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A study on geopolymer concrete with fly ash

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ABSTRACT

The use of Portland cement in concrete construction is under critical review due to a high amount of carbon dioxide gas released to the atmosphere during the production of cement. From few years, attempts to increase the utilization of fly ash to partially replace the use of Portland cement in concrete are gathering momentum. Geopolymer concrete is a 'new' material that does not need the presence of Portland cement as a binder. Instead, the source of materials such as fly ash, metakaolin that are rich in Silicon (Si) and Aluminium (Al) are activated by alkaline liquids to produce the binder. Hence concrete with no Portland cement. This study reports the details of the development of the process of making low calcium based fly ash and Metakaolin-based geopolymer concrete. In the present experimental study, attempts are made to study on the various strength properties like compressive strength, split tensile strength, an also durability properties like initial surface absorption test on Geopolymer concrete made up of fly ash and Metakaolin. ISAT test was held on long-term durability properties of Geopolymer concrete. Experiments were conducted on Geopolymer Concrete with different percentages of metakaolin and molarity of alkaline activator. Studies were made on the residual compressive strength of Geopolymer Concrete mixes. It was observed that as the addition of Metakaolin to control the concrete mix of fly ash increases, the workability of the concrete mix was found to decrease as compared to Fly ash based control mix. It is observed from the experimental results and its analysis, that compressive and splitting tensile strength of geopolymer concrete increases with using high molarity NaOH solution and 25 to 50 percent Metakaolin. The replacement of fly ash up to this percentage shows 10 to 12% increment in Compressive strength and 28 to 34% increment in the split tensile strength of geopolymer concrete at 28 and 90 days respective.

Keywords— *Alkaline activators, Metakaolin clay, Fly ash, Workability, Compressive strength, Split tensile strength*

1. INTRODUCTION

Concrete is the maximum ample artificial fabric in the global. One of the primary substances in an everyday concrete mixture is Portland cement. However, the production of cement is accountable for about 5% of the sector‟s carbon dioxide emissions. In order to create a more sustainable global, engineers and scientists must expand and positioned to use a greener building material. This painting will talk about the usage of geopolymer concrete. Additionally, this paintings will explore the regions wherein geopolymer concrete out plays regular concrete. Geopolymer concrete uses base substances which can be wealthy in silicone and aluminum oxide like Fly ash, a prime derivative made out of the burning of coal. Currently, the majority of fly ash is dumped into landfills, inflicting environmental problems. The production of geopolymer concrete permits fly ash to be recycled and removed from landfills. Geopolymer concrete is also greater immune to harm than trendy concrete. For example, geopolymer concrete is more potent underneath anxiety and compression than its cement primarily based counterpart. It is likewise extra proof against salts, acids, seawater corrosion, and fireplace. There are a few dangers of geopolymer concrete that ought to be conquered before its incorporation into the construction industry, lots of in an effort to be discussed. Presently, it's far difficult to create geopolymer concrete out of doors of a laboratory setting as its miles still being researched by means of engineers and scientists. However, if this fabric can be with ease and correctly produced at low costs it will modernize the construction enterprise

2. MATERIALS USED

2.1 Fly ash

In the existing experimental work, low calcium, Class F (American Society for Testing and Materials 2001) dry fly ash become used as the base cloth. The chemical compositions of the fly ash have to be because the molar ratio of Si- to-Al become about 2, and the calcium oxide content material became very low

2.2 Metakolin clay

Metakaolin is pretty reactive metastable clay this is an anhydrous aluminosilicate acquired from calcining kaolin to around 650–7000C. Metakaolin became used because of the secondary aluminosilicate source fabric because it's far extensively used as aluminosilicate supply in geopolymeric structures as well as a mineral admixture in Portland cement. Metakaolin is a lot finer than the flyash. This will increase its particle floor region and subsequently have an impact on residences of the concrete made from it. The chemical composition of metakaolin can be visible in Table 3.1

