IN THIS ISSUE... POROUS ASPHALT ON THE M25; SURFACE DRESSING BINDERS — THE RIGHT APPROACH; MICROsurfACING AS A RAPID AND DURABLE SOLUTION AT A LOW COST; BBA ASSESSMENT OF A COLOURED AGGREGATE; THE USE OF HYDROLOGY IN SURFACE TREATMENTS PLUS... NEWS AND PRODUCT INFORMATION
The BBA assessment of SightGRIP coloured aggregate

Hoben Industrial Minerals has funded what is believed to be the first independent assessment of coloured high friction surfacing to measure colour change in addition to the traditional mechanical properties commonly quoted for such materials.

As with any other material used on the highway, the engineer looks to define the relevant properties of a coloured surface in a non-subjective manner for tenders and specifications – this has been exceptionally difficult with colour retention: its perception is so dependant on the observer and the fact the changes such materials undergo when laid cannot be observed over a short length of time, make trial sites inappropriate as a precursor for projects needing materials in the following months rather than following years.

By establishing a number of laboratory tests to rank the performance of coloured materials, potential equivalents of routinely specified existing tests to predict relative in-service performance for aggregates like the AAV (Aggregate Abrasion Value) and PSV (Polished Stone Value) – might be found to measure potential for in-service colour change. PSV is routinely used to rank materials resistance to polishing but with a complex traffic dependant relationship with in-service performance (as measured using the pendulum, SCRIM or Grit tester). Perhaps the Delta E parameter for overall colour change may end up being a PSV for colour?

At the very least a benchmark level of performance for coloured materials can now be established where nothing exists at present. The Engineer must remember... the long-term performance of coloured materials cannot be predicted by their as-laid appearance!

The BBA assessment report

Hoben Industrial Minerals sought the advice of TRL, the British Board of Agrément (BBA) and the Paint Research Association when considering an appropriate test programme, the valuable advice they received led to the tests being carried out by the BBA as a Product Assessment (using ASTM, BS and TRL tests) with the tests chosen to closely reflect the processes acting upon SightGRIP as-laid.

The BBA Product Assessment compares the relative performance of SightGRIP, a non-SightGRIP red coated calcined bauxite (Product A) and a red coloured high-friction thermoplastic material (Product B). SightGRIP is manufactured by coating a graded calcined bauxite aggregate with a coloured epoxy resin binder. Fig 1 illustrates a typical SightGRIP application.

Colour measurement methods

Colour measurement methods have been used in the pigment industry for many years to measure colour in terms of colour co-ordinates in “colour space” (Fig 2): the industry standard method – (Centre International d’Eclaireage L*A*B method; CIELAB 1976) expresses overall colour change in terms of ΔE (the bigger the value the greater the colour change). This method measures changes in both the base colour and the intensity of that colour and is commonly used for both quality control and performance monitoring. Other earlier methods do exist to measure colour (the XYZ and Yxy methods) these were also used by the BBA to measure the colour in the course of their work should this information be needed at a later date.

Tests Carried out:

Samples of Red SightGRIP, a Non-SightGRIP red coated bauxite (both laid with a proprietary red polyurethane binder and prepared by Hoben Industrial Minerals at the BBA and Colas’s laboratory in Rowfant) and a red coloured high friction thermoplastic (applied by screw box on site by a contractor) were tested for the effects of Scuffing1 and Wear2 (samples prepared on aspalt slabs in accordance with TRL Report 176 15.10.96 Draft). Red SightGRIP was also tested for the effects of freeze-thaw3 and diesel exposure4 (assessed using the Scuffing Test after pre-conditioning).

The Wear Test and the Scuffing Test (along with the diesel and freeze-thaw pre-conditioning) were developed by TRL for subsequent incorporation after further revision into the HAPAS (Highways Authorities Product Approval Scheme) for high-friction systems.

Note: A HAPAS Assessment was not carried out on SightGRIP as Hoben Industrial Minerals Ltd is a manufacturer of high friction and other coloured aggregates (system components) rather than an installer of and/or manufacturer of a complete high-friction system.

