# Relationship of Road Surface Properties To Skidding

Report of Subcommittee D to the First International Skid Prevention Conference
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● THIS REPORT is based on papers presented on September 11 before the First International Skid Prevention Conference. Nineteen papers were given at that Conference, together with a number of discussions. Obviously, I can only hope to give you the highlights which, in the main, have been agreed to by the Conference Subcommittee and later also by the Steering Committee.

Professor Moyer and I were co-chairmen of the Conference subcommittee, an arrangement necessitated in part by geographical location.

## Highlights of Existing Knowledge Which Are of Outstanding Importance

The following statements are based on the various presentations given on the program of September 11. In some cases, these observations did not meet with universal agreement between all investigators and therefore should be subject to further research for verification.

1. Pavements of all types are much more slippery when wet than when dry. The skidding hazard is greatest during the first few minutes of rainfall following a period of dry weather, while after a continued downpour the slipperiness is greatly reduced.
2. Many road surface factors affect skid resistance, including surface condition, surface construction type, surface maintenance, type of aggregate, cement or binder, surface texture, road roughness, foreign material, and surface contamination, water, surface scouring, age, weathering and climatic effects, time effects, temperature, traffic, and highway design.
3. The effect of surface texture on flexible pavements was the subject of some disagreement. Although no one denied the hazard of a smooth texture caused by an excess of bitumen in contact with the tire, the relative merits of coarse and fine texture as related to aggregate size were still in debate. Several cited the advantage of a coarse, open texture on which surface water can drain away rapidly; this type of texture was described by some as "nobby." However, other data indicate that the highest coefficients of friction may be obtained on pavements constructed of very fine aggregate the greatest proportion of which may pass a No. 40 sieve. Even sheet asphalts with around 10 percent asphalt binder and 12 percent aggregate passing the No. 200 sieve have been reported to have very satisfactory skid resistance.
4. It is well recognized that rounded aggregates and the presence of an excess of asphalt are common causes of slipperiness. However, the polishing of certain types of aggregate used in surface construction is rather generally believed to be the principal cause of pavement slipperiness in most of the United States. Cases have been reported where even "nobby" textured surfaces built of such aggregates have become extremely slippery as a result of the polishing action of rubber tired traffic.
5. On multi-lane surfaces, the driving lane generally is appreciably more slippery than the passing lane. This is due to the polishing action of greater traffic, and in part to the greater accumulation of oil films.
6. Almost all aggregates will become polished under intense traffic, some, however, much sooner than others. Certain sandstones and gneisses are said not to polish in the laboratory. The softer stones generally polish sooner than the harder stones. However, in service, many roads built with the softer stones have not polished sufficiently to cause slipperiness; their skid resistance is adequate for the traffic conditions.
7. Work in Europe, both in England and the Netherlands, has indicated that the skid resistance depends partly on the deformations of the rubber due to projections in the surface. Apparently for the best results, individual particles in the road surface should have angles at their tips of 90 deg or less.

8. On ice, the most hazardous condition exists at temperatures near the freezing point. Thus, at -30 F, the bare tire skid distance is around 80 ft, but at +35 F it is 250 ft. It is found that tire chains are most beneficial under the severest conditions. Special tires are effective 85 to 90 percent of the winter period. But no matter what may be the tire equipment, speeds should be considerably reduced when driving on ice and snow. Snow tires and tire chains are apt to give a false sense of security. Reduction in speed is highly important.

9. The geometric design of pavements is dependent on the frictional resistance between the tires and the road surface. The friction coefficients suggested are as follows:

a. Maximum side friction factors[1] ranging from 0.16 at 30 mph to 0.12 at 70 mph are used with practical super-elevation slopes to determine minimum safe radii of horizontal curves for open highway conditions.

b. For intersection curves where design speeds are less than 50 mph maximum side friction factors ranging from 0.32 at 15 mph to 0.16 at 40 mph, similarly are used to determine minimum safe radii.

c. Straight-ahead or braking friction factors[2] for wet weather conditions ranging from 0.35 at 30 mph to 0.28 at 70 mph are used to determine safe stopping distances which establish minimum sight distances for provision throughout the highway.

d. Speed-change rates used to establish length of deceleration lanes are equivalent to straight-ahead or braking friction factors ranging from 0.18 to 0.28 for deceleration from initial speeds of 30 to 70 mph, respectively.

