Discussion

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Physical characterisation of UK pulverized-fuel ashes for use in concrete*

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Contribution by W. B. Butler

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The authors are to be congratulated for producing a meaningful contribution to the bank of knowledge on pfa but more particularly to the understanding of BS 3892: Part 1 test methods.

It is rightly pointed out that the test for pozzolanic activity indese does not measure pozzolanicity. However, what is more important at the end of the day is to have a measure of the influence upon concrete properties of the inclusion of fly ash. Since the test method takes into account the water reducing effect of the ash as well as the pozzolanic reaction, the end result is more meaningful in a practical sense. It is unfortunate that as found by Mehta⁽¹⁾, pozzolanicity tests on mortar do not necessarily give a good indication of performance in concrete.

I am a little concerned that the authors have seen fit to ignore some of their results in order to get a good correlation between fineness and compressive strength. There are valid exceptions to the rule. In fact it continues to amaze us that a test which is such a

crude indication of ash particle size is in fact the best standard test for assessing potential performance in concrete.

In Australia there is now available, a highly reactive ash having sieve residue in terms of BS 3892 of about 30%. As a result, a new means of assessment is now being sought. Long term, it seems inevitable that laser particle size testing will be widely used. From a standardization viewpoint the problem is that each brand of machine gives a slightly different result.

The proposed progressive classification for pfa suggests even tighter quality limits than BS 3892 Part 1 for premium ash. Such material will work well in the laboratory but could present handling problems in the poorly 'designed' silos so common in concrete plants.

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Reply by the authors

We thank Mr Butler for his interest in our paper and for his comments which we shall try to answer in the order raised.

We must agree that what is required is a test which

measures the influence of pulverized-fuel ash (pfa) on concrete and which is 'meaningful in a practical sense'. We must continue to disagree, however, that the BS pozzolanic activity index (PAI) test achieves this desired end. While the PAI test does take account of the water reducing effect of pfa, as we showed in the

* Pages 75 to 87 of MCR 131

paper and as Mr Butler re-affirms, the BS water requirement test on mortar relates poorly to the actual water demand in concrete for practical purposes.

Contrary to Mr Butler's suggestion, we did not ignore some of our results to improve quoted correlations. As we stated the two results omitted from the regression analysis were omitted purely because they seemed to us to be outside the general trend of the relationship between pfa fineness and concrete strength. To put it another way, they were taken as 'exceptions to the rule'. We are interested to learn of the relatively coarse but nonetheless very reactive pfa available in Australia and we would very much like to receive some details of this from Mr Butler. It should, however, be noted that the paper reported the results of an investigation on UK pulverized-fuel ashes, and that it is possible that the precise form of the relationship between pfa fineness and concrete strength may vary with a different national source.

As Mr Butler states, at first sight it does seem amazing that the widely used, very simple 45 μm sieve residue test for pfa fineness, a test quoted by Davies *et al.*⁽³⁾ in 1937, should continue to give the best assessment of its potential performance in concrete. We are aware of the recent developments in particular shape factor measurement⁽²⁵⁾, as determined using the Fisher sub-sieve sizer and the Malvern lasar apparatus, but wonder whether these more sophisticated methods necessarily give any better indication of potential performance of pfa in concrete. We are not aware of any published data on this subject. Interestingly we have found in further work at Dundee⁽²⁶⁾ that, however arbitrarily the 45 μm sieve residue test was originally chosen, the rank order of fineness which it indicates for a range of pfa materials is reflected through the whole particle size distribution. In this instance it would seem that simplicity does not mean crudeness.

We think Mr Butler has misunderstood the purpose of our proposed classification for pfa. As we stated in our paper the classification is meant solely as a guide to the potential of particular pulverized-fuel ashes and is not meant to be restrictive in the sense of the present BS 3892: Part 1⁽⁷⁾. What we have demonstrated, which supports a long held view at Dundee⁽⁸⁻¹³⁾, is that while most UK pulverized-fuel ashes can be utilized in concrete the choice of a pfa for a particular set of operating conditions is dictated purely by economics. An indication of this can be obtained from our proposed pfa fineness classification. The final assessment, however, must be based on trial mixes as is the case for Portland cement. It should also be noted that economics of pfa utility can vary with national pfa source, a model for which has recently been present⁽²⁷⁾.

It is apparent from Table 5 that premium grade pulverized-fuel ashes are not widely available in the UK, but they are by far the most effective pfa for use in concrete. A decision to accept or to reject any grade of pfa must be based on the user's own circumstances. Not to use the finest, and thus by implication the highest quality pfa, purely on the basis of 'poorly designed silos' does not seem to make any practical sense.

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