PREDICTION OF UK SURFACING SKID RESISTANCE USING WEHNER SCHULZE AND PSV

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ABSTRACT

Skid resistance has been the most important property of a surface layer in the UK for many years. It has been provided by the use of aggregate with high polished stone value and mixes designed with high texture. However, in recent years this traditional approach has been subject to investigation and the simplistic relationship between texture depth and polished stone value questioned. The polished stone value test has been found to be a ranking method dependant on the stressing conditions imposed during the tests i.e. vary the stress during testing and different aggregates will react in different ways to achieve a new equilibrium level. The German Wehner Schulze test is now proposed within Europe as a replacement to the polished stone value test. This method subjects either laboratory prepared asphalt samples or cores extracted from the pavement surface to simulated trafficking and measures change in skidding resistance with time. The method has been accepted by German contractors to predict performance of the mix. This paper details an investigation of the Werner Shultz equipment to assess UK asphalt surfacing mixes.

1. INTRODUCTION

The British polished stone value test method (PSV) has been used for many years to measure the polishing properties of aggregate (BS EN 1097-8 2000). Recent studies have found that the method is dependant on the test conditions used (Jellie 2003, Woodward 2003).

With the need to improve prediction of in-service performance a major concern with the PSV test is that it assesses only the 6.3 to 10mm aggregate component of an asphalt mix. In contrast the German Wehner Schulze test (WS) was developed during the 1960's to test asphalt cores and so assess the trafficked textured surface of a graded aggregate and bitumen mix (Huschek, 2004).

This paper summarises the findings of a comparative evaluation of the PSV and WS test methods for a range of UK asphalt mix and aggregate types.

2. The PSV TEST METHOD

The PSV test is probably the most widely used method to assess the polishing characteristics of surfacing aggregate. The method was originally developed in 1940's and became a UK specification requirement in 1976. It is now the European Standard to assess this aggregate property (BS EN 1097-8: 2000).

The test uses single sized aggregate that passes a 10mm sieve and is retained on a 6.3mm sieve. This is deflaked to remove flat and elongate particles. The cubic single sized 10mm particles are used to make curved test specimens. These are mounted on an accelerated polishing machine and subjected to two three-hour stages of simulated polishing.

In the first stage a coarse emery grit is used to initially roughen the aggregate surface and then cause it to become partially polished. In the second stage, a fine emery flour is used to continue polishing the particle surface. After 6 hours, the test specimens are washed and their skid resistance is measured using a pendulum skid resistance tester.

3. THE WEHNER SCHULZE TEST METHOD

The Wehner Schulze (WS) was developed during the 1960's by Wehner and Schulze at the Technical University of Berlin. Most of the 12 WS machines are located in Germany. The WS equipment was developed to assess the aggregate frictional properties of either 225mm diameter cores extracted from actual roads, as cored laboratory prepared slabs of asphalt or made using the aggregate only.

The polishing is done by a rotating head of three rubber covered grooved conical rollers rotating at 500rpm and a water / quartz dust mix. The test is typically stopped after 30,000 rotations i.e. 90,000 roller passes. A friction coefficient is measured using a friction measuring head with three rubber slider feet.

This is rotated to 3000rpm (a tangential speed of 100km/h) water is sprayed onto the test specimen surface and the test head lowered unto the test specimen surface. As the test head decelerates the friction coefficient is measured against speed. The friction coefficient at 60 km/h is reported as the WS value.

4. OTHER TEST METHODS TO SIMULATE POLISHING

In terms of polishing an asphalt surface in the laboratory there are only a limited number of devices available. The National Center for Asphalt Technology (NCAT) developed a slab polishing machine that can assess slabs prepared for the DFT (McDaniel and Coree 2003).

This was further developed by Douglas and Dunn (2005). The NCAT apparatus is essentially similar to the WS apparatus in that three loaded small wheels are used to simulate trafficking. However, the NCAT wheels are pneumatic with the diameter of the trafficked surface designed to allow testing with the DFT.

The Road Test Machine at the University of Ulster (Nicholls 1997) assesses 305 x 305 x 50mm slabs fixed to a rotating table and subjected to trafficking by two loaded car tyres. Changes in skid resistance and texture depth are monitored using the British pendulum tester and sand patch test respectively.

The University of Ulster ULTRA apparatus is a high-speed internal drum machine that is used to assess surfacing material properties such as skid resistance, texture depth, noise generation and rolling resistance.

