Library Progress International *Print version ISSN 0970 1052*
Vol.44, No.4, Jul-Dec 2024: P.237-242 *Online version ISSN 2320 317X*

Original Article *Available online at www.bpasjournals.com*

A study on effect of fly ash and GGBS on the mechanical properties of geopolymer concrete

[1]Akash Timashetti,[2] Nityanand S. Kudachimath, [3]Keerti M.Nashimath,[4]Shashank U.Vanakudari,[5] B. J. Panditharadhya

[1]PG Student, M. Tech, Department of Civil Engineering, Jain College of Engineering, Belagavi, Karnataka, India.
[2] Associate Professor, Department of Civil Engineering, Jain College of Engineering, Belagavi, Karnataka, India.
[3] Assistant Professor, Department of Civil Engineering, KLS Gogte Institute of Technology, Belagavi, Karnataka, India.
[4] Assistant Professor, Department of Civil Engineering, Jain college of Engineering, Belagavi, Karnataka, India.
[5] Assistant Professor, School of Civil Engineering, KLE Technological University, Hubballi, Karnataka, India.

How to cite this article: Akash Timashetti, Nityanand S. Kudachimath, Keerti M.Nashimath,Shashank U.Vanakudari, B. J. Panditharadhya (2024). A study on effect of fly ash and GGBS on the mechanical properties of geopolymer concrete. Library Progress International, 44(4), 237-242

ABSTRACT
In this day and age concrete is second most consumable product in the world. The production of cement is emitting carbon to the atmosphere and it increases greenhouse gases. Geopolymer Concrete is a special kind of concrete that is manufactured by use of industrial waste like coal-based fly ash and GGBS which are considered alternative to Ordinary Portland cement concrete. This project work focuses mainly on the effect of fly ash and GGBS on the mechanical properties of geopolymer concrete, by utilizing Fly Ash and GGBS as it reduces the terrible effect on environmental. Geopolymer concrete is good alternative to cement concrete which reduce the emission and cost of production. Using different trial bases 5 different percentage of FA and GGBS is mixed with sodium based alkaline activators such sodium silicate and sodium hydroxide. The tests are carried out for compression and split tensile test, on the concrete specimen. Specimens were casted and cured for 7,14 & 28 days. In our project ambient temperature is preferred, so GPC was done at ambient temperature without keeping it in water unlike conventional concrete.

KEYWORDS
Geopolymer, concetre, flyash, GGBS etc.

Introduction
The development activities and industrial sector growing at rapid rate all over the word increase the CO_2 emission in to atmosphere all over. One of the most widely used artificial items in the world is concrete, however the sustainability of traditional or conventional concrete is always a concern because the production of cement releases carbon dioxide gases, which cause the greenhouse effect.
Man-made emissions have disrupted the atmosphere. Daily industrial activities pollute the air and boost cement use in the construction industry. CO_2 emissions are high from cement production.
Processes like cement production and fossil fuel combustion may raise CO_2 emissions. Human-caused emissions have disrupted the atmosphere. Rapid industrial activity creates air pollution, which depends on construction and cement use. Cement manufacture emits lots of CO_2, such as fly ash or slag.
Because cement adds aesthetics to a structure and ease of doing work compare to that of other building materials, it is impossible to totally avoid using Cement in construction. Therefore, considering the other OPC concrete alternative might be the best course of action.

Basically, the source of emission is based on the cement plant from chemical conversion of raw material. Burning fossil fuel required for production.

Geoploymer

Geopolymer concrete is a type of green concrete that can be created by alkali activating Production of cement and using fossil fuels may enhance this emission. The atmosphere is unbalanced by human emissions. Industrial activities cause air pollution, which depends on construction and cement use. Cement manufacturing emits much of CO_2.This chemical process, known as polymerization, produces a compound structure that is similar to that of naturally occurring zeolitic materials but has an amorphous microstructure as opposed to a crystalline one. A rapid chemical exchange with Si-Al minerals in an alkaline environment is what causes the polymerization process, it produces a Si-O-Al-O bond-based three-dimensional polymeric chain and ring structure.

This structure is represented as: Mn [-(SiO2) z-AlOz] n. WH_2O (2-1), where the symbol denotes the presence of a bond, denotes the degree or amount of polycondensation or polymerization, and z is a value between 1 and 32. M represents the alkaline component or cation (potassium, sodium, or calcium).

Polymerization

Geopolymer concrete is produced by polymerization between source material having high silica and alumina content. Sulphate, chloride, and acid resistance are excellent in geopolymer concrete.

Source material includes industrial byproducts, garbage, and natural raw materials like steel mill fly ash and slag.

Rice husk and silica flume are aluminosilicate-rich.

The reaction between source material and alkaline activators is an inorganic polymerization process, therefore geopolymerization.

