Smaller stone size surface dressings for high stone surface mixes

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ABSTRACT

High stone asphalt surfacing mixes are widely used around the world. Although their high stone content has reduced problems with permanent deformation they pose a problem when they become polished and don't meet minimum requirements for safety. It may be possible to overlay with another thin surfacing, remove and recycle or re-texture. Each process has differing merits in terms of sustainability. This paper considers chip seal as an alternative method. Traditionally, chip seal has been viewed as being noisy and has not been considered for use in urban areas where noise is an important factor in the selection of a new surface. Research at University of Ulster in noise prediction highlighted that smaller stone size chip seal surfaces can achieve significant noise reduction so offering an additional alternative for resurfacing. A laboratory study of chip embedment has investigated change in texture depth and skid resistance for a range of chip sizes and asphalt mix types. This has developed laboratory techniques that appear to rank the embedment of chip seal aggregates in relation to underlying road material. This study has shown less embedment for high stone mixes and confirms the findings of limited small stone size chip seal road trials where skid resistance and texture depth was monitored. This paper reports the findings to date.

KEY WORDS

Chip seal, embedment, aggregate, performance, noise, prediction.

1. INTRODUCTION

Surface dressing is one of the oldest and most widely used forms of treatment used in highway surfacing. In its simplest form it involves spraying a coat of bitumen to seal the existing road surface from the ingress of water followed by the application of aggregate to provide a texture surface for wet skid resistance. This simple process has steadily evolved over the years with the use of polymer-modified binders, modifiers and differing applications of aggregate sizes. This has widened its application to increased number of trafficking conditions where it has been proved as a cost-effective, durable and safe surface treatment.

In the UK, Europe and around the world there has been a major change in surface treatments. A growing number of performance expectations now influence the choice of surfacing materials. As well as cost, durability and safety, other properties such as reduced noise, smoother longitudinal profiles and better rolling resistance characteristics are now expected. In the UK, this expectation has resulted in the almost total replacement of hot rolled asphalt (hra) by high stone skeleton mixes such as SMA and proprietary thin surfacing.

Although the high stone content of these types of mix have reduced problems with permanent deformation they will pose a problem when they become polished and fail to meet minimum requirements for safety. It may be possible to overlay with another thin surfacing, remove and recycle or re-texture. This paper considers chip seal as an alternative method.

Traditionally, chip seal has been viewed as being noisy and has not been considered for use in urban areas where noise is an important factor in the selection of a new surface. Noise is now a major factor for all new types of road surfacing. Similar to hra, different types of chip seal form a positive textured surface that typically generate greater noise than smoother or negatively textured newer types of asphalt mix surface. The latest UK guidelines for surface treatment restrict the use of surface dressing as a result.

Research at University of Ulster in laboratory noise prediction highlighted that smaller stone size chip seal surfacings can achieve significant noise reduction so offering an additional alternative for resurfacing those materials where excessive embed ment would not be an issue i.e. high stone content asphalt surfacings.

This paper reports the initial findings of a current research project to study chip seal performance in relation to provision of quieter highway surfacings. 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 base i.e. a soft sand asphalt, 14mm SMA and concrete.

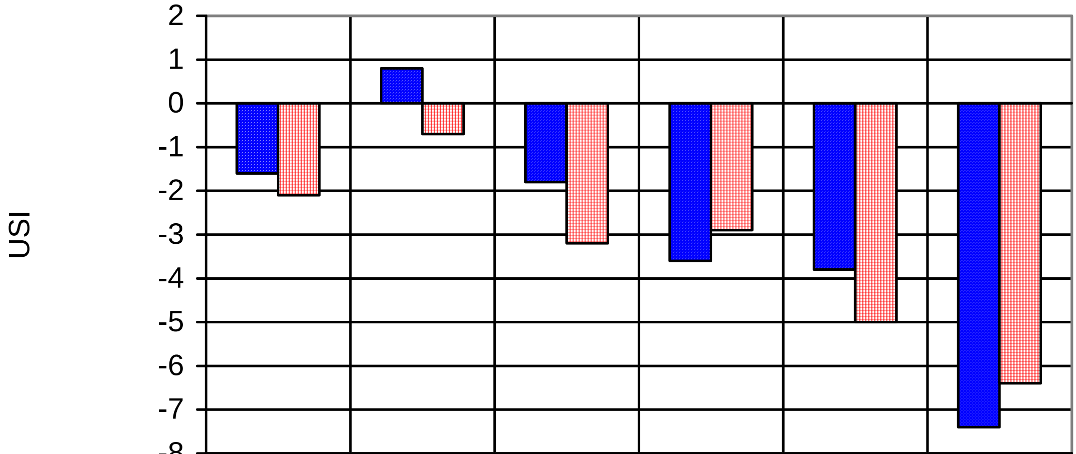
2. DEVELOPMENT OF A LABORATORY TEST TO PREDICT TYRE / ROAD NOISE

