

International Journal of Engineering Research and Science & Technology



www.ijerst.org

ISSN : 2319-5991

Vol. 21 No. 3 (1) 2025



ijerst.editor@gmail.com
editor@ijerst.com

Research Paper**INFLUENCE OF INDUSTRIAL WASTE BINDERS ON
STRENGTH AND DURABILITY OF GEOPOLYMER
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Engineering Sultanpur, Sultanpur, Choutkur, Telangana 502273**Abstract**

This research investigates the influence of industrial waste binders on the strength and durability properties of M40-grade geopolymer concrete, utilizing fly ash and ground granulated blast furnace slag (GGBS) as primary binders. The study involves an experimental analysis with varying fly ash content levels of 0%, 25%, 50%, and 75%, assessing performance across multiple curing ages of 7, 14, 28, and 56 days. An alkaline activator solution composed of 8M sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) is used at a solution-to-binder ratio of 0.38. Workability is examined through slump tests for each binder variation, while compressive strength and durability are evaluated based on acid resistance tests. This comprehensive experimental approach aims to provide insights into the optimal binder composition for enhanced strength and durability, contributing to sustainable concrete technology by utilizing industrial waste products.

Keywords: Geopolymer concrete, Flyash, GGBS, Sodium Hydroxide, Sodium Silicate

Received: 06-08-2025

Accepted: 08-09-2025

Published: 15-09-2025

1. Introduction

Many humans are inquisitive about finding sustainable alternatives to regular cement-based concrete because of the developing call for such materials in the constructing industry. Geopolymer concrete is an progressive and environmentally friendly substance that uses industrial waste substances as binders to decrease carbon emissions. It's a ability opportunity. The cementitious matrix that produces geopolymer concrete has extraordinary mechanical qualities and lengthy-lasting durability; it's far made via activating alumino-silicate minerals with alkaline answers. One Good opportunity to conventional Portland cement a primary source of CO_2 emissions global is geopolymer concrete, which makes use of business waste materials like fly ash and floor granulated blast furnace slag (GGBS) in location of cement. Geopolymer concrete's ability to encompass a

diffusion of waste materials, transforming by means of-merchandise into useful resources, is the key to its promise in sustainable building. Two commonplace industrial waste binders utilized in geopolymer concrete are GGBS, which comes from the steel enterprise, and fly ash, that's a spinoff of coal combustion in power vegetation. Because in their high alumino-silicate content material, those materials might also undergo the chemical activation necessary for geopolymerization. Geopolymer concrete is made easier to work with and has extra strength and sturdiness way to fly ash, which is ordinarily tiny particles.

However, the reactive calcium oxide in GGBS, that is found in denser and bigger particles, aids in early-age energy acquisition. By combining fly ash and GGBS in one of a kind quantities, geopolymer concrete can also obtain its complete capability in terms of workability, durability, and mechanical strength. An alkaline activation answer, including sodium

hydroxide (NaOH) or sodium silicate (Na_2SiO_3), is utilized in geopolymerization to motive the aluminosilicate compounds within the binders to dissolve and re-polymerize. A thick, long-lasting matrix with first-rate chemical resistance is the end result of this technique, making it applicable to a wide range of environments. During activation, the molarity, or concentration, of NaOH could be very essential. Optimal geopolymerization turned into performed on this paintings by way of the use of an 8M NaOH answer together with Na_2SiO_3 . Because this ratio has this sort of profound effect on the concrete's consistency, go with the flow, and ultimate structural traits, it's miles kept at a regular 0.38 to assure a balance between workability and strength.

The workability of concrete, indicated by slump value, is a critical factor in construction as it influences the ease of placement, compaction, and finishing. Workability testing in this study will explore the slump values achieved at different fly ash levels, providing insights into how binder composition affects concrete handling. A comprehensive understanding of workability is essential for ensuring that geopolymer concrete meets the practical requirements of construction applications, especially when using high-alkaline activators.

Objectives of the study

1. To assess the workability of geopolymer concrete with varying fly ash and GGBS proportions, analyzing its impact on slump values and overall ease of handling for different ages.
2. To evaluate the compressive strength development of M40 grade geopolymer concrete using varying proportions of fly ash (0%, 25%, 50%, 75%) and GGBS, with an 8M NaOH and Na_2SiO_3 solution as activators, across curing periods of 7, 14, 28, and 56 days
3. To investigate the durability properties of geopolymer concrete, including acid resistance, with varied fly ash and GGBS contents, aiming to determine the optimal binder mix for enhanced long-term durability.