This alternative to traditional concrete matches concrete characteristics and supports industrial reuse of water. This use of industrial byproducts in concrete decreases pollution and water disposal issues.

Geopolymers Uses and Applications

- Ceramics, bricks, and fire safety an illustration of low CO_2 cements, concrete, radioactive, and toxic waste
- Fiberglass composites, sealants for industry, foundry equipment types, and heat-resistant composites.

Fiber composites those are heat- and fire-resistant.

Literature Review

1. **Mr. Abhinav badge Mr. Akshay jamgade:**

They study geopolymer concrete strength and characteristics. Geopolymer concrete was compared to normal concrete for life and strength. Production is flexible, cost-effective, and eco-friendly. The great early strength of geopolymer concrete makes it ideal for repairs and precast construction. Fly Ash, power plant waste, is used to build environmentally friendly concrete. This project will use quarry dust and varied sodium hydroxide and sodium silicate concentrations to replace natural sand and fine aggregates. Study geopolymer concrete's features and recommend it instead of OPC concrete based on test findings. The study has some limitations, including expensive alkaline solution costs, activated solution risks, and base materials like ash flyash and GGBS being near the production site. Geopolymer concrete has higher compressive strength than traditional concrete, according to tests. The compressive strength is 1.5 times that of normal concrete. Like OPC concrete, geoplymer concrete worked well.

2. **N Manoj Kumar, P.Hanitha :**

The comparative study of geopolymer concrete made with fly ash and GGBS instead of cement illustrates their use in different ways. GPC has higher compressive strength than ordinary concrete in 7, 14, and 28-day tests. GPC absorbs less water than concrete. After researching two mix proportions of low calcium fly ash-based geopolymer concrete, mix design was created. Additional water reduction is done with super plasticizer. The possible usage of fly ash-contaminated soil and building waste is identified. Type of alkaline liquid affects concrete strength. It also found that calcium-rich fly ash is strong. High strength and binding are achieved using low-calcium fly ash.

3. **Vignesh K Vivek:**

In this paper, researchers investigated the strength parameters of fly ash-based geopolymers concrete with GGBS. They found that low calcium content yields high compressive strength at ambient temperature, while workability and strength characteristics were not considered. Concrete mix formulation is based on trial data.

4. **Ismail Amer and Mohammed Kohail**

This paper represent the review on current knowledge about AAC. The study on alkaline activators are eco friendly alternative to PCC the reaction mechanism and product depend on alkaline activator.
This article showed that AAC compressive strength boosts GGBFS and outperforms PCC. Reduced GGBS lowers compressive strength. The ambient curing is better than room temperature. Better raised temperature resistance than PCC alkaline activators allow greater temperatures.

5. **Maria s Sebastian, Thahzin Rasha V R**

This article details the results of a study on geopolymer concrete that included fly ash and ground glass beads. For both the 7- and 28-day curing periods, the concrete specimen was mixed in the proportions 1:1.3:3.1. The polymerization process now makes use of GGBS instead of cement, sodium silicate, and sodium hydroxide. The strength is imparted by geopolymer concrete made entirely of GGBS. Presented below is the outcome of the cost analysis, which demonstrates when related to regular concrete, the GGBS base geopolymer is more cost-effective. Other aluminosilicate materials, such as metakaolin, which is derived from rice husks, are recommended in the paper. This product is very helpful and economical for precast construction applications.
The cost analysis is done in this project all project cost involved in doing particular work the cost analysis is done with comparison of conventional concrete and 100% GGBS and 100% flyash. In the study report conventional concrete cost 3500 per cum and 100% Fly Ash cost 3000 per cum and 100% GGBS cost about 3100 per cum. The conventional concrete cost higher than Fly Ash and GGBS concrete.

6. **Sanjay Chetan Nanavati Siddarth Jaywant Lulla**

This study explains how the GPC might help decrease landfill trash by making use of fly ash, a byproduct of thermal plants. Many precast production processes can benefit from GPC. Because of its adaptability, low cost, and high early strength, geopolymer concrete is a viable option for the precast industry. Geopolymer concrete is versatile and can be used for a variety of repair and restoration applications. It is suggested to use geopolymer concrete for constructing infrastructure like culverts, bridge girders, and road pavement.
Quarry dust should be used in place of natural sand because it contains high silica content. Natural sand is highly sought after, but it is also expensive. Thus quarry dust should be used to substitute natural sand, either entirely or partially.

