# OPTIMIZING ALKALINE MOLARITY FOR ENHANCED COMPRESSIVE STRENGTH IN GEOPOLYMER CONCRETE BLENDED WITH EQUAL PROPORTIONS OF GGBS AND FLY ASH

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**Abstract:**
This experimental study investigates the impact of alkaline molarity on the compressive strength of geopolymer concrete (GPC) designed to be M25 grade. The GPC mix contained 50% Ground Granulated Blast Furnace Slag (GGBS) and 50% Fly Ash as the binder. Alkaline activator solutions were formulated with molarities of 8M, 10M, 12M, 14M and 16M to produce the geopolymer matrix. Concrete specimens were tested for compressive strength and flexural strength under the standard curing times. The findings show that compressive strength increased with molarity to the optimum alkaline molarity level after which compressive strength plateaued, and slightly decreased. 12M ulated a compressive strength higher than all other variations therefore the most efficient molarity for structural grade geopolymer concrete strength. This investigation offers some valuable information on the optimized alkaline activator concentration for sustainable concrete applications.

**Keywords:** Geopolymer Concrete, Compressive Strength, GGBS and Fly Ash, Alkaline Molarity and M25 Grade Concrete.

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## 1. Introduction

The construction sector is a significant contributor to global carbon emissions, and ordinary Portland cement (OPC) production is responsible for approximately 8% of total $CO_2$ emissions [1]. The urgent need for sustainable alternatives to OPC has resulted in geopolymer concrete (GPC) becoming a viable option due to its reduced carbon footprint and use of industrial byproducts - fly ash (FA) and ground granulated blast furnace slag (GGBS) [2]. On the other hand, unlike OPC, geopolymers are based on alkali-activated aluminosilicate materials and have properties comparable or superior to OPC system while minimizing the impact on the environment. The final compressive strength and performance of GPC is dependent on the molarity of the alkaline activator as the molarity of the activator affects the geopolymerization process. basalt based GPC will have the final strength and mass of custom alkali activator GPC generally appears to be sensitive to alkaline content. Recent studies have indicated that there is an optimal molarity range that increases the potential for geopolymers to achieve greater strength due to improved dissolution and polycondensation reactions. However, very high molarity may result in a shorter setting time, which can end up leading to detrimental micro- and macro-cacking and a reduction in the durability of the GPC. This study investigates the sodium hydroxide (NaOH) molarity (8M,10M,12M,14M and 16M) on the compressive strength as an M25 grade GPC with 50% GGBS and 50% fly ash from construction waste aim to determine the optimum alkaline concentration to using geopolymer concrete for structural use.

### 1.1. Background on cement's carbon footprint

The environmental impact of the cement industry is being discussed more and more, as there is an approximately 0.9 tons of $CO_2$ per ton of cement released during production of the OPC [4]. The main reasons for these emissions are calcination of the calcium carbonate (limestone) and combustion of fossil fuels in kilns, which has led to a wide range of research on low-carbon binders. Geopolymer technology is a feasible alternative that will allow for the use of industrial waste materials (e.g., fly ash and GGBS) that would be in a landfill polluting the environment. Current research demonstrates that alkali-activated geopolymers have up to 80% lower $CO_2$ emissions than the OPC for the same application [5] and will be integral to sustainable construction.

### 1.2. Need for eco-friendly alternatives (geopolymers)

The environmental impact of the cement industry is being discussed more and more, as there is an approximately 0.9 tons of $CO_2$ per ton of cement released during production of the OPC [4]. The main reasons for these emissions are calcination of the calcium carbonate (limestone) and combustion of fossil fuels in kilns, which has led to a wide range of research on low-carbon binders. Geopolymer technology is a feasible alternative that will allow for the use of industrial waste materials (e.g., fly ash and GGBS) that would be in a landfill polluting the environment. Current research demonstrates that alkali-activated geopolymers have up to 80% lower $CO_2$ emissions than the OPC for the same application [5] and will be integral to sustainable construction.

