



# A Study on Water Absorption and Sorptivity of Geopolymer concrete

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## To Cite this Article

Sunkara Jahnavi, Gandikota Chiranjeevi, Nagarikanti Ajay & Y. Kiranmai (2026). A Study On Water Absorption and Sorptivity of Geopolymer concrete. International Journal for Modern Trends in Science and Technology, 12(SI01), 1242-1246. <https://doi.org/10.5281/zenodo.19863314>

## Article Info

Received: 12 March 2026; Revised: 07 April 2026; Accepted: 10 April 2026.

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### KEYWORDS

Concrete, compressive strength, split tensile strength, Flexural strength.

### ABSTRACT

Throughout this study, the water absorption and sorptivity properties of fly-ash primarily based geopolymer concrete were studied very well. Geopolymer concrete is one in all the steps taken towards property construction. It's a lower greenhouse footprint than ancient concrete. The impact of accelerated corrosion on geopolymer concrete was conjointly studied and therefore the results were compared with management concrete. It absolutely was ended through the study that geopolymer concrete is a smaller amount porous and incorporates a lesser linear curve as compared to manage concrete.

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## INTRODUCTION

Concrete usage round the world is second solely to water. normal hydraulic cement (OPC) concrete is that the most well liked and wide used building materials, attributable to convenience of the raw materials everywhere the globe, its ease in preparation and fabrication altogether forms of conceivable shapes. About 1.5 a lot of raw materials is required within the production of each ton of OPC, at identical time regarding the quantity of CO<sub>2</sub> free throughout the producing of normal hydraulic cement (OPC) attributable to the calcinations of rock and combustion of fuel is within the order of 1 ton for each ton of OPC created. On the opposite hand, the extensive convenience of ash worldwide creates. Opportunities to

utilize this by-product of burning coal, as a substitute for OPC to manufacture Concrete. It's essential to seek out alternatives to form atmosphere friendly concrete.

an alternate to form environmentally friendly concrete is that the development of Inorganic alumina- salt compound, referred to as Geopolymer, synthesized from materials of geologic origin or by-product materials like ash that's made in chemical element and atomic number 13. in step with Davidovits, geopolymerization is age of synthesis that with chemicals integrates materials containing chemical element and atomic number 13. Throughout the method, chemical element and atomic number 13 atoms square measure combined to create the building blocks that square measure with chemicals and structurally love those binding the natural rocks. By

exploitation the ash primarily based geopolymer concrete reducing the 2 environmental connected problems i.e. the high quantity of free to atmosphere throughout production of OPC and utilization of ash.

In this study, style mixture of M25 grade was used for the tests. Factors like alkalescent liquid to ash quantitative relation =0.4, soluble glass to hydrated oxide quantitative relation =2.0, Morality=M14, set temperature =750C, set Time = 24hours, relief = 1day, Admixture indefinite quantity =2% were unbroken constant throughout the tests. The most objective of the study was to compare the water absorption capability and sorptivity of management and geopolymer concrete.

#### A. DESIGN AND MATERIALS OF GEOPOLYMER CONCRETE

Utilization of concrete as a major construction material is a worldwide phenomenon and the concrete industry is the largest user of natural resources in the world

(1). This use of concrete is driving the massive global production of cement, estimated at over 2.8 billion tonnes according to recent industry data

(2). Associated with this is the inevitable carbon dioxide emissions estimated to be responsible for 5 to 7% of the total global production of carbon dioxide. Significant increases in cement production have been observed and were anticipated to increase due to the massive increase in infrastructure and industrialization in India, China and South America

#### B. GEOPOLYMER PRECAST CONCRETE PRODUCTS

High-early strength gain is a characteristic of geopolymer concrete when dry-heat or steam cured, although ambient temperature curing is possible for geopolymer concrete. It has been used to produce precast railway sleepers, sewer pipes, and other prestressed concrete building components. The early-age strength gain is a characteristic that can best be exploited in the precast industry where steam curing or heated bed curing is common practice and is used to maximize the rate of production of elements. Recently, geopolymer concrete has been tried in the production of precast box culverts with successful production in a commercial precast yard with steam curing [Siddiqui, 2007; Cheema et al, 2009].

Geopolymer concrete has excellent resistance to chemical attack and shows promise in the use of aggressive environments where the durability of Portland cement concrete may be of concern. This is particularly applicable in aggressive marine environments, environments with high carbon dioxide or sulphate rich soils. Similarly in highly acidic conditions, geopolymer concrete has shown to have superior acid resistance and may be suitable for applications such as mining, some manufacturing industries and sewer systems. Current research at Curtin University of Technology is examining the durability of precast box culverts manufactured from geopolymer concrete which are exposed to a highly aggressive environment with wet-dry cycling in sulphate rich soils. Gourley and Johnson [2005] have reported the details of geopolymer precast concrete products on a commercial scale. The products included sewer pipes, railway sleepers, and wall panels. Reinforced geopolymer concrete sewer pipes with diameters in the range from 375 mm to 1800 mm have been manufactured using the facilities currently available to make similar pipes using Portland cement concrete. Tests performed in a simulated aggressive sewer environment have shown that geopolymer concrete sewer pipes outperformed comparable Portland cement concrete pipes by many folds. Gourley and Johnson [2005] also reported the good performance of reinforced geopolymer concrete railway sleepers in mainline tracks and excellent resistance of geopolymer mortar wall panels to fire.

