INFLUENCE OF THE GRITTING MATERIAL ON THE PAVEMENT PERFORMANCE

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ABSTRACT

Gritting materials are widely applied during the winter services to help thawing ice and snow on the road surface. They remain on the road for a certain period of time, which may affect the surface performance of pavement, such as the skid resistance. In this paper, asphalt specimens are taken from the test track and are subjected to successive polishing load in laboratory conditions with various gritting materials as the polishing medium. The skid resistance of these specimens is determined according to the Wehner/Schulze method. The skid resistance behaviour was analysed and the influences of the de-icing agent on the aspect of bitumen removal and polishing of the aggregates are evaluated. Results show that in comparison with sands, de-icing salt has a positive effect on the skid resistance, for de-icing salt removes the bitumen film on the surface of the aggregates very fast while polishes the aggregates only to a minimal extent. It is therefore an optimal option for de-icing in winter services in view of the skid resistance and traffic safety.

RESUMEN

Los materiales arenosos son frecuentemente aplicados durante el mantenimiento en invierno para ayudar en la descongelación del hielo y la nieve de la superficie de la carretera. Estos materiales permanecen en la carretera durante un cierto periodo de tiempo que podría afectar al redimiento de la superficie del pavimento, como la resistencia al deslizamiento. En este documento son recogidas muestras de asfalto de un tramo de prueba y sometidas a sucesivas cargas de pulido en condiciones de laboratorio con varios materiales arenosos como medio de pulido. La resistencia al deslizamiento de estas muestras se determina según el método Wehner/Schulze. Fue analizado el comportamiento de la resistencia al deslizamiento y evaluadas las influencias del agente antihielo de cara a la eliminación del betún y del pulimento de las particulas agregadas. Los resultados muestran que en comparación con las arenas, la sal antihielo tiene un efecto positivo en la resistencia al deslizamiento y elimina la película bituminosa de la superficie de los agregados rápidamente mientras que los pule en un grado mínimo. Por lo tanto, es una opción óptima para la descongelación de la carretera durante el mantenimiento en invierno, en términos de resistencia al deslizamiento y seguridad.

1. INTRODUCTION

Skid resistance of road surfaces is essential to traffic safety. Statistics show that the accident rate of road traffic is closely related to the skid resistance level [1]. The wet accident rate and the accident rate under dry conditions both decrease with higher skid resistance. In winter in case of ice and snow, the skid resistance will be drastically reduced for a certain period. As a result, higher accident rate is generally observed in winter. Measures need to be taken to remove the ice and snow on the road surfaces to ensure sufficient contact and traction of the tyre to the road surface, especially the micro texture. Applying de-icing agent is a most frequently taken measure.

In the winter road maintenance in Germany, various gritting materials are spread on the road surface to keep the traffic safety by lowering the slipperiness. These include for example, the stone chippings, sand or granules, as well as de-icing salts.

In this background, it is always problematic that the gritting material remains on the road surface after the frost period, even if they will be cleaned up. These remaining grits have ordinarily a maximum grain size up to 2 mm, for grains bigger than this will be either cleaned off or be brought away to the edge of the road. This material will then act as a kind of polishing agent in the tyre-road contact area and magnify the polishing effect. This brings a structural change in the aggregates and bitumen film, which further changes both the micro and the macro texture of the surface.

In the scope of this project, it will be investigated, to which extent a positive or negative influence of the applied gritting materials along with the magnified polishing will effect on the surface performances. For this purpose, the polishing effect on the road will be simulated with the Aachen Polishing Machine (APM). By using commercially typical personal car tyre, the APM enables a practical relevant simulation.

Through variation of the grain size and formation of the gritting material as well as the existence of water, various polishing conditions can be fulfilled. Based on the test results, the skid resistance development and different texture indicators depending on the polishing conditions can be obtained. From this, recommendation for choosing the gritting materials should be put forward considering the long term skid resistance of the road surface.