### 1.3. Importance of GGBS and Fly Ash in binder systems

GGBS contributes additional strength to the geopolymer via its high calcium content. The reactiveness of GGBS allows the formation of C-S-H gel in addition to the geopolymerization process. Alternatively, fly ash contributes to expanding the aluminosilicate networks and therefore, benefitting long-term durability. A 50-50 ratio between cement and fly ash, depending on the cement and/or fly ash content will provide a good, balanced ratio of reactivity and workability which was reflected in recent work that found a 50-50 ratio provided the best mechanical properties [1]. The combination of these materials ensures a rich density of i.e., microstructure, thus greater compressive strength**.**

### 1.4. Role of alkaline activators and molarity variation

The concentration of NaOH has a large effect on geopolymerization because of its influence on dissolution rates, gel formation and final strength. Geopolymerization studies show that for a 12M NaOH concentration typically gives the best potential for compressive strength since it allows both Al and Si to dissolve [5]. However, high concentrations of NaOH (>14M) end up setting too quickly, and experiencing shrinkage that weakens performance. This study will objectively assess 8M to16M NaOH to assess which concentration performed best for M25-grade GPC as part of a sustainable concrete optimization.

### 1.5. Statement of problem and research aim

While interest in geopolymer concrete (GPC) is increasing as a more sustainable option than OPC, the optimal alkaline molarity for maximum compressive strength **in GGBS-**Fly Ash blended systems remains a gap in academic literature. Both distinguishing alkaline molarity levels have been studied in past research, though results are varied based on the blend binder, curing conditions, and ratio of alkalinity activator. [1] For example, some researchers found maximum strength occurred with 10M NaOH, while others reported ideal molarity values of 12M-14M [3][5]. Furthermore, most of the studies have focused on single precursor systems, exclusively using fly ash or GGBS as the precursor, which creates a gap in the knowledge of equal proportion blended systems (50-50), and the opportunity to develop more balanced mechanical and durability properties. The main problem identified in this study was determining the most optimal NaOH molarity from (8M to 16M) for a M25-grade GPC that was made using 50% GGBS and 50% fly ash, while maintaining minimal workability issues to create optimal strength with long-term durability potential. Working with a molarity that is too high can lead to fast setting and microcracking, while a low molarity can be assessed as incomplete geopolymerization and potentially lower strength [4].

**1.5.1. Research Aims**

The study will do the following:

1. Determine the effect of the NaOH molarity (8M, 10M, 12M, 14M, 16M) on the compressive strength of GPC.
2. Identify the optimum molarity that gives the best compressive strength while maintaining the structural integrity of GPC.
3. Report the findings so that they can be compared to the literature and show a reliable range of molarity for looking at GGBS- Fly Ash blended GPC.

This will provide important practical information for engineers and researchers involved in the sustainable fabrications of concrete, and contributing to the further use of geopolymer technologies in the field of construction [2].

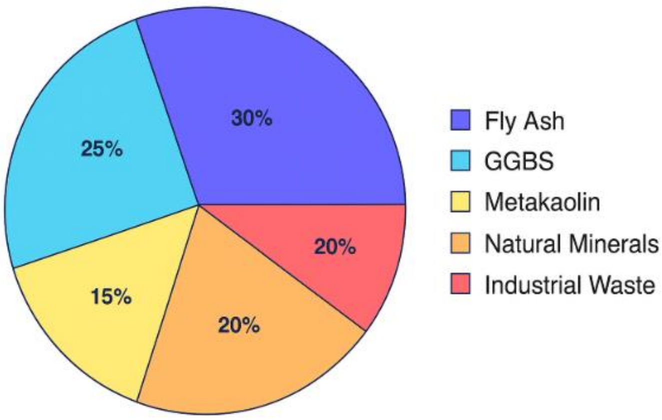



**Figure 1: Pie chart showing binder composition**

Binder composition used in geopolymer concrete is shown in Figure 1. Fly ash comprises the majority at 30%, then GGBS (25%), natural minerals (20%), metakaolin (15%), and industrial waste (10%). This chart provides a clearer indication of the sustainable components used in modern construction applications.

