Challenges contemporizing Australian Standards: Supplementary Cementitious Materials

Craig Heidrich

1Ash Development Association of Australia, Suite 2 – Lvl 1 –336 Keira Street Wollongong, NSW Australia

KEYWORDS: Australian Standards, internationalization, fly ash, slag, amorphous silica

ABSTRACT

The review of Australian Standards AS 3582, Part 1 – 1998 (Fly ash), Part 2 – 1991 (Slag – Ground granulated iron blast-furnace) and AS/NZS 3582, Part 3 – 2002 (Amorphous Silica) commenced in 2011 aimed at contemporising these material Standards of which selected standards have not been reviewed for more than 20 years.

In planning and undertaking this review process, a major function was to consult with, and seek the views of, major stakeholders prior to the commencement of the formal Standards review, through Standards committee BD-031. A collaborative pathway with Standards Australia was funded to achieve the review.

The review process included various producers, manufacturers and suppliers of these materials being consulted through the key industry association stakeholders. Considerable energy was spent on reviewing the existing national standards, elaborating proposed changes, collating supporting information for those changes and consulting across the appropriate membership groups to ensure alignment across the supply chain (generators, process and consumers). A review of international standards was undertaken to compare and contrast standards and test methods to ensure Australian standards are aligned, where appropriate.

The purpose of this paper is to inform of the work of Standards Committee BD031 which commenced in July 2014 on changes to Australian Standards AS 3582, Part 1 – 1998 (Fly ash), Part 2 – 1991 (Slag – Ground granulated iron blast-furnace) and AS/NZS 3582, Part 3 – 2002 (Amorphous Silica), rationale and supply uncertainty issues.

INTRODUCTION

Large-scale use of coal in power generation gives rise to significant quantities of coal combustion products from which important ‘hard won’ end use markets have been established after many years, i.e. cement and concrete. The earliest recorded use of fly
ash to enhance the properties of concrete occurred in the 1930s by the Cleveland Electric Illuminating Company based in the USA (Abdun-Nur 1961).

Existing and proposed end use markets for coal combustion products (CCPs) are not only of critical importance to the economics of power generation, but also to the established supply chain participants which have invested, researched, developed and promoted CCPs use into various applications, for example the construction sector use large quantities of CCPs. (Heidrich et al, 2013) reported globally, the continued growth in utilization of CCPs is dependent on many factors beyond the quality and characteristics, e.g. security of supply.

Appropriate legislation and regulation coupled with the development of international classification systems, standards and codes of practice are only a few of the important enablers for easing the way towards increasing utilization and securing the ‘legal certainly’ for continued investment. Maintaining contemporary standards are essential to functional supply chains (Heidrich et al, 2014).

CONTEMPORIZING AUSTRALIAN STANDARDS

Focusing on Standards within Australia, a review of Australian Standards AS 3582, Part 1 – 1998 (Fly ash), Part 2 – 1991 (Slag – Ground granulated iron blast-furnace) and AS/NZS 3582, Part 3 – 2002 (Amorphous Silica) commenced in 2011 aimed at contemporising these material Standards of which selected standards have not been reviewed for more than 20 years. These supplementary cementitious materials (SCM’s) account for more than 30 percent of all cementitious materials used in the Australia (ASA, 2013, ADAA, 2013, ASiAA, 2013).

In planning and undertaking this review process, Standards Australia strongly encouraged the stakeholder Association’s to consult with, and seek the views of, major sectors prior to the commencement of the formal Standards review, through nominated representatives to Standards committee BD-031. The stakeholder Association’s funded a collaborative pathway.

The review process, prior to submitting the ‘Project Proposal’ was conducted over two (2) years, during which time the various, generator, processor and suppliers of these materials were consulted through the respective industry associations of Ash Development Association of Australia (ADAA), Australasian (iron & steel) Slag Association (ASA), Amorphous Silica Association of Australia (ASiAA) and Cement Concrete Aggregates Australia (CCAA).

