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EXPERIMENTAL PROJECT:
ENHANCED DRAINAGE BY USE OF PAVEMENT GROOVING
INTERSTATE 295 NORTH

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Federal Highway Administration
and
Rhode Island Department of Transportation

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RESEARCH AND TECHNOLOGY

Draft

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OBJECTIVE: To evaluate the effectiveness of the grooving system on drainage of water from the pavement surface under traffic and to assess the impact of the grooves on pavement noise.

BACKGROUND: During a recent FHWA-sponsored technology transfer visit to Slovakia, the technology transfer team was shown a new system for improving drainage from pavement to reduce the water's effect on traction. It consists of a series of cuts in the pavement at a 45° diagonal to the direction of travel. A path of least resistance is created, helping to move the water off of the riding surface. The pattern is repeated every meter. (See Figure 1). A machine was modified by the contractor with custom-built cutters to make the specific groove pattern required.

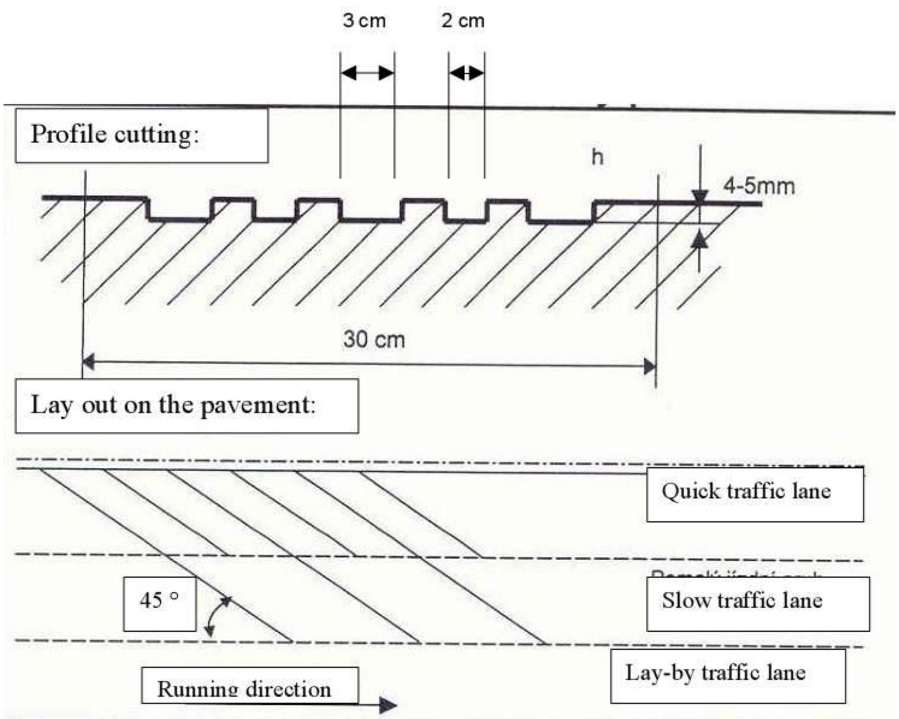


Figure 1 – Drainage Groove Patterns

A test section was selected on I-295. which includes a section of the on-ramp just prior to the merge and a section shortly after the first, including the merge (see Figure 2). This area was selected because of a higher than normal incidence of accidents, particularly for a straight section. The width of the pavement makes carrying water off to the shoulder problematic. As a result, water stays longer in the travel lanes and creates the potential for issues with hydroplaning and black ice formation. The pavement will be overlaid with friction course during the next construction season, so repairs will not be required once the study is complete. The grooves have been put into place prior to the winter season, to observe the effects of the plow blades.