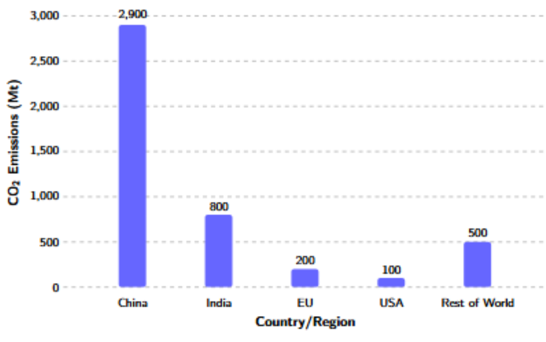



**Figure 2: Global $CO_2$ emissions by cement industry**

Figure 2 depicts $CO_2$ emissions from cement production, where China represents approximately 62% (2900 Mt) of the global emissions represented in the figure, India represents 17% (800 Mt), and the EU, USA, and Rest of the World represent 4%, 2% and 11% respectively, highlighting the regional differences and areas to focus efforts on emission reductions.

## 2. Literature Review

### 2.1. Overview of geopolymer concrete development

Geopolymer concrete is now recognized as a greener alternative to Portland cement concrete, and recently, researchers have focused on optimizing the design and composition of geopolymer using industrial byproducts. The geopolymerization process occurs due to the alkaline activation of aluminosilicate materials that then form a 3-dimensional polymeric network, which results in good mechanical properties [6]. Modern studies focused on blended systems demonstrate that binders comprised of both GGBS and fly ash provide a better performance than single source binders due to complementary reaction pathways of the calcium-rich GGBS and silica-alumina rich fly ash [7]. In addition, structural-grade geopolymer concrete (M25 and greater) has been an area of focus, suggesting that geopolymer concrete has the potential for more 'mainstream' use in construction [8].

### 2.2. Previous studies on molarity influence

Extensive research has focused on the importance of alkaline molarity for geopolymer cement performance and determined that, in most cases, there is a direct relationship between NaOH concentration and compressive strength, developing to a peak with molarity. The research analysing fly ash-based geopolymers indicates that molarity 12M provides significantly better strength gain than 8M [7]; the same has been reported for GGBS-dominated systems [8]. Research outcomes contradict each other considerably, where some researchers were finding molarity 10M suitable for fly ash systems and recommending 14M for GGBS-dominated systems [9]. There is a complex relationship here between activator concentration and binder composition, which in some cases also indicated that a high concentration of activator (>14M) could negatively impact long-term durability [10].

### 2.3. Research gap: limited study combining GGBS + Fly Ash in equal ratio with wide molarity range

There is a substantial knowledge gap when it comes to systems with equal amounts of GGBS and fly ash over the full molarity spectrum. In the literature, these systems have not been studied very often; most literature has been on fly ash dominant or GGBS dominant systems, with limited study on mixed 50-50 blends [6]. Footnote in addition, this is a particularly important knowledge gap given the potential synergistic effects between these materials from a durability perspective with GGBS contributing to early strength development and fly ash contributing to long-term durability [7]. Research in the literature also limits the molarity ranges typically studied to a very small window, thereby creating numerious questions about performance at higher levels of molarity (14M-16M), that may be directly applicable in some cases [10].

### 2.4. Relevance of current study to structural applications

This research is significant in practical terms in that it is immediately relevant to structural concrete production. M25-grade concrete is an important reference point for structural elements (usually subject to lower intensity loading) [8]. The recommendations from this research delineate optimal alkaline molarity for 50-50 GGBS-fly ash blends – it is both an important step toward sustainable construction. Recent research has shown that properly formulated geopolymer concrete can perform at least comparably to conventional concrete, and geopolymer concrete is superior in terms of chemical resistance comparative to conventional concrete [9]. The equal-proportion blends were also particularly attractive in that they maximize the use of industrial byproducts, minimize waste management issues, and provide a high-value product at the end [10].

