Coal combustion products for the manufacture of precast masonry units in the United Kingdom

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Abstract

Autoclaved aerated concrete (AAC) and aggregate masonry units account for most of the building blocks marketed in the United Kingdom. Coal combustion products (CCP) are used extensively for the manufacture of these precast masonry units. Coal fly ash, also referred to as pulverised fuel ash (PFA), is a major silica source used for the production of autoclaved aerated concrete. Furnace bottom ash (FBA) and coal fly ash are established raw materials for the manufacture of aggregate masonry units.

The performance of coal fly ash and furnace bottom ash in the manufacture of both types of masonry units is discussed. The technical and environmental benefits of using these coal combustion products are reviewed.

Introduction

Concrete blocks are the most common building units manufactured in the United Kingdom. Two block types are generally available: autoclaved aerated concrete (AAC) and aggregate concrete masonry units. The latter can be further subdivided into dense and lightweight products. Large amounts of coal combustion products (CCP) are used in the manufacture of these blocks. Fly ash and furnace bottom ash (FBA) are used extensively. Gypsum obtained from flue gas desulfurisation is not normally used. The use of CCP offers considerable advantages for the manufacture of concrete masonry units.

Figure 1 - Aerated (front), lightweight aggregate (middle) and dense aggregate (back) concrete masonry units

CCP usage in the United Kingdom block market

Coal combustion products are used extensively in the United Kingdom for the manufacture of both aerated and non-aerated concrete blocks. Fly ash is used in the manufacture of around two thirds of the autoclaved aerated concrete produced in the United Kingdom. Fly ash is the major raw material in such AAC, contributing up to around 70% of the product by mass. Fly ash is also used in aggregate masonry units, particularly those in the higher density range. In lightweight aggregate blocks, furnace bottom ash (FBA) is a significant component, at up to around 50% of the product by mass.

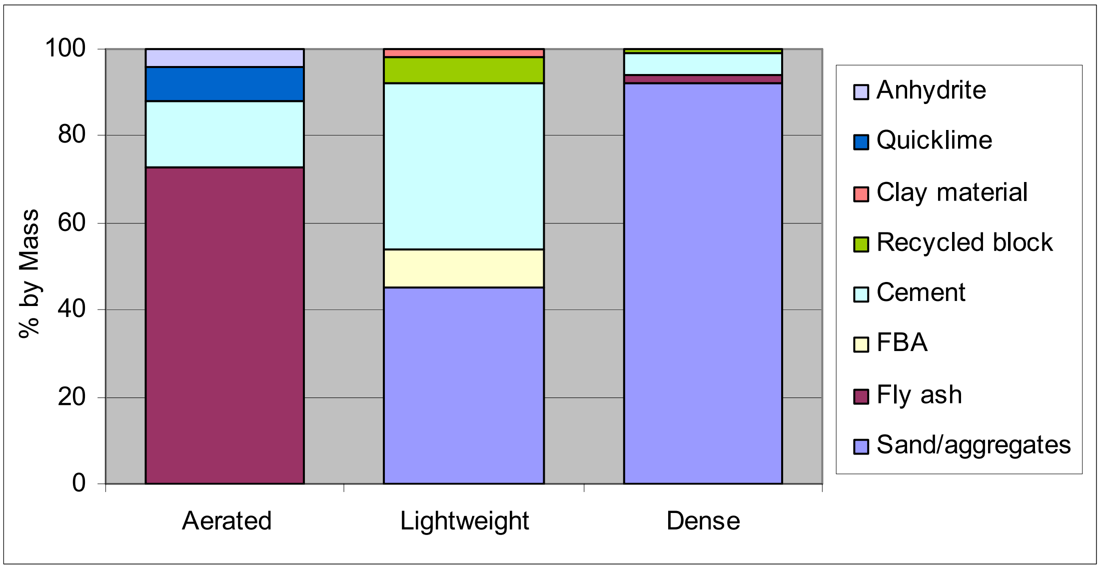

Figure 2 -Typical composition of 7N masonry units

Artificial lightweight aggregates, derived from fly ash, may also be used in the manufacture of aggregate concrete masonry units. The most significant material of this type to be used within the United Kingdom was “Lytag”. However, since the closure of the production plant at Eggborough in Yorkshire, lightweight aggregate has been imported from Continental Europe. Much of this material is based on sintered clay, rather than CCP.

Market Status

The current total block market in the United Kingdom is in the region of 90 million square metres per year (Fig 3). There has been a steady increase in the total block production since the late 1990’s, peaking at over 96 million m^2 in 2003, followed by a tail off in the last two years[1].

Dense aggregate blocks account for the largest proportion of the market, currently around 40%. Although the market share for dense blocks showed gradual decline in the early 2000’s, this has reversed in the past two years. Conversely, the generally growing market for AAC has shown a slight downturn, but still accounted for just over 30% of production in 2005. Lightweight blocks form the smallest share of production, but this has shown continued slow growth in recent years, and contributed just less than 30% of the market in 2005.

