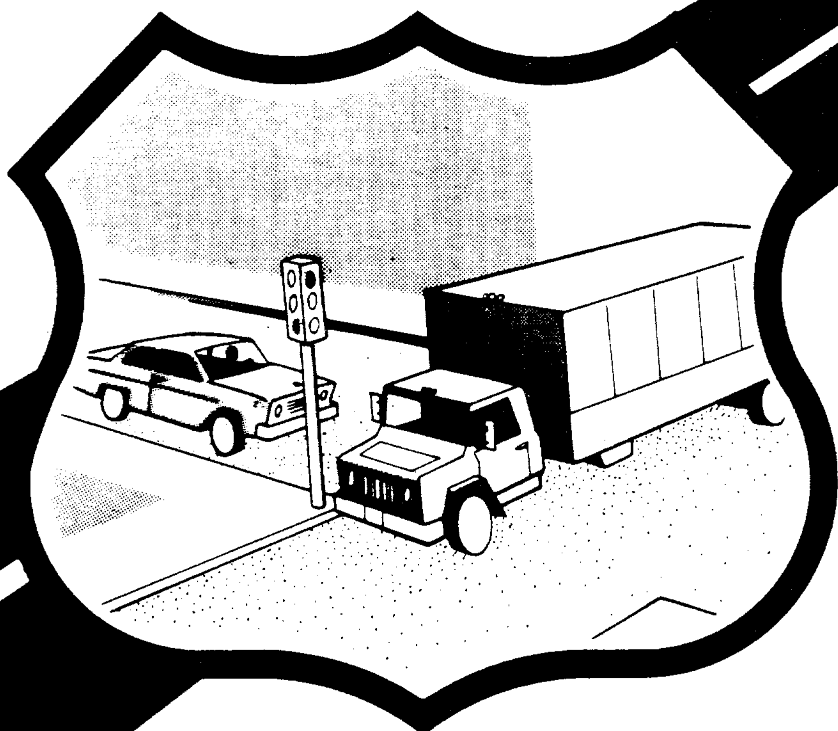

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B. Pavement Grooving

Pavement grooving is the process of making a pattern of parallel, shallow cuts of uniform depth, width, and shape in the surface of an existing pavement. The grooves are usually cut with a diamond saw. Portland cement concrete pavements are most frequently grooved, but grooving has been accomplished successfully on older bituminous pavements where the asphalt is well-cured. Grooving should not be confused with texturing of new portland cement concrete pavements, which is a finishing process that is accomplished while the concrete is in the palstic state. The International Grooving and Grinding Association makes the distinction that patterns spaced less than 12.7 mm (1/2 in.) center-to-center are considered to be "texturing" and patterns spaced more than 12.7 mm (1/2 in.) center-to-center are considered to be "grooving."63/

Most grooving in the United States uses center-to-center spacings between 12.7 mm (1/2 in.) and 38.1 mm (1-1/2 in.). Both longitudinal and transverse grooves have been used, but longitudinal grooves are more common. The objective of this treatment is to place grooves in the tire-pavement interface which provides a path for water to escape from under the tire. Thus, grooving acts like other forms of pavement macrotexture in reducing the potential for hydroplaing. However, despite its proven wet-pavement accident reduction effectiveness, longitudinal grooving does not normally increase the skid number of a pavement surface. Thus, this form of texturing does not influence skid number in the same manner as the random macrotexture of open-graded asphalt surfaces or the pattern macrotexture of finished portland cement concrete surfaces. There is some indication that transverse grooving may increase skid number.

Some foreign countries have employed pavement grooving effectively for a different purpose than used in the United States. Zipkes reports on a highway section in Switzerland that has been grooved transversely at center-to-center spacings of 254 to 1,016 mm (10 to 40 in.).84/ This wide spacing does not necessarily keep a groove within the tire footprint at all times, as with more closely spaced grooves. The only objective of widely spaced grooving is to facilitate the flow of water off the pavement to the shoulder. The reduction in the depth of water on the pavement reduces the potential for hydroplaning by increasing the critical speed at which hydroplaning will occur.

1. Specification: There are some variations in the depth, width and spacing of grooves that have been used in the United States. Typical ranges are 2.4 to 6.4 mm (0.095 to 0.25 in.) for groove width, 3.2 to 0.64 mm (0.125 to 0.025 in.) for groove width, 3.2 to 0.64 mm (0.125 to 0.025 in.) for groove depth and 12.7 to 38.1 mm (0.5 to 1.5 in.) for center-to-center spacing. The most common specification for grooves is 2.4 mm (0.095 in.) width, 6.4 mm (0.25 in.) deep, and 19.1 mm (0.75 in.) center-to-center spacing. The grooves cut by a diamond saw have a rectangular cross-section.

The usual practice in most states is to groove the center 3 m (10 ft) portion of a 3.7 m (12 ft) lane and leave a 0.3 m (1 ft) strip ungrooved at the edge of each lane. Appendix B contains a sample specification for pavement grooving used by the Louisiana Department of Highways.

