every effort to build the maximum possible amount of skid-resistance into all road surfaces. He should not build surfaces with, or permit surfaces to develop, a polished or glazed condition. He should make every effort to maintain a surface with a “sand-paper” finish, or with a smooth, gritty finish in which hard abrasive aggregate is securely held in place by a somewhat softer cementing medium (Fig. 9). The ideal skid-

![Fig. 9. A typical non-skid surface as developed by the California State Highway Department. Hot 94+ road oil covered with \( \frac{1}{2} \) inch to \( \frac{1}{8} \) inch screenings. The use of screenings of this size makes an effective non-skid cover which will not be kicked out readily by traffic.]

resistant surface is one in which this gritty surface condition is continually renewable under the action of traffic. With our present knowledge of the causes of slippery surfaces and the remedies to prevent slipperiness, construction and maintenance departments should now be able to develop construction and maintenance standards which will insure that every mile of road is skid-resistant. When this is brought about, “slippery when wet” signs will disappear from our streets and highways and another milestone in traffic safety will have been passed.

DEVELOPING NON-SKID ROAD SURFACES
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I consider Professor R. A. Moyer’s report, published in the December, 1933, Proceedings of the Highway Research Board of the National Research Council, entitled, “Skidding Characteristics of Road Surfaces,” as one of the greatest contributing factors to the solution of the highway safety problem. This subject naturally has for its background safer highways, as otherwise there would be no point in its discussion. It is true that many things contribute to accidents. Unless we attack all the causes, little progress will be made in solving the problem. Causes vary in degree. Some are difficult to solve,
such as those pertaining to the individual. Accidents resulting from defects in the car and defects in the road are largely capable of solution. This latter is the problem of the highway engineer. Hence road engineers must be interested in this subject or be delinquent in their duty.

Professor Moyer has spoken of the skid-resistance of rock asphalt. A study of these surfaces shows that they consist largely of fine angular sand grains of hard silica with a hardness of 7 (a diamond has a hardness of only 10). A knowledge of this point might lead engineers to study the methods of making other road surfaces non-skid. It can be justly said that the non-skid character of sandstone rock asphalt and the highly non-skid character of certain sheet asphalts is due to the myriad of little prickly points of the sand grains which are in contact with the tire all the time.

An attempt has been made to make some types of pavement non-skid by the introduction of corrugations, or by producing a pebbly surface. This, at first thought, would seem to be very effective. However, Professor Moyer’s report indicates clearly that this is not necessarily true. For instance, this report gives the coefficient of friction of a tire on portland cement concrete, rough finish, as 0.37 to 0.48, and on a smooth finish, 0.40 to 0.46.

It is true that with the rough finish there will be, with a non-skid tire, a certain amount of mechanical interlocking of the tire surface with the roughened highway surface. It is also a well-known fact that the friction of any one surface upon another, other things being equal, is proportional to the area of the surface in contact. It is for this reason that one deflates his tires to drive on an icy pavement.

On the corrugated surface, the contact area between the tire and road surface is reduced, and, apparently, from tests actually made, what little advantage may be secured in the mechanical interlocking effect of the tire and surface is counteracted by the reduced area in contact.

The same principle can be well illustrated in the slippery surfaces we find on our old, badly worn, granite block pavements. The edges are worn off and polished and the contact area of tire and road surface greatly reduced; and as a result, many of these old stone block pavements are very slippery.

Another fact bearing on this subject has just recently come to our attention. Some of our maintenance men reported that they had greater difficulty cleaning the ice from the corrugated surface. The grooves hold the water much longer than a smooth surface; and as a result, the water may freeze, thus forming ice, so that under certain conditions at least part of the surface consists of ice, which otherwise would not have formed.

This illustrates again why we must carefully investigate before we draw definite conclusions that we have solved a new
problem. I doubt if the corrugations in the average road surface have decreased its hazards as a driving surface.

The State of Connecticut made extensive studies on the cause of accidents in 1933, and reported that nearly 25% of the accidents involved skidding of the vehicles. This only adds to the importance of a non-skid surface in building safer highways.

I would like to stress further the fact that non-skid surfaces will cause a very evident decrease in the number of accidents. For example, our State Road 37, south of Martinsville, was an old penetration-type surface which had become very slippery and dangerous on the numerous hills and sharp curves. In 1935, there were many serious accidents and two fatalities on a section of this road beginning 6.3 miles south of Martinsville and extending to the north city limits of Bloomington. In 1936 this same section of road was resurfaced with Kentucky Rock Asphalt, and since that time we have had only a few minor accidents and not one fatality. I believe that this clearly shows the importance of resurfacing some of our old-type surfaces which have become slippery and dangerous.

In his paper, Professor Moyer states that 25% of the accidents in winter months on Iowa roads were caused by skidding. The way to correct a slippery surface condition caused by ice or mud is to apply a gritty substance. When treating an icy surface, calcium chloride should be mixed with the grit to anchor it to the surface. Tests show that care must be taken in the amount of calcium chloride that is used on a concrete road, as otherwise it may damage the pavement by causing scaling. Our experience shows that calcium chloride properly used for correcting slipperiness on road surfaces has not been detrimental to the bituminous type of pavement.

This subject of developing non-skid road surfaces is very clearly a most important one, and every highway engineer should give it the fullest consideration that the economics of the problem will permit. We have solved greater problems than this, and it is quite evident that we can solve this one if the proper study of the subject is made.

THE APPLICATION OF SOIL MECHANICS TO HIGHWAY IMPROVEMENT—A SUMMARY AND A REVIEW

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I am somewhat at a loss as to how to begin on my assigned subject, "The Application of Soil Mechanics to Highway Improvement." The breadth of this title is appalling. If it were possible for me to talk to you gentlemen three hours each week for one full school year, I would know just what to say. Under the present circumstances, I shall have to try to tell you briefly