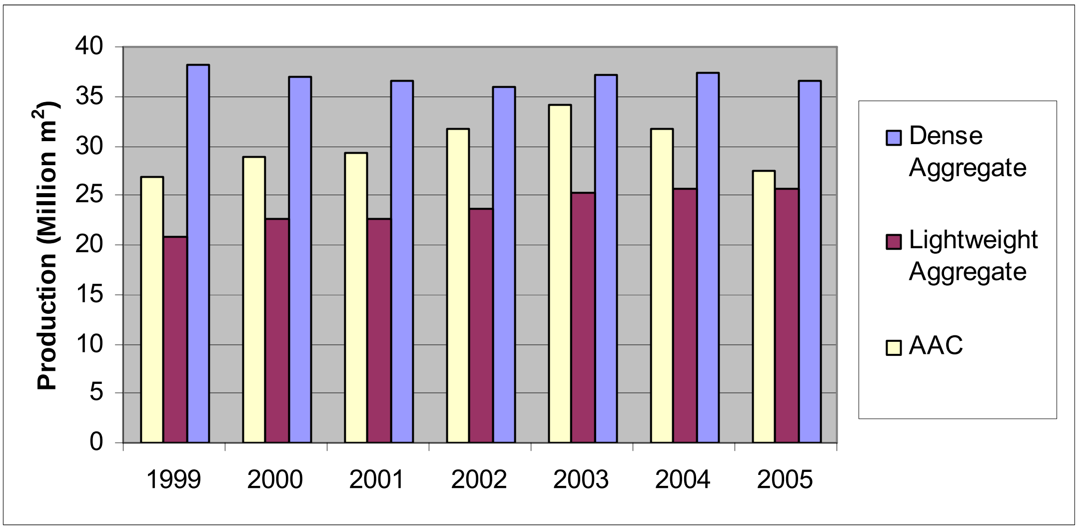

Figure 3 - Annual block production in the UK[1]

CCP Utilisation

Furnace bottom ash production in the United Kingdom has varied between around 0.7 and 1.1 million tonnes per year over the past six years (Fig. 4). Almost all of this is used for aggregate masonry production. There is a significant shortfall in supply, so FBA is also imported from continental Europe, where it is a surplus material[2].

Production of fly ash has grown steadily in the United Kingdom in recent years, from 4.5 million tonnes in 1999 to 6.5 million tonnes in 2004. AAC accounts for the largest proportion of the national fly ash market, at between 13 and 17% of total utilisation. There has been a general increase in the consumption of fly ash for AAC production during the past six years, from around 600,000 tonnes to almost one million tonnes. However, this has declined recently, following the fallback in AAC production over the last two years.

A much smaller amount of fly ash is used in aggregate masonry unit manufacture, typically around 200,000 tonnes per year (3-4% of total) between 1999 and 2003. However, there was a sharp increase in use to over 0.5 million tonnes in 2004. This reflects both an overall increase in aggregate block production and a greater utilisation of fly ash in such products.

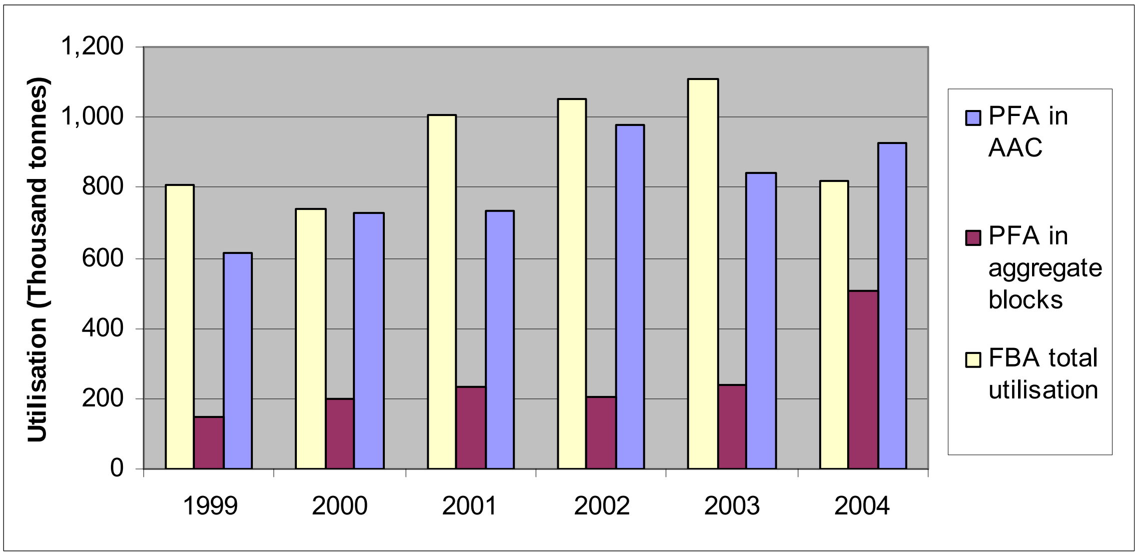

Figure 4 - CCP usage for block manufacture in the UK[2]

Formation of Fly Ash and FBA

Within a modern coal-fired power station, fuel is pulverised to less than 300 μm, with a median particle diameter of 50 μm being typical[3]. The coal particles are drawn into the combustion zone of the boiler with the primary air. Retention times within the boiler are only three to four seconds, but temperatures of 1450 ±200°C are encountered.[4] The organic matrix of the coal fragments burns rapidly in the oxidising conditions. However, the inorganic components are transformed by the high temperatures. Volatilisation of alkali metal salts occurs and compounds of heavy metals may boil or sublime. A char structure forms that includes many mineral inclusions. This weakens and collapses, liberating molten droplets. Surface tension ensures that these molten droplets remain spherical.

Outside the combustion zone rapid cooling occurs, which leads to vitrification and the formation of amorphous glasses. Volatised alkalis condense as fine particles, often adhering to larger particles. The fine particles are swept out of the boiler with the flue gases and are collected on electrostatic precipitator plates as fly ash. Alternatively, the molten droplets may meet the metal surfaces of the boiler and form a film of slag. Again, rapid cooling gives vitrification and the formation of a glassy matrix. This material is furnace bottom ash (FBA). It falls to the bottom of the furnace, where it is intermittently removed with high-pressure water jets, which also help to cool the ash. Large lumps are crushed to less than 25 mm and placed in storage pits.

