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RESEARCH ARTICLE

# Mechanical Properties of Geo Polymer Concrete (GPC) by Using Steel, Polypropylene and Glass Fibers

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## Abstract

**Objectives**: To find the mechanical properties of fly ash and GGBS-based Geopolymer concrete (GPC), and to economize GPC production. **Methods:** Geopolymer concrete was developed by adding equal proportions of Flyash and GGBS as binding materials, to activate the polymerization reaction and to make GPC production an economical, impure form of sodium silicate named "water glass" used as the activator. By varying the water glass-to-binder ratio, Binder content, and total aggregate-to-binder ratio, Concrete specimens of size 100mmx100mm are cast and curing is done at ambient conditions. The compressive strength of GPC was examined under ambient curing, from these data G20 and G30 mix proportions are developed. For these grades of GPC, the optimum dosage of Glass, Steel, and Polypropylene fibers was found. By using the optimum dosage of fibers split tensile, Flexural, and Shear strength properties were examined. **Findings:** It was identified that Water glass improved the Mechanical properties of GPC, and the addition of fiber steadily increased strength up to some limit after that strength started to diminish. The optimum dosage of steel fiber is 1.5%, Glass 0.8%, and Polypropylene fingers 0.6% respectively. The impact of fibers on shear strength was comparatively moderate when contrasted with their influence on flexural and split tensile strength. **Novelty:** To activate polymerization reaction, a combination of NaOH and Na2SiO3 are commonly used as activators in GPC, but these are not cost-effective and when GGBS is used as the binder in GPC it will react quickly with these activators. In the Present investigation instead of this activator, Water glass was used as an activator; it economized the GPC production and improved the workability and mechanical properties of GPC.

**Keywords:** Geopolymer Concrete; Water Glass; Compressive Strength; Glass Fiber; Polypropylene Fiber; Steel Fiber

## 1 Introduction

The impact of fibers on the fundamental mechanical characteristics of Geopolymer concrete establishes a sturdy groundwork for advancing the exploration and utilization of fiber-reinforced Geopolymer concrete's toughness. Over the last three decades, global industrialization and urbanization have spurred a remarkable surge in cement production. Cement, being the primary material in building construction, has experienced exponential growth due to these processes. As a consequence, the cement industry has emerged as the second-largest contributor to industrial CO2 emissions worldwide, accounting for approximately 25% of the total global industrial CO2 emissions [(1)]. The utilization of GGBS activated with water glass proved highly effective in extending both the initial and final setting durations of slag-based Geopolymer concrete. This approach successfully addressed the rapid setting process without the necessity of incorporating retarders or water reducers within the concrete mix [(2)]. By maintaining a consistent binder content, it is observed that increasing the solution-to-binder ratio enhances compressive strength up to a certain point. However, beyond this threshold, the strength starts to diminish due to the elevated liquid content associated with higher solution-to-binder ratios [(3)]. Increasing ratio of H2O/Na2O facilitates polymerization reaction, it was observed that the degree of reaction for FA-based Geopolymer at 60°C during the 0 to 12-hour period increased from 4.9% to 5.6% with a greater H2O/Na2O ratio [(4)].

Curing conditions exerted a substantial influence on the Strength properties of the Geopolymer concrete [(5)]. Geopolymer concrete exhibits a higher level of brittleness compared to conventional concrete. To mitigate this brittleness in Geopolymer concrete (GPC), the incorporation of fibers becomes essential. Fiber-reinforced concrete (FRC) has been increasingly preferred for real-world engineering applications owing to its exceptional tensile strength, flexural strength, durability, and fracture properties. The addition of fibers in GPC enhances its overall performance and makes it more suitable for practical engineering applications [(6)]. By incorporating both micro and macro steel fibers without any additional increase in the total fiber volume, significant enhancements were observed in bond strength and initial bond stiffness, with improvements of up to 31% and 60%, respectively [(7)].

