Cost Benefits

Construction project: Pavements - Roads, Car Parks etc.

Application:

Product:

Material: Recycled asphalt
   Pulverized-fuel ash

Region: West Midlands

Title: The re-use of asphalt arisings with secondary material on the A52 Staffordshire, Stoke to Ashbourne

Financial: A direct cost saving of 24% was achieved in comparison with a conventional construction comprising granular sub-base and bituminous base. This saving amounted to approximately £16,000. It is worthy of note that the execution of these works was prior to the introduction of the Aggregate Levy.

Date: July and August 1997

Background

In May 1997 Staffordshire County Council invited tenders for the reconstruction of the A52 at Kingsley Bank, midway between Stoke and Ashbourne. Tilcon (South) Limited (now Tarmac Central Limited) were awarded the contract and commenced work on site in July 1997.

The works comprised the reconstruction of approximately 1 km of single carriageway ascending Kingsley Bank using Granulated Fly Ash (GFA). Steep gradients of up to 12.5% were present and the existing surface indicated structural failure, in particular on the ascent side. The road and surrounding area is geologically unstable and prone to slips. Investigation revealed significant distress in the existing bituminous layers but a relatively sound and strong formation. This was probably the result of the large numbers of heavy goods vehicles (HGVs) using the road, in the most part delivering quarry products from a number of nearby limestone quarries to the pottery towns and beyond.

In accordance with their policy on recycling and the use of local industrial by-products, Staffordshire County Council decided to recycle the existing bituminous layers with lime and pulverized-fuel ash from the local power station at Rugeley, to form the new sub-base and base for the road. The contract required the removal of the existing pavement and its replacement with a two 150 mm layer of GFA sub-base and base, 70 mm of macadam binder course and 30 mm of stone mastic asphalt surface course. Provision was also made for the removal of unsuitable material below formation level, kerbing to the total length of the works, installation of road gulleys and associated pipe laying and footway construction.

Bruce Cook Road Planing Limited were awarded a sub-contract to plane the existing surface (comprising, bituminous materials with a small amount of granular material underlying it) and to haul the arisings to a nearby Council owned depot. Here the arisings were processed by crushing and screening into coarse and fine fractions and then recombined using a continuous pug mill mixer with pulverized-fuel ash and lime to provide the GFA. Roadstone Recycling Limited, a joint venture established by Bruce Cook and Tarmac Heavy Building Materials, carried out these tasks. The mixed materials were returned to site and laid in two equal 150 mm layers using conventional paving equipment.
Cost Benefits

Direct savings

The following tables show the actual costs of the production of GFA on site together with the costs that would have been incurred for a conventional construction. No allowance is made either for the cost of the arisings (the cost of planings) nor has any notional value been attached to them. The reasons for this are that the planing would have taken place anyway and at the time the ‘value’ of planings in the area were at best equal to the cost of their delivery to the next user. A cost of haulage for the arisings to the process site is included though it could be said that this, or a greater cost would also have incurred in disposal of the arisings in a conventional scenario.

<table>
<thead>
<tr>
<th>GFA component cost</th>
<th>Cost (£/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobilization of equipment</td>
<td>2.80</td>
</tr>
<tr>
<td>Haulage of arisings to process site</td>
<td>3.00</td>
</tr>
<tr>
<td>Process arisings</td>
<td>2.10</td>
</tr>
<tr>
<td>Mixing cost</td>
<td>5.75</td>
</tr>
<tr>
<td>PFA including wastage allowance (12% addition)</td>
<td>0.85</td>
</tr>
<tr>
<td>Lime including wastage allowance (3% addition)</td>
<td>2.70</td>
</tr>
<tr>
<td>Haulage of GFA to site</td>
<td>3.50</td>
</tr>
<tr>
<td>Wastage allowance</td>
<td>0.65</td>
</tr>
<tr>
<td>Total</td>
<td>21.35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>‘Conventional’ component cost</th>
<th>Cost (£/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1 Granular sub-base material</td>
<td>12.40</td>
</tr>
<tr>
<td>Dense bitumen macadam roadbase</td>
<td>43.50</td>
</tr>
<tr>
<td>Total per m³</td>
<td>55.90</td>
</tr>
<tr>
<td>150 mm Sub-base</td>
<td>1.86</td>
</tr>
<tr>
<td>150 mm Base (Roadbase)</td>
<td>6.52</td>
</tr>
<tr>
<td>Total per m2</td>
<td>8.38</td>
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<tr>
<td>Composite cost</td>
<td>27.93</td>
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</tbody>
</table>

The above tables illustrates a direct cost saving of approaching 24% of the GFA pavement compared to a conventional design in this contract amounted to £15,800

Any future use of this material will deliver outputs in excess of those achieved in this project. Selling prices of primary materials have increased considerably since the time of execution of the works, sub-base prices rising by around 80% and bituminous products by around 60% (Autumn 2003). Input costs for GFA remain similar to those shown in this study, the only substantial increase being in the value of planings that has risen to probably £2.00/tonne at the point of arising. If this project were repeated now savings could be expected to amount to around 40% as opposed to the 24% achieved in 1997. In addition, far more options now exist in respect of re-use of arisings into new bituminous material production and consequently the 75% saving in consumption of primary materials could easily rise to 85% or more with all the attendant benefits.

