ISSN PRINT 2319 1775 Online 2320 7876

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Experimental Investigation on Geopolymer Concrete with Partial Replacement by Sugarcane Bagasse Ash and Waste Tyre Rubber Fiber

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ABRSTACT
Countries are quickly growing these days, necessitating additional infrastructure on a daily basis for current and future growth. Cement serves a critical function in concrete, which is needed for the construction of infrastructure and the economic growth of every nation. Geopolymer technology is one of the most effective methods for the reutilization of pozzolanic waste materials. The advent of geopolymer concrete (GPC) technology has resulted in long-term growth in the building industry. We investigated the strength and durability of GPC when Flyash (FA) and Ground Granular Blast Furnace Slag (GGBFS) are substituted with Sugarcane Bagasse Ash (SCBA) and Coarse Aggregates Rubber Fiber (RF) from old tyres in this study. Retaining structures, accident barriers, and even pavement constructions may all benefit from GPC using waste tyre rubber fiber. SCBA is used in GPC at 10% and 20% concentrations. RF is added at five percent, ten percent, fifteen percent, and twenty percent. The molarity of the alkaline solution is maintained at 12M, as recommended by numerous studies. With the rise in RF %, workability has reduced. Compressive Strength has decreased as the proportion of RF in GPC has increased. RF The post-crack toughness of GPC with RF is greater than that of GPC without RF. Acid assaults are more susceptible to GPC with RF. The Split Tensile Strength of GPC has risen as the RF % has increased, while the Split Tensile Strength of SCBA has decreased as the SCBA percentage has increased. Flexural strength has decreased as the percentages of SCBA and RF have increased.

KEYWORDS: Geopolymer Concrete (GPC), Sugarcane Bagasse Ash (SCBA), Rubber Fiber (RF) from used tyres, Molarity (M), Toughness, Strength, Acid Attacks

1. INTRODUCTION

1.1 GENERAL
Countries are quickly growing these days, necessitating additional infrastructure on a daily basis for current and future growth. Cement serves a critical function in concrete, which is needed for the construction of infrastructure and the economic growth of every nation. The Indian cement business is one of the world's largest cement producers. India's cement industry has grown at an exponential rate. Cement manufacturing capacity in India is now 500 MTPA, with 298 million tonnes produced annually. India's per capita cement usage is 195 kg, much less than the global average of 500 kg and China's 1000 kg. Cement output in

ISSN PRINT 2319 1775 Online 2320 7876

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India is expected to reach 500 million tonnes by 2020 and 800 million tonnes by 2030, thanks to increased infrastructural development. Cement production has resulted in significant CO2 emissions into the atmosphere, resulting in pollution and global warming. With significant modernization and the adoption of cutting-edge technology, Indian cement factories are now the most energy-efficient and environmentally friendly in the world in every regard, whether it's kiln size, technology, energy consumption, or environmental friendliness. Fly ash (FA), ground granulated blast furnace slag (GGBFS), sugarcane bagasse ash (SCBA), metakaolin (MK), and used rubber tyres (URT) are also significant ecological and environmental concerns. We can't keep discarding them, which will create land annoyance and landfill problems, thus the pace and quantity of their production has been a significant problem. Researchers have been attempting to replace cement in concrete with environmentally acceptable alternatives for many years. FA, GGBFS, SCBA, and MK are some of the materials that may be utilized to partly or fully replace cement in concrete, depending on our needs.

