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Research Paper

STRENGTH APPRAISAL OF CONCRETE USING METAKAOLINE AND FLY ASH

Dipali S Borse^{1*}, S S Bachhav² and S K Dubey³**Corresponding Author: Dipali S Borse* ✉ deepsborse74@gmail.com

The infrastructure development is an important aspect for the overall development of country. India is developing as a major hub for service industry, automobile industry and for which the infrastructure development plays an important role. In case of infrastructure development construction of bridges, aqueducts, high rise buildings, off shore structures, nuclear power stations, dams, high strength concrete above M55 is commonly adopted. The necessity of high strength concrete is increasing because of demands in the construction industry. In all construction works, concrete is an important and costly issue, which governs the total cost of the project. Concrete can generally be produced of locally available constituents, However, environmental concerns, stemming from the high energy expense and CO₂ emission associated with cement manufacture have brought about pressures to reduce cement consumption through the use of supplementary materials. It reduces the cost, makes concrete more durable and it is ecofriendly. Concrete is probably the most extensively used construction material in the world. The addition of mineral admixture in cement has dramatically increased along with the development of concrete industry, due to the consideration of cost saving, environmental protection and conservation of resources. However, environmental concerns both in terms of damage caused by the extraction of raw material and carbon dioxide emission during cement manufacture have brought pressures to reduce cement consumption by the use of supplementary materials. High Performance Concrete (HPC) is the latest development in concrete. It has become more popular these days and is being used in many prestigious projects. Mineral admixtures such as fly ash, rice husk ash metakaolin, silica fume, etc., are more commonly used in the development of HPC mixes. Addition of such materials indicated the improvement in the strength and durability properties of concrete. The utilization of calcined clay, in the form of High Reactivity Metakaolin (HRM). In concrete has received considerable attention in recent years.

Keywords: Carbon dioxide, High performance concrete, Fly ash, Rice husk, Metakaolin, Silica fume, Calcined clay

INTRODUCTION

The utilization of calcined clay in the form of

Metakaolin (MK) as a pozzolanic addition for mortar and concrete has received considerable

¹ M.E. Student, Department Of Civil Engineering, S.S.V.P'S B.S. Deore College Of Engineering Dhule, Maharashtra - 424 005, India.

² Associate Professor, Department Of Civil Engineering, S.S.V.P'S B.S. Deore College Of Engineering Dhule, Maharashtra - 424 005, India.

³ Associate Professor, Department of Civil Engineering, S.S.V.P.S B.S. Deore College of Engineering, Dhule, Maharashtra-424 005, India.

interest in recent years. Much of this interest has been focused on removal of the CH, which is produced by the hydration of cement and which is associated with poor durability. Reduction of CH makes the concrete and mortars more resistive to sulphate attack and reduces the effect of alkali - silica reaction. This provides enhanced strength which is derived from the additional cementitious phases generated by the reaction of CH with MK. MK is processed from high - purity kaolin clay by calcinations at moderate temperature (650°C-800°C). The silica and alumina in the MK reacts effectively with the CH. The principal reasons for the use of clay-based pozzolans in mortar and concrete have been due to availability of materials and durability enhancement. In addition, it depends on the calcining temperature and clay type. It is also possible to obtain enhancement in strength, particularly during the strength of curing. The very early strength enhancement is due to a combination of the filler effect and acceleration of cement hydration. Consequently, these effects are improved by the pozzolanic reaction between MK and the CH produced during the hydration of cement.

Therefore MK is a very effective pozzolan and results in enhanced early strength with no detriment to the long-term strength. MK modifies the pore structure in cement paste, mortar and concrete and makes the mixes more resistive to the diffusion of harmful ions and penetration of water which lead to degradation of the matrix. Presently Metakaolin is more expensive than Portland cement, as is Silica Fume, even though moderately low temperatures are required for its processing and its overall production cost is significantly less than that of Portland cement.

Figure 1: Metakaolin



LITARATURE REVIEW

There have been extensive experimental and theoretical investigations performed on the topic of Strength appraisal of concrete using metakaolin and fly ash. The experimental studies performed in this field are presented in following paragraphs.

Erhan G KasumMermerdas (2007) have presented the results of an investigation on the use of metakaoline (MK) as a supplementary cementing materials to improve the performance of concrete. Two MK replacement level were employed in the study: 10% and 20% by weight of the Portland cement used. plain and PC-MK concretes were designed at two water

cementitious materials (w/cm) ratio of 0.35 and 0.55. The performance characteristics of the concretes were evaluated by measuring compressive strength and splitting tensile strength, water absorption, drying shrinkage, and weight loss due to the corresponding drying. The porosity and pore size distribution of the concretes were also examined by using Mercury Intrusion Porosimetry (MIP). Tests were conducted at different ages up to 120 days. The results revealed the drying shrinkage strain, but increased the strength of the concrete in varying magnitudes, depending mainly on the replacement level of MK, w/cm ratio, and age of testing. It was also found that the ultrafine MK enhanced substantially the pore structure of the concretes and reduced the content of the harmful large pores, hence made concrete more impervious, especially at replacement level of 20%.