The compressive strength of steel fiber reinforced concrete (SFRC) exhibited a trend of initial increase and subsequent decrease with the growing steel fiber content [(8)]. The water-to-binder ratio plays a crucial role in determining the ideal amount of fibers for optimal performance. Concrete flow ability is negatively influenced by glass fibers, as their increased surface area leads to greater flow resistance. Although the addition of glass fibers did not show a substantial improvement in compressive strength, it significantly enhanced tensile and flexural capacity. This improvement is attributed to the glass fibers' ability to effectively resist cracking [(9)].The optimal fiber content can be influenced by the water/binder ratio. Based on the initial analysis of scanning electron microscope (SEM) observations, one of the primary factors is the significant rise in pore size and quantity, which arises from the combined effect of increased water/binder ratio and fiber content [(10)].Upon examining the microstructures of fiber-reinforced concrete, it becomes evident that augmenting the fiber dosage might not lead to improved overall mechanical performance. Instead, it can result in ineffective interweaving and agglomeration of fibers, potentially increasing the occurrence of micro-cracks within the internal concrete structures [(11)]. The mix SPFRC-C, which incorporates crimped steel fibers, exhibits the most substantial increase in flexural strength. When using the SPFRC-C mix, the flexural strength experiences a remarkable enhancement of 120% [(12)].

Integrating fibers slightly diminishes the compressive strength of Recycled Aggregate Concrete (RAC) to a certain degree. However, the amalgamation of varying fiber sizes and types mitigates this adverse impact, leading to a notable enhancement in freeze-thaw resistance and overall durability. The synergy achieved by these blended fibers significantly bolsters the durability of RAC. Notably, longer fibers outperform shorter ones in enhancing the robustness of RAC [(13)]. A comprehensive mechanical properties testing dataset is formed for fiber-reinforced Geopolymer concrete, encompassing a substantial sample size. This repository facilitates the investigation of Geopolymer basics in mechanical attributes, while also serving as a foundational resource for delving into the structural characteristics, numerical modeling, and fracture mechanics of Geopolymer concrete in subsequent studies [(14)]. Research gap: Many researchers focused on the compressive strength behavior of GPC by varying different parameters. it holds significant importance to delve into the response of GPC concerning its capacity to bear shear and flexural loads. Such an understanding is crucial for harnessing the structural potential of GPC effectively.

## 2 Methodology

For the optimum utilization of fly ash and to arrest the quick setting behavior of GPC equal proportions of Flyash and GGBS were used as binding materials in GPC. To understand the behavior of the Water glass to the binder, its ratio was varied from 0.4 to 0.65.

## 2.1 Materials

In the context of the binder material OPC (Ordinary Portland Cement), the current study focuses on the complete substitution of cement with fly ash and GGBS, both of which are residual products from industrial processes. The chemical composition of these materials is detailed in (Table 1). In this investigation, 50%Flyash and 50%GGBS combination is used as binding material, and Water Glass is selected as the activator, with varying ratios of water to water glass (W/WG). To enhance the mechanical characteristics of GPC different proportions of steel fibers, polypropylene fibers, and glass fibers are added to the GPC.

**Table 1.** Chemical composition of GGBS and fly ash (% mass)

| Chemical Composition | SiO2 | $Al_2O_3$ | CaO | MgO | $Fe_2O_3$ | $Na_2O$ | $SO_3$ | LOI |
|---|---|---|---|---|---|---|---|---|
| Flay ash | 60.12 | 26.35 | 4.21 | 1.26 | 4.1 | 0.23 | 0.35 | 3.25 |
| GGBS | 34.29 | 20.15 | 32.4 | 7.39 | 0.8 | Nil | 0.91 | 3.85 |

The fine aggregate employed is natural river sand, material passed through a 4.75-mm and retained by a 0.075 mm size was selected. Coarse aggregates consist of granite chips with a nominal maximum size of 10mm. Glass fiber (GF) is a material composed of numerous exceedingly fine glass fibers, each measuring 12mm in length and possessing a density of 603 kg/$m^3$. Polypropylene Fiber (PPF) is a linear synthetic polymer fiber resulting from the polymerization of propylene. These fibers, also 12mm in length, exhibit a density of 905 kg/$m^3$ and offer advantages such as lightweight, robustness, toughness, and resistance to corrosion. Steel fiber (SF) comprises small, discontinuous fragments of specially produced steel, characterized by a diameter of 0.75 mm and a length of 60mm.

