

This digest is one of a series produced by the Aggregates Advisory Service to provide information on aggregates efficiency issues.

The aim of this service, funded by the Department of the Environment, Transport and the Regions, is to assist the Government to achieve its objective of reducing the construction industry's dependence on landwon primary aggregates and increasing the contribution from secondary and recycled materials.

Further information on aggregates efficiency issues, whether relating to primary, secondary or recycled materials, can be obtained from the Aggregates Advisory Service on Freephone no.0800 374 279, or visit the AAS website at <http://www.planning.detr.gov.uk/aas/index.htm>



USE OF PULVERISED FUEL ASH FOR CONSTRUCTION PURPOSES

This digest briefly describes pulverised fuel ash (PFA) and its potential uses in construction.

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Ash is relatively stable physically but is often chemically mildly reactive. It is generally low in density and this together with its chemical properties, which enhance cementation binding, have resulted in its widespread use as a lightweight aggregate.

The bulk of the ash available in the UK is produced from the combustion of coal in the electricity generation industry. The uniformity of the feed substrate and consistent combustion conditions produces a homogenous product which is attractive for use in many construction applications.

Coal Ash from Power Generation

In a typical modern coal fired power station approximately 80% of the ash will be produced as a fine powder known as Pulverised Fuel Ash (PFA), (also known as "Fly Ash" in some countries). Being light and fine, the PFA is carried in the gas stream out of the boiler, ultimately being collected by mechanical arrestors and/or electrostatic precipitators.

Introduction

Ash derived from the combustion of hydrocarbon based materials largely comprises mineral residues. The characteristics of the ash product depend upon the nature of the original substrate and the method and temperature of the combustion process.

The remainder of the ash (about 20%) is much coarser and is generally known as Furnace Bottom Ash or FBA (also referred to as “clinker” or “coarse ash”). FBA falls to the bottom of the power station boiler into a hopper and is usually removed by high pressure water jetting along sluiceways to a coarse crusher.

While FBA and PFA have similar chemical properties, their physical properties differ with FBA particles ranging in size from 50 mm to less than 50 micron and PFA typically ranging in size from 0.5 to 150 microns. All FBA produced in the UK is used as a lightweight aggregate in block manufacture.

Properties of PFA

PFA is similar in colour to Portland Cement with pozzolanic and self hardening properties. It consists of largely rounded particles and has a specific gravity approximately two thirds that of Portland Cement, generally in the range 2.1 - 2.4. There are three main elemental oxides found in PFA:

- silicon;
- aluminum; and
- iron.

These elements make up approximately 75% to 95% of the material. The remainder consists of various other oxides together with a small proportion of carbon from the incomplete combustion of the coal.

A small proportion of PFA, 1-2% by weight, consists of hollow spherical particles known as

cenospheres with a specific gravity of less than unity. This material can be recovered by flotation techniques and has applications in a number of industrial processes.

As a consequence of these various properties, PFA has become a major raw material for the building and construction industry where it is used:

- as structural fill;
- in block and lightweight aggregate manufacture;
- as a cement replacement and additive in concrete;
- as a constituent in free flowing grouts; and
- in brick manufacture.

The properties of ash from the different power stations vary depending upon the combustion process and as a result ashes from specific sources may be best suited to particularly challenging applications.

