BASIS OF EVALUATION FOR METHODS OF SKID RESISTANCE PREDICTION

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ABSTRACT

In order to achieve a reliable prediction of grip values for pavement surfaces it is necessary to simulate the actual loading scenario in the field at the time of prediction in the laboratory as realistically as possible. For this purpose, specimens were taken from road sections which had been exposed to traffic for a long period of time. In addition, specimens were produced in the laboratory and subjected to the action of a testing devices (Wehner-Schulze-Apparatus; PWS).

Between the laboratory grip measurements with PWS performed on the extracted cores and the 1 m SKM (german SCRIM) values there existed no correlation. However, when the measured values for the cores and the 1 m values were ordered seperately to increasing value, a well-defined relationship was apparent between the values measured on the cores and the 1 m values with the SKM.

Because the aggregate used in two of the three asphalt pavement sections was still available, it was possible to produce laboratory specimens. On comparing the development of skid resistance of the laboratory specimens with that of the cores, it is conspicuous that the final skid resistance of the laboratory specimens is below the final skid resistance of the cores.

Keywords: Sustainability, skid resistance, friction after polishing, precision, conception of asphalt mixtures

1. INTRODUCTION

In Germany tests with the Wehner/Schulze apparatus (now part of EN12697-49 [1]) are used to be done since about 50 years to get a prediction of the skid resistance. In the beginning the apparatus was used to polish aggregates but more and more surfaces of asphalt layers were polished too to find out an optimal conception for the asphalt mixtures to be used on heavy trafficked roads. With this tests it is possible to construct sustainable roads with a long service to use.
In 2001 in Germany requirements on the skid resistance of pavement surfaces at the time of acceptance and until expiry of the liability period for claims on defects were stipulated by contract. The measurement of the skid resistance of pavement surfaces is performed in the field using the sideway force coefficient routine investigation machine (SCRIM). In the meantime, the measuring principle employed by this device has come to be known as the lateral load gauge method (SKM). Compliance testing is permitted with the combined measuring method SRT pendulum / discharge gauge. Especially at the time of expiry of the liability period for the guarantee, these regulations pose the threat of an unfulfilled contract for the contractor (supplier of aggregate, asphalt and concrete manufacturers, road construction industry) because the current evaluation situation does not - even from an economical aspect - allow the conception of pavement surfaces which also reliably fulfil the requirements over and above the period of liability. In order to achieve a reliable prediction of grip values for pavement surfaces it is necessary to simulate in the laboratory the actual loading scenario in the field at the time of prediction as realistically as possible.
In the present paper, investigations on the prediction of the development of skid resistance for test road sections were performed using the Wehner/Schulze testing method (PWS/FAP). Earlier investigations have shown that the method is principally suitable for the performance of skid resistance prediction.

2. TEST DEVICE AND EVALUATION OF TEST METHOD

The test device is shown in Figure 1.

Figure 1: Test device for Wehner/Schulze (left: apparatus; right: upper picture: polishing rollers; lower picture: skid resistance measuring device)

The sample is polished and the friction force is measured. The polishing station, which is continuously supplied with a mixture of water and quartz powder, contains three polishing rollers that can be lowered and that move across the test surface at a predefined slip and contact pressure. A measuring head with three rubber pads rotates declutched while it is lowered onto the test surface and water is being added. The braking torque generated by the contact between the pads and the surface is continuously measured and recorded until the measuring head comes to a standstill. The Laboratory Skid Resistance is calculated from the friction torque measured at 60 km/h.
When the measurements with Wehner/Schulze started the test method was like following showed [2]:

Stage [0]	Measuring of the skid resistance (PWS) in the beginning without polishing
Stage [1]	Measuring of the skid resistance (PWS) after 90.000 passes of the polishing rollers
Stage [2]	Measuring of the skid resistance (PWS) after a sand-blasting of the surface of the sample
Stage [3]	Measuring of the skid resistance (PWS) after again 90.000 passes of the polishing rollers
Stage [4]	Measuring of the skid resistance (PWS) without polishing up to a constant level of skid resistance

With the test method using the 5 stages you only get points of the skid resistance curve and you don't can give any comments to the development of the skid resistance. Therefore in a research programm [2] a test method was tested with which the development can be shown. With this method the skid resistance is measured after several amount of passes of the polishing rollers. Usually measurements were done after 4.500, 7.500, 15.000, 22.500, 30.000, 45.000, 135.000, 180.000, 225.000 and 270.000 passes. Figure 2 shows the comparison of the two methods.

