IMPACT OF MOLARITY ON COMPRESSIVE STRENGTH OF GEOPOLYMER CONCTRETE

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Abstract

Concrete is a building material that is made up of fine concrete, coarse aggregate, water, and cement. Cement processing, on the other hand, produces a large number of carbon emissions, which contribute to global warming and climate change. Geopolymer concrete is an environmentally friendly alternative to traditional concrete, which uses fly ash as a binder material and GGBS as a fly ash replacement. To start the polymerization process, an alkaline activator made of sodium hydroxide and sodium silicate solutions is mixed with the binder material. In addition, geopolymer concrete has several advantages over conventional concrete, including high compressive strength, thermal resistance, and low cost. The effect of sodium hydroxide molarity on the strength properties of geopolymer concrete versus conventional concrete is discussed in this paper. The different molarities of NaOH used in the study were 8M, 10M, 12M, and 14M, and the results showed that the molarity of the mixture is directly proportional to compressive strength, so increasing the molarity increases the compressive strength of geopolymer concrete and vice versa. In addition, a questionnaire with a few questions about the importance of geopolymer concrete was developed. It could be concluded that responses say geopolymer concrete has better advantages over normal concrete and molarity impacts on strength properties of concrete

Keywords:

Eco-friendly material, Geopolymer concrete, alkaline solution, Compressive strength, Molarities.

Introduction:

To construct any structure the first step for a civil engineer is to think of the materials used in construction and one of the main materials which are widely used around the world is concrete. Concrete is a composite material made of aggregate, water, and cement and it has a lot of properties that make it desirable for use in various types of structures as it gives the structure stability, strength, durability, and high resistance to fire (PCA 2019). However, cement which is an essential ingredient of concrete is tested with a lot of scientists who discovered that is a harmful material to the environment as it releases a high amount of CO2 which leads to generates a high temperature to the earth and increase global warming as producing cement can provide more than 8% of the global warming (Ramsden 2020). As saving the earth is a general responsibility and civil engineers are responsible to decrease the amount of harm and hazard that faces the earth by selecting sustainable materials or good alternatives to harmful materials, so scientists discovered a good alternative to the normal concrete that contains cement which is geopolymer concrete that uses fly ash as an alternative to cement and this fly ash is made of burning the coal and it is added in different proportions to decrease the uses of cement in the concrete mixture and therefore decrease the amount of CO2 releases (Green spec 2021). Though there are various SCM obtained from industrial wastes. Kiran (2016) studied the effects of admixing hypo sludge from a paper mill with Portland concrete at different substitution stages. The properties of M20 grade concrete were investigated when maintaining an ideal amount of hypo sludge, which is the most useful cementitious material as far as everyone knows (SCM). Geopolymer concrete is a new type of concrete that is classified as an eco-friendly and sustainable material used instead of normal concrete because of its low release of CO2 and its several characteristics such as high compressive strength, high workability, durability, and more. Geopolymer concrete is comprised of aggregate, water, fly ash, and activator solution which can be made of sodium hydroxide and sodium silicate or potassium hydroxide and potassium silicate but in this research paper the focus would be on the most common activator which is made of sodium hydroxide and sodium silicate, and as it can be used with different molarities so the paper aims to study the effect of the different molarities on several properties of geopolymer concrete and especially the compressive strength. The objectives of the paper are:

1. Comparing the compressive strength of normal concrete and geopolymer concrete using different molarities.
2. Assessing the effect of different molarities on compressive strength of GPC.
3. Assessing the effect of GGBS on the compressive strength of GPC.

