Studies of polypropylene fibres' effect on strength and workability of slag based geopolymer concrete

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Abstract. The most useful, desirable, adaptable, emerging, reliable, and enduring construction material is concrete. After water Concrete is the most usable substance, and it requires a lot of Cement. The source of carbon dioxide pollution in the atmosphere, after the automobile is due to production of Ordinary Portland Cement and additionally, a significant quantity of energy was used to produce cement. The replacement of OPC or elimination of OPC in concrete is very much important to avoid global warming; A novel construction material called geopolymer concrete is created through the chemical reaction of inorganic molecules. The by-product of coal from a thermal power plant known as fly ash is widely accessible worldwide. Flyash is abundant in alumina and silica. This paper is aimed at studies on the strength and workability of conventional and geopolymer concrete. G40 grade of geopolymer concrete, which equivalent to M40 grade of conventional concrete has been developed by conducting various mixes. The conventional concrete specimen are casted and cured in water and in geopolymer concrete, these are cured with the help of oven for one day after one day rest period and rest of the days kept in atmosphere until testing. The test results have shown that the compressive strength is increased and workability is decreased with the addition of polypropylene fibres.

Key words. Geopolymer Concrete, Flyash, GGBS, Polypropylene and Compressive Strength.

1 Introduction

As a Portland cement cover for binders, the geopolymer technology offers a lot of potential for use in concrete. Davidovits (1988; 1994) suggested using an alkaline liquid to react with the silicon (Si) and aluminium (Al) in a source material of geological origin or in by-product accoutrements cover such as fly ash and GGBS to make binders in relation to global warming.

2 Literature Review

Hemn unis Ahmed et al.[1] In order to better understand the structural behaviour of GPC beams, this study was reviewed and examined for certain crucial material parameters, including fresh features i.e. mechanical properties including workability. In the construction sector, geopolymer concrete is seen as a sustainable substitute for Portland cement. The mechanical and durability qualities of concrete are improved by the addition of nanomaterials to the geopolymer matrix. High tensile strength and strong endurance characteristics define carbon nanotubes (CNTs). However, because of their size and high specific surface area, CNT particles struggle with adherence and dispersion in geopolymer matrix. It was revealed that the geopolymer mix that contained (2.5%) NC combined with (0.01%) CNTs had the highest compressive strength. Noah Lermanet al.[5] at this study, the geopolymer concrete was created using a metakaolin precursor that contained polypropylene fibres at concentrations of 0.3, 0.5, and 1% along with monomers in ratios of 2, 2.5, and 3. Then, using the scanning electron microscopy technique, a number of engineering parameters including microstructure, have been studied at the of 90 days. Chithambar Ganesh V et al.[6] In this study, an effort was made to make geopolymer concrete less brittle by incorporating glass (high modulus) and polypropylene (low modulus) fibres into M-sand-based GGBS geopolymer concrete. Different ratios of glass and polypropylene fibres were introduced, including 1/0, 0.75/0.25, 0.5/0.5, 0.25/0.75, and 0/1. The study found that the structural qualities of geopolymer concrete improved during ambient curing. Mazin Abdul-Rahman[7]. The literature review have been done by many researchers regarding different types of fibres, which includes sugar cane bagasse fibre, steel, glass, nylon fibrrs etc; but there is limited work has done on polypropylene fibre. “It was revealed that the geopolymer mix that contained (2.5%) NC combined with (0.01%) CNTs had the highest compressive strength. Noah Lermanet al.[5] at this study, the geopolymer concrete was created using a metakaolin precursor that contained polypropylene fibres at concentrations of 0.3, 0.5, and 1% along with monomers in ratios of 2, 2.5, and 3. Then, using the scanning electron microscopy technique, a number of engineering parameters including microstructure, have been studied at the of 90 days. Chithambar Ganesh V et al.[6] In this study, an effort was made to make geopolymer concrete less brittle by incorporating glass (high modulus) and polypropylene (low modulus) fibres into M-sand-based GGBS geopolymer concrete. Different ratios of glass and polypropylene fibres were introduced, including 1/0, 0.75/0.25, 0.5/0.5, 0.25/0.75, and 0/1. The study found that the structural qualities of geopolymer concrete improved during ambient curing. Mazin Abdul-Rahman[7]. The literature review have been done by many researchers regarding different types of fibres, which includes sugar cane bagasse fibre, steel, glass, nylon fibrrs etc; but there is limited work has done on polypropylene fibre. “ therefore it is very important to study the properties of this type PP fibre.

3 Materials And Methodology

3.1. Cement

Cement is a type of material, which has binding property and this material used in manufacturing of different elements in which, hardens and bind different materials to bind them together.

Figure 1: 53 Grade of Cement (OPC)

3.2. Fine Aggregate

Fine aggregate is basically river sand particles taken from the ground through mining system, fine aggregate includes ordinary sand or crushed stone particles with size of 4.75mm or less.

Figure 2: Fine Aggregate

3.3 Coarse Aggregate

Gross rough refers to granular, unpredictable materials such as sand, stone or crushed stone and is used to produce concrete.