### *2.1.1 Proportions of GPC*

Geopolymer concrete mix proportions was established through a comprehensive strength assessment of GPC, by varying the activator-to-binder ratio, binder content, aggregate-to-binder ratio, water-to-water glass ratio, and a fly ash-to-GGBS ratio of 50:50.

## 2.2 Optimum dosage of fibers

The Optimum dosage of fibers can be identified based on the compressive strength of GPC. By adding different percentages of fibers into the concrete mix. These fibers ranging from 0.5% to 2% for steel fibers, 0.2% to 0.8% for polypropylene fibers and 0.2% to 1% of glass fibers.

## 2.3 Shear behavior of Geopolymer concrete

The shear strength behavior of Geopolymer concrete (GPC) was examined by using the push-off specimens, these specimens comprised two interconnected L-shaped blocks, united and served as the locus for the application of shear stress. To ensure resistance against potential flexural failure, longitudinal reinforcement with a 10 mm diameter was incorporated, along with 6 mm diameter stirrups arranged in a two-legged configuration. The dimensions of the specimen were set at 340 x 200 x 100 mm. This shear strength evaluation encompassed both G20 and G30 concrete grades, incorporating various fiber combinations within the specimens.

## 2.4 Split tensile strength of GPC

Cylindrical samples measuring 150mm x 300mm were cast and subjected to curing under ambient temperature conditions. The split tensile strength evaluation procedure involved placing the specimen horizontally between the loading surface of a compression testing machine and an applied load. This load was incrementally increased until the cylinder eventually experienced failure along its vertical axis.

## 2.5 Flexural strength of GPC

Prism specimens, each measuring 100mm x 500mm, were meticulously fabricated across various grades of Geopolymer Concrete (GPC). Following a curing period of 28 days under ambient conditions, these specimens were horizontally positioned between the loading surfaces of a flexural testing machine. Progressive loading was applied until the prism specimens eventually reached failure.

# 3 Results and Discussion

## 3.1 Compressive strength of GPC

To assess compressive strength, conventional cubic specimens of dimensions 100mm x 100mm x 100mm were prepared. These specimens were subjected to compression testing using a 3000kN tester, adhering to the recommended standard load rate stipulated by IS 516.

### *3.1.1 Compressive strength of GPC for different WG/B ratios*

The ratio of water glass to binder significantly affects the compressive strength of GPC. Achieving an appropriate equilibrium is vital to optimize geopolymerization, and attain the intended strength. Water glass plays a pivotal role as a geopolymerization as activator. Increasing the water glass to binder ratio could potentially augment the concentration of alkali activator, expediting the polymerization process and potentially leading to enhanced early-age strength. Elevated water glass content has the potential to elevate the alkalinity within the mixture, thereby impacting the solubility of silicate raw materials and the ensuing polymerization reactions. Determination of Geopolymer concrete's compressive strength was examined by changing the Water glass to binder ratios of 0.4, 0.45, 0.5, 0.55, 0.6, and 0.65 while maintaining a Flyash to GGBS ratio of 50:50. Notably, a progressive augmentation in GPC strength was noted with the increase of the water glass to binder ratio, up to the point of 0.5. Beyond this, a subsequent decrease in strength was observed. These strength results are represented in (Figure 1). With every fixed binder content, surpassing a specific threshold in the solution-to-binder ratio does not further enhance strength but does improve workability. Conversely, concrete mixes formulated with a lower solution-to-binder ratio exhibit reduced workability[(4)]. The water glass exhibits a dual-layer arrangement in its structure. A lower water-glass module results in a more extensive diffusion layer, prompting greater activation of CaO, SiO2, and Al2O3 within the raw materials. This enhancement, in turn, bolsters the strength of GRAC. Geopolymer products display two distinct gel structures, namely N-A-S-H and C-A-S-H. Reducing the water-glass module is linked to an increased formation of N-A-S-H gel, contributing to this shift in gel composition[(15,16)].