Siddiqui [2007] and Cheema et al [2009] demonstrated the manufacture of reinforced geopolymer concrete culverts on a commercial scale. Tests have shown that the culverts performed well and met the specification requirements of such products. Reinforced geopolymer concrete box culverts of 1200 mm (length) x600 mm (depth) x1200 mm (width) and compressive cylinders were manufactured in a commercial precast concrete plant located in Perth, Western Australia. The dry materials were mixed for about 3 minutes. The liquid component of the mixture was then added, and the mixing continued for another 4 minutes. The geopolymer concrete was transferred into a kibble from where it was then cast into the culvert moulds (one mould for two box culverts) as shown in Figure 3. The culverts were compacted on a vibrating table and using a hand-held vibrator. The cylinders were cast in 2 layers

with each layer compacted on a vibrating table for 15 seconds. The slump of every batch of fresh geopolymer concrete was also measured in order to observe the consistency of the mixtures.

After casting, the cylinders were covered with plastic bags and placed under the culvert moulds. A plastic cover was placed over the culvert mould and the steam tube was inserted inside the cover. The culverts and the cylinders were steam-cured for 24 hours. Initially, the specimens were steam-cured for about 4 hours; the strength at that stage was adequate for the specimens to be released from the moulds. The culverts and the remaining cylinders were steam-cured for another 20 hours. The operation of the precast plant was such that the 20 hours of steam-curing has to be split into two parts. That is, the steam-curing was shut down at 11 p.m. and restarted at 6 a.m. next day. In all, the total time taken for steam-curing was 24 hours.

## II. MANUFACTURE OF TEST CULVERTS AND CYLINDERS

The box culvert made of geopolymer concrete mix 4 (Table 4) was tested for load bearing strength in a load testing machine which had a capacity of 370 kN and operated to Australian Standards, AS 1597.1-1974. The culvert was positioned with the legs firmly inside the channel supports. Load was then applied and increased continuously so that the proof load of 125 kN was reached in 5 minutes. After the application of the proof load, the culvert was examined for cracks using a crack-measuring gauge. The measured width of cracks did not exceed 0.08 mm. The load was then increased to 220 kN and a crack of width 0.15 mm appeared underside the crown. As the load increased to about 300 kN, a crack of 0.4 mm width appeared in the leg of the culvert. The load was then released to examine to see whether all cracks had closed. No crack was observed after the removal of the load.

According to Australian Standard AS 1597, a reinforced concrete culvert should carry the proof load without developing a crack greater than 0.15 mm and on removal of the load; no crack should be greater than 0.08 mm.

## CONTRIBUTIONS OF GEOPOLYMER CONCRETE TOWARDS

Coal is often used in the generation of a major proportion of the power not only in many parts of the world such as India, China, Australia, and the USA. The

huge reserves of good quality coal available worldwide and the low cost of power produced from these resources cannot be ignored. Coal-burning power stations generate huge volumes of fly ash; most of the fly ash is not effectively used. As the need for power increases, the volume of fly ash would increase if we continue to largely rely on coal-fired power generation. On the other hand, concrete usage around the globe is on the increase to meet infrastructure developments. An important ingredient in the conventional concrete is the Portland cement. The production of one ton of cement emits approximately one ton of carbon dioxide to the atmosphere. Moreover, cement production is not only highly energy-intensive, next to steel and aluminium, but also consumes significant amount of natural resources.

For sustainable development, the concrete industry needs an alternative binder to the Portland cement. Such an alternative is offered by the fly ash-based geopolymer concrete, as this concrete uses no Portland cement; instead, utilizes the fly ash from coal-burning power stations to make the binder necessary to manufacture concrete. The use of fly ash-based Geopolymer Concrete contributes through the process of Carbon Reduction Scheme between the Power Generators, Coal Producers, the Government Agencies, and other industries including the cement producers.

## III RESULTS AND DISCUSSION

### Compressive strength

Two geopolymer concrete mixture proportions used in laboratory studies are given in Table 2. Numerous batches of these mixtures were manufactured during a period of four years. For each batch of geopolymer concrete made, 100x200 mm cylinders specimens were prepared. At least three of these cylinders were tested for compressive strength at an age of seven days after casting. The unit-weight of specimens was also determined at the same time. For these numerous specimens made from Mixture-1 and Mixture-2 and heat-cured at 60o C for 24 hours after casting, the average results are presented in Table 3. In order to observe the effect of age on compressive strength of heat-cured geopolymer concrete, 100x200 mm cylinders were made from several batches of Mixture1 given in Table 2. The specimens were heat-cured in the oven for 24 hours at 60o C. Test data show that the compressive

strength increased with age in the order of 10 to 20 percent when compared to the 7th day compressive strength.

