



EXPERIMENTAL ANALYSIS OF GLASS FIBER AND GGBFS AS A PARTIAL REPLACEMENT OF FINE AGGREGATE IN GEOPOLYMER CONCRETE

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ABSTRACT: Geopolymer cement concretes' (GPC) an inorganic polymer material to become a significant component of environmentally sustainable construction, offering an alternative or supplement to conventional concrete. Ground granulated Blast furnace Slag (GGBFS) and fly ash based on Geopolymer concrete. In which cement is fully replaced by pozzolanic material that is rich in silicon GGBFS is a by-product of Steel manufacturing industry, to get the desired strength with conventional concrete. By conducting short-term and long-term tests, efforts to find the most suitable proportion of fly-ash and GGBFS give the closest strength results to conventional concrete. Cement is replaced 100% by fly ash and GGBFS as a partial replacement fine aggregate with an interval 10%,20%,30%,40% in Geopolymer concrete with addition of 2% Glass fiber in Geopolymer concrete. M30 grade concrete, mechanical and durability tests were conducted.

KEYWORDS Alkaline liquid; Glass Fiber; Ambient temperature curing; Flyash; Geopolymer concrete; Ground granulated blast furnace slag (GGBFS).

I. INTRODUCTION

Concrete is a widely used construction material that solidifies over time and consists of cement, fine aggregates (such as sand) and coarse aggregates mixed with water. Portland cement is the most commonly utilized type of cement in concrete production. It finds extensive application in the construction of foundations, columns, beams, slabs, and other load-bearing elements in buildings. Geopolymer concrete exhibits high strength, and resistance to acid attack, chloride penetration, etc., are considerable good. These are usually obtained by alkali activation of industrial alumino-silicate surplus materials such as FA, GGBS and Bagasse ash, and have less Greenhouse effect compared to conventional concretes. The paste used in concrete typically comprises Portland cement, water and may incorporate supplementary cementing materials like slag cement and admixtures. However, conventional concrete has some limitations. Its tensile strength is relatively low compared to other building materials.

II. MATERIALS

2.1 Fly Ash: Fly ash is the residue from the combustion of pulverized coal collected by mechanical or electrostatic separators from the flue gases of thermal power plants. One of the important characteristics of fly ash is the spherical form of the particles. This shape of particle improves the flow ability and reduces the water demand.

2.2 Fine Aggregate: Basalt stone smashed sand is utilized as fine total. The sand components must give least void proportion the higher voids substance prompts need of additionally blending water. The Specific gravity of sand is 2.64 and fineness modulus is 3.35 and the mass thickness of FA is 1593.10kg/m³

2.3 Ground granulated blast-furnace slag (GGBF): The use of iron blast-furnace slag as a constituent of concrete, either as an aggregate or as a cementing material, or both, is well known. The use of ground granulated blast-furnace (GGBF) slag in the production of blended cements began in 1905 in the United States. Recent attention has been given to the use of GGBF slag as a separate cementation's constituent of concrete. This report primarily addresses the use of GGBF slag as a separate cementitious material added along with Portland cement in the production of concrete.

Table 1: Comparison of physical properties of Sand & GGBFS as a Fine aggregate

Materials Properties	Fine Aggregate (sand)	Fine Aggregate (GGBFs)
Specific gravity	2.61	2.52
Fineness modulus	2.79	3.35
Bulk density loose	1.511gm/cc	1.0379gm/cc
Bulk density Compacted	1.66gm/cc	1.164gm/cc