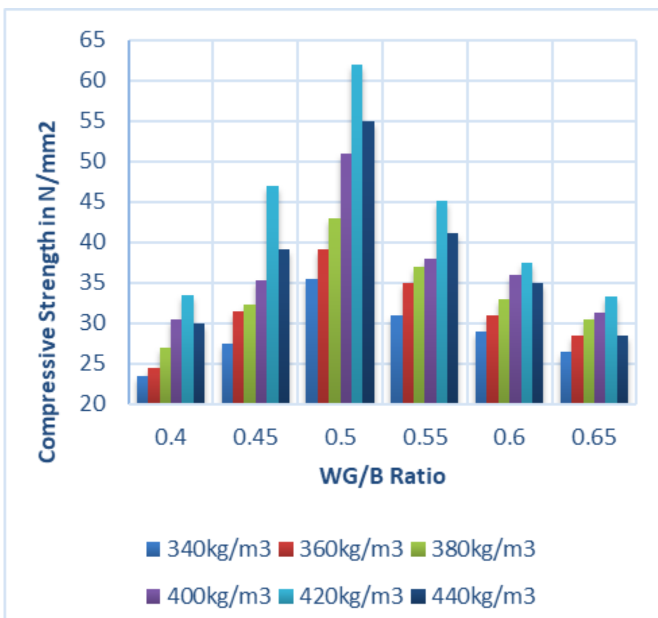


**Fig 1.** Compressive Strength of GPC for different Liquid to binder ratios And Fly-ash to GGBS ratio 50:50

### *3.1.2 Compressive strength of GPC for different binder content*

The compressive strength of Geopolymer concrete (GPC) experiences alterations when the binder content is modified. Generally, increasing the binder content tends to elevate the compressive strength of GPC until a certain limit. This effect is rooted in the fact that higher binder content encourages the formation of more Geopolymer gel, leading to a denser and stronger concrete matrix. However, exceeding the optimal binder content can lead to a situation where particles become overly concentrated, offering limited additional strength and potentially causing a decline in mechanical properties. Achieving the