Wheel-tracking equipment, normally used to assess permanent deformation, has been used to evaluate chip seal embedment and the corresponding affect on texture depth, skid resistance, noise generation and rolling resistance (Yaacob 2006).

The Dynamic Friction Tester (DFT) is a stationary skid resistance tester designed to measure dynamic friction coefficient (ASTM 2003). The measuring principle is similar to the WS and incorporates three rubber pads fitted to a rotating disk 254mm in diameter.

5. EVALUATION OF UK ASPHALT MIXES USING WEHNER SCHULZE

Eleven types of asphalt surfacing mix were assessed using the WS. Most were propriety asphalt surfacing mixes developed under the UK HAPAS product approval scheme. They can be classified in terms of nominal coarse aggregate size i.e. from 20mm to 6mm, by PSV of the aggregate used and by rock type. The mixes were:

- Superhitex14 batched in the laboratory using a gritstone aggregate with a very high PSV of 70, limestone filler and polymer-modified binder.
- Superhitex14 mix batched replacing the crushed rock fines with an animal incinerator ash residue.
- SMA14 made with an andesite aggregate of PSV 60 using 40/60 penetration grade bitumen.
- Superflex14, Superflex10 and Urbanpave6 mixes were plant batched using two different types of aggregate i.e. granite with a PSV 55 and andesite with PSV 60. A limestone filler and polymer modified binder was used for both mixes. An additional 0.2% of cellulose fibres were used in the Urbanpave6 mix using andesite aggregate.
- Hot rolled asphalt contained 30% coarse andesite aggregate with a PSV of 60, sand, limestone filler and 40/60 penetration grade bitumen. Texture for this material is achieved by rolling pre-coated 20mm gritstone chippings of PSV 65

into the material whilst still hot. Samples were made using 0, 7 and 14kgm^2 of coated chippings.

Each material was either batched in a 20 litre Hobart mixer at its specified mix temperature and or reheated and then compacted using a Cooper roller compactor to form test slabs 305 x 305 x 50mm in size. Three slabs were prepared for each mix. After cooling the surface texture of each slab was determined using the 25ml volumetric sand patch method.

The slabs were then assessed using the Wehner Schulze equipment at the Technical University of Berlin with testing stopped periodically and friction coefficient determined. Testing was completed after 180,000 passes.

Figure 1 plots the average change in friction coefficient for the three slabs for each of the 11 asphalt mixes. The data shows a ranking of mixes in terms of friction coefficient. Generally the plots show an initial increase in friction coefficient with maximum values occurring at approximately 20,000 passes.

