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A Comparative Analysis of the Performance and Characteristics of Single-Part and Two-Part Geopolymer Concrete

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Abstract: Cement continues to be the predominant binding material in civil engineering applications; however, its production is associated with significant environmental concerns, particularly its high carbon footprint. The cement industry alone is responsible for nearly 8% of global CO_2 emissions. To address this challenge, the present study explores the complete replacement of cement with ground granulated blast furnace slag (GGBS) activated using high-alkaline solutions such as alkali hydroxides and alkali silicates. In this investigation, GGBS was combined with Fosroc Conplast SP430 DIS as a chemical admixture. The study examines the performance of geopolymer concrete prepared in both one-part and two-part systems, highlighting their respective advantages and limitations. The experimental program was designed for M40-grade concrete, with specimens cured under ambient conditions for 7, 28, 56, and 84 days. Mechanical properties were evaluated through compressive and flexural strength tests to assess the overall behavior of the developed mixes.

Keywords: GGBS, alkali activators, geopolymer, compression, flexural strength

1. Introduction

Sustainability has become a central consideration in modern development, as it ensures that present demands are met without compromising the ability of future generations to satisfy their own needs [1]. However, several industrial practices continue to threaten environmental sustainability, among which cement production is regarded as one of the most critical contributors. Cement concrete remains the most widely used construction material owing to its excellent binding properties, ability to enhance strength, and versatility across structural applications. At the same time, the cement industry accounts for a substantial proportion of global CO_2 emissions, making it a leading cause of environmental degradation. The rising demand for concrete has accelerated CO_2 release, aggravating the issues of global warming and posing health risks to humans, animals, and ecosystems alike [2]. In fact, nearly 65% of global warming is attributed to greenhouse gases, with CO_2 being the most dominant agent, intensifying the greenhouse effect and contributing significantly to climate change.

To address this pressing challenge, researchers have turned to sustainable alternatives, including the utilization of industrial by-products such as Ground Granulated Blast Furnace Slag (GGBS) and silica fume as partial or complete substitutes for cement. The disposal of these waste materials presents a severe environmental hazard; however, their integration into concrete not only reduces the burden of waste management but also provides a sustainable pathway to minimize cement usage and its associated CO_2 emissions[3]. While cement offers advantages in terms of strength, fire resistance, and durability, complete elimination is a difficult task. Nevertheless, the chemical composition and binding potential of many waste-based materials are comparable to that of cement, making them viable substitutes capable of maintaining structural performance while enhancing environmental sustainability. This strategy leads to the production of “green concrete,” more commonly referred to as geopolymer concrete, which is a promising eco-friendly alternative to conventional cement-based concrete. The present study focuses on evaluating the durability and strength characteristics of such sustainable geopolymer concrete. A noteworthy innovation in this field is the introduction of one-part geopolymer binders, also known as “geopolymer cement,” which function similarly to Portland cement in their application. Unlike traditional two-part geopolymers that require liquid alkaline solutions, one-part geopolymers are prepared using solid alkali activators and solid aluminosilicates that are pre-blended and later activated simply by adding water [4]. This simplified processing eliminates the need for handling corrosive alkaline solutions, thereby offering a more practical and user-friendly approach for large-scale construction.

Although earlier studies highlighted shortcomings in one-part geopolymer systems, particularly their lower compressive and mechanical strength compared to two-part counterparts, subsequent advancements have addressed many of these limitations. Through continuous research and optimization, compressive strengths as high as 57 MPa have been achieved under ambient curing conditions, thereby demonstrating the potential of one-part geopolymers to compete with two-part systems. Furthermore, ongoing studies emphasize the importance of selecting appropriate activators, optimizing binder proportions, and tailoring mix designs to achieve desirable mechanical and durability properties. These developments mark a significant step toward promoting one-part geopolymer systems as practical, sustainable, and high-performance alternatives to traditional cement-based concretes.

2. Materials used in One-part and Two-part geopolymer concrete

In the present investigation, both one-part and two-part geopolymer concretes are produced using alkali activators in combination with aluminosilicate-rich solid wastes as the primary source materials [5],[6]. The key constituents of geopolymer concrete, along with representative examples, are illustrated in Fig. 1 [7], [8]. Furthermore, aluminosilicate-based source materials can generally be classified into three major categories: municipal wastes, industrial by-products, and agricultural residues**,** each contributing to sustainable binder development through the valorization of otherwise discarded materials