2. EXPERIMENTAL PROGRAM

Asphalt plates with a dimension of 320mm x 260mm x 40mm were taken from a 25m x 1.2m test track (Figure 1). These test plates were polished under different conditions using the APM. The skid resistances were measured with W/S. The influences of the different polishing conditions can be demonstrated by the parameters of the skid resistances envelopment.

Figure 1 – Construction of asphalt mixture on the test track

For an asphalt road, the traffic first increases the skid resistance through removing the binder from the top of the aggregates, so that the aggregates are ready to contribute to the force transmission. After complete removal of the binder from the top, the skid resistance reaches its maximum (μ_{peak}) and then falls down due to smoothing and levelling effect, especially on the micro-texture of the aggregate. This process is more frequently called polishing effect and the skid resistance decreases to a constant level (μ_{end}) (s. Figure 2).

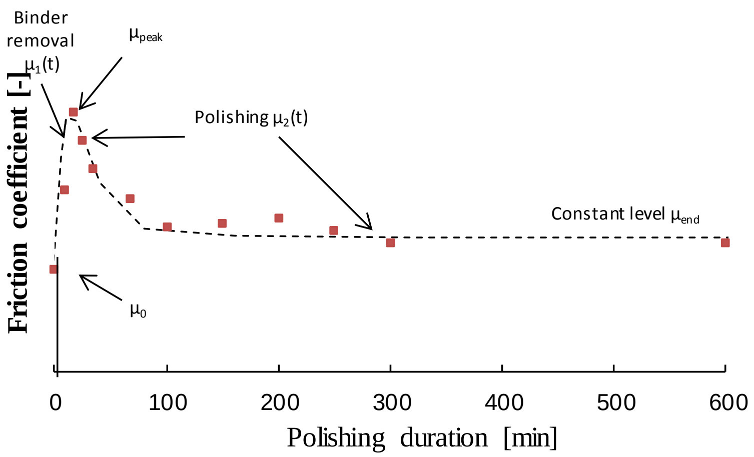


Figure 2 – Parameters to describe the skid resistance development of an asphalt road

2.1. Aachen Polishing Machine

Under the combination of mechanical load and weathering action, skid resistance of road generally decreases in the course of polishing [2-4]. The polishing effect from tyres under practical conditions was simulated by using the Aachen Polishing Machine (Figure 3) with real vehicle tyres (Type: Vanco-8, 165/75 R 14 C 8PR 97/95 R TL from Continental), which has already been successfully employed for studies on stone plates [5-6]. In this machine, the test pieces were subjected to the shear stress from a superimposed translational and rotational motion. The translational motion was realized by a horizontally movable sled in which the test plates are fixed, while the rotational motion was realized by rotating a vertical axle with two wheels. The polishing through the APM was performed with a tyre inner pressure of 2 bar and an imposed load of 1500 N. The sled moved horizontally 9 times back and forth per minute, while the tyres spinned 41 rotations per minute. The middle points of the two tyres were 55 cm apart, the velocity of the circular motion was therefore about 1.2 m/s.

Figure 3 – Aachen Polishing Machine (APM)

2.2. Wehner/Schulze machine

The Wehner/Schulze machine (Figure 4 left) includes a polishing unit for accelerated simulation of the 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 the polishing agent and the lubricant (Figure 4 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 has typically a Shore scale hardness of 65 (Figure 4 right). During measurement they are accelerated to a velocity of 100 km/h and then lowered to the test surface till decelerated to stationary state while adding water. The coefficient of friction can be continuously determined and normally the value corresponding to the velocity of 60 km/h is recorded. Many prediction models of the aggregates and asphalt road are developed based on [7-11].

