Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 15, Issue. 2 : 2024
ISSN :**1906-9685**

EFFECT OF METAKAOLINE M SAND ON STRENGTH AND DURABILITY OF M60 GRADE GEO POLYMER CONCRETE

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Abstract *Research for complete OPC free concrete is still evolving and there is a need for developing alternative binding agents which are environmentally friendly. One such alternative is identified to be geopolymer which often consists of fly ash, sodium silicate, and sodium or potassium hydroxide (NaOH or KOH). Since, many coal based power plants in India have been retiring due to thrust towards cleaner energy production and this may lead to scarcity of fly ash in future. The production of Ordinary Portland cement and the usage of normal river sand are increased due to the demand of concrete in construction Industries. The emission of CO2 increases during the production of cement and at the same time the availability of river sand is also becoming costlier and scarcity due to illegal dredging of river sand. The main intension of this research paper is to focus the eco friendly alternative material for the cement and river sand.*

Hence the objective of this study is to incorporate other Pozzolanic materials in geopolymer concrete. In line with objective two Pozzolanic material metakaolin was used to replace fly ash in geopolymer concrete and the percentage of M-sand in place of river sand. Concrete mix design of M30 were done based on Indian standard code guidelines. Concrete cubes specimens were tested for evolving the strength and durability by varying the percentages of metakaolin and M-sand in concrete

The percentage replacement of metakaolin and M-sand in Geopolymer concrete by using 0%MK+0%M-sand, 2.5%MK+5%M-sand, 5%MK+10% M-sand, 7.5%MK +15%M-sand, 10%MK+20%M-sand. The various tests like compressive, tensile, flexural and Durability tests are performed on geopolymer concrete by varying percentages of metakaolin and M-sand.

Key words: *OPC, geopolymer, sand, metakaolin, strength, durability, concrete.*

1. INTRODUCTION

India is a growing economy. Infrastructure facilities are to be stepped up to compete in the global arena. Boom in the construction activity, escalates the demand for cement as it is the largely used construction material. Production of 1 ton of cement releases 1 ton of CO2 into the atmosphere. In this study, geopolymer is presented as an alternate construction material. Synthesis of geopolymer involves no cement. Geopolymers can be synthesised to be as strong as and more durable than cement concrete depending on the starting material. Curing is eliminated as Geopolymers are self-curing at temperate climates. Precast products can be used in colder regions. Geopolymer concrete is a viable alternative to cement concrete considering the abundant availability of raw materials and the carbon footprint left on the environment is very much less compared to cement. This research investigates the performance of Fly ash as geopolymer precursor to meet the growing demands of construction industry for a reliable and an efficient material. The gain in strength is early as it is highly reactive and Fly ash based geopolymer concrete reduces the carbon dioxide emission as it replaces cement and gains carbon credit.

The experimental investigation was conducted to study the strength and durability of fly ash based geo

polymer concrete is made the trials are assumed with varying percentages of metakaolin and m sand mix *by using 0%MK+0%M-sand, 2.5%MK+5%M-sand, 5%MK+10% M-sand, 7.5%MK +15%M-sand, 10%MK+20%M-sand*.

2. MATERIALS USED

Metakaolin

Metakaolin is produced under carefully controlled conditions to refine its colour, remove inert impurities, and tailor particle size such, a much high degree of purity and pozzolanic reactivity can be obtained. Metakaolin is white, amorphous, highly reactive aluminium silicate pozzolan forming stabile hydrates after mixing with lime stone in water and providing mortar with hydraulic properties.

Fly ash

Fly ash, also known as "pulverised fuel ash" in the United Kingdom, is a coal combustion product that is composed of the particulates(fine particles of burned fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler is called bottom ash.

M Sand

Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word.

Coarse aggregates

Locally available crushed granite stone aggregate of 10mm size was used as coarse aggregate. The coarse aggregate passing through 10mm and retaining 4.75mm was used for experimental work.

Fine aggregates

The locally available river sand, passing through 4.75 mm was used in this experimental work. The properties of fine aggregates were determined as per IS: 2386-1963

Alkaline solution

A combination of sodium silicate solution and sodium hydroxide solution was used as alkaline solution.