Indirect savings

- Operational savings due to the ability to produce and stockpile the material prior to use and thereby reducing time spent waiting for materials to be delivered;
- It is estimated that productivity of the paving operation increased by over 20%;
Cost Benefits

- Savings in time and fuel consumption resultant of the planing arisings being re-used rather than disposed of to sundry locations;
- Other savings that can’t be valued but nonetheless are real result from the characteristics of GFA in comparison to Bituminous Base and primarily, related to end product quality. GFA can be laid, compacted and then re-worked if needed. Deficiencies in compaction can be rectified at any time and incorrect levels can be addressed and rectified at basically nil cost as material can be added or removed at any time. These characteristics also result in the virtual elimination of any waste such as that arising from joint trimming etc.

Costs

- The client incurred additional cost in trials, testing and specification development; however these can legitimately be considered as ‘one offs’ and to have no relevance in any ongoing use of the material;
- Site operations incurred no additional costs save for trial mixes but even then the materials produced were used in the works for the replacement of unsuitable material below formation level.

Indirect benefits

- 75% reduction in the use of primary materials compared to a conventional design;
- The location of the works was unusual in that it was in the vicinity of at least 3 major limestone quarries and therefore the reduction in vehicle movements/haul distance was not significant. Such circumstances are exceptional and in any other location substantial additional reductions in transport movements and associated emissions would be made;
- It was proved that the technology is sound, immediately traffickable, the material practical in use and in fact easier to use than conventional types encouraging the consumption of significant amounts of pulverized-fuel ash of which there are substantial stocks nationwide;
- All planings were reused in the GFA for the pavement or to reinstate soft spots in the subgrade, thus there was no disposal material to landfill;
- The use of GFA reduced the primary material content by reducing overall pavement import from effectively 400 mm to 100 mm and the asphalt import from 250 mm to 100 mm;
- GFA for basecourses is a cold-mix product, therefore there are energy saving benefits compared to hot-mix basecourses;
- Since GFA does not require curing periods, subsequent operations can proceed immediately.

Lessons learned

GFA is a slow hardening mixture which behaves as a very stable unbound material in the short-term but which hardens in the medium to long-term to produce a material with the structural properties of a bound material. GFA was chosen by Staffordshire County Council for its laying flexibility, immediate stability under traffic and development of significant stiffness and strength. These attributes were necessary because access to the site was only possible from either end of the site. Thus any paving material had to be capable of immediate use as well as being able to accommodate the future heavy slow moving in-service traffic, including quarry lorries.

The execution of the works was extremely successful. The weather during the GFA operations was variable. This necessitated tight control of moisture content particularly in the stockpiles. On two occasions, over-wet GFA was laid. This was rectified by ‘opening-up’ the laid GFA using a toothed JCB bucket. This allowed excess water to evaporate and permitted compaction later. This ‘opening-up’ was possible up to 3 days after mixing, after which setting and hardening commenced. Such rectification would not be possible with conventional asphalt or cement-bound materials.
Technical data

The project consisted of the various phases:

- The removal, by planing, of a 400 mm depth of existing pavement and transfer to a Staffordshire County Council depot 8 km from the site;
- Processing the planings into two recycled asphalt gradings, 20 to 5 mm and <5 mm;
- Blending and mixing the two recycled asphalt gradings with pulverized-fuel ash and lime in a continuous pug-mill mixer to produce GFA;
- Transportation of the GFA to site;
- Laying and compaction of the 150 mm GFA sub-base layer by paver and compaction by vibrating and pneumatic tyred rollers, the latter to produce a good finish to the layer and to check the ability of the layer to support immediate trafficking;
- Laying and compaction of the 150 mm GFA base layer by paver and compaction by vibrating and pneumatic tyred rollers;
- Surfacing with 100 mm 2-course surfacing consisting of stone mastic asphalt surface course on dense bitumen macadam binder course.

Based on a formation CBR of 15% and channelled in-service traffic of 8 million standard axles, the pavement design for the job was as follows:

- 30 mm Stone Mastic Asphalt surface course;
- 70 mm Dense Bitumen Madacam 100 binder course;
- 150 mm GFA base;
- 150 mm GFA sub-base.

Specification

The specified mixture proportions for the job on a dry basis were 3% lime, 12% pulverized-fuel ash and 85% recycled asphalt. This mixture was necessary to meet the Staffordshire County Council specification developed by John Kennedy for GFA which required a T2 performance (ultimate NAT stiffness between 10 & 25 GPa, ultimate tensile strength greater than 0.65 MPa). The following Specifications were used in the project:

- GFA – Staffordshire County Council Particular Specification
- Macadam binder course – BS 4987
- Stone mastic asphalt – Highways Agency Guidance and Staffordshire County Council Particular requirements
- Specification for Highways Works – works in general

The GFA specification and pavement design was developed for Staffordshire County Council by John Kennedy

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