Figure 4 – Wehner/Schulze machine (left), the polishing unit (middle) and the skid resistance measuring unit (right)

3. RESULTS AND DISCUSSION

3.1. Influence of the polishing agent on skid resistance development

In order to determine the influences of the polishing agent (the gritting material) on the skid resistance development, especially μ_{peak} and μ_{end}, asphalt specimen from the test track were polished in APM with various polishing agents:

- (V 1) without spreading as the reference variant,
- (V 2) quartz powder with a maximum grain size of 0.4 mm and a mean grain size of 0.04 mm,
- (V 3) quartz sand I, with a maximum grain size of 2 mm and a mean grain size of 0.4 mm, with 100% crushed and broken surfaces
- (V 4) quartz sand II, with a maximum grain size of 2 mm and a mean grain size of 0.4 mm, with 50% crushed and broken surfaces and
- (V 5) the de-icing salt with a maximum grain size of 2 mm and a mean grain size of 1.06 mm

Before polishing, all stone grains on the surface of the asphalt plates are coated with bitumen. The 10 specimens of 5 variants show a mean W/S value of μ_0 = 0.375±0.019. Despite an almost equal initial skid resistance, the asphalt plates have different skid resistance development curves (Figure 5 and Table 1) under different polishing conditions.

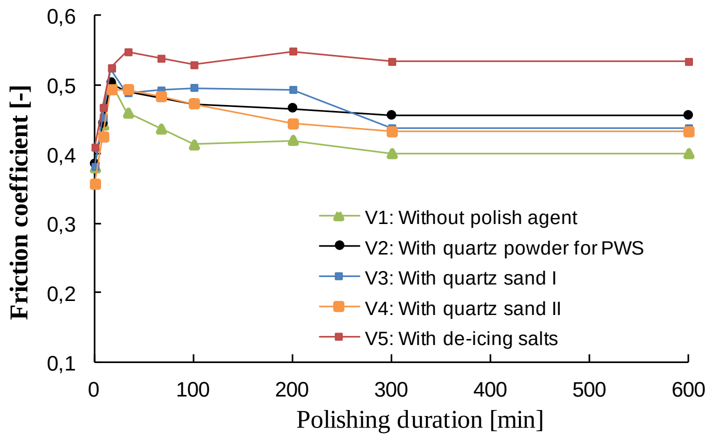


Figure 5 – Influence of polishing agent on the skid resistance development using the example of asphalt concrete surface

Table 1 – Influence of the polishing agent on the skid resistance development using the example of surface layer from asphalt concrete

	$\bar{\mu}_0$	t_{peak}	μ_{peak}	μ_{end}
V1	0.387	13.9	0.503	0.406
V2	0.370	8.02	0.504	0.456
V3	0.369	7.53	0.514	0.437
V4	0.378	23.6	0.498	0.432
V5	0.396	38.6	0.587	0.536

It can be seen that the application of polishing agent influences the μ_{peak}, t_{peak} and μ_{end}. Under the application of different polishing agent, the removal speed of the bitumen is very different. The maximum and final values of the skid resistance (μ_{peak} and μ_{end}) are also different. The time to the peak value of the skid resistance (t_{peak}) is longest in case of de-icing salt (V5), followed by quartz sand II (V4) and the reference variant (V1), quartz sand I (V3) and quartz powder (V2) the lowest. The peak skid resistance (μ_{peak}) is almost the same for V1 – V4, while that for V5 is the highest.

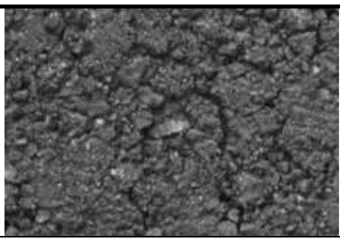
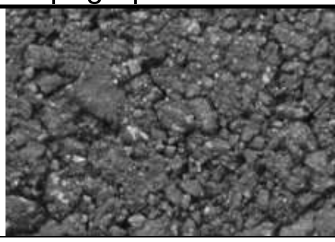
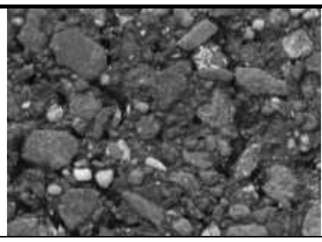
The values of μ_{end} are in the order:

$$\mu_{end,\,V5} > \mu_{end,\,V2} > \mu_{end,\,V3} \approx \mu_{end,\,V4} > \mu_{end,\,V1}$$

