AN EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF CONCRETE BY PARTIALLY REPLACING CEMENT WITH METAKAOLIN

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ABSTRACT: 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, energy saving, environmental protection and conservation of resources.

Nowadays there is an increasing trend of utilization of waste/non-conventional materials in cement and concrete matrices. These materials are often used as a part replacement of cement reducing the cost of construction and help to overcome the deficiencies associated with the use of Ordinary Portland Cement (OPC) alone in which 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. Metakaoline is a waste/non-conventional material which can be utilized beneficially in the construction industry. From the recent research works using Metakaoline is a evident that it is a very effective pozzolanic material and it effectively enhances the strength parameters of concrete. However, the workability is slightly compromised and durability of concrete is increases.In the present work, an experimental investigation was carried out, replacing cement with 10%, 20%, 30% and up to 100% in M30 grades of concrete. For improving the mechanical and durability properties of concrete by adding the metakaoline. The test results are compared with conventional concrete.

I.INTRODUCTION

The application of concrete in construction is as old as the days of Greek and roman civilization. But for numerous reasons, the concrete construction industry is not sustainable. It consumes a lot of virgin materials and the principal raw material of concrete i.e. cement is responsible for green house gas emissions causing a threat to environment through global warming. Therefore, the industry has seen various types of concrete in search of a solution to sustainable development. Infrastructural growth has witnessed many forms of concrete like High Strength Concrete, High Performance Concrete, and Self Compacting Concrete.

The history of cementing material is as old as the history of engineering construction. Some kind of cementing materials were used by Egyptians, Romans, and Indians in their ancient constructions. It is also believed that the early Egyptians mostly used cementing materials, obtained by burning gypsum. The story of the invention of Portland cement is, however,

attributed to Joseph Aspdin, a Leeds Builder and brick layer, even though similar procedures had been adopted by other inventors. Joseph Aspdin took the patent of Portland cement on 21st October 1824. The fancy name of Portland was given owing to the resemblance of this hardened cement to the natural stone occurring at Portland in England. In his process Aspdin mixed and ground hard lime stones and finely divided clay into the form of slurry and calcined it in a furnace similar to a lime kiln till the CO2 was expelled. The mixture so calcined was then ground to a fine powder.

Roman builders used volcanic tuff found near Pozzuoli village near Mount Vesuvius in Italy. This volcanic tuff or ash mostly siliceous in nature thus acquired the name Pozzolona. Later on, the name Pozzolona was applied to any other material, natural or artificial, having nearly the same composition as that of volcanic tuff or ash found at Pozzuoli.

II.LITERATURE REVIEW

This chapter deals with the review of literature related to studies on Ternary Blended Concrete and Effects and performance of concrete with ternary blends.

Till three-four years ago, hardly anybody in India was aware of the use of metakaolin in concrete. During these four years, the developments that have taken place include increased awareness of the huge potential of production of metakaolin in the country (with huge mineral resource, that is, kaolin availability across the country), start of indigenous commercial production and many investigations on the development of concrete mixes containing metakaolin.

THE USE OF METAKAOLIN IN COMBINATION WITH FLY ASH

The benefits of using metakaolin or fly ash separately in concrete as partial replacement for Portland cement are fairly well-established, especially for fly ash. However, because the cost of metakaolin is about 4-5 times the cost of ordinary Portland cement, thus using metakaolin alone as a supplementary cementitious material (SCM) may not be cost effective. On the other hand, the slow reaction rate of fly ash can make its use impractical

when rapid early strength development is required. However, use of these materials in combination – as a ternary blend – has the potential to overcome the higher cost associated with metakaolin concrete and the slower strength development associated with fly ash concrete [6].

EFFECTS OF FLY ASH

Fly ash has standards in many countries. A significant problem is that two ashes, both meeting a specific standard, can give very different performance in concrete. Therefore, strict procedures for evaluation and specification of ash for concrete are required. Fly ash usually is beneficial in providing long-tem strength and impermeability. However, fly ash has a low rate of hydration which means that both short term strength and chloride resistance are typically detrimentally influenced.

This slow development of properties is critical when the structure in question will be exposed to a chloride environment after 2-3 days or less. Fly ash has documented good performance concerning the resistance to chloride penetration.

At volumes of 20 % and up there is a very good effect -after hydration is complete. Lesser volume has less effect. The cause of beneficiation from fly ash is believed to be to a minor part from better particle size distribution, for the major part from binding of chlorides by the aluminum in the flyash.

EFFECT OF METAKAOLIN

Metakaolin removes chemically reactive calcium oxide from the hardened cement paste. Metakaolin reduces the porosity of hardened concrete, Metakaolin densities, reduces the thickness of the interfacial zone, this improving the adhesion between the hardened cement paste and particles of sand or aggregate.

Blending with Portland cement Metakaolin improves the properties of concrete and cement products considerably by Increasing compressive and flexural strength, providing resistance to chemical attack and Reducing permeability substantially.

