FLY ASH POWDER

AN ULTIMATE STRENGTH-INCREASING (POZZOLANIC) POWDER ADDITIVE FOR CONCRETE, MORTARS, GROUT, OTHER PORTLAND CEMENT-BASED MIXES & POTENTIALLY, AS A LOW COST, SPHERICAL PARTICLE EXTENDER/MODIFIER/INERT FILLER FOR COATINGS, ADHESIVES, PLASTICS & OTHER COMPOSITE MATERIALS.

Ability's Fly Ash powder is a fine siliceous dust selectively collected in Australia from the controlled combustion of pulverised black coal. During the combustions process, the bulk of the particles formed are microscopic spheres. Light grey in colour, the particles are generally finer (85% pass a 45 μm screen) and are of a much more rounded particle shape than Portland cement.

In the presence of hydrating Portland cement, Ability's Australian Fly Ash powder behaves like a secondary cement by reacting slowly at ambient temperatures with Calcium Hydroxide (lime) liberated during these long-term hydration reactions of water with cement.

Chemically, the spherical particles of Ability's Fly Ash are composed mainly of glassy compounds of silica, alumina, iron and calcium. The product can be regarded as virtually inert and therefore may, after adequate testing be suitable for incorporation into coatings, plastics, adhesives, rubber and other composite materials as a non-hiding, light grey extender/filler pigment at low cost.

Inclusion of Fly Ash in Portland cement-based plastic concrete mixes improves concrete workability whilst also reducing the water content for a given consistency. The spherical particles create a 'ball bearing' effect in the mix – thus improving workability. Fly Ash particles also fill voids in the mix which reduces the water requirement for a given plastic consistency. Workable Fly Ash concrete, places easier, finishes better and produces better 'off-form' surfaces than plain Portland cement concrete. For use in concrete, Fly Ash is referred to as a 'supplementary cementitious material'.

ADVANTAGES & BENEFITS:

Although Fly Ash has been in use for about half a century, it is only in the last 20 years that modern technology, with advanced quality control measures have made it a reliable material suitable for a variety of construction and industrial applications.

The variations in the day-to-day running of power stations and inconsistency in the raw feed sometimes experienced in earlier years has been overcome with the implementation of modern quality control techniques.

TEST FIRST BEFORE ACTUAL USE — TRIALS ARE ESSENTIAL.

The selective collection of Fly Ash and its classification to a controlled level of fineness and loss on ignition has resulted in a product able to be specified and used with confidence.

Although Fly Ash has been used in mass concrete for about 50 years, and in structural concrete for about 30 years, there is no evidence of any detrimental effects in the concrete itself or to the steel reinforcement, which can be demonstrated to be caused by the use of Fly Ash. In fact, there is evidence that shows many beneficial of its use in construction applications over many years.

The use of Ability's Fly Ash in Portland cement based concrete can significantly enhance the performance characteristics of the final product. Additionally, the dose rate proportion for Portland cement, ranges from 15% to 30% replacement in pre-mixed concrete and 20% to 50% with autoclave during in concrete blocks, bricks and pavers for a given ultimate compressive strength which lowers the cost of production.

FEATURES:

Fly Ash may be effectively used as a supplementary cementitious binder component (partial cement replacement) and/or for partial fine aggregate replacement in Portland cement concrete, as well as in bituminous (asphaltic) concrete and other pavement materials.

In freshly mixed concrete, Fly Ash enhances workability and reduces voids, allowing unit water content (or the bitumen binder content in bituminous concrete) to be reduced.

PUMPED CONCRETE:

Highly pumpable concrete using Ability's Fly Ash can usually be produced more economically.

In the presence of moisture, following concrete placement and compaction Fly Ash reacts with lime to produce complex hydrated metal silicates and aluminates similar to those formed in the hydration of Portland cement. It may therefore be referred to as a secondary hydration reaction product.

The lime source may be the Fly Ash itself, added hydrated lime or Quicklime powder or the hydrated lime by-product from Portland cement hydration.

SPECIFIC BENEFITS:

In plastic concrete:

- ☑ Reduced water requirement for a given plastic consistency.
- ☑ Reduced bleeding of mix water to the surface and the reduction or elimination of segregation of the aggregates from the cementitious paste.
- ☑ Easier placement and improved workability.
- ☑ Improved pumpability, extrudability and spray ability.
- ☑ Improved finishability.

In hardened concrete:

- ☑ Greater ultimate mechanical strengths.
- ☑ Reduced drying-shrinkage and creep (volume deformation under sustained load).
- ☑ Reduced permeability to liquids.
- ☑ Increase resistance to sulphate attack from sulphate containing ground waters.
- ☑ Enhanced resistance to alkali aggregate reaction (AAR) and subsequent sporling.
- ☑ Lowered heat of hydration to prevent cracking in large volume, mass pours.
- ☑ Increased resistance to freezing and thawing degradation.
- ☑ Less potential for efflorescence (we recommend the use of Ability's **'EFFLOREIN®' Mark 2** powder for greater control of efflorescence – leached, white salt crystalline bloom).
- ☑ Greater resistance to acids and chemical attack.