Sodium hydroxide

Sodium hydroxide is soluble in water, ethanol and methanol. This alkali is deliquescent and readily absorbs moisture and carbon dioxide in air. Pure sodium hydroxide is a whitish solid, sold in pellets, flakes, and granular form, as well as in solution.

Sodium silicate

Sodium silicate is the common name for compounds with the formula Na2(SiO2)nO Concrete treated with a sodium silicate solution helps to significantly reduce porosity in most masonry products such as concrete. A chemical reaction occurs with the excess Ca(OH)2 (portlandite) present in the concrete that permanently binds the silicates with the surface, making them far more durable and water repellent.

Admixture

To acquire workability of clean Geopolymer Concrete, Sulphonated napthalene polymer based totally wonderful plasticizer Conplast SP430 in the shape of a brown liquid right away dispersible in water, Use of superplasticizer lets in the discount of water to the quantity up to 30 percentage without lowering the workability, in assessment to the feasible reduction up to fifteen percentage in case of plasticizers. The use of superplasticizer is practiced for production of flowing, self leveling, self compacting, and for production of excessive strength and high performance concrete.

3 METHODOLOGY

In order to test the strength and durability of geopolymer concrete using metakolin and M sand for compressive strength, split tensile strength, flexural strength and durability of various curing periods. Along with those strength tests workability is also studied for various trial mixes. For this project the following methodology is used.

3.1 Batching

Batching is the process of taking the quantity of materials required for the project. Generally measuring the material quantity is done by two methods one is weight batching, second is volume batching. In the present study weight batching is considered to measure the materials quantity.

3.2 Mixing of the concrete

After measuring the materials quantity mix the materials as per the trails. Firstly we have to mix

coarse aggregates, fine aggregates, metakolin, fly ash and m sand for some time to get uniform mix after that add alkaline solution to the mixture again mix for some more time to get same mix throughout the material. Now add the water as per the calculations from the mix design to make freshly prepared concrete for M30 grade concrete.

3.3 Casting of specimens

After mixing the concrete materials we have to cast the specimens like cubes, cylinders, prisms to check the strength and durability at 7days, 14 days and 28 days curing period along with these strength we have to cast 15 cubes for the durability of concrete for these five trial mixes.

3.4 Curing of the Specimens

In case of compressive strength, split tensile and flexural strength studies we have to cure the specimens for 7 days, 14 days and 28 days of curing periods with all five trial mixes. While in case of durability we have to cure the specimens to at least for acid attack and alkaline attack tests.

3.5 Mix trials used

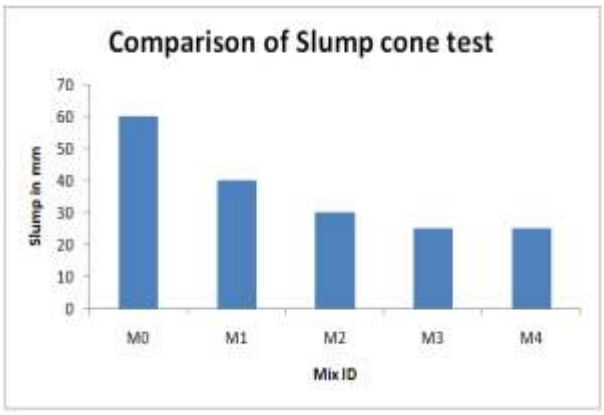
The following are the trial mixes used for the project they are named as M0, M1, M2, M3 and M4. The details are given in the below

1. M0 - 0%MK+0%M-sand
2. M1- 2.5%MK +5%M-sand
3. M2- 5%MK +10%M-sand
4. M3- 7.5%MK +15%M-sand
5. M4- 10%MK +20%M-sand

4. RESULTS AND ANLYSIS

4.1 Workability of Concrete

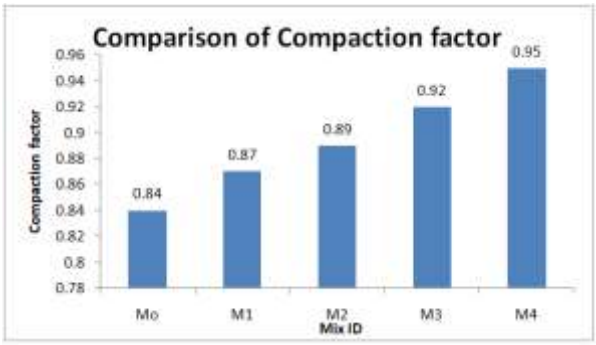
Workability is one of the most important property of the freshly prepared concrete mixtures in the present study workability of concrete mix is find out with the help of the slump cone test and compaction factor tests the below graph shows the slump cone comparison for various mixes