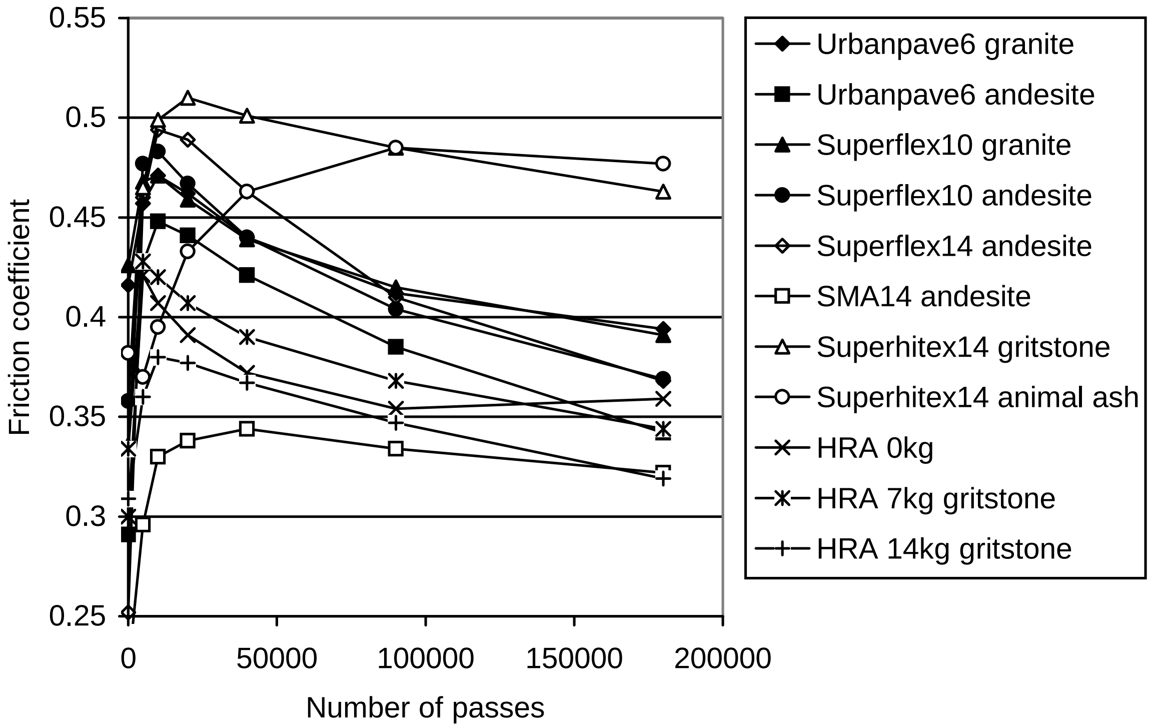

Figure 1 Average WS friction coefficient

This is due to the development of an early life surface roughness or texture on the surface of the coated aggregate particles. After this point friction coefficient tends to decrease as this roughness is worn off the coated aggregate surface and the exposed aggregate starts to polish.

This phenomena is comparable to onsite evaluations where a GripTester has been used to investigate the development of early life skid resistance through to equilibrium conditions (Woodward, 2003).

However, the WS data shows that equilibrium i.e. the value where friction coefficient remains constant, had not been reached after 180,000 passes.

Figure 2 plots WS for the different asphalt mixes against PSV of the aggregate used in the mix. As expected this fails to show a meaningful correlation between the two measures of skid resistance.

The plot suggests a decrease in friction coefficient with increasing PSV from 55 to 65 and then a marked jump for the mix made with PSV 70.

The data clearly shows that correlation of WS and PSV data needs further explanation i.e. there are other variables to consider.

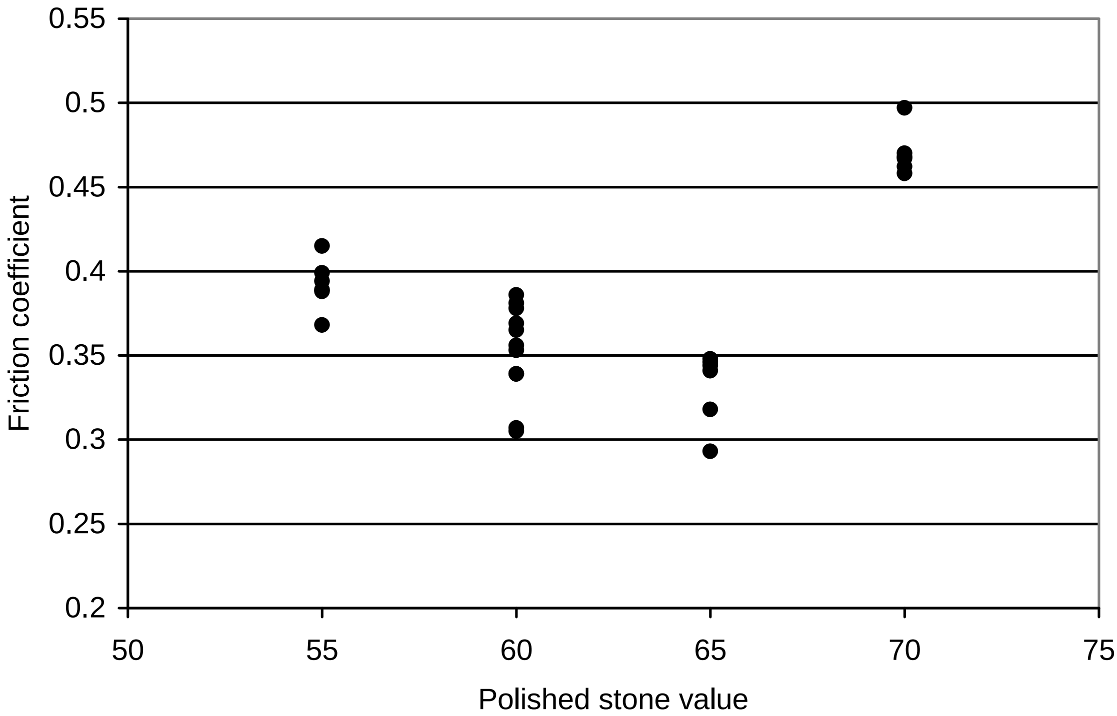

Figure 2 Plot of WS for the asphalt mix against PSV of the aggregate used

Figure 3 plots WS for the asphalt mix against nominal aggregate size in relation to PSV. This initially suggests that in terms of WS the 14mm nominal size provides the greatest WS.

