Ash Development Association of Australia

GUIDE TO THE USE OF FLY ASH IN CONCRETE IN AUSTRALIA

FLY ASH REFERENCE DATA SHEET No. 1
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INTRODUCTION

Fly ash has been used in concrete in construction projects in Australia since the early 1960's (1, 2). Improvements in workability, mix efficiency (with regard to binder optimisation) and improved concrete placement characteristics have largely driven the use of fly ash in concrete since that time (3, 4). Determination of the economically - optimum binder proportion when using fly ash has been undertaken in various ways since that time (5). With the availability of quality fly ashes in Australia, significant benefits have been derived through optimising fly ash contents in concretes. Published examples of this are available in the literature (6). This material has been used to develop concretes that provide efficient solutions to complex design and constructional requirements, examples inclusing concrete for the World Tower building in Sydney, the Q1 Tower on the Gold Coast and many conventional buildings involving both normally reinforced concrete and post-tensioned concrete (7, 8). With the wider availability and use of fly ash, Australian standards for the material and its use in concrete have undergone change and now better reflect the capability of this material.

Fig 1: The Sea Cliff Bridge: an award-winning project involving the effective utilisation of Coal Combustion Products.

FLY ASH IN AUSTRALIAN STANDARDS

Specification and Design

The Building Code of Australia is produced and maintained by the Australian Building Codes Board on behalf of the Australian Government and State and Territory Governments. It largely defines requirements for building regulations in Australia. This code calls up Australian Standard AS3600 (Concrete Structures) to specify minimum requirements for the design of concrete structures (9). AS3600 further references Australian Standard AS1379 in regard to the specification and supply of concrete (10). AS1379 nominates Normal Class Concretes for more generalised applications of concrete and Special Class Concretes for all other concrete applications. In relation to fly ash, AS1379 references two commonly used standards, namely: AS3582.1, Supplementary Cementitious Materials for Use With Portland and Blended Cement, Part 1 – Fly Ash (11), and AS3972, Portland and Blended Cements (12).

Fly Ash in AS3582.1

Australian Standard AS3582.1 sets out the requirements for fly ash as a cementitious material in concrete and mortar (11). Fly ash has been defined as a "solid material extracted from the flue gases of a boiler fired with pulverised coal". There are two grades of fly ash nominated in this standard, Normal Grade and Special Grade. The criteria for classification of fly ashes are based on tests described in various parts of AS3583 (13) with key specified requirements noted below:-

- Fineness (% passing the 45 micron sieve),
- Loss on ignition,
- Moisture content, and
- SO_3 content.

In addition to the above, AS3582.1 lists the following as reportable properties:-

- Available alkali content,
- Relative density,
- Relative water requirement,
- Relative strength, and
- Chloride ion content.

Special Grade Fly Ashes, commonly referred to as ultrafine fly ashes, have much the same properties as fine grade fly ashes with the additional requirement of achieving 105% for Relative Strength when tested in accordance with AS3583.6. In general, Special Grade Fly Ashes are either specifically selected from power station precipitator banks that collect finer material from the flue gases, or are collected and post-milled or classified to produce a fine product conforming to the AS3582.1 definition. A summary of the above classifications is given in Table 1.

Property	Fineness % passing 45_sieve	Loss on ignition	Moisture content	SO_3 Content	Relative strength
Spec.	% min	% max	% max	% max	% min
Standard Test Method	3583.1	3583.3	3583.2	3583.8	3583.6
Fine	75	4.0	1.0	3.0	-
Medium	65	5.0	1.0	3.0	-
Coarse	55	6.0	1.0	3.0	-
Special	75	4.0	1.0	3.0	105

Table 1: Classification (Grading) of Fly Ash in AS3582.1 (11)

The Role of Fly Ash in Portland and Blended Cements in AS3972

The Australian Standard AS3972 definition for Portland cement clinker is "a partially fused product resulting from the mixing of calcareous and argillaceous or other silica, alumina, or iron-bearing materials or combinations of these materials, and burning them at clinkering temperatures" (12). It further defines "mineral additions" as selected fly ash, ground granulated iron blast furnace slag (slag), limestone or combinations of these materials (12). A Portland cement is defined as a combination of Portland cement clinker, calcium sulfate and containing up to 5% mineral addition. The Standard defines blended cement in a similar way to Portland cement but having greater than 5% fly ash, slag or both.

The Standard nominates the following cement types in its classification:-

- Type GP – General Purpose Portland Cement
- Type GB – General Purpose Blended Cement
- Type HE – High Early Strength Cement
- Type LH – Low Heat Cement
- Type SR – Sulfate Resisting Cement
- Type SL – Shrinkage Limited Cement.

Each of the above cements have further requirements for compressive strength, soundness and SO_3, as well as peak temperature, expansion and shrinkage as defined by Standard mortar tests where appropriate (14).