Srinivasa Rao *et al.* (2002) have studied durability properties of steel fiber reinforced Metakaolin blended concrete, when it is exposed to certain types of chemicals. Metakaoline is a thermally structured, ultra fine pozzolan, ash, etc. An experimental investigation has been carried out to evaluate the durability in terms of chemical resistance and weight loss of steel fiber reinforced concrete with and without metakaolin for concrete of M20 grade. The results show that the percentage of weight loss is reduced and compressive strength is increased in the case of 10% metakaolin replaced concrete when compared to normal concrete.

Shekarchi *et al.* (2009) have studied the durability of concrete improved by using blended cement materials such as fly ash, silica fume, slag, and more recently, metakaolin. By changing the chemistry and microstructure of concrete,

pozzolans reduce the capillary porosity of the cementitious system and make them less permeable to exterior chemical sources. This paper presents the results of study on the transport properties and durability characteristic of concrete containing different level of metakaolin. The minimum replacement level required for mitigating ASR and the relationship between physical and chemical effects of metakaolin were discussed.

METHODOLOGY

Materials

Cement

Ultra Tech 53 grades Ordinary Portland cement is used for this study. This cement is the most widely used one in the construction industry in India.

Course and Fine Aggregates

Maximum size of Coarse aggregates is 20 mm used for this study and natural sand of river bed is used conforming to grading Zone –II of IS 383 were procured from Maharashtra.

Fly Ash

Fly ash is obtained from DIRK-INDIA COMPANY, Nasik city in Maharashtra.

Water

Drinking water is used for casting and curing of the concrete blocks.

Metakaolin

Metakaolin is obtained from golden micro chemicals purna village bhivandi (Mumbai).

Testing

Preliminary Testing

In the preliminary testing includes Fineness modulus of course and fine aggregates, specific

gravity of course aggregates, fine aggregates, fly ash and Metakaolin, water absorption test of course aggregates and fine aggregates.

Laboratory Testing

In the present study, triple blending cement concrete mixes have been tried for various strength properties. Mineral admixtures like FA and MK have been employed along with cement and triple blended cement concrete mixes are prepared. The respective percentages of FA have been 0% to 5% & MK have been varied from 7% to 8% as replacement of cement.

In the present study M20 grade have been considered. The mixes were designed by the IS method. The specimens are tested for Compressive strength test, Split tensile strength test and Flexural strength test.

Mixing, Casting, Curing and Testing

All the triple blended composites were mixed in the pan mixer. Required number of specimens for various combinations was cast. Continuous curing was maintained up to the age of 7 days and 28 days. Mixing, casting, curing and testing were carried out as per the standard specifications.

TEST RESULTS AND DISCUSSIONS

In the present experimental study of triple blended cement concrete mixes, cement is replaced by Fly ash and Metakaolin with different percentages from 0 to 15% and 7 to 8%. Cubes, cylinders and beams were cast with M20 grade concrete design mixes. The results can be discussed under the following heads. Figures 1 and 2 are plotted for compressive strength of M20 concrete. Similarly Figures 3 and 4 for tensile strength and 5 and 6 for flexural strength are plotted for the three different percentages.

I. Compressive Strength: It has been observed (Figures 1 and 2) that with the addition of fly ash and Metakaolin, the strength of concrete at the age 7 days of 28 days has increased with various proportions of the mix. The increase in strength is in the range of 7.52% and 10.52% when compare with the control mix specimen.

Figure 2: Seven Days Compressive Strength

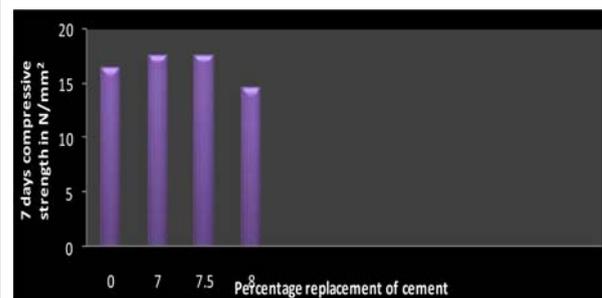
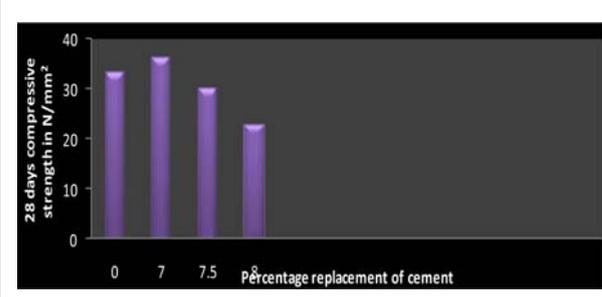