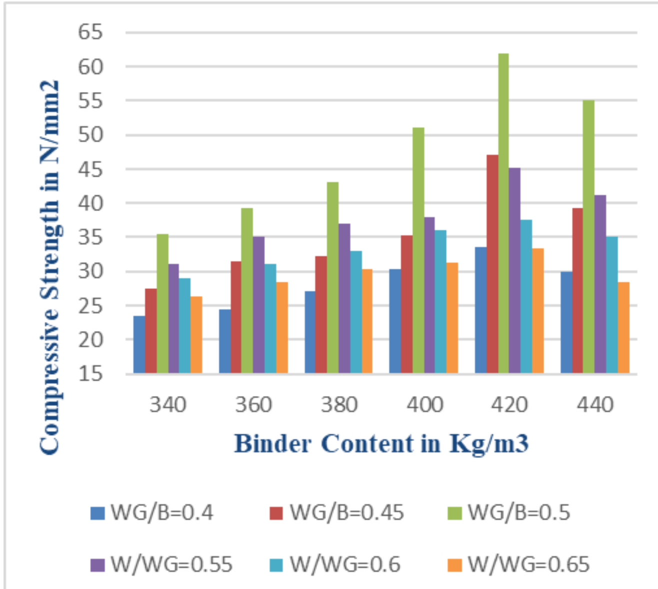


**Fig 2.** Compressive Strength of GPC for different Binder content and for flyash to GGBS ratio 50:50

right balance in binder content is essential for reaching the desired compressive strength goals. This determination necessitates careful deliberation of aspects like workability, economic viability, and long-term durability. The perfect harmony relies on variables such as the specific mix design, type of binder, curing circumstances, and a range of other factors. The assessment of Geopolymer concrete's compressive strength encompassed a systematic adjustment of binder contents of 340kg/m3, 360kg/m3, 380kg/m3, 400kg/m3, 420kg/m3, and 440kg/m3 while maintaining a constant Flyash to GGBS ratio of 50:50. It was determined that the strength of GPC exhibited a steady rise in response to increased binder content, reaching its maximum at 420kg/m3. Beyond this point, a subsequent decline in strength was observed. These strength variations are represented in (Figure 2). With the increase of binder content, the split tensile strength of GPC also rises, and its response to changes in the solution/binder ratio similar behavior exhibited [(4)].

### *3.1.3 Compressive strength of GPC for total AG/B ratio*

The ratio of aggregate to binder assumes a pivotal role in dictating the compressive strength of GPC. Achieving an optimal equilibrium is vital to guarantee efficient compaction, robust interfacial adhesion, and the enduring durability of the Geopolymer concrete. Within a reasonable range, elevating the aggregate-to-binder ratio has the potential to boost the compressive strength of GPC. A harmonious ratio promotes the effective arrangement of aggregates within the Geopolymer matrix, thereby enhancing the durability of the concrete. The evaluation of Geopolymer concrete's compressive strength involved the systematic alteration of the aggregate-to-binder ratio. Notably, the highest compressive strength was attained at an aggregate-to-binder ratio of approximately 4.21, beyond which the strength of GPC exhibited a gradual decline. The determination of the aggregate-to-binder ratio within the mix was predicated on an assumed GPC density of 2400 kg/m3. This trend in strength variation is illustrated in (Figure 3). To examine the Shear behavior of GPC with and without using fibers the following mix proportions are considered.

### *3.1.4 Optimum Dosage of fibers in GPC*

Increasing the proportions of 20mm length glass fibers up to 0.75% leads to improvements in mechanical properties. However, at a percentage of 1.00%, there is an observable buildup of multifilament fiber branches, which in turn contributes to increased drying shrinkage [(17)]. Three different percentages of PPFs (1%, 2%, and 3%) and three NS percentages (5%, 10%, and 15%) were introduced to the specimens. A range of performance indicators for Ultra-High-Strength Geopolymer Concrete (UHS-GPC) was assessed, encompassing aspects like fresh properties, compressive strength, modulus of elasticity, split tensile strength, flexural strength, bonding strength, drying shrinkage, load-displacement behavior, fracture resistance, and response to elevated temperature. The optimal enhancement in UHS-GPC's performance was observed when utilizing 2% polypropylene fibers and 10% Nano-silica. This combination resulted in a 17.07% increase in compressive strength, a 47.1% improvement in split tensile

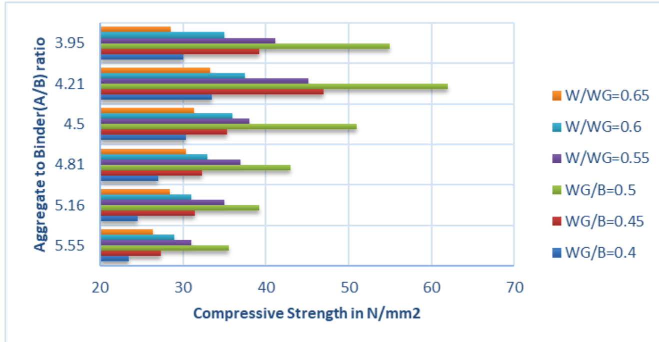


**Fig 3.** Compressive Strength of GPC for different aggregate to binder ratios and for the Flyash: GGBS 50:50

strength, a 36.52% enhancement in flexural strength, and a 37.58% boost in bonding strength. Additionally, the modulus of elasticity saw a notable 31.4% rise at the 56-day [18]. Determining the optimal fiber dosage in concrete relies on a range of factors. These encompass the type of fibers employed, the precise purpose of the concrete, and the targeted characteristics. Various fiber types—steel, polypropylene, and glass—impart distinct effects on concrete properties, each with its own dosage sweet spot. The length and aspect ratio of fibers also contribute to their efficacy. The concrete's comprehensive mix design further influences the ideal fiber dosage. Moreover, the specific attributes you intend to enhance—such as flexural strength, impact resistance, or durability—contribute to defining the optimal fiber dosage. The optimal fiber dosage in Geopolymer concrete can vary based on the specific fiber type employed.