During this period considerable effort was committed to reviewing the existing documents, elaborating proposed changes, collating any supporting information for those changes and consulting across the appropriate membership groups to ensure alignment within the supply chain. In particular, changes in use and availability of materials meeting the requirements of AS 3582, was undertaken to understand the changing supply chain practices and emerging capacity constraints.
EMERGING CAPACITY CONSTRAINTS

Over the last decade, a number of changes have occurred in the coal-fired power generation sector that has impacted on CCPs production volumes (supply), physical and chemical characteristics (quality), and environmental legislation. These changes include: modifications to coal-fired power generation plants to reduce emissions (in-boiler and post combustion); the development of more fuel-efficient and more operationally flexible boiler plants; fundamental changes to the basic combustion process to prepare for carbon-capture technologies (for example oxyfuel combustion); changed legislative operating environment, e.g. impost of carbon tax, renewable energy targets, alone or together impacting of base load demand as reported by (Heidrich, 2013) and more recently the continued privatization of the public power generation.

Being by-products of coal fired power generation, CCPs in particular fly ash as defined in AS3582.1, has come under increased scrutiny for intermittent supply and quality issues in selected regions by major consumers. These regional shortages have raised concerns about changing economic impacts and practices of ‘rationing’ fly ash, from what is generally considered an abundant resource (ADAA, 2013). This supply uncertainty has resulted in major consumers conducting adhoc reviews of key specifications where, SCM’s have secured hard won inclusions.

SUPPLY UNCERTAINTY

Increasingly major consumers of CCPs report concerns regarding ongoing supply and availability issues across Australia. Examples of statements by major users such as “...these supply shortages are unacceptable and costly.....there clearly will be no [fly] ash available in 5 years as all power stations are shut down”.... “we [major user] need to consider alternative materials for projects if these shortages continue” and “.... we [major concrete pavement construction company] are aware of supply constraints on fine grade fly ash and are concerned about specifying fly ash in upcoming projects” . These are just some examples of conversations with major consumers.

On investigation of these supply shortages claims during interviews with selected generator(s) advised they had undertaken various unplanned capital works (maintenance programs) with power stations units being placed into shut down, accordingly impacting on regional supply of graded fly ash. Given the planned nature and limited supply chain inventory associated with fly ash shortages had occurred. In isolation (one site) these activities would have limited impact, however in combination (multiple sites) these events seem to have resulted in what has been termed by major consumers that supply (cement and concrete) companies are ‘rationing’ fine grade fly ash, from what is an abundant resource.

Questions arising from this preprimary investigation identified the following questions

Q. Is fly ash rationing occurring?
Q. What are the facts about continued coal fired generation and accordingly coal combustion products supply?
Q. Has coal fired generation capacity reduced i.e. Stations closed, resulting in shortages?
Q. Are there capacity constraints and if so what capacity for other various grades exist and what is the role for the Standards review?

The first question.. *Is fly ash rationing occurring?*.. is fraught with difficulties in determining, moreover uncovering the facts. The role of collection, processing and distribution of fly ash is primarily controlled by companies owned or operated by cement companies, with a few exceptions. Requests for details are treated as commercial in confidence. Accordingly, no reliable analysis can be conducted on this question by the author. The remaining questions can be addressed using available primary and secondary data of the Associations to determine the facts about production and capacity to produced fine grade fly ash, moreover possible corrective measures and amendments to Standards.

**PRODUCTION AND CAPACITY ANALYSIS**

Fortuitously a ‘Production and Capacity Analysis’, albeit limited in scope was undertaken, as part of the Cement Industry Action Agenda (DTIR, 2006), with the primary objective being to understand current coal fired generation capacity, fuel burned, coal combustion product generated and total stored which could be exploited by the cement industry. The analysis has been expanded and completed again in 2011 and 2013 providing some historical comparison and insights into changes for fly ash production; furnace bottom ash production; production capability for - Graded (fine), Ungraded (coarse & medium) and furnace bottom ash.

The production and processing capability stated in Table 1 is based on installed site design infrastructure capability at 100% utilisation. For example ‘Generation Capacity’ is the total MW installed for a given operating site at a given point in time, where as ‘CCP Generated’ is a function demand for energy i.e. ‘Coal (fuel) Burned’ x apparent ash content of coal. ‘Fly Ash Graded Capability’ means where processing capacity exists onsite to collect, capture and load vehicles with fine grade fly ash (AS3582.1). ‘Fly Ash Ungraded Capability’ means where processing capacity exists onsite to collect, capture and load vehicles with ungraded fly ash (1 to 300um). See Table 1 – Capacity Analysis 2006 to 2013.
Table 1 – Capacity Analysis 2006 to 2013

OBSERVATIONS FROM THE ANALYSIS

Since 2006 total coal fired power generation capacity installed mega watts (MW) has decreased by 441MW or -1.5%. Plant maintenance upgrades to capacity at various sites across Australia, less closure of older plant having been retired during the period. Retired sites were not identified as significant supply sites for fine grade ash. To summarise no significant change to install power generation capacity has occurred.

