Trial of Epoxy-Resin/Calcined-Bauxite surface dressing on A1, Sandy, Bedfordshire, 1968

by

J. G. James
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SURFACE DRESSING ON A1, SANDY,
BEDFORDSHIRE, 1968

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TRIAL OF EPOXY-RESIN/CALCINED-BAUXITE SURFACE DRESSING ON A1, SANDY, BEDFORDSHIRE, 1968

ABSTRACT

Increasing use is being made of a surface-dressing process using an epoxy-resin binder and small chippings (2 to 3 mm) of calcined Guyana bauxite. In order to establish if this small size of aggregate is capable of giving good resistance to skidding at high speeds, a length of about 200 m was laid on Trunk Road A1 in October, 1968 and is being tested regularly at speeds up to 130 km/h.

This Report gives details of the installation of the trial area and reports the results up to August 1970. So far very good results at all speeds have been maintained and the condition of the material is still good.

1. INTRODUCTION

The use of epoxy resins as binders for surface dressing was first investigated in the U.S.A. about 15 years ago. For certain special sites, where success with bituminous binders seemed doubtful, epoxy resins were used to bond small-sized aggregates (usually from 1 to 3 mm) to roadways or bridge-decks. The aggregates used in America were usually silica sand or crushed-rock fines, but occasionally naturally occurring emery or expensive synthetic abrasives such as silicon carbide were employed. In the United Kingdom it was shown in trials by the Road Research Laboratory that calcined Guyana bauxite could give unusually good and lasting resistance to skidding.

The technical feasibility of using epoxy-resin/calcined-bauxite surface dressings had been amply proven by the early 1960's and it was suggested that appropriate sites for their use were roundabouts, approaches to traffic lights, road junctions, etc. However, comparatively little commercial work was done in the UK until 1967 because of the high cost of epoxy resins (about £500/Mg) compared with bitumen or tar (about £20/Mg). In that year Hatherly demonstrated the economic viability of the process by showing that at the approaches to very busy junctions in the Greater London area the reduction in accidents following treatment was such that a net economic gain to the community resulted. This work in Greater London provided the industry with the necessary incentive to develop specialized application machinery and resulted in the collaboration of one major epoxy-resin manufacturer with a major road-marking contractor to produce a commercially available system which was publicly launched early in 1968 under the name "Shellgrip".

The laying and performance of a trial length of this material in Bedfordshire is described in this Report.
2. OBJECTIVES OF THE PRESENT TRIAL

Measurements of pendulum skid-resistance made with the portable tester on calcined-bauxite/epoxy-resin surface dressings almost invariably give very high values. The pendulum tester, however, gives a result related to the performance obtained with a vehicle travelling at about 50 km/h; it had been queried whether this type of surfacing, with its relatively small-sized aggregate, would also have a good resistance to skidding at higher speeds. Measurements of Sideway Force Coefficient (SFC) at speeds up to 80 km/h, and measurements of Braking Force Coefficient (BFC) which can be made at still higher speeds, were clearly desirable.

Unfortunately, most of the areas treated with Shellgrip in London were poorly suited to making high-speed test runs, partly because of the high traffic density, partly because of their location at busy road junctions, and partly because of their relatively short length, usually from 40 to 70 m.

One long stretch of Shellgrip was laid on a test-track at Crystal Palace in 1968 as a publicity demonstration for the launching of the material, and the opportunity was taken to obtain BFC measurements there at speeds up to 100 km/h. The results were very satisfactory (ranging from 0.6 to 0.8) but, of course, they only referred to newly-laid material which had carried virtually no traffic. It was decided, therefore, to lay a special 200 m length of the surfacing on a straight stretch of trunk road where high-speed measurements could be made at intervals throughout its life. From this length, results would establish whether the material is capable of maintaining its performance under heavy traffic.

3. THE "SHELLGRI" SYSTEM

The three essential parts of this proprietary system are the aggregate, the binder and the application machinery.

The aggregate consists of 2-3 mm calcined Guyana bauxite of the type used in the original British trials.

The binder consists of an epoxy resin with a suitable hardener, modified by the addition of cut-back bitumen; this cheapens it considerably and also makes it more ductile. The tensile strength on the other hand is considerably reduced by the addition of bitumen and the best balance between tensile strength and ductility is still the subject of trials being conducted jointly by the Greater London Council and the producer. The working range, however, is established sufficiently well to enable the system to be used with confidence. The mechanical properties of the binder, as stated by the manufacturer, are given in an Appendix to this Report.