Geopolymer technology is one of the most effective methods for the reutilization of pozzolanic waste materials. Davidovits used the term "geopolymer" in 1978 to characterize a group of mineral binders having a chemical composition comparable to zeolites but an amorphous microstructure. Unlike conventional Portland cements, geopolymers rely on the polycondensation of silica and alumina precursors to provide structural strength rather than calcium-silicate-hydrates for matrix formation and strength. Source materials and alkaline liquids are the two primary components of geopolymers. The silicon (Si) and aluminium (Al) content of the raw materials for alumino-silicate should be high (Al). By-product materials such as fly ash, slag, silica fume, red mud, rice-husk ash, and so on may be used. In contrast to other alumino-silicate materials, geopolymers are also distinctive. The advent of geopolymer concrete (GPC) technology has resulted in long-term growth in the building industry. Geopolymer concrete made from landfilled trash may have a lower global warming effect than conventional OPC concrete. As a result, the goal of this study is to achieve a number of goals, including lowering FA, GGBFS, URT disposal problems, and CO2 emissions, as well as assisting in the sustainable manufacturing of cement composites. For the production of GPC, geopolymer technology uses pozzolanic materials such as fly ash and slag as a binder instead of cement. It also eliminates the requirement for pozzolanic materials to be treated before disposal. Overuse of natural resources must be avoided in order for nations to grow sustainably, and eco-friendly materials or end-products must be used instead to minimize waste. Steel and polypropylene fibers, scrap tyre chips, and rubber crumbs from old tyres have all been utilized by researchers to replace coarse aggregates in traditional concrete and GPC in recent years. Compressive and flexural strength of concrete and GPC are decreased as percentages rise, but permeability is enhanced [1]. However, by using admixtures and pre-treatments, we can slow down the deterioration of strength characteristics. Experiments in the lab have shown that adding waste tyre rubber chips to GPC improves its toughness, impact resistance, and plastic deformation, indicating that it has a lot of promise for application in retaining structures, sound (or) crash barriers, and pavement constructions. It is widely recognized that adding short fibers to concrete, such as steel fibers, may improve its strength, hardness, and fracture resistance. To determine the mechanical and durability characteristics of GPC, FA and GGBFS are partly replaced at various percentages by SCBA and coarse aggregates by rubber fibers from old rubber tyres.

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1.2 MOTIVATION

Cement use is growing all over the globe, yet cement includes a lot of Si-Al (silica and alumina). As a result, fly ash is utilized as an alternative novel material. FA is made up of a lot of Si-Al compounds and is a byproduct of coal used in thermal power plants. It has a lot of cementitious properties.

Cement is substituted with fly ash in geopolymer concrete, which has a higher compressive strength than regular concrete and many other benefits. Fly ash is also less expensive than cement, and it is a waste product that may be repurposed.

The primary benefit of geopolymer concrete is that traditional concrete generates more CO2, which contributes to global warming. To prevent CO2 emissions into the atmosphere, geopolymer concrete was developed. When compared to other kinds of concrete, geopolymer concrete offers more advantages, which prompted us to pursue this idea.

1.3 OBJECTIVE OF THE PROJECT

The goal of the research is to investigate the impact of substituting FA-GGBFS binder with SCBA at 10%, 20%, and coarse aggregates with RF of used tyres at various percentages of 5%, 10%, 15%, and 20% in GPC to determine their workability, strength, and durability characteristics.

1.4 SCOPE OF THE PROJECT

- To test the workability, compressive strength, split tensile strength, and flexural strength of GPC when SCBA and Rubber Fiber (RF) from old tyres were used to replace coarse aggregates at various percentages.
- Determine the best proportion of RF from old tyres that can be utilized to replace CA in GPC to achieve acceptable characteristics.
- To achieve a GPC with a high level of toughness.
- To minimize waste, discarded SCBA and old rubber tyres are utilized.
- Determine the acid resistance characteristics of the material.

2. METHODOLOGY

2.1 GENERAL:

This chapter addressed the physical and chemical characteristics of ingredients, mixture proportions, the mixing method, and the curing conditions of geopolymer concrete.

2.2 MATERIALS USED AND THEIR PROPERTIES:

Low-calcium fly ash, fine and coarse aggregates, alkaline liquids, additional water, and rubber tyre fiber were utilized to make fly ash-based geopolymer concrete examples.

2.2.1 FLYASH [FA]:

FA Class F of Ramagundam Thermal Power Station, Telangana, was acquired from a building site in Medchal for this study. Table 3.1 shows the physical characteristics of fly ash as determined by IS: 1727-1967.

Table-2.1 Physical Properties of FlyAsh

S. No.	Properties	Test Results

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1	Specific Gravity of Flyash	2.35
2	Fineness, Percentage passing on 150 µm sieve	99.2%
3	Fineness, Percentage passing on 90 µm sieve	97.9%

FIG. 2.1. Flyash from Ramagundam Power Station, Telangana

2.2.2 GROUND GRANULATED BLAST FURNACE SLAG [GGBFS]:

The Steel Manufacturing Plant provides GGBFS. It is available in powder form and may be substituted with FA. It is high in calcium silicate and gives concrete its strength. When GGBFS reacts with an alkaline solution, it produces a cementitious material that does not release CO2, and its usage in GPC improves the durability and mechanical characteristics of the material. GGBFS has a specific gravity of 2.7.