The fly ash and FBA obtained from the same boiler will have similar elemental compositions (Table 1). This is expected since each ash type has been produced from the same coal source. Some differences in mineralogy may arise. Molten fly ash particles solidify rapidly and do not generally interact with each other. However, within the deposits from which FBA is obtained, some blending of compositions may arise. In certain regions of the boiler, cooling may be relatively slow, allowing some crystallisation of phases to occur and reducing the glassy content of the FBA.[5]

% by mass	Fly ash	FBA
SiO_2	49.6	49.5
Al_2O_3	23.1	24.2
Fe_2O_3	14.0	15.5
CaO	4.37	6.39
MgO	1.95	2.54
TiO_2	0.87	0.90
K_2O	1.87	1.67
Na_2O	0.44	0.53
SO_3	0.58	0.14
Mn_3O_4	0.18	0.21
P_2O_5	0.34	0.35
BaO	0.17	0.18

Table 1 - Elemental composition of fly ash and FBA from the same source[6]

Table 1 gives the mean elemental analysis for fly ash and FBA obtained from Ratcliffe Power Station, whilst burning Daw Mill coal, a local fuel source[6]. Within the limits of analytical error, the compositions are comparable. There is good agreement in respect to the three main elements of silicon (SiO_2), aluminium (Al_2O_3) and iron (Fe_2O_3). In addition, the amounts of sodium and potassium are similar. There is significantly less sulfur in the FBA compared with the fly ash. One explanation is that the sulfate is removed from the FBA by its treatment with water.

British power stations generally burn bituminous coal and the ashes derived are low in lime but high in amorphous aluminosilicate glass. Quartz, mullite, haematite and magnetite are dominant crystalline phases present in fly ash and FBA. Due to the installation of low NO_x burners, a relatively large amount of unburned carbonaceous material may also be present.

FBA particles act as an aggregate within masonry blocks and are coarse relative to the cement grains. There is little chemical interaction with the cementitious matrix. The performance of FBA is therefore largely determined by its physical properties, rather than chemical composition. Conversely, fly ash is fine and is subjected to autoclaving during the manufacture of AAC. Many particles are solubilised under the conditions of high alkalinity, temperature and pressure. Consequently, the elemental composition and mineralogy of fly ash affect its performance within AAC.

Properties of precast masonry units

Since 1st April 2006, aggregate concrete masonry units are manufactured in accordance with BS EN 771-3, whereas AAC must comply with BS EN 771-4. Properties covered in both standards are:

- Dimensions
- Configuration
- Density
- Compressive strength
- Thermal conductivity
- Durability
- Water absorption
- Drying shrinkage
- Water vapour permeability
- Reaction to fire
- Shear bond strength
- Flexural bond strength

Compressive strength and thermal conductivity (λ) are the prime properties that determine the performance of both aggregate concrete masonry units and AAC blocks. One defines the load bearing capacity of any structure, the other the extent of thermal insulation achieved. Figure 5 shows published thermal conductivity plotted against density for products from several UK manufacturers. There is a broad relationship between the density and lambda value for AAC and aggregate blocks.

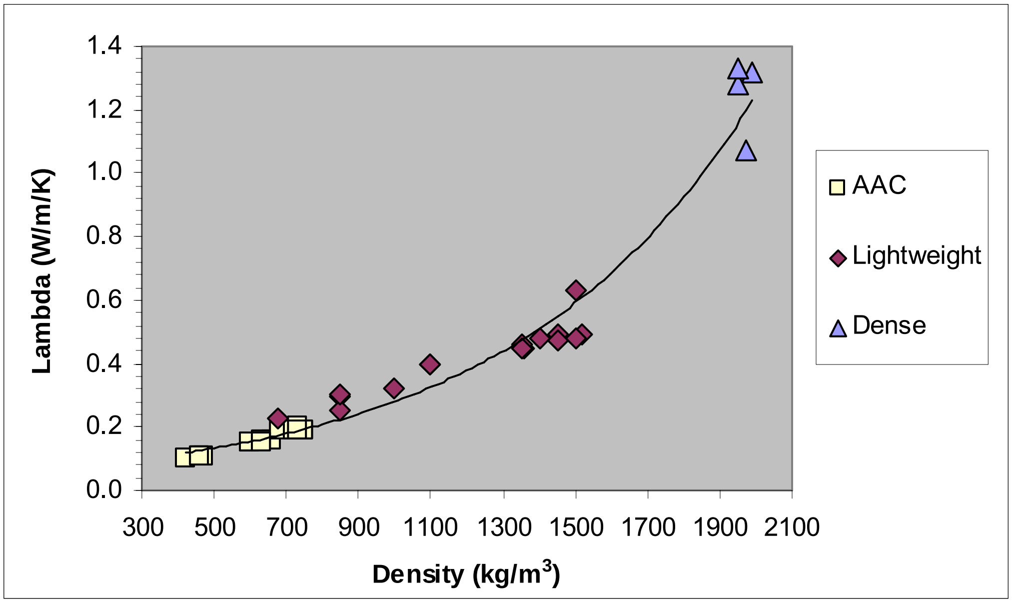

Figure 5 - Thermal conductivity against density for UK masonry units

Figure 6 is a plot of published compressive strength against density for blocks marketed in the UK. There is a general relationship between strength and density for AAC blocks. However, aggregate concrete blocks are manufactured to a range of different strength specifications at a given density. This is achieved by changing the amount of binder or altering the curing regime.

