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RESEARCH ARTICLE

Experimental Study on Durability Property on Geopolymer Concrete by using Metakaolin and M-Sand

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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. Geopolymer, which is made out of fly ash, sodium silicate, and sodium or potassium hydroxide, is one such option (NaOH or KOH). Since several coal-fired power stations in India have been shut down owing to a push for greener energy, there may be a scarcity of fly ash in the future. The demand for concrete in the building industry has boosted the production of ordinary Portland cement and the use of ordinary river sand. Due to unlawful mining of river sand, CO2 emissions grow during cement manufacture, while river sand supply becomes more expensive and scarce. The major goal of this study article is to focus on environmentally acceptable alternatives to cement and river sand. As a result, the goal of this research is to include different Pozzolanic elements in geopolymer concrete. Two Pozzolanic materials, metakaolin and M-sand, were utilised to substitute fly ash in geopolymer concrete and the proportion of M-sand in lieu of river sand, respectively. 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

INTRODUCTION

India's economy is expanding. Infrastructure facilities will be improved in order to compete on a global scale. The increase in construction activity raises demand for cement, which is the most often used construction material. One tonne of cement produced emits one tonne of CO2 into the environment. Geopolymer is provided as an alternative building material in this study. Geopolymer is made without the need of cement. Depending on the starting material, geopolymers can be synthesised to be as strong as and more durable than cement concrete. Geopolymers are self-curing in temperate areas, therefore there is no need to cure them. In cooler climates, precast goods can be used. Because raw ingredients are readily available, geopolymer concrete is a feasible alternative to cement concrete, and its carbon footprint is significantly lower than cement. This study examines the performance of fly ash as a geopolymer precursor in order to address the rising need for a dependable and efficient material in the building sector. Because it is extremely reactive, it builds strength quickly. Fly ash-based geopolymer concrete also decreases carbon dioxide emissions by replacing cement and gaining 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.

MATERIALS USED

Metakaolin
Metakaolin is manufactured under strict circumstances to improve its colour, eliminate inert impurities, and tune particle size to achieve a high degree of purity and pozzolanic reactivity. Metakaolin is a white, amorphous, extremely reactive aluminium silicate pozzolan that, when mixed with lime stone in water, forms stable hydrates and gives mortar hydraulic qualities. The metakolin sample is shown in the below figure 1.

Fly ash
Fly ash, also known as "pulverised fuel ash" in the United Kingdom, is a coal combustion product made up of particulates (fine particles of burnt fuel) and flue gases that are expelled from coal-fired boilers. Bottom ash is ash that settles at the bottom of the boiler. The fly ash sample is shown in the below figure 2.

M Sand
River sand can be replaced by manufactured sand. The demand for sand has risen dramatically as a result of the fast-growing construction sector, resulting in a scarcity of adequate river sand in most parts of the world. The M Sand sample is shown in the below figure 3

Coarse aggregates
As coarse aggregate, crushed granite stone aggregate with a size of 10mm was employed. For the experiments, coarse aggregate flowing through 10mm and retaining 4.75mm was employed.

Fine aggregates
In this experiment, the locally accessible river sand with a grain size of 4.75 mm. Fine aggregate characteristics were assessed according to IS: 2386-1963.

Alkaline solution
As an alkaline solution, a mixture of sodium silicate solution and sodium hydroxide solution was utilised.

Sodium hydroxide

Water, ethanol, and methanol are all soluble in sodium hydroxide. This alkali is deliquescent, absorbing moisture and carbon dioxide from the air quickly. Pure sodium hydroxide is a yellowish substance that can be purchased as pellets, flakes, granules, or as a solution.

Sodium silicate

Compounds having the formula Na2(SiO2)nO are known as sodium silicates. Most masonry products, such as concrete, can be treated with a sodium silicate solution to dramatically reduce porosity. The additional Ca(OH)2 (portlandite) in the concrete causes a chemical reaction that permanently bonds the silicates to the surface, making them significantly more robust and water resistant.

Admixture

To acquire workability of clean Geopolymer Concrete, Sulphonatednapthalene polymer based totally wonderful plasticizer Conplast SP430 in the form of a brown liquid immediately dispersible in water, Use of superplasticizer allows for a water reduction of up to 30% without lowering workability, compared to a possible reduction of up to 15% with plasticizers. The use of superplasticizer is common in the manufacture of flowing, self-leveling, self-compacting, and high-strength, high-performance concrete.

