Effect of Membrane Curing on Geopolymer Concrete

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ABSTRACT

The production of cement not only consumes huge amount of the natural resources i.e. limestone and fossils fuel but also produces almost 5 to 7% of the total production of carbon dioxide which causes green-house effect. So it is very essential to replace the ordinary Portland cement by the other binder which have the same or better properties than OPC. Geopolymer concrete is innovative green concrete in which binding properties are developed by the interaction of source material or by-product that is rich in silica and alumina i.e. Fly Ash, Ground granulated blast furnace slag (GGBS), Rice husk with alkaline solution of sodium hydroxide or potassium hydroxide and sodium silicate or potassium silicate. A by- product of coal like fly ash obtained from the thermal power plant reacting with alkaline solution produces alumino-silicate gel that acts as the binding material for the concrete. It utilizes a large amount of industrial waste materials such as fly ash and slag and also reduce the emission of carbon dioxide gases so it is eco-friendly and help to sustainable development. The main objective of this review to put the light on the constituents as well as various factors that can affect the compressive strength of geopolymer concrete. This paper also deals with the various application, economical and environmental benefits of geopolymer concrete.

Keyword : - *Geopolymer Concrete, Membrane Cured, fly Ash, Alkaline Solution.*

I. Introduction

Geopolymer is a new invention in the world of concrete in which cement is totally replaced by pozzolanic material that is rich in silica and alumina like fly ash and activated by alkaline liquids to act as a binder in the concrete. (Subhash V. Patankar, 2013). The demand of concrete is increasing day by day for satisfying the need of development of infrastructure facilities. It is well established fact that the production of OPC not only consumes significant amount of natural resources and energy but also releases substantial quantity of carbon dioxide to the atmosphere. Therefore, it is essential to find alternatives to make the concrete environment friendly.

Cement industries releases CO2 in the atmosphere, which is one of cause of global warming. Also, in Most of the fly ash is disposed off as a waste material that coves several hectors of valuable land. So, efforts are needed to make concrete more environmental friendly by using fly ash which helps in reduce global warming as well as fly ash disposal problem. (Satpute Manesh B,2012). Thermal Power Plant are the two major issues concern with the environmental pollution and human health. Both these issue can be solve partially by utilizing fly ash in concrete by partial or full replacement of cement. Geopolymer concrete is a new cementitious material which is produced by chemically activation of fly ash with highly alkaline solutions like sodium hydroxide and sodium silicate.

II. Literature Review

S. S. Jamkar et al [1] have highlighted on the effect of fly ash fineness on the compressive strength of geopolymer concrete. The specimens were cured in an oven for 4, 8, 12, 16, 20 and 24 hours at 90°C. The compressive strength results show that the fly ash fineness plays a vital role in the activation of geopolymer concrete. An increase in the fineness increased both workability and compressive strength. It was also observed that finer particles resulted in increasing the rate of reaction needing less heating time to achieve a given strength.

Subhash Patankar et.al [2] recommended that effect of concentration of sodium hydroxide, temperature, duration of heating, and test period on the development of geopolymer mortar. It is observed that the workability as well as compressive strength of geopolymer mortar increases with increase in concentration of sodium hydroxide solution in terms of molarity. It is also observed that the compressive strength of geopolymer concrete increases with increase in test period up to three days. The suitable preparation of geopolymer mortar, 13-molar solution of sodium hydroxide is recommended on the basis of workability and compressive strength.

Prakash R. Vora et.al [3], have described the experimental work conducted by casting 20 geopolymer concrete mixes to evaluate the effect of various parameters affecting its the compressive strength in order to enhance its overall performance. Various parameters i.e. ratio of alkaline liquid to fly ash, concentration of sodium hydroxide, ratio of sodium silicate to sodium hydroxide, curing time, curing temperature, dosage of super plasticiser, rest period and additional water content in the mix have been investigated. The test results show that compressive strength increases with increase in the curing time, curing temperature, rest period, concentration of sodium hydroxide solution and decreases with increase in the ratio of water to geopolymer solids by mass & admixture dosage, respectively. The addition of naphthalene based superplasticiser improves the workability of fresh geopolymer concrete. It was further observed that the water content in the geopolymer concrete mix plays significant role in achieving the desired compressive strength.