2.2.3 SUGARCANE BAGASSE ASH [SCBA]:

It's a pozzolanic admixture, which means it's made up of amorphous aluminosilicates that aren't inherently cementitious but react with Calcium Hydroxide [Ca(OH2)] and water to create Cementous compounds. SCBA is made up of highly reactive silica and may be utilized as pozzolanic components in concrete rather than being discarded. Sri Gayathri Sugar Mills in NizamSagar provides it. SCBA has a specific gravity of 1.91.

Table-2.2 Chemical Composition of FA, GGBFS and SCBA in comparison with OPC

Chemical Composition (%)	**OPC**	**FA**	**GGBFS**	**SCBA**
Silicon dioxide (SiO_2)	21.04	56.66	34.58	84.16
Calcium Oxide (CaO)	63.56	1.94	40.67	1.8
Aluminium Oxide (Al_2O_3)	5.46	23.97	13.69	1.68
Ferric Oxide (Fe_2O_3)	2.98	7.56	0.44	4.40
Sulfur trioxide (SO_3)	2.01	0.57	0.56	0.1
Sodium Oxide (Na_2O)	0.32	0.33	0.15	<0.01
Pottasium Oxide (K_2O)	0.70	0.8	0.32	0.57
Magnesium Oxide (Mgo)	2.52	1.34	7.05	1.6
Loss of Ignition	1.38	2.76	1.13	0.8
Others	0.03	4.07	1.41	4.88

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Sugarcane Bagasse Ash obtained from Sri Gayathri Sugar Mills, NizamSagar

2.2.4. RUBBER FIBER [RF] FROM USED TYRES:

Different studies have thoroughly documented the health and environmental hazards presented by discarded tyres, which include fires, various health effects, and environmental pollution owing to fires in stock heaps. Tyre stocks, whether legal or illicit, provide a significant fire danger. Tyre fires are difficult to put out, produce poisonous smoke and fumes, and pollute the environment with residue left behind after the fire has burned out. Carbon monoxide and sulphur oxides, as in all fires involving hydrocarbon products, provide the most immediate danger to human health, with concerns of carbon monoxide poisoning and asphyxia. Other hazards to human health include illegally discarded tyres and waste tyre stockpiles. This is due to their doughnut shape, which enables them to readily collect water and serve as an excellent insect breeding site. The goal of this study is to utilize the waste from old rubber tyres as an RF replacement for CA in GPC by cutting them into different thicknesses and lengths to determine the most optimal and desired use.

Tyres are classified according to their thickness, as well as whether they have steel belt wires or not. We collect fiber samples from old heavy and light motor vehicle tyres for our study. Mechanical cutting was used to collect the discarded tyre fibers. For best results, RF are pre-treated by soaking them in 60°C hot water for 30 minutes. Test specimens are produced with various percentages of Tyre fibers in coarse aggregates, ranging from 5%, 10%, 15%, and 20%, and have dimensions of 50mm in length and 10mm in breadth.

2.2.5 COARSE AGGREGATES:

As coarse aggregate, crushed granite stone aggregate with a maximum size of 20mm was utilized. For the experiments, coarse material flowing through 20mm and retaining 4.75mm was utilized. The characteristics of coarse aggregates were determined according to IS: 2386-1963 and are shown in Table 3.2, whereas sieve analysis is shown in Table 3.3. Figure 3.1 depicts the coarse aggregate gradation curve.

Table-2.3 Properties of Coarse Aggregates

S. No.	Properties	Test Results
1	Specific Gravity	2.45
2	Fineness Modulus	8.38
3	Bulk Density	1540 Kg/m3
4	Water Absorption	0.5%

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Table-2.4 Sieve Analysis of Coarse Aggregate

IS Sieve Size (mm)	Weight Retained (%)	Cumulative Weight Retained (%)	Cumulative Weight Passing (%)
20	45.00	45.00	55
16	38.00	83.00	17
12.5	15.00	98.00	2
10	1.35	99.35	0.65
4.75	0.05	99.40	0.60

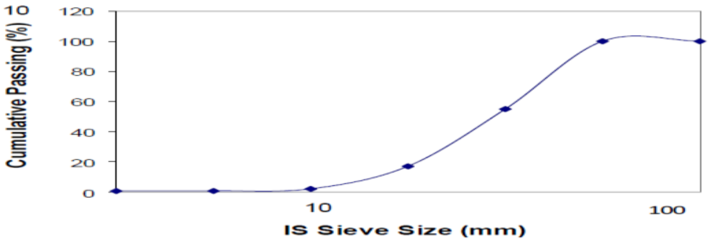

Figure-2.2 Gradation curve of Coarse Aggregates

2.2.6 FINE AGGREGATE:

This experiment was carried out using locally accessible river sand that had a grain size of 4.75mm. The characteristics of fine aggregate were determined according to IS: 2389-1963 and are shown in table 3.5, whereas sieve analysis is shown in table 3.6. Figure 3.2 depicts the coarse aggregate gradation curve.

