

HISTORY OF ANTI-SKID PROGRAM MANAGEMENT IN THE UNITED STATES

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•MANY of the topics discussed at the Anti-Skid Program Workshop were thoroughly investigated in a comprehensive research program on skidding characteristics of automobile tires that I initiated in 1932 at Iowa State University. The measurement of the skid resistance of pavements of all types—dry and wet, ice- and snow-covered—using a two-wheeled skid test trailer operating at a wide range of speeds was a major pioneering breakthrough in this comprehensive research program. Another feature of this program was theoretical analyses, confirmed by road tests, to determine the friction requirements and the friction attainable at the tire-road interface in braking, cornering, acceleration, and gradability of cars and trucks. The major objective of the theoretical analyses and the road tests was to develop factually based geometric highway design standards to replace the outmoded rule-of-thumb standards used by state highway departments at that time (1, 2, 3).

A two-wheeled skid test trailer was developed in this early research to measure the coefficients of friction on dry and wet pavements in locked-wheel braking and impending skid braking and to measure the side skid coefficients of friction. The soundness of this procedure is indicated by the fact that in the United States today a two-wheeled skid test trailer has been adopted as a standard test method by the ASTM Committee E-17 to measure the skid resistance of pavements in terms of locked-wheel-braking coefficients of friction. In Great Britain, the Road Research Laboratory has developed a routine testing machine consisting of a single-unit truck carrying a fifth wheel to measure the sideway-force coefficient of friction at speeds up to 60 mph.

The British Road Research Laboratory currently is recommending minimum sideway-force coefficients of friction of 0.5 to 30 mph and 0.45 at 50 mph for average sites on motorways or on other high-speed roads. Kummer and Meyer (4) recommended a minimum interim skid-resistance standard using the ASTM skid test trailer locked-wheel-braking test method that provided for coefficients of friction of 0.37 measured at a speed of 40 mph for a highway with a mean traffic speed of 50 mph and of 0.41 measured at a speed of 40 mph for a highway with a mean traffic speed of 60 mph. These decisions substantiate recommendations made by me almost 40 years ago (3).

The development of comprehensive anti-skid programs, however, is not solely a matter of developing test method and skid-resistance standards. The research and management problems in developing comprehensive anti-skid programs are very complex. Progress in this area has been insufficient. The anti-skid programs being developed by the National Highway Safety Bureau, the U. S. Department of Transportation, and the state highway departments in each of the 50 states should now finally bring about improved traffic safety. Two important features of comprehensive statewide anti-skid programs should include (a) annual accident studies covering all streets and highways to identify high-accident locations and sections of streets and highways with high accident rates where slippery-when-wet pavements may be a major contributing factor and (b) an inventory of the skid resistance of all streets and highways and, especially, the measurement of the skid resistance of the pavements that have been identified as high-accident locations or that have a high accident rate under wet or icy pavement conditions.

It is difficult to identify skidding accidents by the use of the computer methods of analysis of traffic accidents because no provision is made on the standard traffic accident report form to classify a given accident specifically as a skidding accident. The weather conditions are identified as clear, raining, or snowing; the road character is shown as straight, sharp curve, turn, or grade; and the road surface is listed as dry, wet, slippery, snowy, or icy. The vehicle condition is listed in terms such as defective brakes or steering, tire puncture or blowout, and worn or smooth tires. The speed of the vehicle or vehicles involved and the accident location are also shown on the accident report form. Many states now have compiled tapes and punch-card records on which all these data are summarized. An analysis of the accident records can then be made to classify and summarize accidents for any given condition or type in a very short time and at a low cost.

Many studies have shown that there is a high degree of correlation between the total number of accidents on a given section of highway and the coefficient of friction as measured by a standard test method. Thus, on dry pavements with coefficients of friction of 0.60 or higher, the normal total accident rate will average 1.00 to 3.00 accidents per million vehicle-miles. On wet pavements with friction coefficients ranging from 0.30 to 0.40 at 50 mph, as measured by the ASTM standard test method, the total accident rate may be doubled to average 2.00 to 6.00 accidents per million vehicle-miles. When the friction coefficients are definitely in the slippery-when-wet range of 0.15 to 0.25, very high accident rates up to 15 and 20 accidents per million vehicle-miles have been reported. I know of no published accident reports listing total accident rates under icy pavement conditions where the coefficients of friction for all unstudded tires at speeds of 10 to 30 mph are less than 0.10, but I am confident that the accident rates far exceed those reported for slippery wet pavements.

One of the most important anti-skid studies urgently needed today is a thorough, impartial fact-finding study to reach a satisfactory solution to the studded-tire controversy. Such a study should clearly determine on a factual basis the benefits derived from the use of studded tires in saving lives and in the reduction of traffic accidents under snowy and icy pavement conditions. It should establish the extent to which studded tires increase the accident hazards resulting from the ejection of studs when cars are traveling at high speeds on wet or dry pavements. It should also determine whether the trough type of pavement wear in the wheel tracks caused by studded tires creates (a) a traffic hazard because of its effect on steering control of vehicles or (b) a hydroplaning skidding hazard during heavy rainstorms when the troughs in the wheel tracks on flat grades are filled with water to a depth of $\frac{1}{2}$ -in. or more or (c) an added skidding hazard on glare ice when the water in the troughs freezes. The study should determine the feasibility and cost of repairing pavement damage caused by studded tires. Cost-benefit ratios should be established if that is possible.