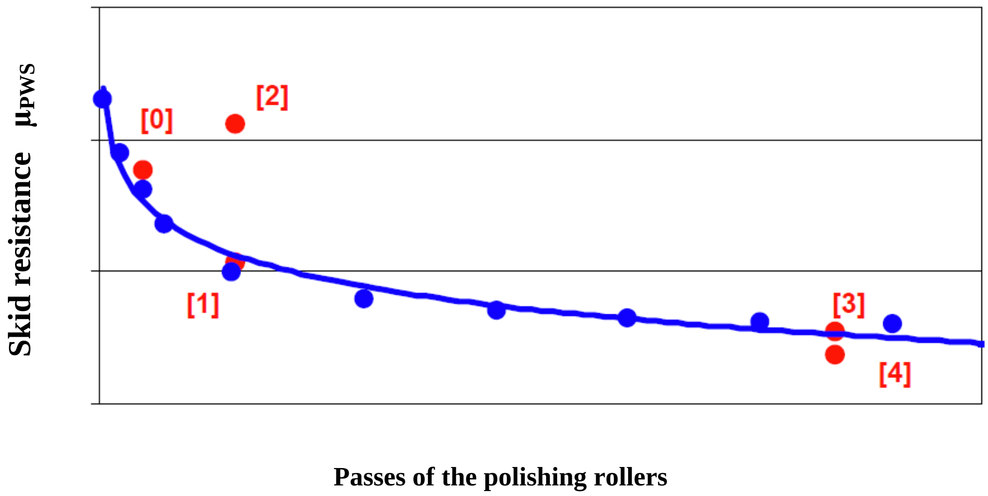


Figure 2: Comparison of the measurement in 5 stages and the measurement after different passes of the polishing rollers

The precision of the skid resistance measurement is quiet good, like it is shown in Figure 3. The three box-plots are the results from measurements after 90.000 passes, 180.000 passes and 270.000 passes on five comparable samples (asphalt slabs made in accordance to EN 12697-33 [3]). After the first 90.000 passes there is still a difference between the samples but after more than 180.000 passes there is no difference.

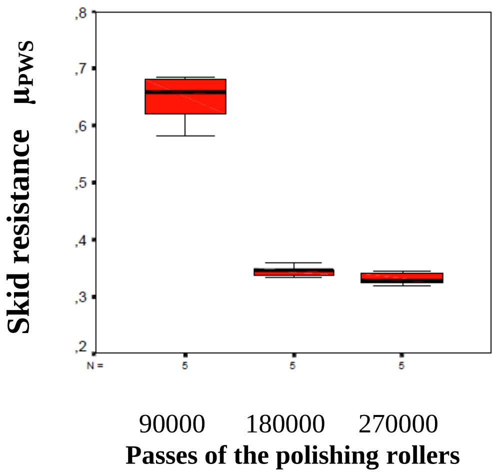


Figure 3: Precision of the test method

3. INVESTIGATIONS [4]

3.1 General

The investigations aimed at the development of a procedure for the investigation of the development of grip using testing equipment in the laboratory for the purpose of skid resistance prediction. Specimens were taken from road sections which had been exposed to traffic for a long period of time and characterised in terms of the condition of their surface. In addition, specimens were produced in the laboratory to enable a laboratory prediction of skid resistance with specimens produced in the laboratory.

3.2 Test Road Sections

In the project three asphalt pavement sections (Table 1) were investigated which gave as large a variation in the level of skid resistance as possible. At the time of core extraction, the sections chosen had been subjected to traffic for a long period of time and largely exhibited even (without large variation due to the measurement method) grip profiles within the regions of core extraction. Cores were extracted from three sections for each site. The same material was used for the first (i.e. inside) and second lanes as well as for the hard shoulder, see Table 1.

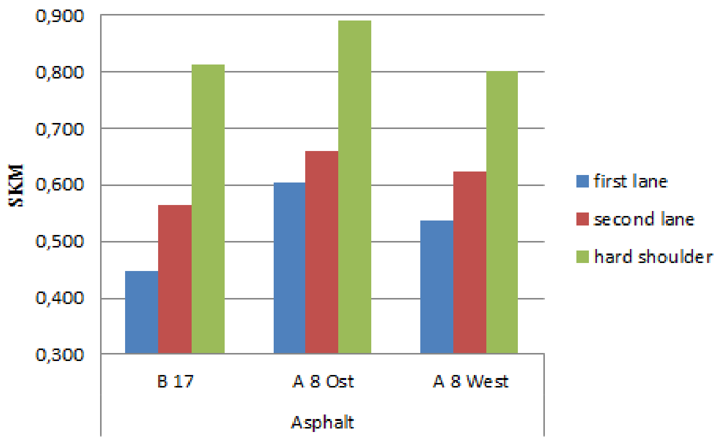
Table 1:Summary of cores extracted to relate laboratory measurements to field conditions