2.3 Coarse Aggregate and fine aggregate

Aggregates available in the laboratory were used. Both coarse and satisfactory aggregates have been in saturated surface dry (SSD) situation, coarse aggregates were received in crushed form; the majority of the particles have been of granite kind. Flakiness index is 4.Fifty eight percentage and elongation index is three. Ninety-six for the coarse mixture. River sand becomes used as fine aggregate. The unique gravity and fineness modulus changed to 2. Fifty-five and a couple of.Ninety-three respectively. The satisfactory aggregate changed into acquired in uncrushed shape

2.4 Super plasticiser

To mend the workability of the fresh geopolymer concrete, a naphthalene sulphonate super plasticiser SP-430 in liquid form, procured from BASF was used in all cases.

2.5 Alkaline activators

To activate the fly ash, a combination of sodium hydroxide solution and sodium silicate solution was chosen as the alkaline activator. The sodium hydroxide used was a technical grade sodium hydroxide in flakes form with a specific gravity of 2.130, 98% purity, and obtained from LOBA chemical. The mass of NaOH solids in a solution

3. RESULT AND DISCUSSION ON EXPERIMENTAL TEST

3.1 Slump test

The workability of concrete mixes turned into determined out by means of droop take a look at as in line with process given in chapter three. Liquid/binder ratio became saved consistent zero.5 for all of the concrete mixes. Super-plasticizer was used to keep the required stoop. The dosage of super-plasticizer was maintained 2% with the aid of weight of binder on all type of mix. It gifts the consequences of the impact of the molarity of alkaline activator on the workability of various concrete mixes which were proven in Table 3.1. Table 3.1 shows that because the addition of metakolin to concrete blend growth, the workability of concrete blend changed into discovered to decrease in comparison to manipulate blend of flyash. The addition of metakaolin into concrete blend similarly decreases the workability.

Table 3.1 Workability value for a different concrete mix

Mix No.	Description	Molarity	(Slump) mm
M1	100%FA	8M	105
M2	25%MK+75%FA	8M	100
M3	50%MK+50%FA	8M	96
M4	100%FA	12M	108
M5	25%MK+75%FA	12M	101
M6	50%MK+50%FA	12M	97
M7	100%FA	16M	115
M8	25%MK+75%FA	16M	110
M9	50%MK+50%FA	16M	99

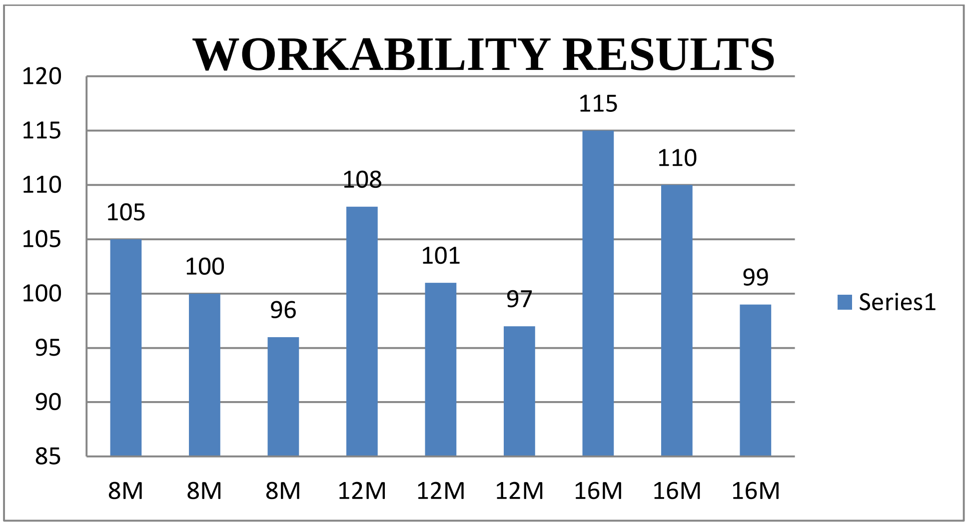

Fig. 3.1: Workability tests

3.2 Compressive strength results

The results of the compressive strength tests conducted on geopolymer concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test was conducted at curing ages of 7, 28, 56 and 90 days. The compressive strength test results of all the mixes at different curing ages are shown in Table 3.2. Variation of compressive strength of all the mixes cured at 7, 28, 56 and 90 days are also shown in Figure 3.1 to 3.3

