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Study on Metakaolin and Fly Ash Based Geopolymer Concrete

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***Abstract*— cement is a well-known binding material indispensable place in construction works. Production and consumption of cement in an index of its industrial development but excess of production of cement pollute the environment by releasing CO2 gas. So it is necessary to replace cement by other binding material. In this experimental study, the test was carried out on concrete specimens with 0%, 10%, 20%, 30%, 40%, 50% replacement of cement by fly ash and metakolin with alkaline liquid such as sodium hydroxide and sodium silicate solution as 12M, moulds were prepared for 7days and 28days and the moulds were kept in a oven at 60º C for 24hours and curing was done under sunlight. The conventional concrete M40 was made using OPC 53 grade for 7 days and 28 days and placed it for water curing. Compressive strength and split tensile test were performed to evaluate optimize ratio and mechanical properties of metakaolin based on concrete and compare with conventional mix.**

Keywords*— Geo polymer GPC; Metakaolin; fly ash; alkaline solutions sodium hydroxide (NaOH), sodium silicate (Na2SiO3); compressive strength; split tensile strength;

I. INTRODUCTION

Concrete is the most commonly used for construction. Cement industry is under constant pressure because it emits large amount of greenhouse gases to convert raw material into cement product and to reduce the CO_2 gas released by the manufacture of cement industries. Different types of cement replacement materials such as metakaolin, fly ash, slag, Nano silica are being used investigated by scientists with different replacement levels of Ordinary Portland Cement (OPC).

Cement is replaced by industrial waste Fly Ash which will reduce the effect on green house caused by CO_2 gas. Replacement of cement by fly ash reduces the water demand for a given slump. When fly ash is used about 20% of the total cementitious, water demand is reduced by approximately 10%. The decreased water demand has little or no effect on drying shrinkage/cracking. Metakaolin (MK) is highly reactive alumino-silicate source material. MK is used as a cement replacement material to enhance durability and mechanical properties of cementitious concrete.

All these materials are finer particles are glassy which help in reducing amount of water and help to increase workability. By using this mineral admixture, cost of concrete is reduced and ecofriendly concrete is developed.

II. LITERATURE REVIEW

M.Narmatha and Dr.T.Felixkala [1] 2017: conducted the test on concrete specimens with 5, 10, 15, 20, 25% replacement of cement by metakoline and fly ash for all mix 10%. The addition of fly ash in concrete improves certain properties such as workability, later age strength development and few durability characteristics. Concrete is the high volume of fly ash and metakaolin as a partial replacement of ordinary Portland cement .The conventional concrete M60 was made using OPC 53 with metakaolin and fly ash. To evaluate optimize ratio and mechanical properties of metakaolin based on concrete and compare with conventional mix .From the optimization 20% cement replacement by metakaolin superior than all the mixes.

Smt. Bhavna K. Shah and Hemant Chauhan [2] 2011: carried an experimental program to achieve this higher strength, OPC as a cementitious material is not sufficient, so in this paper industrial waste like activated fly ash (class F), Iron Oxide and Metakaolin are used as supplementary cementitious materials in various proportions. By using this mineral admixtures with OPC cement, different five types of cement were prepared and same were used to find compressive strength of concrete cubes at 3,7,14,28 and 56 days.

A.R.R. Kalaiyarrasi [3] 2017: The objective of this research is to synthesize MK based GP concrete, by replacing FA in GP by MK in 25, 50, 75% and test for strength and durability. Three MK samples with Si/Al mass ratio of 0.87(M1), 1.11(M2), 1.21(M3) have been used in this research. Study of Micro structural property of MK based GP using Fourier Transform Infra-Red Spectroscopy (FTIR), Electron Dispersive Spectroscopy (EDS) and Scanning Electron Microscopy (SEM) techniques has been carried out. Evaluation of axial compressive strength of MK geo polymer brick masonry (MKBP) with aspect ratio between 2 and 5 has been done and compared with the compressive strength and Elastic modulus of Clay Brick Prism (CBP).

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III. METHODOLOGY

The experimental investigation is to case study the properties of metakaolin and fly ash in increase in compressive strength of concrete by replacing cement. Strength characteristics of concrete with partial replacement of fly ash by metakaolin at 0%, 10%, 20%, 30%, 40% and 50% for M40 grade.

1) Materials are collected and properties are studied.
2) The mix design is carried out for M40 grade according to the material properties.
3) The moulds are prepared at 0%, 10%, 20%,30%, 40% and 50% of metakaolin by replacement of fly ash for 7days and 28days
4) The prepared moulds are heated at 60°C for 24 hours and placed it for sunlight curing.
5) The conventional concrete moulds are also prepared for 7days and 28 days and placed it for water curing.
6) The compressive strength and split tensile strength are determined at 7 and 28 days in hydraulic compression testing machine.
7) Based on results the conclusions are drawn.