Material/Texture		Road	Core extraction position
Stone mastic asphalt (SMA)	1	BAB A8 Ost near Unterhaching direction Salzburg	Hard shoulder (SS) first lane, right hand tyre track (FS) second lane, right hand tyre track (ÜS)
	2	BAB A8 West near Dachau direction Munich	
Asphalt concrete (AB)	3	B 17 near Königsbrunn direction Landsberg	

3.3 Measuremants with SKM

Before the cores were extracted the skid resistance was measured with the SKM (German SCRIM), see Figures 4 and 5. The results of the SKM measurements (100 m values) are shown in Figure 4.

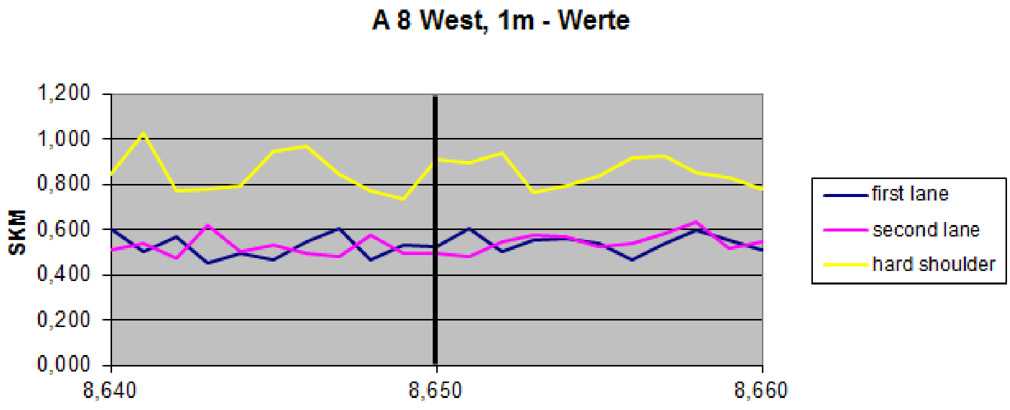
Figure 4: Results of the SKM measurements (100 m values)



Independent of the pavement section, the 100 m (and the 20 m) values were found to be relatively homogeneous. However, the 1 m values exhibit a large degree of scatter (Figure 5). The variation of the 1 m values is, at best, near a μ_{SKM} - value of 0.1 and has a maximum at 0.4. These values apply to a length of 20 m. During the planning phase it was, unknowingly, decided to extract a large number of cores from each road section and lane for the laboratory investigations. In view of the scatter observed with SKM, this decision was absolutely essential. The scatter of the results shows that the results of measurements made at single points to determine skid resistance must be considered critically.

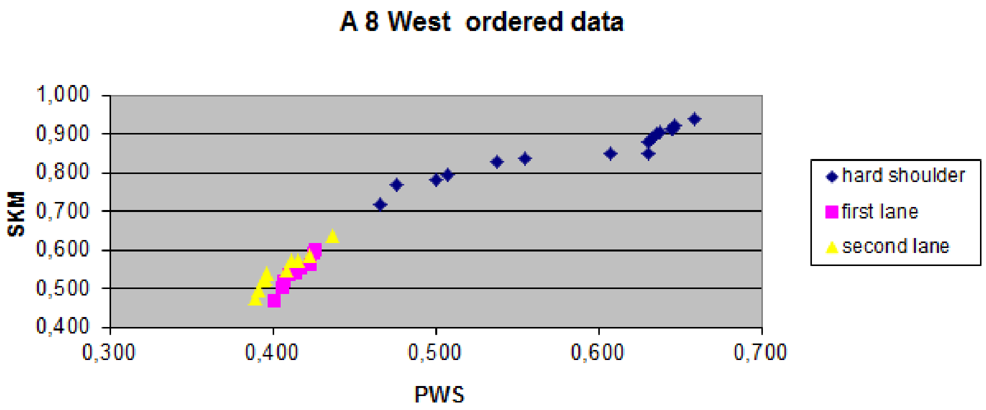
At the time of core extraction, values for the available grip were determined using PWS for all cores with a diameter of 225 mm. At first, the values measured on the cores were compared to the corresponding 1 m values. In this case, there was no correlation between the data at all. However, when the results for the cores and the 1 m values were both ordered separately according to increasing values, a well-defined relationship was apparent for the values measured on the cores and the 1 m values with the SKM, Figure 6. It can be seen in the figure that separate consideration of the individual lanes leads to a better result. This means that the level of grip affects the relationship between the laboratory results and the values measured on the road section.