Table-2.5 Properties of Fine Aggregate

S. No.	Properties	Test Results
1	Specific Gravity	2.65
2	Fineness Modulus	2.49
3	Bulk Density	1260 Kg/m3
4	Water Absorption	1%

Table-2.6 Sieve analysis of Fine Aggregate:

IS Sieve Size	Weight Retained (%)	Cumulative Weight Retained (%)	Cumulative Weight Passing (%)
4.75mm	1.15	1.15	98.85
2.36mm	0.6	1.75	98.25
1.18mm	20.85	22.6	77.4
600µm	25.55	48.15	51.85
300µm	29.75	77.9	22.1
150µm	20.5	98.4	1.6

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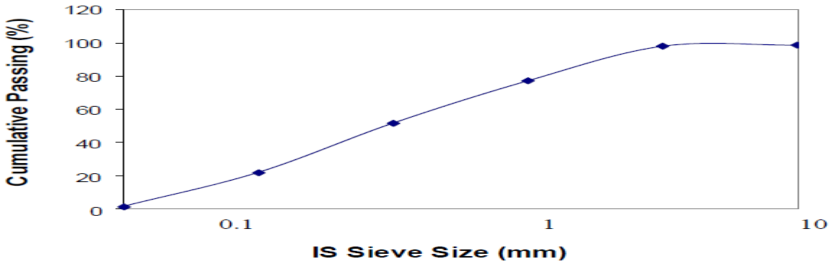

Figure-2.3 Gradation curve for Fine Aggregates

2.2.7 ALKALINE SOLUTION:

As an alkaline solution, a mixture of sodium silicate solution and sodium hydroxide solution was employed. The sodium solution A53 was employed, which had a SiO2 to Na2O mass ratio of about 2, i.e. (Na2O = 14.7 percent, SiO2 = 59.4 percent, and water 55.9% by mass). The sodium was utilized in flake or pellet form, with a purity of 95-96 percent. To produce a solution with the necessary concentration, the solids must be dissolved in water. The sodium hydroxide solution concentrations were set at 12M, and the mass ratio of sodium silicate solution to sodium hydroxide solution was set at 2.5 since sodium silicate solution was cheaper than sodium hydroxide solution.

2.2.8 WATER CONTENT OF MIXTURE:

The water in OPC concrete interacts chemically with the cement to form a paste that bonds the particles. The water in a low-calcium fly ash-based GPC combination, on the other hand, does not produce a chemical reaction. In reality, the chemical reaction that happens in geopolymers results in the release of water from the binder. However, the amount of water in the geopolymer concrete mixture had an impact on the characteristics of the concrete in both the fresh and hardened states. A single metric termed the "water to geopolymer solids ration by mass" was used to indicate the amount of water in a GPC combination.

The sum of the mass of the binder (i.e. mass of fly ash, GGBFS, and SCBA), the mass of sodium hydroxide solids, and the mass of sodium silicate solution is the mass of geopolymer solids in this parameter. The mass of water in the sodium silicate solution, the mass of water in the sodium hydroxide solution, and the mass of additional water added to the combination make up the total amount of water. The 'water to geopolymer solids' ratio was set at 0.19 as a constant number in this experiment to see how other factors affected the strength characteristics of GPC.

2.3 PROPORTIONS IN THE MIXTURE:

The coarse and fine particles make up approximately 75 to 80 percent of the bulk of geopolymer concrete, just as they do in Portland cement concrete. The application determines the performance requirements for geopolymer concrete. The performance criteria are chosen to be the compressive strength of hardened concrete and the workability of fresh concrete. The alkaline liquid to binder mass ratio, water to geopolymer solids mass ratio, heat curing temperature, and heat curing duration are chosen as parameters to satisfy the performance requirements.

Rangan has suggested design recommendations for low calcium fly ash based geopolymer concrete that is heat cured. The statistics in Table 3.7 for the design of low calcium fly ash based geopolymer concrete were suggested based on the results of many mixes produced in

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the laboratory over a four-year period. In this project, the above-mentioned technique for determining mixture percentage was used.

