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Influence of the gritting material applied during the winter services on the asphalt surface performance

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ABSTRACT

Gritting materials such as de-icing agents are widely applied during the winter to help thawing ice and snow on road surfaces. They remain on the road for a certain period of time, which may affect the surface properties of the pavement, such as micro- and macro-texture and thus the skid resistance. In this paper, asphalt specimens are taken from a test track and subjected to a successively increasing polishing duration with various gritting materials as polishing agents with the Aachen Polishing Device. The skid resistance of these specimens is determined according to the Wehner/Schulze method. Results show that the skid resistance behavior was influenced by de-icing agent in terms of bitumen removal and polishing of the aggregates. In comparison with sand, de-icing salt has a positive effect on the skid resistance since it removes the bitumen film on the surface of the aggregates very fast while polishing the aggregates only to a minimal extent. It is therefore an optimal option for de-icing in winter services with regard to skid resistance and traffic safety.

1. Introduction

Skid resistance of road surfaces is essential to ensure traffic safety. Statistics show that the risk of skidding accidents decreases with an improved skid resistance (Wilson, 2006). Skid resistance mainly depends on the road surface texture, which is characterized by two scale levels: micro-texture and macro-texture. The micro-texture per definition comprises wavelengths less than or equal to 0.5 mm in length and depth (Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV) et al., 2012; Wilson, 2006). Furthermore, the roughness of an aggregate has a decisive influence on the magnitude of the micro-texture of a road surface (Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV) et al., 2012; Wilson, 2006). The macro-texture is characterized by surface irregularities with dimensions ranged between 0.5 and 50 mm horizontally and between 0.1 and 20 mm vertically (Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV) et al., 2012; Wilson, 2006). The micro- and macro-texture of a road, which have a significant impact on the activation of the frictional force between vehicle tires and road under wet conditions, are influenced by the roughness, choice, grain size, arrangement and grading of the aggregates (Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV) et al., 2012; Ech et al., 2012; Senga et al., 2013; Wang et al., 2014a).

Due to ice and snow during the winter months the skid resistance is drastically reduced for a certain period. As a result, a higher accident rate is generally observed in winter. Measures need to be taken to remove ice and snow from the road surfaces to ensure sufficient contact and traction of the tire to the road surface. Applying de-icing agents is the most frequently used option.

As part of winter road maintenance in Germany, various gritting materials are spread on the road surface to keep the traffic safety by lowering the slipperiness. These materials include, for example, stone chippings, sand or grains as well as de-icing salts. With consideration of these measures it is always an issue that that the gritting material remains on the road surface after the frost period, even if they are cleaned up. These remaining grits usually have a maximum grain size of up to 2 mm. Grains bigger than this will either be cleaned off or moved away to the edge of the road. This material residue will then act as a kind of polishing agent in the tire-road contact area and intensify the polishing effect (Wang et al., 2014a; Wang et al., 2013a; Wang et al., 2014b; Wang et al., 2013b). This causes a structural change in the aggregates and bitumen film which further changes both the micro- and the macro-texture of the surface (Wang et al., 2013b).

In the scope of this paper, it will be investigated to which extent of the applied gritting materials, attended by the intensified polishing effect, may have a negative or positive impact on the surface performances. For this purpose, the polishing effect on the road will be simulated with the Aachen Polishing Device (APD). By using a conventional typical personal car tire while polishing the APD enables a practically relevant simulation. Through variation of the grain size and shape of the gritting material, various polishing conditions can be simulated. Based on the test results, the skid resistance development and different

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texture indicators depending on the polishing conditions can be obtained. From this, recommendations for a selection of gritting materials may be derived considering the long-term skid resistance of the road surface.

2. Experimental program

Asphalt plates were taken from the test track where they were paved and compacted under realistic conditions (Fig. 1). These test plates were polished by the APD which has been developed by the Institute of Highway Engineering (ISAC) at the RWTH Aachen University. With this device, the three-dimensional state of stress due to traffic can be reproduced. Thus, the effect of the most unfavorable stress on the road surface can be simulated in the laboratory. After polishing under different conditions using the APD, the skid resistances were measured with Wehner/Schulze device (W/S) corresponding to the velocity of 60 km/h. This velocity is close to the SCRIM measuring speed and was chosen purely out of conventional reasons. This method has been accepted by German contractors to predict the skid resistance of pavement surfaces of laboratory-prepared and in-situ samples. The influences of the different polishing conditions on the skid resistance can be demonstrated by a sensitivity analysis of the parameters of skid resistance prediction model.

