Discussion Forum

Comparison of effects of ultra fine fly ash and silica fume in concrete

The paper 'Comparison of effects of ultra fine fly ash and silica fume in concrete' published in the February 2006 issue of ICJ has created a lot of misunderstandings in the mind of the discusser, some of which are given below.

(i) The use of a superplasticiser has a very important role in the performance of the mix. But the dosage of the same used in each mix is not mentioned. Superplasticiser not only improves workability, but also helps in achieving efficient particle packing with pore refinement, giving rise to reduced permeability as also perhaps the rate of hydration indirectly. It is assumed that different dosages of superplasticiser were used in the nine mixes reported in the paper.

(ii) Cement replacement with just ten percent fly ash is rather too low. Even then 28-day strengths was more than 7-day strength by 13.3 to 16.6 percent for all w/b ratios; whereas for normal concrete it varied from 7.7 to 17.3 percent. Thus, there was hardly any advantage in using ultra fine fly ash (UFFA) excepting from the point of durability. In India, early strength development had been achieved by using normal fly ash with around 5 percent silica fume or an accelerator. It is not understood why such a ternary blended concrete was not also tested in the U.S.A. by the authors.

(iii) By the by, what is the definition of UFFA? It was observed that fly ash with a mean size of 3 mm has been actually used in the tests. Cost wise, how does it compare with silica fume on weight basis?

(iv) The explanatory statement for equation 3 is not very clear. Further, two terms 'Strength Efficiency of Cement.' and 'Cementing Efficiency Factor' have been used. Is cementing factor of normal cement (OPC) one?

(v) Almost comparable performance for HPC has been reported on some of the recent projects in India with blended fly ash cement (fly ash content much higher than 10 percent) further admixed with silica fume, if and as required (total silica fume content in cement being 5 to 7.5 percent generally). Is there any need of embarking on another costly venture to produce UFFA?

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The authors' reply

The authors thank Mr P.K. Singha Roy for initiating the discussion on the paper on. Below is our point-by-point reply to the queries raised by Mr Singha Roy.

(i) The authors agree that superplasticiser (SP) plays a very important role in the performance of any concrete, especially so in case of high-performance concrete. Generally, the dosage of SP used should not affect adversely the cured concrete. The variation in SP dosages in the present study was minor as the carboxylic ester-based SP was utilised. This latest-generation SP is a highly efficient superplasticiser. The SP was added to only achieve workability for ease of compaction by vibration and the dosage ranged from 0.1 to 0.3 percent.

(ii) Fly ash content has to be generally high, say more than 20 percent, to achieve significant improvements in the microstructure of hardened concrete. But, in the present case, UFFA was used. This being a processed fly ash, it is an expensive material and is expected to act as an alternate material to silica fume. Therefore, in the present case, the effectiveness of UFFA was compared with silica fume with similar contents. It is to be noted

that silica fume is inherently fine and a highly efficient pozzolanic material; hence, lower dosages are adequate to achieve significant improvements in strength as well as microstructure. Moreover, from cost considerations also, silica fume is added in lower dosages only. The present test data, as pointed out correctly by the writer, shows that there is no particular advantage of using UFFA from strength considerations; however, durability characteristics are improved by adding UFFA, when compared to control concrete. Incidentally, many experiments have been conducted at SERC on triple blends using ordinary fly ash and silica fume; the test results show that strengths of fly ash concretes are enhanced by the addition of silica fume[1,2]. The investigation reported in the present paper was related to only comparison of effects of UFFA and silica fume in concrete and triple blended concretes were not considered in the investigations.

(iii) The ultra fine fly ash with a mean size of 3 microns is very fine in nature as compared to ordinary fly ash as collected from ESPs in thermal power plants. The conventional fly ash may have particle sizes ranging from 5 to 100 microns, the mean value is often about 20 microns. To achieve a mean size of 3 microns in UFFA, the fly ash has to be processed specially and this involves costly operations. The behaviour of such processed fly ash will be significantly different from both considerations of pozzolanic activity and filler action. Therefore, UFFA needs to be compared with silica fume, which is another pozzolanic material of very high fineness. There is no major difference between UFFA and silica fume from weight point of view.

(iv) The "Strength Efficiency of Cement in Concrete" (SECC) measures the strength achieved in concrete per unit content of Portland cement in concrete[3]. Blended concretes (with fly ash or silica fume) have lower contents of Portland cement and hence, when the SECC is calculated as the ratio of f_c/C, (f_c = compressive strength, C = content of Portland cement), the blended concretes show higher SECC values than control concretes, even though sometimes concretes with pozzolanas may be lower in strengths. Thus, Portland cement is used more efficiently in blended concretes. The "Cementing Efficiency Factor" (CES), 'k, term is used for expressing the effectiveness of pozzolana to act as a cementing material. Since, the pozzolanic reaction of fly ash is slower than cement hydration, at a given age, the contribution of fly ash towards strength of concrete is less and thereby, the value of 'k' of fly ash is considered to be less than unity. However, the 'k' of fly ash increases with age and it may exceed unity over a long period. Thus, fly ash concretes attain higher strengths than ordinary concretes in the long run. However, with silica fume, 'k' is usually more than unity even at early ages, indicating that the blending of silica fume as a partial cement replacement material acts more than Portland cement from strength considerations. This means that at the same water-binder ratios and at a given age, silica fume blended concretes can be expected to have higher strengths as compared to control Portland cement concretes. In contrast, fly ash concretes may have comparatively lower strength as 'k' of fly ash is likely to remain less than unity for very long period.

(v) Apart from the works mentioned by the writer, there are many Indian publications, including those from SERC, wherein fly ash concretes with and without silica fume have been shown to possess desirable enhanced performances. Therefore, UFFA may be required to be viewed as a new material with special properties and the appropriate applications need to be identified for this material so that specific properties of UFFA are utilised comprehensively.

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Refrences

1. Rajamane, N. P. and Peter, J. Annie, Effect of fly ash on silica fume concrete of 125 MPa strength, *International congress on fly ash, fly ash India 2005*, December 2005, Chapter VI, Paper No 0020, pp. 1-23

2. Rajamane, N. P., Peter, J. Annie, Dattatreya, J. K., and Gopalakrishnan, S. Influence of blending of fly ash into silica fume concretes at strength levels above 110 MPa, *Proceedings of the all India seminar on fly ash utilisation and disposal*, October, 2003, Chennai, organised by Indian Institute of Engineers (I), TN Centre, pp. 92-110.

3. ______*Handbook on Concrete Mixes (Based on Indian Standards).* SP 23 (S&T)-1982, Bureau of Indian Standards,New Delhi.

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