Figure 5: Results of the SKM measurements (1 m values) on the BAB A 8 West (Stone mastic asphalt)



20 m long section of the road (km 8,640 to km 8,660)

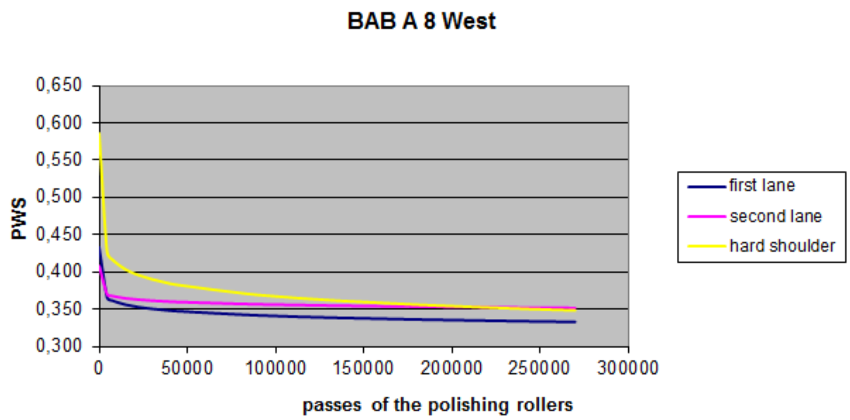
Figure 6: Comparison of PWS measurements on cores with the SKM values (BAB A 8 West, stone mastic asphalt)



3.4 Measurement with Wehner/Schulze on cores

The surfaces of cores taken from the individual sections were also polished after measurement of the grip values in order to determine the subsequent development of skid resistance and, most importantly, the final skid resistance. In Figure 7, the results for BAB A 8 West (asphalt pavement, stone mastic asphalt) are presented as mean values taken over the individual cores for the first and second lanes and the hard shoulder. The measured values are shown as a logarithmic function fitted to the data. The coefficient of determination was 0.76 for the first lane and above 0.99 for the second line and the hard shoulder.
As already shown, the difference in skid resistance (SKM) between the hard shoulder and the first and second lanes is apparent at beginning of the curves. The curves show that no substantial changes in skid resistance of lanes one and two will occur after the initial decrease and that the final skid resistance is effectively reached after 270,000 roller load repetitions (passes). This is also confirmed by the value for the hard shoulder where the final value was the same.
The stone mastic asphalt from the two autobahn sections (BAB A8 East and West) exhibits similar behaviour; the final polish values for both lanes and the hard shoulder are at a similar level. Opposed to this, the hard shoulder and the second lane of the asphalt concrete section (B 17) differ from the first lane where an overall lower level of skid resistance is encountered.

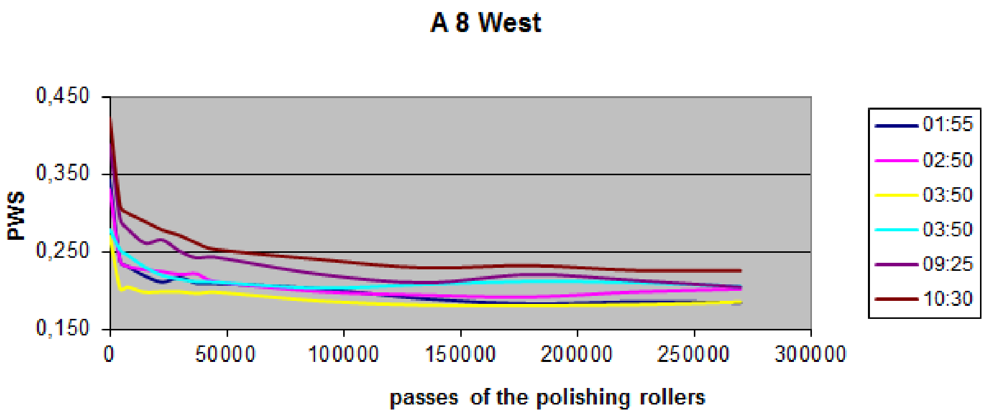
Figure 7: Skid resistance development on cores taken from BAB A 8 West (stone mastic asphalt)



3.5 Measurement with Wehner/Schulze on laboratory specimens

Because the aggregate used in two of the three asphalt pavement sections was still available, it was possible to produce laboratory specimens in the form of slabs with a roller sector compactor in accordance to EN 12697-33. During the preparation of the slabs, sand blasting was carried out only in a controlled sand blasting cabinet. However, the duration of sand blasting varied. The original treatment envisaged, e.g. preparation with solvents, was not carried out owing to negative experience with this method in other projects. The results for the laboratory slabs of the BAB A 8 WEST (stone mastic asphalt) are in Figure 8.