In this paper, the test plates were not polished by Wehner/Schulze device due to its limitations. In a W/S test, the specimen is polished using three rubber cones with quartz powder and water. As a standard laboratory test procedure, however, the polishing units in the W/S test are not real tires and the polishing medium can only partly represent the actual compositions of dust and wetness conditions on the road surface.

2.1. Properties of the asphalt specimens

An asphalt mixture was constructed on a 25 m × 1.2 m test track using a real paver and compactor (Fig. 1). Asphalt plates with the dimensions of 320 mm × 260 mm × 40 mm were taken from the test track. The paving and compaction conditions on the test track are very similar to real conditions and much more realistic than laboratory compaction (Wang et al., 2013b).

The asphalt mixture is a typical asphalt concrete AC 8 DS that is frequently applied as the surface layer for heavy-duty roads in Germany and around the world. The composition and volumetric properties of the asphalt mixture are shown in Table 1.

Table 1
Composition and volumetric properties of the asphalt.

Aggregates	Composition	Grain size	Mass percent and Stone type
		<0.063 mm	7.0 M.-%, Limestone
		0.063–0.125 mm	28.0 M.-%, Basalt
		0.125–2 mm	13.0 M.-%, Nature sand
		2–5.6 mm	23.0 M.-%, Basalt
		5.6–8 mm	29.0 M.-%, Basalt
	Apparent density of the mineral grains		2.292 g/cm^3
	Polished stone value (PSV, EN 1097–8: 2009)		50 (Basalt)
Binder	Polymer modified bitumen 25/55–55, 6.8 M.-%		
Asphalt mixture	Apparent density of the asphalt mixture 2.638 g/cm^3 Air void percentage 3.1 vol.%		

2.2. Polishing test using Aachen Polishing Device (APD)

The polishing effect of vehicle tires was simulated by the APD since it reproduces the polishing mechanism much more realistically. In comparison to W/S, the APD (Fig. 2) uses real vehicle tires (Type: Vanco-8, 165/75 R 14 C 8PR 97/95 R TL from Continental). With this device two test specimens were subjected to shear stresses from a superimposed translational and rotational motion. The translational motion was realized by a horizontally movable sled onto which the test plates are fixed, while the rotational motion was realized by rotating a vertical axle with two wheels. The polishing through the APD was performed by a tire with an inner pressure of 0.2 MPa and an imposed load of 200 kg. The sled moved horizontally 9 times back and forth per minute, while the tires spun 41 rotations per minute. The centroids of the two tires were 55 cm apart; the velocity of the circular motion was therefore about 1.2 m/s. This meant that the entire test plate was subjected to almost equal polishing load, unlike the annular area polished by the W/S. Since dust on the road consists of about 60–80 M.-% of SiO_2 (Wang et al., 2013b), quartz or quartz powder were selected as polishing agents. During a typical polishing test, the polishing agent and water are spread evenly over the surface at a rate of 27 ± 7 g/min. According to former research, the polishing duration is fixed to be 300 min (Wang et al., 2014a; Wang et al., 2013a; Wang et al., 2014b; Wang et al., 2013b). After 300 min of polishing, the sample has reached an equilibrium in relation to the test conditions and changes only very little or not at all as a result of further polishing action (Wang et al., 2013b).

2.3. Wehner/Schulze device

The Wehner/Schulze device (Fig. 3, left) includes a polishing unit for an accelerated simulation of traffic load. It consists of three conical rubber rollers which rotate at a speed of 17 km/h and with a contact pressure of 0.4 N/mm^2. A mixture of quartz powder and water is added as a polishing agent and lubricant (Fig. 3, middle). In the friction measurement unit, three measuring rubbers are arranged in a circular path with a diameter of 18 cm. Each rubber is 14.5 mm wide, 30 mm long and typically has a Shore scale hardness of 65 (Fig. 3, right). During the measurement, they are accelerated to a velocity of 100 km/h, dropped to the test surface and decelerated under the addition of water until a stationary state is reached. The coefficient of friction can be determined continuously and normally the value corresponding to the velocity of 60 km/h is recorded. The repeatability of the test procedure is approximately ±0.026 according to the EN12697-49. Many prediction models for aggregates and asphalt roads are developed based on

Fig. 1. Test track, paver and asphalt compaction.