The binder-application machinery is shown in Plates 1 and 2. It was developed by the contractors in 1968 from a prototype machine which they had assembled for the first large-scale trials for the Greater London Council in 1967. Essentially it comprises two heated tanks containing the binder components, metering pumps which deliver them in precisely equal proportions, a mixing head, and a spray-bar which sprays the binder onto the road in a strip 1.3 m wide. The binder temperature is maintained at about 50°C and the rate of spread at about 1.35 kg/m² (2½ lb/sq yd); both of these figures may be changed slightly according to the prevailing temperature and the texture of the road surface.

The gritting is done in a conventional manner from a separate wheeled hopper (Plate 3). The aggregate is spread to give complete coverage with a slight excess; this excess is removed after the resin has set and before the road is opened to traffic.
4. THE SITE

A suitable site was found on Trunk Road A1 in Bedfordshire at the point where A603 from Bedford to Sandy crosses it. The location of the site is shown in Fig. 1. As can be seen from the map the junction is a staggered one; traffic using the A603 from Bedford has to turn right and travel on the south-bound carriageway of A1 for about 100 yds before turning off again left to Sandy; the opposite applies for west-bound traffic on A603. There are thus two sets of linked traffic lights, one at each of the A603 junctions. The area chosen for the application of Shellgrip in the present trial is a 200 metre length of the south-bound carriageway terminating at the traffic lights at A603.

Traffic lights are not common on A1 and vehicles frequently brake hard when approaching the lights at this junction. Because the site is thus a potentially hazardous one, the Local Authority decided to treat in a similar manner the corresponding 200 m length at the approach to the lights on the north-bound carriageway. This stretch, however, does not form part of the RRL trial.

The existing surfacing at the site was low-stone-content rolled asphalt, seven years old, with a moderately good surface texture (0.7 mm).

5. LAYING DATA

The new Shellgrip spraying machine did not become available for use until the late summer of 1968 and it was then scheduled to be employed fully by the Greater London Council for the remainder of the year. However, circumstances in London caused the Council’s work to be held up for a few days and the contractor’s machinery and crew were diverted to Sandy where work began on Monday 28th October.

Although each 1.3 m wide run of the machine took only a few minutes, the work took three days to complete. This slow progress was due partly to the cool showery weather then prevailing, partly to the comparatively short hours of daylight, and partly to the complications in organization caused by the weaving pattern of traffic at the site.

No elaborate preparation of the existing road surface was made apart from sweeping away any obvious dirt and masking off the white lines with specially-cut strips of roofing felt. The temperature of the binder was kept within 2 degrees of 50°C throughout the work. The proportions of the two components of the binder were kept equal, with a tolerance of ± 3 per cent. The ambient temperature varied between 10°C and 18°C, usually with a strong cool breeze, and the setting time of the binder was subjectively judged to be generally between 3 and 4 hours.

The aggregate was all supplied dried, in paper bags loaded on pallets, and was stored under tarpaulins until required.

No difficulties with uneven coverage of binder or aggregate were noted.

6. RESISTANCE TO SKIDDING OVER THE FIRST TWO YEARS

The Sideway Force Coefficient (SFC) and the Braking Force Coefficient (BFC) have been measured each year at various speeds. No measurements of SFC were made in 1968 because the test section was not laid until the autumn but one set of BFC measurements was obtained in October. Both SFC and BFC measurements were made in May, July and September 1969, and in April, June, and August 1970. The SFC was
measured at 50 km/h and 80 km/h. The BFC was measured at 50, 80 and 130 km/h. The results are
given in full in Table 1 and the “mean summer values” have been plotted graphically in Figs. 2 and 3.

6.1 SFC results at 50 km/h and 80 km/h (Fig. 2)

The standard criterion of resistance to skidding is the Sideway Force Coefficient (SFC). The SFC
results obtained at Sandy are very good. As could be expected, the left-hand lane has polished more than
the right-hand lane, the results at 80 km/h are lower than those at 50 km/h, and there is a slight downward
trend overall from 1969 to 1970. Nevertheless, no result lower than 0.7 has so far been obtained in the
left-hand lane, while the right-hand lane still gives values over 0.8.

These values reflect the high Polished Stone Value (PSV) of calcined bauxite and it is known from
measurements on other roads where this aggregate has been used that, as long as it remains intact and bonded
to the road, good SFC results will continue to be achieved for many years. For instance, on Tower Bridge,
where 4 mm calcined bauxite and epoxy resin were used in 1962, the mean summer value of SFC at 50 km/h
was still 0.67 in 1970. On A30 at Blackbushe where 9 mm and 12 mm calcined-bauxite chippings were used
in bituminous surface dressings and in rolled asphalt in 1962, the mean summer value of SFC at 50 km/h
has never fallen below 0.70.

6.2 BFC results at 50 km/h and 80 km/h (Fig. 3)

The main purpose of this trial was to study the performance of Shellgrip at high speeds and for
this reason BFC measurements (which can be made at speeds up to 130 km/h) were obtained as well as
SFC measurements. BFC values are about 20 per cent lower than SFC values.