Figure 8: Development of skid resistance on laboratory slabs of the BAB A 8 West (stone mastic asphalt) for different periods of sand blasting (1:55 to 10:30 min)

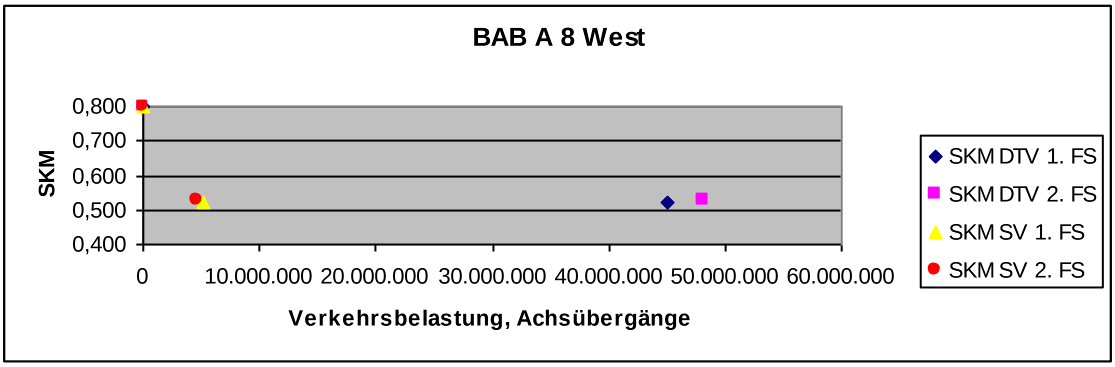


The comparison with the results determined for the cores suggests that sand blasting should last between approximately 3 and 4 minutes. In view of the small number of samples considered, this specification must be confirmed by experience in practice.
On comparing the development of skid resistance of the laboratory specimens with that of the cores, it is conspicuous for both methods that the final skid resistance of the laboratory specimens is below the final skid resistance of the cores. For the laboratory method PWS a pronounced loss of skid resistance occurs particularly at the beginning of the polishing action; the initial skid resistance of the laboratory specimens is below the initial skid resistance of the cores. Nevertheless, comparison of the curves indicates that the above specified duration of sand blasting is within a realistic range. However, on the basis of results for only two test road sections it is not possible to generalise the conclusions made here.

3.6 Inclusion of Traffic Load in Investigations on Skid Resistance Prediction

Since the effect of surface polishing in the laboratory should simulate the action of traffic, the evaluation of the development of the properties during loading in the laboratory must take the real action of the traffic into account. In the further consideration of the results it is assumed that the hard shoulders - neglecting the effect of the environment – reflect the situation at the time when the pavement was opened for traffic. Figure 9 was obtained by plotting the grip values are as a function of the real number of vehicle axle passes. It may be derived from Figure 9 that particularly the polishing action of heavy vehicles (SV) affects skid resistance much more than the normal traffic (DTV).

Figure 9: Skid resistance (SKM) of the BAB A 8 West (stone mastic asphalt) with respect to the number of vehicle axle passes



The investigations with the asphalt specimens always exhibited a very pronounced decrease in skid resistance during the first 10,000 to 30,000 roller load repetitions for both cores and laboratory slabs. This means it is only possible to determine accurately a final skid resistance value. Intermediate values, at for example the time of the expiry of the liability period for claims on defects cannot be specified.

3.7 Non-Contact Surface Measurements

Laboratory measurements were performed with the double triangulation sensor on the surface of cores extracted from the asphalt pavement sections. The characteristic values describing the primary surface properties evaluated from the data could be assigned to the characteristic properties of the surfaces, e.g. the asphalt of a particular lane. In fact, it was found that the characteristic values measured enabled the location of the point of extraction on the pavement surface itself. All in all, the number of non-contact measurements was still not large enough to permit the determination of the actual performance properties from the measured characteristic values.

4. CONCLUSIONS

The investigations made show that with the testing device Wehner/Schulze as described in prEN 12697-49 a prediction of skid resistance is possible with a good precision. It is not only possible to predict the skid resistance for existing roads and to predict their resting livetime, it is also possible to influence the conception of new asphalt mixtures by selecting aggregates for sustainable roads.

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