A concrete mix designed to incorporate Fly Ash combined with the process of curing, ensures final concrete that is more durable, denser and has, subject to the quality and skill of the site processors/finishers, a better surface finish whilst providing significant savings and cost advantages.

A properly designed mortar or concrete mix as well as the utilisation of Ability admixtures such as **'EFFLOREIN®' Mark 2** in combination with Fly Ash will further enhance the specific benefits for you.

An understanding of the beneficial complementary relationship between Fly Ash and Ability's range of admixtures is extremely important to the end user. In order to obtain the maximum benefit from the use of supplementary cementitious materials in concrete, it is often necessary to also use appropriately formulated admixtures. Similarly, in many concrete mix designs employing admixtures, the use of Fly Ash is considered by many concrete technologists to be almost essential.

The integration of Fly Ash and Ability admixtures in a concrete mix, backed by Ability's expertise and technical support will help produce the optimum concrete performance. This ideal performance is particularly relevant in terms of workability and finishing, and combined with the process of preventing the evaporation of the mix water (curing) after finishing, to the concrete's strength, abrasion resistance and durability achievable.

PROPERTIES	REQUIREMENTS OF AUSTRALIAN STANDARD AS 1129-88 'SUPPLEMENTARY CEMENTITIOUS MATERIAL	TYPICAL RESULTS	
		PRIMARY FLY ASH	CLASSIFIED FLY ASH
Residue: 45μm sieve)	50% maximum	30% maximum	15% maximum
Loss on ignition % maximum	-	4.0 ± 2.0	3.5 ± 1.5
Sulphuric Anhydride (SO_2)	2.5% maximum	0.3	0.3
Bulk density kg/m³	-	1980 ± 40	2040 ± 40
SG (true density)	-	2.13	2.13
pH (10% aqueous solution)	-	9.7	9.7

USES:

For Portland cement based structural members, concrete pavements and all concrete products.

Also as a cost lowering, binder reducing and abrasion resisting additive for plastics, paints, adhesives, rubber etc, virtually all types of mortars/grouts, floors, screeds and toppings etc. In bituminous concrete, slab-jacking, soil stabilisation, mine shaft fill, filtration, as a plastic consistency improving additive for baked clay products etc, road base, in embankment construction, as well as for back fill etc.

It should be fully evaluated before actual use in paints and membranes, cementitious paints and as a low cost extender/filler in plastics and other composites materials.

METHOD OF USE IN CONCRETE:

The effects of the addition of Fly Ash to concrete will vary. Individual situations will be influenced by the type and amount of admixtures used, the degree of freshness and type of cement, the aggregates and their gradation, the mixing time, the concrete temperature plus the hardened concrete strength requirements of the mix design.

- Under ideal curing conditions, such as when a good curing compound* is applied to freshly placed concrete, *immediately* after the final finishing operation, up to 30% Fly Ash may be used as a direct replacement for Portland cement in concrete.

- Where retention of early age strength is vital and/or the fine aggregate is deficient in fines, it is normal to adopt the replacement-addition method where part of the Fly Ash is used as a sand supplement. Sand batch weights are adjusted to control the volume yield of the concrete.

It is difficult to outline all the possible variables of the use of Fly Ash in this data but our representatives have been trained to assist and nominate the appropriate approach for each situation as it arises. Please contact us for specific assistance.

STORAGE:

Ability's Fly Ash powder is available in multi-wall bags of 25kg net. It is also available on firm advance order in 'Concrete-Friendly®' degradable bags for easy, convenient use in pre-mixed concrete.

* **'Duro-Seel'** liquid, 'turps' based rubber resin curing compound, sealer, stain is available in clear and colours

Bulk Fly Ash must be stored in weather-tight bins or silos. In compartmented bins/silos, precautions should be taken to ensure that no leakage is possible from one compartment to another.

TRANSFER:
Ability's Fly Ash, having a rounded, spherical particle shape is, when aerated, an extremely fluid powder and may be made to flow easily through scew conveyors. The use of air slides and fast acting valves has proven to be the best method of transferring the product from silos to weigh hoppers.

BATCHING:
Fly Ash is normally batched through the cement weigh hopper. A sequence of cement first and Fly Ash second is recommended.

SAFETY:
Dust from Fly Ash is regarded as an 'inert dust' as far as any respiratory effects are concerned. However, no person should be continuously exposed to concentrations of respirable dust exceeding 5mg/m³ of air. The use of suitable face masks and eye protection is therefore highly recommended.

CIVIL ENGINEERING WITH ABILITY'S HIGH PERFORMANCE FLY ASH:
Ability's high performance Flay Ash is of potential interest to the civil engineer both in the broad area of soil stabilisation and in Portland cement concrete.

SOIL STABILISATION:
There are two primary mechanisms by which soils can be made more suitable for engineering applications:

1. Improvement of the soil's inherent properties, such as decreasing its plasticity index and volumetric shrinkage.

2. Cementation of the individual soil grains to produce an increase in both strength and durability characteristics as well as a decrease in permeability.