The overall reduction in coal (fuel) used on the base line (2006) equates to 20 million tonnes or 15.5% reduction. Reduced fuel used means less total energy (MWh) being generated by coal fired power generation. In other words there is less demand for energy from coal with demand gaps being primarily filled by other renewable sources, driven mainly by government incentives and regulation, e.g. Renewable Energy Targets.

Interestingly, while there has been a reduction in total fuel used, coal combustion products generated have increased slightly by 0.540 million tonnes or 4%. This is consistent with trends identified in annual membership surveys that coal fired generator are using more marginal thermal coal sources with higher ashing contents - a trend that continues here and overseas. So in real terms, whilst energy from coal has reduced by some 15%, fly ash production has remained mostly unchanged over 10 years.

Focusing on graded\(^1\) materials, capacity is reported at 2.5 million tonnes concentrated within NSW and QLD within two (2) power station sites. Whilst no data was captured in 2006, no significant change has been observed over the period. CCP used in cement and concrete applications for the 2013 was 1.6 million tonnes or 61% and in 2011 some 2.1 million tonnes or 81% of capacity utilised. Some possible factors attributed to a supply constrains;

\(^1\) Fine Grade Fly ash -- Australian Standards AS 3582, Part 1 – 1998 (Fly ash)
High concentration (> 60%) of fine grade (Graded) processing capacity centralized into limited coal fired power stations. Any unplanned interruptions in fly ash production will quickly translate to shortages.

- No significant additional processing capacity for graded (fine) fly ash has been added in over 10 years.
- Limited to no evidence of supply chain demand planning to compensate for low inventory capacity. Contributing factors to reduced volumes.
- Renewables and lower emissions fuels being used in preference to coal.
- Current Standards limit capability to use ungraded fly ash, where performance could be demonstrated.

Installed coal fired power generation capacity and accordingly coal combustion products have not changed significantly in over ten (10) years, however capacity constraints for processing of fine grade ash have featured over the period through selective unit shut downs with sites where more 60% of processing capacity exists. Capacity for 3.7 million tonnes of ungraded materials has been installed over the past 10 years, but this material is poorly exploited by the current Standards. The question arises what is the role for the Standards review?

**ENABLING FUTURE CHANGE**

The first change is in the title, and this change is proposed for all of the parts of AS 3582. The previous AS 3582 documents are entitled “Supplementary cementitious materials for use with Portland and blended cements”. The current proposal is to limit the title to “Supplementary cementitious materials”. There has been an attempt, for some time, to have the fly ash Standard in particular cover all aspects of fly ash use – not only for concrete, but for renders, mortars, grouts, stabilisation and various other potential uses such as geopolymers. The only real exception is when used as a mineral filler for asphalt residing in another Standard. By keeping the title to Supplementary Cementitious Materials (SCM) it is less specific about the options, but does at least confine them to cementitious uses.

The major areas of change in the draft are related to:

- alignment with AS3972 (2010) – Cement
- change in classification of the Grades of fly ash
- change in specified properties for Grades of fly ash
- adopt strength index (similar to ASTM)
- include measures of consistency for fineness and LOI values
- removal of available alkali test requirement given long term data
- review of testing frequency and reporting requirements
- alternate test method validation process
- alignment with AS3582.2 and AS3582.3
Standards are referenced in AS3600, AS1379 and AS3972. Where appropriate consequential amendments and alignment required to AS3600, AS1379 and AS3972 were considered along with consequential amendments and alignment with various Federal and State agencies infrastructure, building and construction related sector specifications. Alignment with international best practice adopted in similar standards globally will be considered as part of the review.

In summary the review consisted of updates of the standard requirements and inclusion of; scope of standard to include non-concrete related uses; new classes of materials; review appropriateness and confirm test methods and general updating of references to ensure the validity of the content. Test methods to be reviewed include

- 3583.1 Method 1: Determination of fineness by the 45 µm sieve
- 3583.2 Method 2: Determination of moisture content
- 3583.3 Method 3: Determination of loss on ignition
- 3583.5 Method 5: Determination of relative density
- 3583.6 Method 6: Determination of relative water requirement and relative strength
- 3583.8 Method 8: Determination of sulfuric anhydride content
- 3583.12 Method 12: Determination of available alkali
- 3583.13 Method 13: Determination of chloride ion content

Once finalized revisions to the Standard(s) will be reviewed by inviting public comment. The working committee currently expects to publish revised AS 3582 Series by the end of 2015.

