

# MATES

## MICHIGAN DEPARTMENT OF TRANSPORTATION

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### FRICITION HELPS YOU DRIVE

Have you ever considered that friction makes it possible to drive your car to work, the local shopping center, or that much needed vacation? We have been conditioned to think of friction as something bad, something to be minimized as much as possible in machinery; but without it we could not steer, stop, or even move our cars. Friction between the tires and the pavement is what makes all these possible.

Sliding Friction is the resistance to movement as one body slides across another. As taught in basic physics, the coefficient of sliding friction is the ratio of two forces; the force required to slide one body across another, divided by the force pressing the two bodies together. Maximum static friction, just before sliding begins, is slightly higher than sliding friction. It makes no sense to state what the friction of one surface is, as friction is a measure of the way two bodies interact. In the case of vehicles, the friction that we are interested in is that generated between the tire and the pavement surface.

The success of a vehicle maneuver, whether accelerating, decelerating, or turning, depends on the friction demand (need) being lower than the friction available. As long as the friction available exceeds or is at least equal to the friction demand, the maneuver can be performed successfully. When friction demand exceeds available friction, skidding and loss of control may occur. The surfaces of ice and snow usually result in low available friction and provide obvious examples of what happens when demands exceed what is available. Similar results occur on wet or even dry pavements, if the available friction is exceeded by demand.

Friction demand is influenced by speed, sharpness of a turn, abruptness of a stopping maneuver, traffic density, and the degree of driver alertness. Available friction is a function of speed, combined micro-/macrotecture of the pavement surface, water depth, and certain wet-traction performance factors of the tires (type of rubber, tread depth and pattern, and basic tire construction). Available friction will be higher for low speeds, for properly textured pavements, and for thinner water films on the driving surface. Since speed increases friction demand and at the same time decreases available friction, while also allowing the driver less time to react to the environment, it is the most significant factor in successful vehicle maneuvers. Let's take a closer look at the factors that affect friction demand and available friction.

#### Friction Demand

Speed - Newton's laws of motion, from basic physics, describe the action of moving bodies. From one of these laws, stopping distance can be estimated by the equation,  $d = \frac{V^2}{30f}$ , where 'd' is stopping distance in feet, 'V' is the initial vehicle speed in miles per hour, and 'f' is the coefficient of friction between the tire and pavement surfaces. We can see that stopping distance is proportional to the square of the vehicle speed. This means that if the speed is doubled, the stopping distance will be four times longer! This also means that if we want to double vehicle speed and yet stop in the same distance, friction demand will increase by a factor of four.

Sharp Turns - Newton's laws also provide an equation for estimating the friction required to conduct a turning

maneuver. This is,  $f = \frac{V^2}{15R} - e$ , where 'f' is the required tire-pavement friction, 'V' is vehicle speed, 'R' is the radius of the turning maneuver, and 'e' is the pavement cross-slope or superelevation. This equation shows required friction to also be proportional to the square of vehicle speed. If the speed around a curve is doubled, the friction demand increases by a factor of four. The equation also shows required friction to be inversely proportional to the radius of the curve. This means the sharper the curve (smaller the radius) the greater the friction demand to allow successful negotiation of the curve at a given speed.

Traffic Density and Lack of Driver Alertness - Traffic density and lack of driver alertness both affect friction demand by reducing the time and/or distance available for a normal maneuver. Under these conditions it is more likely that a panic or emergency maneuver will be required which always creates a high friction demand.

#### Available Friction

Speed - Again, not only does vehicle speed affect friction demand, it also affects available friction. An increase in speed results in a decrease in available wet friction. This is primarily due to the decreased time available for water to be squeezed out from between the areas in which the tire contacts the pavement as the tire rolls at higher speeds. Maximum friction can only be attained when the rubber tire and the pavement are in intimate contact. As a tire rolls faster, a wedge of water can begin to force its way in and separate it from the pavement; when there is full separation, 'hydroplaning' is said to occur. It is not uncommon for the coefficient of wet friction between tire and pavement at 20 mph to be more than twice that at 60 mph. If there is ample tire tread depth, or if the surface is quite rough or open textured, passages exist to assist the water in escaping from beneath the tire and better friction levels will be available at somewhat higher speeds. Figure 1 shows typical relationships between wet and dry friction and speed.

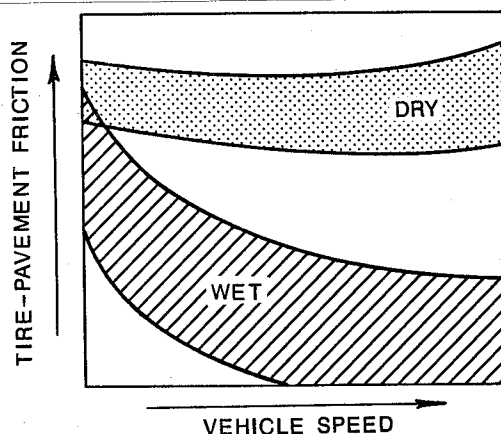


Figure 1. Frictional trends for slipping and skidding tires on dry and wet pavements.\*

Micro- and Macrotecture of the Pavement Surface - Macrotecture is generally described in terms of visible pavement roughness features, while microtexture is a 'grittiness' property of the individual stone particles that

is generally difficult to see with the naked eye. Figure 2 shows the types of texture on pavements, and how these textures generally perform in providing tire-pavement friction. A combination of coarse macrotexture and gritty microtexture provide high friction under most conditions.