Fly Ash in AS1379 and the Definition of "Cement"

In AS1379, the term "cement" is defined as a hydraulic binder composed of Portland or blended cement used alone or combined with one or more supplementary cementitious materials. Fly ash, therefore, fits within the definition of cement in AS1379 and can be incorporated into Normal or Special Class Concrete either as a blended cement, or added directly into the concrete at a batch production facility. There are also more specific requirements for compressive strength, workability and other fresh and hardened concrete properties in this Standard (10). The use of fly ash and other Supplementary Cementitious Materials (SCMs) in concrete is limited in AS1379 by the requirement of a minimum 7 day compressive strength for the different grades of Normal Class Concrete.

A summary of the relevant codes and standards for fly ash for use in concrete in Australia and their relationships is presented in Fig. 1.

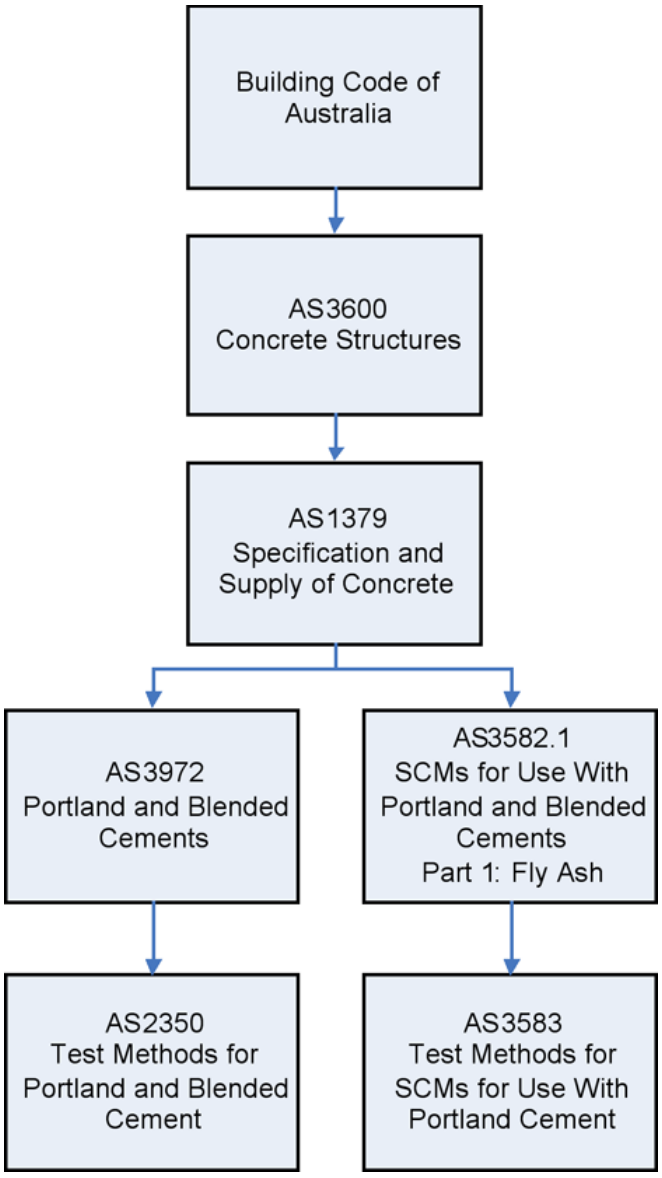

Fig. 2: Codes and Standards Relating to Fly Ash for Use in Concrete and Mortars in Australia

OPPORTUNITIES WITH USING FLY ASH IN CONCRETE

On the basis of the Australian Standards definitions for fly ash, the opportunities for using the material and concretes are as follows:-

- At less than 5% as a mineral addition in a portland cement
- At less than 5% as a mineral addition in a blended cement where fly ash is not otherwise used in the blend
- At greater than 5% in a blended cement
- By direct addition into AS1379 Normal Class Concretes (20 MPa, 25 MPa, 32 MPa, 40 MPa and 50 MPa grades) to levels where minimum 7 day compressive strength requirements are achieved.
- By direct addition into AS 1379 Special Class Concretes where imposed performance requirements are achieved.
- Use of Special Grade Fly Ashes (AS3582.1) in Normal and Special Class Concretes (AS1379) to achieve specific project outcomes.
- Use of combinations of Normal Grade and Special Grade Fly Ashes (AS3582.1) in Normal and Special Class Concretes (AS1379) to achieve project outcomes.

Fly ash is a valuable product that will allow efficient design and construction solutions in areas such as:-

- Plastic concrete
  - Workability enhancement
  - Placement and finishing efficiency
  - Pumping efficiency
  - Reduced concrete water demand

- Hardened concrete
  - Engineering design efficiency
  - Reduced drying shrinkage where lower water demands are achieved
  - Increased long-term compressive strength development

- Durability and other properties
  - Increased sulphate resistance
  - Increased chloride resistance
  - Increased resistance to alkali-silica reaction
  - Achieving greater sustainability with supplied materials.

CONCLUSIONS

High quality fly ashes have been available in Australia for some 30 years and their use has increased in concretes during that time. There are many grades of fly ash that are now available and their application in concrete is widespread. This area has become increasingly complex with time as more information on fly ash and its use has becomes available. It is hoped that this guide provides producers and users of the material a framework by which increased benefits can be derived with continued fly ash application.

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