Satpute Manesh B et.al[4] have studied of effect of duration and temperature curing on compressive strength of geopolymer concrete. Geopolymer concrete is manufactured by cement fully replacing with processed fly ash which is activated by alkaline solutions like Na2Sio3 and NaoH. Cubes of size 150mm X 150mm X 150mm were made at solution to fly ash ratio of 0.35 with 16 Mole concentrated sodium hydroxide solution. The specimens were cured in oven at 60°C, 90°C and 120°C for 6, 12, 16, 20 and 24 hour’s duration. Test results show that the compressive strength increases with increase in duration and temperature of oven curing up to 24 hrs.

Subhash Patankar et.al [5] studied that the flow of geopolymer concrete increases with increase in water-to-geopolymer binder ratio after changing the quantity of water. Geopolymer concrete becomes more viscous with decrease in water-to-geopolymer binder ratios because of the less quantity of water in the mixture. The compressive strength of geopolymer concrete is inversely proportional to the water-to-geopolymer binder ratio. Suitable range of this binder ratio is in the range of 0.25 to 0.35.

Sandeep Hake, et al [6], the oven heat curing of geopolymer concrete has been attempted by various researchers, but for curing of geopolymer concrete is quite difficult on site by using oven, so there is scope on types of curing which makes geopolymer concrete cure easily. The oven heat curing for geopolymer concrete is mostly used. The researchers studied only for different curing temperature in oven curing, but only few of them work on steam, membrane curing and no one work on accelerated curing, as well as comparison on steam, accelerated, membrane, natural and oven curing. So there is scope on method of curing of geopolymer concrete. Also researchers studied for different curing time like 6,12,18,24 and the optimum strength obtained at 18 Hrs of Curing. The different curing temperatures like 60°C, 90°C, 120°C and 150°C. The different type of curing like Oven, Accelerated, Membrane and Steam curing are need to be Study. The effect on compressive strength of Geopolymer concrete by using these parameter need to be study.

Davidovits introduced the term geopolymer in 1978 to represent the mineral polymers resulting from geochemistry [7]. Geopolymer are a class of inorganic polymer formed by the reaction between the alkaline solution, silica and alumina present in source material. The hardened material has an amorphous 3-dimensional structure similar to that of an alumino silicate glass. However unlike a glass these materials are formed at low temperature and as a result can incorporate an aggregate skeleton and a reinforcing system if required, during the forming process. The most common activator is a mixture of water, sodium hydroxide and sodium silicate but other alkali metal systems or mixtures of different alkalis can be used.

Djwantoro Hardjito and etal. [8] studied the influence of curing temperature, curing time and alkaline solution-to-fly ash ratio on the compressive strength. It was reported that both the curing temperature and the curing time influenced the compressive strength. The authors confirmed that the temperature and curing time significantly improves the compressive strength, although the increase in strength may not be significant for curing at more than 60°C. In addition, the compressive strength decreases when the water-to-geopolymer solids ratio by mass increased. The drying shrinkage strains of fly ash based geopolymer concretes were found to be significant.

Subhash V. Patankar et al.[9] studied the effect of quantity of water, temperature duration of heating on compressive strength of fly ash based geopolymer concrete. Na2Sio3 solution containing Na2O of 16.45%, SiO2 of 34.35% and H2O of 49.20% and sodium hydroxide solution with concentration of 13 Molar were used in geopolymer concrete as alkaline activators. Geopolymer concrete mixes were prepared with 0.35 solutions to processed fly ash ratio. Workability was measure by flow table apparatus. Geopolymer concrete cubes of 150 mm X 150 mm X 150 mm were cast. The temperature of curing was varied as 40°C, 60°C, 90°C, and 120°C for each period of 8, 12 and 24 hours of oven heating and tested after a rest period of 1,2,3,7and 28 days after demoulding the concrete cube. Test results show that the quantity of water plays important role in balancing workability but not effect on strength. While higher temperature requires less duration of heating to achieve desired strength and vice versa. Author says that the rest period of 3 days is sufficient after heating at and above 900C temperature

V.M. Malhotra [10] uses the fly ash in 1930 as a workability-improving admixture. Later on its application increases as people are aware about pozzolanic reactivity of fly ash. It is used in the manufacture of Portland Pozzolana Cement (P.P.C.), partial replacement of cement and workability-improving admixture in concrete. But its utilization is limited to 20% throughout the world. An important achievement in this regard is the development of high volume fly ash (HVFA) concrete that utilizes up to 60 percent of fly ash, and yet possesses excellent mechanical properties with enhanced durability performance.

