Discussion Forum

Availability and management of fly ash in India

N.P. Rajamane*, J. Annie Peter** and P.S. Ambily***

The write-ups on fly ash by Prof. V. M. Malhotra and the 'Analyst' published in the August 2005 issue of ICJ (pp. 17-21) were very interesting. We wish to present the following points for further consideration by the readers/engineers.

While agreeing that considerable progress is made in India on the awareness about the use of fly ash (FA) in concrete, Prof. Malhotra comments harshly on the central and state agencies. However, in view of the prevailing construction practices in India and the lack of information among the common engineers on various aspects of use of FA, there seems to be some lethargy in adopting FA very widely, due to bad experience with portland pozzolana cement (PPC) in early 1970s[1]. Recently, there has been considerable change in attitude of many agencies and FA is being adopted more commonly now. We are aware of many efforts by fly ash producing companies and government bodies to promote the use of FA. Prof Malhotra's suggestion of developing a data base on an on-going basis on the characterisation of the fly ash from their plants is worth following. This would help the FA producers to guarantee chemical and physical properties of FA, as the cement companies do; in that case the users may be willing to pay, as the use of good-quality FA enhances the performance of concretes[2,3,4]. The present practice of preferring finer fly ash for use as cement replacement also needs be reviewed, since, the comparatively coarser variety can still act as a sand and, may be, its pozzolanic contribution to the cement matrix improvement could take longer time. This has been indirectly accepted in recent Indian Standard specification, IS 3812: Part 2: 2003 *Pulverised Fuel Ash - Specification - Part 2,* which suggests the use of FA admixture in cement mortar and concrete. The conventional use of FA as pozzolana in cement, cement mortar and concrete has been recognised under IS 3812: Part 1: 2003 *Pulverised Fuel Ash - Specification - Part 1.* Therefore, as such, the Indian code permits the use of any pulverised fuel ash in Portland cement. With regards to coarse and fine aggregates for concrete, work has been already carried out at SERC, Chennai. Mixture proportioning formulae have been developed to use FA as partial replacement for sand[5].

As regards the use of fly ash for aggregates, sintered fly ash aggregates produced in Regional Research Laboratory (RRL) Bhubaneswar, a CSIR laboratory, have been found to act as a coarse aggregate in place of conventional crushed granite aggregate, and the concretes of strengths more than 40 MPa have been produced[6,7,8]. Bonded fly ash aggregates produced at SERC, Chennai, were also found to produce concretes of strengths more than 45 MPa[9,10]. Thus, for most of the constructions, FA-based aggregates can reduce the present ecologically-damaging practices of quarrying of sand and stone. The concretes with fly ash based aggregate being lightweight in nature, offer many advantages to engineers. Despite the porous nature of FA aggregates, concretes prepared were found to be satisfactory in durability related properties.

Prof Malhotra's suggestion of exporting fly ash to other countries has been already taken up by at least one FA producer in India and the steps are being undertaken to set up quality assurance system for FA in the plant. Regarding the use of beneficiated fly ashes with particle size approaching 1 to 3 microns instead of silica fume, the work by SERC scientists has shown that this is feasible and a technical paper has been submitted to *ICJ* in this regard[11]. Grinding of FA can also improve its performance in concrete[12].

It is difficult to agree that no significant research is being done on the use of fly ash in India, and that whatever is being done is of poor quality. There is

*Deputy Director and Head, **Assistant Director, ***Scientist, Concrete Composites Laboratory, Structural Engineering Research Centre, Chennai.

a scope for improvement; and because of efforts of many Indian academic and serious-minded practical engineers, considerable awareness has been generated and many constructions of importance have come up with FA as ingredient of concrete. In SERC, Chennai, the compressive strengths in excess of 100 MPa have been produced with fly ash in concrete and a three-decade old building utilising FA in every component (plaster, brick masonry joints, precast elements – prestressed as well as RCC, etc) on SERC campus, is demonstrating the success of Indian efforts in the use of FA[3]. However, it is still necessary to undertake co-ordinated initiatives in research and development for still wider spread of use of fly ash. In this regard, it is gratifying to note that the Fly Ash Mission and CPWD have come forward to support a R&D project at SERC to generate specific data on some aspects of use of fly ash in concrete. The carbon trading under the Kyoto protocol needs serious consideration in India and there is a need for making available this information in more details. Moreover, the 'greenness' of fly ash concrete can be highlighted in so many ways[13].