Funding by the UK Road Surface Dressing Association (RSDA) allowed an investigation using the ULTRA apparatus at the University of Ulster to determine whether it was possible to rank different types of highway surface in terms of noise generation under laboratory-controlled conditions. The ULTRA test equipment is an internal drum designed to simulate a rolling road surface. .Development of the method is reported by Woodward et. al. (2004, 2005). The resulting USI test does not simulate actual traffic but rather allows calculation of an ULTRA Road Surface Influence (USI) value that may be used to rank each surface and test condition combination.

Latex peels were taken from different types of road surface around the UK. These were used to caste test specimens that were mounted on the internal lip of the ULTRA drum. These were then subjected to a range of conditions including variation in test speed, loading, tyre type with the noise generated at the tyre / test specimen surface measured. The values obtained were then compared to a hra with 2mm of texture depth control surface.

Figure 1 shows an example of the data obtained. With the exception of 50km/h 14/6mm chip seal, all the surfaces shown are quieter than the hra control surface. It also shows that by reducing the aggregate size, it is possible to reduce the noise generated. Figure 2 plots the relationship between USI and texture depth showing that as texture depth is reduced then less noise is generated.

These findings formed the basis of the research presented in this paper i.e. could smaller sized aggregate chip seals be used to produce quieter highway surfacings. Given their small size, embedment due to trafficking and its effect on texture depth and skid resistance was considered the key issue for investigation.



	14mm SMA	14/6mm chip seal	10mm chip seal	10/6mm chip seal	6mm chip seal	Smooth
50km/h	-1.6	0.8	-1.8	-3.6	-3.8	-7.4
100km/h	-2.1	-0.7	-3.2	-2.9	-5	-6.4

Figure 1 USI data for smooth tyre, test speed 50 and 100km/h, load 40kg and tyre pressure 138kpa

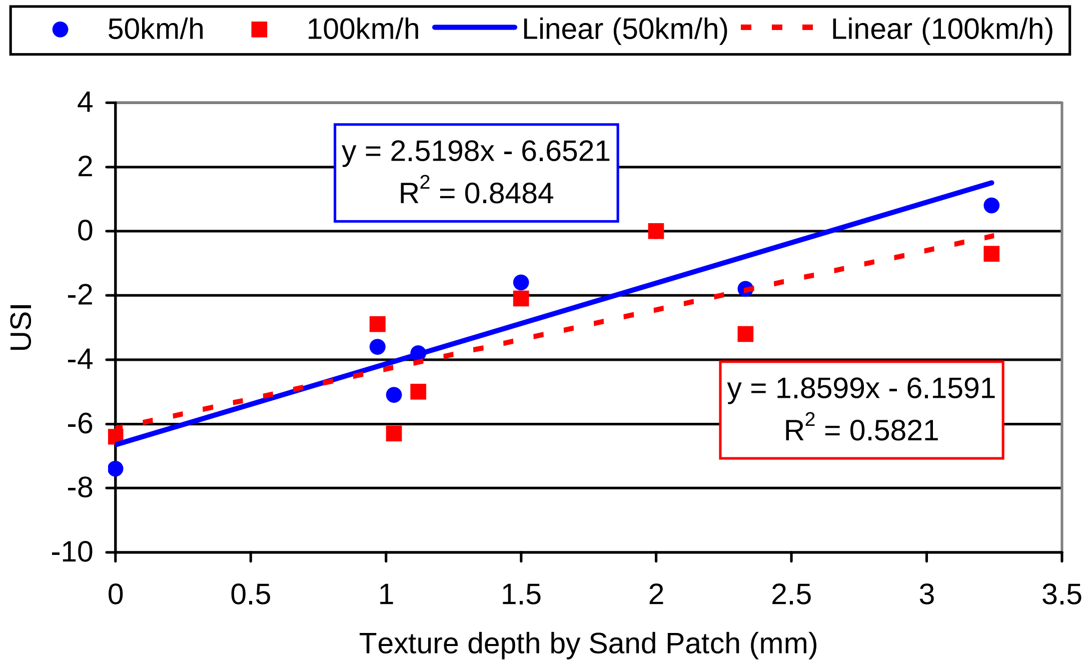


Figure 2 Plot of USI v. texture depth for a smooth tyre

3. CHIP SEAL EMBEDDMENT

Embedment of chip seal aggregate will lead to changes of texture which in turn effect properties such noise generation, skid resistance and rolling resistance. Studies have shown that a certain amount of embedment is necessary to ensure performance and durability. It results from the combined effects of traffic compaction, temperature and hardness of the underlying surface.