Currently accepted practices for achieving these two mechanisms are cement stabilisation of coarse grained soils and lime stabilisation of highly plastic clay soils.

Coarse grained materials with plasticity indices of less than 25, in most cases can be stabilised effectively and economically with lime-Fly Ash or cement-Fly Ash mixtures. From a brief review of the current relevant literature, it will become evident that Fly Ash or cement-Fly Ash mixtures have become accepted as a construction material. Fly Ash has also been used most successfully with lime in conjunction with non-pozzolanic clay.

PAVEMENT:
Although the civil engineer fraternity may be a little more conservative than others, and rightly so, bit increases have been made in the use of Fly Ash in pavements. Such uses range from the medication of granular sub-bases to improved gradation, through a multitude of pozzolanic pavement materials involving cement, hydrated lime and/or flue dusts, to the more conventional Portland cement concrete base and sub-base materials.

Ironically, in Australia, upside-down pavements are not uncommon, where a granular base overlies high Fly Ash sub-base concrete. This type of sub-base is also used with a more traditional high strength, highly abrasion resistant concrete 'wearing' course.

These sub-grade concretes typically contain more than 200kg of Flay Ash per m³ with about 80kg of cement. Such concrete can be placed by a paving train or may be roller-compacted in smaller pavement works.

In wear resistant concrete courses where as much as 30% of the cement is replaced by Fly Ash, design strength can be attained at critical ages by specifying the technique of addition/replacement quantities in the mix design.

Benefits derived from the inclusion of high performance Fly Ash in concrete pavements include:

- ☑ Improved workability, placeability and finishing.
- ☑ Reduced segregation and bleeding.
- ☑ Enhanced resistance to ground waters (acids or sulphate) and de-icing salts.
- ☑ Minimised alkali/aggregate reaction.

CONCRETE WORKABILITY:

It is generally agreed that Fly Ash increases the workability of plastic concrete. However, concrete workability is a complex subject and is not readily defined by standard tests. It involves the ease of handling, transportation by pump, placing, compaction and finishing of plastic concrete. The 'water of convenience', in excess of that required for cement hydration, is the major contributor to concrete workability in ordinary Portland cement mixes. This 'excess' water has a highly detrimental influence on hardened concrete strength and durability at all ages! As with *all* concrete, a 'keen eye' should be kept by all concerned in effecting the preferred use of *low* water:cementitious material ratios at all times. Fly Ash assists in this important quality requirement.

CONCRETE SHRINKAGE & CREEP:

Various investigators have reported that Fly Ash concretes shrink and crack *less* upon aging than do plain concretes – particularly when a liquid curing compound confirming to Australian Standard AS3799-1990 'Liquid Membrane-Forming Curing Compounds for Concrete', is applied (in a single layer *immediately* after the final set on the *same* day as placement) to all surfaces of the concrete in place exposed to air.

Also, concretes containing relatively high percentages of Fly Ash shrink less than those with small amounts. With 30% replacement of cement with Fly Ash, Tuthill reports a 10% reduction in 'drying' shrinkage at one year.

Similar results were obtained by Alexander et al with regard to creep. Such findings are not unexpected when it is known that a prime factor in creep and shrinkage is the water content of the freshly mixed concrete and that Ability's high performance Fly Ash, preferably together with Ability's admixture **'EFFLOREIN® Mark 2** powder is a most effective aid to water reduction for a given slump in concrete.

HEAT OF HYDRATION:

As concrete hydrates, heat is generated. This heat assists with the development of concrete strength but can cause thermal cracking and disruption in mass concrete (eg raft slabs, dam construction etc). Concrete can be designed using Fly Ash with substantially lower heat of hydration – heat generated by the secondary hydration reaction will be about half that of the cement replaced and will occur later in the curing cycle, further reducing the early temperature rise. This permits larger placements and greater speed of construction.

THE IMPORTANCE OF CONCRETE CURING:

Some believe that Fly Ash concrete requires more efficient curing than plain concrete. This is not necessarily true. However, obtaining the full strength and durability potential from any concrete mix, regardless of the specific ingredients, is *always* dependent upon proper and adequate curing processes. At low cement levels in low strength mix designs, plain concrete may be slightly more tolerant of poor curing than Fly Ash concrete, but poorly cured low strength concrete is seldom satisfactory in performance anyway.

The most critical period for moisture evaporation prevention (continuous curing) of concrete is the first three to seven days. Concrete which retains its optimum amount of mix water during its early life, is better able to cope with abuse at later ages. If neglected and allowed to dry out during the critical early period, concrete *cannot* reach its full strength and durability potential.

In concrete the combination of Ability's Fly Ash with **'EFFLOREIN® Mark 2** water reducing, multi-functional admixture, plus the specified and adhered to use of Ability's 'Duro-Seel' liquid film-forming curing compound are all positive steps towards the production of more durable concrete. This statement is based on the premise that virtually any ethical brand of concrete admixture that causes a water reduction for a given slump or consistency, plus the retention of that reduced water content after finishing within the concrete, is highly beneficial for the durability and service conditions required of it when hardened.

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