The views expressed by the "Analyst" are very apt and represent, in general, the Indian perspective. There are many cases of utilisation of fly ash in building components such as bricks and blocks, roads and embankments, hydraulic structures, reclamation of low-lying areas, mine fills, agriculture, manufacture of zeolites, manufacture of alumina and cement clinker. The creation of awareness about the necessity of the use of FA in Portland cement as a performance enhancer may possibly take care of the economics of FA in concrete since then FA concrete need not be lower in cost than that of Portland cement concrete. This has been already the case in some construction activities in India, and some construction agencies are buying the processed fly ash at additional cost. The fact that the share of portland pozzolana cement (PPC) has dramatically jumped from 26.17 to 44.36 percent during 2000-01 to 2003-04, shows the growing acceptance of fly ash by engineers in India. It is observed that in some parts of India PPC is sold at a marginally higher cost than that of OPC. The customers are thus ready to pay more (although marginally) since they have found that the factory-made PPC meets their requirements satisfactorily! Many cement plants are fast approaching the limit of 35 percent FA in PPC as permitted by the BIS. However, great caution is required to increase this level to 50 percent and more, as the concretes would then require considerably longer period to achieve denser microstructure having high degree of impermeability. There is also a need to have an understanding of limit of FA content in concrete with reference to availability of lime in concrete. The data on long term stability of C-S-H in the presence of reduced or zero content of lime is required to be produced. However, many short-term tests on HVFA blended cement concrete indicate their satisfactory structural performance as well as superior durability properties when compared to that of portland cement concrete[14]. Thus, HVFA blended cement is a promising option for the typical Indian conditions. Automated ready-mixed concrete plants can easily promote the use of fly ash.

Many short-term tests on HVFA blended cement concrete indicate their satisfactory structural performance as well as superior durability properties .... thus, HVFA blended cement is a promising option for the typical Indian conditions.

Regarding the fly ash lightweight aggregates, work at SERC shows that energy intensive process of sintering is not necessary and a temperature of less than 100°C would be sufficient to manufacture aggregates suitable to produce structural grade concretes. If a waste steam or hot water available in thermal power plants can be used to produce aggregates, then the cost of aggregates may match that of natural aggregates hauled from longer distances.

I agree with Dr Malhotra's suggestion of setting up a broad-based research facility funded by the coal-based electrical utilities. Already, educational institutions and national laboratories are playing a major role in promoting the use of FA. There is also a scope for developing entirely new kind of concretes using FA when it is activated to act itself as a binder without the presence of portland cement[15,16,17,18]. FA has almost become a necessity in preparation of modern concretes such as self compacting concretes which would assure a quantum jump in quality of concrete construction in India[19,20,21,22].

References

1. Dattatreya, J. K., Rajamane, N.P., Neelamegam, M., Annie Peter, J., and Gopalakrishnan, S. Technical considerations for use of fly ash in structural concrete – a critical view, *New Building Materials and Construction World*, October 2002, Vol. 8, No. 4, pp. 56-71.

2. Gopalakrishnan S., Annie Peter, J., and Rajamane, N.P. Strength and durability characteristics of concretes containing high volumes of fly ash with and without processing, *International Conference on Recent Trends in Concrete Technology*, (INCONTEST 2003), 10-12 September 2003, Coimbatore, pp. 203-206.

3. Rajamane, N.P., Annie Peter, J. and Gopalakrishnan S. Effects of high volumes of replacements of cement by fly ash cement in high performance concretes of strength above 100 MPa strength, *Innovative World of Concrete –2003 (IWC 2003)*, International conference and exhibition, 19-21 September 2003, Pune (in CD form).

4. Rajamane, N. P., Annie Peter, J., Dattatreya, J. K. and Gopalakrishnan, S. Influence of blending of fly ash into silica fume concretes at strength levels above 110 MPa, *Proceeding of the All India Seminar on Fly Ash Utilisation and Disposal*, 11-12 October 2003, Chennai, organised by Indian Institute of Engineers (I), TN Centre, pp. 92-110.

5. Rajamane, N.P. , Annie Peter, J., Nagaraju P., and Maheswarappa, S. M. Study on methodology for concrete mix design for replacement of sand by fly ash, *National Conference on Advances in Civil Engineering Materials and Construction Technology* (AMCT 2004), 21-22 May 2004, SSIT, Tumkur, pp. 44-52.

6. Annie Peter, J., Rajamane, N.P. and Gopalakrishnan, S. Structural grade concretes using sintered fly ash aggregates, *Proceedings of the International Conference on Advances in Concrete Composites and Structures*, ICACS-2005, 6-8 January 2005, SERC, Chennai, pp 177-188.

7. Annie Peter, J., Rajamane, N.P. and Ambily P.S. Corrosion resistance of lightweight concrete using fly ash based coarse aggregates, *Rehab Technology Summit on Inspection, Assessment, Condition Survey, Repair and Rehabilitation,*

Retrofitting and Protection of Concrete Bridges and Buildings, March 2005, Hyderabad, pp.14-20.