Figure 3 shows an example of texture change with time for conventional binders on the M40 High Wycombe by pass (Jacobs, 1983). This found that the decay of texture depth with time is not linear, but rapidly falls off in the first year or two. Figure 2 shows the findings of Nicholls and Frankland (1997) who subdivided the life of a chip seal into 3 main phases:

Phase 1 - rapid decay of texture during which the combined mechanism of chipping re-orientation, embedment and initial abrasion of high-spots occurs until a stable mosaic is formed.

Phase 2 - slow decay of texture during which the chip seal is fairly stable but suffers from a gradual loss of macro texture caused by continued slow embedment, abrasion and fragmentation.

Phase 3 - erratic behaviour during which texture continues to decay but at variable rates followed by possible increase in texture due to fretting i.e. the onset of failure conditions.

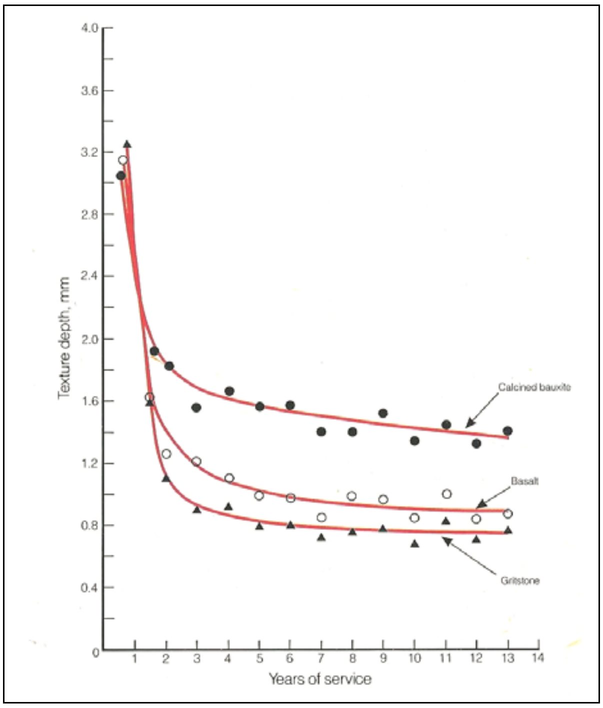


Figure 3 Reduction in texture depth with time (Jacobs, 1983)

