Performance and Characterization of Geo-Polymer Concrete Reinforced with Short Steel Fiber

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Abstract: **In a growing country like India a huge amount of usage of cement is polluting the environment. With reference to the statement, this study aims at utilization of industrial by product such as fly ash, silica fume, Slag etc, for value added application. In addition the waste used can improve the properties of construction materials. The fly ash, silica fume, Slag, sodium silicate and sodium hydroxide has been used in this project. The mentioned materials were tested as concrete ingredients. Cement was 100% replaced by fly ash, silica fume, Slag with different mix proportions along varying percentage of fly ash, silica fume, slag for concrete with suitable water cement ratio. The compressive strength, split tensile strength and flexural strength were conducted for the above replacements. The results showed fly ash, silica fume and slag with addition of sodium silicate and sodium hydroxide improves the mechanical properties and strength of concrete. The advantages of this project are that the 100% replacement of cement with fly ash, silica fume, slag and which are economically cheap and as well as a superior concrete can be produced.**

***Index Terms* – Steel fibre, Sodium Silicate, Sodium Hydroxide, Fly Ash, Silica Fume, Slag, Compressive Strength, Flexural Strength, Split Tensile Strength.**

1. INTRODUCTION

Geo-polymer was the name given by Daidovits in 1978 to materials which are characterized by chains or networks or inorganic molecules. Geo-polymer or inorganic alumnus-silicates polymer is synthesized from predominantly silicon and aluminum materials of geological origin or by product materials, such as fly ash. The chemical composition of geo-polymer is similar to that of zeolite, but amorphous in microstructure. Fly ash-based geo-polymer binders show excellent short and long-term mechanical characteristics. The development of geo-polymer concrete described in this paper includes the chemical reaction, the source materials, and the manufacturing process. The workability and the setting time of fresh concrete as well as the compressive strength and the long-term characteristics of hardened geo-polymers concrete are discussed. The search for environmentally friendly construction materials is imperative, as the world is facing serious problems due to environmental degradation. There is a significant expectation on the industry to reduce carbon dioxide (CO2) emissions to the atmosphere. In view of this, one of the efforts to produce environmentally friendly concrete is to reduce the use of Portland cement by using by-product materials, such as fly ash. It is known that production of one ton of Portland cement accounts for about one ton of carbon dioxide released to the atmosphere, as the result of de- carbonation of limestone in the kiln during manufacturing of cement, i.e. significant advance in the usage of fly ash in concrete is the development of high volume fly ash (HVFA) concrete, which partially replaces the use of Portland cement in concrete(up to 60%), while maintaining excellent mechanical properties with enhanced durability performance .Another development is geo-polymer, i.e. inorganic alumina-silicates polymer synthesized from minerals of geological origin or by- products materials, such as fly ash, rice husk ash etc., that are rich in silicon (Si) and aluminum (Al).Fly ash is abundantly available world-wide, and efforts to utilize it in concrete production is of significant interest to the concrete technologists and industry.

2. OBJECTIVES

The main objectives of this project are as follows:

- To study the proportion of alkali activated concrete.
- To characterize the materials required to make geo polymer concrete like Fly ash and Silica Fume and study their suitability for use.
- To investigate the properties of the concrete like compressive strength, split tensile strength, characteristics etc.
- To study the tensile strength of optimum mix of alkali activated concrete.
- To analyze future scope of application of alkali activated concrete.

3.LITERATURE REVIEW

General

Geo polymer was introduced to the world in the late 1970’s. It was developed in 1978 by French scientist Joseph Davidovits, the use of the material increased during 1980's for nonstructural applications. Many literature sources have been reviewed to understand the properties of geo polymer concrete in which cement is fully replaced by Fly ash and GGBFS and the fine aggregate by M-sand activated in the presence of alkali activator some of them are found useful to our project work they are discussed in this chapter.

Literature survey:

A. Dattatreya J K, Rajamane NP, Sabitha D, Ambily P S, Nataraja MC the beams were designed with 1.82 to 3.33% tension reinforcement (82-110%) of corresponding balanced section reinforcement. Performance aspects such as load carrying capacity, moments, deflections, and strains at different stages were studied. The failure modes were also recorded for the beams, the cracking, service and ultimate moment carrying capacity of the test beams calculated using the conventional reinforced concrete principles and strain compatibility approach showed good correlation between the test and predicted values. The studies showed that the computational methods used for evaluating the performance parameters of the reinforced Portland cement concrete (RPCC) beams at different stages can also be extended to reinforced geopolymer concrete (RGPC) beams. However, the predictions may not be conservative in all the cases and therefore use a capacity reduction factor may be necessary for design Purposes.