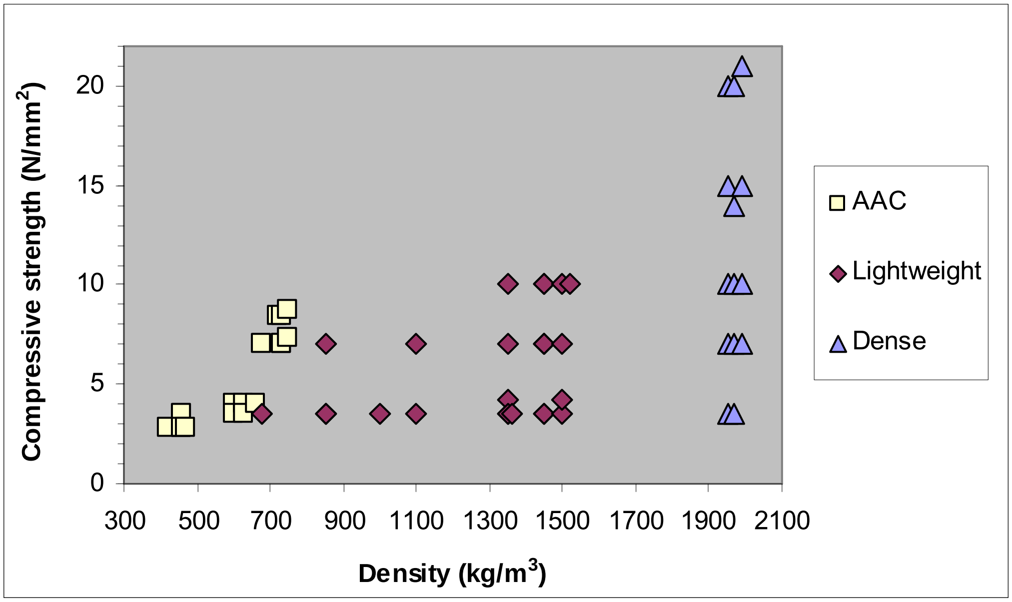

Figure 6 - Compressive strength against density for UK masonry units

Manufacture of Masonry Units

AAC blocks and aggregate concrete masonry units can be supplied to the same construction market and there is some overlap in properties. However, their manufacturing processes are radically different.

Manufacture of AAC

History of AAC

Autoclaved aerated concrete was patented in 1924 by Dr Johan Axel Eriksson of the Royal Institute, Stockholm, Sweden[7]. All the aspects of current manufacturing were covered in the invention. The patent described the preparation of a water-based slurry, containing calcareous and siliceous raw material, formation of a cellular structure by hydrogen gas generated from aluminium powder and hydrothermal curing using high-pressure steam. Interestingly, Eriksson used slate ash, an aluminosilicate, as the silica source. Manufacture of AAC began in 1929 at Yxhult, Sweden, using the trade name Ytong.

Interest in AAC within the United Kingdom can be traced to a patent filed by John Laing and Son in 1948[8]. The trade name Thermalite was registered in 1948 and a factory was built in Reading in 1951. This was the first AAC manufacturing plant in the United Kingdom and used fly ash as its primary raw material. In 1957/1958, a larger factory was built next to the Hams Hall Power Station near Birmingham.

The market for AAC within the United Kingdom expanded throughout the 1960's and 1970's. Factories were generally located either on the site of coal-fired power station or within close proximity. AAC factories using quartz sand were established in the United Kingdom, notably Durox and Tarmac in the 1960's and Quinnlite in 1995. The latest factory commissioned, owned by Thomas Armstrong Ltd, was constructed at Catterick in 2003.

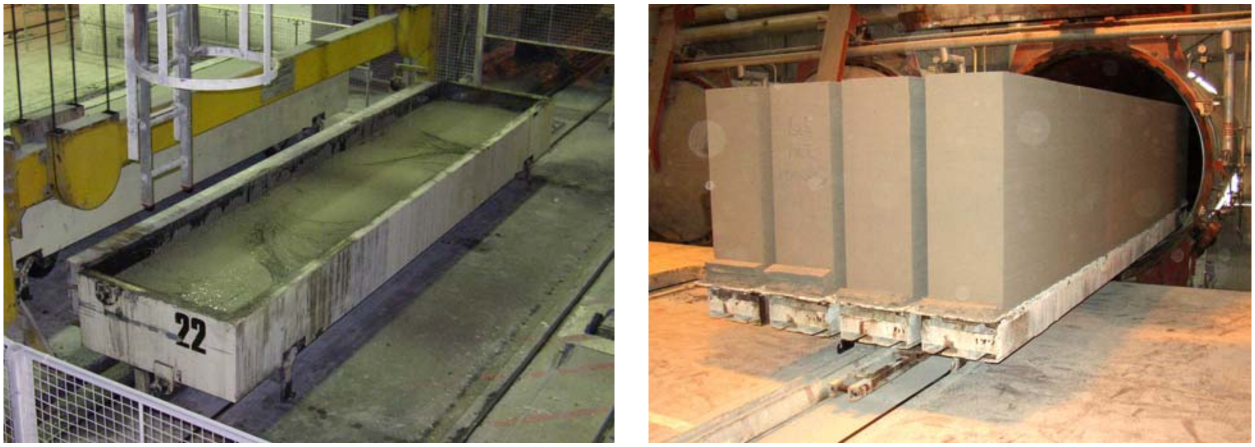

Figure 7 - Casting (left) and autoclaving (right) of AAC

Manufacture of AAC

Manufacture of AAC blocks is unlike that of conventional concrete or mortar. The raw materials are fine powders, without aggregate particles of any significant size and the starting point is a water-based slurry.