Figure 3: Coarse Aggregate

3.3. Flyash

The combustion of pulverized coal that can produce Fly ash, which is a finely divided residue. This can be used to increase concrete durability and workability, while reducing permeability.

Figure 4: Flyash

3.4. Sodium Hydroxide

Sodium hydroxide (NaOH) in the form of accessible pellets, crumbs and powders. These drops are used to arrange the required moles. We used 12M NaOH to prepare the GPC mixture.

Figure 4. Sodium Hydroxide

3.5. Sodium Sillicate

Sodium silicate In concrete, it's far used as an adjustable accelerator pedal and moreover used as a mineral silicate paint to enhance waterproofing and broaden extra strength

Figure 5. Sodium Sillicate

3.6. Water

The potable water can be used for making concrete as per IS 456-2000. This water will participate in chemical reaction with the Bouge's compounds which are presents in the cement. Then as the time is going on, the concrete gets harden.

3.7. Super Plasticizer

There are many types of superplasticizers available in the market, but all are not compatible with the particular mix of concrete. So it is required to check the particular super plasticizer, which will be useful for high strength, standard grade or lower grades of concrete. As per the type of concrete it is suggested to use the plasiticizers.

3.6 Methodology

The information about geopolymer concrete was collected through literature review by studying may research papers. Based on the information gathered, preliminary work was carried out by gathering various materials, which includes cement, flyash, GGBS, sodium silicate, sodium hydroxide, coarse aggregate, and water.

Basic tests on the materials have been conducted to determine their suitability for use in the production of concrete. According to IS 10262-2019, the mix design for concrete of grades

M40 and G40 had been done and the mix was used to determine the strength property and workability. The specimen of size 150mm cube has been used in the present study. The required number of samples have been made, and then cured for necessary period until testing is done. The slump cone test was conducted to determine the workability and as per codal procedure the compressive strength was evaluated.

4. Experimental Results and Discussions

Basic physical tests are done on materials like cement (IS:1226-2013), coarse aggregate (IS:383-2016), and fine aggregate (IS:383-2016). Based on the previous studies cement is fixed and the mix proportions are calculated as per the IS10262:2009 for desired strength and workability. The workability in terms of slump is checked with addition of 1% and 1.5% of super plasticizer by weight of cement.

From the results, it has been observed that the workability is decreased with an addition of polypropylene fibre and compressive strength is increased. The different mixes have been tried with different percentages of polypropylene fibres and finally an optimum strength is achieved at 5%. The compressive strength is increased with an addition of PP fibre, as the percentage of PP fibre is increased, the strength is increased up to 2% of fibre, beyond that it started decreasing the strength and it leads to segregation also. The reason behind decreasing strength is may be due to less in bonding between matrix of the mix.

Table 1: Physical Properties of Materials

S.No	Material	Properties	Results
1.	Cement (OPC 53 Grade)	Specific gravity	3.15
		Normal consistency	33%
2.	Fine aggregate	Specific gravity	2.64
		Fineness modulus	2.88
3.	Coarse aggregate	Specific gravity	2.64
		Sieve analysis (FM)	4.68
		Water absorption	0.7%
		Bulk density	1.5 g/cm^3
		Impact test	25.16%
		Crushing strength	24.75%

Table 2: Mix Proportions of M40 and G40

Mix Proportions of M40	
Grade of Concrete	M40
Cement (kg/m^3)	390
Fine Aggregate(Kg/m^3)	671.1
Coarse Aggregate (Kg/m^3)	1155.6
Super plasticizer (Kg/m^3)	5.2(1%)
Ratio of mix proportion	1:1.72:2.96
W/C ratio	0.45
Workability(mm)	110

Mix Proportions of G40		
Fly ash (kg/m^3) (85%)	333.88	392.8
GBS(kg/m^3) (10%)	58.92	
Fine Aggregate (kg/m^3)		671.1
Coarse Aggregate (kg/m^3)		1155.6
NaOH solids 16Molarity (kg/m^3)		18.2
Na2SiO3(kg/m^3)		126.3
Super plasticizer (kg/m^3)		3.9(1%)
Ratio of mix proportions		1:1.70:2.94
Liquid/binder ratio		0.45
Workability(mm)		75 - 100

Table 3: Workability of Concrete

Type of Concrete	**Slump in mm**	**Degree of workability**
CC	105	Medium
GPC	90	Medium

Table 5: Compressive Strength of Concretes in MPa

No. of days	CC	PPF	GPC	PPF
3Days	21.11	23.24	38.91	39.12
7Days	34.42	36.56	41.32	42.36
28Days	49.63	51.22	50.26	52.45

5. Conclusions

From the experimental investigations, it is concluded that :
The workability of conventional and geopolymer concrete is decreased with an addition of polypropylene fibre and the compressive strength of both the concretes is increased and an optimum strength is achieved at 5% of polypropylene fibre. An optimum compressive strength has been selected based on required target mean strength and workability.

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