A standard UV test (ASTM GS3-90J) and a standard salt spray resistance test (BS 3900: Pt P12) were also carried out on the full range of SightGRIP colours along with samples of Products A & B. Samples for both these tests were prepared on metal plates (150x75mm aluminium for the UV tests and 150x100mm stainless steel for the salt spray). Red coated bauxites (SightGRIP and Product A) were mounted using the proprietary red PU binder, the remaining SightGRIP colours were mounted using the same resin as was used to coat the calcined bauxite.

Scuffing and Wear Tests methods

The Scuffing Test1 (Appendix G TRL Report 176) is a high energy test "which simulates the turning action of traffic and identifies the potential for debonding".

The degree of erosion of the surface (Erosion Index) and the sand patch texture depth before and after the test are used to assess the performance of the high friction surfacing material. For the SightGRIP aggregate assessment, sand patch texture depth, SRF, XYZ Tristimulus/Yxy Colour Space, CIELAB Colour Space and Spectral reflectance graphs were recorded for the control samples and after scuffing.

The resistance to Scuffing after freeze/thaw conditioning (Appendix L TRL Report 176) and exposure to diesel (Appendix M TRL Report 176) was established using freeze/thaw cycling

Fig 1: A23 Priority (Red) Route 1 Wyeccliffe Road South, Purlow. Reproduced by kind permission of The Traffic Director for London.
of the test specimen or exposure of the surface of the test specimen to diesel fuel prior to a standard Stuccing Test.

For the SighthGRIP aggregate assessment, sand patch texture depth and XYZ Tristimulus/Yxy and CIELAB Colour Space and Spectral reflectance graphs were recorded for the control samples then after freeze/thaw conditioning or diesel pre-treatment and finally after stuccing.

The Wear Test2 (Appendix H TRL Report 170) is a low energy test which simulates the long term wear caused by turning traffic. After 100000 cycles of the Wear Test, the Erosion Index, sand patch texture depth (before/after) and the pendulum measured skid–resistance (SRV) (before/after), were used to assess the performance of the high-friction surfacing material. For the SighthGRIP aggregate assessment, sand patch texture depth, SRV and XYZ Tristimulus/Yxy and CIELAB Colour Space and Spectral reflectance graphs were recorded for the control samples and after 10000, 60000 and 100000 wheel passes.

In addition to the effect of freeze/thaw3 and diesel4 on the SighthGRIP (assessed in the Stuccing Test), the effect of UV and Salt exposure on the materials was established.

Additional samples of the other SighthGRIP colours along with samples of the non-SighthGRIP red coated bauxite and the red coloured high friction thermoplastic (prepared at TRL), were submitted for the following tests:

The ASTM G53–96 – Resistance to Accelerated Weathering Test5. This test was carried out “to assess the colour retention properties of the samples after exposure to a combination of UV-A radiation and moisture at an elevated temperature”, the QUVA evacuated tubes selected for the tests have a frequency curve close to that of natural daylight (reducing the likelihood of a false failure using the alternative quicker QUVB–B tubes).

Samples were exposed in a QUVA Weatherometer operated in accordance with ASTM G53–96 and under the following UV–A light/condensation cycle: four hours UV–A light at 45°C followed by four hours condensation at 50°C. Spectrophotometer colour measurements were made after 0, 500, 1000 and 2000 hours total exposure times which correspond to 0, 250, 500, 1000 hours UV–A light exposure times. The measurements included XYZ Tristimulus/Yxy Colour Space, CIELAB colour space and spectral reflectance graphs.

Visual observations were also made after the 2000hr exposure period (1000hrs UV–A light exposure) Photographs were taken after 0, 500, 1000 and 2000 hours exposure.

The BS3900: Part F12 1985(1991) Resistance to neutral salt spray at 35°C Test was carried out “to assess the effect of a five percent neutral salt solution on the colour of the samples tested”. This test is commonly used to assess the durability of anti-corrosion coatings and provided a very severe test of the resistance of the colour coated materials to the action of salts from de-icing processes.

Samples were exposed to salt solution spray at 35°C for 500 hours. Spectrophotometer colour measurements were made after 0, 100 and 500 hours salt spray exposure. The measurements included XYZ Tristimulus/Yxy Colour Space, CIELAB colour space and spectral reflectance graphs.