Graph 1: Comparison of slump cone test

4.2 Compaction Factor

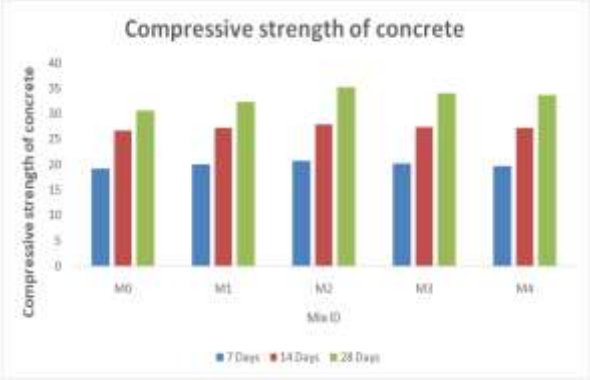
Compaction factor is the weight of partially compacted concrete to the weight of full compacted concrete. For the present study compaction factor is determined with the help of mix trials from mix trial 1 to mix trial 5 the below graph shows the compaction factor test results.



Graph 2: Comparison of compaction factor

4.3 Compressive Strength of Concrete

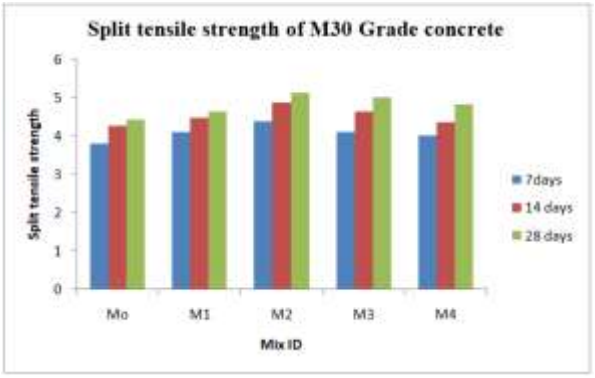
After curing cubes the compressive strength of concrete is resolved with the assistance of universal testing machine (UTM) for trial 1 to trial 5. The below figure shows the compressive strength of concrete for 7 days, 14 days and 28 days curing.



Graph 3: Comparison of Compressive strength

4.4 Split Tensile Strength

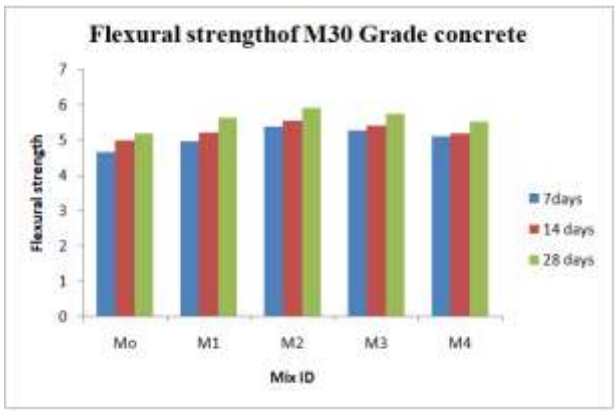
Split tensile strength of concrete is determined for M35 grade concrete with the help of cylinder specimens for various mix trials from trial 1 to trail. The dimension of the cylinder was taken as 150mm diameter and 300mm length. The below graph shows the split tensile strength for 7days, 14 days and 28 days.