However, the 14mm aggregate mix used the highest PSV aggregate of 70 but with texture depths similar to the small aggregate size mixtures.

The plot shows that granite with the lowest PSV of 55 outperformed the andesite with a greater PSV of 60 for both the 6 and 10mm nominal size mixes.

The plot also shows that the PSV 55 granite used in the 6mm and 10mm nominal sized mixes outperformed the PSV 65 gritstone when used as 20mm sized chips applied to the hot rolled asphalt.

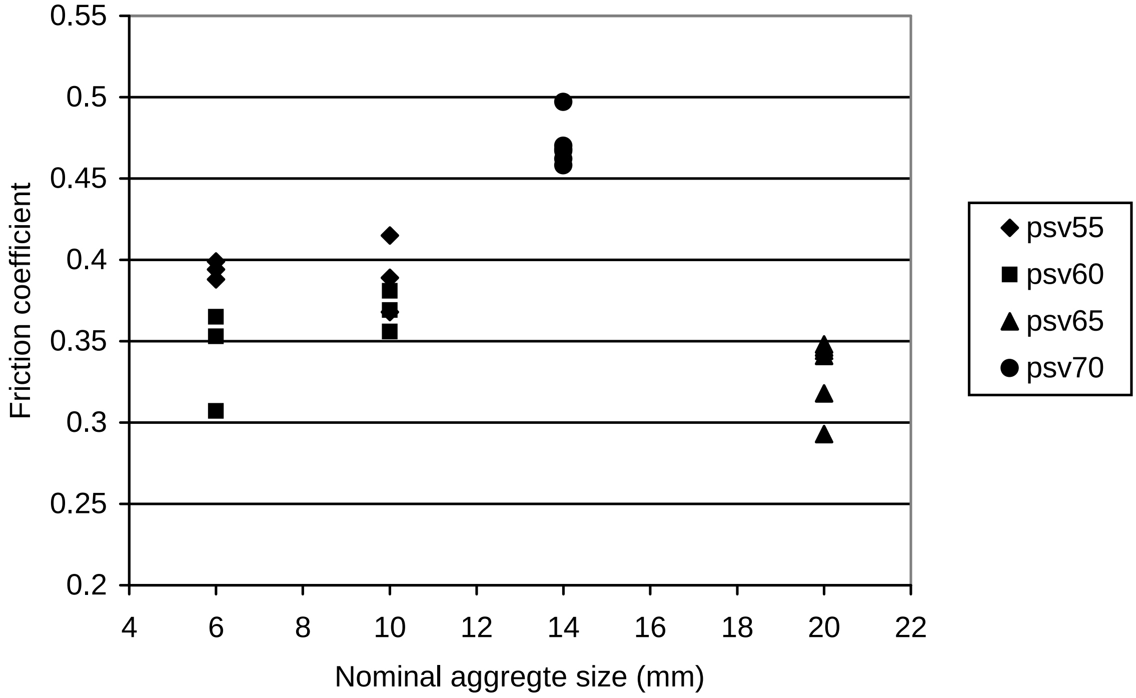

Figure 3 Plot of WS for the asphalt mix against nominal aggregate size in relation to PSV