In order to study the effect of age on the compressive strength of fly ash-based geopolymer concrete cured in laboratory ambient conditions, three batches of geopolymer concrete were made using Mixture-1 given in Table 2. The test specimens were 100x200 mm cylinders. The first batch was cast in the month of May 2005, while the second batch was cast in the month of July 2005 and the third batch in September 2005. The ambient temperature in May 2005 during the first week after casting the concrete ranged from about 18 to 25°C, while this temperature was around 8 to 18°C in July 2005 and 12 to 22°C in September 2005. The average humidity in the laboratory during those months was between 40% and 60%. The test cylinders were removed from the moulds one day after casting and left in laboratory ambient conditions until the day of test.

Test results show that the compressive strength of ambient cured geopolymer concrete significantly increased with the age [12]. This test trend is in contrast to the effect of age on the compressive strength of heat-cured geopolymer concrete.

Age (Days)	Compressive Strength (MPa)
0	12
7	18
14	21
28	24

#### Flexural Strength Test

Testing of the specimens The checking out of concrete plays a vital role in controlling and confirming the first-rate of cement concrete works (Shetty, 2007). Systematic trying out of uncooked substances and fresh concrete are inseparable parts of any control programme for concrete. The main task is that when different materials are used in the concrete, careful steps are to be taken at every stage of work for different tests. The tests also have a deterring effect on those responsible for construction work. Tests are made by casting prisms from the respective concrete. It is to be noted that the standard compression test specimens give a measure of the potential strength of the concrete, not of the strength of the concrete in structure. In this study total experimentation consists of Flexural strength test.

Flexural strength is a measurement that indicates the resistance of a material to deformation when placed under load. The beam specimens were 100 x 100 x 500 mm in cross-section. The geometry of the beam specimen is shown in Figure 4.5



Flexural Strength

#### Sorptivity

Sorptivity property of each style of concrete has been studied by performing tests at one, 2, 3, 4, 5, 9, 12, 16, twenty and twenty five minutes quantity and alter in weight of the specimen once every interval. The Table four and Table five show the readings and calculations for every interval for management concrete and geopolymer concrete severally. The Sorptivity curve was found to be less linear compared thereto of management concrete. The speed of absorption, that has vital impact on sturdiness property of concrete, was found less in geopolymer concrete than the management concrete.

Table 4: Sorptivity Readings and Calculations of management Concrete

Water absorption characteristics of the concrete play a very important role for the sturdiness of the structure. Ingress of water deteriorates concrete and in ferroconcrete structure, corrosion of the bars passed which ends up it no cracking and spalling of the concrete and ultimately reduces the generation of the structure. Check results of water absorption check square measure shown in Table six. The result indicates that the water absorption of geopolymer concrete is a smaller amount compared to manage concrete. Though the distinction answerable for of gain in weight is extremely less.

### Accelerated Corrosion check

This study evaluated the corrosion based mostly primarily sturdiness characteristics of low metallic element ash based geopolymer concrete and its comparison with management concrete subjected to the marine atmosphere. The resistance of corrosion has been evaluated by mensuration current readings of the specimen at regular interval and conjointly by visual examination has been done. Supersonic Pulse speed (UPV) readings were conjointly taken to check the amendment in concrete quality attributable to the corrosion incorporated. Comparison of Current readings and UPV readings is shown in severally.

The crack initiation of management concrete was discovered once 116 hours by amendment in current yet as visual observation. Geopolymer specimen took longer time with crack initiation once a hundred and forty four hours. The check results indicated wonderful resistance of the geopolymer concrete to chloride attack, with longer time to corrosion cracking, compared to manage concrete. UPV results shows that the reduction of speed readings for geopolymer concrete was seven.62% compared thereto of ten.26% that of management concrete.

Half cell potential meter readings were conjointly taken to check the extent of corrosion in geopolymer and management concrete specimen. The initial readings of geopolymer concrete were considerably over the management concrete. This might ensue to the alkalescent liquid composed of soluble glass and hydrated oxide. Even supposing the incidence of cracking in geopolymer specimen was delayed, the reading indicates additional corrosion in geopolymer specimen. Hence, these results are discarded.

### IV CONCLUSION

The mix style of M25 geopolymer concrete was employed in the study. The results were compared thereto of management concrete. it absolutely was found that The Sorptivity curve is a smaller amount linear as compared thereto of management concrete. Which means the speed of absorption of geopolymer is a smaller amount. Check results of water absorption check shows that the body of geopolymer concrete is a smaller amount as ash is okay than OPC and leads to to less water absorption than the management concrete. Accelerated Corrosion check was conjointly performed

on cylinders of one hundred fifty millimetre diameters and three hundred millimetre height with chrome steel bar and HYSD bar embedded in it. Affected current technique was adopted with 30V constant power provide. Corrosion resistance was evaluated by amendment in current, 0.5 cell potential meter readings, UPV results and visual examination. The results showed that the corrosion incidence in geopolymer concrete takes longer time than management concrete.

### Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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