Pozzolanic Efficiency of Local Crushed Bricks for use as Supplementary Cementitious Material

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Introduction

Supplementary cementitious materials (SCMs) as a potential replacement for cement has gained wide acceptance in the past few years as it reduces the clinker production and makes use of industrial by – products. However, the usage of common SCMs becomes limited as they are not locally available in many places and hence not accessible to all. As inefficient production techniques of Indian brick industry lead to an annual massive wastage of bricks, these waste bricks from kilns in crushed form (Crushed Brick Powder or CBP) can be studied for use as potential SCMs. Use of CBP to reduce carbon dioxide emissions (Filho et. al., 2007), effect of ground clay brick powder on the fresh and hardened properties of both plain concrete (Ge et. al., 2015) and self compacting concrete (Heikal et. al., 2013) has been widely studied by researchers. Microstructural behaviour of cement paste replaced with CBP has been studied by Bediako et. al., 2018; Ortega et. al., 2018. Use of red clay waste brick for manufacture of masonry units (Robayo – Salazar et. al., 2017) and for use as a decorative plaster (Li et. al., 2016) has also been reported.

A common problem encountered in developing countries is the lack of availability of brick powder conforming to prescribed standards of pozzolanicity. Outdated manufacturing technologies leading to production of underburnt or overburnt bricks inhibit the pozzolanicity of CBP. This brings about a scarcity of standard supplementary materials to be used in manufacture of cement clinker in these countries. Limited research has been done on the utilization potential of such non – conforming waste materials in cement production. The present work analyzes the capability of one such locally obtained CBP to be utilized as a cement supplement despite not satisfying standard chemical composition of calcined clay given in IS: 1344 - 1981.

Materials and Methods

Ordinary Portland cement of grade 43 conforming to standard code IS: 8112 – 2013 was used in this experiment. Discarded clay bricks from a local brick kiln in Mesra, Ranchi were used. They were crushed in a concrete crusher and further milled in a pulveriser to get a fine powder. After that, this powder was passed through two sieves: 150 µm and 75 µm. Hence two different size fractions, i.e. passing through 150 µm but retained on 75 µm; and passing through 75µm were obtained. EDS data of CBP showed that net percentage of oxides of Si, Al and Fe is 57.33%, which is less than the minimum percentage required by IS 1344: 1981. Mortar specimens for testing of compressive strength were prepared and tested according to standard IS codes after 3, 7, 28 and 90 days respectively. Paste samples for TGA and XRD tests were prepared and tested for similar hydration periods according to standard procedures described in literature (Schöler et. al., 2015; Scrinever et. al., 2018).

Results and Concluding Remarks

Compressive strength of blended samples did not exceed that of control at any stage of hydration upto 90 days. But, the 90 days compressive strength of blended mortars was found to be significantly higher than their corresponding 28 days strength, whereas the compressive strength of control mortar did not increase adequately from 28 to 90 days. Hence, blended mortars showed weak pozzolanicity, observable only at advanced curing ages. This is due to presence of crystalline phases (detected from XRD) inhibiting pozzolanicity like cristobalite. However, presence of additional phases like AFm and early appearance of

common phases like monosulfoaluminate indicate that the volume of hydrates produced in blended samples is higher as compared to that of OPC sample, which maybe responsible for higher compressive strength of blended mortars at 28-90 days. Intensity of portlandite peaks observed from XRD graphs and quantification of portlandite from TGA data both indicate that OPC has lesser CH content than CBP blended samples at 90 days, confirming the weak pozzolanic action of CBP. 10 – 15% replacement of OPC by CBP was found to be optimum for mortar samples.

As it has been proved extensively in literature that CBP has pozzolanic characteristics which can be easily detected after 28 to 90 days of hydration, it can only be concluded that the chemical characteristics of CBP varies from place to place and depends upon the geological characteristics of the raw clay as well as the manufacturing process adopted in producing the brick. Presence of kaolinite, followed by montmorillonite, which show the highest pozzolanic activity (Ambroise et. al., 1985; Tironi et. al., 2013) were not observed from the XRD scans and only illite was detected. Due to these reasons, the CBP obtained from a local brick kiln in Mesra, Ranchi, India did not show adequate pozzolanic characteristics. Based on the above findings, it has been concluded that CBP selected from a proper site can be replaced upto 15% in OPC for attainment of long term mechanical strength and for secondary construction works like plastering of walls.

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