Fiber dosages are expressed as a percentage of the total volume of the concrete mixture. In the pursuit of enhancing the strength attributes of Geopolymer concrete, steel fibers were introduced in dosages of 0.5%, 1%, 1.5%, and 2.0% by volume. Notably, the observed trend indicated a gradual strengthening up to 1.5% of steel fibers, beyond which strength diminished. These compressive strength findings are depicted in (Table 2 ). In the case of Polypropylene fibers, dosages ranged from 0.2%, 0.4%, and 0.6%, to 0.8% of the total volume of the Geopolymer concrete mix. The addition of Polypropylene fibers had minimal impact on compressive strength; a modest increase was noted up to 0.6% of fibers, followed by a subsequent decline in compressive strength. Glass fibers were integrated at dosages of 0.2%, 0.4%, 0.6%, 0.8%, and 1% of the total weight of the Geopolymer concrete mix. Comparable to Polypropylene fibers, the inclusion of Glass fibers showed limited influence on compressive strength. An incremental strengthening effect was discerned up to 0.8% of fibers, beyond which strength decreased. By determining the optimal fiber dosages in Geopolymer concrete, an investigation was conducted into the split tensile strength, flexural strength, and shear strength of the material both with and without fibers. The highest strength in the Mix G30PF0GF0SF1.5 was observed in the G30 grade, while for G20 the Mix G20PF0GF0SF1.5 highest strength was achieved by employing the optimal amount of steel fibers. In the context of polypropylene fibers, the mixes G20PF0.6GF0SF0 and G30PF0.4GF0SF0 yielded the greatest strengths. When Glass fibers were incorporated, the G20PF0GF0.8SF0 and G30PF0GF0.8SF0 mixes exhibited the highest strengths.

## 3.2 Shear strength of GPC

Evaluating the shear strength of Geopolymer concrete (GPC) using pushup specimens encompasses a distinct testing procedure. Within this methodology, the concrete undergoes exposure to a shear force aligned with the plane of the pushup specimen. Quantification of GPC's shear strength involves capturing the maximum force exerted during the test and subsequently computing the shear stress. This methodology sheds light on how GPC withstands shear forces, especially relevant for scenarios involving lateral loads or forces, such as in beams and slabs. The insights drawn from pushup shear tests contribute to understanding the material's shear behavior and its implications for structural performance. These outcomes inform engineering decisions and design considerations for projects that incorporate GPC. The mechanical characteristics of Geopolymer concrete (GPC) with a noticeable correlation between shear strength and the GPC grade were observed. The incorporation of steel fibers led to a notable 17% increase in shear strength, showcasing the most significant increment among the fiber-reinforced GPC variations. These improved shear strength outcomes are visually presented in (Figure 4).