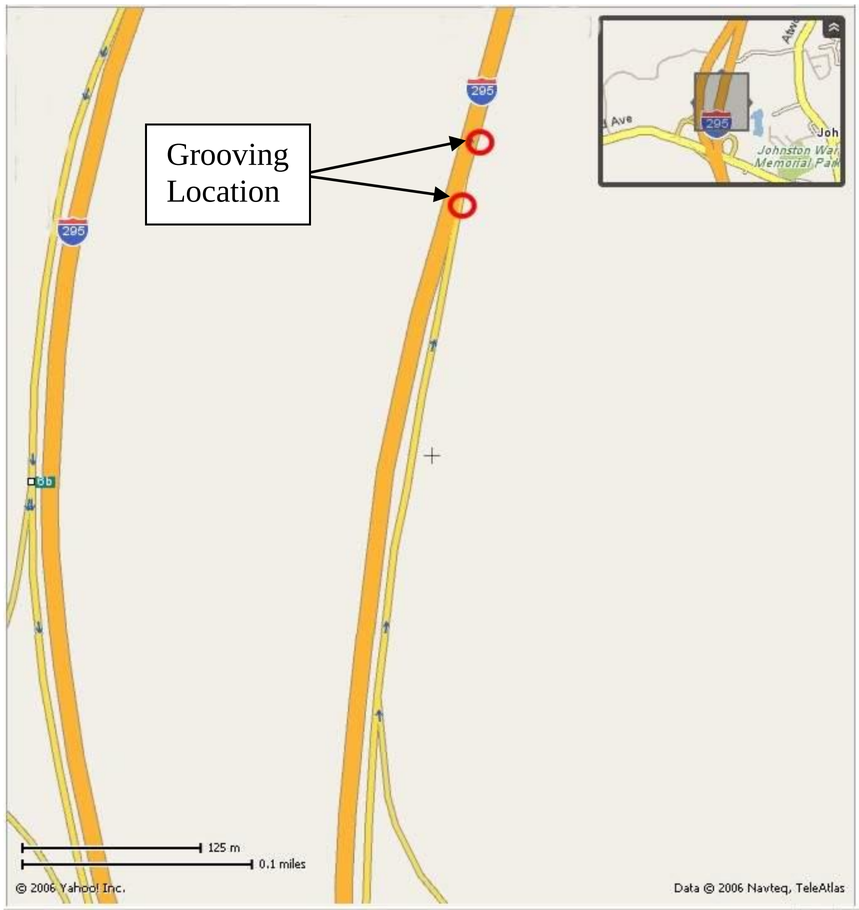


Figure 2 – Pavement Drainage Grooving Location

QUESTIONS:

1] Can the effect of the grooves be effectively measured, either objectively or subjectively?

2] Do the grooves increase the ambient and peak noise levels when traffic moves along the pavement?

3] How susceptible are the grooves to plow damage?

PROCEDURE:

A section of I-295 was selected that had Class I-1 surface course (other sections have friction course). A baseline data set was developed for the pavement sections to be grooved. These consisted of sound level readings (Minimum, maximum and average readings over an eleven minute period) and observations during rain events. The sound level meter employed had the capability of sampling over a selected interval (one second was used) and storing the values and the time. A fixed location, adjacent to the section to be grooved, was used for both sets of readings. The meter was set at a height of about four feet, which was about two feet above the pavement surface. The sound levels were taken when the pavement was dry (there was concern that the instrument might be damaged if used in a significant rain event), during the start of the evening rush hour. The observations were recorded using a still camera and a camcorder. These were taken from various perspectives relative to the placement of the grooves. Pre- and post-grooving recordings were made during a moderate to heavy rainfall at mid-morning. Subjectively, the events were judged to be of the same approximate intensity.

The grooves were driven over in both wet and dry conditions to gauge the "feel" of the pavement. Driving over the pavement prior to cutting of the grooves was considered unnecessary, since the comparison would be less subjective using the adjacent un-grooved pavement as a reference at the same time.

Only the sound level tests were objectively quantifiable and provide measured values. But by using a group of several people for the observations, it was possible to obtain a qualified indication of the influence of the grooves on drainage and vehicle handling.

TEST DATA AND OBSERVATIONS:

The following photos (Figures 3 through 8) demonstrate pre- and post-grooving conditions (Figure shows the grooves as they are being cut). Figure 9 plots the sound levels over the same time period (hour of the day) before and after the grooving.

A number of individuals traveled over the section in both dry and wet weather. A few people also listened by the side of the highway as vehicles moved over the grooves. While a difference in the character (tone) of the tire noise was heard while traveling over the grooves, the concurrence was that subjectively the noise level was relatively unchanged. The noise seemed to have a higher pitch and would be expected not to travel as far as a result. Inside the vehicles, the higher pitched components were nearly indiscernible. This is reasonable, given the characteristics of sound above the bottom end of the audible spectrum (i.e., mid-range and high frequencies).

There appeared to be reduced misting from the tires in the post-grooved section, although rainfall, tire weight, tire design, ambient temperature and other factors may have contributed over the two different days. Water did not seem to collect in the area around the grooves (see Figure 7). This can be seen more clearly in Figure 8. Note that while there is water before the grooves (the leading edge), the space between and after the grooves is dry. The inset shows water flowing off the end of the grooves. Note that the grooves end where the shoulder meets the low speed lane

The measured noise level was actually lower after grooving (see Figure 8), but without a more rigorous and detailed experimental setup to reduce variables, it should be stated conservatively that the process had minimal impact on the tire noise. One observer who travels the road regularly with a personal vehicle noted that the 'on/off' tire noise (created by the gaps between groove sets) became somewhat grating over time. The comparison was to driving over rumble strips, although not as severe.

