Fly Ash

Technical Bulletin 3

Frequently Asked Questions

AshResources
Fly ash products

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General

What is Fly Ash and Furnace Bottom Ash?

The ash carried out with the flue gases in a pulverised coal fired power station is called ‘Fly Ash’.

To prevent the ash polluting the atmosphere, the flue gases are passed through electrostatic precipitators or bag filters to separate the Fly Ash from the flue gases. The Fly Ash is collected in silos from where it is either sold dry for use in concrete or moistened (called conditioning) for less demanding applications such as fill, grouts or as a fine aggregate replacement.

Conditioned ash (PozzSand®) can also be easily transported in open top trucks, which are covered to suppress dust.

Classified Fly Ash is a higher quality grade product, which has been processed a step further by Ash Resources. The ash is passed through equipment called Classifiers from which particles of a specific size range are extracted.

This more highly specified material is marketed under Ash Resources’ brand names: DuraPozz®, DuraPozz® Pro, SuperPozz® and SuperPozz® Pro.

Furnace Bottom Ash (FBA) is an agglomeration of larger particles that were not removed in the flue gases and fall to the bottom of the furnace. FBA is normally extracted wet, graded and sold to make concrete bricks and blocks. Internationally, FBA has gained an excellent reputation as a lightweight aggregate in these applications.

When Fly Ash is referred to as PFA, what does this mean?

PFA stands for Pulverised Fuel Ash and is a misnomer for Fly Ash. Pulverised fuel refers to coal that has been crushed and ground to a fine talcum-like powder. This increases the efficiency of combustion in power station furnaces. The carbon in the pulverised coal burns very quickly (typically within 2-4 seconds) and is completely combusted at temperatures of over 1250^0 C. The sum total of all the ash is PFA i.e. to be correct PFA = Fly Ash + bottom ash.

What are some of the uses of Fly Ash?

Fly Ash can be used in all site-mixed, readymixed or precast concretes. Incorporating Fly Ash in a concrete mix can be achieved by using factory pre-blended cements, in compliance with SANS 50197-1 common cements, or by the concrete producer blending in a concrete mixer.

Cement producers sometimes use Fly Ash in their raw mix for the production of clinker.

In the precast market, conditioned Fly Ash is successfully used as a fine aggregate replacement.

Other applications for Fly Ash include road base materials, flowable fills, waste stabilisation and manufactured coarse aggregate.

In recent years, ultra-fine fraction ash has been used as an inert mineral filler for composite plastics and rubber products.

How much Fly Ash can be put into a concrete mix?

There are no technical reasons why large proportions of Fly Ash cannot be used in certain types of concrete. Having 60-70% of the cementitious content as Fly Ash is, for example, commonplace for mass concrete in gravity dam walls.

The recognised limits to how much Fly Ash can be utilised as part of the binder content are covered in SANS 50197-1 (formerly SABS EN 197 -1) for factory made cements and for mixer blended concretes SANS 10100: Part 2 Materials and SANS 1200G, which provides guidelines on the use of Fly Ash in concrete.

What is the environmental impact of using Fly Ash In concrete?

Fly Ash has three main beneficial effects:

- Using Fly Ash in concrete transforms a waste product from power stations into a valuable by-product.
- Cement producers, as mentioned, can use Fly Ash as a valuable source of alumina and silica in the cement making process, as well as its use in the manufacture of factory blended cements.

Using Fly Ash in these ways reduces the need for the extraction of non-renewable raw materials and also reduces the total energy demand of producing cement. Cement process kilns require high temperatures normally generated using hydrocarbon fuels. Fly Ash blended cements contain less clinker, resulting in less decarbonisation of limestone in the cement kilns – the major source of harmful CO_2 emissions – and, correspondingly, the quantity of fuel burnt in the manufacturing process is also reduced. This also reduces CO_2 emissions.

- When Fly Ash is incorporated in structural concrete there is a reduction in the potential for leaching. The pozzolanic reaction of the Fly Ash reduces the permeability of the concrete effectively preventing any significant leaching from the Fly Ash, the Portland cement or the aggregates.

What specifications do Ash Resources' Fly Ash products conform to?

Ash Resources believes that by conforming to the respective standards and specification for our products we offer our customers 'peace of mind' in terms of product consistency and quality.

Classified Fly Ash - e.g. DuraPozz® and DuraPozz®Pro - complies with:

SANS 50450 -1: introduced in 2011. This covers the definitions, specifications and conformity criteria governing the use of Fly Ash in concrete. Under this new specification, Category "S" denotes a classified Fly Ash with a maximum 12% retained on a 45µm sieve.

ASTM C618: American Standard: DuraPozz® complies with most requirements in ASTM C618, Class F.
SANS 50197-1 - Common Cement Specification: Composition, specifications and conformity criteria for constituents of common cements. When included as a constituent in common cements, the use of siliceous Fly Ash is denoted with a "V".

Unclassified Fly Ash - e.g. PozzFill® - complies with:

SANS 50197-1 - Common Cement Specification: Composition, specifications and conformity criteria for constituents of common cements. In terms of reactive silicates, free lime and loss on ignition (LOI) values, PozzFill® is fully compliant with the standard.

Ultra-fine Fly Ash (UFFA) - e.g. SuperPozz® - complies with:

Category S in SANS 50450 – Part 1.

Technical

What is the difference in chemical composition between Fly Ash and Portland Cement?

