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CHANGES OF SURFACE DRESSING TEXTURE AS RELATED TO TIME AND CHIPPING SIZE

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Abstract: Surface dressing has been a popular maintenance alternative for many years. The in-service performance of surface dressing relates to balancing properties such as skid resistance against changes in time as the aggregate particles embed into the underlying road and react to trafficking. This paper summarises the development of predictive laboratory methods to better understand the inter-relationships between embedment and how performance characteristics such as skid resistance and texture depth change with time. The influence of chipping size is also discussed. The findings of this laboratory based research appear to rank materials according to their in-service performance and should result in more sustainable use of limited high quality materials for road maintenance and constructions purposes.

Keywords: *skid resistance, embedment, surface dressing, aggregate size, maintenance*

1.0 Introduction

Surface dressing is the most widely used road maintenance technique in the UK. In its simplest form it consists of spraying a thin film of binder onto the road surface, followed by the application of a layer of stone chippings. Surface dressing offers considerable potential to meeting the UK government's commitment to promoting sustainability in the environmental, social and economic aspects of its road construction. As the most cost effective option in road maintenance, it becomes the first choice in constructing roads which highlight safety as its main priority. Despite successful use in terms of providing a safer road surface, its use starts to reduce due to public perception that it is noisy. Nowadays, its usage has become less accepted with the development of new types of surfacing such as propriety thin surfacing and micro asphalts which are significantly quieter than the traditional surface dressing.

The conflicts between skid resistance and noise properties of surface dressing are mainly depending on its surface properties which rely on the embedment of the aggregates into the underlying surface with time after being open to traffic. Apart from that, the increase of temperature will also lead to embedment of aggregate into the softer underlying surface. A global warming situation today will certainly create a worse situation where higher temperature will influence the aggregate embedment and result on an unexpected change in skid resistance and noise properties of surface dressing. Highway engineers need to revise the current specifications on surface dressing and look forward to predict the performance of surface dressing in future. Research at University of Ulster in laboratory noise prediction highlighted that smaller stone size in surface dressing can achieve significant noise reduction hence; offering another alternative for resurfacing those materials where excessive embedment would not be an issue i.e. high stone content asphalt surfacing (Woodward *et al.*, 2005)

This paper reports the findings of a research project to study surface dressing performance in terms of its aggregate embedment due to trafficking. It summarises the findings of an investigation into the change in texture depth and skid resistance for a range of smaller chipping sizes embedded into three types of underlying surfaces i.e. soft sand asphalt, 14mm Stone Mastic Asphalt (SMA) and concrete.

2.0 Methodology

2.1 Determination of Underlying Surface Hardness

The different types of surface dressing were applied to three types of underlying test specimen. Two types of test specimen were prepared i.e. slabs with 91mm wide × 305mm long × 40mm thick and cylinder with 150mm diameter wide × 50mm height. The hardness of the underlying test specimen is essential since it influences the rate of spread of binder and chippings. The hardness was determined using a CTRA road-hardness probe (British Carbonization Research Association, 1974). Prior to this test; the specimens were placed in an oven maintained at the desired test temperature. All specimens were kept in the oven for a minimum of five hours to permit uniform temperature distribution throughout the specimens. Each specimen was removed from the oven and immediately subjected to penetration of the steel probe at five different locations. Table 1 shows the hardness level i.e. very soft, normal and very hard for sand asphalt, SMA and concrete based on Road Note 39 (TRL, 2002) guidance.

The following procedure was used to prepare the surface dressed test specimens. The underlying test specimen was heated at 30ºC - this temperature is considered the average temperature of the roads expected at the time of surface dressing operations (Wright, 1980).The area of the underlying test specimen was calculated and the required amount of K1-70 emulsion was applied using a paintbrush. The increase in weight was checked during this stage to ensure the correct binder application rate. Chippings were spread by hand on the specimen surface. Different rates of chipping spread were used depending on their size. Care was taken to obtain a chipping layer with its least dimension in the vertical direction.