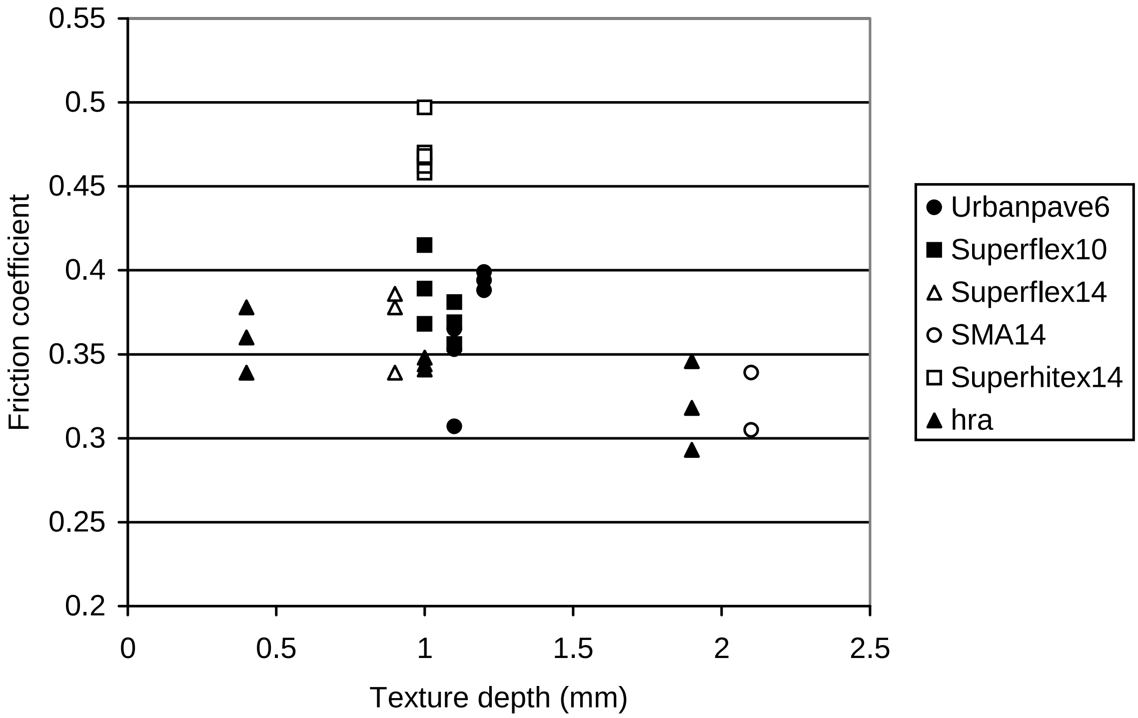

Figure 4 Plot of WS for the asphalt mix against texture depth in relation to mix type

Figure 4 plots WS and texture depth each of the mixes. The plot shows a number of interesting relationships. There is a distinct grouping of the mixes around the 1mm level of texture depth.

This grouping at 1mm texture depth also coincides with the highest values of WS. Additional increases in texture depth has resulted in a decrease in WS for both the high chipped hra mix and the SMA.

The data seems to suggest that increased texture depth results in greater concentration of polishing action to the smaller amount of point contacts within the contact patch of these mixes. This is shown by the hra data were WS friction coefficient decreases with increasing texture depth.

By reducing texture depth and nominal aggregate size it is possible to increase either the number of contact points or increase the area of rubber / tyre contact within the trafficked contact patch.

6. CONCLUSION

This paper reports one of the first investigations between the German Wehner Schulze and PSV test methods for a range of UK asphalt surfacing mixes. The aim was to determine whether the Wehner Schulze test method could improve prediction of skid resistance compared to the PSV test and so provide better understanding of asphalt mix skid resistance.

The best WS friction coefficient data was found for the mix made with the highest PSV 70 aggregate. However, granite mixes made with PSV 55 aggregate out-performed similar andesite types of mix made with PSV 60 aggregate in terms of WS friction coefficient.

The three hot rolled asphalt mixes performed poorly despite the application of PSV 65 20mm chippings. Based on WS it would appear that the increasing use of 20mm chippings to achieve higher values of texture depth resulted in a lowering of WS friction coefficient.

This is an important conclusion as the basis of UK skidding standards was primarily based on the assessment of hot rolled asphalt with 20mm chips. The use of hot rolled asphalt has been substantially replaced by higher stone content mixes of smaller nominal size, lower texture depth and varying degrees of porosity.

The WS data suggests that the skid resistance of hot rolled asphalt is greater when less 20mm chippings is used i.e. a lower texture depth mix or one with a greater fines content exposed to the degree of polishing measurement.

It should be acknowledged that the surface texture of a 20mm hot rolled asphalt is considerably different compared to a thin surfacing or porous material made with smaller nominal sized aggregate.

Based on the various mix combinations evaluated, the WS testing suggests that the optimum texture depth would appear to be 1.0mm with further improvement achieved by decreasing the nominal aggregate size or increasing the PSV of the aggregate used. This contrasts with a value of 1.5 or 1.2mm currently specified in the UK.

In conclusion, the paper shows by assessing the asphalt mix, the Wehner Schulze test is questioning traditional UK assumptions of what contributes towards optimising the skid resistance properties of asphalt surfacing materials.

The data presented reflects only a fraction of the asphalt type / aggregate type / nominal size mix / bitumen type combinations possible in the UK. Further work will be necessary to improve understanding of optimising mix performance.

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