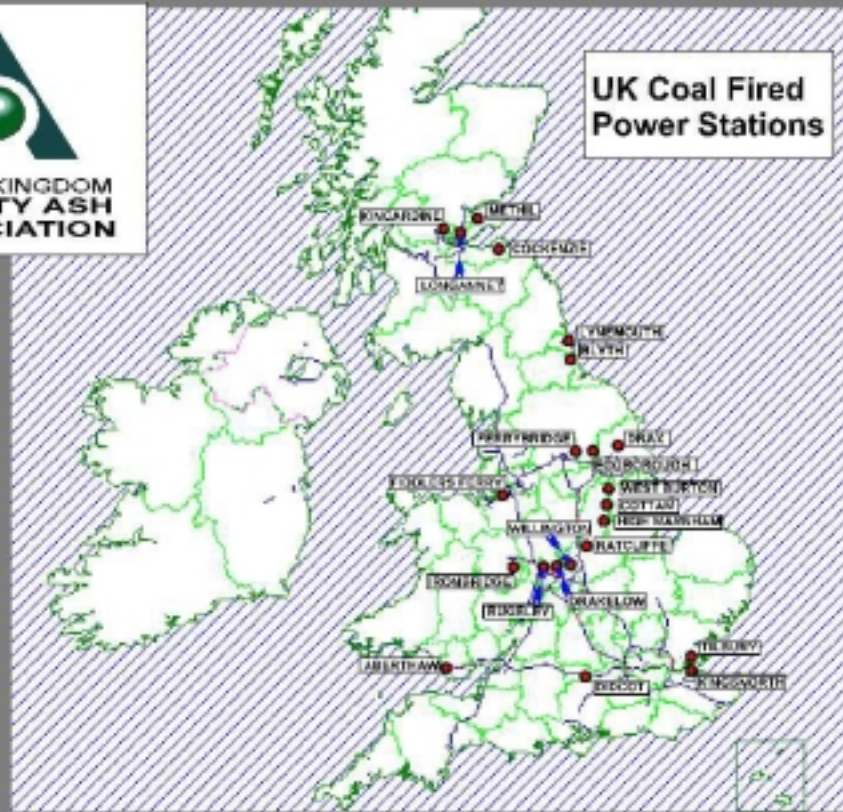
Utilisation of PFA

In some parts of Europe and in particular France all PFA is utilised. In the UK however the current demand is below production.

UK Annual Production Rate	7 x 10 ⁶ tonne/yr
Utilisation Rate	approx 50%
Stockpiled material available	250 x 10 ⁶ tonnes

Availability of PFA

Ash is produced at a number of power stations across the UK hence it is available on a wide geographical basis.



Applications of PFA

PFA is also used in the production of proprietary lightweight aggregates where rounded pellets of PFA are sintered and subsequently graded into

- as aggregate in concrete;
- in horticulture as a growth media;
- as a thermal insulator;
- as a refractory material; and
- as a specialist surface for sport facilities.

A52 Staffordshire

During reconstruction of the A52, GFA (a granular material consisting of a mixture of crushed graded aggregate, PFA and lime) was used to reinstate the carriageway. In this application the PFA/lime combination acted as a binder. The work was

carried out under contract for Staffordshire County Council and consisted of:

- The removal of 400mm of the existing pavement by planing;
- Processing and grading the recycled planings to produce the required aggregate;
- Mixing the graded planings with PFA/lime in a batching plant to produce GFA;
- Relaying and compacting the pavement using 300mm of GFA under 100mm of new bitumen surfacing.

The section of road repaired is known as Kingsley Bank and is in a steep windy, hilly section of the A52 between Kingshill and Froghall. The GFA process was chosen for its potential flexibility in what is known to be an area of potentially unstable ground. The mix design consisted of:

3% CaO + 12% PFA + 85% recycled planings.

The GFA was placed in two 150mm layers using a conventional paver and compacted by vibrating and pneumatic tyred rollers.



The finished GFA was kept damp during the process when necessary, however moisture contents were strictly controlled. It was found that if too wet, GFA was difficult to compact. This was rectified by opening up the laid GFA using a toothed excavator bucket thus allowing evaporation and later compaction.

This process was not found to have a detrimental effect on the finished road because the lime/PFA reaction gains strength slowly.



The road has been laid for approximately 18 months and has demonstrated the practicality and success of this technique.

The Future

PFA is a versatile material which is widely available in the UK in considerable quantities. In contrast with continental Europe, the UK has been conservative in using such material in road construction. However with an increasingly innovative approach to road construction, particularly in maintenance works, it is anticipated that PFA will become widely used in this application in parallel to its already accepted role in other areas of the construction industry.