7. **P Abhilash C Sashidhar**

They studied strength properties of GGBS and fly Ash based products. According to the study results, blended GPC mixes made of GGBS and FA achieved improved mechanical properties at room temperature on their own without the requirement for heat curing like GPC. Although it is still strong, 100% fly ash demonstrated a decrease in strength. The cost is also lower than a mixture of 50% fly ash and 50% GGBS.
In all curing times, flexural strength decreased significantly as the amount of fly ash increased from 50% to 100%. Reducing the GGBS replacement level lowers the Silica content of GPC, which in turn lowers its flexural strength while keeping its strength constant. In conclusion, the microstructure of GPC is compromised by increasing the fly ash replacement level, which in turn reduces the splitting tensile strength of GPC, albeit to a lesser extent. The trial base in this study is evaluated with varying proportions of GGBS and fly ash.

8. R swami ranga reddy:

The study details the techniques and calculations for the mix design of materials and alkaline solutions used in the production of geopolymers based on fly ash. The preparation of GPC mix proportion is similar to that cement concrete. They suggested dry mix of aggregate and flyash then add activator solution.
When evaluating the workability of freshly mixed geopolymer concrete, tests like the slump cone test are not applicable since the concrete will sink with time and cannot flow freely in the compaction factor test due to its viscous nature and the water released during polymerization. For workability, a flow table test is therefore advised.

3.0 Experimental setup

This chapter about procedure for making geopolymer concrete based on GGBS and fly ash and conventional concrete of grade M40 was developed. While mixes for Geopolymer concrete are formed by trial and error because there is no set procedure for designing mixes for Geopolymer concrete, M40 grade concrete is designed in accordance with Indian Standards Code 10262:2009.

For this project, the blinder used to make geopolymer concrete is GGBS and fly ash. Alkaline activators based on sodium are utilized in this investigation.

Curing times for both the GPC and OPC cubes and cylinders are identical, taking place at room temperature (site conditions) for seven and twenty-eight days, respectively.

According to the test process outlined in IS 516-1959, the compressive, split tensile, and flexural strengths of concrete are experimentally tested

3.1 Material used

Materials Below are the materials employed for the investigation:

➢ Cement (JK Super cement)

➢ Fly ash

➢ GGBS

➢ Fine aggregate (River sand)

➢ Coarse aggregate (20mm down size)

➢ Sodium hydroxide (Pellets, MW 40)

➢ Sodium silicate (Solution, MW 122.5)

➢ Water

➢ Super plasticizer (FOSguard, Conplast SP430 DIS)

3.2 MIX DESIGN OF GPC

The present study selected ranges for the components of the mixtures depend on the limited earlier study on geopolymer pastes that is accessible in the literature

The characteristics of course and fine aggregates in the trial geopolymer concrete mix were 70% by mass of the total mixture; this value is comparable to OPC concrete, which has a mass percentage range of 75% to 80%. Thirty percent of the aggregates were fine aggregate.

From previous literature, it's evident that the average density of fly ash-based geopolymer concrete aligns with OPC concrete (2400 kg/m³).

The mass of the combined fly ash and alkaline liquid was computed using the concrete's known density.

The masses of sodium hydroxide and sodium silicate solutions were determined, with the ratio of sodium silicate solution to sodium hydroxide solution maintained at 2.5, and the alkaline liquid to fly ash ratio assumed to be 0.4. The concentration of the NaOH solution was set at 10M for this experiment.

- To ensure workability, separate water from alkaline solutions was added. Below is the mix design process. Assuming 75% to 80% aggregate, ranging from 72% to 80% mass in kg/m³, we can construct a geopolymer mix using a 10 M sodium hydroxide solution. Illustration of the above process follows.
- The mixture of alkaline solution and binder (geopolymer paste) makes up the remaining mass.

SPECIMEN CASTING

In the context of concrete testing, specimens refer to specially prepared samples of concrete that are used to evaluate its properties and performance. These specimens are typically shaped and cured according to specific standards to ensure accurate testing.

3.3 TESTING

1.0 COMPRESSIVE TEST

▪ Concrete samples in the form of cubes, cylinders, or beams are cast from the same mix used in construction.

▪ The specimens are cured under carefully monitored circumstances, usually moist or for a set amount of time (e.g., 28 days) in a water bath. The specimen is put into a compression testing apparatus that has plates to equally distribute the load.

▪ Gradually apply compressive load at a specified rate (e.g., 140 kg/cm² per minute) until the specimen fails.
▪ Utilizing the following formula, determine the specimen's compressive strength after noting the highest force applied to it just prior to failure:
Compressive Strength: Maximum Load / Specimen's Cross-Sectional Area
▪ The area is usually calculated from the size of the specimen. Compressive strength value obtained provides insights into the quality and durability of the concrete for structural design and construction purposes.