Formation of an AAC matrix is achieved by reacting together finely divided calcareous and siliceous raw materials in saturated steam at temperatures above 100°C (hydrothermal conditions). The calcareous raw material is normally quicklime (calcium oxide), or a combination of quicklime and Portland cement. The siliceous component is often finely divided quartz, obtained from sand or sandstone. Alternatively, a raw material containing amorphous silica, or aluminosilicate glass, may be used. Fly ash is a suitable siliceous raw material and is extensively used within the United Kingdom for the manufacture of AAC.

A low viscosity water-based slurry, containing fly ash, cement, quicklime and anhydrite is produced in the mixer. Finely divided aluminium powder is the final raw material added to the mix, which reacts in the alkaline environment, liberating hydrogen gas.

The mix is discharged to a mould, where it begins to expand to form a cellular structure within the stiffening cementitious mass (Fig 7). When the "cake" has risen and has gained sufficient green strength, it is demoulded and cut into blocks before steam autoclave curing (Fig 7).

	Drax	**Didcot**	**Tilbury**	**Kingsnorth**	**Rugeley**	**Ratcliffe**
SiO_2 (%)	50.6	46.6	50.9	48.8	46.9	47.0
Al_2O_3 (%)	25.9	24.3	20.5	23.0	25.7	24.6
Fe_2O_3 (%)	8.70	4.81	5.15	5.50	5.88	10.7
CaO (%)	2.54	4.79	3.21	4.89	6.44	3.56
MgO (%)	2.07	1.88	1.89	2.47	2.26	2.14
TiO_2 (%)	1.05	1.29	0.90	1.15	1.23	0.97
K_2O (%)	3.06	1.06	1.78	1.77	1.58	2.46
Na_2O (%)	1.14	0.61	0.86	0.91	0.82	0.94
SO_3 (%)	0.70	0.77	0.73	0.81	0.95	1.00
MnO (%)	0.07	0.06	0.07	0.08	0.13	0.13
Cr_2O_3 (%)	0.03	0.03	0.03	0.04	0.03	0.03
P_2O_5 (%)	0.41	0.90	0.74	0.90	0.94	0.39
LOI (%)	3.76	12.9	13.3	9.64	7.21	5.96
D_{50} (μm)	25.3	27.5	48.6	52.8	20.3	27.6
n =	*21*	*10*	*11*	*10*	*8*	*12*

Table 2 - Mean elemental and particle size analysis of run of station fly ash from six UK coal-fired power stations (2003-2005)

Table 2 contains mean analyses for fly ash obtained from six major United Kingdom coal-fired power stations, sampled from 2003 to 2005. The composition of the fly ash influences the hydrothermal reactions that occur during autoclaving and affects the compressive strength that can be achieved at a given density. Generally, a "good" fly ash is characterised as having a high silica (SiO_2) content, low iron (Fe_2O_3) and low carbon (LOI). However, the performance of a particular fly ash cannot be predicted from its chemical analysis. Trial mixes must be produced, autoclaved and tested for strength and other properties.

Manufacture of aggregate concrete masonry units

History of aggregate concrete masonry

Manual processes for moulding concrete blocks developed in the late 19th century. The Besser Company began block making in the United States at the turn of the 20th century. In 1909, a powered tamping machine was developed by the company, which gave a significant increase in productivity[9]. Besser developed the "vibration under pressure" design in 1939, which became the preferred method for high-volume block manufacturing. This system eliminated the high wear on the facing liners caused by tamping. More consistent compaction could also be achieved. Production units of this type spread worldwide and manufacturers such as Columbia and KVM offered similar equipment.

Plants may be either static, or "egg laying". In a static plant, the blocks are transported from the fixed moulding machine to a curing area. In an egg-laying plant, the moulding machine itself is mobile, and moves along casting the blocks on the ground, where they are left to cure. Static plants are most commonly used in the UK.

A feature of modern block making units is the ability to cope with a large variety of aggregates and binders, sourced locally. By changing mould sizes and shapes, and the use of cores when required, a wide range of block configurations can be made using a single unit.

Manufacture of aggregate concrete masonry

Aggregate concrete masonry units are made by blending together known proportions of coarse and fine aggregates, Portland cement and water to make a mix of earth-dry consistency. In a static plant, the mix is dropped into an array of steel moulds and formed into blocks by the combined application of high pressure and vibration (Fig 8). The blocks are demoulded within seconds onto a pallet and transported to a curing kiln (Fig 8). Within this sealed and thermally insulated chamber, the heat generated by the hydration of the cement accelerates the curing of the blocks. The green strength of the block builds as hydration continues. However, due to its low water content, the typical mix will not fully hydrate the cement. It is desirable to cure blocks within a controlled environment of high temperature and elevated humidity. This increases the rate of strength development within blocks. A combination of water vapour curing with high CO_2 concentration may also be used to further accelerate curing. The induced carbonation partially seals the pores within the matrix, encouraging hydration of cement grains between aggregate particles, enabling the strength to build up more rapidly and allow a higher final compressive strength to be achieved. The blocks are removed from the kiln after 24 hours, assembled into cubes and placed on a stockyard for at least a further six days, in order to allow the required compressive strength to develop.