III. Materials and Mixing

The geopolymers concrete mainly includes alkaline solution, fly ash, aggregate. The properties of materials are explain as follows:

3.1 Source materials:

Fly ash is a by-product of burning pulverized coal in an electrical generating station. Two classes of fly ash are defined by ASTM C618: Class F fly ash and Class C fly ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned (i.e., anthracite, bituminous, and lignite). Class C Fly ash produced from the burning of younger lignite or sub bituminous coal and having more than 20% lime (CaO). In addition to having pozzolanic properties. The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash and having less than 10% lime (CaO). This fly ash is pozzolanic in nature, and require some activator. . GGBS is a byproduct as it is produced during extraction of iron from ore. Silica fume, Containing silica, silicone or silicone-or micro-alloys produced by the production of a product by itself. SF is an amorphous solid high silica content with.

3.2 Alkaline solution

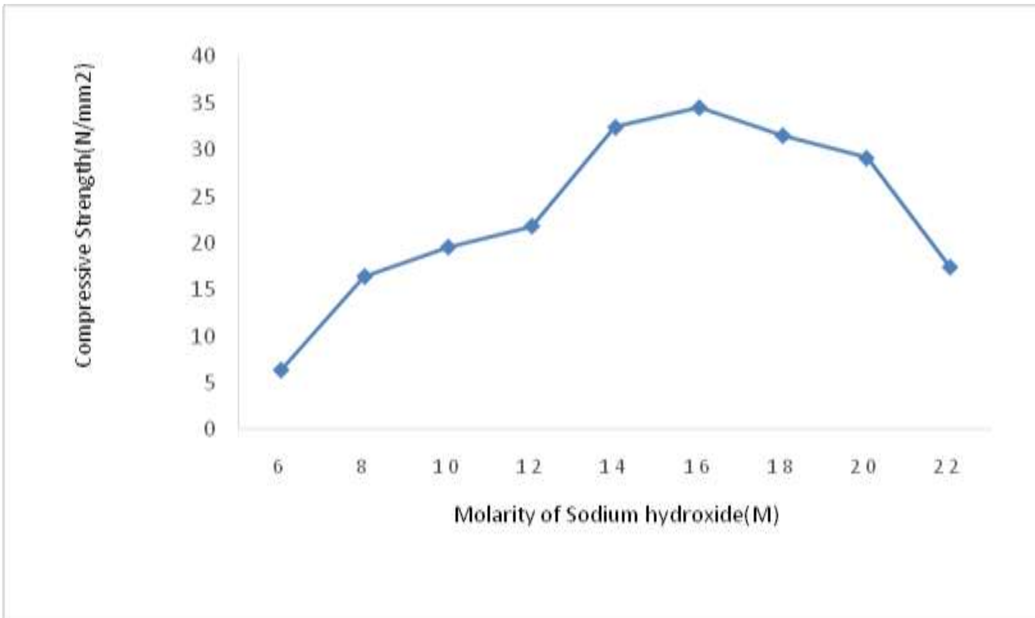
The common materials used as alkaline solution in producing fly ash-based geopolymers are sodium silicate and potassium hydroxide or sodium hydroxide. Generally NaOH is available in market in pellets or flakes form with 96% to 98% purity where the cost of the product depends on the purity of the material. The solution of NaOH was formed by dissolving it in water with different molarity. It is recommended that the NaOH solution should be made 24 hours before casting. Sodium Silicate (Na2SiO3) is also known as water-glass which is available in the market in gel form and also in the solid form. The ratio of silicon dioxide (SiO2) and sodium oxide (Na2O) in sodium silicate gel highly affect the strength of geopolymer concrete. Mainly it is seen that a ratio ranging from 2 to 2.5 gives a satisfactory result. Usually the sodium silicate which in the form of gel mixed with sodium or potassium hydroxide to produce the alkaline solution. The alkaline solution is prepared a day before it is mixed with fly ash. Then, the materials are mixed together with fine aggregate and coarse aggregate to form concrete and curing process is done.