According to (Budh and Warhade 2014), geopolymer concrete is an advanced technique used to decrease the amount of CO2 which is produced from the cement in the normal concrete and this amount of gas can lead to huge hazard to atmosphere and environment, so geopolymer concrete substituted the cement with fly ash and it contains an activator that made of sodium hydroxide and sodium silicate in addition to the basic ingredient which is fine and coarse aggregate. The molarity identifies the concentration of sodium hydroxide in the alkaline activator and it can affect several characteristics of geopolymer concrete and especially the compressive strength as it is one of the important properties that should be provided in the concrete because it can affect the performance of the mixture and gives the high strength and quality for the structure which is made of. (Madheswaran et al, 2013), the paper agreed that geopolymer concrete would be a desirable material that is used widely in several structures not only because it is an eco-friendly material, but because of its easiness of mixing design, its durability, workability, less time of curing, compressive and tensile strength, so the paper focuses to study the compressive strength rates changes which can be achieved with using different molarities of sodium hydroxide. Three mixtures with different molarities were prepared and exposed to a compressive strength test, so all the results obtained from the test were analyzed and discussed to identify the suitable molarity that can be used to increase the compressive strength of geopolymer concrete to the maximum. Besides, the percentage of GGBS added to the mixtures was verified from 50%, 75%, and 100%, so the effect of these percentages towards the compressive strength and the relationship between the increase of GGBS amount and compressive strength was determined. According to (Khanna et. al 2017), the geopolymer concrete replaces the cement with fly ash to control the amount of the release of CO2 and its effect on global warming and other environmental issues. This research paper targets to show using of another type of activator which comprises potassium hydroxide and sodium silicate and the effect of using different molarities of it on the compressive strength of geopolymer concrete. Besides different temperatures for curing were used to compare results and identify the optimum temperature and molarity that provides the highest rate of compressive strength. Kiran, et.al, (2020) studies say that geopolymer mortar is a cost-effective, environmentally friendly alternative to traditional cement mortar. In their paper, they demonstrated the effectiveness of a single solution in the mix. The molarity, sum of sodium hydroxide, and curing time all affect the strength of geopolymer mortar. The amount of sodium hydroxide in mortar increases as the molarity rises, increasing mortar strength. Kiran et. al. (2020) discussed the effects of different molarities of sodium hydroxide on concrete strength are different. The amount of sodium hydroxide increases as molarity rises, resulting in a decrease in sodium silicate content. When sodium hydroxide and sodium silicate are used to make an alkaline solution, 8 Molarity is used. The amount of sodium silicate used, on the other hand, is determined by the amount of sodium hydroxide solution. First, 320 grams of NaOH (for 8M) pellets are placed in a 1-liter container, mixed with water, and thoroughly stirred to make a NaOH solution, before weighing the mixture. Kiran, et.al (2020) studied the emphasis and benefits of established with Ground Granulated Blast Furnace Slag (GGBS) and flyash as binding materials and alkaline activator combination of sodium hydroxide and sodium silicate solution) for M25 grade of concrete. Various specimens are cast in fly ash with and without GGBS (10%, 20%, and 30%) with different strength activator ratios (1.5 and 2.5) to assess compressive strength, split tensile strength, and ultrasonic pulse velocity test for 7 and 28 days under ambient curing and oven curing at 60 C for 24 hours to determine compressive strength, split tensile strength, and ultrasonic pulse velocity test. According to the findings, geopolymer concrete with 30% GGBS replacement and a 1.5 ratio is the best choice.

Methodology:

According to (Bidwe and Hamane 2015), the first step in implementing the geopolymer mixture is the preparation of ingredients with specific proportions. The fine and coarse aggregate was prepared and exposed to several tests such as sieve analysis, fineness modulus, and determining its specific gravity as the fine aggregate specific gravity was 2.61 and the fineness modulus is 2.76, however, for the coarse aggregate the specific gravity was 2.66 and fineness modulus was 8.14. The essential component is the alkaline solution. The preparation of alkaline solution would be done three times as three different molarities were used in this experiment, 8M, 10M, and 12M. The first step is to identify the weight of NaOH pellets by multiplying the weight of sodium hydroxide used which is 40 with the molarity and the results as following:

Molarity	Weight of NaOH (grams)
8 M	320
10 M	400
12 M	480

Table 1: NaOH Pellets weight

In a one-liter jar, 320ml of the jar with NaOH was added, followed by 300ml of water, which was mixed, and the rest of the jar was filled with water until the NaOH pellet dissolved. One kg of sodium hydroxide was taken and mixed with 2500 kg of sodium silicate to generate the alkaline solution, and it was kept in a suitable place for one night, it could generate a high amount of heat.90% of fly ash is mixed with 10% of GGBS until it gives single color, which means that it is mixed, then the alkaline solution is added, After that, steel molds of 60 mm* 60 mm* 60 mm are prepared and mixtures are poured into the molds in two layers, the mixture is compacted between each layer to avoid pores and obtain accurate results. All mixtures are kept outside for 7 days for high-temperature curing. Then the samples are cooled to expose to a compressive strength test.