Figure 8 – Static concrete block forming machine (left) and curing kiln (right)

Natural aggregates such as gravel, crushed rock or sand can be used. Alternatively, recycled, secondary or artificial aggregates may be used. FBA is a secondary aggregate widely used in the United Kingdom for block manufacture. It has a bulk density in the range of 800 to 1100 kg/m^3, which is lower that most other aggregates and is therefore suitable for lightweight aggregate masonry units. Although FBA is generally weaker than natural aggregates, when incorporated successfully within a concrete block it provides acceptable compressive strength for most load-bearing applications. It may be used “as received” from the power station, or more commonly crushed. It is normal to use a combination of coarse and fine FBA. Typical gradings are given in Table 3.[2]

Sieve size (mm)	% Passing	
	Coarse	Fine
37.5	98	100
20	85	95
10	61	90
5	44	70
2.36	37	55
1.18	29	50
0.6	21	40
0.3	14	25
0.15	7	14

Table 3 - Typical size grading for FBA[2]

Fly ash may also be used as a minor component, where it acts as fine inert filler. It is used particularly if the main aggregate is relatively coarse. The presence of the small spherical ash particles makes the mix more cohesive, which aids the block forming process. A more cohesive mix ensures that the blocks cast have sharply defined edges and are capable of supporting themselves after demoulding. There is little evidence that the fly ash undergoes pozzolanic reactions during manufacturing or storage on the stockyard. This is not surprising considering the low water content of the mix. It is common to use a propriety admixture to reduce the viscosity of the mix.

The compressive strength achieved for an aggregate concrete masonry unit is a combination of several factors. Of significance are cement content, aggregate morphology, aggregate strength, compaction efficiency, curing time and the conditions of temperature and humidity. There is a large range of compressive strengths offered by manufacturers. Generally, at a given density, the compressive strength achieved after 28 days storage is primarily determined by the cement content of the block.

Benefits of using coal combustion products

Environmental benefits

The 'Ecopoints' scoring system is a method developed by the Building Research Establishment (BRE) to evaluate environmental life cycle assessment data for construction products. The Ecopoint score represents a measure of the overall impact of a particular product or process, taking into account factors such as energy use, mineral extraction, waste disposal and transport. One hundred Ecopoints are equal to the impact of one United Kingdom citizen per year. The higher the score, the greater the environmental impact of manufacturing the building product. The use of CCP can lead to a significant reduction in the Ecopoints score for a particular product and therefore provides a more sustainable building option.

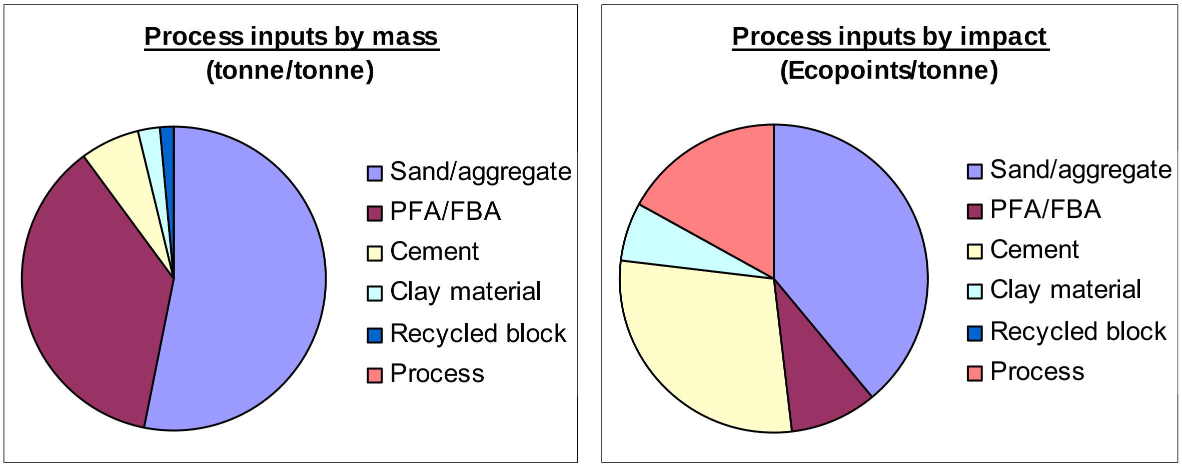

Figure 9 - Environmental profile for a generic 3.5 N lightweight block[10]

Figure 9 illustrates the process inputs for a generic 3.5 N/mm^2 lightweight concrete block.[10] Although CCP form 37% of the product by mass; they only contribute 9% of the Ecopoints score per tonne. Sand, aggregates and cement have the most significant environmental impact, illustrating the benefit of replacing them with CCP where possible. Surprisingly, dense aggregate blocks typically have a lower Ecopoint score per tonne than lightweight, due to their lower cement content.

Replacing the fly ash in Hanson Thermalite AAC blocks with ground sand would cause the Ecopoints score per tonne to rise from 1.9 to 2.4. This represents a considerable increase in environmental impact due to the burden of primary aggregate extraction and grinding.

Thermal Conductivity

AAC produced with fly ash as the silica source has a lower thermal conductivity than material of the same density made with ground sand. This is shown in Figure 10, in which tabulated values from EN1745 for AAC made with ground sand are compared with measured results for specimens made with fly ash. Within AAC made with ground sand, significant amounts of unreacted quartz remain after autoclaving. In material made from fly ash, any unreacted particles are likely to be amorphous aluminosilicate glass. The rate of heat flow through the matrix containing crystalline quartz is higher than through the amorphous matrix, and therefore the thermal conductivity is increased.