2. Literature review

Jamdade P.K (2014) Advanced the utilization of modern waste fly slag as the swap for concrete. Analysts done tests on relieving time, restoring temperature of geopolymer concrete. The

compressive quality ascents from 12 hrs to 24 hrs at 60°C . The investigation demonstrates that, for polymerisation the temperature 90°C is very adequate. Geopolymer solid gives more quality than ordinary cement in least time of relieving. Geopolymer concrete has bigger compressive quality with higher relieving temperature.

Krishnan L (2014) Led considers and inferred that the geopolymer innovation is appropriate for application in solid industry as an elective cover to the Portland bond.. The goal of this examination work was to create a carbon dioxide outflow free cementitious material. Geopolymer concrete is such a material, to the point that stays away from such destructive impacts. The discharge of carbon dioxide amid the creation of conventional Portland bond is especially high.

3. Materials and mix proportioning

Coarse aggregates

Locally accessible pulverized rock stone total of 10mm size was utilized as coarse total. The coarse total going through 10mm and holding 4.75mm was utilized for exploratory work. The properties of coarse totals were resolved as per IS: 2386-1963.

Fine aggregates

The locally accessible stream sand, going through 4.75 mm was utilized in this test work. The properties of fine totals were resolved according to May be: 2386-1963.

Fly ash

Fly ash is classified into two main categories as per ASTM C-618. Most of the current literature designates these two classes as Class F and Class C, respectively, based on the kind of coal that is burnt. Fires that burn subbituminous or lignite coal often create Class C fly ash, while fires that burn anthracite or bituminous coal typically produce Class F fly ash. What follows is a discussion of the key features shared by these two ash kinds.

Low calcium ashes, which are Class F fly ashes with a calcium oxide (CaO) composition of less than 6%, often display pozzolanic qualities rather than self-hardening. According to loss on ignition (LOI), these ashes had over 2% of unburned carbon. The primary crystalline components of fly ash, which is produced by bituminous coal, are quartz, mullite, and haematite. Class F fly ashes have been the focus of

the vast majority of studies on their potential application in concrete and cement.



Fly ash

GGBS

Granulated Blast Furnace Slag is acquired by quickly chilling (extinguishing) the liquid fiery remains from the heater with the assistance of water. Amid this procedure, the slag gets divided and changed into formless granules (glass), meeting the prerequisite of IS 12089:1987 (fabricating detail for granulated slag utilized in Portland Slag Cement). The granulated slag is ground to wanted fineness for creating GGBS.



GGBS

Alkaline solution

A mix of sodium silicate arrangement and sodium hydroxide arrangement was utilized as soluble arrangement.

Sodium hydroxide

The most well-known soluble activator utilized in geopolymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate (Na_2SiO_3) or potassium silicate (K_2SiO_3). The sort and convergence of salt arrangement influence the disintegration of Pozzolanic material. It is a white strong and exceptionally caustic metallic base and soluble base salt which is accessible in pellets, drops, granules, and as prepared solutions at various diverse fixations. Sodium hydroxide flakes an approximately half (by weight) soaked arrangement with water.



Preparation of NaOH solution

Silicate

Sodium silicate is the basic name for mixes with the equation $\text{Na}_2(\text{SiO}_2)$. Concrete treated with a sodium silicate arrangement serves to significantly reduce porosity in most stone work items, for example, concrete. A synthetic response occurs with the overabundance $\text{Ca}(\text{OH})_2$ (portlandite) exhibit in the solid that for all time ties the silicates with the surface, making them undeniably strong and water repellent.

ADMIXTURE

To secure usefulness of clean Geopolymer Concrete, Sulphonated naphthalene polymer based absolutely great plasticizer Conplast SP430 in the state of a dark colored fluid immediately dispersible in water,

4. Mix design

Trial Mix used in the project

Material	Content (kg/m^3)
GGBS (Binder)	400
Sodium Hydroxide (8M)	50.67
Sodium Silicate	101.33
Coarse Aggregate	1036.8
Fine Aggregate	691.2
Water	12
Super plasticizer	4

Mix trials used in the study

1. 0%FA+100%GGBS (Mo)
2. 25%FA+75%GGBS (M1)
3. 50%FA+50%GGBS (M2)
4. 75%FA+25%GGBS (M3)
5. 100%FA+0%GGBS (M4)

5. Experimental Investigation

Manufacture of Fresh Concrete and Casting

Geopolymer concrete can be manufactured by adopting the conventional techniques used in the

manufacture of Portland cement concrete. In the laboratory, the fly ash and the aggregates were first mixed together for 3 minutes. The aggregates were prepared in saturated surface dry condition.