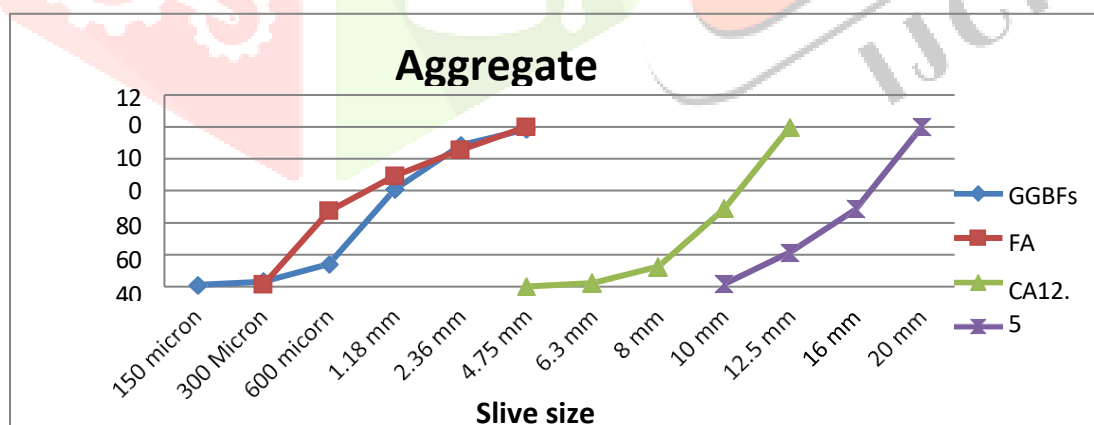


Fig. 1: Gradation curves of Natural rivers and GGBFs as fine aggregate

2.4 Sodium hydroxide (NaOH)

The sodium hydroxide (NaOH) is available in white powder or fragments shape. In this research NaOH pellets is used.

2.5 Sodium silicate (Na₂SiO₃)

Na₂SiO₃ is used here in liquid form.

2.6 Super plasticizer

SNF-Sulphonated Naphthalene Formaldehyde. SNF based solutions are high-performance admixtures used in concrete that are made from Sulphonated Naphthalene Formaldehyde (SNF)

III. PREPARATION OF ALKALINE SOLUTION

In this work alkaline liquid is prepared by mixing the Na_2SiO_3 and NaOH solution. Calculation of molarity of NaOH

$M = \frac{\text{gm solute or molecular mass}}{\text{solution volume for 1 liter of water}}$, 12 M