8. Rajamane, N. P., Annie Peter, J., Sabitha, D. and Gopalakrishnan, S. Studies on development of structural grade concretes using sintered fly ash aggregates, *National Conferences in Advances in Concrete Construction and Mechanics of Materials*, IITM, September 2004, Chennai, pp. 203-209.

9. Rajamane, N. P., Annie Peter, J., Sabitha D and Gopalakrishnan, S. Studies on development of 'bonded fly ash aggregates' for use as coarse aggregate in structural grade concretes, *National Conference on Materials and Construction Techniques for Fast Track Projects,* May 2004, SIT, Tumkur (in CD form).

10. Rajamane, N.P., Annie Peter, J., Sabitha D. and Gopalakrishnan S. Studies on development of bonded fly ash aggregates for use as coarse aggregate in structural grade concretes, *New Building Materials and Construction World,* October 2004, Vol.10, No. 4, pp. 60-70.

11. Dattatreya, J.K., Rajamane, N.P., Neelamegam, M, Annie, Peter J and Gopalakrishnan, S A study on comparison of effects of ultra fine fly ash and silica fume in cement concretes, *(paper submitted to The Indian Concrete Journal).*

12. Gopalakrishnan, S., Annie Peter, J. and Rajamane, N.P. Strength and durability characteristics of concretes containing high volumes of fly ash with and without processing, *International Conference on Recent Trends in Concrete Technology,* (INCONTEST 2003), 10-12 September 2003, Coimbatore, pp 203-206.

13. Rajamane, N. P. Making concrete 'green' through use of fly ash, Green Business Opportunities, *Confederation of Indian Industry (CII)*, October-Decement 2003, Vol. 9, No. 4, pp. 22-29.

14. Rajamane, N.P., Neelamegam, M., Balasubramanian K., Bharatkumar B.H. and Dattatreya, J.K. Studies on utility of fly ash in structural concretes, *National Seminar and Business Meet on Use of Fly Ash in Roads and Embankments*, 5-6 June 2005, Allahabad, Organised by TIFAC, Fly Utilisation Programme, New Delhi (in CD).

15. Rajamane, N. P, Sabitha, D., Sajana, Mary James, and Gopalakrishnan, S. Studies on development of geo-polymeric low-energy cement from fly ash for structural applications, *Proceedings of the International Conference on Advances in Concrete Composites and Structures*, ICAS 2005, 6-8 January 2005, SERC, Chennai, India, pp. 219-226.

16. Rajamane, N. P., Sabitha, D. and Sajana Mary James, Potential of industrial wastes to produce geo-polymeric mortar of practical utility – A study, *Indian Concrete Institute Journal*, January-March 2005, Vol. 5, No 4, pp. 9-20.

17. Rajamane, N. P., Sabitha, D. and Shijna, P. K. Inorganic polymer mortar from Class 'C' fly ash and blast furnace slag powder without Portland cement, *New Building Materials and Construction World,* February 2005, Vol. 10, No. 8, pp.10-19.

18. Rajamane, N. P., Sabitha, D. and Shijna, P. K. Feasibility of achieving 40 MPa in 40 hours in mortars without Portland cement using Class F fly ash and blast furnace slag powder, *Civil Engineering and Construction Review*, April 2005, New Delhi, Vol. 18, No. 4, pp 36-44.

19. Peter, J. A., Lakshmanan, N., Manoharan, P. D., Gopalakrishnan, S. and Rajamane, N.P. Studies on utility of fly ash in development of self compacting concretes, *Proceedings National Seminar on Advances in Concrete Technology and Concrete Structures for the Future* (ADCONST-2003), Annamalai University, Annamalainagar, 18-19 December, 2003, pp. 59- 66.

20. Dattatreya J K, Neelamegam, M., Rajamane, N. P., and Gopalakrishnan, S. Assessment of workability characteristics of self compacting concretes – a review, *Innovative World of Concrete –2003* (IWC 2003), International conference and exhibition, 19-21 September 2003, Pune (in CD form).

21. Annie Peter, J., Lakshmanan, N., Manoharan, P. D., Gopalakrishnan, S. and Rajamane, N.P. Studies on proportioning of self compacting concretes and evaluation of strength and durability related characteristics, *Proceedings International Symposium on Celebrating – People, Practice, Technology and Structures, Role of Concrete in Sustainable Development,* University of Dundee, Scotland, 3-4 September 2003, pp. 463-476.

22. Annie Peter, J., Lakshmanan, N., Manoharan, P. Devadas, Rajamane, N.P. and Gopalakrishnan, S. Flexural behaviour of reinforced concrete beams using self- compacting concrete, *The Indian Concrete Journal*, June 2004, Vol. 78, No. 6, pp. 66-72.

● ● ●