**Table 2.** Mix proportions of G20 and G30 grade concrete

| Mix ID | Fly ash (kg/m3) | GGBS (kg/m3) | Fine Aggregate (kg/m3) | Coarse Aggregate (kg/m3) | Water glass (kg/m3) | Polypropylene Kg/m3 | Glass Fiber Kg/m3 | Steel Fiber Kg/m3 | Compressive Strength (N/mm2) |
|---|---|---|---|---|---|---|---|---|---|
| **G20PF0GF0SF0** | 216 | 144 | 910 | 948 | 162 | 0 | 0 | 0 | 29 |
| **G20PF0GF0SF0.5** | 216 | 144 | 910 | 948 | 162 | 12.5 | 0 | 0 | 30.5 |
| **G20PF0GF0SF1** | 216 | 144 | 910 | 948 | 162 | 25 | 0 | 0 | 33 |
| **G20PF0GF0SF1.5** | 216 | 144 | 910 | 948 | 162 | 37.5 | 0 | 0 | 37 |
| **G20PF0GF0SF2** | 216 | 144 | 910 | 948 | 162 | 50 | 0 | 0 | 31 |
| **G30PF0GF0SF0** | 240 | 160 | 882 | 918 | 180 | 0 | 0 | 0 | 39 |
| **G30PF0GF0SF0.5** | 240 | 160 | 882 | 918 | 180 | 12.5 | 0 | 0 | 41 |
| **G30PF0GF0SF1** | 240 | 160 | 882 | 918 | 180 | 25 | 0 | 0 | 42 |
| **G30PF0GF0SF1.5** | 240 | 160 | 882 | 918 | 180 | 37.5 | 0 | 0 | 45 |
| **G30PF0GF0SF2** | 240 | 160 | 882 | 918 | 180 | 50 | 0 | 0 | 40 |
| **G20PF0GF0.2SF0** | 216 | 144 | 910 | 948 | 162 | 0 | 5 | 0 | 29 |
| **G20PF0GF0.4SF0** | 216 | 144 | 910 | 948 | 162 | 0 | 10 | 0 | 30 |
| **G20PF0GF0.6SF0** | 216 | 144 | 910 | 948 | 162 | 0 | 15 | 0 | 30 |
| **G20PF0GF0.8SF0** | 216 | 144 | 910 | 948 | 162 | 0 | 20 | 0 | 32 |
| **G20PF0GF1SF0** | 216 | 144 | 910 | 948 | 162 | 0 | 25 | 0 | 27 |
| **G20PF0GF0.2SF0** | 240 | 160 | 882 | 918 | 180 | 0 | 5 | 0 | 40 |
| **G20PF0GF0.4SF0** | 240 | 160 | 882 | 918 | 180 | 0 | 10 | 0 | 41 |
| **G20PF0GF0.6SF0** | 240 | 160 | 882 | 918 | 180 | 0 | 15 | 0 | 41 |
| **G20PF0GF0.8SF0** | 240 | 160 | 882 | 918 | 180 | 0 | 20 | 0 | 43 |
| **G20PF0GF1SF0** | 240 | 160 | 882 | 918 | 180 | 0 | 25 | 0 | 39 |
| **G20PF0.2GF0SF0** | 216 | 144 | 910 | 948 | 162 | 5 | 0 | 0 | 29 |
| **G20PF0.4GF0SF0** | 216 | 144 | 910 | 948 | 162 | 10 | 0 | 0 | 30 |
| **G20PF0.6GF0SF0** | 216 | 144 | 910 | 948 | 162 | 15 | 0 | 0 | 30.5 |
| **G20PF0.8GF0SF0** | 216 | 144 | 910 | 948 | 162 | 20 | 0 | 0 | 27 |
| **G30PF0.2GF0SF0** | 240 | 160 | 882 | 918 | 180 | 5 | 0 | 0 | 39 |
| **G30PF0.4GF0SF0** | 240 | 160 | 882 | 918 | 180 | 10 | 0 | 0 | 41 |
| **G30PF0.6GF0SF0** | 240 | 160 | 882 | 918 | 180 | 15 | 0 | 0 | 41 |
| **G30PF0.8GF0SF0** | 240 | 160 | 882 | 918 | 180 | 20 | 0 | 0 | 38 |

### 3.3 Split Tensile Strength of GPC

The analysis revealed a gradual increase in split tensile strength in accordance with the GPC grade. The corresponding split tensile results are visually presented in (Figure 4). Notably, the incorporation of fibers led to an increase in split tensile strength. Among the various fiber types, the most substantial enhancement was observed in the case of steel fiber reinforcement, resulting in an impressive strength improvement ranging from 50% to 73%. The presence of fibers results in greater tensile strength in GPC, primarily due to the bridging effect they exert on fractures.