Graph 4: Comparison of Tensile strength

4.5 Flexural Strength Of Concrete

Generally flexural strength of concrete is determined for prism specimens of 150mmX150mmX700mm dimensions. The flexural strength of prism specimens is determined for trials 1 to trails 5 for M35 grade concrete, the below graph shows the flexural strength of concrete for 7days, 14 days and 28 days curing

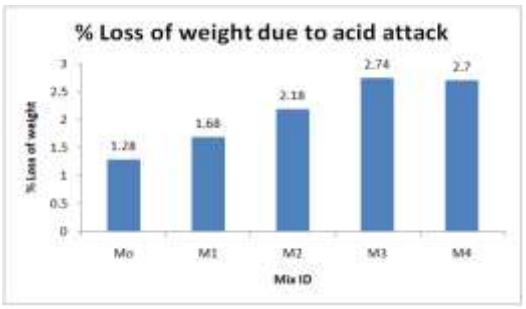


Graph 5: Comparison of Flexural strength

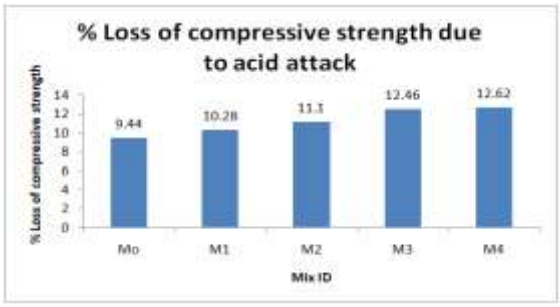
4.6 Durability Of Concrete

Durability is one of the most critical pieces of concrete on account of its focal rate in the usefulness life of structures. In such manner, breaking accept a key activity in the quality of strong structures. Durability is one of the most significant viewpoint in concrete this property is controlled by restoring the block samples in corrosive arrangement and basic arrangement the beneath chart shows the rate loss of weight and rate loss of compressive quality for both relieving techniques.

