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An experimental study on Geopolymer concrete with varying molarity

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Abstract
The production and the utilisation of cement is increasing rapidly as the construction industry is growing day by day. Cement is very harmful to the environment as one kg of cement emits one ton of carbon-di-oxide. Production of geo-polymer concrete is also one of the best ways to reduce the pollution as this concrete completely omits the usage of the cement in the construction. This paper reviews about the influence of concentration of sodium hydroxide solution on strength parameters of geopolymer concrete. Flyash is taken from locally available factory. The molarity is varied from 8M to 14M. The specimens are heated at 60 ºC in hot air oven for 24hours. The results show that the geopolymer concrete has obtained its optimum strength at 12M for both 7 and 28 days. The results show that all mechanical properties of geopolymer concrete have the same optimum level achieved at same molarity. Results also states that, all the mechanical properties are improved than the normal concrete when compared to geopolymer concrete.

Keywords: Geopolymer concrete, molarity, strength

Introduction

Construction industry is rapidly growing sector in world as buildings construction is rising these days to meet the population needs. Cement should be produced in much quantity as it is the main material in the building sector. However, cement is very harmful for both humans and nature. So, researches are being made from long time to find out a very good alternative for cement. Replacement of materials is also necessary for better performance of special engineering applications.

Cement is extensively using in construction world. The increased demand for the manufacturing of cement leads to pollution through emission of greenhouse gases. Cement industry is solely accountable for 5 to 7% of CO2 emission into atmosphere. This is extremely hazardous and there is a need to reduce these emissions in atmosphere has to maintain the sustainability. In 2015, the production of Portland cement reached 4.1 billion tones globally it increases a very fast rate of 24% from 2010. As the population is increasing in the whole word, there is a huge demand for infrastructure. This leads to a high pressure on cement manufacturing industries. The main reason for carbon footprint is to increases the demand of infrastructure, necessity of production of concrete using natural materials also increased.

Geopolymer concrete is the best option one can make for an eco- friendly building. Geopolymer concrete is certain kind of concrete where cement is completely eliminated. In place of concrete, any material which is rich in silica and aluminum content is used. By this, we can also reduce the ground pollution by avoiding them to mix into soil.

The replacement of Portland cement by these industrial by-products reduces the release of greenhouse gases into the atmosphere which also avoids the pollution problems to some extent. Common type of alternative materials using for replacing cement in concrete are fly ash, ground granulated blast furnace slag, metakaolin, rice husk ash, palm oil fuel ash. Among, all the available cementitious materials, fly ash is the most available material and enormously used by many researchers.

Flyash is produced from coal combustion. In India above 100million tons of flyash is produced every year. This amount of waste is very large to get dispose. Due to the pozzolanic property of flyash, it is used as cement. It contains alumina and silica as main constituents.

Flyash is a good substitute for cement. Flyash improves workability, mechanical and durability properties and reduces heat of hydration.

Materials used in preparation of geopolymer concrete

1. Flyash
2. Fine Aggregate
3. Coarse Aggregate
4. For Alkaline Solution:
   a. Sodium Hydroxide (Pellets Form)
   b. Sodium Silicate (Liquid Form)
5. Water

Preparation of alkaline solution

- Alkaline Solution concentration is measured in molarity.
- Alkaline Solution should be prepared before 24 hours of mixing concrete.
- To prepare the alkaline solution, sodium hydroxide pellets are required.
- To get one molarity concentration of solution, 40grams of sodium hydroxide is mixed with one litre of water. (Sodium Hydroxide molecular weight = 40grams)
- So, to get required molarity of solution, molarity is multiplied with molecular weight of NaOH. i.e., to get 2 molarity, we have to mix 2X40=80 gms of NaOH.
- When NaOH is mixed with water, heat is generated. It takes 24 hours to get completely cool down. So, after 24 hours only it is acceptable to use.

Table 1: Properties of materials used in GPC

Material	Property	Value
Flyash	**Fineness**	
	(a) Sieve Analysis	43.33%
	(b) Blaine Apparatus	349 m²/kg
	Specific Gravity	3.12
Fine Aggregate	Specific Gravity	2.64
	Fineness Modulus	2.66
	Bulking of Sand	6%
Coarse Aggregate	Specific Gravity	2.84
	Fineness Modulus	7.94
	Flakiness Index	20%
	Elongation Index	18.16%

Mix design of geopolymer concrete

Geopolymer concrete does not have any standard mix design as there are many researches are going on. As there is no any standard mix design, some people use nominal concrete mix design for GPC production. Many types of mix designs are available for geopolymer concrete. But any of the designs are not given the standardstatus by the Indian Standard codes. Here, we are using the mix design which is proposed by Rangam B.V in 2008. This is very most commonly used mix design as it was one of the first most and almost accurate mix design proposed.

The quantity of ingredients obtained by mix design suggested by B.V. Rangam are tabulated.