Although the above friction factors are not referred to any particular form of test, they necessarily represent values which correspond with those measured by braking a vehicle. They were determined as those to be nearly all-inclusive regarding variations in roadway types, vehicle and tire and weather conditions. Relatively uniform roadway surface characteristics necessarily are assumed. For other than completely adverse conditions the values used provide a substantial safety factor for the large majority of existing roadway surfaces.

The criteria used in geometric design made no allowance for unusually low frictional values resulting from ice, bleeding asphalt, oil slicks, or very highly polished aggregates on the pavement surface. It is assumed that these are temporary conditions which will be eliminated by maintenance.

Wet roadway surface friction factors used to determine design braking distances (9c) are logical check criteria for determination of roadway surfaces that require corrective measures to provide essential highway safety.

10. One prolific source of skidding accidents is the presence of ruts in the shoulders immediately adjacent to pavement surfaces. Such ruts are extremely hazardous and should be guarded against with vigilance.

11. Preventive and Corrective Measures. Methods reported to have been used to improve the skid resistance of bituminous pavements with no other deficiencies include seal coats with non-polishing aggregate cover, resurfacing with siliceous rock asphalt, resurfacing with fine sand mixes designed to simulate rock asphalt, coating with epoxy resins with abrasive cover, and coating with asphalt-rubber latex covered with non-polishing aggregates. The use of thin silica sand mortar overlays for resurfacing slippery concrete surfaces was also reported.

## Deficiencies in Our Present Knowledge

There are deficiencies in our present knowledge, notwithstanding the tremendous amount of research which has been done in this country and in Europe. It is difficult to catalogue all of the subjects which might profitably be investigated. However, the following will indicate at least a few of the more prominent deficiencies.

1. Although some ingenious friction measuring devices have been built to determine coefficient of friction, it seems to be desirable that these methods be carefully reviewed

[1] AASHO Policy on Geometric Design of Rural Highways, pp. 128-133 (1954).
[2] ibid., pp. 112-117.

with the idea of insuring that all of the forces involved be fully accounted for. Devices of a given type should give practically identical results and until that can be assured, such devices cannot safely be used in a national standard. This does not at all imply that such devices are not valuable for comparing different road surfaces. They are extremely useful for rating road surfaces for slipperiness. A simple device for comparing the various methods used in different states is much to be desired.

2. Of immediate importance is the development of methods for proportioning and building road surfaces which will have built-in non-skid properties.

a. Concrete Pavement. In the concrete pavement, possibly this can be done by the use of more sand in the mix with the idea of creating a thicker mortar surface than has been customary for many years. Air entrainment may possibly make this idea practicable. This is suggested as worthy of research.

In the building of concrete pavement surfaces there is the possibility of vibrating anti-skid aggregate into the surface during construction. This has been done successfully in the laboratory. It needs work in actual construction. Also, when necessary, two-course construction can be resorted to, using a mortar top course.

b. Asphaltic Pavements. In the asphalt type of pavement proper proportioning and the use of anti-stripping agents to prevent flushing of the asphalt to the surface are desirable. Research along this line should be profitable.

Also, in the asphalt type, more work on the minimum percentage of siliceous sand needed to provide anti-skid properties is necessary. Possibly also that proportioning of the mix which will result in the more rapid wear of the matrix than of the coarse aggregate may be beneficial. Possibly basic research on the asphaltic cement would be profitable.

3. The method of using a sand-asphalt, thin surface mixture as practiced in Virginia needs more widespread investigation throughout the country in order to determine if this relatively lean surface mixture will be sufficiently durable under all conditions. If this type of mix is not found to be sufficiently durable, then further research on the durability phase of this type of mixture will be needed. Also, the contention by some that in heavy downpours, such fine textured surfaces may lose their skid resistance, especially with regard to vehicles traveling at high speed, needs further investigation. The work of the NACA at Langley Field, showing the tendency of tires to "aquaplane" over heavy films of water at high speed, is cited.