RESULTS AND DISCUSSION: The compressive strength of geopolymer concrete cubes is determined using a compressive testing machine after three days and 28 days. As shown in table (.3.) the compressive strength results obtained.

Grade of Concrete	Molarity	3 Days Comp. Strength (Mpa)	28 Days Comp. Strength (Mpa)
M20	8M	13.48	29.62
M20	10M	15.26	31.39
M20	12M	17.03	33.17
M25	8M	16.80	32.43
M25	10M	18.57	34.21
M25	12M	20.35	35.98
M30	8M	20.41	42.80
M30	10M	22.19	45.02
M30	12M	23.97	47.24

Table.3: test results of the GPC

In addition, to compare the Compressive Strength of GPC to the Compressive Strength of Normal Concrete, normal concrete cubes were cast, and their strength was tested at three and 28 days. The compressive strength results are shown in Table 2.

Grade of Concrete	3 Days Comp. Strength (Mpa)	28 Days Comp. Strength (Mpa)
M20	10.22	20
M25	12.64	24.32
M30	15.98	29.62

Table.4: test results of the normal concrete.

Regarding the results which are obtained from the test of normal Concrete and geopolymer Concrete, it is concluded that the rate of the strength of geopolymer concrete was higher than the normal Concrete. At the ages of 3 days and 28 days, the maximum compressive strength of geopolymer concrete is higher than that of normal concrete. This rapid strength gain property allows geopolymer concrete to be used in places where a quick and reliable repair is required, such as highways. The quicker a highway can be fixed, the better it can be reopened, and traffic flow can be restored. The relationship between molarities and compressive was observed from the result, and it was obvious that increasing molarities increase the compressive strength of geopolymer concrete.

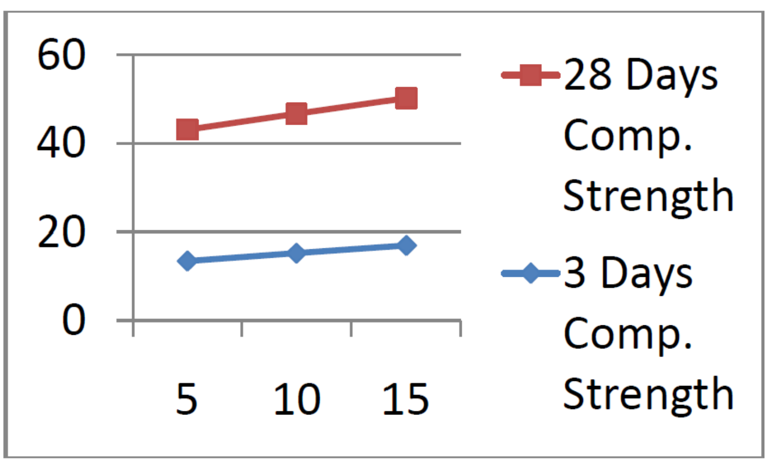

Fig.1: Compressive Strength of M 20 Grade GPC at 3 and 28 days of age for various molarities of NaOH Solution.

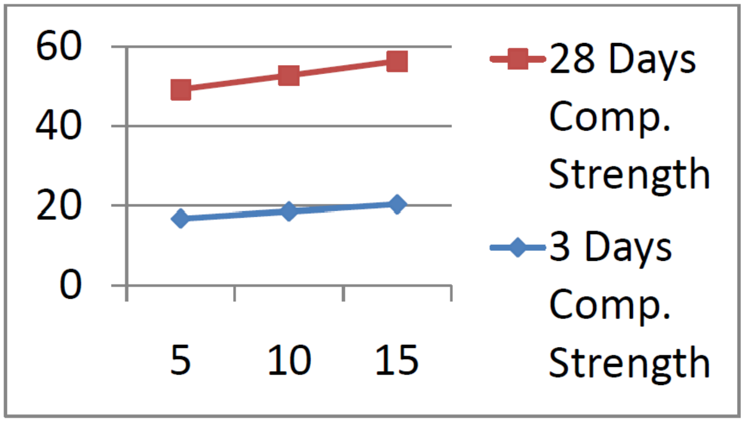

Fig.2: Compressive Strength of M 25 Grade GPC at 3 and 28 days of age for various molarities of NaOH Solution.

