A Study on Fresh and Hardened Properties of M25 & M45 grade Concrete, Partially Replacing Cement with Fly Ash, Metakaolin & Fully replacing Natural sand With Robosand

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***Abstract*—Concrete is the most extensively used construction material in the world, which consumes natural resources like lime, aggregates and water. The worldwide production of cement has greatly increased, due to this production environmental pollution increases with emission of CO2 gas. To reduce this effect cement was replaced by some supplementary materials like Metakaolin, Fly ash, Bottom Ash, Ground Granulated Blast Furnace Slag (GGBS) and Rice Husk etc. In this content Metakaolin and fly ash Pozzolanic material used in wide range in replacement of cement. Metakaolin is dehydroxylated aluminum silicate, Fly ash due to its Pozzolanic activity the strength properties and durability properties of concrete increases and reduction in Porosity and Permeability also.**

Now-a-day's availability of natural sand is constraint, so alternative material called ROBO Sand (having similar properties as that Natural Sand) is used in place of Natural sand to study the fresh hardened properties of concrete. In this present investigation cement is replaced partially with Metakaolin and Fly ash in varying percentage i.e., 0%, 5%, 10%, 15% and 20% and natural sand with 100% ROBO sand to get the different concrete mixes. The fresh and mechanical properties of concrete i.e., workability (slump test) and compressive strength, split tensile strength and flexural strength at 7 days, 14 days, 28 days and 90 days are studied of the different concrete mixes and results are compared with conventional concrete.

Keywords: Fly ash, Metakaolin, compressive strength, split tensile and flexural strength.

1.INTRODUCTION

Concrete is a composite material that is widely used throughout the world. It is obtained by mixing cementitious materials, aggregate and water in the required quantities. The word "concrete" comes from the Latin verb "concretes", which means "to grow together". The characteristic strength of concrete depends on the properties of the components of the material and their combined effect. Cement production emits more CO2 gas; This results in damage caused by natural weather influences. In order to reduce cement consumption, cement is partially replaced with some supplementary cementitious materials such as metakaolin, fly ash, bottom ash, rice husk, GGBS and silica fume, etc. in the concrete mix. Metakaolin is a dehydroxylated form of the clay mineral kaolin.

1.2 Constituent Material Used

The constituent material used are cement, Fly ash, Metakaolin, Fine aggregate, ROBO sand, Coarse aggregate and water. There commended materials have been described below.

1.2.1 Cement

Cement can be defined as a sticky substance capable of uniting fragments or masses of solid matter into a lumpy whole. Leah et al. (1970). Various types of cement can be used in the manufacture of concrete.

1.2.2 Admixtures

Mixture is defined as the material other than cement, sand, water and aggregate used as a component of concrete. The mixture is a material that is usually added to the cement clinker at the cement factory at the time of grinding

1.2.3 River Sand

An extensive study by experts has shown that riverbed sand supplied for construction purposes is virtually worthless and unusable unless tested. Contains 25-30% slime vs. 5% allowed. The sludge content is between 20% and 25% against the allowable limit of 2% to 5%, showing that stone sand is a viable substitute for river sand.

1.2.4 Metakaolin
Metakaolin, commonly referred to as "calcined clay", is a reactive alumina-silicate pozzolan produced by heating kaolinite to a specific temperature range. Kaolinite is the clay mineral that gives the raw material its plasticity and changes into a durable material when fired.

1.2.5 Fine Aggregates
The most common fine aggregate used in concrete is river sand. River sand is an essential ingredient in the manufacture of the two most common building materials, viz. Cement and Mortar. The sand must be clean, hard, solid and free from organic impurities and contaminants. It must be able to produce a sufficiently workable mix with a minimum water-cement ratio.

1.2.6 ROBO sand
ROBO sand is an ideal substitute for rivers and is made the way nature has been doing for more than a million years. ROBO-Sand is manufactured through a brick-on-brick crushing technique using state-of-the-art equipment and machinery with world-class technology

1.2.7 Coarse Aggregates
Aggregates are created by the natural naming of rock or by artificially crushing rock or gravel. Gross aggregate properties include chemical and mineral composition, spectrographic description, specific gravity, hardness, strength, physical and chemical stability, pore structure, and color. absorption, etc. All of these properties can have a significant impact on the quality of the fresh and solid state of the concrete.