With no polishing agent (V1) the final skid resistance is the lowest, because very little surface was exposed from bitumen; after polishing, the surface shows no difference from the initial state in colour (Table 2). The final skid resistance in V3 and V4 is almost the same and is a higher than in V1. The binder is completely removed from the top of the aggregates, so that almost all stone grains can be seen. After a polishing duration of 600 minutes, almost all aggregate grains on the surface are exposed (Table 2) and strongly polished, so that the final skid resistance μ_{end} is significantly less than the value in the case with quartz powder.

The final skid resistance for V2 is still higher than in the above mentioned three cases. More bitumen was removed from the top of the aggregates; underlying grains are still completely covered by bitumen after polishing. With de-icing salt (V5), the final skid resistance is highest. Hardly any bitumen remains on the surface. The aggregates are totally free from bitumen. For the low hardness and the strong solubility of salt crystals, the aggregates will be polished on to a minimal extent. These reasons lead to the highest finial skid resistance. Through the comparison between V3 and V4, it can be found that the percentage of the crushed and broken grains mainly influences μ_{peak} and t_{peak} and has only minimal effect on μ_{end}. With 100% crushed grains (V3), the bitumen film can be removed very fast and so quickly μ_{peak} is reached.

Table 2 – Results of the topographic consideration

Example of images			
Variants	Without polishing agent	With quartz powder	With quartz sand I & II

3.2. Influence of water and polishing agent on the skid resistance development

In Figure 6 and Table 3, the influence of water added during the polishing process is demonstrated. It is easy to recognize that the plates polished in presence of water possess higher W/S value throughout the polishing process than those polished without water. The difference between the final skid resistance values (μ_{end}) in case with and without water lies in 0.11 and 0.05, for the conditions with quartz powder and quartz sand as the polishing agent respectively.

This difference in skid resistance can be explained through the rubber abrasion, as found out by the topographic analysis with the incident light microscope (Figure 7). In the case of polishing with no water, it can be ascertained that the polishing agent blends with the rubber abrasion and sticks to the bitumen. In this way, a thin, slight deposition is formed on the surface. This deposition behaves like a lubrication layer, which protects the aggregates from further polishing and also fills the hollows of the texture, so that the macro-texture depth (MTD) is reduced. The adhesive bonding of the deposition to the surface depends on the applied polishing agent and the polishing duration. In case of quartz powder, the adhesion is distinctly better that in case of quartz sand. In the case of polishing with water, rubber abrasion is hardly seen. On the one hand, the abrasion of binder material and the minerals that were loosened by the polishing agent are strongly increased through water. On the other hand, the rubber abrasion and the added polishing agent are constantly flushed away.