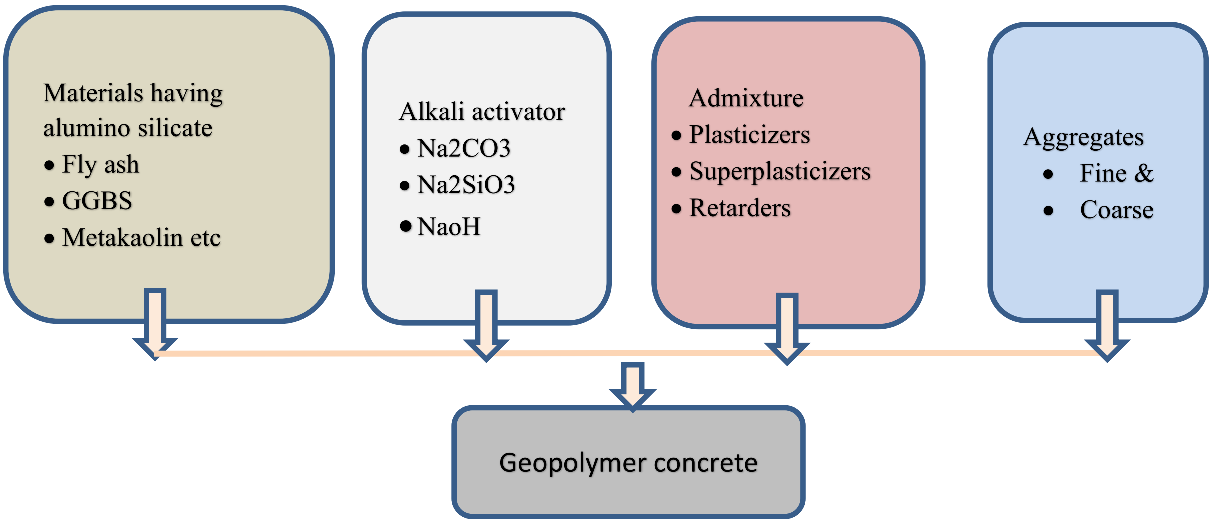

Fig.1. Constituents of Geopolymer concrete [8] [7]

2.1 Aluminosilicate Materials

The primary raw materials used as binders in geopolymer concrete are those rich in silica (SiO_2) and alumina (Al_2O_3), which undergo alkali activation to form the binding gel matrix. Several types of aluminosilicate sources have been investigated for this purpose, including fly ash, ground granulated blast furnace slag (GGBS), metakaolin, and silica fume[9].

- Fly Ash (Class F): Widely available as a by-product of coal-fired power plants, Class F fly ash is one of the most common source materials for geopolymer binders. It offers advantages such as low cost, fine particle size, and pozzolanic activity**,** making it suitable for large-scale applications. However, its variable chemical composition and dependency on the source of coal can sometimes affect consistency in performance.

- Ground Granulated Blast Furnace Slag (GGBS): Produced as a by-product of the iron and steel industry[10][11]. During the smelting process, fluxing agents react with the iron ore—which primarily consists of iron oxides, silica, and alumina—to produce two molten products**:** iron and slag [11],[12]. The treatment of molten slag depends on the desired end product. When the slag is rapidly quenched with high-pressure water jets, it solidifies into a glassy, granular material known as Ground Granulated Blast Furnace Slag (GGBS)**.**GGBS is valued for **its** latent hydraulic properties, which contribute to improved early-age strength and long-term durability of geopolymer concrete. The main limitation lies in its regional availability, as it depends on the presence of steel production facilities. As a by-product of the iron and steel industry, GGBS is generated simultaneously with molten iron in the blast furnace[13]. The raw feed for iron production typically includes powdered iron ore, limestone, and coke, which are subjected to temperatures of approximately 2,700 °F (≈1,480 °C). The residual molten slag is quenched in water to produce a sand-like, glassy substance. Once dried, this material is finely ground into a powder, yielding GGBS suitable for use as a sustainable supplementary cementitious material in concrete.

- Metakaolin: Obtained by calcining high-purity kaolinite clay, metakaolin is a highly reactive aluminosilicate material. It enhances the rate of geopolymerization, mechanical strength, and durability of concrete. Nevertheless, its high production cost and limited large-scale availability restrict its widespread use compared to industrial by-products such as fly ash and GGBS.
- Silica Fume: Silica fume, also known as micro-silica [13], [14], is an amorphous polymorph of silicon dioxide (SiO_2) that is non-crystalline in nature. It is produced as an ultrafine powder consisting of nearly spherical particles, with an average particle size of approximately 150 nm, and is collected as a by-product during the manufacture of silicon and ferrosilicon alloys [15],[16],[17]. Its primary application is as a pozzolanic material in high-performance concretes, where it significantly improves compressive strength, durability, and resistance to chemical attack. Due to its extremely fine particle size, silica fume enhances particle packing, reduces porosity, and contributes to the formation of additional calcium silicate hydrate (C–S–H) gel within the concrete matrix. Silica fume is often mistakenly equated with fumed silica; however, the two differ substantially. While silica fume is an industrial by-product obtained from silicon alloy production, fumed silica is manufactured synthetically via flame hydrolysis of silicon tetrachloride. Consequently, their production processes, particle morphology, and fields of application vary considerably, with fumed silica being more commonly used in industries such as coatings, adhesives, and polymers rather than in concrete technology.

Among these materials, Class F fly ash and GGBS are the most widely adopted due to their abundant availability, favorable reactivity, and ability to enhance both workability and strength, making them practical and sustainable options for geopolymer concrete production.

2.2 Alkaline activators

Alkaline activators play a crucial role in the synthesis of geopolymer binders by initiating the dissolution of silica, alumina, and, in some cases, calcium from precursor materials. Commonly used activators include sodium hydroxide, sodium silicate, and sodium carbonate [18]. These activators are typically classified into two forms: liquid and solid.