Concrete:
Concrete is the most commonly used artificial structure in the world. It is obtained by mixing cementing materials, water, aggregate and sometimes additives in the required proportions. Fresh concrete or plastic concrete is a freshly mixed material that can be poured into any shape and hardens into a stone-like mass known as concrete.

1.2.8 Water
The mixing water must be clean, fresh and drinkable. The water must be free from impurities such as clay, loam, soluble salts, which lead to a deterioration in the properties of concrete. Drinking water is suitable for mixing and curing concrete

1.2.10 TYPES OF MIXES
Nominal Mixes
In the past, concrete specifications prescribed the proportions of cement, fine and coarse aggregates. These mixes, with a fixed cement to aggregate ratio that ensures sufficient strength, are called nominal mixes. These offer simplicity and under normal circumstances have a higher resistance range than advertised. However, due to the variability of the mix ingredients, the nominal concrete for a given workability will vary widely in strength.

Standard mixes
Nominal mixes with specified cement-to-rock ratio (by volume) vary widely in strength and can lead to - or too rich mixtures. For this reason, a minimum compressive strength has been included in many specifications. These mixtures are referred to as standard mixtures. IS 456-2000 has designated concrete mixes of various grades as M10, M15, M20, M25, M30, M35 and M40. In this designation, the letter M refers to the mixture and the number to the stated bulk strength of the mixture at 28 days in N/mm2. Mixtures of the types M10, M15, M20 and M25 roughly correspond to the mixing ratios (1:3:6), (1:2:4), (1:1), (5:3) or (1:1:2).

1.3 Objective of Present Study
The research work is titled "Experimental study of the properties of concrete partially replacing cement with fly ash and metakaolin and natural sand with Robo-Sand" and aims to improve the strength properties of concrete with the partial Replacement of concrete to improve cement with metakaolin and natural sand with Robo-Sand.

2.LITERATURE REVIEW

2.1 General
Metakaolin is refined kaolin clay that is fired (calcined) under carefully controlled conditions to produce anamorphic alumina-silicate that is reactive in concrete. Like other pozzolan (fly ash and silica fume

are two common pozzolan), metakaolin reacts with calcium hydroxide (lime) by-products formed.

2.2 Review of Literature
Venn Malagavelli et al. (2010) have studied the properties of M30 concrete with partial replacement of cement by ground granulated blast furnace slag (GGBS) and sand by ROBO sand (crusher dust). OPC Grade 43 was used to make the concrete mix.

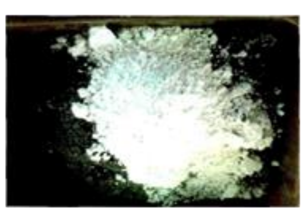
M. R. Chitlange et al.1. (2010) The study shows that mixtures with artificial sand as a fine aggregate have consistently higher strength than mixtures with natural sand. The sharp edges of the artificial sand particles bond with the cement better than the rounded particles of natural sand, resulting in higher strength. Excessive bleeding of the concrete is reduced by using artificial sand.

2.3 Discussion on Literature Review
From reviewing the literature, it was concluded that little work had been done on the properties of concrete using metakaolin and ROBO sand. Therefore, in the present study, an attempt was made to investigate the effect of metakaolin and ROBO sand on the fresh and hardened concrete properties.

3.EXPERIMENTAL PROGRAMME

3.1 General
This chapter deals with the properties of the material used and the methods for preparing concrete mixes with metakaolin and ROBO sand in different proportions. The main properties studied were the workability of fresh concrete and the compressive strength, splitting tensile strength and flexural strength of hardened concrete at different ages.

3.2.2 Metakaolin
Metakaolin is brought from Vadodara having more than 55% of SiO2 and Specific gravity 2.5 and finer than Cement.