Considering first the BFC values obtained at 50 km/h and 80 km/h only, it can be seen that the
overall pattern of results is very similar to that obtained with the SFC results. The left-hand lane gives lower
results than the right-hand lane, the results at 80 km/h are lower than those at 50 km/h and there is a slight
drop from 1969 to 1970. Exceptionally high results were obtained in 1968 when the material was new and
the drop from 1968 to 1969 was large but normal; from now on it is expected that there will be only a very
slow fall and that this will be largely masked by seasonal variations.

6.3 BFC results at 130 km/h (Fig. 3)

Although the skidding resistance decreased as speed increased from 50 km/h to 80 km/h there was
no further fall from 80 km/h to 130 km/h; on the contrary there was a slight rise. This effect has often been
observed with conventional surfacing materials at other sites and is always associated with a good depth of
surface texture, usually of the order of 1 mm or more as measured by the sand-patch test.

6.4 Texture-depth measurements

The texture-depth of Shellgrip at Sandy and at several other sites has been measured. It has an
initial texture of about 1.5 mm which falls to about 1.0 mm in the first few months, as traffic removes the
most lightly-held particles of aggregate, but thereafter changes little. Despite the relatively small size of
the aggregate it does not become submerged because of the non-thermoplastic nature of the epoxy-resin
binder.

6.5 Longitudinal variation

Hatherly found in his study of London road-junctions that there is always a detectable area of
very highly polished road corresponding with the area of maximum braking and/or turning and it is
possible, using results from the pendulum skid-resistance tester, to plot iso-skid-resistance “contours”.
It is to be expected therefore that there would be variation along the 200 m length of Shellgrip at Sandy
i.e. a lowering of value as each set of traffic lights is approached.
In Fig 4 the SFC values at 80 km/h have been plotted at 10 m intervals and it can be seen that there is a general downward trend from about 0.8 to about 0.7 towards the lights. There is an unexpected rise in the area immediately next to the lights but this may reflect a last-minute relaxation of braking effort.

7. INTERIM CONCLUSIONS

It is concluded that surfacings of the Shellgrip type are quite adequate for high-speed roads. Excellent resistance to skidding at speeds up to 130 km/h can be obtained with a surface dressing using 3 mm Guyana calcined bauxite providing a non-thermoplastic binder with good adhesive properties, such as an epoxy resin, is employed.

Although the results obtained in the present trial cover a period of only two years, results from low-speed testing on older surfacings indicate that good results will probably continue to be obtained for a further two years at least.

However, in considering uses for this type of process, it must be borne in mind that the initial cost is currently relatively high (£1.25 - £2.00/m²). The economic viability of the process will depend on the skidding accident risk and the possible inadequacy of a conventional treatment at the site in question.

8. ACKNOWLEDGEMENTS

Acknowledgement is made to the Divisional Road Engineer (Eastern Division) and to the County Surveyor of Bedfordshire for their help in providing the site and organising the work. Acknowledgement is also made to the County Police for their assistance in controlling traffic during the work and during subsequent site measurements. This Report was produced in the Materials Section of the Construction Division.

9. REFERENCES

1. JAMES, J. G. Epoxy resins as binders for road and bridge surfacings, Rds & Rd Constr. 1963, 41 (488), 236-43.


3. JAMES, J. G. Calcined bauxite and other artificial, polish-resistant roadstones, RRL Report LR 84, Crowthorne, 1967 (Road Research Laboratory).


Table 1

Results of BFC and SFC tests on Shellgrip; A.I. Sandy, Bedfordshire

All values are the means of two, three, or four runs.