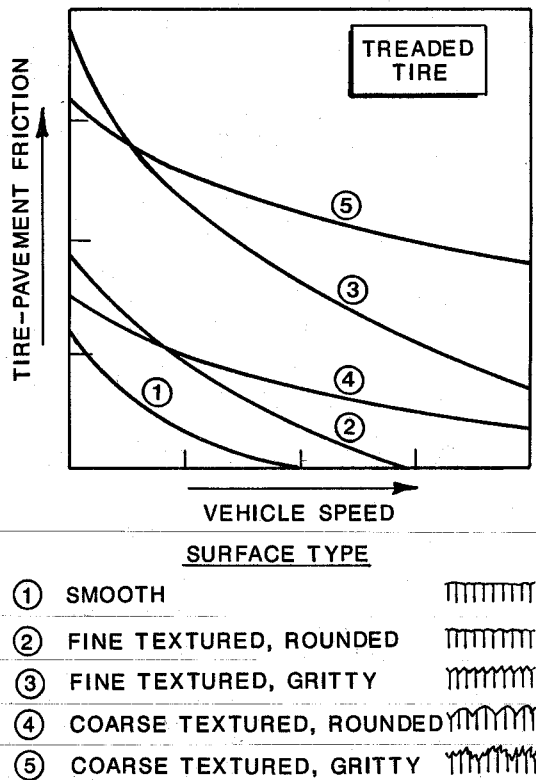


Figure 2. Classification of pavement surfaces according to their friction and drainage properties.\*

Microtexture is the essential element in providing pavement friction at any speed. Macrotexture is important at higher speeds since it serves to help diminish the loss of available friction with increasing speed or increasing water depth, by providing low pressure escape channels to allow the water to escape from between the tire and the pavement. Macrotexture is especially important when the tire tread is badly worn and provides no escape channels for water. Macro- and microtexture generally become less effective in time due to the polishing effects of traffic. The rate of this polishing and accompanying decline in friction is dependent on traffic volumes and the nature of the aggregate particles. MDOT is combatting this decline in available friction by specifying aggregates that are less susceptible to polishing when used in the wearing surfaces of bituminous pavements with high traffic volumes. Wet freeze-thaw cycles help rejuvenate polished surfaces by creating new sharper edges. Grinding, grooving, and milling are mechanical methods of improving friction levels by increasing macrotexture.

**Water Depth** - Friction is rarely a problem on dry pavement; however, when the pavement becomes wet, friction levels begin to diminish due to intrusion of water between the tire and pavement, resulting in decreased tire contact with the pavement's microtexture. The greater the water depth, the greater the intrusion, especially at higher speeds. If a layer of water completely separates the tire and pavement, friction drops to near zero, hydroplaning occurs, and the driver can no longer turn or brake the vehicle. Hydroplaning is most likely to occur when a car with little or no tread on the tires runs into a layer of water, perhaps an inch or so deep, while traveling at high speed. Still

less water will suffice if both tire tread and pavement macrotexture are lacking. The design feature intended to enhance water run-off is the crown or cross-slope of the pavement. Cross-slope, however, must be limited to prevent adverse handling effects, especially on ice covered pavements. Pavement grooving can be of benefit at very high speeds or for vehicles with poor tire tread by providing low-pressure escape channels for water beneath the tire.

**Tire Characteristics** - The primary tire characteristics that influence available friction are tread-rubber composition, tread depth, and tread pattern. Rubber composition affects the friction attainable, while tread depth and pattern function much like pavement macrotexture in diminishing friction loss at higher speeds by providing low-pressure channels for water to escape from between the tire and the pavement. Badly worn tires have no such passages for water to escape; thus they depend entirely upon pavement macrotexture to provide this function, and tend to lose traction much sooner on wet surfaces.

#### A Final Word

In this article we have tried to call to your attention some aspects of the importance of friction with respect to our highways. MDOT engineers are continually striving to lessen friction demand through improvements in signing, roadway geometry, and good engineering design principles. At the same time, our engineers work towards the enhancement of available friction through the use of the best available materials, designing the best pavement cross-section, and improving the pavement's texture. There are also some contributions that the motorist can make. Some of the factors, of course, that cause loss of control due to exceeding the available friction are beyond the control of even a reasonable driver. However, several factors of primary importance can be controlled, speed being the most obvious and of greatest consequence. Maintaining adequate stopping distance and being attentive to traffic conditions can give the motorist more time to maneuver, decreasing the probability that friction demand will exceed supply. Replacing tires before they become bald gives an additional edge in safety of operation.

In keeping abreast of the role of friction in Michigan's highways, MDOT has a program for monitoring available friction levels statewide. This program, carried out by the Materials and Technology Division, will be the subject of a future MATES article.

-Bob Felter

\*After Kummer, H. W., and Meyer, W. E., "Tentative Skid-Resistance Requirements for Main Rural Highways," NCHRP Report 37, 1967.

## TECHADVISORIES

### NEW MATERIALS ACTION

The New Materials Committee recently:

Approved the following products for trial installations:

Medex MDF-Medium Density Fiberboard Sign Panel  
Structurwood Products for Traffic Sign Panels

Approved the following products:

Rhino Channelizer Barrel  
Perma-Loc PVC Storm Drain Pipe PS-10  
Ultra Rib PVC Sewer Pipe  
Contech Strip Drain

It should be noted that some products may have restrictions regarding use. For details please contact Don Malott at (517) 322-5687.

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