In conventional two-part geopolymer systems, liquid activators are most frequently employed, whereas solid activators are more common in one-part geopolymer systems. The use of solid activators offers practical advantages such as reduced cost, lower environmental footprint, and easier handling and transportation[19]. Despite differences in their physical state, the fundamental chemical mechanism remains the same in both cases, involving the dissolution of Si, Al, and Ca species from aluminosilicate precursors, followed by polycondensation to form the geopolymeric network [20].

2.3 Coarse aggregates and fine aggregates

Aggregates constitute nearly 70% of the total volume of concrete, making them a fundamental component that significantly influences both the mechanical behavior and durability performance of the composite. In typical concrete mixes, the mass distribution is about 65% coarse aggregate **and** 35% fine aggregate, providing the required strength and workability balance.

To ensure quality and suitability, aggregates must undergo standard laboratory tests such as sieve analysis (to determine gradation), impact and crushing tests (to evaluate strength and toughness), and specific gravity and water absorption tests (to assess density and porosity) [21],[22].

In addition to these tests, aggregate properties such as shape, surface texture, and moisture content play a crucial role in fresh and hardened concrete performance. Well-graded aggregates with angular shapes and rough textures enhance the bond between binder paste and aggregates, thereby improving strength. Conversely, rounded aggregates may increase workability but could reduce interfacial bond strength. Similarly, moisture condition directly influences the water-to-binder ratio**,** which is critical for both ordinary Portland cement (OPC) and geopolymer concretes.

Thus, careful selection and testing of aggregates are essential steps in ensuring that concrete achieves the desired performance in terms of strength, durability, and long-term serviceability.

2.4. Admixtures

Admixtures are supplementary materials incorporated into concrete to modify its rheological and performance characteristics in the fresh state [23]. They are widely used to enhance workability, control setting behavior, and improve overall mix performance without altering the fundamental composition of the binder.

Among the most commonly used admixtures are superplasticizers**,** which are high-range water-reducing agents that significantly improve the slump value and workability of concrete while maintaining the desired strength by lowering the water-to-binder ratio. Similarly, retarders are employed to delay the setting time of concrete**,** providing additional workability time, which is particularly beneficial in hot climates **or for** large-scale placements where extended handling and finishing are required [7], [8].

3. Methodology

In this comparative investigation, two variants of geopolymer concrete were developed: one-part geopolymer concrete and two-part geopolymer concrete. Geopolymer concrete eliminates portland cement entirely, instead using aluminosilicate-rich source materials such as fly ash, silica fume, and ground granulated blast furnace slag (ggbs). These materials act as binders and are activated using alkaline solutions, specifically sodium hydroxide and sodium silicate, to trigger the geopolymerization reaction.

The mix design methodology was employed to determine the required quantities of binders, activators, and aggregates for casting test specimens. Two different binder proportions were adopted for both one-part and two-part GPC mixes. For each mix variation, three identical specimens were prepared, and the average value of their test results was taken as the representative strength.

Test Specimens are as listed below

- Cubes (150 × 150 × 150 mm): for compressive strength tests.
- Cylinders (100 × 300 mm): for split tensile strength tests.
- Beams (100 × 100 × 500 mm): for flexural strength tests.

The Curing Method is mentioned below

All specimens were cured under ambient room temperature conditions, eliminating the need for water curing. This property represents a key advantage of geopolymer concretes over OPC concrete, particularly from a sustainability and water conservation perspective.

The Testing Schedule is as follows

- Compressive strength**:** 7, 28, 56, and 84 days.
- Split tensile strength and flexural strength**:** 28 and 84 days[24].

3.1 Mix design

The quantities of raw materials required for the preparation of geopolymer concrete were determined based on modified mix design guidelines for geopolymer concrete**,** developed with reference to the Indian Standard specifications [25]. These guidelines were adapted to account for the absence of Portland cement and the incorporation of aluminosilicate binders activated by alkaline solutions.

The calculated proportions included the required amounts of binders (fly ash, GGBS, silica fume), alkaline activators (sodium hydroxide and sodium silicate), aggregates (coarse and fine), and admixtures where necessary. The detailed quantities of each constituent material used in the mix design are presented below

Table 1. Quantities of the materials for One-part GPC in kg/m3

Mix	GGBS	Sodium Hydroxide	Fine Aggregate	Coarse Aggregate
Mix 1	955.8	106.2	1385.91	917.57
Mix 2	902.7	159.3	1308.92	866.6
Mix 3	849.6	212.4	1231.92	815.62

Table 2. Quantities of the materials for Two-part GPC in kg/m^3

Mix	GGBS	Sodium Hydroxide Solution	Extra Water	Fine Aggregate	Coarse Aggregate
Mix 1	955.8	116.82	19.11	1385.91	917.57
Mix 2	902.7	175.23	18.05	1308.92	866.6
Mix 3	849.6	233.64	16.99	1231.92	815.62

3.2 Methods involved in preparation of One Part and Two Part Geopolymer Concrete

In the present study, two kinds of geopolymer concrete are developed. They are:

a. One-part Geopolymer concrete

b. Two-part Geopolymer concrete

a. One-part Geopolymer concrete

In the case of one-part geopolymer concrete (OPGPC), ordinary Portland cement is completely eliminated and replaced by ground granulated blast furnace slag (GGBS) as the primary binder. To initiate the geopolymerization process, sodium hydroxide in powder form is incorporated as the solid activator. This approach simplifies the mixing process by eliminating the need for liquid activator solutions, making the system more practical and user-friendly.