III. SIGNIFICANCE OF STUDY

Only a few research studies have examined the incorporation of metakaolin in ternary blend systems, resulting in a body of knowledge which is much less complete compared to the literature available for fly ash, silica fume, and slag ternary blend systems. Reductions in free drying shrinkage, restrained shrinkage cracking width, and chloride diffusion rate have been reported when metakaolin is used in combination with silica fume, as compared to concrete where these SCMs have been used alone.

Another study showed that when metakaolin is combined with fly ash, the effects of metakaolin and fly ash on the temperature-rise tend to compensate for one another. For example, the temperature-rise for a 10% Metakaolin–10% fly ash mortar is the same as that of the plain cement control. For water-cured concrete made with Portland cement, fly ash, and metakaolin, increasing the metakaolin content enhanced the 28-day compressive strength and reduced sorptivity to values below that of the control, whereas the sorptivities of fly ash concrete exceeded that of the control.

Thus, it is believed that a combination of metakaolin and fly ash in a ternary cement system (i.e., Portland cement being the third component) should result in a number of synergistic effects, some of which may include:

- Fly ash increases long-term strength development of metakaolin concrete.
- Fly ash offsets increased water demand of metakaolin.
- Fly ash compensates for higher heat release from metakaolin cement.
- The relatively low cost of fly ash offsets the increased cost of metakaolin.
- Metakaolin compensates for low early strength of concrete with fly ash (binary blend of cement and fly ash).
- Metakaolin reacts with CH to produce C-S-H, thus potentially improving the behavior of higher CaO fly ash for reduces the normally high levels of high CaO fly ash required for ASR prevention
- Thus significant improvements in mechanical and durability properties could be achieved upon replacing some of the cement with metakaolin, and fly ash.

SCOPE OF PRESENT INVESTIGATION
OBJECTIVES

The principal objective of this research was to build upon the prior research in Phase I, which examined the effect of metakaolin addition rate on compressive and flexural strength development, plastic concrete properties, shrinkage, permeability, and durability to address issues not previously considered in Phase I and to examine with further testing those results from Phase I which were inconclusive. A major focus of this continued research is the development and characterization of metakaolin/fly ash ternary-blended concrete.

The specific objectives of the present investigations are as listed below

a) To conduct study of producing Blended concrete with Metakaolin admixture
b) To conduct study of producing Blended concrete with Fly ash admixture
c) To study the effect of partial replacement of cement by Metakaolin and Flyash in different percentages at 7 and 28 days compressive strength, split tensile strength modulus of elasticity, and flexural strength
d) Super plasticizer: Conplast SP- 430 Super plasticizer was used as water reducing agent, mainly to improve the Workability

The scope of present investigation is to study and evaluate the effect of replacement of cement by various percentages of Metakaolin (0, 5, 10, 15, and 20) along with fibers [0 to 1] for water cement ratio 0.32 and to produce Ternary Blended Concrete. Cubes are cured at 7 and 28 days and tested for compressive strength. Similarly cylinders and beams of size are tested for split tensile strength and flexural strength.

IV. CONCLUSIONS

The following conclusions have been arrived from the study:

1) Metakaolin is an effective pozzolona and results in enhanced early strength and ultimate strength of concrete.
2) The compressive strength of young concrete, i.e., 7 days is improved by blending the OPC with 10% of metakaolin by weight.
3) The 10% replacement with metakaolin is the most optimum replacement, enhancing the concrete's compressive strength at all ages.
4) The 28-days compressive strength of concrete was improved by partial replacements of OPC by metakaolin in the range up to 10% by weight, and was at the 20% level still maintained. The highest 28-days strength improvement of concrete can be expected at partial replacements in the 10-15% range.
5) The combined use of metakaolin and a super plasticizer allowed increasing the aforementioned partial replacement levels, i.e. to 20% in the case of maintaining strength.
6) Ternary blending by Metakaolin in combination with Fly Ash was found leading to further technical improvements to concrete strength. Especially, blended concrete mixtures with Metakaolin / Fly Ash -ratio to 50/50 by weight revealed higher efficiency for improving strength at older ages.
7) Addition of flyash results in economy of the mix because of low cost of fly ash.
8) Addition of fibers to all the mixes clearly indicate improvements in all the properties such as compressive strength, split tensile strength, and most importantly increased flexural strength, this property is very useful in arresting the cracks to a large extent.

V. SCOPE FOR FURTHER STUDY

From this study, the following recommendations are made for the future work:

1. It is observed that the optimum
2. In this study, there is only one kaolin sample used for the experiment. Future study should gather more kaolin samples from various sources. It is important to study the different behavior of metakaolin-concrete calcined from different kaolin to look into the performance contingency of the samples.
3. Future study should look into the durability aspect of the metakaolin-
4. concrete which is not covered in this study. The advantages of replacement percentage for metakaolin in this study is only 10% that is comparatively low compared to others cement replacement materials. It is suggested that additional of lime is needed to increase the replacement percentages. Additional lime increases the amount of CH to react with metakaolin. In this situation, the replacement percentage with metakaolin is increased. However, the additional lime will bring many impacts to the properties of concrete especially the durability aspect. On this matter, further study is needed.

metakaolin-concrete in the durability aspect should be able to widen the application of metakaolin-concrete.

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