Cost Benefits

Construction project: Pavements - Roads, Car Parks etc.

Application: Hydraulically bound sub-base

Product: Fly ash bound material

Material: Pulverized-fuel ash

Region: South East

Title: The use of Pulverized-fuel ash as a binder for the A259 Ramsgate Harbour approach road in Kent

Financial: Through the use of the secondary binding material there was a reported direct saving of £50,000 compared to the use of conventional materials.

Date: October 1999 - February 2000

Background

The project involved the construction of a 1.4 km stretch of single carriageway on the A259 Ramsgate Harbour approach road in Kent. The construction was commissioned by Kent County Council and involved a joint construction arrangement between Taylor Woodrow and Perforex. Of the 1.4 km construction project 50% of this took place within a tunnel.

Granular Fly Ash (GFA) was used as a direct replacement for both Type 1 Granular sub-base material and bituminous base layers. (GFA) is a mixture of crushed graded aggregate with lime and Pulverized-fuel ash, which act as a binder. GFA is produced with sufficient moisture to enable compaction with a roller, in a similar way to cement bound materials. In total 4,300 tonnes of roadbase was laid using granite aggregate incorporating an average of 10% Pulverized-fuel ash with lime activator. The roadbase was a 170 mm thick layer of GFA in place of a hot mix asphalt layer 120 mm thick. The majority of Pulverized-fuel ash used was acquired from the Didcot Power Station and was supplemented with ash from other sources throughout the project.

Two mixes were used in the road construction. One mix contained 90% granite aggregate, 8.5% Pulverized-fuel ash and 1.5% lime and was used for initial production during October. A second mix was then used for the rest of the project which contained 87% aggregate, 11% Pulverized-fuel ash and 2% lime. The higher binder content was used in the winter to provide a higher early strength for construction traffic.

Direct savings

Through the design of the pavement using GFA a total direct saving of around £50,000 was made on direct materials cost.

<table>
<thead>
<tr>
<th>Application</th>
<th>Cost saving (£)</th>
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<tbody>
<tr>
<td>Sand filling in tunnel</td>
<td>5,000</td>
</tr>
<tr>
<td>Base layer</td>
<td>45,000</td>
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<tr>
<td>Total direct savings</td>
<td>50,000</td>
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</tbody>
</table>
Cost Benefits

<table>
<thead>
<tr>
<th>GFA component cost</th>
<th>Cost (£/tonne)</th>
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</thead>
<tbody>
<tr>
<td>Mobilization of equipment</td>
<td>0.00</td>
</tr>
<tr>
<td>Granite aggregate</td>
<td>8.55</td>
</tr>
<tr>
<td>Mixing cost</td>
<td>2.74</td>
</tr>
<tr>
<td>Pulverized-fuel ash including wastage allowance (10% addition)</td>
<td>0.47</td>
</tr>
<tr>
<td>Lime including wastage allowance (1.83% addition)</td>
<td>0.50</td>
</tr>
<tr>
<td>Haulage of GFA to site</td>
<td>0.25</td>
</tr>
<tr>
<td>Wastage allowance</td>
<td>0.18</td>
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<tr>
<td>Total cost</td>
<td>12.69</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>‘Conventional’ component cost</th>
<th>Cost (£/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense bitumen macadam roadbase</td>
<td>30.00</td>
</tr>
<tr>
<td>Total cost</td>
<td>30.00</td>
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</tbody>
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Indirect savings

- Avoidance of Landfill Tax at £2/tonne for the suppliers of the Pulverized-fuel ash, totalling £860;
- The indirect benefits to the contractor listed below were estimated at approximately £30,000.

Costs

No significant costs have been identified.

Indirect benefits to the contractor

- The mixer for the GFA was primarily installed on site to provide concrete for the in situ tunnel lining; the ability to manufacture GFA increased the utilisation of the plant. The GFA could be mixed when the plant was not otherwise engaged and the material transported to the laying gangs from a stockpile if necessary. This capability improved efficiency, as the laying gangs could lay the material faster than plant production;
- The same base aggregate as used for the tunnel concrete was used simplifying stock control;
- Utilisation of trucks was increased;
- The contractor had complete control over the delivery process;
- The laid material could be trafficked immediately without damage;
- Reduction in imported material as fill below the pavement in the tunnel invert.

Indirect benefits to the wider community

- Reduction in the use of primary materials, avoiding associated environmental impacts;
- Pulverized-fuel ash as a binder is more energy efficient than the alternative cement;
- Avoidance of landfilling 430 tonnes of Pulverized-fuel ash;
- GFA pavements result in energy and environmental savings, through less asphalt.

Lessons learned

This project has demonstrated that GFA will perform well enough to permit trafficking immediately after laying and without curing. Although not recommended, this was achieved even when GFA was placed in the winter and when subject to frost. The long term strength and stiffness of the surface has also been found to be satisfactory. It was also found using published information on energy usage in production, transportation and laying that the use of the PFA as a binder in the GFA was a more energy efficient option than the normal use of cement or use of bituminous
material. It is estimated that the total energy of mixing and laying the GFA was 695 GJ compared to 1,400 GJ using the conventional hot mix asphalt solution. Through night time batching of the GFA, daytime work did not have to be disrupted as enough material was readily available.

**Technical data**

All of the mixture designs were similar in terms of compressive strength and complied with the requirements of an average compressive strength of 10 MPa at 14 days using 40°C curing determined on groups of 5 cylindrical specimens with no individual value less than 6.5 MPa. To provide sufficient GFA for an 8 hour working day the GFA had to be batched continuously for 16 hours overnight and was stockpiled ready for the laying gang to use during the day. This was only possible because of the slow set characteristics of the lime/Pulverized-fuel ash binder combination. The GFA was generally placed in three layers, the first layer within the tunnel had to be laid using a blade rather than a paver as there was not enough traction. The GFA outside the tunnel was laid during January and February 2000, and was fully exposed to the winter elements. Despite this, no ill effects were observed and the GFA performed well.

Throughout the construction of the road the GFA was continually graded and was tested for moisture content, strength and compacted density. In each case the results were compliant. In situ performance testing was also carried out on the road in March 2000. Coring was performed in the tunnel section, acceptable performance was found in all layers and core strengths were unexpectedly high but the sand sub-grade may well have inhibited proper compaction in lower layers.

Long term mechanical properties were measured after 500 days using three sets of laboratory manufactured cylinders. One set of specimens had an average compressive strength of 10 MPa and the other two sets had an average compressive strength of 22.5 MPa. The lower strength was attributed to the very low density of the test specimens. The final set of testing started in April 2000 when a falling weight deflectometer survey was undertaken at 3, 6 and 12 months. The results showed that over time the materials became progressively stiffer. Overall the results have been promising and the predicted strength gain has been achieved.

**Specification**

Babtie, on behalf of the Client, specified a roadbase of hydraulic bound material using Phosphoric slag imported from Holland. This is a secondary aggregate comprising by-products from the phosphorus and steel making processes. The latter forms the coarse aggregate and activator for the steel slag binder. The specification for this material could be equated to the performance of an equivalent Portland cement bound material for design purposes. A DBM 50 base alternative was also available.

The contractor proposed an alternative material which, although it used virgin aggregate, was cheaper but also environmentally friendly. The mix design proposed by the contractor was thoroughly investigated by Babtie on behalf of the Client to check that equivalent performance to the originally specified material would be achieved.

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Contractor: Perforex

Supplier: Didcot Power Station

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