### Table 1: Test Results: Full results including the other SighthGRIP colours are given in BBA Product Assessment Report 1378

<table>
<thead>
<tr>
<th>Test</th>
<th>Property</th>
<th>SighthGRIP Red Epoxy–Resin Coated Coloured Bauxite</th>
<th>non-SighthGRIP Red coated bauxite</th>
<th>Red coloured high friction thermoplastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRL Scuffing1</td>
<td>EI Δ7</td>
<td>13.0–15.8</td>
<td>22.6–24.4</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>SPD0 (init)</td>
<td>2.1</td>
<td>1.5</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>SPD0 (final)</td>
<td>1.5</td>
<td>1.5</td>
<td>20.0</td>
</tr>
<tr>
<td>TRL Wear2</td>
<td>EI Δ7</td>
<td>12.1–12.5</td>
<td>13.1–13.9</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>SRV (init)</td>
<td>70</td>
<td>78</td>
<td>6.2</td>
</tr>
<tr>
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<td>SPD0 (final)</td>
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</tr>
<tr>
<td></td>
<td>SPD0 (init)</td>
<td>1.3</td>
<td>1.1</td>
<td>6.2</td>
</tr>
<tr>
<td>TRL Freeze–Thaw + Stucc3</td>
<td>EI Δ7</td>
<td>7.1–8.3</td>
<td>14.1–14.0</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>SPD0 (init)</td>
<td>1.7</td>
<td>1.8</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>SPD0 (final)</td>
<td>1.5</td>
<td>1.5</td>
<td>9.8</td>
</tr>
<tr>
<td>TRL Diesel + Stucc4</td>
<td>EI Δ7</td>
<td>11.4–14.0</td>
<td>6.9</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>SPD0 (init)</td>
<td>1.8</td>
<td>2.1</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>SPD0 (final)</td>
<td>1.5</td>
<td>2.1</td>
<td>9.8</td>
</tr>
<tr>
<td>ASTM 1000hrs</td>
<td>EI Δ7</td>
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<td>9.8</td>
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<tr>
<td>QUV–A exposure5</td>
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<tr>
<td>BS 500hrs Salt Spray6</td>
<td>EI Δ7</td>
<td>1.35</td>
<td>2.11</td>
<td>0.99</td>
</tr>
</tbody>
</table>

EI-1st Letter: 0 test – 80 worst, SRV: Skid Resistance Value (6 minimum requirement), SPD0: Sand Patch Texture Depth (mm).
surface in a relatively short time, all materials showed a similar degree of colour change in the Wear test, however the Non-SightGRIP red coated bauxite showed the greatest colour change of any of the materials tested (see Table 1).

Weathering Test Results
(summary) – The action of the UV-A and moisture produced colour change to a varying degree in all samples. Table 1 gives the results. The only red coloured high friction thermoplastic tested showed 30% more UV-A induced colour change than the cold applied Red SightGRIP over the same test duration.

Salt Spray Test Results (summary) – “Exposure to a neutral salt spray solution had no significant effect on any SightGRIP colour evaluated except for a noticeable loss in gloss”. It was thought unlikely that any significant colour change would result from the salt exposure, however the degree of colour change of the non-SightGRIP red coated bauxite with $\Delta E=2.11$ was 50% more than the measured maximum value for all the other materials (maximum $\Delta E$ = 1.38 for Green, $\Delta E$ = 0.22 for Oxide Red).

Observations
The nature of the colour change seen in the Scuffing and Wear tests was one of erosion of the coatings at the point contact between the test tyre and the coarse aggregate particle – a similar degree of colour change was observed for all the materials in the Wear test but the final texture depths varied between the materials tested.

More variation in colour change was seen between the materials in the Scuffing Test but with little difference in terms of final texture depth.

Conditioning of Scuffing Test panels using diesel exposure or repeated freeze–thaw cycles failed to produce detrimental effects on performance of the Red SightGRIP both in terms of colour change and scuffing resistance.

Salt Spray tests showed the non-SightGRIP red coated bauxite to have the least resistance to the effects of salt of any of the materials tested. The red coloured high friction thermoplastic had 30% more Accelerated Weathering (QUV–A) induced colour change than the Red SightGRIP.

Conclusions
The differences in colour change due to the variation in the resistance of the coloured coatings to erosion observed during the Scuffing and Wear tests have been quantified in the colour changes (Delta E) measured by the spectrophotometer.

The reversible nature of the solidification of the red coloured high friction thermoplastic may have led to softening/melting during the high-stress short-duration scuffing test allowing rubber from the test tyre to be picked up by the sample contributing towards the highest colour changes measured in the Scuffing Tests.