Table 3.2 Compressive strength (MPa) result of all mix at different curing age

Mix	Molarity	Description	7 Days	28 Days	56 Days	90 Days
M1	8M	100%FA	16	22	24.1	25.2
M2	8M	25%MK+75%FA	17.5	23.4	25.1	26.2
M3	8M	50%MK+50%MK	19	24.1	25.3	26.8
M4	12M	100%FA	16.5	22.1	24.5	25.6
M5	12M	25%MK+75%MK	18	23.2	25.6	26.5
M6	12M	50%MK+50%FA	19.3	24	26.4	27.2
M7	16M	100%FA	17.6	23	24.8	24.2
M8	16M	25%MK+75%FA	19.7	22.9	26.1	26.5
M9	16M	50%MK+50%FA	22.5	25	27	27.4

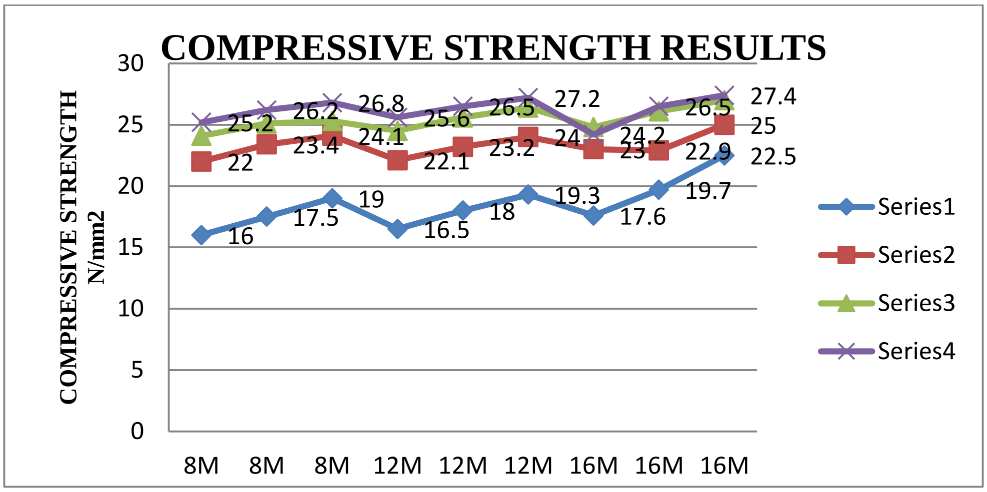

Fig. 3.2 Compressive strength results

5.3. Split tensile strength results

The results of the splitting tensile strength tests conducted on geopolymer concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 7, 28, 56 and 90 days. Effect of different molar concentration on test results of all the mixes at different curing ages is shown in Table 3.3. Variation of splitting tensile strength of all the mixes cured at 7, 28, 56 and 90 days is also shown in Figure 3.2.

