Highway Factors Attachment – Pennsylvania Department of Transportation District Highway Safety Guidance Manual on Wet Pavement Crashes dated May 2019

Mount Pleasant, PA

HWY20MH002

(5 pages)

5.6.18 Wet Pavement Crashes

Wet pavement crashes, injuries, and fatalities have frequencies, severities, and characteristics associated with the speed of vehicles coupled with the type of highway, friction characteristics of the pavement surface, portion of time that the pavement is wet, rutting depths that can further reduce available friction and increase potential for hydroplaning, AADT, the type of area (urban/rural), and friction requirements in the section. The primary countermeasures to reduce the frequency and level or severity of crashes associated with wet pavement are:

- Application of a skid resistant surface on highways that have a high number and proportion of wet pavement crashes and a low friction surface
- Speed reductions on highways that have a high number and proportion of wet pavement crashes and a low friction surface, which lessen the need for available friction

The effectiveness and relative cost of countermeasures is shown in **Table 5.6.18–1**.

Table 5.6.18–1: Wet Pavement Crashes Countermeasures

Countermeasure #	Countermeasure	Effectiveness	Relative Cost
		Crash Reduction Factor (%)	$ = Low Cost $$ = Moderate Cost $$$ = High Cost
Countermeasure #1	Install Skid Resistant Surface	57% for wet pavement crashes	$$
Countermeasure #2	Identify and Correct Drainage Problems for Safety	Varies	Varies

Countermeasure #1 – Install Skid Resistant Surface

Description

Drivers need a varying level of pavement surface friction to safely remain within travel lanes under a variety of operating circumstances. Pavement surface friction varies based on a variety of factors including type of aggregate, surface macro-texture, pavement age, extent of surface polishing, rutting, time since last rainfall, and depth of water in wheel tracks. Drivers can also influence the amount of surface friction generated based upon tire friction characteristics, tread depth, and vehicle operating speed.

The amount of surface friction needed to maintain safe control of a vehicle is a function of the specific circumstances of the driving situation, which includes the types of vehicle and tires, operating characteristics, and highway environment.

Fundamental Principles:

- As operating speeds increase, wet pavement friction decreases. The rate of decrease differs by pavement type, but often drops 20 – 25 percent when speeds increase from 30 to 50 MPH.
- In general, higher friction surfaces are needed on higher speed facilities.
- As water depth increases in the wheel path, pavement surface friction decreases and the potential for hydroplaning increases.
- Pavement surfaces with minimal macro-texture (minimal voids) coupled with bald tires or tires with minimal tread depths are more likely to produce hydroplaning conditions given sufficient water depths and operating speeds.
- Pavement surface friction characteristics vary significantly throughout the year. Lower values are found during summer months under light rain conditions, immediately after long dry intervals.
- Pavement friction characteristics vary depending on the surface's coarse aggregate type and size and the amount of aggregate exposed. "Flushed" surfaces comprised primarily of asphalt with little coarse aggregate exposure have lower friction characteristics. As aggregates wear, they normally polish from tire contact, resulting in generally lower friction values. The rate of decrease in friction values is dependent on a variety of factors, but primarily the rate at which the coarse aggregate polishes. PennDOT has adopted skid resistance level (SRL) ratings for a variety of aggregates that are applied to different AADT volume groups such that the surface should provide acceptable pavement friction over the life of the pavement.

Higher Friction Need Areas

If all traffic moved at relatively constant speed on a tangent level section of highway, friction requirements would be minimal. However, when abrupt speed changes involving hard braking or traversing sharp curves at high speeds occur; additional friction is needed to minimize the potential for loss of control.

Examples of conditions which have a higher potential for increased friction demand are:

- Curves with a design speed substantially less (i.e., less than 16 MPH difference) than the legal speed limit or 85th percentile operating speed. Note that curves that meet this condition and are on a steep downward gradient, have intersection or driveways within the curve, or have significant rutting increase the need for friction
- Compound, reverse, or broken back curves on highways with speed limits of 50 MPH or greater
- Tangent sections with speed limits of 50 MPH or greater or 85th percentile speeds above 50 MPH and a high frequency of access points (i.e., 10 or more driveways or intersections per mile)
- Section of crest vertical curve with significant shortfalls in stopping sight distance (i.e., 200 feet or greater shortfall) and one or more intersections or driveways within sight distance limitations
- Area of mainlines and ramp junctions in interchange areas where deceleration and acceleration lanes are 500 feet or less in length
- Sections with observable frequent skid markings
- Intersection approaches on the through highway with high operating speeds (i.e., in excess of 40 MPH) through the intersection and high turning volumes (i.e., 10 percent or greater turning left or right)
- Surfaces that are almost entirely devoid of aggregate (e.g., flushed or polished) with operating speeds greater than 40 MPH
- Surfaces that have substantially different skid qualities in each wheel path and frequent hard stopping is anticipated

Potential Improvements

A hierarchy of suggested improvements is as follows:

1. Eliminate or substantially reduce the need for friction. This is often non-attainable, especially on non-programmed sections where it may require significant physical improvements such as curve flattening and/or addition of turning lanes at intersections
2. Install a new pavement surface that has micro- and macro-texture skid resistant qualities
3. Attempt to lower operating speeds in the section and thus lessen the friction needs of vehicles

Candidate Surface Improvement Sections

The recommended candidate wet pavement surface friction treatment crash threshold is:

- Urban or rural sections that have speed limits greater than 40 MPH and eight or more wet pavement crashes and a wet/total crash ratio of 0.30 or greater

Highway sections that meet these thresholds need to be field reviewed by the District Highway Safety Engineer to determine if a high friction demand may exist within the section. If so, the District Highway Safety Engineer should initiate a skid test request to determine the friction characteristics of the section.

Actions should be recommended for those sections that meet all of the following provisions:

- Sections that meet the wet pavement surface friction treatment crash thresholds identified above
- Sections that have at least one high friction demand need to be identified from the field review
- Ribbed tire test results that yield skid numbers of 35 or less or smooth tire test results that yield skid numbers of 20 or less

The District Highway Safety Engineer should coordinate with the Pavement Engineer for the determination of an appropriate course of action.

At those sections where a more skid resistant surface is recommended, it is appropriate to consider interim improvements that may reduce the potential for a wet pavement crash until the new surface is applied. The installation of a "Slippery When Wet" warning sign with a word placard underneath may be considered. However, the effectiveness of these signs to reduce wet pavement crashes has not been determined. Another alternative that may be considered is sign and marking initiatives, such as the use of speed reduction markings to lower speeds and thus reduce the level of friction needed.

The District Highway Safety Engineer and Pavement Engineer should present their recommendations and cost estimates for all sections that meet the above criteria to the Maintenance Programming Engineer by the end of each calendar year. The ADE-Maintenance and the Maintenance Programming Engineer will determine the funding effort that can be made available to address surface friction needs based upon annual funds available and other priorities and defined needs. The ADE-Maintenance will program that amount in the annual work plan and the 213 Program each year. The ADE-Maintenance will also consider unfunded locations as candidates for future betterment programs. Contracts should be let in the spring of each year such that all work can be accomplished by October 1. All four engineers will determine the priority sections to advance with the funds available.

Effectiveness

The application of skid resistant surfaces on skid deficient pavement surfaces is expected to reduce wet pavement crashes by 57 percent.