Evaluation of performance of concrete with calcined clay limestone cement

Discussion by M.C. Nataraja

Replies by Ashok K. Tiwari, Sandeep Keskar and Subrato Chowdhury

Dear Sir,

This is a discussion on the paper titled 'Evaluation of performance of concrete with calcined clay limestone cement', authored by Ashok K. Tiwari, Sandeep Keskar and Subrato Chowdhury, published in The Indian Concrete Journal (March 2017, Vol. 91, Issue 3, pp. 49-55.)

Replacement of ordinary Portland cement by the addition of high amounts of calcined clays and limestone is one of the hot research area and many technical papers at the national and international level have been published. These ternary blends- calcined clay limestone cement (CCLC) can become more ecological and economical binders to answer many problems of sustainability issues related to concrete worldwide [1-3]. It is reported that even using easily available technology, a good quality CCL cement can be produced. A building was constructed in Jhansi, India where this was the only cement used in reinforced and plain concrete elements.

It has been demonstrated that up to 60% of cement can be replaced by such combined addition of pure metakaolin and limestone with acceptable compressive strengths after 7 and 28 days. With natural clays, with about 50% kaolinite content, cement can still be replaced by 45% with mixtures of calcined clays and limestone without significantly impairing strength development. The pozzolanic activity of the natural clays showed good correlation with the content of kaolinite and the specific surface of calcined clays. One of the studies confirms that natural clays other than pure kaolinite can be interesting pozzolanic materials when thermally activated [4].

The good compressive strengths developments have been explained by the synergetic formation of carboaluminates phases and the porosity refinement. The aluminates from the metakaolin react together with the carbonates from the limestone and calcium hydroxide, from cement hydration. The durability aspects of these novel blends were studied by many investigators and they have found that these ternary blends have very low ionic diffusion coefficients, more than one order of magnitude lower than Portland cement. This explains the good resistance of CCL cement to chloride ingress [2].

The work reported by the authors is in the direction of evaluation of performance of concrete with calcined

clay limestone cement consisting of calcined clay, limestone, and Portland cement clinker as compared to two traditionally used fly ash based Portland pozzolana cement. They have reported that though the concrete made with clay based cement attains higher early age strength, the later age strength in mortar is lower as compared to commercial fly ash based cement concrete. The authors have concluded that these concretes have high water demand, resulting lower workability, but also needs higher dosage of superplasticizers, if used. Obviously this increases the cost of concrete for same strength. In addition such concretes have higher early age strength compared to the later age strengths. They have also concluded that concrete from such ternary cement shows better durability characteristics. These results are quite encouraging and the discusser is sure that in the days to come such ternary blend concrete will pick up and may replace the modern OPC. The discusser congratulates the authors for publishing a quality technical paper.

From the point of better understanding of the behavior of such cements, the discusser seeks few clarification and answers from the authors of the paper. The queries are:

1. Is there any company in India or abroad producing such calcined clay limestone cement commercially? What may be the cost of such cement compared to the conventional OPC.

   Reply: No one is producing this kind of cement, as there is no BIS specification for the cement yet.

2. It is reported that the Limestone and calcined clay were ground separately and intermixed with ground clinker. This ternary blend had a combined specific surface of 686 m^2/kg as reported in Table 2. Obviously the limestone and the clay were very finely ground beyond 700m^2/kg and clinker also must have been finely ground. This will definitely increase the cost of grinding and hence the cost of cement. As the limestone and clay are relatively soft compared to the clinker, the grinding energy requirement may be less compared to clinker. Still the commercial production many not be cost effective.

   Reply: The cost is not going to be very high, as clinker % is low and will take care of finer grinding of clay and limestone.

3. Even with such a high fineness, the water requirement for a given consistency is relatively same as PPC as reported in Table 2. It means for the same fineness, the water requirement may be still less which leads to highly workable mortar or concrete even at relatively low water cement ratios. Which means the requirement of chemical admixture is also less decreasing the cost of concrete.

   Reply: Water demand is higher not only due to high fineness, but also due to limestone and clay. NC is not the right measure of water demand

4. The discusser feels that such high fineness of cement might increase the shrinkage strain and the concrete is more susceptible to creep as well. This might increase the plastic shrinkage of fresh mortar or concrete. Any results in this direction to show that this is not a major concern.

   Reply: This aspect is not discussed in this paper

5. The consistency of clay cement is more or less same compared to the other two PPCs used in the investigation. It means for given water all cements exhibits the same stiffness (or flow behavior). However the concrete with such cement has very low slump (60 mm compared to 190 mm of PPC1) for the same amount of water used while mixing. What is the reason for such as drastic change in the behavior of concrete? Initial and final setting time of cement and the heat of hydration might explain this behavior which needs further investigation.

   Reply: NC is not the correct measure of water demand

6. As seen from Table 2 and also from Figure 6, the CCLC though blended is more or less similar to OPC (43 grade) from the point of strength

development with respect to age. The increase in strength of CCLC beyond 28days is insignificant. Can any modification or the addition of fly ash improve the strength beyond 28 days as found in PPC1 or PPC2 (Figure 6).

Reply: Yes, it is possible

7. The results shown in Table 2 is for cement having 15% limestone, 31% calcined clay, and about 50% portland cement clinker with remainder being gypsum. It may be possible to change the percentages of limestone and clay keeping clinker at 50% which might result in better strength at later ages as reported in the literature.

Reply: Yes, it is possible

8. Can the percentages of these ternary blends be optimized to get the comparable performance of concrete from the point of view of strength and durability properties? Otherwise the readers may think that this composite clay cement behaves differently and the performance is relatively on to the lower side. This might discourage the use of such special ecofriendly cements.

Reply: It could be possible

9. It is reported in the literature that the optimal calcination conditions for dehydroxylation are clay specific, which depends on mineralogy of clay, presence of deleterious impurities and companion minerals in addition to clay particle size and humidity content. Many authors have reported that the calcination temperature to be about 600 to 700 degree Celsius [4]. In the present work the authors have gone up to 900 degree centigrade for optimum calcination. Will it not increase the cost of production of cement?

Reply: Calcination temperature depends upon the type and purity of clay. For the said clay, the optimum temperature is used

10. Though the cement is blended but behaving differently, it is advisable to develop compressive strength vs. water cement ratio curves for this blended cement at different ages such as 7, 28 and 90 days so that these curves can be used for developing computerized mix design of standard concretes as per IS 10262 [5,6]. Surely the authors must have some results developed in their laboratory in this direction and may kindly be shared if available.

Reply: As there is no BIS specifications and hence no manufacturer, not such attempt is needed in near future.

References

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Discussion by

Dr. M. C. Nataraja, Professor, Civil Engineering Department, Sri Jayachamarajendra College of Engineering, Mysore , Karnataka, India.

Replies by

Professor Ashok K. Tiwari, Vice President (Technical), UltraTech Cement Limited.

Sandeep V. Keskar, Manager, Concrete Technology, Central R&D, UltraTech Cement, Taloja, near Mumbai.

Dr. Subrato Chowdhury, PhD, FNAE, Former Head of Research and Development for Aditya Birla Group, Cement Business.