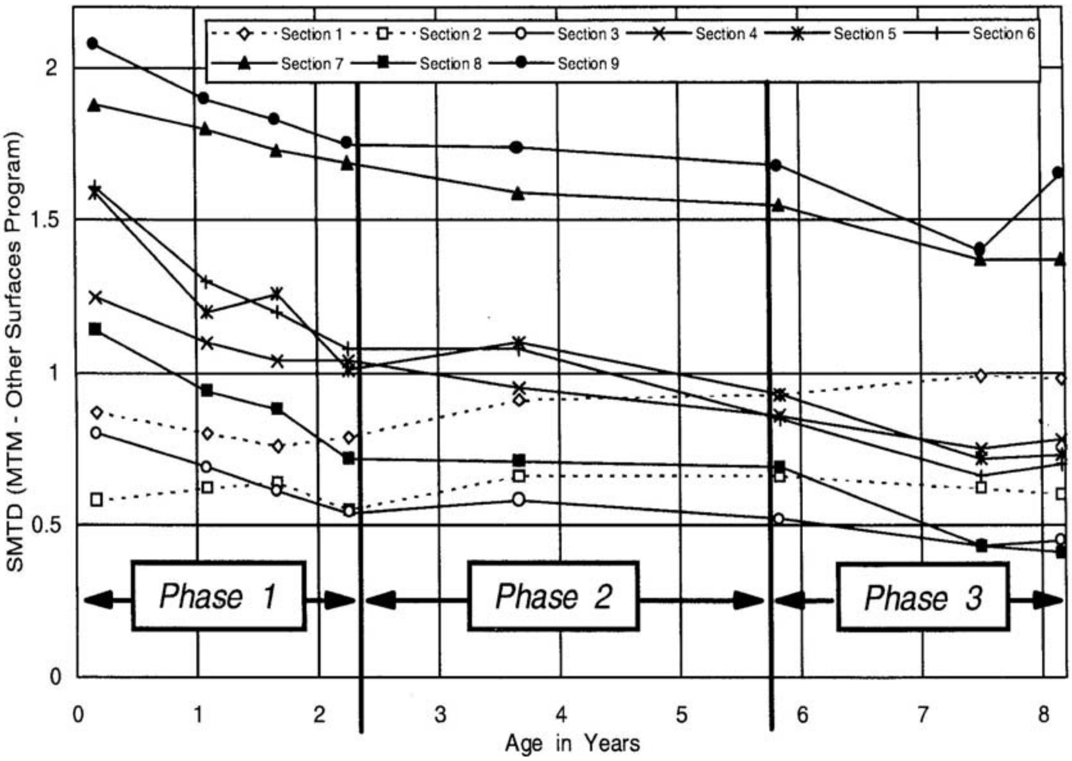


Figure 4 Three phases of chip seal texture depth change with time (Nicholls and Frankland, 1997)

4. DEVELOPMENT OF A LABORATORY METHOD TO CAUSE CHIP SEAL EMBEDDMENT

The research into noise measurement showed that smaller stone size chip seals generated less noise. Previous research such as the examples given in Figures 3 and 4 show the mechanisms of embedment. The research therefore wanted to recreate these found conditions in the laboratory and produce a predictive test method that could be used to design quieter surfacings without risk of premature trial site failures i.e. a predictive method of reduce risk.

Three types of road surface base were selected for investigation i.e. a soft hra sand asphalt mix, a 14mm SMA and a hard concrete. The sand asphalt and concrete represent the two extremes in terms of road hardness with the 14mm SMA typical of a high stone content road surface. Three aggregate sizes were selected i.e. single size 10mm, 6mm and 3mm. These were Silurian greywacke from the same source in Northern Ireland with a PSV of 65. A K1-70 emulsion was used as the binder.

Rectangular test specimens 300mm x 50mm x 50mm were prepared using a roller compactor for the bituminous materials. The concrete test specimens were allowed to cure for 28 days prior to use. The change in hardness of each test specimen was periodically checked using a road hardness probe. Pre-calculated amounts of binder and aggregate were applied to the surface of each test specimen to form the chip seal. After a period of curing, intial values of texture depth using sand patch and skid resistance using the pendulum tester were measured. The narrow slider was used with a slide length of 76mm. A modified immersion wheel track apparatus was used to track each test specimen. The testing reported in this paper was carried out at a standard room temperature of 20 +/- 2^0C. Loadings of 20, 25 and 30kg were used to accelerate embedment. Testing was periodically stopped and changes in texture depth and skid resistance determined. As the tyre of the wheel-tracker was 40mm wide, measurement had to be restricted in width.

This necessitated a modified Sand Patch test to be developed. A template with a slot the same width of the tyre was placed on the tracked surface and a known volume of sand applied. This was carefully extended along the width of the wheel track and its length used to calculate texture depth. Comparative trials on chip sealed road surfaces hasfound good agreement between the two methods. Testing continued to 960 minutes with periodic checks on texture and skid resistance changes.

5. CHIP SEAL EMBEDMENT TEST DATA

Early testing considered the optimisation of test conditions. Figure 5 shows an example of change in texture depth for a sand asphalt base for the three aggregate sizes and loadings. The general trend of the laboratory data is similar to that found onsite as shown in Figures 3 and 4. Figure 5 shows that loading has a small effect on texture reduction with the data clearly ranked depending on aggregate size. Following this intial work, a load of 30kg was used for subsequent testing.

Figure 6, 7 and 8 show the change in texture depth for the three aggregate sizes, using a 30kg loading for sand asphalt, SMA and concrete respectively. Again, the found behaves as expected i.e. greater embedment with the sand asphalt with the SMA performing similar to the concrete. The resulting texture was again related to chipping size.