Table-2.7 Data for design of low calcium flyash based GPC mixture as reported by Rangan

Water to geopolymer solids ratio, by mass	Workability	Design compressive strength (wet mixing time of minutes, steam curing at 60°C for 24hrs after casting),MPa
0.16	Very Stiff	60
0.18	Stiff	50
0.20	Moderate	40
0.22	High	35
0.24	High	30

2.4 MANUFACTURE OF GPC:
2.4.1 PREPARATION OF LIQUIDS:
To produce the solution, the sodium hydroxide (NaOH) solids were dissolved in water. The mass of NaOH solids in a solution changed based on the solution's concentration, measured in molar, M. For example, a 12M NaOH solution had [(12x40)=480 grammes] of NaOH solids (in flake or pellet form) per liter of solution, with 40 being the molecular weight of NaOH. The mass of NaOH solids was determined to be 393 grams per kilogram of 12M NaOH solution. It's worth noting that the quantity of NaOH solids was just a small part of the total mass of the NaOH solution, with water being the most important component. To make the alkaline liquid, combine the sodium silicate solution with the sodium hydroxide solution at least one day ahead of time.
Concentration of Alkaline Solution
Molecular weight of NaOH = 40g/mol
[(1 liter of water + 40g of NaOH) = 1M]
For 12M,
40*12 = 480g of NaOH in 1 lit of water
Heat of up to 80oC may be produced during the production of alkaline solution, which is damaging to the skin. By allowing it to cool for 24 hours after preparation, it is safe to use.

2.4.3 MANUFACTURE OF FRESH CONCRETE AND CASTING:
Geopolymer concrete may be made using the same methods as are used to make Portland cement concrete. The fly ash and aggregates were mixed together in the pan mixer for approximately 3 minutes in the laboratory. The aggregates were produced with a saturated, dry surface. The alkaline solution was then added to the dry ingredients, and the mixing process was maintained for another 4 minutes to create the new concrete. Fresh concrete may be handled for up to 120 minutes without showing signs of settling or losing its compressive strength. After mixing, the new concrete was poured into the moulds in three levels for cubical specimens of 150mm x 150mm x 150mm. Each layer was given 60 to 80 hand strokes with a Roding bar to compress the specimens.

2.4.4 CURING OF GEOPOLYMER CONCRETE:

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Heat curing of geopolymer concrete based on low calcium fly ash is usually recommended. The chemical reaction that happens in the geopolymer paste is greatly aided by heat curing. The compressive strength of geopolymer concrete is influenced by both curing time and curing temperature. The cure period ranged between 4 and 96 hours. The polymerization process was enhanced with a longer curing period, resulting in greater compressive strength. Up to 24 hours of curing time, the rate of growth in strength was fast, but beyond that, the gain in strength was only modest.

The compressive strength of geopolymer concrete increased as the curing temperature increased. Steam curing or oven-dry curing are both options for heat curing. The compressive strength of oven-dry cured geopolymer concrete exceeds that of steam cured geopolymer concrete by around 15%. Heat curing may be done at temperatures as low as 30°C. The environmental circumstances in tropical regions may offer this temperature range. Furthermore, the commencement of heat curing for geopolymer concrete may be postponed for many days. The compressive strength did not degrade after a five-day delay in starting the heat curing process. In fact, delaying the commencement of heat curing improved the compressive strength of geopolymer concrete significantly. This may be related to the geopolymerization that happens before heat curing begins.

2.4.5 TEST SPECIMENS CURING:

Geopolymer concrete examples were cured immediately after casting. In this research, two kinds of curing were used: oven curing and ambient curing. The test specimens were cured in the oven for Oven curing and were left at room temperature for Ambient curing. The specimens were oven-cured for 24 hours at 60 and 100 degrees Celsius. To prevent a dramatic change in the ambient conditions, the test specimens were kept in the moulds for at least six hours after the curing time. The specimens were allowed to air-dry in the laboratory after demoulding until the day of testing.

3. EXPERIMENTS CONDUCTED

3.1 WORKABILITY:

The amount of effort required to achieve complete compaction is referred to as workability. The ease with which newly mixed concrete can be correctly mixed, put, consolidated, and finished without segregation is determined by its workability.

Workability in GPC is influenced by the following factors:

The following are some of the variables that influence concrete's workability:

a. Alkaline Solution and Water content
b. Mix Proportions
c. Size of aggregates
d. Shapes of aggregates
e. Surface texture of aggregates
f. Grading of aggregates
g. Use of admixtures

Tests for Workability:

1. Slump Test
2. Compaction Factor Test

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3. Vee-Bee Consistometer Test

The workability of new concrete was assessed using the traditional slump test (IS: 1199). (1989). The slump value of the fresh concrete was measured using slump cones before it was cast into moulds.