Table 1: Hardness of underlying test specimens

Location	Sand asphalt	SMA	Concrete
1	13	5	Nil
2	14	3	Nil
3	15	3	Nil
4	12	5	Nil
5	11	5	Nil
Average	13	4.2	Nil
Type of Hardness	Very soft	Normal	Very Hard

2.2 Preparation of Laboratory Surface Dressed Test Specimens

The test specimens were compacted using a 17kg hand roller compacter with a minimum of 10 passes until the chippings were laid on their least dimension. Each test specimen was kept in an oven at 20^0C for 24 hours to remove the water present in the emulsion. The rate of spread of binder and chippings was in accordance to Road Note 39. The surface dressing test specimens were categorized as having a low traffic level, defined as a 24 hour flow of less than 100 commercial vehicle per lane. Vehicles with an unladen weight in excess of 1.5 tones were classified as commercial vehicles. The hardness category was based on the north category with less than 200m altitude graph. For the sand asphalt and concrete underlying surfaces, the binder rate was decreased and then increased by 30% respectively. It was felt that the richer binder content of the sand asphalt could cause bleeding in the early stages of testing. Increasing by 30% of the binder content helped to avoid chipping loss from the concrete surface. Table 2 gives the rate of spread of binder and the rate of chippings used in the study.

2.3 Simulated Trafficking using a Wheel Tracker

The wheel-tracking test was originally developed to simulate the in-service rutting of asphalt materials. The test involved a slab of material subjected to a rolling wheel load which passes the specimen at a constant temperature under a standard load. In this investigation the wheel-tracker equipment was used to simulate trafficking of a small scale pavement structure and test for chipping embedment into the underlying material over a period of 960 minutes. Testing was periodically stopped and changes in texture depth and dry skid resistance determined. Two types of wheel tracker were used in this type of testing i.e. the standard dry wheel tracker and a modified immersion wheel tracker. The modified immersion wheel tracker was run without water at ambient room temperature and loadings of 20, 25 and 30kg.

Table 2: Rate of spread of binder and chippings

Sample	Rate of binder (L/m^2)	Rate of chipping (kg/m^2)
SA+3SD	1.4+30%less	6
SA+6SD	1.5 + 30% less	7
SA+10SD	1.6 + 30% less	9
SMA+3SD	1.6	6
SMA+6SD	1.7	7
SMA+10SD	1.8	9
CON+3SD	1.6+ 30% more	6
CON+6SD	1.8 + 30% more	7
CON+10SD	2 + 30% more	9

2.3 Texture change due to simulated trafficking

The following procedure was for the dry wheel tracker test equipment. The test specimen was placed in the wheel tracker. The required test temperature was maintained for 12 hours prior to testing. The specimen was run on the wheel tracker for a specified period of time to give the desired number of wheel passes. Texture depth and dry skid resistance was measured. Testing was stopped after a total of 960 minutes. A similar procedure was carried out for the modified immersion wheel track testing with the exception that all testing was carried out at ambient room temperature.

2.4 Measurement of Dry Skid Resistance using the Pendulum Test

The change in dry skid resistance was determined using the pendulum test (BS EN 13036-4, 2003) fitted with a narrow slider of 31.75mm wide. This was to accommodate the 40mm tracking width. A slide length of 76mm was used. All tests were performed in dry condition and result was reported in Pendulum Test Value (PTV)

2.5 Measurement of Texture Depth using a Modified Sand Patch Test

In the standard sand patch test (BS 598-105, 2000); a known volume of sand is spread to form a circular patch. The texture depth of the surface is determined by dividing the volume of sand by the cross sectional area of the sand patch. However, the size of the test specimens being used in this investigation required that a modified version of the sand patch test be developed. Testing found that the volume of sand had to be reduced to 7ml for the slab test samples and 3ml for the circular test samples. A rectangular template with a slot the same tyre width was placed on the tracked surface and the sand was spread along the length of the template. The length of the sand patch was then recorded in three positions, as shown in Figure 1, and used to calculate the value of texture depth. A comparative trial on surface dressed road surface was done using the standard and modified methods. Figure 2 shows good agreement between the two methods with an R^2 value of 0.89.