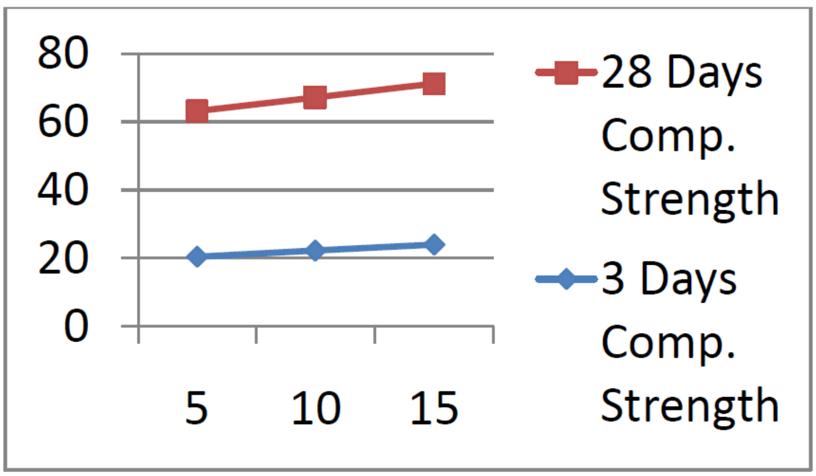

Fig.3: Compressive Strength of M 30 Grade GPC at 3 and 28 days of age for various molarities of NaOH Solution.

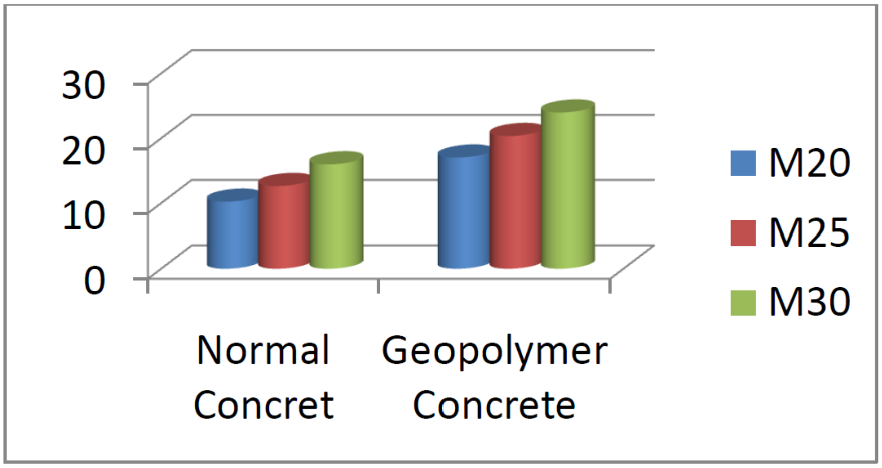

Fig.4: Compressive strength of concrete at the age of three days for various grades.

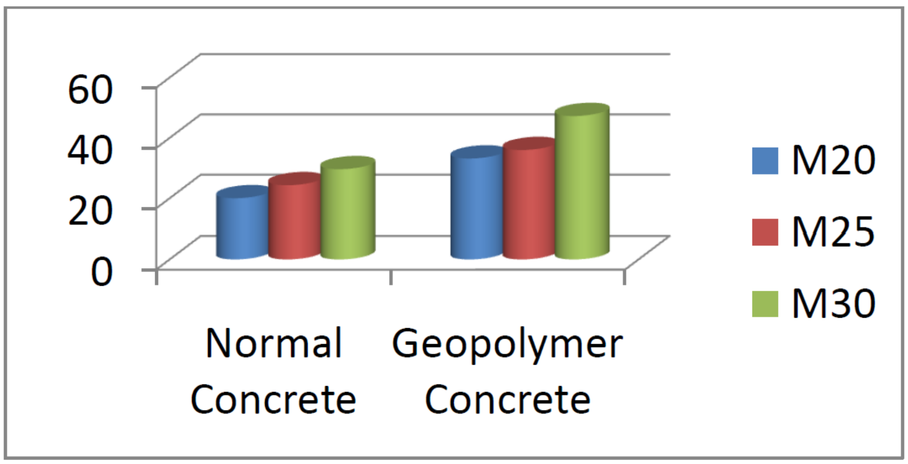

Fig.5: Compressive strength of the concrete at the age of 28 days for various grades.