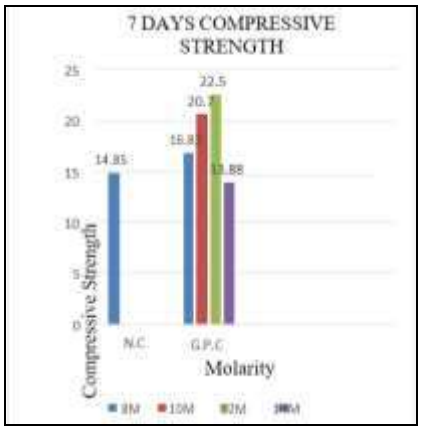
Table 2: Show the ingredients and extra water quantity

Ingredients	Flyash	NaOH	Na2SiO3	Sand	C.A	Total Water	Extra Water
Quantity (kg/m³)	363.5	42.4	84.817	624	1326	95	26.775
Proportion	1		0.35	1.717	3.648	0.261	0.074

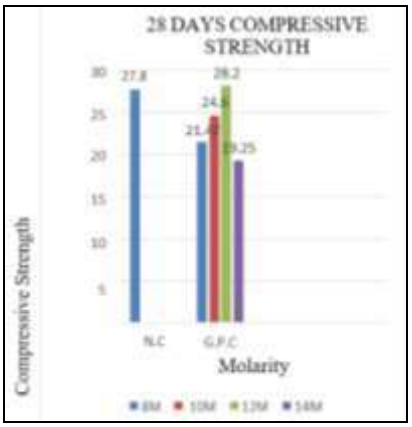
Results and Discussion

Table 3: The different of compressive strength split tensile and flexural

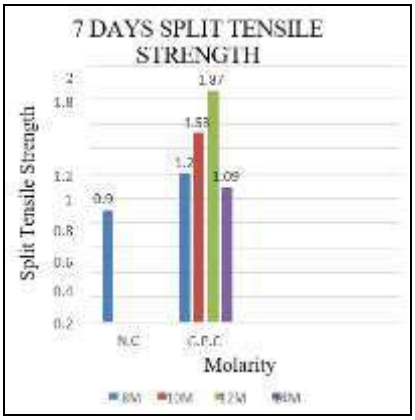
Molarity	Days	Compressive Strength (N/mm²)	Split Tensile Strength (N/mm²)	Flexural Strength (N/mm²)
8M	7	16.88	1.2	2.78
	28	21.47	1.96	3.24
10M	7	20.7	1.53	3.185
	28	24.6	2.25	3.472
12M	7	22.5	1.87	3.32
	28	28.2	2.59	3.713
14M	7	13.88	1.09	2.608
	28	19.25	1.78	3.017
Normal Concrete	7	14.85	0.9	3.19
	28	27.8	1.87	3.50



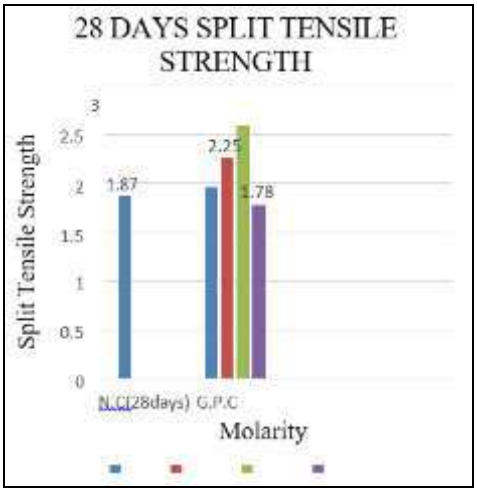
7 Days Compressive Strength



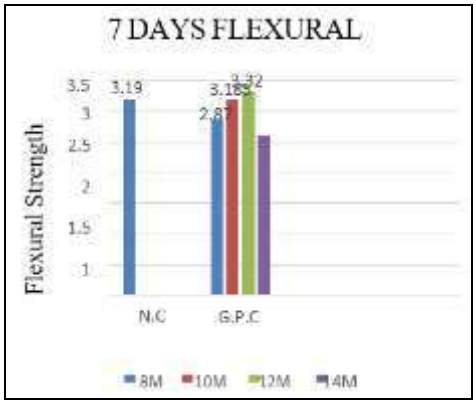
28 Days Compressive Strength



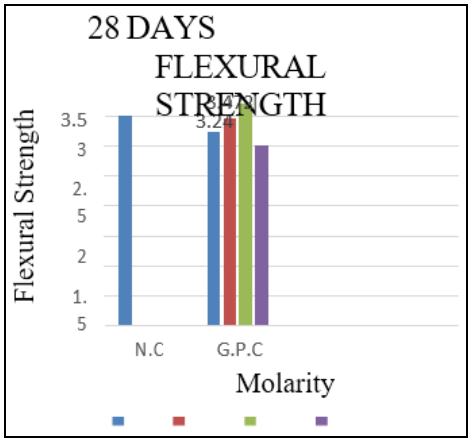
7 Days Split Tensile Strength



28 days split tensile strength



7 Days Flexural



28 Days Flexural Strength

Conclusions

- The concentration of the sodium hydroxide influences the strength of the geopolymer concrete.
- The highest compressive strength obtained for this geopolymer concrete is 28.2 N/mm² obtained for the 12M for both 7 and 28 days.
- The highest split tensile and flexural strength obtained are 2.59 and 3.71 N/mm² which are also obtained at the 12M for both 7 and 28 days.
- Compressive Strength is improved by 0.4%, Split Tensile Strength is improved by 0.72% and flexural strength is improved by 0.21% than nominal concrete.
- The increasing concentration of the sodium hydroxide leads to the formation of solids at the bottom of solution as well as it also leads to the decreasing of the strength of concrete after optimum level.
- Strength of GPC also depends on curing temperature. Increase in temperature leads to increase in molarity which leads to increase in strength.

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