The investigation should determine the type and extent of use of studded tires in the snow-belt states. Recent reports indicate that the majority of car owners currently equip their cars with studded tires on the rear wheels only to provide increased traction as a replacement for tire chains. The use of studded tires on rear wheels only raises some grave questions in regard to improved performance and added safety provided by the use of studded tires versus the use of snow tires and/or the use of tire chains under icy pavement conditions. Tests conducted by the National Safety Council Winter Driving Hazards Committee have shown consistently that the friction coefficients for unstudded tires on glare ice are in the range of 0.06 to 0.08 at ice temperatures of 15 to 32 F. If studded tires are used on two wheels only, the coefficients of friction are increased by 50 percent; if studded tires are used on all four wheels, the coefficients are doubled. These test results apply to studded tires when new. Test results for worn studded tires have rarely been reported and are not conclusive. Obviously, the coefficients of friction for worn studded tires on icy pavements are lower than those for new studded tires.

It is significant to note that, in the National Safety Council tests of studded tires, the coefficients of friction on glare ice rarely exceed 0.12 at ice temperatures ranging from 15 to 32 F. Many studies have shown that, in normal day-to-day driving on dry pavements, 25 to 50 percent of all vehicles require friction coefficients in the range of 0.30

to 0.40 in braking, cornering, and acceleration. This is why a braking coefficient of 0.40 at 40 mph and a sideways-force coefficient of 0.50 at 30 mph are today recommended as the minimum coefficients of friction for wet pavements by the leading authorities in the United States and Great Britain. This is also why studded tires, which increase the coefficients of friction from 0.08 to 0.12, are not effective in preventing wet-pavement accidents.

It should also be realized that to achieve the maximum potential of studded tires in tire performance on glare ice will require more studs per tire than are currently used in the United States and Canada and will require studded tires to be used on all four wheels according to the National Safety Council tests and tests of studded tires by European testing agencies. Under these conditions it is reasonable to expect that the pavement wear per car will double the current wear rate for cars with studded tires on the rear wheels only.

Published results of friction tests comparing studded tires with snow tires under various snow conditions, such as hard packed, loosely packed, and virgin snow, are very limited. In general, the friction coefficients for all tires range from 0.20 to 0.50. This wide range is due primarily to variations in the type, texture, and crystalline properties of the snow. It has generally been observed that, at snow temperatures in the range of 20 to 30 F, the effect of compaction of the snow by traffic is to form a thin glazing of ice on the packed snow surface for which friction coefficients as low as 0.15 for snow-tread tires have been measured. It is only when the packed snow is coated with a thin glazing of ice that studded tires provide slightly improved performance in braking, cornering, and acceleration when compared with the performance of snow-tread tires. Under loosely packed and virgin snow conditions, studded tires do not provide improved performance when compared with the performance of snow tires.

The California Division of Highways and the California Highway Patrol adopted a policy in 1971 that permits the use of snow-tread tires during snowy pavement conditions but requires tire chains to be carried under those conditions for emergency use and for use when the "chains required" signs are posted. In California and in many other states, an elaborate snow-removal and bare-pavement maintenance program has been developed that has been very effective in reducing winter driving hazards. Although drivers protest the required use of tire chains because of the inconvenience and difficulty frequently experienced installing tire chains, the National Safety Council tests under snow and ice conditions clearly showed a marked superiority in traction and in stopping ability for cars equipped with tire chains compared with cars equipped with studded tires. Only when studded tires were used on all four wheels was improved performance obtained in cornering tests with friction coefficients of 0.10 to 0.12 on glare ice; in similar tests, coefficients of 0.07 to 0.08 on glare ice were obtained for cars equipped with snow tires or with tire chains on rear wheels only.

It is a well-known fact that tire chains are used for the most part only under snowy and icy pavement conditions. Drivers remove the chains as soon as the pavements are free of snow and ice. Thus, pavement wear caused by tire chains has been minimal.

It will be difficult to obtain a satisfactory solution to the studded-tire controversy. Nevertheless, it is important that appropriate government agencies take steps now to make an impartial and thorough investigation of the accidents occurring with studded tires, snow tires, and tire chains under snowy and icy pavement conditions to establish the relative merits of each type of operation. All other factors that have an important bearing on reaching a final decision in the use of studded tires should also be made a part of such an investigation.

In the interim, highway departments should continually improve winter highway bare-pavement maintenance programs by prompt removal of snow and ice, thereby providing the maximum anti-skid safety possible under winter driving conditions. The use of snow-tread tires and of tire chains should be required depending on the snow and ice conditions that require their use. Strict enforcement of speed regulations, e.g., limiting speed to 25 mph under snowy and icy pavement conditions when the "chains required" signs are posted, is an important feature of a winter driving anti-skid program. The recommendations proposed by the participants at the Anti-Skid Workshop and the HRB

Annual Meeting should contribute to the development of an outstanding anti-skid management program, not only for safe winter driving but also for safe year-round driving.

REFERENCES

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