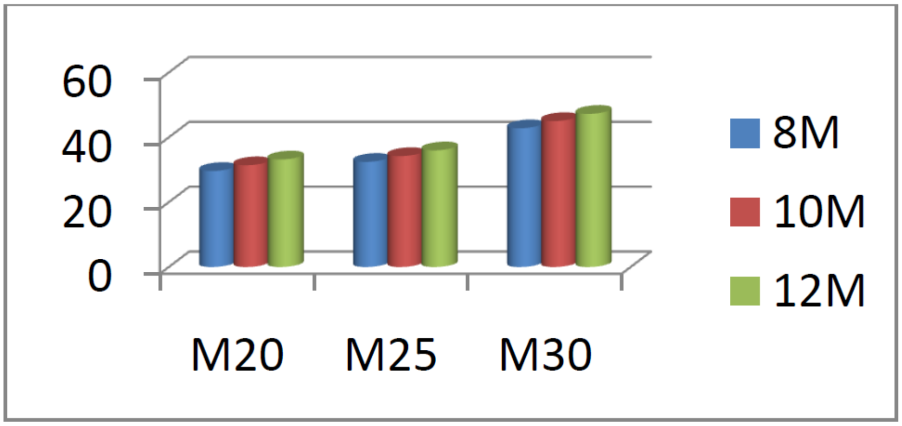

Fig.6: GPC Compressive Strength Variation at 28 Days for various Grades at various molarities of NaOH Solution.

Conclusion:

The project's goal is to identify a new technology that is being used around the world, which was discovered by scientists and civil engineering experts, as well as others who are concerned about the environment and understand the importance of using suitable materials in constructions to protect the environment and all of the animals who exist in it. Furthermore, the activated solution, also known as the alkaline solution, is an essential component of geopolymer concrete. Since this solution affects various properties of geopolymer concrete, especially compressive strength, another aim of the project is to determine the relationship between different molarities of the alkaline solution and compressive strength. The project's goal was accomplished by using a variety of sources to gather published and reliable information, such as articles for the literature review and a questionnaire to obtain accurate responses from civil engineering practitioners. The following are the key conclusions of the literature review:

- Geopolymer concrete is more effective than traditional concrete that contains Portland cement since it provides more stability, strength, and durability to structures.
- Geopolymer concrete has many properties, including becoming an environmentally friendly material, having easy-to-found components, high thermal insulation, fire resistance, and the ability to withstand extreme temperatures.
- It was apparent from all of the tests that the variation in molarity affects the compressive strength of geopolymer concrete proportionally, as increasing the molarity of NaOH in the mixture increases the rate of compressive strength.
- Different molarities affect velocity, as velocity rises as molarity rises in a certain combination.
- A combination of potassium hydroxide and potassium silicate is another solution that can be used in geopolymer concrete; however, it gives compressive strength to the concrete,

but at a lower level than the solution with sodium hydroxide; however, it is characterized by its shorter settling time than the solution with sodium silicate.

- Different qualities, such as tensile, break, and flexural strengths, may be influenced by different concentrations of NaOH, which increases with increasing molarity.
- Fly ash and GGBS are critical components in the production of geopolymer concrete because their reactions increase the concrete's strength while decreasing permeability.
- The effect of GGBS on compressive strength was investigated, and the findings revealed that increasing the ratio of GGBS increases the concrete's compressive strength. Furthermore, it was obvious from comparing many journals that the maximum compressive strength of 60MPa was achieved using 100 percent GGBS.
- Based on evidence from many journals, the optimal curing temperature for achieving maximal compressive strength is between 70 and 80 degrees Celsius.

The most important observations from the survey

- A large number of civil engineers have a strong understanding of geopolymer concrete, its importance, and its features, as shown by the fact that a large number of them provided reasonable and precise responses.
- The desire and readiness of Oman's population to consider modern approaches, such as using geopolymer concrete, was shown by the majority of responses, who were in favor of using geopolymer concrete because of its many advantages for buildings and the environment.

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