No damage as a result of plowing was seen, but given the mild nature of the recent winter season and the lack of snowfall, little effect would be expected. There has been no apparent deformation of the groove pattern under traffic loading. No ice in the grooves was noted during the colder weather. If the friction course is placed as planned, the grooves will not be exposed to another winter season.

Figure 3 – Prior to Grooving

Figure 4 – Prior to Grooving – Light Rain (note misting behind tires)

Figure 5 – Groove Cutting Equipment and Process

Figure 6 – Grooved Pavement – Moderately Heavy Rain Event (reduced misting behind tires)

Figure 7 – Close View of Groove Patterns During Moderately Heavy Rain Event

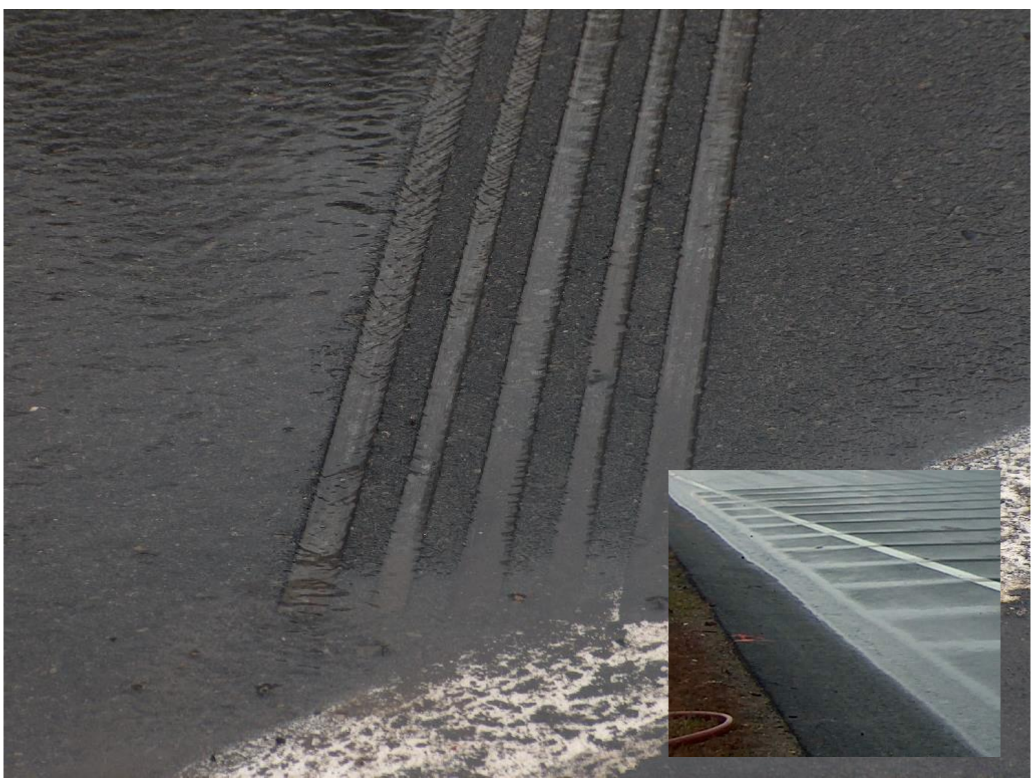
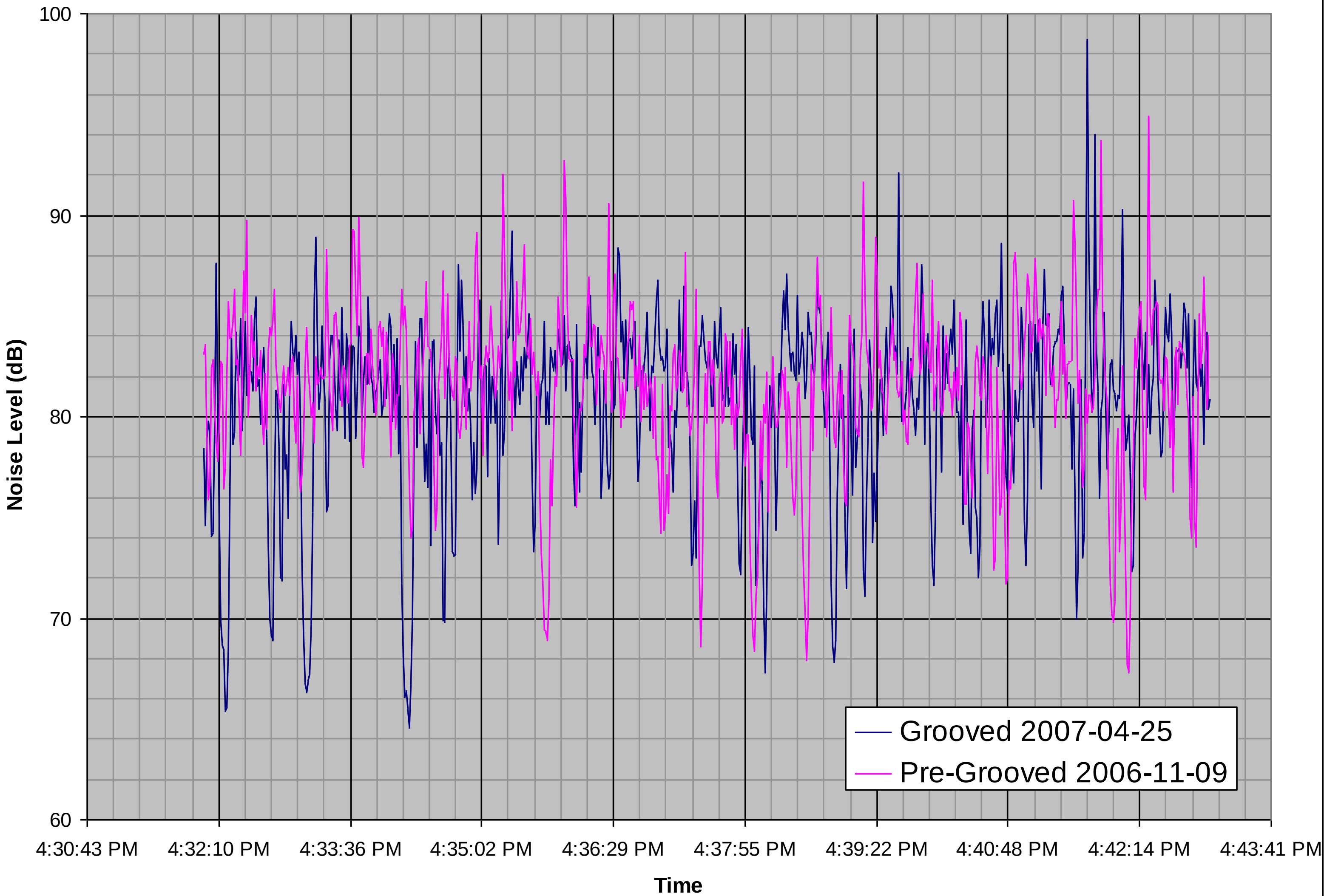


