UNITED KINGDOM QUALITY ASH ASSOCIATION

Applications for PFA in concrete

Introduction

Pulverised Fuel Ash (PFA) has been used in concrete for many years. In the UK the use of finer PFA complying with BS 3892 Part 1 has been commonplace, but more recently there is the option to use PFA, known as fly ash in the standard, conforming to EN450. The following are recent applications in which PFA has been used in their construction:

Heathrow Airport Terminal 5, London

In a period of 5 years ~135,000 tonnes of PFA is being used in a variety of concrete applications in the construction [i]. One novel application is a new design of pavement concrete for taxiways for the airplanes. The greater flexural strength of this concrete means that a reduced thickness is required, even though load is increasing from 23 tonnes to 28 tonnes per wheel for aircraft like the A380 Airbus [ii]. Less concrete means less cement and as up to 40% of the cement content is PFA; the overall amount of CO_2 is significantly reduced compared to Portland cement. All PFA deliveries to the T5 site are being made by rail as opposed to road tankers, thereby reducing CO_2 emissions even further.

Channel Tunnel Rail Link (CTRL)

The Channel Tunnel Rail Link will be Britain's first major new railway for over a century. It is 68 miles long running between St Pancras station in London and the Channel Tunnel. The new high speed line is being built in 2 Sections, the first section runs between the Channel Tunnel and Fawkham Junction in north Kent and opened in September 2003. Section 2 completes the new line into London's St Pancras and is on schedule for completion by early 2007.

Over 120,000 tonnes of PFA has been supplied to concrete used in the CTRL track beds, walkways and precast concrete tunnel lining segments. PFA is routinely chosen for tunnel lining segments because it;

- Enhances the long term durability of the concrete due to the;
  - Reduced oxygen permeability, which reduces the risk of corrosion of reinforcement;
  - Lower peak temperatures to reduce thermal cracking;
  - And its resistance to Alkali Silica Reaction, chloride ingress, etc.
- Also using PFA minimizes the environmental impact of producing the high strength concrete for such demanding applications.

During the project 4m high walkways had to be slip formed that were required to stand up immediately after casting. After much trial mix work, a very dry concrete mix was used incorporating EN450 fly ash that made the concrete cohesive and enabled slip forming of the walkways to the required shape, but also achieving a tight, high-standard, blemish free surface finish.

In addition numerous precast wall and roof segments, panels, troughing, lids and various accessories have been supplied to the contract, most containing PFA.

Canary Wharf

This project has used in excess of 300,000m³ of concrete in a single year, with some 80% of the concrete containing PFA. 'Environmental Design considerations' [iii] were cited as playing a key role in the decision to adopt PFA in the contract. Mixes containing 40% PFA were used in the Heron Quay 5 project to reduce heat of hydration problems and eliminate cracking for the 3m thick raft containing some 40,000m³ of concrete. PFA was able to keep the maximum temperature down and to control the temperature differentials. Differential setting times can be problematic and were combated by retarding the earlier pours to reduce the time differential and therefore the temperature difference, eliminating cracking. The PFA concrete was pumped up to a height of 158m with a single stage pumping system, a testament to the cohesive nature of PFA concretes.

M6 Toll Road

The M6 toll road is the first tolled road in the UK and again PFA was chosen for its economy, its durability and reduction in the heat of hydration properties. Over 22,000 tonnes was used in the road pavement and 16,000 tonnes for associated structures, in the construction of the 43km of highway with 72 bridges and culverts. As with the other projects PFA was chosen due to the reduced heat generation and increased durability characteristics. In addition to providing a better finish, a reduced water content is required, meaning a greater strength can be found without compromising on workability.

From wind farms to fish farms

PFA is not only used in major projects, but for general use in concrete. For example, the concrete in wind farms has to withstand some of the most aggressive weather conditions, simply as a result of their location. Many wind farms are constructed using PFA concrete, such as these examples from Scotland. PFA is chosen because of the long term durability of PFA concrete.

Fish farms also have to withstand the worst of the Scottish weather and again they prefer PFA, to give the strength and long term durability to the concrete.

Self compacting concrete

PFA is used in self compacting concrete, because it imparts the rheology needed to make high quality formed finishes with no compactive effort. The rheology of the mortar fraction must be such to flow around the formwork and reinforcing and be able to expel entrapped air using its own self weight. Therefore, the proportions and nature of the finer materials, cement, additions such as PFA, fine aggregate, etc can have a significant bearing on the final concrete.

The photograph shows a column produced using self compacting PFA concrete. PFA is often included within SCC because of its water reducing properties and the effect the spherical particle has on the thixotropic nature of the concrete. This reduces segregation of the coarse aggregate particles within the mortar matrix. Segregation defines the difference between a well designed SCC concrete and a badly designed one. Depending on the particle size distribution and particle shape of the fine aggregate, varying proportions of PFA can be utilized both as a Type I and II addition.

---

i   RMC press release, 7 April 2004

ii   SPARKS A, New mix reduced concrete on T5, New Civil Engineer, 3 April 2003

iii NCE, PFA at Canary Wharf and M6 Toll Road, NCE Concrete Special 2001, 15 November 2001

In general usage the term 'fly ash' is used for pulverized 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 predominantly coal in power stations.