3.2.3 Fine Aggregate (Coarse Sand)

Locally available river sand was used as a Fine aggregate

3.2.4 ROBO Sand
ROBO sand is collected from a locally available crushing plant. It was initially dry when collected and sieved through IS 4.75mm. It has a particle shape like cubic particles.

3.2.5 Coarse Aggregate
Locally available 20mm and 10mm quarry sandstone was used as coarse aggregate. The results of sieve analysis and physical properties of the 20mm and 10mm coarse aggregates

3.3 Concrete Mix Design
Concrete Mix Concrete grades M25 and M45 have been designed according to the recommended guidelines of IS: 10262-2009. The mix ratio is 1:1.79:3.05 keeping the water to cement ratio at 0.40.

3.4 Casting of Specimens
The ingredients were mixed manually. Processability was measured by the slump cone test. The 150mm x 150mm x 150mm cubes of compressive strength

specimen, 150mm x 300mm cylinders for split tensile strength and 500mm x 100mm x 100mm beams for flexural strength were tested in accordance with IS: 516-1959 melted. A total of 108 samples (36 cubes, 36 cylinders and 36 beams) were cast in this study. Samples were tested on the Compression Tester at 7, 14, 28 and 90 days of age.

3.6 Testing of Hardened Concrete

The Following tests were performed on the hardened concrete.

Compressive strength test on cube specimens to evaluate to compressive strength of concrete at 7 days, 14, 28 and 90 days.

Split tensile strength to evaluate the split tensile strength on cylinders at 7 , 14, 28 and 90 days.

Flexural strength to evaluate the Flexural strength on beams at 7,14, 28 and 90 days

3.6.1 Compressive Strength

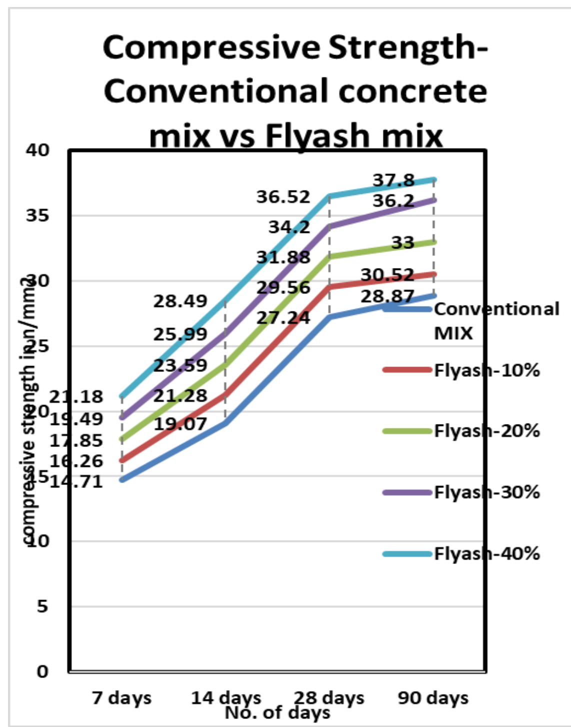
Cube specimens were tested at 7 days, 14 days, 28 days and 90 days of age in a Compression Testing Machine (CTM) after drying at room temperature according to IS: 516-1959. The load was shock and shock-free and evenly at 140 N/cm/minute. The breaking load that each sample took was recorded.

Compressive strength = $\frac{maximumloadappliedtothespecimens}{crosssectionalareaofthecubespecimens}$