The non-SightGRIP red coated bauxite visibly had a greater loss of coating, this resulted in nearly twice the measured colour change in the Scuffing Test seen for the SightGRIP samples. The red coloured high friction thermoplastic also showed more observed and measured colour change in the Scuffing Test but precisely how much of this was due to coating loss could not be established owing to the colour change caused by rubber pick up (see Table 1).

The strength and abrasion resistance of the shoulder–to–shoulder bauxite matrix of the cold applied high-friction surfaces potentially offers a level beyond which further erosion of the surface textured is extremely difficult, the mix of bauxite, other aggregates, and the thermoplastic in the red coloured high friction thermoplastic does not appear to possess this “base–level” which may account for the relatively high loss of texture seen for this material in the Wear Tests.

Colour change as a response to Salt and UV-A exposure resulted from a combination of loss of transparency (chalking) of the coating material entraining the pigments and changes in the pigments themselves – the red coloured high friction thermoplastic showed visual evidence of chalking in the QUV-A tests and this could be measured as a greater Delta E value compared to other non-chalked samples. The Non–SightGRIP red coated bauxite also showed a numerically low but still unexpectedly high value of $\Delta E$ in the Salt spray tests in comparison to the range of values obtained for the other materials tested.

Certain coated bauxite materials obtained from elsewhere in the past have shown an almost total loss of coating when exposed to salt solution, the routine use of a salt exposure test may eliminate the possibility of improving colour retention elsewhere by sacrificing the resistance of the coating to salt.

SightGRIP has also been shown to exceed the minimum levels of SRV (SRV 265) required for classification as a high–friction aggregate. The BBA has confirmed “SightGRIP aggregate may be used as an alternative approved source of calcined bauxite by a HAPAS High Friction System Agreement Certificate holder.”

The tests have shown that the relative performance of an aggregate such as SightGRIP using high quality pigments and applied using a commercially available binder can be measured in the laboratory against others which may be considered as equivalent in terms of as-laid appearance (scrred lines in hot applied materials not withstanding) offering the user a means of comparing as–laid costs with the long term colour performance of the materials under consideration.

The degree of variation seen in the performance of only three materials supports the continuing need for a specification for the minimum properties of coloured high–friction surfaces (potentially based around the tests carried out here) to ensure the material is controlled in a manner commonplace with materials used elsewhere in the highways field.

As the BBA Product Assessment concluded: “At present there are no guidelines or requirements for the colour retention properties of coloured aggregates. In addition there is no correlation between the UV ageing period, under UK climatic conditions, for this type of product”. However the results “…give a reasonable indication of which materials are the most resistant to colour change over any given period and conditions. In practice the loss of colour will depend on specific site conditions including traffic levels and the position of the site.”

The values obtained by the BBA for SightGRIP represent the first laboratory determined numerical representation of the colour retention properties of a road proven product, the extension of this work to provide a national specification for the colour retention of all coloured high–friction aggregates/systems via HAPAS may well require a larger study incorporating site monitoring. The philosophy of basing a specification on measurements made for time–proven products is still a very valid one.

References
1 Transport Research Laboratory (TRL) Report 176 (15.10.96 Draft) Appendix E Simulates the turning action of traffic and assesses the potential for de–bedding.
2 Transport Research Laboratory (TRL) Report 176 (15.10.96 Draft) Appendix H Simulates long term wear caused by turning traffic.
3 Transport Research Laboratory (TRL) Report 176 (15.10.96 Draft) Appendix L 25 x 14–17hrs @ -262°C / seven to eight hours @ room temperature cycles before Scuffing.
4 Transport Research Laboratory (TRL) Report 176 (15.10.96 Draft) Appendix M Surface of sample soaked in diesel for 48 hours before Scuffing.
6 AASTO G639–96 Standard Practice for “Operating Light and Water – Exposure Apparatus (Fluorescent UV-Concentration Test) for Exposure of non–metallic Materials”, 2000 hours exposure as cycles of four hours UV–A light at 45°C followed by four hours condensation at 50°C.
7 $\Delta E_0$ Overall Colour Change CIELAB 1976
Method = determined by spectrophotometer (CIE: Commission Internationale d’Eclairage): the larger the $\Delta E$ the greater the colour change.
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