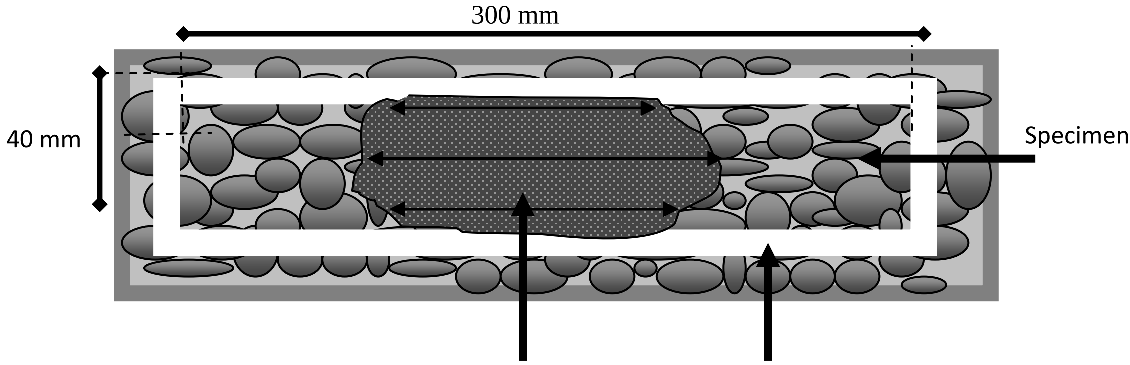

Figure 1: Modified sand patch test for slab test specimens

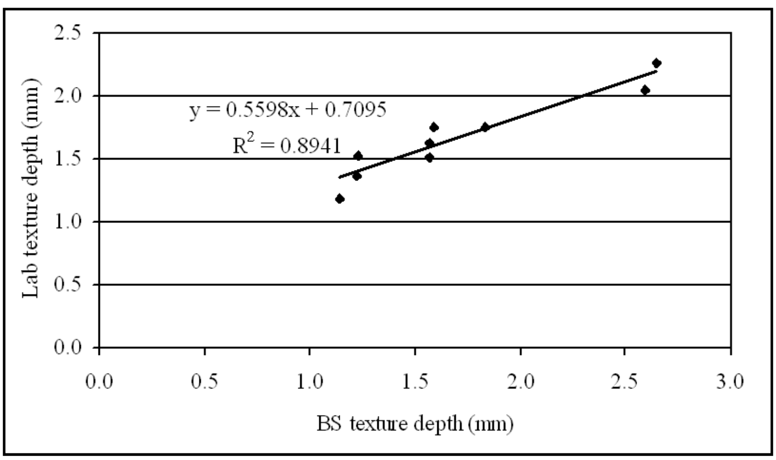

Figure 2: Comparative trials between modified sand patch test and British Standard sand patch test

3.0 Results and Discussion

3.1 The Effect of Tracking Time on Texture Depth

The texture depth data plotted in Figure 3 shows that as tracking time increased texture depth decreased at a gradually rate. Embedment was rapid during the initial stages after which the rate slows down which is expected as the chippings become interlocked. This laboratory data is similar to that found on site by Nicholls and Frankland (1997).

The data can be divided into three stages as shown in Figure 4. The first stage lasts for approximately 1960 passes of wheel tracking, followed by a second stage of between 1950 to 6240 passes. After 6240 passes, the test specimen enters the third stage where the rate of chipping embedment becomes minimal. The rate of texture depth change in stage one is much greater than during the later two stages. Table 3 shows the percentage texture depth change during the three stages of study. More than 50% of the chipping embedment occurred during the first stage. This is similar to what was found on site by Jacobs (1983) who stated that the first stage of embedment represented the first two years of a newly laid surface dressing.

Table 3: Percentage of texture depth reduction during the three stages of measurements.

Surface	Stage 1 (%)	Stage 2 (%)	Stage 3 (%)
SA+3SD+30	33	33	33
SA+6SD+30	67	22	11
SA+10SD+30	50	30	20
SMA+3SD+30	86	14	0
SMA+6SD+30	58	25	17
SMA+10SD+30	50	30	20
CON+3SD+30	60	40	0
CON+6SD+30	69	31	0
CON+10SD+30	73	20	7