3.6.3 Flexural strength

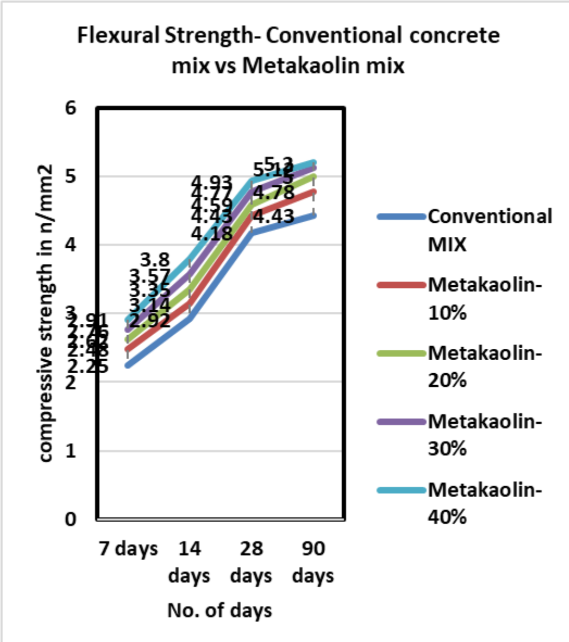
The bed of the testing machine shall be fitted with two 38mm diameter steel rollers on which to support the specimen and these rollers shall be mounted so that the center to center spacing is 60cm x 15.0cm specimen 40 cm for 10.0 cm samples. The load is applied via two similar pulleys mounted at the third points of the support span, i.e. H. at a distance of 20 or 13.3 cm center to center. The load is distributed equally between the two load rollers and all tenders are mounted so that the load is applied axially and the sample is not subjected to torsional stress or constraint.

$$Flexuralstrength = \frac{PL}{bd^2}$$



4.5 Flexural Strength

The effect of Metakaolin and ROBO sand used in the present study on Flexural strength of concrete for M25 grade of concrete with varying dosages as 0%, 10%, 20%, 30% and 40% of Metakaolin& fly ash replacing cement by weight and natural sand with 50% ROBO sand at 7 days, 14 days, 28 days and 90 days.



Variation of Metakaolin and ROBO sand on Flexural strength of different concrete mixes.

From the test results, it was observed that the flexural strength of mixed concrete decreased after 7 days initially with 0% metakaolin substitute and after the strength had increased to 10% replacement is 2%, 8% and after The strength gradually decreased after 14 days. Concentrations were 4% and 8%, with 5% and 10% metakaolin replacement after potency decrease. Similarly, after 28 days, % and 11.5% to 5% and 10% metakaolin replacement after the strength has decreased.

5. CONCLUSION

On the basis of experimental investigation of the present research study, the following conclusions have been drawn.

Compressive strength

From the test results, it was observed that the compressive strength of various concrete mixes increased at each age compared to the control mix. The percentage increases are 4.5%, 25%, 30.9%, 18.2%, and 8%.8% at 7 days, 2.4%, 4.4%, 9.2%, 3% and 1% at 14 days and 2.3%, 4.3%, 9.7%, 2.8% and 0.56% after 28 days and 90 days compared to the control concrete. The increase in compressive strength of various concrete mixes is due to the fact that calcium hydroxide as a by-product account for up to 25% of hydrated Portland cement. Metakaolin fly ash combines with calcium hydroxide to create additional cementitious compounds, the material responsible for holding concrete together. Less calcium hydroxide and more cementitious compounds mean stronger concrete.

Split Tensile strength

From the test results it has been observed that the Split tensile strength of different concrete mixes also increases at all ages in comparison of the control mix. The percentage increases are 6%, 10%, 15.2%, 11.9% and 8.8% at 7 days, 2.4%, 8%, 19.16%, 5.3% and 0.6% at 21 days and 2.2%, 7.5%, 17.5%, 5% and 0.5% at 28 days as compared to control mix concrete.

Flexural strength

From the test results, it was observed that the flexural strength of various concrete mixes increased at each age compared to the control mix. Percentage increases are 2%, 8% and 4% and 8% at 5% 10% metakaolin replacement 14 days after the strength wears off. Similarly, after 28 days, 6.5% to 5% and 10% metakaolin replacement and after the strength has decreased. All test results show that the concrete mix (M3) i.

With 10% replacement of cement with metakaolin and natural sand with 50% ROBO sand, better durability is achieved compared to other concrete mixes. If the proportion of metakaolin increases above 10%, the strength decreases due to the greater fineness.

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