The experimental program considered different binder proportions of GGBS and sodium hydroxide, which are detailed below. These variations were adopted to evaluate their influence on the mechanical properties and overall performance of the one-part geopolymer concrete.

Table. 3 Mix proportions details for One-part GPC

Mix	GGBS	Sodium Hydroxide
Mix 1	90%	10%
Mix 2	85%	15%
Mix 3	80%	20%

b. Two-part Geopolymer concrete

In two-part geopolymer concrete (TPGPC), cement is entirely replaced with ground granulated blast furnace slag (GGBS), which functions as the binder. An alkaline activator solution, prepared using sodium hydroxide, is incorporated to initiate the geopolymerization process. The chemical reaction between the binder and the activator leads to the formation of a stable and durable matrix.

The experimental program was designed with different binder proportions of GGBS and sodium hydroxide, which are presented in the following section. These variations were selected to examine their influence on the mechanical behavior and performance characteristics of the two-part geopolymer concrete.

Table 4 Mix proportions details for Two-part GPC

Mix	GGBS	Sodium Hydroxide
Mix 1	90%	10%
Mix 2	85%	15%
Mix 3	80%	20%

4. Results and Discussions

Different proportions of binders and activators were adopted in both one-part and two-part geopolymer concrete mixes to evaluate their influence on fresh and hardened properties. A series of tests were performed to assess workability in the fresh state as well as mechanical performance in the hardened state.

Standard specimens, including cubes, cylinders, and beams of Indian Standard dimensions, were prepared for testing. The fresh concrete tests focused primarily on workability, while the hardened concrete tests were carried out to determine compressive strength, split tensile strength, and flexural strength.

The results obtained from these experimental investigations are summarized and discussed in the following sections.

4.1 Properties of Fresh Concrete

In this study, the workability of geopolymer concrete mixes was evaluated by conducting the slump cone test and the compaction factor test. These tests were performed for both one-part and two-part geopolymer concrete mixes with varying binder–activator proportions, in order to assess the influence of mix variations on fresh concrete properties.

The results obtained from these tests are summarized below.

4.1.1 Slump test

The slump test is the most widely used method for determining the consistency of fresh concrete, and it can be performed both in laboratory settings and on construction sites. In the present study, the slump test was carried out for both one-part and two-part geopolymer concretes (GPC) to evaluate their workability characteristics.

It should be noted that the slump test may be unsuitable for concretes that are very dry or highly fluid, as it does not capture all parameters influencing workability. Depending on the behavior of the concrete during the test, different types of slumps can be observed:

- **True slump**: a uniform subsidence of the concrete.
- **Shear slump**: occurs when one side of the cone shears off and subsides.

In cases where a shear slump was observed, the actual slump value was determined by measuring the difference between the height of the mould and the average subsidence height of the displaced concrete.

The measured slump values for one-part geopolymer concrete are summarized in **Table 5**.

Table. 5 Slump details for One-part GPC and Two-part GPC

Mix	Slump in One-part GPC (mm)	Slump in Two-part GPC (mm)
Mix 1	21	23
Mix 2	23	25
Mix 3	29	32

4.1.2 Compaction Factor Test

The compaction factor test is a commonly employed method to evaluate the workability of concrete**,** and while it is primarily conducted in laboratories, it can also be performed on-site. This test is particularly useful for concretes that require vibration during placement and is considered more accurate and reliable than the slump test when dealing with low-workability mixes**.**

In this study, the compaction factor test was conducted for both one-part and two-part geopolymer concretes (GPC) prepared with varying binder–activator proportions. The comparative results obtained are summarized in **Table 6**.

Table. 6 Slump details for One-part GPC and Two-part GPC

Mix	Compaction factor for One-part GPC	Compaction factor for Two-part GPC
Mix 1	0.82	0.80
Mix 2	0.85	0.82
Mix 3	0.90	0.88