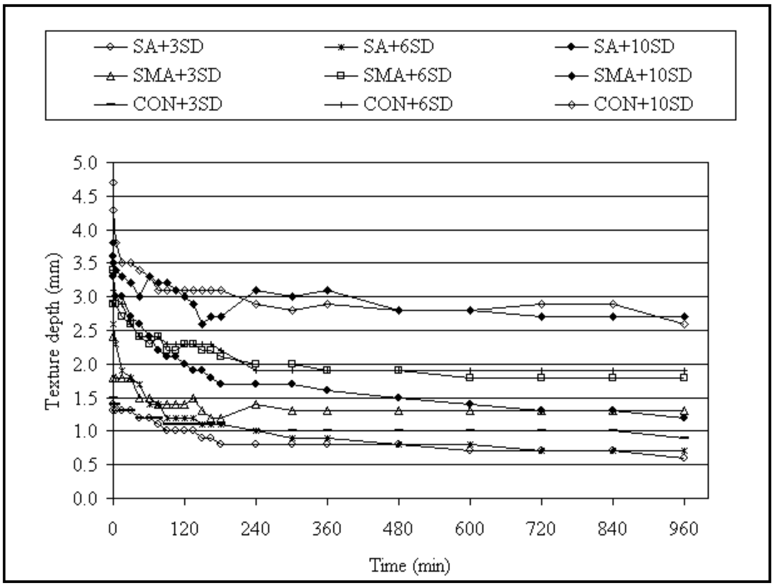

Figure 3: Change of texture depth with time

The first stage can be explained by the combined mechanism of chipping re-orientation, embedment and some abrasion. With continued tracking, the chippings become more stable due to their interlocking position and thus the embedment rate becomes slower, as shown in stage two of Figure 4.

The second stage reflects stable conditions but with continued steady loss of macro texture due to slow embedment and/or abrasion / fragmentation. At this stage, the penetration of chippings could be considered as yielding of the underlying surface under the action of the chipping stress. Previous research has shown that the rate of chipping embedment depends mainly on temperature and load duration (Abdulkareem, 1989). During stage three, the chippings continue to penetrate into the underlying surface. However, the chippings must displace the underlying material causing surface binder and some of the binder in the mix to be squeezed up the sides of the stone chippings leading eventually to bleeding especially for the sand asphalt test samples.

3.2 The effect of tracking time on dry skid resistance

Figure 5 plots the change in dry Pendulum Test Value (PTV) over the 960-minute test duration. This shows that the development of early life dry skid resistance is not as predictable as the decay in texture depth. Rather, there are complex inter-actions as the aggregate particles re-orientate, start to embed and polish during prolonged tracking. In general terms, this appears to cause an initial increase in skid resistance followed by a gradual reduction. Skid resistance attains a maximum value soon after construction, when all the asphalt film on the surface has been worn away and the fresh gritty surface of the aggregate is exposed. With time skid resistance reduces under the action of traffic and environmental factors. This is similar to observations during the measurement of early life skid resistance of asphalt surfacing mixes (Jellie et. al, 2004).