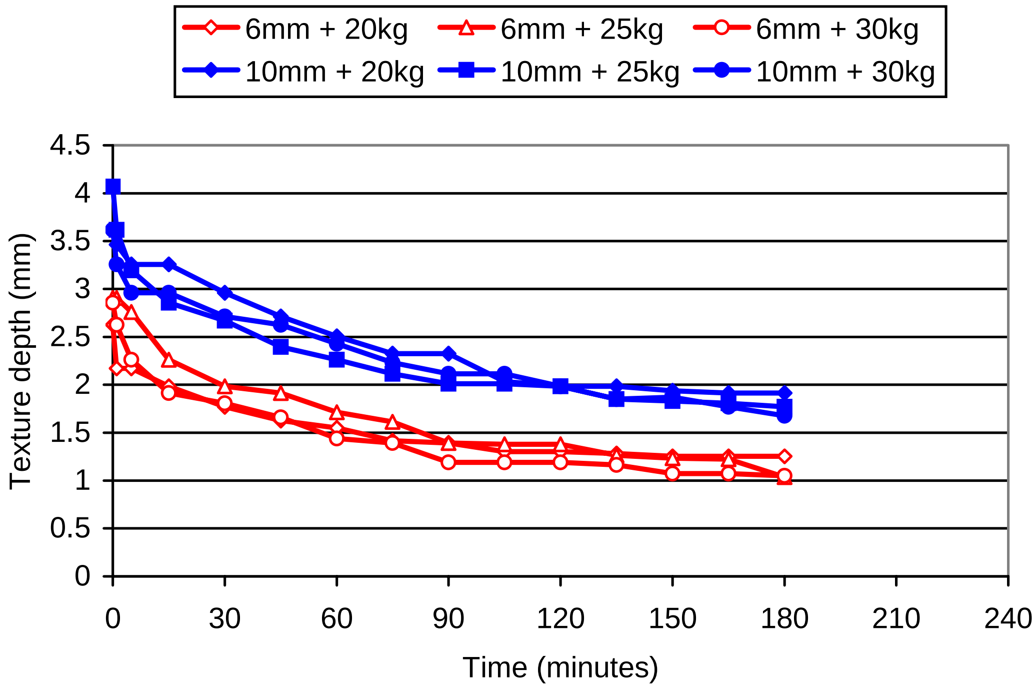


Figure 5 Change in texture depth depending for sand asphalt base

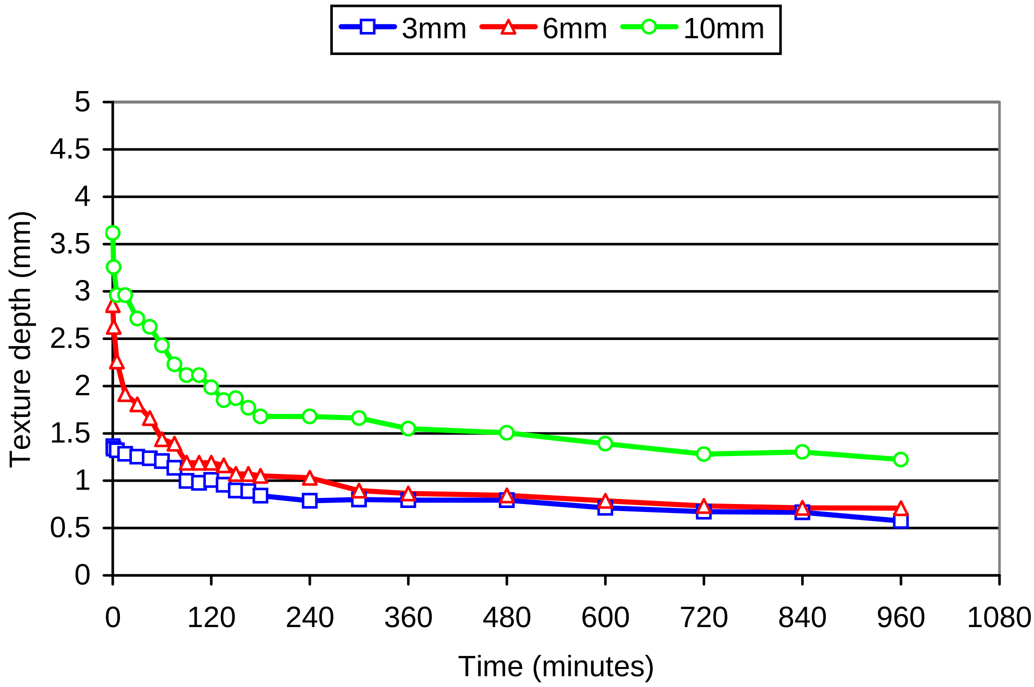


Figure 6 Change in texture depth for sand asphalt base (30kg load)