ABUNDANT AND POTENTIALLY EXPLOITABLE RESOURCE

The various utilisation pathways for CCPs reliant on the legislative, regulation and economics that drive the different participants (coal suppliers, generators, ash marketers and ash users) can have polarised interests in regards to the overarching utilisation goals. For example coal suppliers and generators prefer ‘demand to be greater than supply’ whereas ash marketers and ash users prefer ‘supply to be greater than demand’ with the corresponding value (Heidrich et al, 2014).

In microeconomics terms, supply and demand has important implications for price determination in any market. As an economic model used in competitive markets, the unit price for goods will vary until it settles at a point where the quantity demanded by consumers (at current price) will equal the quantity supplied by producers (at current price), resulting in an economic equilibrium for price and quantity.

The market for utilisation of CCPs however can be very broad, with an enormous range of potential applications. These applications range from cementitious uses through to bulk fills and emerging agricultural opportunities (Aiken et al, 2015). In addition a wide range of niche uses contribute small increases in total tonnages sold.
The beneficial use of coal combustion products (CCPs) consolidated during 2013 with 5.7 million tonnes or 52% effectively utilised resulting in the conservation of energy, finite natural resources, the reduction of greenhouse gas emissions and recovery of mineral by-product resources that would otherwise be placed into long term storage or emplacement.

The survey results for CCP production and categorised end uses for the period January to December 2013 can be found at (www.adaa.asn.au). In summary from the 12.3 million tonnes of all CCPs produced some 52% of were effectively utilised within various civil and construction applications throughout Australasia (Australia and New Zealand). This compares well, given the uncertainty over with the introduction and subsequent withdrawal of Carbon Tax Legislation and wide ranging environmental reforms over the past 3 years. For previous periods of 2001, 2011, 2010, 2009 and 2008 resulted in effective utilisation of 42%, 48%, 41%, 34% and 31% respectively.

SUMMARY

The review of the AS/NZS 3582 series was a planned process aimed at contemporizing these material Standards having not been reviewed for more than 13 years. In planning and undertaking this project a staged approach was considered in consultation with Standards Australia. That is, the project proponents consulted with, and sought the views of, major stakeholders prior to the commencement of the formal Standards review, through Joint Standards Australia/Standards New Zealand Committee BD-031.

The initial project review encompassed the various manufacturers, suppliers, users and academics with interest in these materials. Stakeholders were consulted through respective industry associations with a series of consultative meetings conducted to determined the review needed to address contemporary performance based approach, widening the Standards application and methods of demonstrating compliance.

The major contributing supply chain factors were identified during the review were related to; closure/retirement of older coal fired power stations, the short-term closure of units to undertake earlier than planned maintenance; unplanned maintenance/repairs and ongoing privatization of coal fired power stations are contributing to uncertainty factors for supply. The net result during 2013 was a continuation of short-term interruptions within the supply chain for fly ash consumers, which highlight the limited and highly centralised processing and distribution capacity for fine grade fly ash across selected cola fired power station sites.

Accordingly, the Standards review introduces new classes of materials, definitions for proven and unproven sources and corresponding testing frequencies, incorporating product conformity requirements in the normative section which was previously in the 'informative' section.

The review considered and recommended, where appropriate, adopting international and national standards; existing referenced standards documents were reviewed,
changes proposed and elaborated upon, and supporting information collated, with consultation across appropriate membership groups to ensure alignment across the supply chain.

In closing, the recovery and reuse of CCPs has been proven to provide positive and significant environmental impacts, including resource conservation and in this case, the reduction of greenhouse gas emissions from the processing of virgin resources, resulting in the reduction of carbon emissions. However, processors and major consumers singular focus on sourcing exclusively using fine grade fly ash, where other ungraded materials maybe suitable is unsustainable without significant investment into additional fine grade capacity.

Given uncertainty factors for with operation of coal fired power stations, more consideration should be given to exploitation or recovery of conditioned coal combustion products placed into ash dams.
REFERENCES