B. Xerses N. Irani1, Dr. Suresh G. Patil, Rampanth (2017):- The objectives of the present work is to finalize the parameters such as Amount of binder used, Molarity of NaOH, Ratio of Na2SiO3/NaOH and Ratio of Liquid to Binder In the present work, experimental investigations were performed such as compressive strength test on the ambient cured geo-polymer concrete. By trial casting geo-polymer concrete parameters were finalized such as binder (Fly Ash : GGBS)as (40 :60), molarity content as 8M, Ratio of Na2SiO3/NaOH of 1.5 and Ratio of Liquid to binder of 0.5. The tests were conducted for Geo-polymer Concrete specimen's atdifferent curing ages of (1, 3 and 7 days). The results of compressive strength of Binder ratio of (fly ash : GGBS) of (40 :60), Molarity of NaOH of 8M ,Ratio of Na2SiO3/NaOH of 1.5 and Ratio of Liquid to binder of 0.5 gave a higher results of 24 N/mm2 ,40 N/mm2 60 N/mm2 for 1,3 and 7 days respectively.

C. Rismy Muhammed1, Deepthy Varkey (2016):-This paper presents results of an experimental program to determine mechanical properties of Polypropylene Fiber Reinforced Geo-polymer Concrete (PFRGPC) pavers which contains fly ash, alkaline liquids, fine & course aggregates & polypropylene fibers. Alkaline liquids to fly ash ratio were fixed as 0.35 with 100% replacement of ordinary Portland cement (OPC) by fly ash. Alkaline liquid consists of sodium hydroxide (NaOH) and sodium silicate (Na2SiO3) solutions. The ratio of Sodium hydroxide solution to Sodium silicate solution was fixed to 2.50. Polypropylene fibers Recrone 3S were added to the mix in volume of concrete. In this paper represent the results of the geo-polymer paver block with the mix proportion of M 40 grade and polypropylene Fiber with the different percentage rate.

D. Chandan Kumar, Krishna Murari, and C.R.Sharma:-Portland cement concrete industry has grown astronomically in recent years. It will continue to grow as the result of continuous urban development. However, Portland cement concrete possess problems such as durability and carbon dioxide emission. Many concrete structures have shown serious deterioration, way before their intended service life, especially those constructed in a corrosive environment (Mehta 1997). Geo-polymer is a class of aluminosilicate binding materials synthesized by thermal activation of solid aluminosilicate base materials such as fly ash, met kaolin, GGBS etc., with an alkali metal hydroxide and silicate solution.

4. WORKABILITY TEST ON FRESH CONCRETE

General

The following table shows the slump values which are observed or obtained from our project work. The slump test is conducted on a different mix proportions of fly ash, silica fume, and slag content with steel fibres.

Table 4.1: Details of mix proportion for one cubic meter

Sl. No	Mix	Fly ash (kg)	Silica Fume (kg)	Slag (kg)	Coarse Aggregate (kg)	NaOH (kg)	Na2Sio3 (kg)	Steel Fiber (%)
1	R1	372	42	578	1073	96	240	1.5
2	R2	351	62	578	1073	96	240	1.5
3	R3	413	00	578	1073	96	240	1.0
4	R4	372	42	578	1073	96	240	1.0
5	R5	351	62	578	1073	96	240	0.5
6	R6	331	83	578	1073	96	240	0.5

Table 4.2: Slump for different mixes

SL No	Mix	Fly ash (kg/ m3)	silicafume (kg/m3)	Steel Fiber (%)	Slump (mm)
1	R1	370.8	41.2	1.5	153
2	R2	350.2	61.8	1.5	126
3	R3	412	0.0	1.0	119
4	R4	370.8	41.2	1.0	110
5	R5	350.2	61.8	0.5	103
6	R6	329.6	82.4	0.5	135