3.2 COMPRESSIVE STRENGTH TEST:

The compressive strength of hardened fly ash-based geopolymer concrete was tested using a typical compression testing equipment with a capacity of 3000kN, according to IS: 516-1959. At the ages of 7 days, 14 days, and 28 days, cubical specimens of 150mm x 150mm x 150mm were cast and evaluated for compressive strength. Each of the compressive strength test results refers to the mean value of three test concrete cubes' compressive strength.

3.3 FLEXURAL STRENGTH TEST:

Flexural strength is determined by casting 100mm x 100mm x 500mm beams to test the flexural strength of concrete. It is also a concrete mechanical test in which the crack width is measured with the peak load on the samples to determine the flexural strength of beams using a Universal Testing Machine in accordance with IS 516-1959.

3.4 SPLIT TENSILE TEST:

Split tensile testing, also known as mechanical testing, is a method of determining the split tensile strength of concrete. The strength is calculated using a cylinder with a diameter of 150 mm and a length of 300 mm. Split tensile strength is measured using a compressive testing equipment.

3.5 DURABILITY TEST:

Durability refers to a concrete's capacity to resist the circumstances for which it was built for an extended length of time without degradation. Concrete's durability is described as its capacity to withstand weathering action. It usually relates to the length of a troubleshooting project's life cycle. -nonstop performance.

3.5.1 TYPES OF DURABILITY OF CONCRETE:

There are many types but major concrete durability types are:

1. Physical durability: Physical durability is against the following actions
   a. Freezing and thawing action
   b. Percolation/Permeability of water
   c. Temperature stress i.e. high heat of hydration
2. Chemical Durability: Chemical durability is against the following actions
   a. Alkali Aggregate Reaction
   b. Sulphate Attack
   c. Chloride Ingress
   d. Corrosion of Reinforcement

3.5.2 FACTORS AFFECTING DURABILITY OF CONCRETE:

Durability of GPC relies upon the following factors:

1. FA content: Mix must be tailored to provide cohesiveness and avoid segregation and bleeding.

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2. Compaction: Inadequate compaction may result in cavities in the GPC as a whole. It is usually determined by the kind of compaction machinery used, the type of formwork utilized, and the density of the steel work.
3. Curing: It is extremely essential to enable appropriate strength growth assist moisture retention and to guarantee hydration process happens fully.
4. Cover: The thickness of the GPC cover must adhere to the guidelines established by the regulations.
5. Permeability: This is the most significant aspect in terms of durability. It's worth noting that greater porosity typically results in higher permeability. Therefore, a proper curing, sufficient binder, proper compaction and suitable concrete cover could provide a low permeability concrete.

3.5.3 SULPHATE ATTACK TEST PROCEDURE:

The test is used to determine the concrete's durability: Procedure:
1. Cut each specimen into a 150*150*150mm cube.
For the casted specimens, a 2.5% H2SO4 solution is utilized to cure them.
3. The casted cubes are then kept in the H2SO4 solution to cure.
4. The cubes are removed and stored for drying once they have completed the necessary curing.
5. The cubes are then weighed and compressed strength evaluated.
6. The compressive strength of the cubes is compared to that of non-sulphate attack cubes.
7. The compressive strength % decrease is then determined.

4. RESULTS

The experimental findings are reviewed and provided in this chapter in the form of tables and graphs. The most frequent test on hardened concrete is the compression test, partly because it is a simple test to run and partly because most of the desired characteristics of concrete are qualitatively linked to its compressive strength. Tests on flexural strength, split tensile strength, and durability were also carried out.

Table-4.1 Test Specimens Label

S. No	Batch of Specimen	Percentage of Flyash in Binder	Percentage of GGBFS in Binder	Percentage of SCBA in Binder	Percentage of RF in CA
1	B1	85	15	0	0
2	B2	74.3	13.5	10	5
3	B3	74.3	13.5	10	10
4	B4	74.3	13.5	10	15
5	B5	74.3	13.5	10	20
6	B6	68	12	20	5
7	B7	68	12	20	10
8	B8	68	12	20	15
9	B9	68	12	20	20

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Table-4.2 Quantities of materials required per $1m^3$ GPC of M40 grade