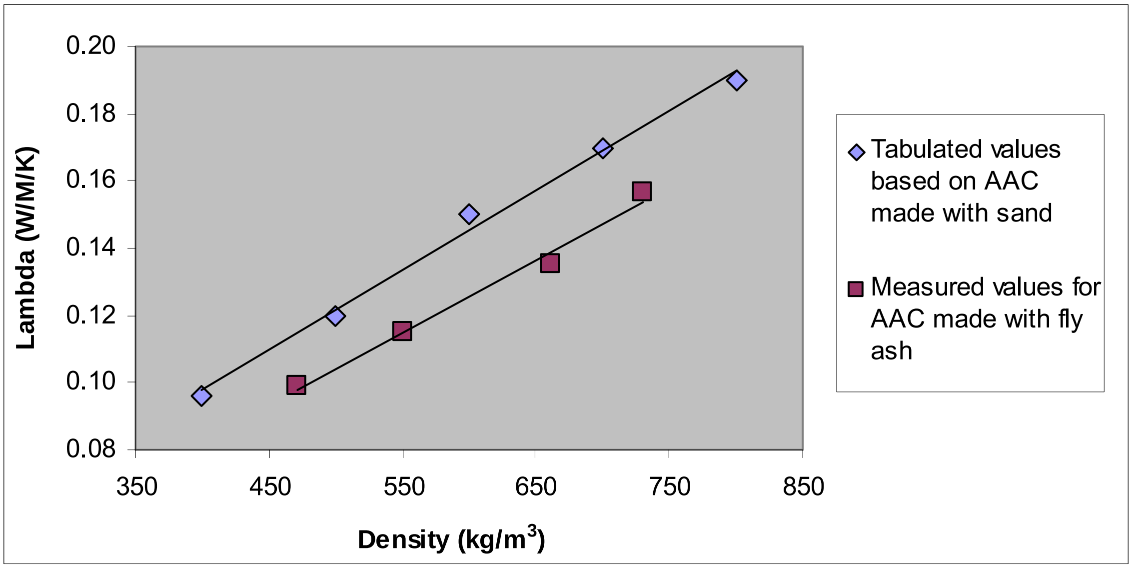

Figure 10 - Thermal conductivity of AAC produced with ground sand and fly ash

Challenges to CCP supply and usage

During the 1980's and 1990's measures were introduced in the United Kingdom to reduce pollutants associated with acid rain. Limits on sulfur and nitrogen oxides (SO_x and NO_x) were introduced for coal-fired power station emissions.

Sulfur capture techniques were introduced at selected stations. However, since this involves the treatment of flue gases, it has no influence on ash properties. In contrast, the introduction of "low NO_x" burners to reduce the proportion of nitrogen oxides has had a significant effect on ash properties. Low NO_x burners were designed to reduce the flame temperature, limiting the oxidation of atmospheric nitrogen. This caused a reduction in combustion efficiency, leading to an increase in the residual carbon content of the ash produced.

Low NO_x burners also give a lower proportion of FBA in the output ash. FBA production has typically fallen from 20-25% of the total ash to 15-20%. The proportion is predicted to fall still further with the introduction of even lower NO_x burners in the future. The properties of the resulting FBA have also changed, becoming finer and softer.[11]

Future environmental legislation is likely to continue to affect ash production and quality, by imposing even more stringent emissions limits. Ammonia contamination of ash may occur if systems such as selective catalytic reduction (SCR) are introduced to further reduce NO_x levels. There is also continual pressure to reduce CO_2 emissions, and older stations without flue gas desulfurisation will eventually be closed, threatening the future supply of quality CCP in the United Kingdom.

Strategies

It may be assumed that greater variability in the properties of United Kingdom run of station ashes can be expected. In particular, carbon contents are likely to increase. Measures to compensate for the greater variability and problematic water demands are considered.

Blending

It is possible to select and blend fly ash from different sources. A high-carbon ash may be blended with a low-carbon raw material to achieve a mix with a satisfactory water demand. However, to be effective a considerable investment in silo storage may be necessary. Haulage costs may rise as ash is obtained from power stations more remote from the factory. Chemical and physical characterisation of each ash source is critical if blending is to be a successful strategy for AAC manufacture.

Beneficiation

Several methods of fly ash beneficiation, to remove unburnt carbon, have been investigated. Techniques worthy of note include burnout using microwaves or conventional ovens, oxidation of carbon using supercritical water, electrostatic separation and wet froth flotation or gravitational separation from slurries. Many attempts at beneficiation have been taken to only experimental or pilot plant scale. Several patents have been filed, but few processes have been commercialised as stand-alone systems.

The RockTron® fly ash beneficiation process is a wet system, with plants registered at two United Kingdom power stations and one ash disposal site[12]. Progress Material's thermal carbon burnout method is operational at two US power stations[13]. However, the most established beneficiation process is the Separation Technologies LLC (ST) electrostatic system. Units have been in commercial operation since 1995 and now a total of twelve have been built in the US, Canada and the United Kingdom. The newest was installed at Didcot A Power Station, near Oxford in 2005.

Inside the separator, the feed ash passes between parallel planar electrodes. The particles become triboelectrically charged by inter-particle contact. The positively charged carbon particles and negatively charged mineral particles are attracted to opposite electrodes and swept away on a moving belt [14].