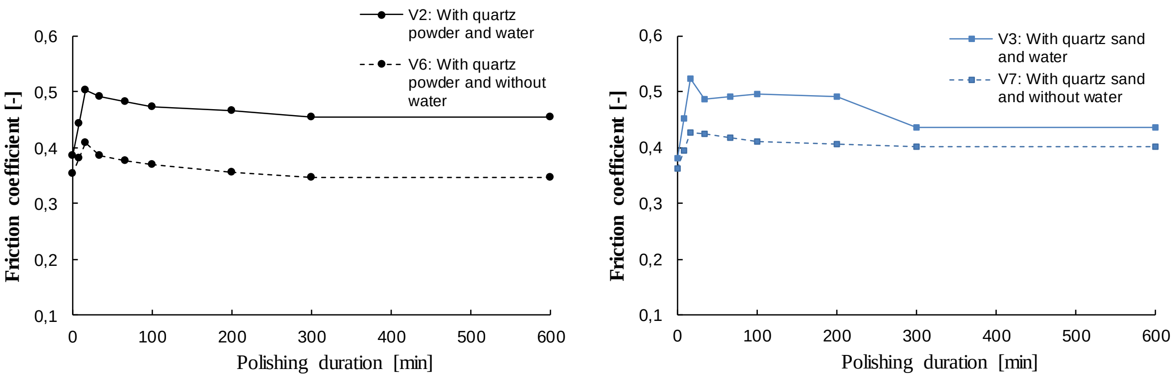


Figure 6 – Influence of water on the skid resistance development depending on the applied polishing agent

Table 3 – Influence of water on the skid resistance development using the example of asphalt concrete surface layer

	$\bar{\mu}_0$	t_{peak}	μ_{peak}	μ_{end}
V2	0,370	8,017	0,504	0,456
V3	0,369	7,529	0,514	0,437
V6	0,344	2,749	0,412	0,347
V7	0,359	17,439	0,427	0,402

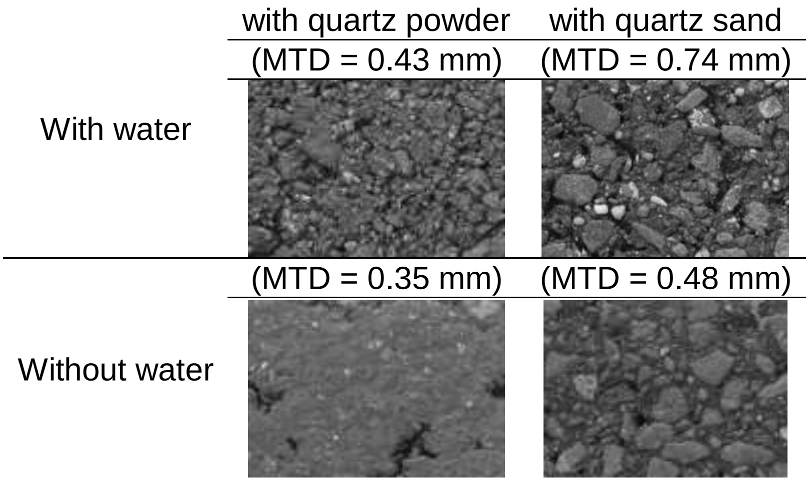


Figure 7 – Surface of the investigated variants after 600 minutes polishing duration with specified macro-texture depth according to EN 13036-1

4. CONCLUSIONS

In this paper, the influences of the de-icing agent remaining from the winter maintenance on the road surface performance were investigated. The process of the binder removal and the polishing of the aggregate were simulated using the Aachen polishing machine. And the skid resistance was determined according to the Wehner/Schulze test method. The influences of the de-icing agents as polishing medium on the peak and long-term skid resistance were found out. Following findings can be ascertained:

The remaining de-icing agent from the winter maintenance acts as a polishing medium and contributes to the removal of bitumen film and the polishing of aggregates, which has a great effect on the skid resistance of the road surfaces.

With no polishing medium, the bitumen is removed very slowly. With sand as the de-icing agent, the short-term skid resistance changes depend mainly on the grain size. The percent of the crushed grains in the sand only influences the removal speed of the bitumen film but has no effect on the finial skid resistance.

De-icing salt only affects the bitumen film on the surface of the aggregates. In the end state, almost all bitumen is removed from the specimen surfaces while the aggregates are only minimally polished. This leads to the highest skid resistance. Therefore, applying de-icing agent is the best option for winter service on road.

If the road surface is dry and polishing agent exists, it can be observed that the polishing agent blends with the rubber abrasion and sticks to the bitumen. In this way, a thin, slight deposition is formed on the surface. The new deposition layer reduces the macro texture depth and the skid resistance of the road surfaces.

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