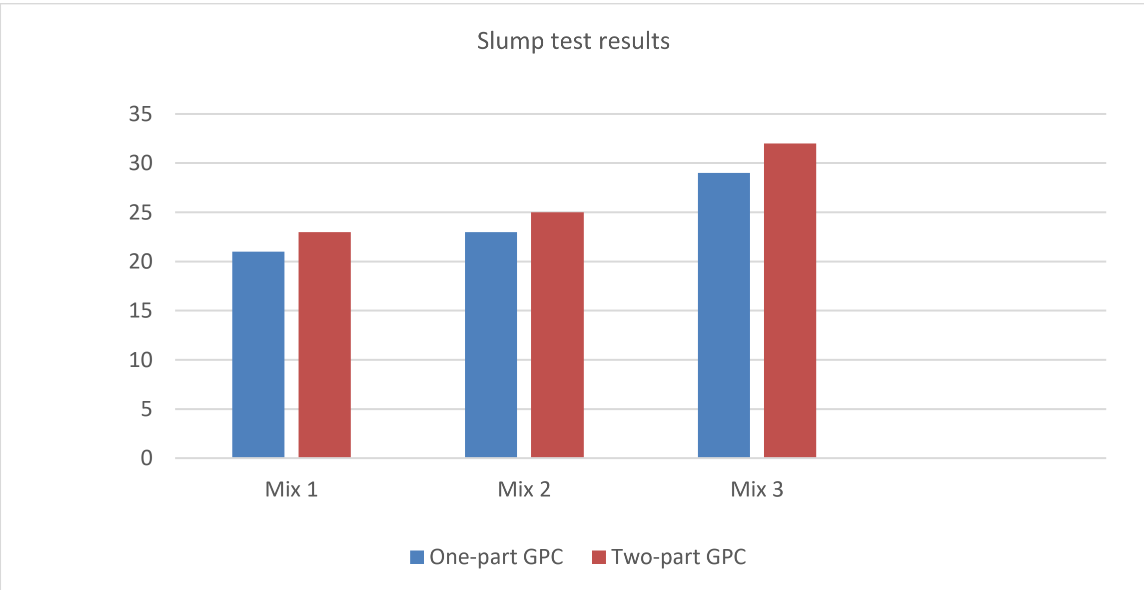

Fig. 2. The comparison among different slump values found from one part and two-part GPC.

As illustrated in **Figure 2**, Mix 2 exhibited the highest slump values for both types of geopolymer concrete. Specifically, the one-part GPC achieved a slump of 29 mm, while the two-part GPC reached a maximum slump of 32 mm for the same mix.

Comparing the two types of GPC, it is evident that the two-part geopolymer concrete demonstrates superior workability based on the observed slump values. This increased workability can be attributed to the use of the liquid alkaline activator in the two-part system, which enhances particle lubrication and flowability within the mix.

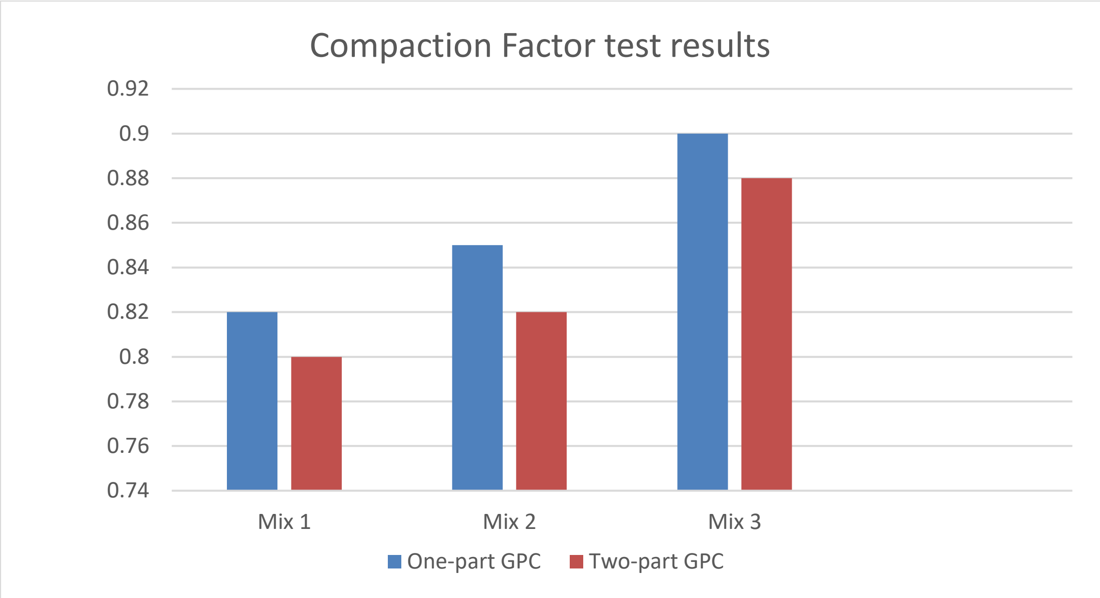

Fig. 3. The comparison among compaction factor values noticed from one-part and two-part GPC.

Figure 3 presents the compaction factor values obtained for the various mix proportions of both one-part and two-part geopolymer concretes (GPC). The results indicate that Mix 2 exhibits the highest workability in both types of GPC. Specifically, the one-part GPC achieved a compaction factor of 0.90, while the two-part GPC reached a maximum value of 0.88 for the same mix.

Based on these results, it can be inferred that the one-part geopolymer concrete demonstrates slightly higher workability than the two-part system when assessed using the compaction factor test. This behavior may be attributed to the solid activator and binder proportions**,** which influence the ease of compaction in the one-part mixes.

4.2 Properties of Hardened Concrete

To evaluate the mechanical performance of both one-part and two-part geopolymer concretes (GPC), the study employed compressive strength, split tensile strength, and flexural strength tests**.** All test specimens were cured at ambient temperature for a period of 84 days, reflecting the typical curing conditions for geopolymer concrete.

The mechanical tests were conducted at 7, 28, 56, and 84 days to monitor the strength development over time. This curing and testing procedure aligns with methodologies adopted in previous studies[26], [27].

The results obtained from these investigations are summarized and analyzed in the sections below.

4.2.1 Compression Strength Test

The compressive strength test is one of the most important evaluations for concrete, as it provides a comprehensive indication of the material's load-bearing capacity and overall quality. In this comparative study, the compressive strength results serve to validate the performance of both one-part and two-part geopolymer concretes (GPC).

The compressive strength of the test specimens was measured after 7, 28, 56, and 84 days of ambient curing. The results obtained from these tests are summarized below.