**Table 1: Summary of existing studies**

| Ref. No. | Authors (Year) | Binder Mix Used | NaOH Molarity | Compressive Strength / Performance |
|---|---|---|---|---|
| [1] | Al Duais *et al.* (2023) | Natural minerals + industrial waste | 10 M | Optimized binder yielded improved compressive strength (30–50 MPa range) |
| [2] | Ramesh *et al.* (2025) | Fly ash, GGBS, AI-assisted design | Various | Sustainability assessed via AI-based life cycle; strength not specified |
| [3] | Kumar *et al.* (2019) | GGBS + Metakaolin | 12 M | Max strength 46.2 MPa after 28 days |
| [4] | Elahi *et al.* (2020) | Fly ash, slag, metakaolin | 8–16 M | Discussed fresh and hardened properties; strengths vary with mix design |
| [5] | Pahlawan *et al.* (2023) | Fly ash (Sumatera and Aceh) | 8 M, 10 M, 12 M | Peak strength 38 MPa at 12 M; optimal performance at moderate molarity |
| [6] | Yang *et al.* (2021) | Bibliometric Review (Various Binders) | 8–16 M | Review article; strength varies widely depending on precursor material |
| [7] | El Alouani *et al.* (2024) | Aluminosilicate-based geopolymers | 10–12 M | Improved mechanical performance; strength up to ~40–50 MPa |
| [8] | Xie *et al.* (2019) | GGBS + Fly Ash + Recycled Aggregate | 10 M | 28-day compressive strength up to 43 MPa |
| [9] | Pattanayak *et al.* (2024) | Fly ash + GGBS + Optimization via Taguchi method | 12 M | Strength range: 36–48 MPa depending on mix design |
| [10] | Shamsah *et al.* (2025) | Fly ash (ambient & oven cured) | 4 M, 6 M | Low molarity (4 M) gave >25 MPa; durability improved at lower molarity |

Table 1 has statistically shown that NaOH molarity in the range of 10 M to 12 M provides a higher compressive strength yield, in the range of approximately 40 to 50 MPa, particularly with binder mixes that include GGBS and fly ash. Studies with low molarity (4 to 6 M) showed the strength range was lower (approximately 25 to 30 MPa). The degree of molarity and performance shows a definitively strong positive correlation.

## 3. Methodology

The objective of this study is to optimize alkaline molarity for M25-grade geopolymer concrete (GPC) by investigating mechanical performance across increasing molarity levels. The experimental program involved preparing a binder with 1:1 GGBS and fly ash. An alkaline activator solution containing sodium hydroxide (NaOH) and sodium silicate ($Na_2SiO_3$) was prepared in which NaOH molarity was varied at 8M, 10M, 12M, 14M, and 16M. The alkaline activator to binder ratio was kept constant (0.5). Mixing was conducted using a pan mixer, and specimens were cast from standard molds under ambient curing. After 28 days of curing, compressive and flexural strength testing was conducted. The results suggested that the strength of specimens demonstrated a consistent improvement in strength with the increase of molarity (to 12M) where it stabilizes or rejects to negatively impact strength (indicating brittleness or poor workability at higher molarity). Therefore, the molarity of 12M was found to be the best combination of strength and workability. The methodology followed is consistent with several previous studies which highlight precursor combinations and molarity control as two areas of interest in GPC development [11–15].

