CASE STUDY

GFA for the A259 Ramsgate Harbour approach road in Kent

UNITED KINGDOM QUALITY ASH ASSOCIATION

Introduction

Between October 1999 and February 2000, GFA was laid as the sub-base and roadbase for the Ramsgate Harbour approach road in Kent. Taylor Woodrow and Perforex constructed the road in a joint venture/partnering arrangement with Kent County Council. The job was 1.4 km of single carriageway with just over 50% in a tunnel.

- ***The use of GFA realised a saving of about £4/m^2 when compared with conventional construction.***

GFA is a mixture of crushed graded aggregate, PFA and lime, where the PFA/lime combination performs as the binder. The mixture has a water content compatible for compaction by rolling. General information on GFA can be found in Technical Datasheet 6.1.

Materials and mix design

An ELBA ESM60 site plant was used for the GFA production. Glensanda granite, 20mm single size, 10mm single size and washed fines, was used as aggregate. Dry run-of-station PFA from Didcot Power Station, supplemented with ash from other sources, was supplied throughout the contract. Three differing mix designs were tested as shown in table 1.

Mix	Proportions by percent Aggregate : PFA : Lime	R_c at 14 days @ 40C MPa	R_c at 40*days @ 20C MPa
1	84 : 14 : 2	12.7	7.0
2	87 : 11 : 2	11.4	6.2
3	90 : 8.5 : 1.5	13.4	7.5

NOTE: R_c designates 1:1 cylinder compressive strength. * Normally this would be 60 or 90 days but contract pressures dictated otherwise.

Table 1: Laboratory mixtures design results

All the mixtures were similar in terms of compressive strength and met the compliance requirement of:

- ***An average compressive strength requirement of 10MPa at 14 days using 40C curing determined on groups of 5 specimens with no individual value less than 6.5 MPa.***

Pavement design for the works

The design of the pavement is shown in Table 2 and used GFA in both base and sub-base layers in accordance with the approach in Datasheet 6.6. The CBR 5% condition applied to the works external to the tunnel where the subgrade was chalk and the CBR 15% condition within the tunnel where the subgrade was concrete overlain with 400mm of sand.

	Subgrade CBR 5%	Subgrade CBR 15%
SMA surface course	30mm	30mm
Binder course	100mm	100mm*
GFA road and sub-base	375mm	320mm

*Actually 120mm since it was necessary to plane the GFA to remove irregularities arising from the heavy channelised trafficking in the tunnel during construction.

Table 2: Ramsgate GFA pavement construction

Construction

In order to produce sufficient GFA for an 8 hour laying day, it was necessary to batch continuously for 16 hours. Batching commenced during the night, with the GFA being stockpiled ready for the laying gang to use the following morning. This was only possible because of the slow-set characteristics of the lime/pfa binder combination.

Mix 3 was used for production during October and mix 2 thereafter until completion in February 2000. Generally, the total thickness of GFA was laid by paver in 3 lifts. In the tunnel, the bottom lift was laid by blade since the underlying sand fill offered insufficient traction for the paver. (Writer's note: Ideally the GFA should have been laid in 2 lifts with minimum and maximum lift thickness of 150mm and 225mm respectively.) A significant proportion of the GFA outside of the tunnel was laid during January and February 2000. This material was directly exposed to frost, but the cold did not affect nor necessitate removal of any GFA, even though it would have had little strength and was under traffic. (NB: Laying GFA in winter is not usually recommended – see Datasheet 6.7). In addition, 50% of the external GFA laid late 1999 was not surfaced until April 2000 but performed satisfactorily under traffic during the winter.

Testing and monitoring during construction

GFA grading, moisture content, strength and compacted density were continuously monitored during construction.

- ***Laid moisture contents averaged 5%.***
- ***14 day/40C compressive strength results fully complied and averaged 10.5 MPa.***
- ***Insitu compaction averaged 98%.***

Performance Testing

The insitu material was tested using cores in March 2000, some 3 to 4 months after laying.

- The coring exercise was carried out in the tunnel. Generally, only the upper layer of the GFA was recovered from 8 of the 15 core attempts. Examination of the core holes revealed sound material in all layers. However it is felt the sand subgrade may have inhibited proper compaction in the lower layers. NB: Normally GFA should be cored at 1 year, not at 3 to 4 months – see Datasheet 6.3.
- Despite the problems with coring, core strengths were unexpectedly high.
- The 5 cores recovered from the upper lift ranged in strength from 18.5 to 24.6 MPa with an average of 22.5 MPa. The 2 cores from the lower lift gave strengths of 11.6 and 12.3 averaging 12 MPa.

- Three sets of laboratory manufactured cylinders were kept for measurement of long term mechanical properties at 500 days. One set of 3 specimens had an average compressive strength of 10 MPa and the other 2 sets of 3 specimens, an average of 22.5 MPa. The density of the specimens indicated that the low strength set had very low density compared to the other 2 sets which had normal density. This indicates the importance of density vis-à-vis strength.
- In April 2000, Babtie-May carried out a Falling Weight Deflectometer (FWD) survey at 3-6 and 18 months. The results are shown in Table 3. It should be noted that the 18 month site stiffness results are very similar to the 500 day stiffness results from the laboratory-manufactured cylinders, which ranged from 20 to 29 GPa.

GFA stiffness moduli (GPa)	Chalk subgrade	On sand subgrade in tunnel
First survey (age of GFA, 3 – 6 months)	16 GPa	5.5 GPa
Second survey (age of GFA, ~ 18 months)	27 GPa	17.5 GPa

Table 3: Comparison of Kent CC FWD surveys

Kent CC observations (Walsh 2002) from the results in Table 3 were as follows:

- ***The results illustrate the slow strength gain of GFA which will thus have the benefit of not suffering reflective cracking***
- ***The results indicate that the predicted strength gain has occurred***
- ***The lower results in the tunnel may be the result of the sand foundation not giving the same support as the chalk subgrade outside the tunnel.***

Conclusions

- The Ramsgate contract further confirms the ability of GFA to perform satisfactorily when trafficked immediately, ***without curing and non-trafficking periods***, yet still develop satisfactory long-term strength and stiffness and thus performance.
- The GFA at Ramsgate proved itself to be constructible in winter and able to perform in the short term even though winter laying is not recommended.
- Through the use of GFA, the JV reported a saving of £80,000, equivalent to about £4/m^2, compared to conventional sub-base and asphalt pavement design.
- The use of a PFA binder is more energy efficient than cement.
- In addition GFA pavements result in energy and environmental savings through the use of less asphalt compared to conventional flexible and flexible composite pavements.

References:

WALSH I D & WILLIAMS G. *Use of fly ash bound material as road base on A259 Ramsgate harbour approach road.* Proceedings of the Fourth European Symposium on Performance and durability of bituminous materials and hydraulic stabilized composites, Nottingham, April 2002.

ALLEN R & PYTLIK P J. *A52 reconstruction - Design construction and performance of bituminous planings treated with PFA and lime*. Proceedings of the Third European Symposium on Performance and durability of bituminous materials and hydraulic stabilized composites, Leeds, April 1999.

In general usage the term 'fly ash' is used for pulverised coal ash but it can also cover ash from burning other materials. Such 'fly ash' may have significantly differing properties and may not offer the same advantages as ash from burning pulverized coal. UKQAA datasheets only refer to PFA / fly ash produced from the burning of coal in power stations.