Table 7. Compression test results for One-part GPC

Mix	Compression test for ambient-cured samples for			
	7 days (N/mm²)	**28 days (N/mm²)**	**56 days (N/mm²)**	**84 days (N/mm²)**
Mix 1	28.6	40.32	41.27	42.01
Mix 2	32.8	46.72	47.82	48.33
Mix 3	27.45	43.93	44.59	45.02

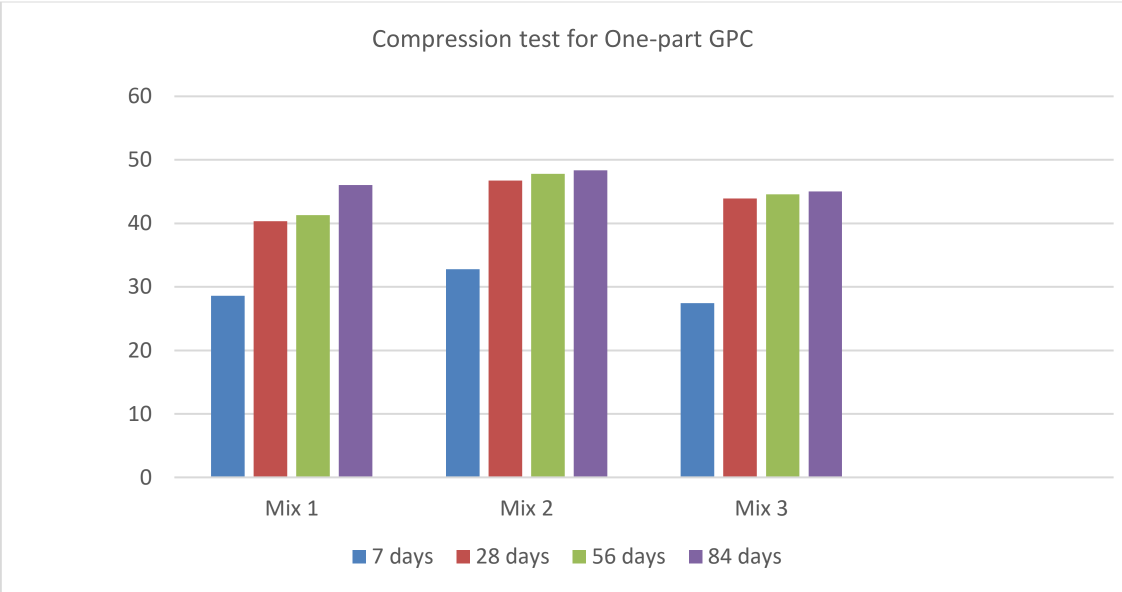

Fig.4 Compression strength of One-part GPC after 7,28,56 and 84 days of ambient curing.

As shown in **Figure 4**, the compressive strength of the one-part geopolymer concrete (GPC) was evaluated after 7, 28, 56, and 84 days of ambient curing. Among the tested mixes, Mix 2 exhibited the highest compressive strength, with values of 32.8 N/mm² at 7 days, 46.72 N/mm² at 28 days, 47.82 N/mm² at 56 days, and 48.33 N/mm² at 84 days**.**

These results indicate that the majority of strength development occurs within the first 28 days, with a slower rate of gain observed thereafter. The superior performance of Mix 2 can be attributed to the optimized proportion of GGBS and solid activator, which facilitates effective geopolymerization and matrix densification.

Table. 8. Compression strength for Two-part GPC

Mix	Compression test for ambient cured samples for			
	7 days (N/mm²)	**28 days (N/mm²)**	**56 days (N/mm²)**	**84 days (N/mm²)**
Mix 1	30.42	47.52	49.07	49.51
Mix 2	36.18	49.39	50.56	51.23