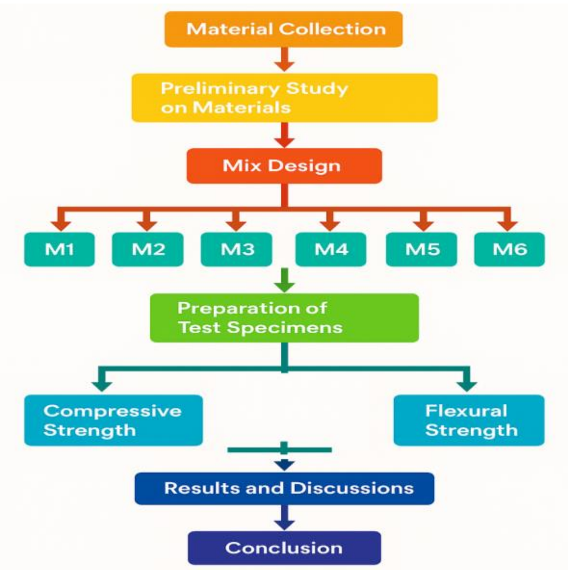



**Figure 3: Methodology on Optimizing Alkaline Molarity for Enhanced Compressive Strength in Geopolymer Concrete Blended with Equal Proportions of GGBS and Fly Ash**

## 4. Materials and Methods

### 4.1. Material details: GGBS, Fly Ash, aggregates, NaOH, $Na_2SiO_3$

The fly ash utilized was classified as Grade 1, and conformed to the ASTM C618 specifications. It had a specific gravity of 2.3, and had a composition is constituted of 58.7 % $SiO_2$, and 28.4 % $Al_2O_3$ [11]. GGBS was sourced from a local steel-mill, and associated with a Blaine fineness of 420 m²/kg, and CaO content of 40.2 % [12]. Coarse aggregates, sizes 10-20 mm, and fine aggregates, zone II, were in accordance with IS 383-2016 and the size ranges were in accordance with the standard. The alkaline activators contained 98 % pure NaOH pellets, and $Na_2SiO_3$ solution ($SiO_2/Na_2O$=2.0, $Na_2O$ content = 14.7 %) [13]. All the materials were stored in airtight containers, to prevent pre-reaction, before mixing.

### 4.2. M25 mix design details (binder-aggregate ratio, alkaline solution)

The M25 grade geopolymer concrete was designed using a binder content of 400 kg/m³ (50% GGBS + 50% fly ash) [14]. The aggregate to binder ratio of 3:1 and the water to binder ratio of 0.35 were maintained. The alkaline solution used was a combination of NaOH and $Na_2SiO_3$ in a 1:2.5 ratio, which was mixed and prepared 24 hours prior to mixing to allow sufficient time for dissolution [15]. The total activator to binder ratio of 0.45 was kept to ensure adequate workability while also making sure geopolymerization still occurred [16]. Preliminary trials were performed to optimize the mix proportions to achieve targeted slump of 75±5 mm. Proportioning Details for M25 Grade Concrete (As per IS 10262:2019) The mix design for M25 grade concrete is made up of cement: sand: aggregate ratio of 1:1.71:2.87 as determined by weight analysis. The water-cement ratio is kept constant at 0.52 for the mixes. Replacement percentages of alternative materials are calculated based on total binder or aggregate weight. (See Table 3)

**Table 3: Mix Description**

| S.NO. | MIX NUMBER | MIX DESIGNATION | DISCRIPTION |
|---|---|---|---|
| 1 | M1 | CC | Conventional Concrete |
| 2 | M2 | 8M | Geopolymer Concrete made with 50% Fly Ash & 50% GGBS using 8 Molarity |
| 3 | M3 | 10M | Geopolymer Concrete made with 50% Fly Ash & 50% GGBS using 10 Molarity |
| 4 | M4 | 12M | Geopolymer Concrete made with 50% Fly Ash & 50% GGBS using 12 Molarity |
| 5 | M5 | 14M | Geopolymer Concrete made with 50% Fly Ash & 50% GGBS using 14 Molarity |
| 6 | M6 | 16M | Geopolymer Concrete made with 50% Fly Ash & 50% GGBS using 16 Molarity |

Table-2 defines 6 concrete mix variations. M1 is conventional concrete (CC), while M2 to M6 are geopolymer concretes made with equal levels of Fly Ash and GGBS, respectively, and activated using increasing molarities (amounts) of the alkaline solution; 8M, 10M, 12M, 14M, and 16M. These mix variations allow for comparisons in terms of performance based on molar concentrations.