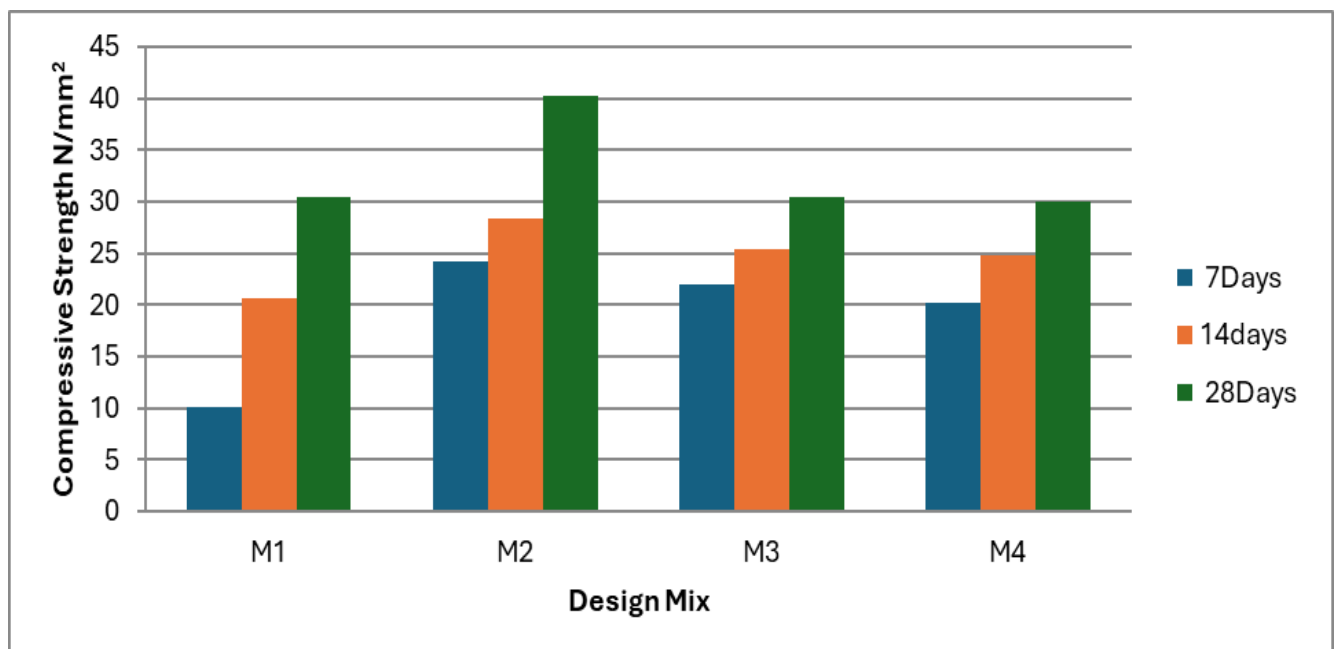
IV. MIX-DESIGN OF GPC

Mix design M30 grade concrete is used. The mixes are design as M1, M2, M3, M4 a for the investigation included Fly ash and GGBFS replacements of (70:30) kept constant by weight of cement and M-sand: GGBFS (70:30,65:35,60:40) as Fine aggregate replacement compared to conventional M30 grade concrete, with a constant 0.2% Glass fiber (GF). A binding solution to binder ratio constant. SP added of 2 % by weight of the binding.

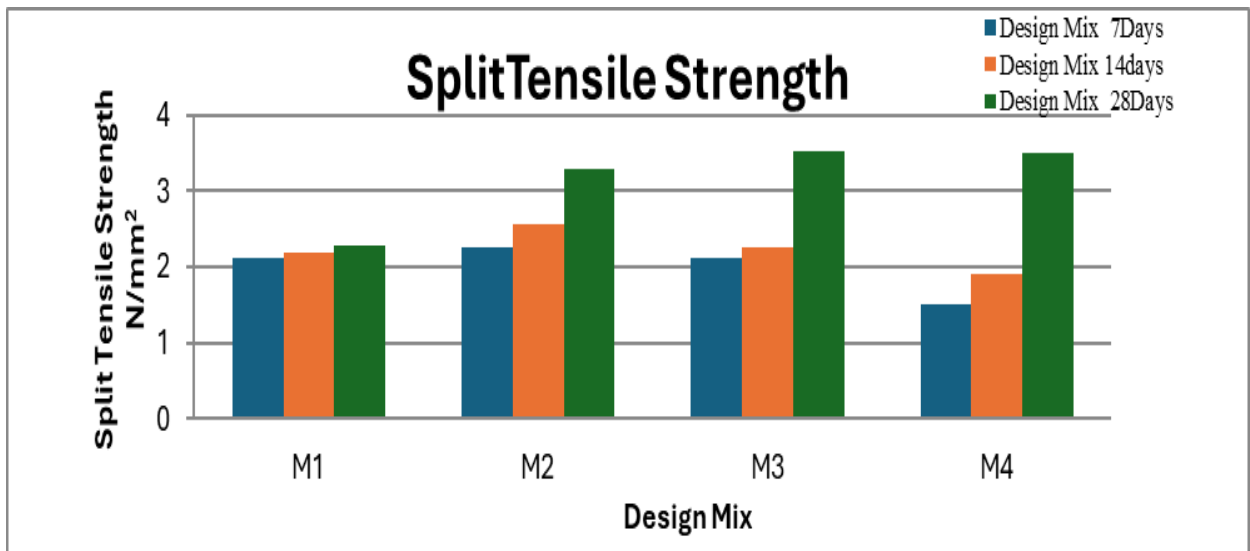
V. RESULTS AND DISCUSSION

TEST 1: Compressive Strength of Concrete with % Replacement of GGBFS

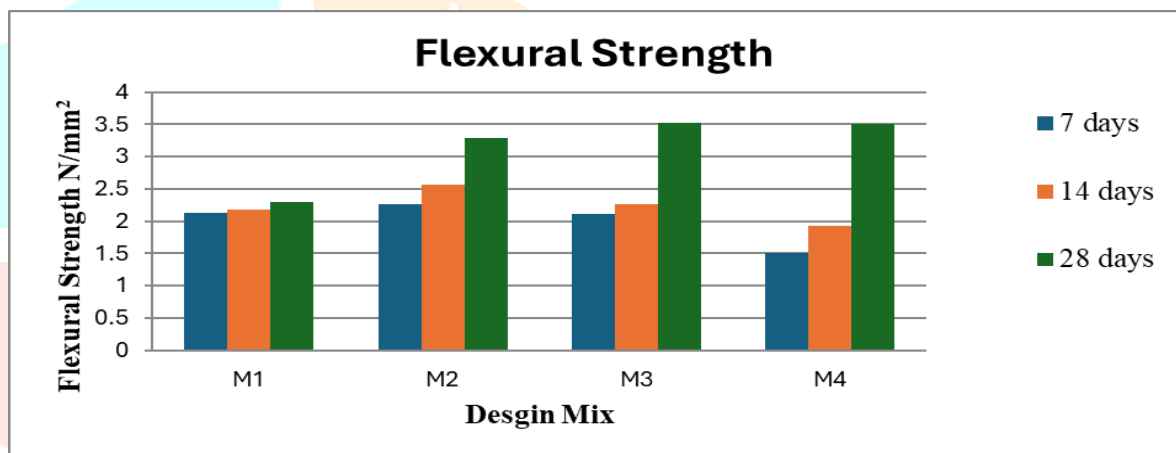
Design MIX M30	Cement		Fine Aggregate		Compressive Strength N/mm ²		
	Fly Ash %	GGBFS %	M SAND %	GGBFS %	7Days	14days	28Days
M1	100	0	100	0	10.08	20.63	30.42
M2	70	30	70	30	24.22	28.45	40.24
M3	70	30	65	35	22.06	25.42	30.47
M4	70	30	60	40	20.21	24.83	30.02