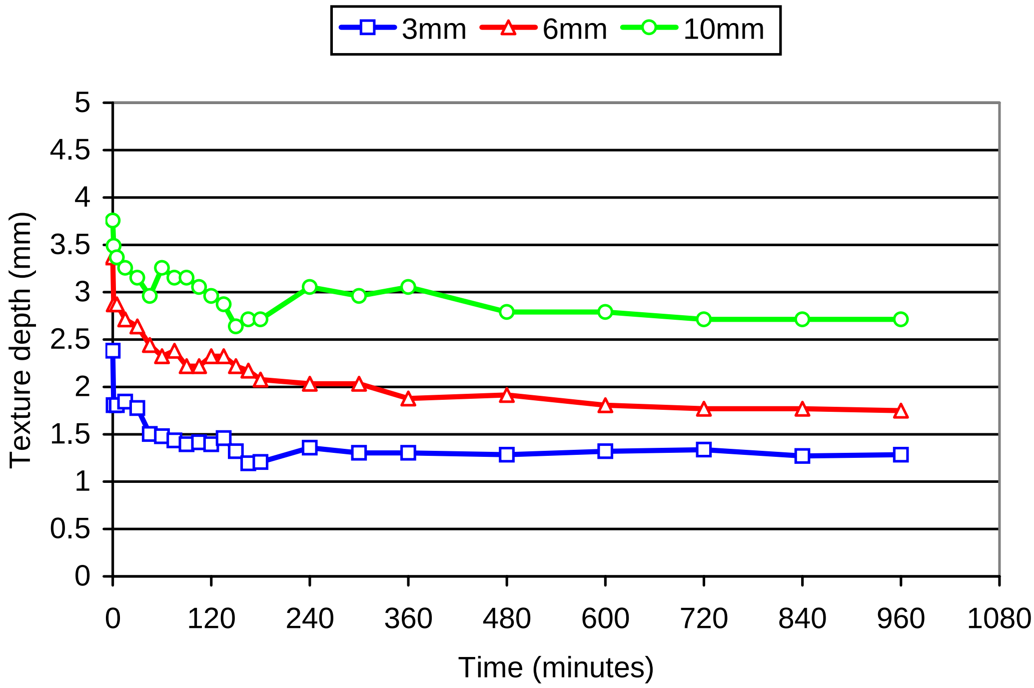


Figure 7 Change in texture depth for SMA base (30kg load)

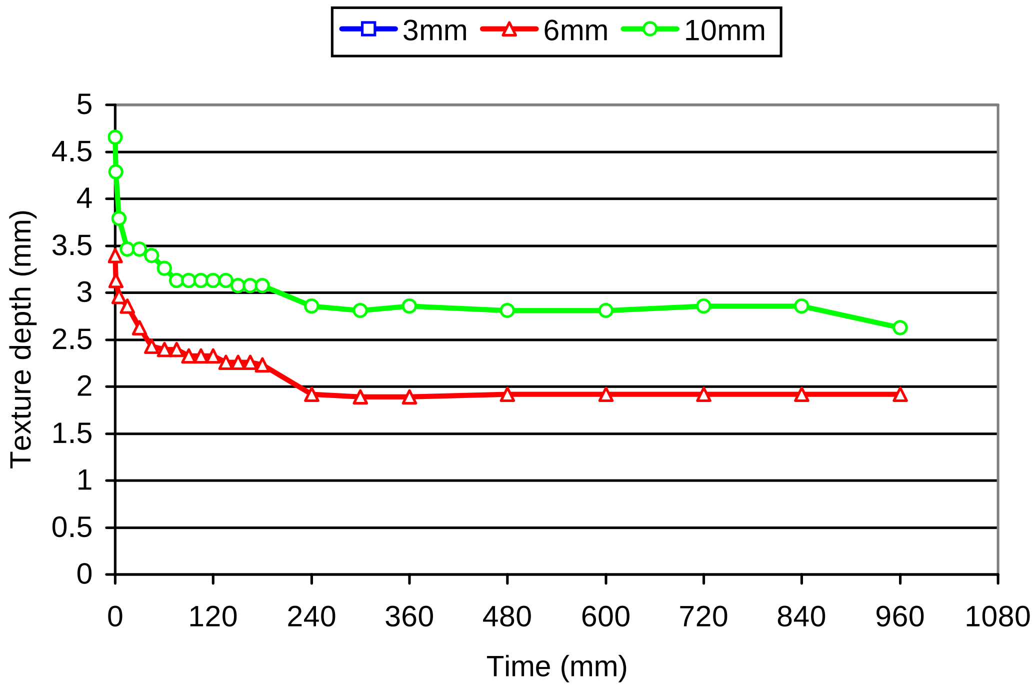


Figure 8 Change in texture depth for concrete base (30kg load)