Mixing of Geopolymer concrete

Curing of Geopolymer concrete

The alkaline solution was then added to the dry materials and the mixing continued for further about 4 minutes to manufacture the fresh concrete. The fresh concrete could be handled up to 120 minutes without any sign of setting and without any degradation in the compressive strength. The fresh concrete was cast into the moulds immediately after mixing, in three layers for cubical specimens of size 150mm x 150mm x 150mm .

Curing of Test Specimens

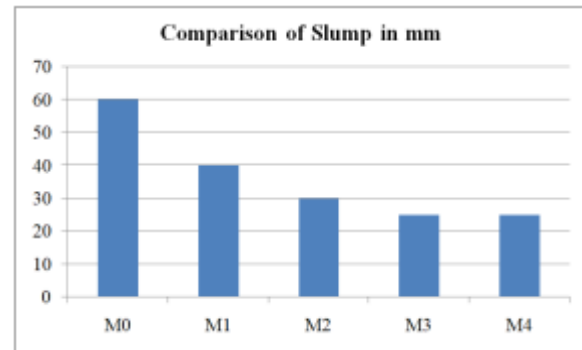
After casting, geopolymer concrete specimens were cured immediately. Two types of curing were used in this study, i.e. Oven curing and Ambient curing. For Oven curing, the test specimens were cured in the oven and for ambient curing, they were kept under ambient conditions for curing at room temperature. The specimens were oven-cured at 60°C and 100°C for 24 hours in the oven. After the curing period, the test specimens were left in the molds for at least six hours in order to avoid a drastic change in the environmental conditions. After demolding, the specimens were left to air-dry in the laboratory until the day of testing.

Tests to be conducted on concrete

Fresh concrete tests
Slump cone test
Compaction factor test
Compressive strength
Durability