A major difference between Fly Ash and Portland cement (PC) is that PC is rich in calcium silicates while its level in Fly Ash is low. High quality Fly Ash is high in reactive silicate glass while PC has none.

Calcium hydroxide is released during the hydration of Portland cement. This calcium hydroxide is a key ingredient in the reaction with the silicates in the Fly Ash to form strong, durable cementing compounds.

Does Fly Ash improve the workability of concrete?

Yes, it is one of the major reasons why concrete producers and contractors like working with Fly Ash mixes. 'Workability' expresses the ease of handling, placing and finishing fresh or 'plastic' concrete. The spherically shaped particles of Fly Ash make a concrete mix workable, enabling a typical water reduction of between 6% and 12% when using classified Fly Ash.

Some benefits of this are:

- Lower slump concrete can be placed more easily because of the better plasticity or higher slump concrete can be produced at the same water content as a CEM I only concrete.
- Segregation and bleeding are reduced because of the increased cohesiveness of a Fly Ash mix. This enhances form finish and sharpness of detail.
- The presence of Fly Ash in a mix allows coarse, clean sands to be used while still achieving good workability.

How does Fly Ash reduce the heat of hydration in concrete?

During the hydration of cement, heat is generated, causing the concrete temperature to rise, which fur ther accelerates the setting time and strength gain of the concrete. In the case of mass concrete, the rapid temperature rise increases the chances of thermal cracking, leading to reduced concrete integrity and durability.

Partially replacing Portland cement with Fly Ash reduces the rate of heat generation due to the pozzolanic reaction occurring over an extended period of time.

What is the impact of Fly Ash on the strength of concrete?

Fine fraction Fly Ash (i.e. classified ash with typically 90% of its particles passing a 45μm sieve), acts as a plasticiser in the concrete. Being spherical in shape, Fly Ash almost acts as ball bearings and reduces the water requirement of the concrete for a given workability. This water reduction and resultant lower water/cement ratio increases the compressive strength.

Fly ash also enhances the strength and overall performance of concrete by the pozzolanic reaction with calcium hydroxide, given off or liberated during cement hydration.

This reaction forms stable calcium silicate hydrate (CSH), transforming the weak crystalline structure to a dense gel-like matrix. By replacing the weak calcium hydroxide in the voids within the concrete, these hydrates increase the strength and reduce the permeability of hardened concrete.
The pozzolanic reaction takes place over time at normal temperatures, resulting in significant strength development at later ages when compared to PC at 112 days and beyond.

Therefore, Fly Ash has a positive impact on the longer term strength of concrete, provided that good site and curing practices are followed.

How does Fly Ash decrease the permeability of concrete?

Fly Ash increases the cementitious compounds in a mix, minimises water demand and the spherical particles fill in potential bleed channels. These factors increase the density of the concrete and give less internal voids with a corresponding reduction in permeability.

How does Fly Ash reduce chloride ingress to concrete?

Not only does the lower permeability of a Fly Ash concrete impede penetration by chlorides - normally in the form of seawater or seashore mist - but chlorides chemically bind to the Fly Ash due to the high aluminate content (3 to 5 times higher than cement).

With sufficient cover, these effects can increase the protection for steel reinforcing by as much as 98%.

How does Fly Ash increase concrete's resistance to sulphate attack?

Fly Ash improves the resistance of concrete to sulphate attack through three main mechanisms:

- The reduced permeability of a Fly Ash concrete minimises penetration of harmful sulphates
- Fly Ash chemically binds the calcium hydroxide in cementitious compounds rendering it unavailable for reaction to form expansive products and preventing gypsum expansion
- Replacing a portion of Portland cement with Fly Ash reduces the amount of aluminates available for sulphate reaction and the formation of ettringite (expansion)

How does Fly Ash decrease the alkali/silica reaction?

Some aggregates contain reactive silica that can react with soluble alkalis, such as the free lime in cement. The reaction products are voluminous and can create destructive expansive forces.

When Fly Ash is incorporated in a mix, it reacts chemically with the alkalis and calcium hydroxide liberated by cement hydration so that they are unavailable for subsequent formation of expansive products by reaction with a potentially reactive aggregate.

The potential damage from the alkali/silica can be serious. In addition to causing the concrete surface to disintegrate, interior stresses may occur which can cause sufficient cracking to critically impair the structural integrity of the concrete and allow the reinforcement to corrode.

Including a minimum of 20% Fly Ash in the mix will usually reduce the reaction sufficiently to protect the concrete and steel reinforcement from these forms of deterioration.

Can Fly Ash be used in mortars and plasters?

Yes! Plasters and mortars made with Fly Ash as part of the binder are however slower to develop strength and need to be cured correctly in line with good site practices.

In cold weather, strength development at early ages will be protracted as is the case with most sand/cement mixes containing blended cements or other extenders.

It is important to have a clean sharp sand in the mix, as often fine clayey sands are used for economic reasons. These sands lead to plasters/mortars of poor strength that are prone to crack and craze. *(SACAA report - South African fly ash: A Cement Extender by J.E. Kruger).*

Some benefits of using Fly Ash in mortar and plaster:

- Water reducing properties at a given workability
- Better water retention than Portland cement (PC) mortar
- Better resistance to the elements than PC mortar
- Lower drying shrinkage

Fly Ash, when used in mortars and plasters, will therefore not have detrimental effects on the subsequent plastic or hardened properties.

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JAN 2024