S.No	Batch of Specimen	FA in kg	GGBFS in kg	SCBA in kg	Fine Aggregate in kg	Coarse Aggregate in kg	RF in kg
1	B1	377	111	0	600	1200	0
2	B2	330.06	59.94	44	600	1140	60
3	B3	330.06	59.94	44	600	1080	120
4	B4	330.06	59.94	44	600	1020	180
5	B5	330.06	59.94	44	600	960	240
6	B6	302	53.28	88	600	1140	60
7	B7	302	53.28	88	600	1080	120
8	B8	302	53.28	88	600	1020	180
9	B9	302	53.28	88	600	960	240

Every batch contains Flyash and GGBFS, which SCBA replaces in the binder by a proportion of their mass. RF is only replacing CA in terms of mass proportion. Each batch includes six test specimen samples: four 150*150*150mm cubes, one 100*100*500mm beam, and one 150mm diameter, 300mm length cylindrical specimen. To obtain better results, all samples are oven-dried for 24 hours.

WORKABILITY:

Increased rubber content causes a decrease in slump, and the downward trend was consistent across all batches, indicating that adding rubber fiber resulted in worse workability.

Table-4.3 Slump Test Height Values

S. No.	Batch	Slump Height value (mm)
1	B1	100
2	B2	133
3	B3	127
4	B4	121
5	B5	116
6	B6	124
7	B7	121
8	B8	115
9	B9	111

COMPRESSIVE STRENGTH:

The compressive strength of GPC specimens was tested at 7, 14, and 28 days for various % replacements of binder and CA. With FA and GGBFS binder, the highest compressive strength is obtained. The addition of SCBA to the binder should improve the strength, however the addition of RF to the CA has had an adverse effect. The potency of SCBA and RF was reduced by 13.8 percent when they were replaced by binder and CA, respectively. A 19 percent decrease in strength was seen when SCBA was replaced at 20% in the binder and RF was replaced at 10% in the CA. Table-5.4 summarises the test findings.

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Table-4.4 Compressive Strength Results of Specimens at different ages

S. No	Batch of Specimen	Compressive Strength of Cube at 7days age (Mpa)	Compressive Strength of Cube at 14days age (Mpa)	Compressive Strength of Cube at 28days age (Mpa)
1	B1	29.4	35.7	39.71
2	B2	27.19	34.16	37.94
3	B3	24.98	30.122	34.23
4	B4	21.55	25.97	29.19
5	B5	17.53	22.35	24.84
6	B6	22.07	30.48	33.87
7	B7	24.12	28.91	32.16
8	B8	21.34	25.24	28.46
9	B9	17.59	22.62	25.14

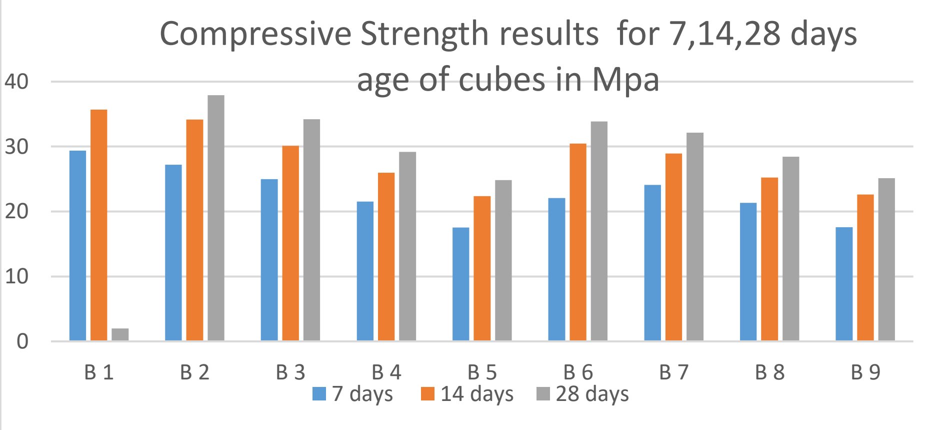

Fig: 4.1.Graph representation of Compressive Strength Results of 28days age for cubes

FLEXURAL STRENGTH TEST:

A flexural test is used to evaluate a material's flexibility by measuring the force needed to bend a beam under a certain load situation. When SCBA is added to a GPC binder, the flexural strength is reduced [29]. The flexural strength of specimens was tested at 28 days of age, and it was discovered that the presence of SCBA and RF in GPC reduces its strength. Because both materials are deteriorating, B6-B9 exhibited a significant decrease of flexural strength when compared to B2-B5.