2.0 SPLIT TENSILE TEST

Split tensile strength of concrete is usually measured using 150 mm diameter, 300 mm height cylinders.
Samples were tested per IS 5816-1999.
The Universal Testing Machine (UTM) was used for testing.
Three specimens underwent the test again, and the mean strength was determined by averaging the results.
The formula is used to determine a cylinder's split tensile strengths.
Strength = 2P/IDL (N/mm²)
Where P is failure load,
D and L are diameter and height of cylinder respectively

RESULTS AND DISCUSSIONS

This chapter contains a tabulation and explanation of the experimental results. The specimens were poured in accordance with the mix design for M 40 grade GPC and OPC; tests are run on six different percentage variations of GGBS and Fly Ash. The cubes and cylinders' hardened properties were tested for OPC, GPC, and split tensile strength. M40 OPC and GPC split tensile and compressive strengths are compared in this chapter.

Compression test: The table below shows OPC and GPC cube compression strength test results after 7, 14, and 28 days with Fly Ash and GGBS content

Split tensile test: The following table lists the findings of the split tensile strength tests conducted on OPC and GPC cylinders with varying Fly Ash and GGBS contents for 7, 14, and 28 days

Conclusion

- This study shows the way GGBS-based geopolymer concrete performs in strength testing.
- Suitable for OPC, user-friendly geopolymer concrete can be utilized.
- Additionally, an increase in concrete strength is observed with age.
- This geopolymer concrete works like ordinary Portland cement concrete and get hardened.
- Geopolymer concrete is ideal for repair works and precast building because to its high early strength.
- Fly ash usage in geopolymer concrete is environmentally benign and reduces landfill waste.
- The study also emphasizes how much better GGBS and fly ash-based geopolymer concrete are than ordinary concrete.
- Interestingly, after curing in ambient circumstances, the compressive strength of the cube for samples with 100% GGBS and 0% fly ash is as follows: 7 days: 54.14 MPa, 14 days: 51.22 MPa, and 28 days: 54.26 MPa.
- The identical mixture (100 percent GGBS and zero percent fly ash) had split tensile strengths of 2.24 MPa after 7 days, 2.31 MPa after 14 days, and 2.40 MPa after 28 days.
- Over the course of seven to twenty-eight days, the geopolymer concrete shows increased strength; a notable increase is noted when 100% of the GGBS is substituted.

References

[1] Mr. Abhinav badge, Mr. Akshay jamagade : geopolymer the concrete of next decade – IJERT ISSN 2278-0181 (vol 11 issue 05 may 2022).
[2] N Manoj kumar, P.Hanita : Geopolymer concrete by using flyash and GGBS as a replacement of cement (IJCE VOL 13, ISSUE 6 VERS V 2016)
[3] P Vignesh K Vivek: An Experimental investigation on strength parameter of fly ash based geopolymers concrete method. IRJET Vol -2 Issue 2 may 2015
[4] Ismail Amera Mohamed Kohail : A Review on alkali activated slag concrete

[5] Marina S Sebastin, Thahzin Rasha VR : An investigation on geopolymer concrete with GGBS and fly Ash : IJERT VOL-10 Issue-8 August 2021.
[6] Sujay Chetan Nanavati siddarthjaywantlulla : A review on flyash based geopolymer concrete (JMCE Vol 14 issue 4 Aug 2017)
[7] P Abhilash C Sashidhar, IV Ramana reddy: strength properties of fly ash and GGBS based geopolymer concrete (IJCR Vol 9 NO 03 2016)
[8] R Swami Ranga Reddy : Mix design for fly Ash based Geopolymer concrete ISSN NO 0377-9254
[9] S J Aher, Prof A H Jamale: comparative study of geopolymer concrete with conventional concrete. (IJERT vol 13 issue 02 Feb 2024)
[10] Manjunath M Katti B M Jagadish, Naveen M Katti Experimental investigation of geopolymer concrete using Fly ash and GGBS (IJCTER Vol 2 issue 5 may 2016)
[11] Ashwath guru, Dr NP Raja mane. Effect of chemical composition of reaction generating liquid on the strength characteristics on high volume fly Ash based geopolymer concrete mix (IJERT -2023)
[12] Aniketh shobha Dilip Rao Hadole: properties of Fly Ash based geopolymer concrete with GGBS & RHA (IJERT Vol 10 Issue 05 may 2021)
[13] Khalid Saifulla, Akshay gada: Effect mineral admixture GGBS on concrete mix design (ISSN 2349-5162)
[14] IS 3812-1 (2003): Specification for Pulverized Fuel Ash, Part 1: For Use as Pozzolana in Cement, Cement Mortar and Concrete [CED 2: Cement and Concrete].
[15] IS 12089 (1987): Specification for granulated slag for the manufacture of Portland slag cement [CED 2: Cement and Concrete].
[16] IS 516-1959: Method of test for strength of concrete
[17] Text book "Sodium hydroxide solutions for geopolymers "by Nirmalakumar P Rajamane.
[18]Text book "Concrete technology, Theory and practice", Revised addition, by M.S. Shetty and S. Chand.