**Table -3: Binder Composition**

| Binder Type | Percentage (%) | Quantity (kg) |
|---|---|---|
| Fly Ash | 50% | 200 |
| GGBS | 50% | 200 |
| **Total Binder** | 100% | 400 |

Table 3 provides a summary of the binder used in geopolymer concrete. It was mixed 50% Fly Ash and 50% GGBS, with each having 200 kg for a total quantity of binder of 400 kg. The equilibrium of these two materials together increases strength and durability as well as supports sustainable construction by utilizing industrial by-products.

### 4.3. Alkaline solution molarities: 8M, 10M, 12M, 14M, 16M

Five molarities (8M, 10M, 12M, 14M, 16M) were prepared using chemically-dried pellets of NaOH. The 12M solution was chosen as the mid-level reference based on previous research studies [17]. All solutions were cooled to room temperature to prevent flash setting before being mixed with $Na_2SiO_3$ for the testing procedure. The $Na_2SiO_3$/NaOH ratio will remain constant between all mixes so that molarity could be the only treatment factor affecting the setting time [18]. The densities of the solutions were also confirmed using a hydrometer to ensure accurate measurement (±0.01M tolerance) [19]. The activator solutions made in the laboratory were controlled under optimized conditions (25±2°C, 60±5% RH).

**Table 4: Alkaline Activator Composition**

| Parameter | Value / Description | Quantity (kg) |
|---|---|---|
| Activator/Binder Ratio | Recommended Ratio | 0.4 |
| Total Activator Required | 0.40 × 400 | 160 |
| NaOH : Sodium Silicate Ratio | Standard | 01:02.5 |
| Sodium Hydroxide (NaOH) | From activator distribution | 45.71 |
| Sodium Silicate ($Na_2SiO_3$) | From activator distribution | 114.29 |

The composition of alkaline activator for geopolymer concrete is summarized in Table 4. In this case, with a ratio of activator to binder of 0.4, you need 160 kg of activator to go with 400 kg of binder. The standard alkaline activator ratio for NaOH to $Na_2SiO_3$ of 1:2.5 gives you 45.71 kg of NaOH and 114.29 kg of sodium silicate.

**Table 5: NaOH Mass Required for Different Molarities (Per 10L Solution)**

| Molarity (M) | Formula Used | NaOH Required (g) | NaOH Required (kg) |
|---|---|---|---|
| 8 M | 8 × 40 × 10 | 3200 | 3.2 |
| 10 M | 10 × 40 × 10 | 4000 | 4 |
| 12 M | 12 × 40 × 10 | 4800 | 4.8 |
| 14 M | 14 × 40 × 10 | 5600 | 5.6 |
| 16 M | 16 × 40 × 10 | 6400 | 6.4 |

For a number of different molarities of sodium hydroxide (NaOH), Table 5 shows how to calculate the mass of NaOH needed to prepare 10L of solution. The calculation is based on the formula M × 40 × Volume (L), and the table calculates NaOH amounts of approximately 3.2 kg for 8M to approximately 6.4 kg for 16M of NaOH, and will ensure there is an accurate alkali concentration in geopolymer mixes.

### 4.4. Mixing, casting, and oven curing at fixed temperature

Mixing of the geopolymer concrete mix was performed in three stages by firstly dry mixing the solids for 1 minute, then adding 80% of the alkaline solution for 2 minutes, and finally using the remaining alkaline solution to adjust the compostion and mixing for one minute [20]. The fresh concrete was cast into 150×150×150 mm cubes and 100×100×500 mm beams, which were placed in three equal layers of approximately the same depth in miniature screed boxes and each layer was vibrated for 15 seconds. After casting, the specimens were covered with clean plastic sheets to prevent moisture loss for 24 hours and were then cured in an oven at 60 degrees celcius for 24 hours [21]. After curing, all specimens were stored at room temperature (27±2°C)) with the total time from mixing to testing in mind, until the testing ages of 7 days, 14 days and 28 days were assessed [22]. Given the limited time frame of this research project, this curing regime was selected to accelerate the geopolymerization process while reasonably mimicing field conditions.