Figure 3: Twenty-eight Days Compressive Strength



II. Flexural Strength: It has been observed (Figures 3 and 4) that with the addition of Fly ash and Metakaolin, the strength of concrete at the age of 28 days has increased with various

Figure 4: Seven Days Flexural Strength

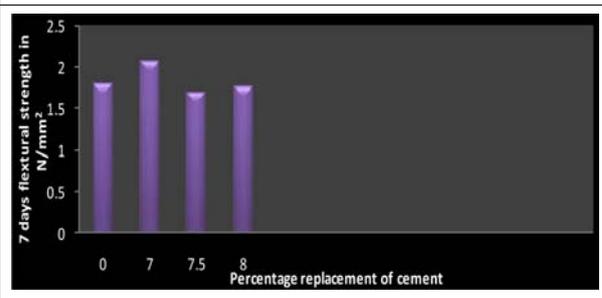
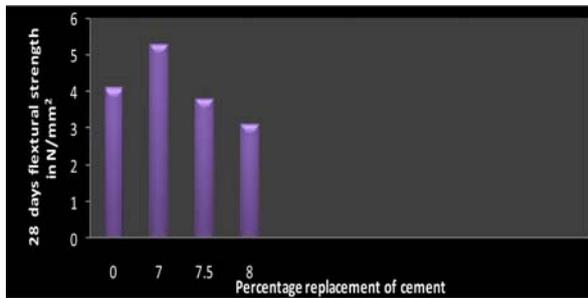


Figure 5: Seven Days Compressive Strength



proportions of the mix. The increase in strength is in the range of 15.56% and 30% for M20 when compare with the control mix specimen.

III. Split Tensile Strength: It has been observed (Figures 5 and 6) that with the addition of Fly ash and Metakaolin, the strength of concrete at the age of 28 days has increased with various proportions of the mix. The increase in strength is in the range of 3.42% - 22.70% for M20 when compare with the control mix specimen.

Figure 6: Seven Days Split Tensile Strength

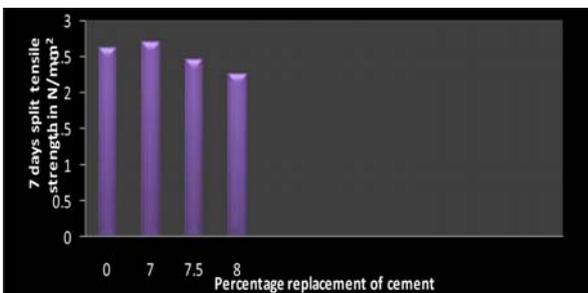
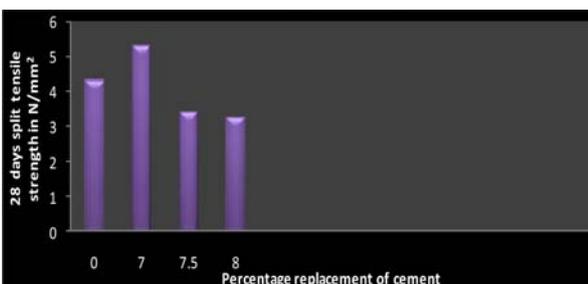


Figure 7: Twenty-eight Days Split Tensile Strength



CONCLUSION

The compressive strengths and flexural strength and split tensile strength of concrete were evaluated and concluded that all test results are increases with increase in metakaoline content up to 7%. Thereafter there is slight decline in strength for 7.5% and 8% due excess amount of metakaoline which reduces the w/b ratio and delay pozzolonic activity. The higher strength in 7% addition is due to sufficient amount of metakaolin available to react with calcium hydroxide which accelerates hydration of cement and forms C-S-H gel. The following conclusions have been drawn.

1. The 7% addition of metakaolin in cement is the optimum percentage enhancing the compressive strength at 7 days by 7.52% and 28 days by 10.52% when compare with the control mix specimen.
2. The 7% addition of metakaolin in cement is the optimum percentage enhancing the flexural strength for 7 days by 15.56% and 28 days by 30% when compare with the control mix specimen.
3. The 7% addition of metakaolin in cement is the optimum percentage enhancing the split tensile strength for 7 days by 3.42% and 28 days by 22.70% when compare with the control mix specimen.
4. From above remark from experimental work we can use the combination of 7% metakaoline and 15%-fly ash replacement of cement in concrete.
5. The strength and durability of concrete increases.
6. Use of Metakaolin accelerates the initial set time of concrete.

7. Compressive strength of concrete increases about 20% with Metakaolin.
8. Metakaolin disperse more easily in the mixer with less dusting.

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Hyderabad, INDIA. Ph: +91-09441351700, 09059645577

E-mail: editorijerst@gmail.com or editor@ijerst.com

Website: www.ijerst.com