Mix 3	28.55	45.73	45.79	46.02

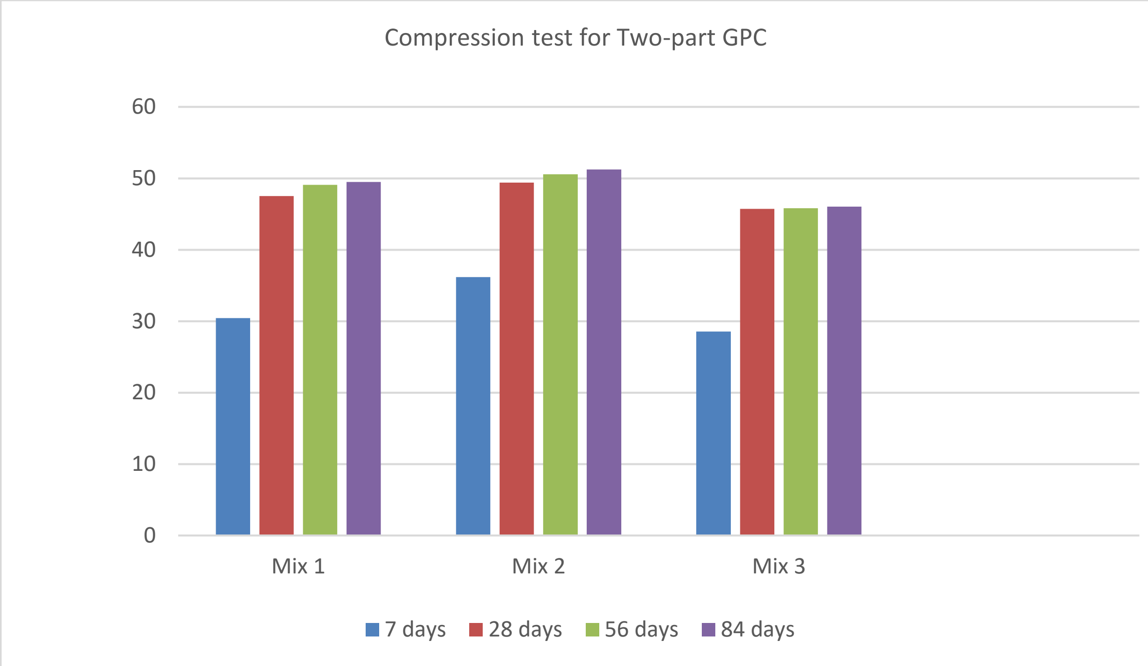

Fig.5. The Compression strength of Two-part GPC after 7, 28, 56 and 84 days of ambient curing.

Figure 5 illustrates the compressive strength development of two-part geopolymer concrete (GPC) specimens cured at ambient conditions for 7, 28, 56, and 84 days**.** Among the tested mixes, Mix 2 demonstrated the highest compressive strength, with values of 36.18 N/mm² at 7 days, 49.39 N/mm² at 28 days, 50.56 N/mm² at 56 days, and 51.23 N/mm² at 84 days**.**

When compared with the one-part GPC, the two-part GPC consistently exhibits higher compressive strength across all curing ages. This enhanced performance can be attributed to the use of liquid alkaline activator, which promotes more uniform geopolymerization and improved bonding within the matrix.

4.2.2 Split-tensile strength

Both one-part and two-part geopolymer concretes (GPC) were evaluated for split tensile strength using cylindrical specimens with a diameter of 150 mm and a length of 300 mm. The test was conducted in accordance with standard procedures for indirect tensile testing of concrete.

The split tensile strength (T) of the specimens was calculated using the following equation:

$T=(2P)/(\pi LD)$

where:

- P = applied load at failure (N)
- L = length of the cylinder (mm)
- D = diameter of the cylinder (mm)

This test provides insight into the tensile behavior of the geopolymer concrete, which is critical for evaluating its cracking resistance and durability.

Table 9, Split-Tensile test for One-part GPC

Mix	Split-tensile strength test for One-part GFC			
	7 days (N/mm2)	**28 days (N/mm2)**	**56 days (N/mm2)**	**84 days (N/mm2)**
Mix 1	0.9	1.82	1.90	1.90
Mix 2	1.2	2.30	2.34	2.35
Mix 3	0.8	1.62	1.62	1.60

Table 10, Split-Tensile test for Two-part GPC

Mix	Split-tensile strength test for Two-part GFC			
	7 days (N/mm2)	**28 days (N/mm2)**	**56 days (N/mm2)**	**84 days (N/mm2)**
Mix 1	0.95	1.70	1.80	1.80
Mix 2	1.60	2.45	2.50	2.50
Mix 3	0.90	2.20	2.15	2.20

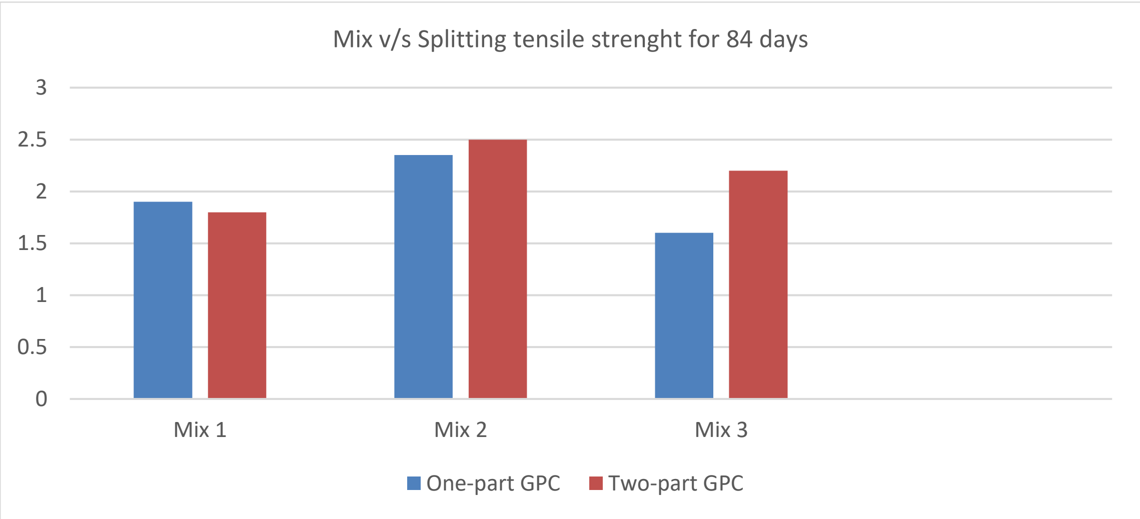

Fig.6 Comparison between One-part and Two-part GPC for split tensile test

The comparative analysis of split tensile strength indicates that the two-part geopolymer concrete (GPC) exhibits consistently higher values than the one-part GPC after 84 days of ambient curing. Among the different mixes tested, Mix 2 provided the most satisfactory performance for both types of GPC, demonstrating its effectiveness in achieving optimal mechanical properties.