TEST 2: Split Tensile Strength of Concrete with % Replacement of GGBFS M30 grade



TEST 3: Flexural Strength of Concrete with % Replacement of GGBFS M30 grade



TEST 4: RCPT test on Concrete with % Replacement of GGBFS M30 grade concrete.

Design MIX	Average compressive strength N/mm ²	Charge passed (Coulombs)	Chloride ion penetrability
M1	30.4	4093.5	high
M2	40.2	2529.07	Moderate
M3	30.47	2153.63	Moderate
M4	30.02	2172.17	Moderate

M2 mix is highest Compressive strength (40.2 N/mm²) and Chloride Ion Penetrability is Moderate its desirable combination.

M1 mix low compressive strength (30.4 N/mm²) and Ion Penetrability is High its not desirable combination compared with other mix.

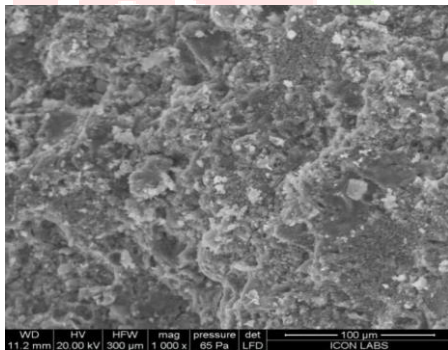
TEST 5: Ultrasonic Pulse Velocity Test

Mix M2, M3 and M4 the of pulse Velocity is good quality concrete (more than 4.0 Km/s and Mix M1 (3.32km/s) the of pulse Velocity is medium quality concrete

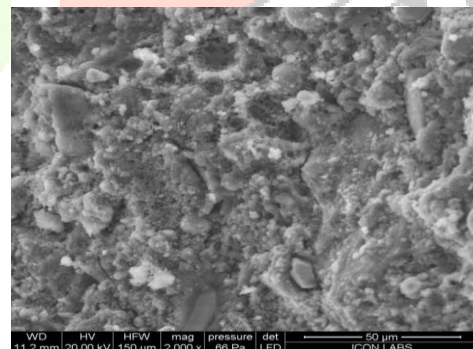
Design MIX	Cement		Fine Aggregate		Pulse Velocity (km/s)	Concrete quality grading
	Fly Ash %	GGBFS %	M SAND %	GGBFS %		
M1	100	0	100	0	3.32	medium
M2	70	30	70	30	4.47	good
M3	70	30	65	35	4.25	good
M4	70	30	60	40	4.3	good

TEST 6: SEM analysis of geopolymer concrete with different percentage of replacement of GGBFS.

SEM provides high-resolution images of a sample's surface by scanning it with a focused beam of electrons. SEM images reveal the topography, texture, and microstructure of the sample and we can observe features like grain boundaries, cracks, pores, or layered structures. Particle-Size and Shape are measured.



(1)



(2)

CONCLUSIONS

- Compressive Strength of GPC rises with the addition of GGBFS in this study.
- Split Tensile Strength of GPC slightly increases by addition of GGBFS in different proportions.
- The RCPT tests on geopolymer concrete and conventional concrete yielded nearly identical results in terms of charge passed in Coulombs.
- Overall, geopolymer concrete with fly ash and GGBFS as Fine aggregate is better for replacement of M30-grade conventional concrete.

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