Table 3.3 Splitting tensile strength (MPa) result at different age of curing

Mix	Molarity	Description	7 Days	28 Days	56 Days	90 Days
M1	8M	100%FA	2.5	3.7	3.8	3.9
M2	8M	25%MK+75%FA	2.8	4.1	4.2	4.8
M3	8M	50%MK+50%MK	2.9	4.3	4.5	4.9
M4	12M	100%FA	2.3	3.3	3.8	3.6
M5	12M	25%MK+75%MK	2.5	4.5	4.9	4.7
M6	12M	50%MK+50%FA	2.6	4.9	4.9	5.2
M7	16M	100%FA	2.8	3.8	4.2	4.8
M8	16M	25%MK+75%FA	3.1	4.7	4.7	5.5
M9	16M	50%MK+50%FA	3.5	4.9	4.9	5.9

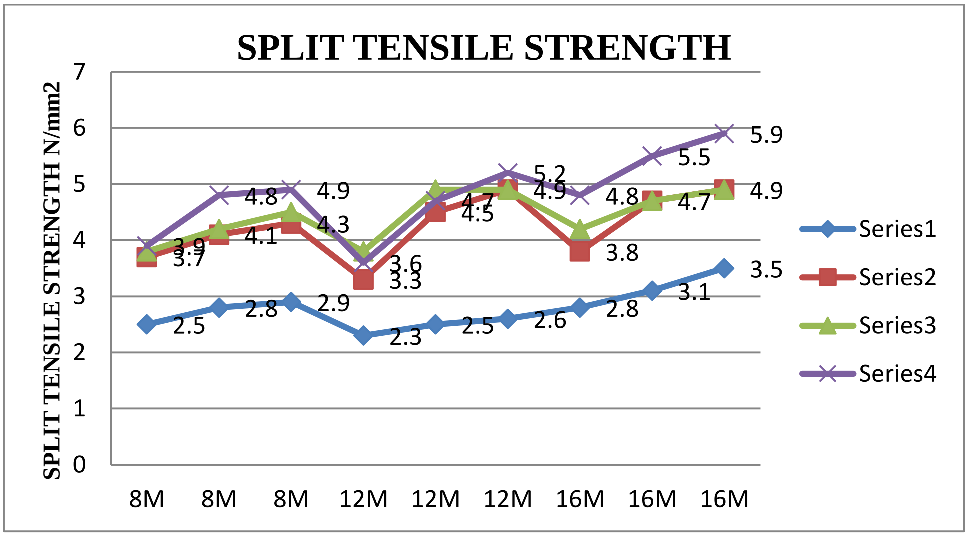

Fig. 3.3: Split tensile strength

Figure 3.3 shows that the splitting tensile strength test results of geopolymer concrete show that in general increment of Metakaolin percentage in the binder accelerate splitting tensile strength of mix. The maximum value of splitting tensile strength obtained for 50%MK+50%FA+16M; the mix was 4.7MPa and 5.9MPa at 28 and 90 days respectively. The lowest split tensile strength was obtained by 100%FA, 12M mix which is 3.16 and 3.1MPa at 28 and 90 days respectively which is 28.2% and 34% less than 50%MK+50%FA+12M mix. In view of these results the strength at 28 days for 16M, 50%FA+50%MK is appeared to have been improved by more than 1.2 and 1.15 times compared to same composition 8M and 12M mix respectively

4. CONCLUSIONS

(i) Reduction in bleeding is observed by increasing the metakolin and concentrations of sodium hydroxide. Slump value of fly-ash-based geopolymer concrete is maximum among the same composition of the mix.
(ii) Replacement of metakaolin up to 25% to 50% and concentration of NaOH up to 16M solution improved compressive as well as the split tensile strength of concrete.
(iii) It was observed that replacement of flyash by Metakaolin up to 50% increases 28 days compressive strength of geopolymer concrete by 10 to 12% compared with only flyash based concrete of their respective molarity batches.
(iv) It has been observed that replacement of flyash by Metakaolin up to 50%, increases 28 days split tensile strength of geopolymer concrete by 28 to 34% compared with only flyash based concrete of their respective molarity batches.
(v) It was observed that the lowest initial surface absorption value is obtained for metakaolin comprising geopolymer. It may be due to low porosity and permeability of only flyash based geopolymer concrete.
(vi) It was found that addition of the Metakaolin in flyash improves the mechanical as well as, durability property and load carrying capacity of geopolymer concrete.

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