### 4.5. Test procedures for compressive strength

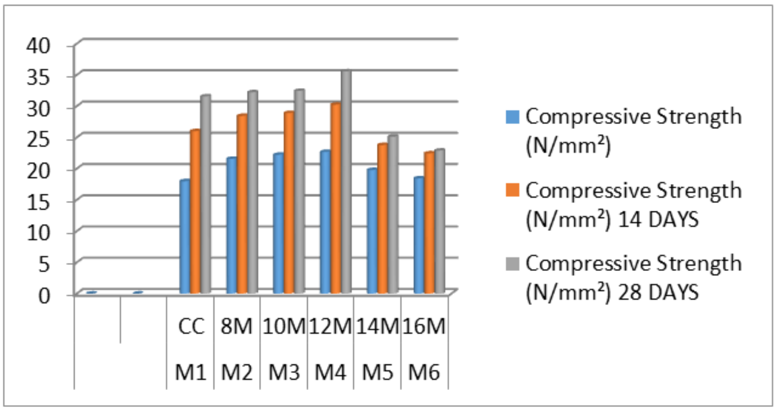
Compressive strength testing used IS 516-2019 as a standard reference with a compression testing machine rated for 3000 kN capacity [23]. Three cubes from each mix were tested at every age of testing at a speed of loading known to be 2.4kN/s. Flexural strength was determined on beam specimens according to IS 516-2019 (third point loading method) [24]


**Figure 4: Photographs of mixing, casting, and testing**

## 5. Results and Discussion

**Table 6: Compressive Strength Test Results**

| S. NO | Mix | Mix Designation | Compressive Strength (N/mm²) | | |
|---|---|---|---|---|---|
| | | | 7 Days | 14 Days | 28 Days |
| 1 | M1 | CC | 18 | 26 | 31.56 |
| 2 | M2 | 8M | 21.56 | 28.44 | 32.22 |
| 3 | M3 | 10M | 22.22 | 28.89 | 32.44 |
| 4 | M4 | 12M | 22.67 | 30.22 | 35.56 |
| 5 | M5 | 14M | 19.78 | 23.78 | 25.11 |
| 6 | M6 | 16M | 18.44 | 22.44 | 22.89 |

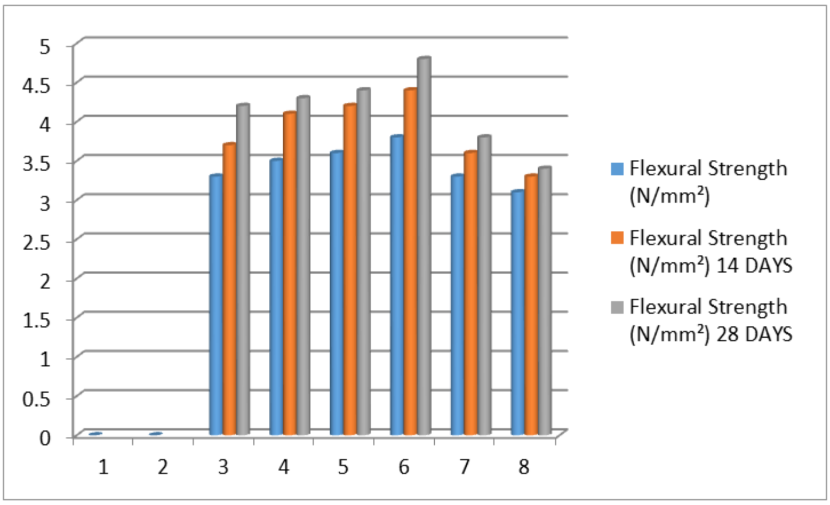



**Graph-1: Compressive Strength Test Results**

The table-6 and graph-1 compares compressive strength gain development between conventional concrete and geopolymer concrete over 7, 14, and 28 days. Generally compressive strength will increase within the curing time frame. The strength of mix M4 (12M) demonstrates the greatest 28-day strength of 35.56 N/mm². However, the higher molarities (14M, 16M) show a reduction, indicating optimal performance with around 12 molarity.