Figure 1:Materials used for concrete mix

MIX DESIGN

A. *PARAMETERS FOR MIX DESIGN:*

- Target Strength – M40
- Type of Cement - OPC 53
- Degree of Supervision - Good
- Type of Aggregate -Crushed Angular
- Maximum Nominal Aggregate Size - 20mm
- Exposure Condition -Normal

B. *TEST DATA FOR MATERIALS:*

- Cement Used – Birla super OPC 53 Gr.
- Sp. Gravity of Cement - 3.15
- Sp. Gravity of Metakaolin - 2.4
- Sp. Gravity of Fly Ash – 2.1
- Sp. Gravity of Fine Aggregate - 2.65
- Sp. Gravity of Coarse Aggregate - 2.67
- Water absorption of 20mm. aggregate - 60%
- Water absorption of 10 mm aggregate - 40%
- Water absorption of sand - 1.20%

C. *MIX PROPORTIONS*

- Cement = 422.48 kg/m3
- Water = 147.87 kg/m3
- Fine aggregate = 776.84 kg/m3
- Coarse aggregate = 1126.33 kg/m3
- Water/cement = 0.35
- Mix ratio = C: FA: CA: W/C
  = 1:1.83:2.66:0.35

Figure 2:Dry mixture with alkaline solutions of NaOH , Na_2SiO_3 and super plasticiser

Figure 3:Oven dry for 12hours at 60°C

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Figure 4:Sunlight curing

D. *TESTS CONDUCTED:*

- *Compressive strength*
- *Split tensile strength*

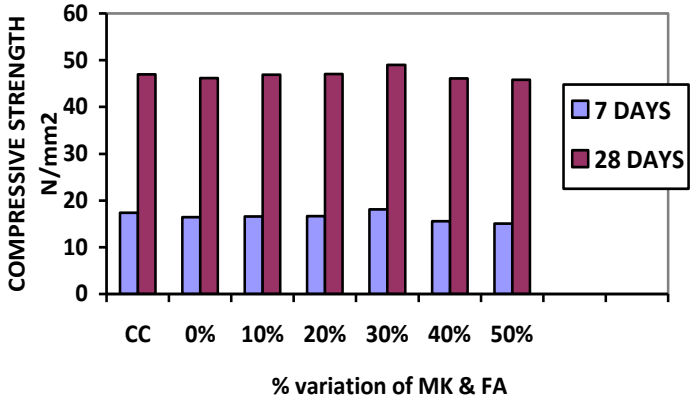
Figure 5:Testing of cube under CTM

Fgure 6:Testing of cylinder under CTM

IV. RESULTS

Result for 7 days of concrete mix

Sl .no	% variation of MK & FA	Compressive strength for 7days	Split tensile for 7days
1.	CC	17.4	1.8
2.	0% MK & 100% FA	16.42	1.59
3.	10% MK & 90% FA	16.56	1.64
4.	20% MK & 80% FA	16.63	1.78
5.	30% MK & 70% FA	18.09	1.91
6.	40% MK & 60% FA	15.56	1.68
7.	50% MK & 50%	15.03	1.51



Compressive strength at 7days & 28days Vs % variation of MK & FA

RESULT FOR 28 DAYS OF CONCRETE MIX

Sl .no	% variation of MK & FA	Compressive strength for 7days	Split tensile for 7days
1.	CC	47	4.71
2.	0% MK & 100% FA	46.2	4.78
3.	10% MK & 90% FA	46.88	4.87
.4.	20% MK & 80% FA	47.03	4.99
5.	30% MK & 70% FA	48.97	5.09
6.	40% MK & 60% FA	46.13	4.49
7.	50% MK & 50%	45.81	4.71

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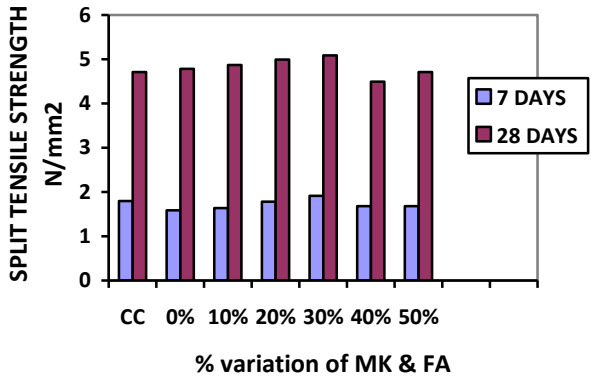

Split tensile strength at 7days & 28days Vs % variation of MK & FA

V. CONCLUSION

- The workability of concrete reduces with increase in the percentage replacement of fly ash and metakaolin upto 30%MK and 70%FA in concrete. Decrease in slump due to porous nature of metakaolin and workability reduces at 60% and 40%.
- Optimum compressive strength increases at 70% FA and 30% MK and it is found about 3.96% and 4.19% strength increased compare to conventional concrete.
- Optimum split tensile strength increases at 70% FA and 30% MK and it is found about 6.11% and 8.06% strength increased compare to conventional concrete.

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