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.

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.

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.

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.

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.

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

RESULTS AND ANLYSIS

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.

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.

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.

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.

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.

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.

CONCLUSIONS

From the above experimental study the following conclusions were made

1. At typical operating room temperature, geopolymer concrete tends to display no substantial physical changes in its characteristics, as is the case with ordinary concrete. Geopolymer concrete specimens can take up to 72 hours to fully set without leaving any reminisces on the surface they are hardened on.
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. For 7 days, 14 days, and 28 days, the ideal value (highest value) of compressive strength was recorded at 7.5 percent MK+15 percent M-sand (M3).
5. For 7 days, 14 days, and 28 days, the ideal value (highest value) of Split tensile strength was recorded at 7.5 percent MK+15 percent M-sand (M3).
6. Flexural strength was shown to be optimal (highest) at 7.5 percent MK+15 percent M-sand (M3) for 7 days, 14 days, and 28 days.
7. The resistance of concrete to acid, alkalinine, and sulphate attack improves as the amount of metakolin and M Sand rises.
8. Fly ash may be utilised to make a geo polymeric binder phase that can bind fine and coarse aggregate systems together to generate geo polymer concrete. As a result, this concrete might be called an environmentally benign material. The higher the ratio of sodium silicate to sodium hydroxide by mass, the higher the compressive, flexural, and split tensile strengths.
9. Increased sodium hydroxide solution content (in terms of molar) leads in higher compressive strength of fly ash based geo polymer concrete. The compressive strength of fly ash-based geo polymer concrete increases as the sodium silicate-to-sodium hydroxide ratio by mass increases.

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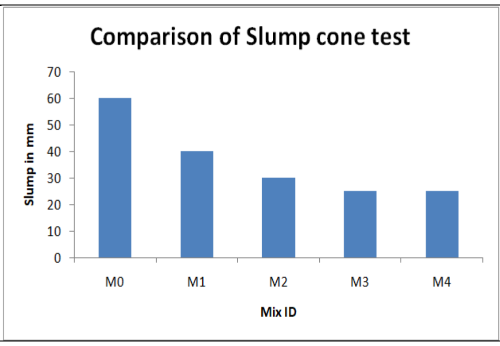
Figure 1: Metakaolin sample