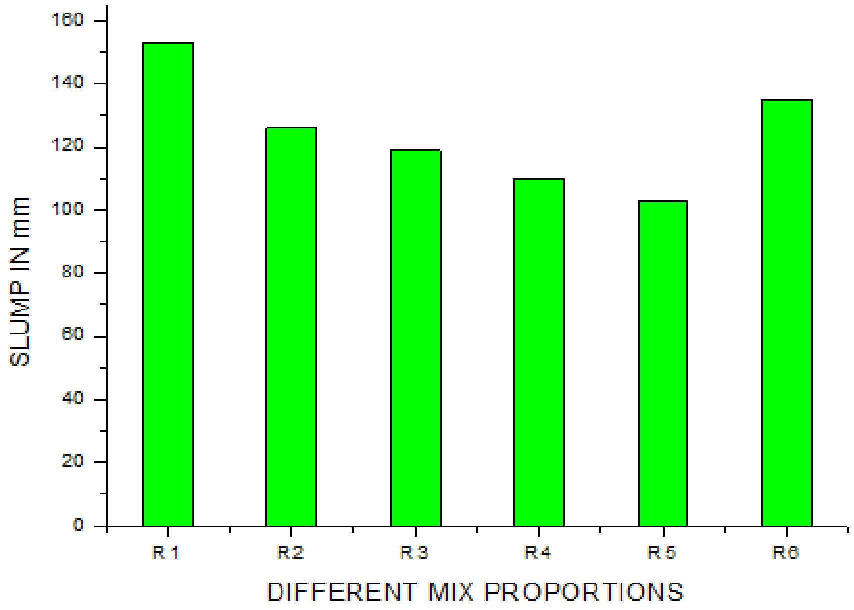

Fig 4.1: Graph Showing different mixes versus slump

Table 4.2 shows the results of slump test too various mix's it is observed that as the silica fume increases the slump value goes down, along with the silica fume the percentage of fiber is also increased due to the specific surface area increase and water that are level as sored by the silica fume and also the increase in fiber will induce shear resistance to the fresh concrete which doesn't slump easily, density of concrete is reduced the percentage of fiber increase its values are showing quit less values as compared to conventional concrete.

5.RESULTS AND DISCUSSION

5.1Compressive strength:-

Fig 5.1.1 Compressive test on GPC

Fig 5.1.2 Compression Failure of GPC

Table 5.1.1: Compressive strength of GPC at different curing ages

Mix	7 Days	28 Days	Density (kg/m3)
R1	26.30	29.63	2500
R2	25.44	28.92	2460
R3	18.87	25.94	2390
R4	21.32	26.12	2360
R5	24.79	28.19	2330
R6	23.51	27.66	2345

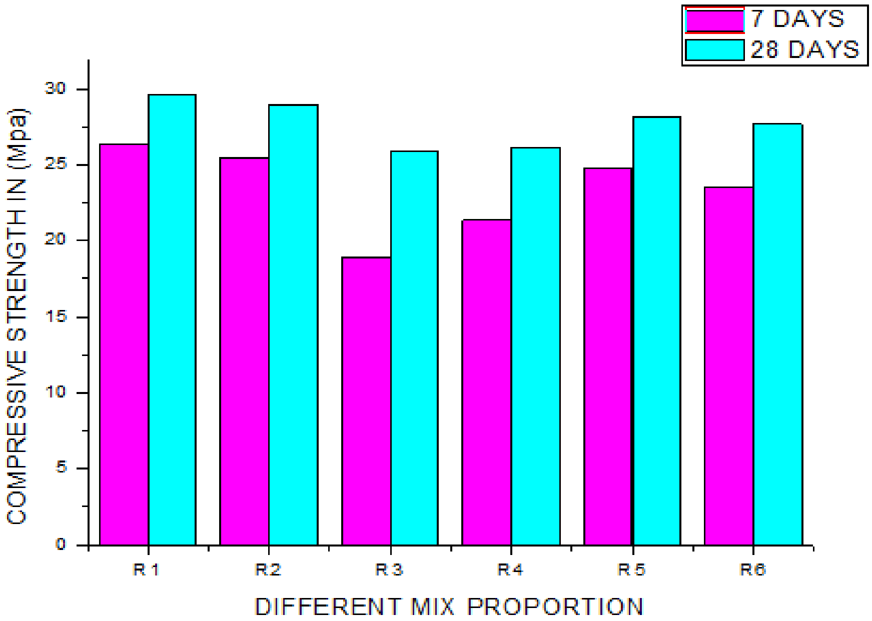

Fig 5.1.3: Graph Showing different mixes versus Compressive Strength

The compressive strength shows that with lesser percentage of silica fume is shows the high value of compressive strength as increase in silica fume and fiber the density as well as strength also reduced from fig 5.2 it can be seen that the values are not showing any constant trends in result, it is observed that may compressive strength has been achieved with in 7days of unsuits curing and only small percentage of increase in 28days of compressive strength as per result obtained 28days of strength for mix R1 is gives higher value.

5.2 Flexural strength:-

Fig 5.2.1 Flexural test on GPC

Fig 5.2.2Flexural Failure of GPC

Table 5.2.1: Flexural strength of GPC at different curing ages

Mix	7 Days	28 Days
R1	3.174	3.55
R2	3.016	2.60
R3	2.44	3.372
R4	2.878	3.13
R5	3.4706	3.38
R6	3.291	3.60

