A Review of European Practices for Laboratory Evaluation of Aggregate Polishing Characteristics

R. E. OLSEN, Federal Highway Administration

•IN OCTOBER 1969, I had the privilege of going to several European countries under the sponsorship of the International Road Federation to review research work in the field of skid resistance of highway pavements. I spent a week at the British Road Research Laboratory at Crowthorne, a day at the Central Laboratory for Roads and Bridges in Paris, a day at the Center for Road Research in Brussels, and 2 days at the Technical University in Berlin, West Germany.

I was impressed by the great concern the Europeans have for skid resistance of highway pavements. They have a right to be concerned; the roads are narrow, the traffic is dense, the speed is relatively fast, and the driver is undisciplined by our standards. However, the fact that I did not see an accident during the 2 weeks I was in Europe proves that these drivers, or their opponents, as the case may be, are excellent operators.

Investigations of the skidding problem have been under way in Europe for some time. In 1929 the British developed a skidding test for pavement surfaces using a motorcycle with sidecar. Today they have a truck-mounted, fifth-wheel apparatus with measuring and recording devices that measure the sideways force coefficient of wetted pavements. These units will be allocated to each highway group for continual monitoring of the skid resistance of pavements, and roads or road sections where skidding values fall below minimum values will be promptly resurfaced.

In 1930 test sections were laid to compare material and design variables. The British are currently continuing such investigations for a better nonskid type of surfacing from both the design and construction points of view, that is, size of stone, rate of application, and special binder. They are also investigating special types of manufactured aggregate. A specific source of calcined bauxite has an exceptionally high resistance to polishing under traffic. However, at this stage it is very expensive—about $75/ton of usable material. Several test sections were laid and, as measured by the British pendulum tester and sideways force coefficient apparatus, the calcined bauxite proved to be better than the best of natural roadstone. This material has a polished stone value of about 75.

It is the hope of the research to find a suitable manufactured aggregate made up of a matrix containing granules of another material that is hard and angular. The ideal matrix should be cheap, be easily mixed with the abrasive granules, have satisfactory strength, and be one that will wear away under traffic at an optimum rate, thus exposing new grit particles. The researchers are of the opinion that the microtexture of the aggregate particles is important but that the road surface should be rough textured.

Road surface texture measurements are being mady by using stereophotographic techniques with computer analysis. A "profile ratio" value is determined, which is the ratio of the length of the profile to the length of the base line. This procedure, however, does not indicate the state of polish of the surface aggregate. Other techniques of assessing the surface roughness are now under investigation. These include

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angularity of the peaks of the exposed aggregate, distribution of projection, and tire penetration. No satisfactory method has yet been developed to determine tire penetration.

The Road Research Laboratory and the Cement and Concrete Association of the United Kingdom have developed an accelerated wear machine for studying portland cement paving mixture. It is, in reality, an enlarged version of the stone-polishing apparatus. The wheel containing the test specimens is about 15 in. in radius, holds 16 specimens that measure about 6⅜ by 3½ in. and is driven at 150 rpm. Two smooth rubber tires are set at 2 deg out of line with the test wheel. The specimens are abraded dry with a fine flint sand for 50 hours and then wet abraded with a fine emory powder for 5 hours. The specimens are tested for skid resistance with the British pendulum tester.

Studies have been made with this test procedure on the influence of types of texturing devices such as wire brooms, rubber rakes, and rollers; the application of polish resistant chippings; the assessment of the relative merits of various fine and coarse aggregate; and the influence of mixture design.

Some general conclusions from these studies indicate the value of a deep and rough texture in the surface of portland cement concrete for high speed traffic; however, such a texture wears very rapidly in heavy traffic. Increasing the cement content and strength of concrete mixtures resulted in a higher degree of polish and, therefore, poorer skid resistance; however, such mixtures retain their rough texture longer. It has been shown that the most important characteristic of the aggregate is the hardness of the fines and that the hardness of the coarse aggregate is of secondary importance.

The French are currently working on surface texture measurements. Their technique is to make a rubber casting of the surface and from this mold a replicate of the surface in epoxy resin. These molds are surprisingly very true to the original surface. The castings are cut so as to show the profile of the pavement, and this is magnified on a screen. The profile ratio is measured and analyzed by computer.

The French are also studying road surface drainage. They are in the laboratory stage of testing small pavement samples for the amount of water retained at variable rates of water application. The relation among slope of the pavement, surface roughness, quantity of water retained on the surface in equilibrium, and quantity of water trapped in the pavement and retained by absorption are being investigated. They are also determining the mean depth of water films on pavement surfaces with nuclear devices.

In the field of portland cement pavements, the French advocate mechanical brushing in the transverse direction to remove surface laitance and choosing a mortar that does not polish. This is accomplished by using a very hard and angular sand so that differential wear of the mortar will leave the sand particles exposed from the cement paste.

The French use the British stone polishing test. They find that it does correlate well with pavement condition and use it for aggregate evaluation. However, they recognize the shortcomings of the test; that is, the shape of stone can affect results and the stone layout or pattern is not realistic. They have found good correlation between the polishing characteristics of aggregate and the Vickers hardness test.

In Belgium studies are concerned with the techniques of texturing portland cement concrete. The Belgians too have developed means to incorporate transverse grooves in fresh concrete and have found them to be effective. One study that has been going on for the past 6 years has shown that the coefficient of friction has remained quite constant at 0.65 to 0.75 at 30 mph. The change in coefficient when testing at slow and fast speeds is less than 0.2. They have found that the decrease in the coefficient of friction with increasing speed is linear with the depth of the groove and is independent of the degree of polishing of the pavement. However, at slow speed the coefficient is independent of the texture and is dependent on the degree of polishing.

In Germany there is interest in profile measurements made with a rubber-coated stylus. The stylus is slowly moved across the pavement surface and reacts to the size and distribution of surface asperities. The force necessary to move the stylus is also

measured, and this can be related to the coefficient of friction of the pavement surface. This method of measurement is believed to take into account the microroughness of the surface of the pavement. It is believed that from these data good predictions of the coefficient of friction of the pavement surface at 50 mph can be made. At the Technical University, studies are under way to investigate the forces and mechanics involved in the phenomenon of hydroplaning. Accident data are being collected to spot locations where skidding accidents occur and to investigate these pavements for characteristics that involve skidding. The Germans believe that accident statistics are the most important parameter when judging the need for resurfacing to improve the resistance to skidding.