<table>
<thead>
<tr>
<th>Date of test</th>
<th>Braking Force Coefficient</th>
<th>Sideway Force Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 km/h</td>
<td>80 km/h</td>
</tr>
<tr>
<td>1968 October</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.H.Lane</td>
<td>0.74</td>
<td>0.69</td>
</tr>
<tr>
<td>R.H.Lane</td>
<td>0.77</td>
<td>0.76</td>
</tr>
<tr>
<td>1969 May</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.H.Lane</td>
<td>0.61</td>
<td>0.49</td>
</tr>
<tr>
<td>R.H.Lane</td>
<td>0.68</td>
<td>0.56</td>
</tr>
<tr>
<td>July</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.H.Lane</td>
<td>0.58</td>
<td>0.55</td>
</tr>
<tr>
<td>R.H.Lane</td>
<td>0.66</td>
<td>0.60</td>
</tr>
<tr>
<td>September</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.H.Lane</td>
<td>0.63</td>
<td>0.56</td>
</tr>
<tr>
<td>R.H.Lane</td>
<td>0.70</td>
<td>0.60</td>
</tr>
<tr>
<td>MEAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.H.Lane</td>
<td>0.61</td>
<td>0.53</td>
</tr>
<tr>
<td>R.H.Lane</td>
<td>0.68</td>
<td>0.59</td>
</tr>
<tr>
<td>1970 April</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.H.Lane</td>
<td>0.57</td>
<td>0.47</td>
</tr>
<tr>
<td>R.H.Lane</td>
<td>0.61</td>
<td>0.54</td>
</tr>
<tr>
<td>June</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.H.Lane</td>
<td>0.57</td>
<td>0.47</td>
</tr>
<tr>
<td>R.H.Lane</td>
<td>0.61</td>
<td>0.54</td>
</tr>
<tr>
<td>August</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.H.Lane</td>
<td>0.65</td>
<td>0.58</td>
</tr>
<tr>
<td>R.H.Lane</td>
<td>0.71</td>
<td>0.63</td>
</tr>
<tr>
<td>MEAN</td>
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<td></td>
</tr>
<tr>
<td>L.H.Lane</td>
<td>0.61</td>
<td>0.52</td>
</tr>
<tr>
<td>R.H.Lane</td>
<td>0.66</td>
<td>0.58</td>
</tr>
</tbody>
</table>
10. APPENDIX 1

Typical mechanical properties of the Shellgrip binder as given by the manufacturer

**PROPERTIES**

Tensile properties (ASTM D 638, D 412)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cured 7 days in air at 25°C</td>
<td>120 kg/cm²</td>
</tr>
<tr>
<td>Tensile strength at 25°C</td>
<td></td>
</tr>
<tr>
<td>Elongation at break at 25°C</td>
<td>50 %</td>
</tr>
<tr>
<td>Tensile strength at 0°C</td>
<td>340 kg/cm²</td>
</tr>
<tr>
<td>Elongation at break at 0°C</td>
<td>12 %</td>
</tr>
<tr>
<td>Elastic modulus at break N/m²x10⁶</td>
<td></td>
</tr>
<tr>
<td>Cured 7 days in air at 25°C</td>
<td>20</td>
</tr>
</tbody>
</table>

Gel time, 60-g sample

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>15°C</td>
</tr>
<tr>
<td>Initial</td>
<td>25°C</td>
</tr>
<tr>
<td>Initial</td>
<td>35°C</td>
</tr>
<tr>
<td>Initial</td>
<td>45°C</td>
</tr>
</tbody>
</table>

Bond strength to various substrates

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Value (kg/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry concrete</td>
<td>10</td>
</tr>
<tr>
<td>Dry concrete, acid etched</td>
<td>* 20</td>
</tr>
<tr>
<td>Wet concrete</td>
<td>2</td>
</tr>
<tr>
<td>Dry asphalt</td>
<td>* 12</td>
</tr>
<tr>
<td>Wet asphalt</td>
<td>1</td>
</tr>
</tbody>
</table>

* rupture occurred within substrate

Graph showing typical curing times
Fig. 1 LOCATION OF SHELLGRIp TRIAL ON TRUNK ROAD
A1., SANDY, BEDFORDSHIRE
Fig. 2. RESULTS OF SFC MEASUREMENTS ON SHELLGRIP SURFACING ON A1 AT SANDY, BEDFORDSHIRE
Fig. 3. RESULTS OF BFC MEASUREMENTS ON SHELLGRIP SURFACING ON A1 AT SANDY, BEDFORDSHIRE
Fig. 4. VARIATION OF SFC AT 80 km/h ALONG THE NEAR-SIDE WHEELTRACK OF THE LEFT-HAND LANE OF THE SHELLGRIP TEST SECTION ON A1 AT SANDY, BEDFORDSHIRE

Mean results of three tests in May, July and September 1969
PLATE 1  Spraying 'Shellgrip' at Sandy, Bedfordshire, October, 1968
PLATE 2 Close-up of spraying in progress  (This photograph and that in Plate 3 were not taken at Sandy but during night-work in London. However the machine and details are identical)
ABSTRACT

Trial of epoxy-resin/calcined-bauxite surface dressing on A1, Sandy, Bedfordshire, 1968:
J. G. JAMES: Department of the Environment, RRL Report LR 381: Crowthorne, 1971 (Road Research Laboratory). Increasing use is being made of a surface-dressing process using an epoxy-resin binder and small chippings (2 to 3 mm) of calcined Guyana bauxite. In order to establish if this small size of aggregate is capable of giving good resistance to skidding at high speeds, a length of about 200 m was laid on Trunk Road A1 in October, 1968 and is being tested regularly at speeds up to 130 km/h.

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