**Table 7: Flexural Strength Test Results**

| S. NO | Mix | Mix Designation | : Flexural Strength (N/mm²) | | |
|---|---|---|---|---|---|
| | | | 7 Days | 14 Days | 28 Days |
| 1 | M1 | CC | 3.3 | 3.7 | 4.2 |
| 2 | M2 | 8M | 3.5 | 4.1 | 4.3 |
| 3 | M3 | 10M | 3.6 | 4.2 | 4.4 |
| 4 | M4 | 12M | 3.8 | 4.4 | 4.8 |
| 5 | M5 | 14M | 3.3 | 3.6 | 3.8 |
| 6 | M6 | 16M | 3.1 | 3.3 | 3.4 |




**Graph-1: Flexural Strength Test Results**

The table-7 and graph-2 displays the flexural strength of a number of concrete mixtures over time. Geopolymer mix M4 (12M) had the maximum flexural strength of 4.8N/mm² at 28-days. The flexural strength increases with molarity up to 12M, but decreased at 14M and 16M, may imply that the high alkali concentration may have a negative impact on performance due to the rapid setting or brittleness.

**Table 8: Compressive and Flexural Strength Test Results**

| S. NO | Mix | Mix Designation | Compressive Strength (N/mm²) | | | Flexural Strength (N/mm²) | | |
|---|---|---|---|---|---|---|---|---|
| | | | 7 Days | 14 Days | 28 Days | 7 Days | 14 Days | 28 Days |
| 1 | M1 | CC | 18 | 26 | 31.56 | 3.3 | 3.7 | 4.2 |
| 2 | M2 | 8M | 21.56 | 28.44 | 32.22 | 3.5 | 4.1 | 4.3 |
| 3 | M3 | 10M | 22.22 | 28.89 | 32.44 | 3.6 | 4.2 | 4.4 |
| 4 | M4 | 12M | 22.67 | 30.22 | 35.56 | 3.8 | 4.4 | 4.8 |
| 5 | M5 | 14M | 19.78 | 23.78 | 25.11 | 3.3 | 3.6 | 3.8 |
| 6 | M6 | 16M | 18.44 | 22.44 | 22.89 | 3.1 | 3.3 | 3.4 |

This table 8 summarizes the compressive and flexural strengths of conventional concrete and geopolymer concrete mixes at 7, 14, and 28 days. The 12M geopolymer mix (M4) showed the highest strengths in both tests (compression: 35.56 N/mm²; flexure: 4.8 N/mm²). However, starting at 12 M and beyond, the strengths show a downward trend. For both compression and flexural, a molarity system exists for optimal properties.

## 6. Conclusion

The experimental study aimed to investigate the compressive and flexural strength of both conventional concrete and geopolymer concrete that used Fly Ash and GGBS in a 50:50 ratios. Six mix designs were compared and evaluated at three curing periods including 7-days, 14-days, and 28-days. The results indicated that all the mixes had a continued strength improvement over time, with geopolymer concrete performing better than the conventional concrete mix in all instances. the geopolymer concrete mixes developed, the other 28-day compressive strength and flexural strength of the 12M molarity mix (M4) was the highest at 35.56 N/mm² and 4.8 N/mm² respectively, therefore indicating that 12M is the ideal molarity used to achieve alkaline activation through this binder system. The use of 50% Fly Ash and GGBS in the blended mix produced effective structural grade geopolymer concrete achieving the mechanical strength demands of M25 grade concrete and ultimately producing a viable green alternative concrete type. Future studies should look at exploring the long term durability, and the possible cost vs benefits as well as its environmental impact. The overall reduction in strength after the 12M molarity could be related to viscosity, rapid set, and or micro cracking from too much alkali concentration which inhibited proper geopolymerization.

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