4.6.1 Acid attack

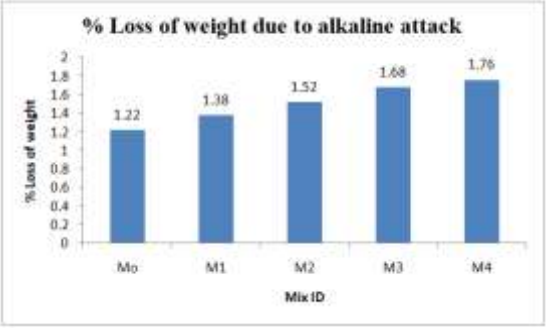


Graph 6: Comparison of percentage loss of weight

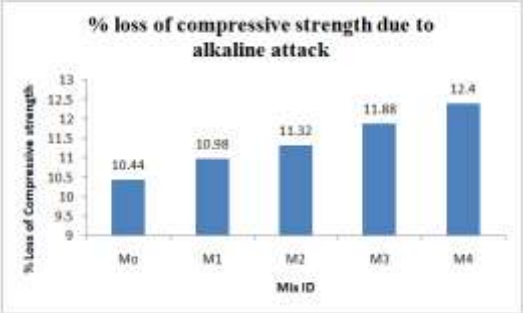


Graph 7: Comparison of percentage loss of strength

4.6.2 Alkaline attack

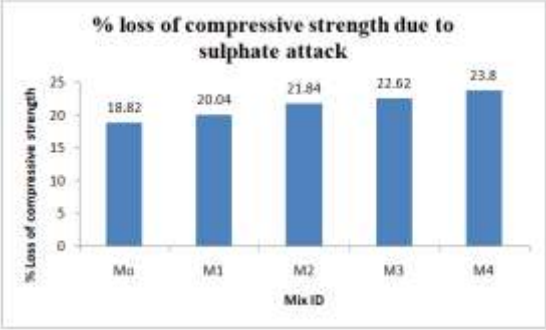


Graph 8: Comparison of weight loss



Graph 9: Comparison of percentage loss of strength

Sulphate attack



Graph 10: Comparison of percentage loss of strength

5. CONCLUSIONS

From the above experimental study the following conclusions were made

1. Geopolymer concrete tends to show no significant physical change in its properties at normal operating room temperature which is observed in case of normal variety. The complete setting of Geopolymer concrete specimens will take upto 72 hours without any reminisces on the surface on which it is hardened.
2. The value of slump decreases from 60mm to 25mm with increase in the percentage of metakolin and M Sand from 0%+0% to 10%+20%.
3. The value of compaction factor increases 0.84 to 0.95 for M30 Grade concrete with increase in the percentage of metakolin and M Sand from 0%+0% to 10%+20%.
4. The optimal value (maximum value) of compressive strength was observed at 7.5%MK+15%M-sand (M3) for 7days, 14 days and 28 days.
5. The optimal value (maximum value) of Split tensile strength was observed at 7.5%MK+15%M-sand (M3) for 7 days ,14 days,28days.
6. The optimal value (maximum value) of Flexural strength was observed at 7.5%MK+15%M-sand (M3) for 7days, 14 days and 28 days.
7. The durability of concrete due to acid attack, alkalinine attack, sulphate attack increases with increase in the percentage of metakolin and M Sand.
8. The fly ash can be used to produce geo polymeric binder phase which can bind the aggregate systems consisting of fine and coarse aggregate to form geo polymer concrete. Therefore these concrete can be considered as eco-friendly material Compressive, flexural and split tensile strengths are increases with the Higher the ratio of sodium silicate -to-sodium hydroxide ratio by mass.
9. Higher concentration (in terms of molar) of sodium hydroxide solution results in higher compressive strength of fly ash based geo polymer concrete Higher the ratio of sodium silicate-to-sodium hydroxide ratio by mass, higher is the compressive strength of fly ash-based geo polymer concrete.

REFERENCES

[1]. Prof. Jamdade P.K, Prof. Kawade U.R, (2014), Evaluate Strength of Geopolymer Concrete by Using Oven Curing, IOSR Journal of Mechanical and Civil Engineering. 11, 63-66.

[2]. Krishnan L, Karthikeyan S, Nathiya S, Suganya K, (2014) Geopolymer concrete an eco-friendly construction material, International Journal of Research in Engineering and Technology,3, 164-167.

[3]. Ali A. Aliabdo, Abd Elmoaty M, Abd Elmoaty, Hazem A. Salem, (2016) Effect of cement addition, solution resting time and curing characteristics on fly ash based

geopolymer concrete performance, Journal of Construction and Building Materials, 123, 581-593.

[4]. Djwantoro Hardjito, Chua Chung Cheak, Carrie Ho Lee Ing (2008) Strength and Setting Times of Low Calcium Fly Ash-based Geopolymer Mortar, Modern applied science,2, 3-11.

[5]. Rashida A Jhumarwala, Rao P.S, Patel T.N (2013) Experimental Investigation on Self Compacting Geopolymer Concrete (SCGC), Paripex - Indian Journal Of Research, 3, 173-175.

[6]. Sashidhar C, Guru Jawahar J, Neelima C, Pavan Kumar D (2015) Fresh and Strength Properties of Self compacting Geopolymer Concrete Using Manufactured Sand, International Journal of ChemTech Research,8, 183- 190.

[7]. Usha T G, Anuradha R, Venkatasubramani G S (2015) Performance of self compacting geopolymer concrete containing different mineral admixtures, Indian journal of engineering and material sciences, 22, 473-481.

[8]. Shankar H. Sanni, Khadiranaikar R.B (2013) Performance of alkaline solutions on grades of geopolymer concrete, International Journal of Research in Engineering and Technology, 366-371

[9]. Faiz Uddin Ahmed Shaikh (2016) Mechanical and durability properties of fly ash geopolymer concrete containing recycled coarse aggregates, International Journal of Sustainable Built Environment.

[10]. Sabina Kramar, Vilma Ducman (2015) Mechanical And Microstructural Characterization of Geopolymer Synthesized From Low Calcium Fly Ash, Chemical Industry & Chemical Engineering Quarterly,21, 13-22.

[11]. Emad Benhelal, Gholamreza Zahedi, Ezzatollah Shamsaei, Alireza Bahadori (2013) Global strategies and potentials to curb CO2 emissions in cement industry, Journal of Cleaner Production,142-161.

[12]. Daniel L.Y. Kong, Jay G. Sanjayan (2010) Effect of elevated temperatures on