Table-4.5 Flexural Strength Test is conducted on specimen at 28days age

S.No	Batch of Specimen	Flexural Strength value at 28days age (Mpa)
1	B1	4.85
2	B2	4.11
3	B3	3.77
4	B4	3.42
5	B5	3.29
6	B6	3.61
7	B7	3.29

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8	B8	2.89
9	B9	2.53

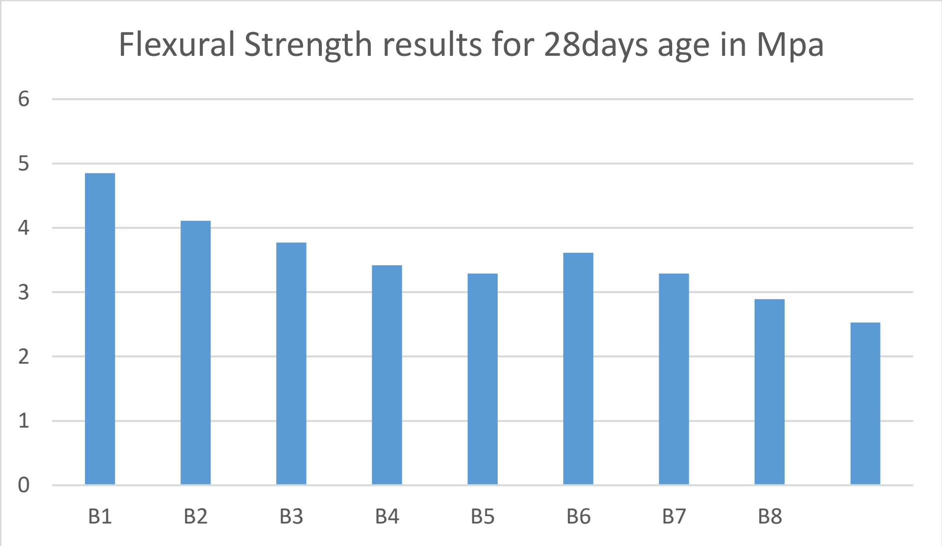

Fig:4.6. Graph representation of Flexural Strength Results of 28days specimens

DURABILITY:

The results of the durability tests for B1, B3 and B7 were obtained because adding 10% RF to GPC and adding 10% and 20% SCBA to GPC yielded best results.

Loss of Weight results of specimen for durability

S. No	Batch of specimen	Loss of Weight (%)
1	B1	1.75
2	B3	2.76
3	B7	3.92

5. CONCLUSION

- With SCBA and RF, Geopolymer Concrete has shown excellent strength and durability characteristics for the intended grade of geopolymer concrete:
- Increased RF concentration in GPC has resulted in a substantial reduction in workability. B1, which has no RF, provides the best workability.
- As anticipated, increasing the SCBA and RF concentration in GPC reduces compressive strength. The decrease in strength values is accomplished mostly via the addition of RF and also by boosting SCBA by more than 10%.
- In comparison to B1, all specimens from B2-B9 had lower flexural strength. When the SCBA and RF percentages in GPC are raised, the strength decreases significantly.
- Split Tensile strength increases as the amount of RF in the GPC increases, but the value decreases when the SCBA increases by more over 10%, according to the findings. Because the SCBA was increased by 20%, the Split Tensile Strength of B3 is higher than B7.
- GPC with a greater RF concentration has a higher Post-crack toughness. Even after the

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maximal load was achieved, the RF added specimens from B2 to B9 had significant deformation in comparison to B1.

- The durability of GPC has been reduced as the RF and SCBA have been increased. With RF and SCBA present, GPC is more susceptible to acid assaults.
- Pre-treating RF by soaking them in 60°C hot water for 30 minutes has shown positive results in terms of strength characteristics.
- SCBA should also improve compressive and flexural strength characteristics, although this is influenced by RF concentration.
- It is possible to utilize a maximum of 10% SCBA and 10% pre-treated Rf in the binder and coarse aggregates without significantly reducing the strength characteristics of GPC. So that SCBA and RF may be utilized in GPC, potentially lowering pollution from old rubber tyres.

SCOPE OF FUTURE INVESTIGATIONS

- As the use of GPC in building grows, it should be examined for all types of potential investigations.
- Admixtures are used in GPC with SCBA and RF to prevent workability, compressive strength, and flexural strength from deteriorating.
- Pre-treating the RF by soaking them in an alkaline solution, cement slurry, and binder for varying amounts of time.
- When using RF, protect the GPC against acid assaults.

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