Figure 8 – Water Draining at Low Speed Shoulder (Inset: Long View)

I-295 Grooved Section Comparative Effect on Noise Levels



Pre-Grooved: 83.4 dB Avg, 67.3 dB Min, 94.9 dB Max

Grooved: 80.5 dB Avg, 64.6 dB Min, 98.7 dB Max

CONCLUSIONS:

Both objectively and subjectively, the grooving appears to have little impact on the noise levels, although it does seem to shift it towards the higher frequencies. This may account for the reduced average level for the grooved pavement, since the meter readings were weighted. Weighting emphasizes some frequencies over others to match the tendencies of human hearing. The ear is most sensitive to the mid-range (2,000 – 4,000 Hz) and increasingly less sensitive as the pitch rises (most adults can hear little above 10,000 Hz). Higher frequencies also do not carry as far as lower ones, which would reduce relative levels at the side of the road (where the meter was placed).

It may also be that the conditions were simply different on the days of the measurements. In any case, the 3 dB difference would hardly be noticeable to most people. The difference in the peak levels is also relatively small and is probably more a function of vehicle noises other than tires on the pavement.

It should be noted that the individual who mentioned an issue with the tire noise was driving one specific vehicle. So his impressions can't be taken as conclusive. However, it does go to the roughness perception of the pavement, so further study may be needed.

No determination can be made regarding the durability of the grooves. They have not been in place long enough to assess wear characteristics. The limited amount of plow activity is not indicative of a typical winter season. So it is unknown whether significant plowing might have caused any appreciable damage.

The observed reduction in the misting trail from the tires is subjective, although shared by several individuals. It does create the sense that the grooves may enhance drainage from the roadway, which is the intent of the system. Further testing would be necessary and would require a more planned and involved experimental approach. However, the images taken during rain events clearly show that the grooves re-direct and drain water to the shoulder.