This observation highlights the influence of the liquid alkaline activator in the two-part system, which enhances binder activation and improves the tensile resistance of the geopolymer matrix.

4.2.3 Flexural Strength Test

Flexural strength represents the tensile capacity of concrete when subjected to bending, and it is a critical parameter for evaluating the load-carrying ability of beams and slabs. In this study, flexural strength was determined for both one-part and two-part geopolymer concretes (GPC) using standard prismatic specimens.

The flexural strength is commonly expressed as the Modulus of Rupture (MR), which provides a quantitative measure of the material's resistance to bending failure under applied loads. This property is particularly important for structural elements subjected to flexural stresses in practical applications.

Table.11 Testing for Flexural strength for One-part GPC**.**

Mix	**Flexural strength test for One-part GFC**			
	7 days (N/mm²)	**28 days (N/mm²)**	**56 days (N/mm²)**	**84 days (N/mm²)**
Mix 1	2.12	3.78	3.78	3.80
Mix 2	2.35	3.91	3.93	3.93
Mix 3	2.04	3.72	3.73	3.73

Table.12 Testing for Flexural strength for Two-part GPC.

Mix	**Flexural strength test for Two-part GFC**			
	7 days (N/mm²)	**28 days (N/mm²)**	**56 days (N/mm²)**	**84 days (N/mm²)**
Mix 1	2.19	3.86	3.85	3.86
Mix 2	2.42	3.98	3.99	3.99
Mix 3	2.17	3.72	3.76	3.78

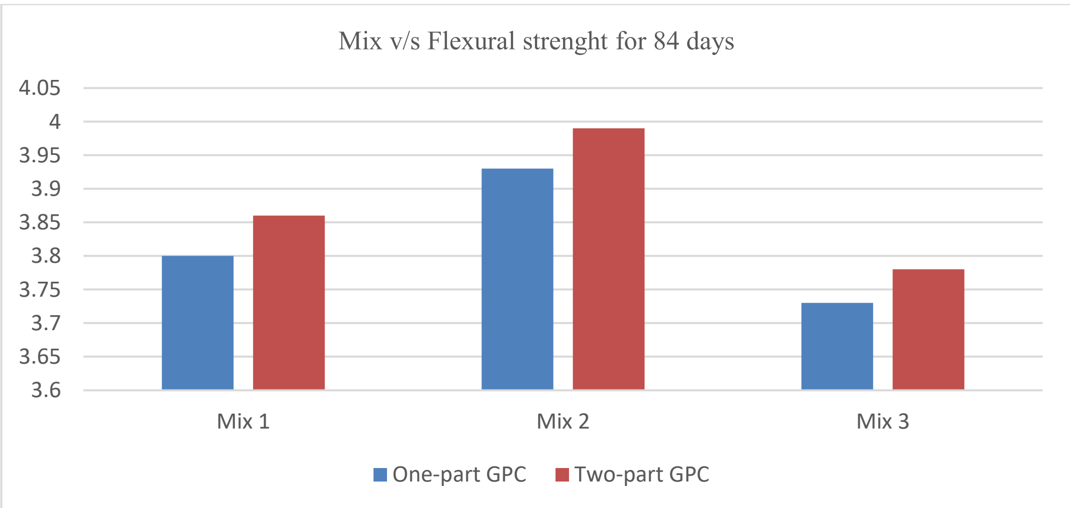

Fig.7. Comparison between One-part and Two-part GPC for the Flexural strength attained at 84 days of ambient curing.

The results of the flexural strength tests indicate that the two-part geopolymer concrete (GPC) demonstrates superior performance compared to the one-part GPC. Specifically, the maximum flexural strength measured after 84 days of ambient curing was 3.99 N/mm² for the two-part GPC.

Among the various mixes tested, Mix 2 consistently exhibited the best performance in both types of GPC, highlighting the effectiveness of the optimized binder–activator proportions in enhancing the bending resistance of the geopolymer concrete.

5 . Conclusion

In this study, the performance of both one-part and two-part geopolymer concretes (GPC) was systematically investigated. The one-part GPC consisted of GGBS, solid sodium hydroxide (activator), fine aggregates, coarse aggregates, and water, whereas the two-part GPC was composed of GGBS, sodium hydroxide solution (alkaline activator), water, fine aggregates, and coarse aggregates**.**

To evaluate both fresh and hardened properties, standard specimens—including cubes, cylinders, and beams—were cast and tested. The fresh concrete properties were assessed using the slump test and the compaction factor test, while the hardened properties were evaluated through compressive strength, split tensile strength, and flexural strength tests.

The experimental results indicate that the two-part GPC consistently outperforms the one-part GPC**,** demonstrating superior compressive strength along with satisfactory slump and compaction factor values. Three different mix proportions were considered for both types of GPC. Among the one-part GPC mixes, Mix 2 exhibited the best overall performance, while Mix 2 of the two-part GPC similarly provided the most satisfactory results across all tests.

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