The depth of pavement grooves is extremely important to their proper functioning as a wet-pavement accident countermeasure. Most state highway departments have adopted a modified tire tread depth gauge to inspect the depth of grooves on construction projects. This relatively simple, but effective, procedure is illustrated by Pennsylvania Department of Transportation Test Method No. 629 also discussed in Appendix B.

2. Cost: The cost for pavement grooving is quite variable and depends on the construction contractor's familiarity with grooving equipment and the hardness of the aggregate in the pavement surface course. Several contractors report typical productivity rates for longitudinal grooving of 0.6 lane-km per hour (0.4 lane-miles per hour). However, extremely hard aggregates produce a noticeable decrease in productivity rates for grooving.

The best available cost estimate for longitudinal pavement grooving is $1.20 per sq m ($1.00 per sq yard). However, lower unit costs for grooving are reported in areas where grooving is used extensively. For example, a typical cost for pavement grooving in the Los Angeles area is $0.72 per sq m ($0.60 per sq yard), while a cost of $1.20 per sq m ($1.00 per sq yard) is more common elsewhere in the State of California. Transverse grooving of in-service pavements is more time-consuming and more expensive than longitudinal grooving. While longitudinal grooving can be accomplished by closing one lane of traffic at a time, transverse grooving requires at least two lanes to be closed for equipment moving. One equipment manufacturer reports that longitudinal grooving can be accomplished 50 times as fast as transverse grooving.

3. Service life: The service life of pavement grooves depends on the type of traffic to which they are exposed. High traffic volumes shorten the service life of pavement grooves, but this effect has not been adequately quantified. The presence of tire chains or studs on vehicles in the traffic stream has an important effect on grooving service life. California reports that grooves 3.2 mm (1/8 in.) deep on highways where tire chains and studs are not used have a service life of 8 to 10 years,[20/] but Pennsylvania reports service life of 3 years or less where tire chains and studs are used.[9/]

4. Performance: Dramatic reductions in wet-pavement accidents have resulted from pavement grooving. Two California studies completed in 1972 and 1975 have found reductions in wet-pavement accident rate of 73 and 70%, respectively.[39,77/] The largest decreases reported were in

sideswipe, fixed object and rear-end accidents. However, the accident reduction effectiveness of grooving does not appear to be consistent. In the 1972 California study, 27 projects decreased in total accident rate, while 11 projects increased. The change in total accident rate with grooving for these 38 projects ranged from a 100% reduction to a 45% increase. A review of 77 grooving projects in 13 states reported by Rasmussen[63] showed an overall decrease of 75% in the number of wet-pavement accidents. The before and after periods in this evaluation range from 2 months to 5 years in length and the decreases in the number of wet-pavement accidents for individual projects ranges from 16 to 100%.

Some users have also observed that longitudinal grooving is effective in increasing the directional control of automobiles. Apparently, the automobile tires penetrate slightly into the grooves and form a mechanical interlock that helps to hold the vehicle in alignment with the roadway.[81] However, a persistent concern exists about handling difficulties of motorcycles and small cars on grooved pavements. Pavement grooves do produce a sensation of instability while riding a motorcycle, but a recent study sponsored by the California Department of Transportation in which seven motorcycles of different sizes were driven by two riders on grooved pavements, found no significant control problem.[77] Furthermore, the 1975 accident study in California found decreases in the number of motorcycle accidents after grooving on both wet and dry pavements, even though total motorcycle registrations and, presumably, motorcycle traffic on the study sections increased by 14.5% between the before and after study periods.[77] However, because the sensation of instability is unsettling to motorcyclists, even though it does not lead to loss of control, the use of warning signs at the beginning of grooved pavement sections is recommended.

5. Advantages and disadvantages: The advantages and disadvantages of grooved pavement as a wet-pavement accident countermeasure are summarized in Table 6.

C. Cold Milling

Cold milling is a technique for retexturing pavements that has come into widespread use recently. Major technological advances within the past 2 years have produced a new type of rotary milling machine that can grind or scarify pavement surfaces more efficiently and accurately than ever before. The milling machine used has a rotating drum with carbide steel teeth that can texture a pavement surface with a pattern of grooves that provide macrotexture for water drainage at the tire-pavement interface. Unlike grooving accomplished with a diamond saw, the grooves made by a milling machine are short and discontinuous. The depth of the grooves can be varied by controlling the forward speed of the milling machine and the rotating speed of the drum. The microtexture of the surface between the grooves is a function of the type of aggregate used in the pavement. Cold milling can be used to retexture both asphalt and portland cement concrete surfaces.

TABLE 6

PAVEMENT GROOVING

Advantages	Disadvantages
1. Wet-pavement accident experience may be substantially reduced.	1. Grooving cannot be used for bituminous concrete pavements unless the asphalt is well cured.
2. Longitudinal grooving can be accomplished quickly and only one lane of traffic at a time has to be closed.	2. The use of studded tires or tire chains reduces the service life of grooved pavement.
3. Traffic can use the pavement surface soon after grooving.	3. Motorcyclists and drivers of small cars may have a sensation of instability.