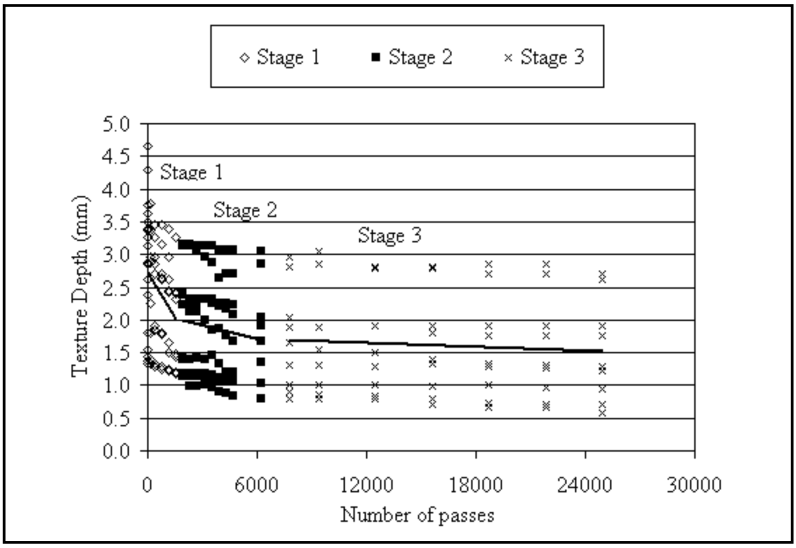

Figure 4: Three stages of texture depth change

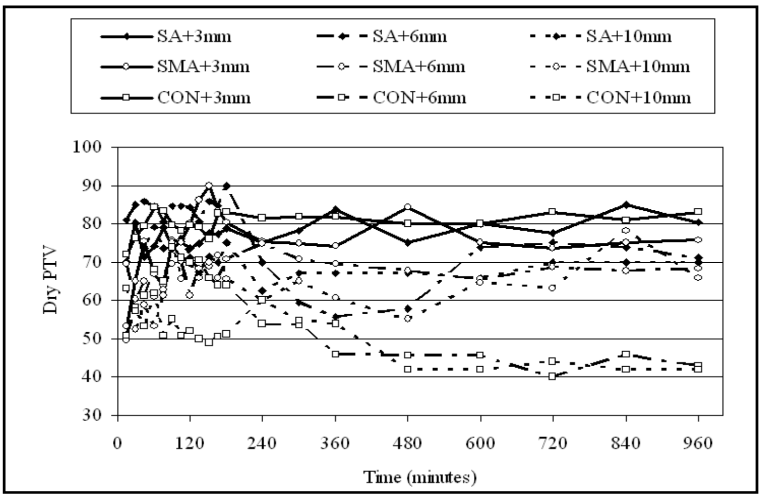

Figure 5 Change in dry PTV with time

3.3 *Effect of Chipping Size on Texture Depth and Skid Resistance*

According to the results in Table 4, the rate of texture depth change was quite similar for all types of specimens in stage 2 and stage 3, but not in stage 1. In stage 1, bigger chippings such as 10mm and 6mm show a slightly higher rate of texture reduction compared to 3mm chippings especially on the soft sand asphalt underlying surfaces. The average least dimension of the 10mm and 6mm chippings are higher than the 3mm chippings resulting in higher texture.

Table 4 Rate of texture depth for different chippings size at different stages

Chippings	Stage 1	Stage 2	Stage 3
SA +3 mm	-0.002	-0.002	-0.000
SMA + 3mm	-0.010	-0.001	-0.000
CON+3mm	-0.005	-0.001	-0.000
SA+6mm	-0.020	-0.002	-0.000
SMA+6mm	-0.013	-0.002	-0.000
CON+6mm	-0.015	-0.003	0.000
SA+10mm	-0.015	-0.004	-0.000
SMA+10mm	-0.008	-0.002	-0.000
CON+10mm	-0.018	-0.002	-0.000

Therefore, the soft sand asphalt has more room to move flow around the 10mm and 6mm chippings and results in increased embedment. In stage two, the effect of chippings size is less important as texture reduction is more dependants on hardness of the underlying surface. In stage three, the texture changes became constant with only major differences in texture depth value due to the differences in chipping size.

In contrast with the texture depth, the smaller aggregate sizes provide higher levels of dry skid resistance. Figure 6 plots the dry skid resistance for three sizes of chipping. This shows that the 3mm chippings maintain 70 to 90 dry PTV throughout the whole 960 minutes of testing. However, a bigger variation occurred for the 6mm and 10mm chippings, especially after 180 minutes of tracking time. The differences were probably due to the larger chippings size that was more sensitive to the different types of underlying surface.

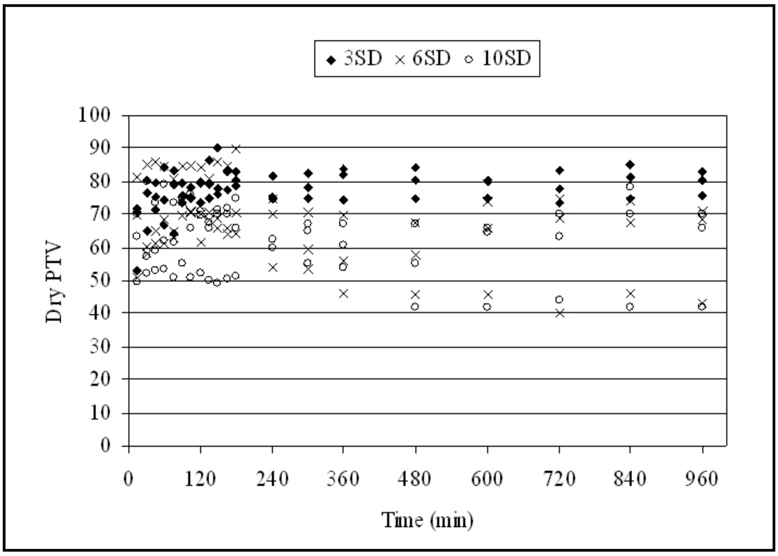

Figure 6. Change in dry PTV due to chipping size on sand asphalt

4.0 Conclusions

The laboratory based investigation has developed a simple method that could rank aggregate size and trafficking time in relation to surface dressing texture changes. Methods were developed using two types of modified wheel tracking equipment. The results indicate similar findings to the surface dressing performance in the field. This study was able to show the texture depth decreased but at a gradually decreasing rate. This change can be distinctively identified at 3 stages namely as stage 1 which is rapid linear decay of texture, stage 2, slow linear decay of texture and stage 3, period of erratic behavior.

In term of chipping size, smaller chippings gave better skid resistance. This is a significant finding as the data tends to suggest a new emphasis towards smaller aggregate sized surface dressings. The skid resistance was also found to be high, initially after construction and started to drop due to the polishing of the gritty surface of the aggregate.

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