### 3.4 Flexural strength of GPC

An incremental rise in flexural strength was noted in correlation with the GPC grade. The most substantial augmentation in flexural strength was observed in the context of steel fiber reinforcement, leading to a remarkable improvement of approximately 40% to 50%. These notable enhancements in flexural strength are visually depicted in (Figure 4). The inclusion of fibers has been observed to result in greater flexural strength when compared to plain Geopolymer concrete. These fibers contribute to the bridging of cracks, effective load distribution, and the prevention of crack propagation. Consequently, this leads to an enhancement in the concrete's capacity to bear loads. The flexural behavior of Geopolymer concrete is affected by the variety of fibers used (such as steel, polypropylene, glass, and fibers) and their respective dose.

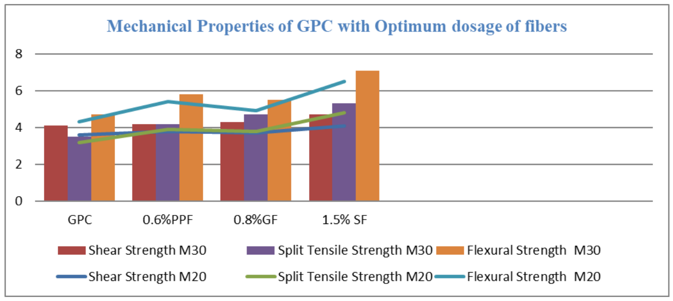


**Fig 4.** Mechanical behavior of GPC with and without using fibers

The strong adhesion and stiffness of mortar and SF (Steel Fibers) within Ultra-High Performance Concrete (UHPC) give rise to numerous micro-fractures at the contact zone during fiber pull-out. In contrast, PF (Polypropylene Fibers) are comparatively more susceptible to breakage. In a specific scenario, PF has been extracted from the mortar without inducing harm to the contact interface[(19)]. The inclusion of fibers increases both the flexural strength and ductility of UHPGPC (Ultra-High-Performance Geopolymer Concrete). However, the degree of this enhancement relies on factors like the type, material, dimensions, and amount of fibers employed, among other considerations. The integration of PF improves the structure of the GP cement paste matrix. This reinforcement reduces the formation of micro cracks and modifies the trajectory of crack propagation[(20)]. Steel fibers (SFs) possess a more resilient surface compared to aggregates. This characteristic not only reduces the presence of pores but also enhances the cohesion between the steel fibers and mortar within the transitional contact region[(17)].

**Fig 5.** Pictures of the experimental setup

## 4 Conclusion

- The Mechanical characteristics of GPC are affected by many factors, such as the Water glass to binder ratio, Aggregate to Binder ratio, Amount of binder content, and Flyash to GGBS ratio. These proportions were systematically varied to formulate Geopolymer concrete of G20 and G30 grades.
- The strength of GPC is relatively less affected by the proportions of polypropylene and glass fibers when compared to the impact of steel fibers. The optimal fiber dosage for G20 and G30 was established through an assessment of compressive strength, achieved by altering the fiber percentage within Geopolymer concrete. The ideal dosages were identified as follows: 1.5% for Steel fiber, 0.8% for Glass Fiber, and 0.6% for polypropylene fibers.
- The incorporation of steel fibers (SF) in GPC resulted in a more significant increase in shear strength, flexural strength, and split tensile strength, compared to the effects of adding glass and polypropylene fibers. It was recommended to improve the flexural and split tensile strength by 50%, need to add 1.5% of steel fibers in GPC.
- The shear strength, flexural strength, and split tensile strength exhibited a progressive augmentation in accordance with the GPC grade. The introduction of steel fibers led to a notable enhancement, with shear strength increasing by 15%, flexural strength by 50%, and split tensile strength by 52%, respectively. Notably, the impact of fibers on shear strength was comparatively moderate when contrasted with their influence on flexural and split tensile strength.

- It was observed that for the polypropylene fibers beyond 0.4%, Glass fibers increased beyond 0.6% steel fibers beyond 1% workability was affected more, and fibers separated from the concrete matrix while being mixing raw materials.

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