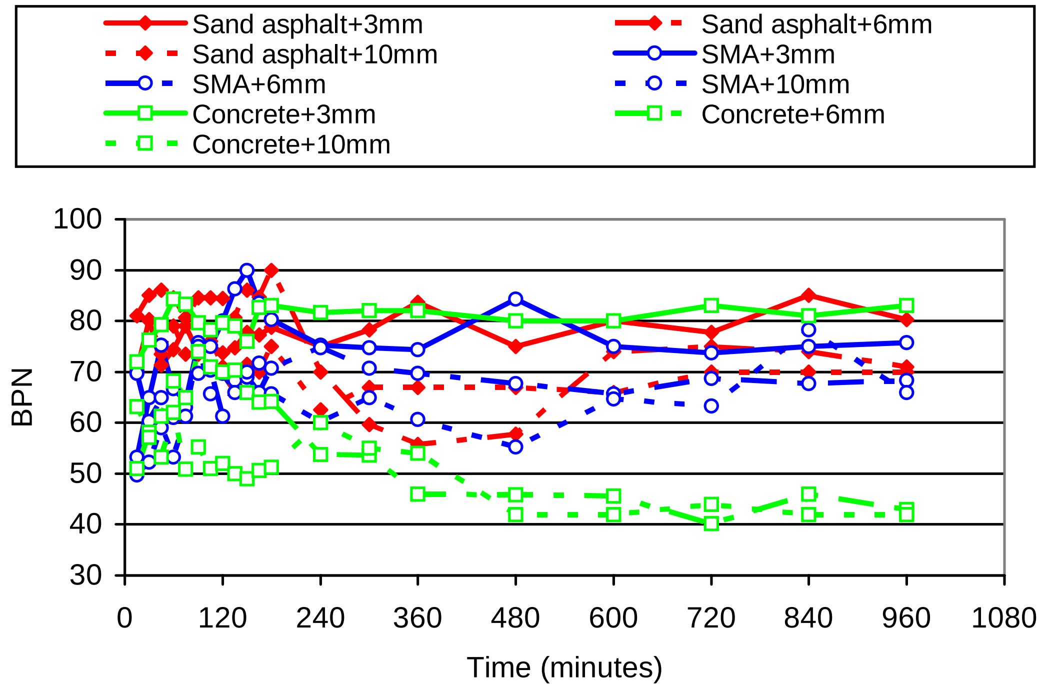


Figure 9 Change in BPN depending on base material and aggregate size

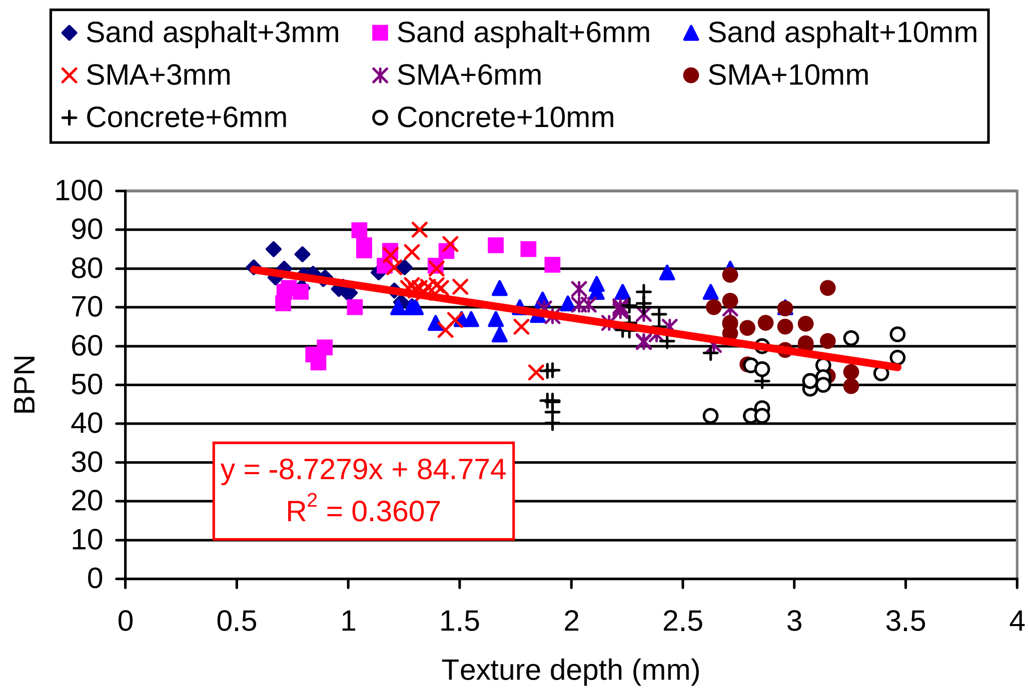


Figure 10 Relationship between BPN and texture depth – all data

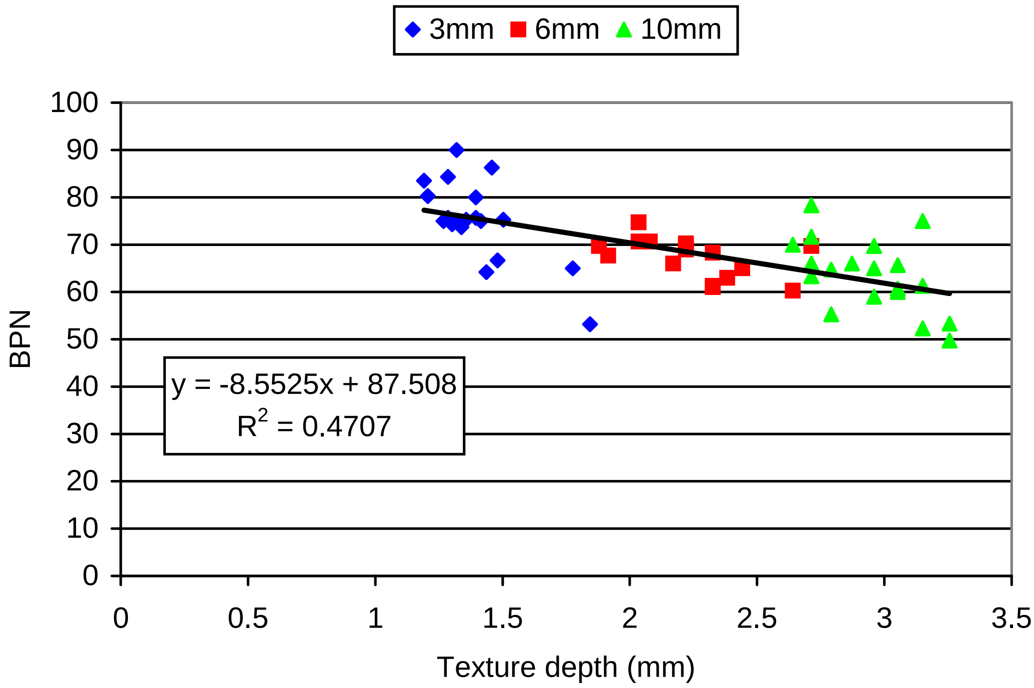


Figure 11 Relationship between BPN, texture depth and aggregate size for a SMA base

Figure 9 plots the change in skid resistance over the 960-minute test duration. This shows that the development of early life 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. This is similar to observations during the measurement of early life skid resistance of asphalt surfacing mixes.

In contrast to texture depth, the smaller aggregate sizes provide higher levels of skid resistance. Figure 10 plots the general trend between skid resistance and texture depth for all the test variables over time. The data shows that skid resistance decreases with increasing texture depth. Again, this general trend hides a complex interaction between embedment, particle re-orientation, polishing and time. Figure 11 shows data for the SMA road base is plotted and illustrates the effect of reducing aggregate size to achieve higher values of skid resistance.

6. CONCLUSIONS

This paper has reported the initial findings of a current research project that aims to determine whether smaller stone size chip seals can be used to re-surface polished high stone asphalt surfacing mixes. Previous research has shown that by reducing the stone particle size, significant noise reduction is possible so offering an additional alternative for resurfacing.

The initial findings of this embedment related laboratory study has shown that the SMA high stone content mix appears to perform similar to the concrete resulting in less embedment. This is a significant finding as the data tends to suggest a new emphasis towards smaller stone sized surface dressings. The data also suggests that it may be possible to achieve greater skid resistance by the use of smaller particle size aggregates.

The laboratory based investigation has developed a simple method that appears to rank chip size, road hardness and trafficking conditions in relation to embedment. The conditions giving less embedment for high stone mixes confirm the findings of limited 6mm small stone size chip seal road trials carried out in the UK. These were laid on a hard hra base and appear to be withstanding heavy trafficking conditions without undue distress.

It is anticipated that the initial research programme be extended to consider the effects of test temperature on embedment. It is anticipated that this will increase embedment for the sand asphalt with the SMA and concrete remaining relatively unaffected. Both the noise data and the embedment data suggest that a 6mm chip seal may offer an optimum for noise and skid resistance properties. It is hoped that full-scale road trials will confirm these findings.

The authors believe that this research may lead to a more sustainable use of aggregate and provision of a safer and quieter highway surfacing technique.

7. REFERENCES

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