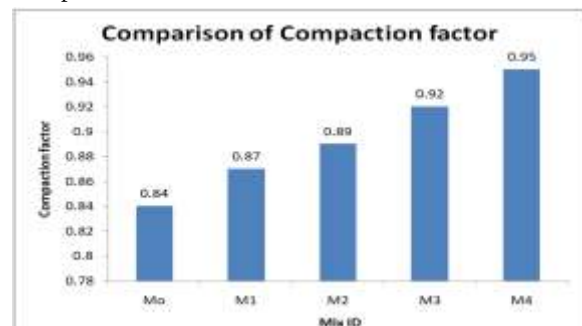
6. Results and Analysis

Workability of concrete
Slump cone test



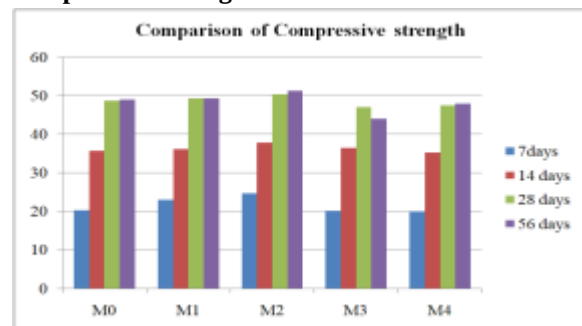
Comparison of Slump in mm

Compaction factor test



Comparison of Compaction factor

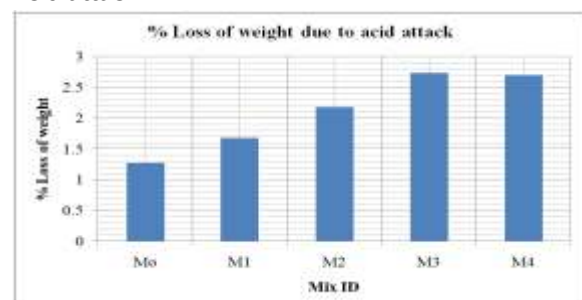
Compressive strength of concrete



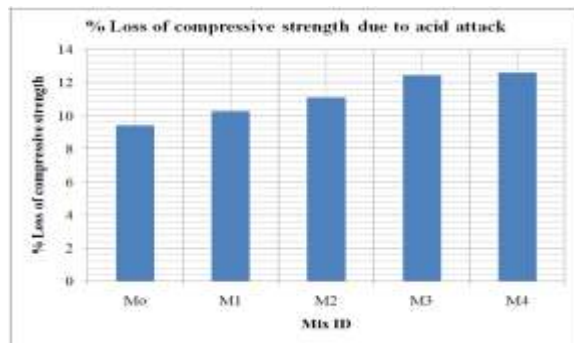
Comparison of Compressive strength

Durability of concrete

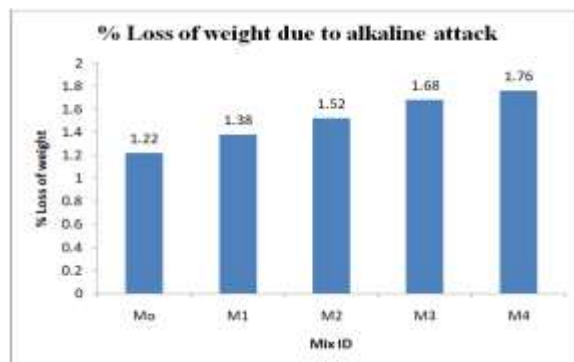
Acid attack



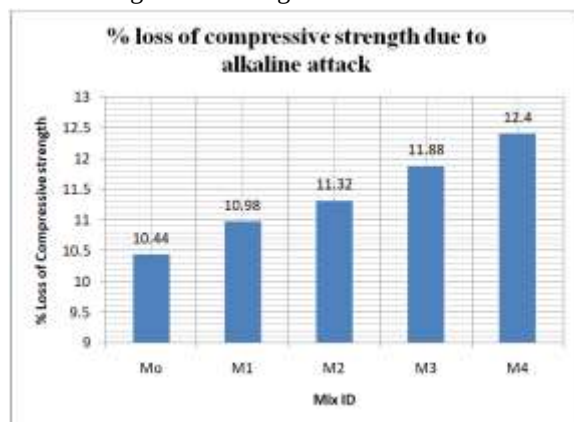
Percentage loss of weight due to acid attack



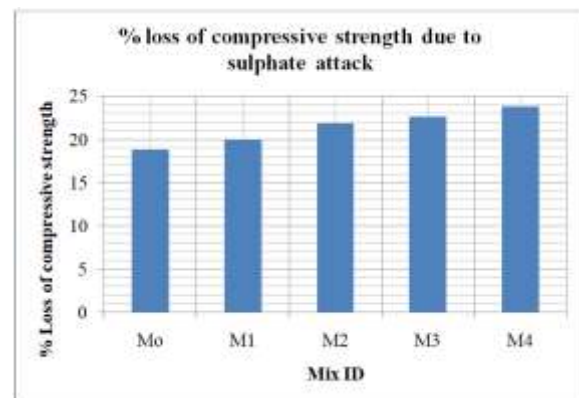
Percentage loss of strength due to acid attack

Alkaline attack

Percentage loss of weight due to alkaline attack



Percentage loss of compressive strength due to alkaline attack

Sulphate attack

Percentage loss of compressive strength due to sulphate attack

7. Conclusions

The following findings were drawn from the aforementioned experimental investigation:

1. At typical operating room temperature, geopolymer concrete does not typically exhibit any noticeable physical changes to its characteristics, as is the case with the standard kind. Without leaving any residue on the hardened surface, the full setting of geopolymer concrete specimens might take up to 72 hours.
2. Slump value drops from 60mm to 25mm when fly ash and GGBS percentages rise, going from 0%GGBS to 100%FA.
3. As the amount of fly ash and GGBS rises from 0%GGBS to 100%FA, the compaction factor for M30 Grade concrete goes up from 0.84 to 0.95.
4. For M40 grade concrete, the maximum compressive strength was found to be 7 days, 14 days, and 28 days after mixing 50% FA with 50% GGBS.
5. Adding more fly ash and GGBS to concrete makes it more resistant to acid, alkaline, and sulphate attacks.
6. Geopolymer concrete, made from a combination of fine and coarse aggregate, may be created by using GGBS to create a geopolymeric binder phase. Thus, these concrete may be seen of as a material that is kind to the environment. An increase in the mass ratio of sodium hydroxide to sodium silicate leads to an increase in compressive strength.
7. Compressive strength of geopolymer concrete based on GGBS increases with increasing

sodium hydroxide solution content (measured in molar terms).

8. The compressive strength of geopolymer concrete based on fly ash is increased when the mass ratio of sodium silicate to sodium hydroxide increases.

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