%	Feed ash	Beneficiated ash
SiO_2	44.4	50.4
Al_2O_3	28.7	33.7
Fe_2O_3	2.47	1.93
CaO	3.91	3.52
MgO	1.93	2.13
TiO_2	1.34	1.44
K_2O	0.47	0.54
Na_2O	0.64	0.49
SO_3	0.89	0.67
MnO	0.03	0.04
Cr_2O_3	0.03	0.02
P_2O_5	0.86	0.85
LOI	14.4	4.26

Table 4 - Analysis of fly ash before and after electrostatic beneficiation

Changes in the chemical composition of fly ash, brought about by electrostatic beneficiation, are shown in Table 4. The elemental analysis of feed ash, with 14% LOI, is compared with a beneficiated product, in which the LOI has been reduced to 4%. The concentrations of most elements increase in the product fly ash. This is particularly notable for silicon and aluminium. However, the amounts of iron, calcium, sodium and sulfur decrease, showing that the levels of these elements are enhanced in the high-carbon fraction. The higher silicon, reduced iron and low carbon are likely to be advantageous for AAC manufacture. The water demand of fly ash is greatly reduced after beneficiation and significant reduction in viscosity is achieved for aqueous slurry of given solids content.

Stockpiles and lagoons

There are large quantities of fly ash deposited in stockpiles throughout the United Kingdom. The UKQAA has estimated that 38Mt of raw material may be available[2]. Experiments and factory experience has demonstrated that fly ash recovered from these stockpiles is generally unsuitable for AAC manufacture.

Problems arise because of the chemical and physical changes that occur to ash particles exposed to water for periods of months to several years. Weathering processes have a profound effect on the fly ash and severely limit its use as a raw material for AAC manufacture. The presence of water and compaction leads to physical agglomeration of ash particles. Exposure to water and atmospheric CO_2 leads to the formation of phases such as calcite, gypsum and ettringite (Fig. 11). Prolonged weathering can lead to some dissolution of the aluminosilicate glass, which constitutes many of the ash particles. An amorphous clay-like material is deposited on the surfaces. The formation of these various reaction products binds discrete ash particles into agglomerates. An impermeable layer forms on the ash particles. This impedes dissolution of silicate ions from the aluminosilicate glass during the autoclaving of AAC. Critically, the formation of calcium silicate hydrates, which bind the intercellular matrix together, depends on the availability of silicate ions. The practical consequence of this reduction in the hydrothermal reactivity of the fly ash is the manufacture of autoclaved aerated concrete with low compressive strength.

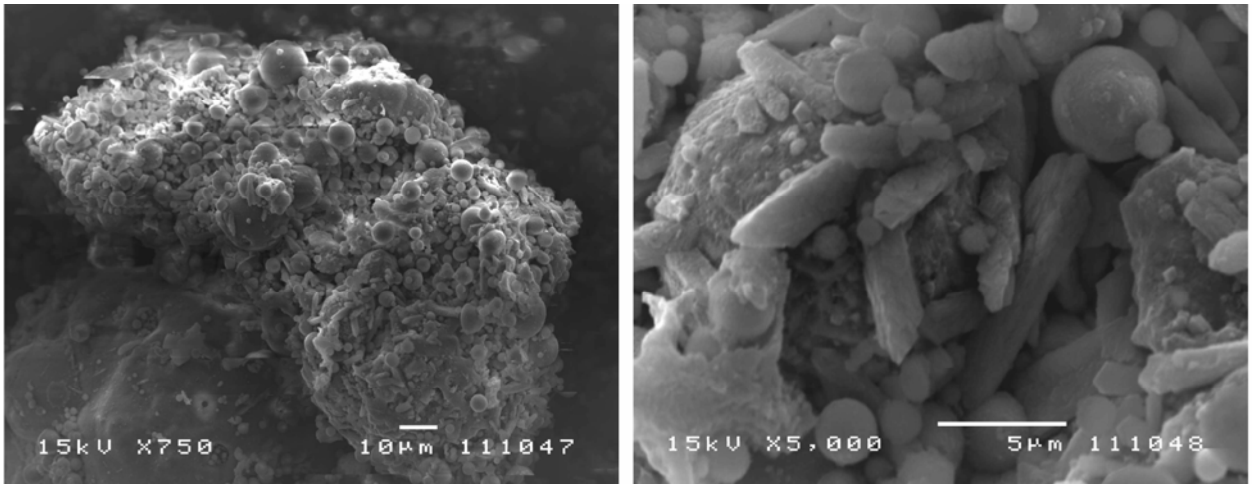

Figure 11 - SEM images of stockpiled fly ash

Agglomeration of the ash gives lumps and "gritty" particles, making handling the raw material troublesome. It is difficult to disperse the fly ash effectively and low quality mixes are achieved. An unsatisfactory cellular structure forms during initial setting and this leads to unstable mixes, which are prone to slumping or collapse. Hanson Building Products has developed methods of processing stockpiles of weathered fly ash to supply raw material for AAC manufacture.

Recovery of FBA from old stockpiles and lagoons may provide a source of lightweight aggregate. Due to its coarseness, weathering of the material is unlikely to have occurred and grading or crushing would be sufficient preparation for block making.

Conclusion

FBA and fly ash are used extensively for the manufacture of precast masonry units in the United Kingdom. Fly ash is firmly established as the main silica source used for the manufacture of autoclaved aerated concrete within the United Kingdom. FBA use in the production of aggregate masonry units is widespread. This is likely to continue, because the benefits of using CCP are considerable, and can be exploited commercially.

Coal combustion products have significant technical and environmental advantages over the main alternatives, such as natural aggregates and ground quartz sand. However, there are challenges associated with their use. These are likely to increase, mainly as the result of environmental legislation at coal-fired power stations, leading to problems such as increased LOI in fly ash and reduced FBA production. Indeed, FBA demand in the United Kingdom exceeds supply, leading to significant import from continental Europe. However, strategies such as blending, processing, and reclamation of stockpiled material can be used to ensure that coal combustion products continue to be viable raw materials for concrete masonry manufacture in the future.

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