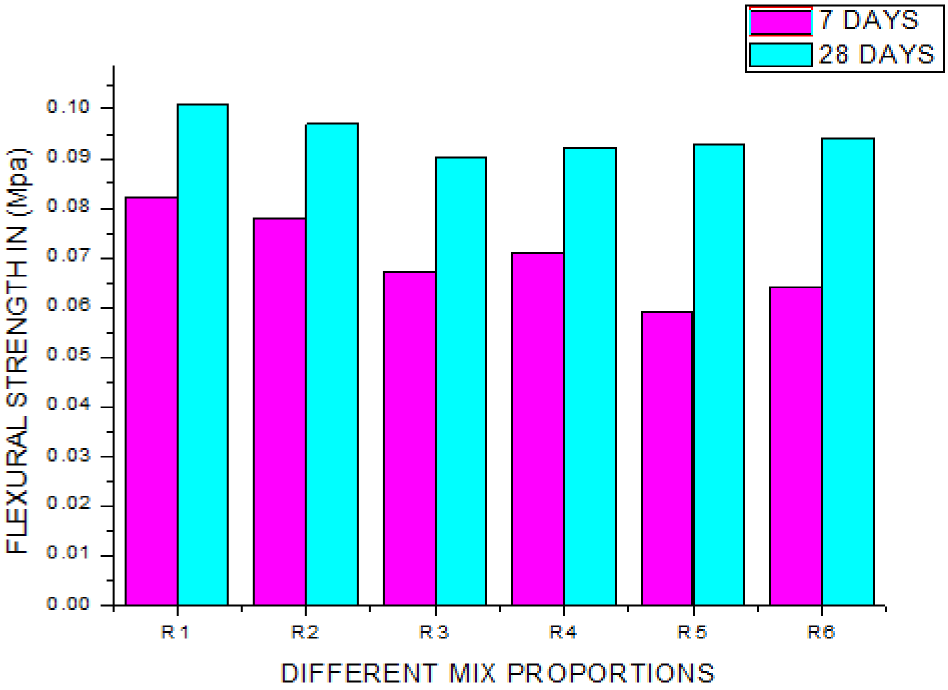

Fig 5.2.3: Flexural strength of various mixes

Table 5.2.1& fig 5.2.1 shows the results for flexural strength of reinforced geo polymer concrete for various mix proportion. It clearly shows that as the % of fibre reduces the flexural strength for all age of curing reduces.

5.3 Split Tensile strength:-

Fig 5.3.1 Split tensile test on GPC

Fig 5.3.2 Split Tensile Failure of GPC

Table 5.3.1: Split tensile strength of GPC at different curing ages

Mix	7 Days	28 Days
R1	2.28	2.78
R2	2.10	2.54
R3	1.25	2.17
R4	1.74	2.31
R5	1.33	2.24
R6	1.82	2.45

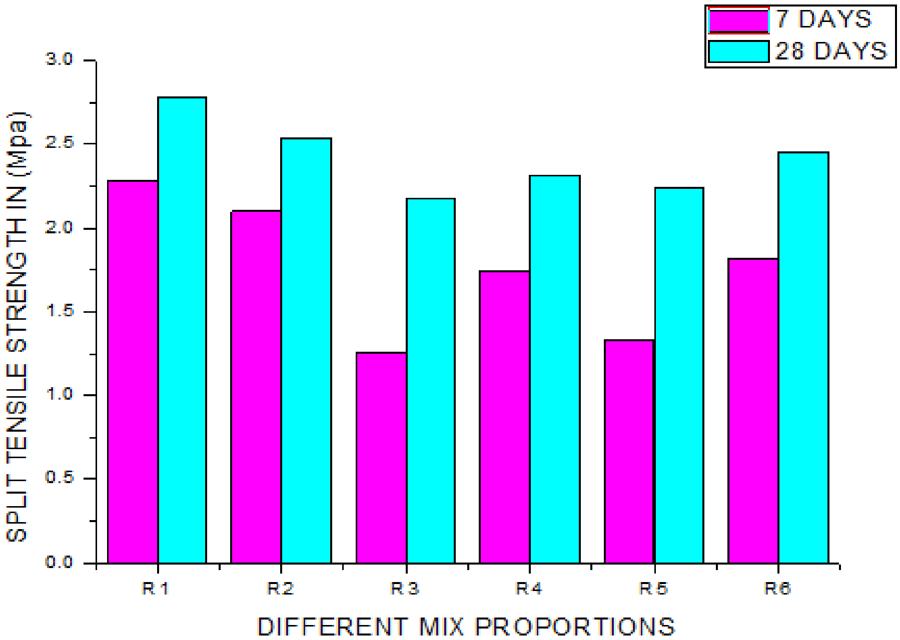

Fig 5.3.3: Split Tensile strength of various mixes

6. CONCLUSION

Based on the outcomes of the work conducted on Alkali activated concrete made with different levels of replacement of Fly ash with silica flame and steel fiber air cured for 28 days, the following conclusions can be drawn.

- Optimum percentage of replacement of Fly ash by silica flame is found to be 100% of Fly ash.
- Beyond 100% replacement of Fly ash by silica flame shows decrease in compressive strength.
- Maximum 28 days' compressive strength obtained is 25.94 MPa
- Maximum 28 days' split tensile strength obtained is 2.17 MPa

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