4. Other economical methods of improving the skid resistance of pavements having no other deficiency should be investigated, both in the laboratory and on actual road surfaces.

5. Laboratory methods for studying pavement slipperiness and methods for overcoming it have been used with apparent success and they offer great promise of furnishing valuable preliminary data prior to proof of these methods under actual road conditions. The calibration of laboratory devices in terms of permissible degrees of actual road slipperiness would be useful.

6. Pavements, like all other structures, need maintenance for their adequate preservation. Intense traffic has brought about the necessity for a new type of maintenance, that for preserving the surface in a sufficiently non-skid condition. Without doubt, many more researches on the improvement of slippery road surfaces could be made with profit. The above are merely suggestions.

## Statement of Methods Which Give Promise of Overcoming Slipperiness

At present, the most effective method of overcoming the slippery surface condition seems to be the use of the fine grained silica sand asphalt mix. This mixture resembles sheet-asphalt in texture, but contains less asphalt (around 8 percent) and fewer fines passing the No. 200 (not over 8 percent, often much lower). The purpose of the lower percent of asphalt is to produce a surface which will gradually wear and expose previously unexposed sand particles. Hydrated lime or certain heat stable chemical additives are usually added to the mix to prevent stripping of the asphalt in the presence of water. This type of mixture is laid hot by one of a number of commercially available spreading devices. The rate of application ranges from 12 to 50 lb per sq yd.

Other means of de-slicking pavement surfaces involve the use of ordinary bituminous surface treatments or seal coats with small size, durable, non-polishing cover aggregates. Such treatments are recognized as temporary and requiring renewal at intervals of several years. Immediately after application, this type of treatment must be protected from damage from heavy traffic, particularly in regions where rainstorms may be expected to occur without warning; otherwise the cover aggregate may be whipped off, leaving a "fat" surface which may become as slippery as the original surface. At best, surface treatments may not be expected to provide as uniform non-skid texture as the fine sand-asphalt plant mixes.

In extreme cases perhaps some of the new developments involving special resins with abrasive cover may be found desirable. At present, however, treatments of this type are too costly for general use.

## RECOMMENDATIONS OF SUBCOMMITTEE D (ROAD SURFACE PROPERTIES AND THEIR RELATION TO SKIDDING)

The following recommendations were agreed to by the Skid Prevention Conference Committee:

1. That all states be encouraged to institute a program of rating highways with regard to slipperiness. This can be done initially on large portions of their systems by reference to skidding accident records, to the experience of local highway and police personnel, and by careful judgment, bearing in mind that appearance of the pavement may be misleading. Pavements with doubtful skid resistance should be subjected to some accepted type of skid test.
2. That every effort be made to develop a standard test method for measuring pavement slipperiness.
3. Further, that the AASHO be encouraged to adopt standards of road slipperiness in terms of minimum coefficients of friction. These standards should be proportioned to the potential skidding hazards created by geometric features such as curvature, grade, sight distance, width, intersections, and to the volume of traffic using the section. These geometric and traffic factors should govern a classification of the skidding hazard as slight, moderate, or critical, and separate road surface friction standards should be set up for each class. Such standards should serve as a basis for determining sections of road which need anti-skid treatment.
4. That all states be encouraged to develop methods of building surfaces having adequate skid resistance at the time of road construction. The findings of the skid resistance measurements on existing roads and of laboratory tests should be utilized to avoid the use of surfaces which are prone to become dangerously slippery in service.
5. That all states attempt to provide a reasonable similarity in the friction levels in contiguous projects through appropriate surface treatments (but with due regard to the friction levels suggested in Section 3).

## CONCLUSION

In conclusion let me acknowledge the assistance and advice of the members of Subcommittee D on "Road Surface Properties and Their Relation to Skidding." This committee consisted of:

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