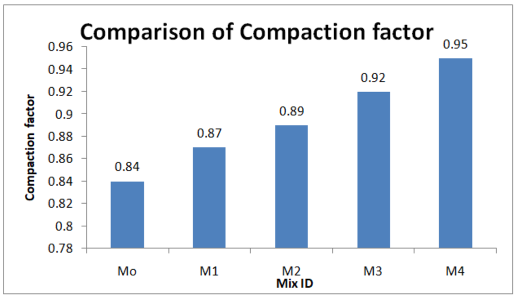
Figure 2: Fly ash

Figure 3: M Sand

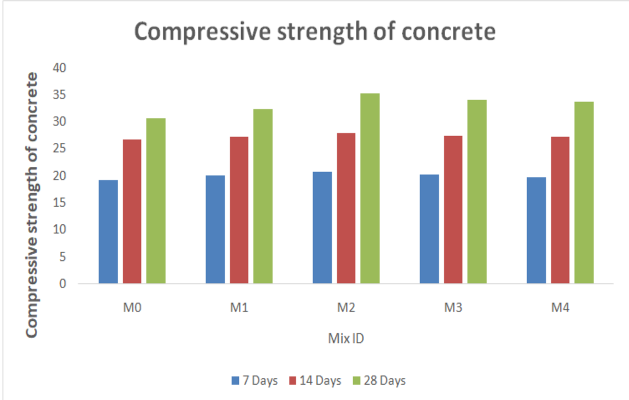
Figure 4: Conplast SP430



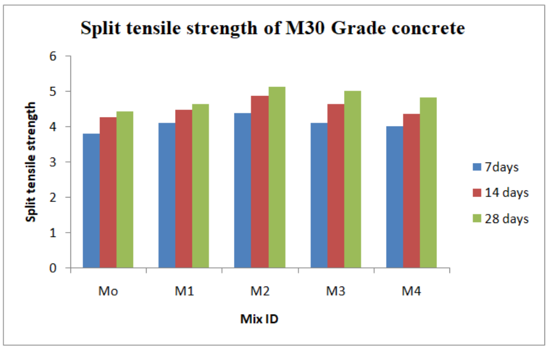
Graph 1: Comparison of slump cone test



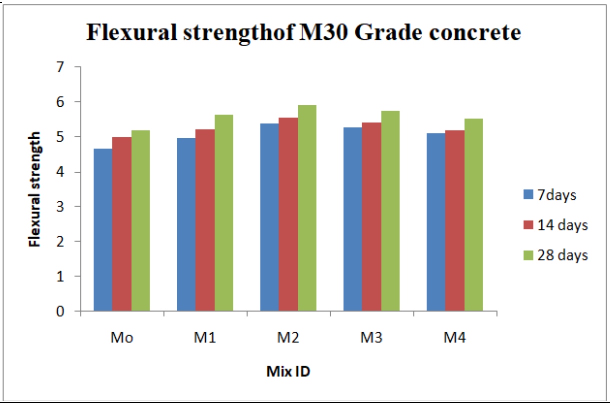
Graph 2: Comparison of compaction factor



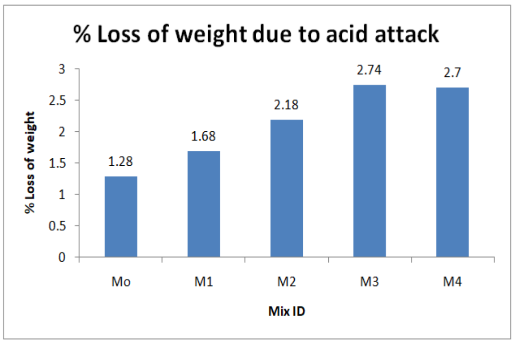
Graph 3: Comparison of Compressive strength



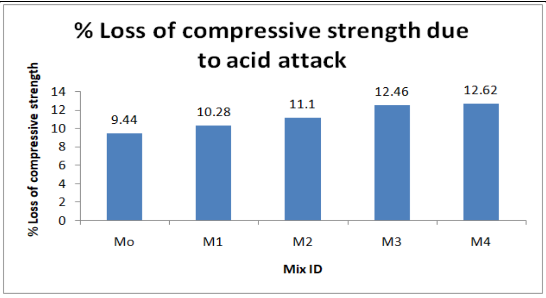
Graph 4: Comparison of Tensile strength



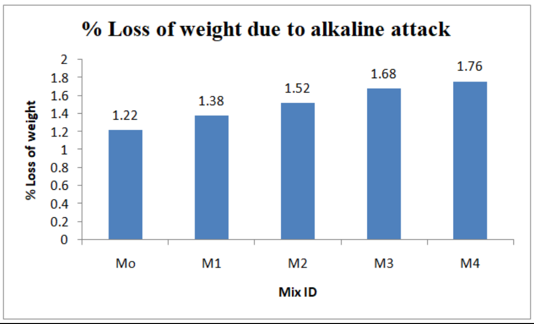
Graph 5: Comparison of Flexural strength



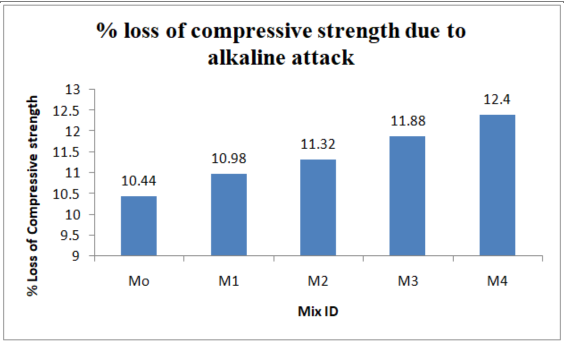
Graph 6: Comparison of percentage loss of weight



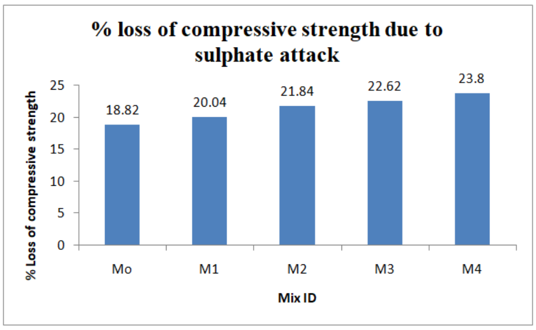
Graph 7: Comparison of percentage loss of strength



Graph 8: Comparison of weight loss



Graph 9: Comparison of percentage loss of strength



Graph 10: Comparison of percentage loss of strength