3.3 Mixing, Casting and Curing of Geopolymer Concrete Specimens

The geopolymer concrete is made up of using fly ash, fine aggregate, Coarse aggregate and alkaline liquid. The alkaline liquids are Sodium hydroxide (NAOH) and Sodium Silicate (Na_2Sio_3). The sodium silicate to sodium hydroxide ratio used is 2.5 and the solution to fly ash ratio is 0.61 [4]. The mass of combined aggregates may be taken to be between 75% and 80% of the mass of geopolymer concrete. In the laboratory, the fly ash and the aggregates is first mixed together in dry state 2-3 minutes to get homogeneous mix. The alkaline solutions which were made one day before is mixed with the super plasticizer and the extra water, if any. This liquid component are added to the mixed aggregate and the mixing continued usually for another 10 - 15 minutes so that binding paste covered all the aggregates and mixture become homogeneous and uniform in color. For preparing say if 16 Mole solution of Sodium Hydroxide in one liter solution the following steps to be adopted. For preparation of 1M solution there is requirement of 40 gms sodium hydroxide pellets in solid form. While we mix 40 gms pellets in one liter solution then we get 1M sodium hydroxide solution. The heat evaluation rate is so high at the time of mixing pellets into water. Due to Sodium hydroxide solution was prepared one day prior to the casting of concrete cubes to avoid any contamination during the mixing of ingredients of geopolymer concrete. Similarly, we prepare 16 M solution for geopolymer concrete by adding 16 X 40 = 640 gms sodium pellets then we get 16 M one liter sodium hydroxide solution. such way with varying molarity from 1M to 22M solutions were prepared and accordingly testing is carried out. The required quantity of Sodium Hydroxide solution and sodium silicate solution with proper proportion was added and mixed until homogeneous mix was formed. After making the homogeneous mix, workability test by slump cone and compaction factor is determined . Then, cubes of size 150 mm X 150 mm X 150 mm were cast in three layers as per standard process. Then after demoulding of cube these cube placed for curing of geopolymer concrete. The specimens are wrapped by plastic sheet(membrane for curing) to prevent loss of moisture and placed in an oven for the specified period. And kept for membrane Curing at various temperatures like 60^0C,90^0C,120^0C,150^0C and tested for respective temperature. These cubes were placed at room temperature after curing up to the testing age. Testing age also varies from 1, 3, 7, 14, 21, 28, 56 days. the testing is carried on CTM with variable parameters. The fresh fly ash-based geopolymer concrete is usually cohesive. The workability of the fresh concrete is measured by means of the conventional slump test. In geopolymer concrete, the high temperature curing is required for the polymerization process. The required temperature may be provided either by oven curing or by steam curing. In membrane curing, the specimens are wrapped by plastic sheet to prevent loss of moisture and placed in an oven for the specified period. After the curing period, the test specimens left in the moulds for at least 4-6 hours in order to avoid a major change in the environmental conditions. After de-moulding, the concrete specimens are allowed to become air-dry in the laboratory until the day of the testing.

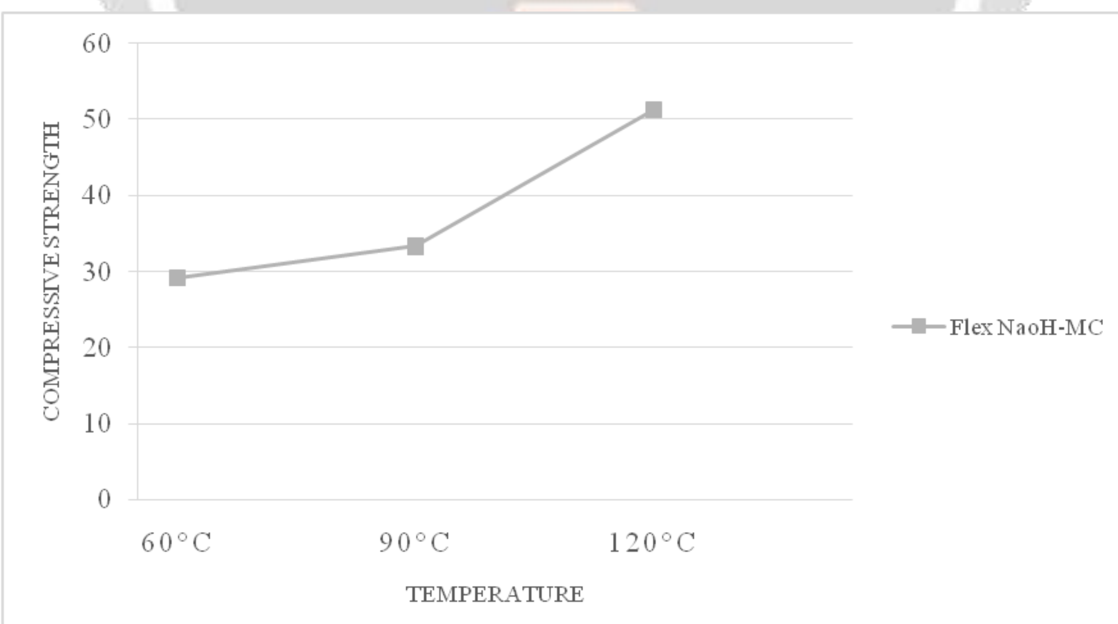
IV. Results and Discussion

4.1. Effect of of Molarity on Membraned cured GPC

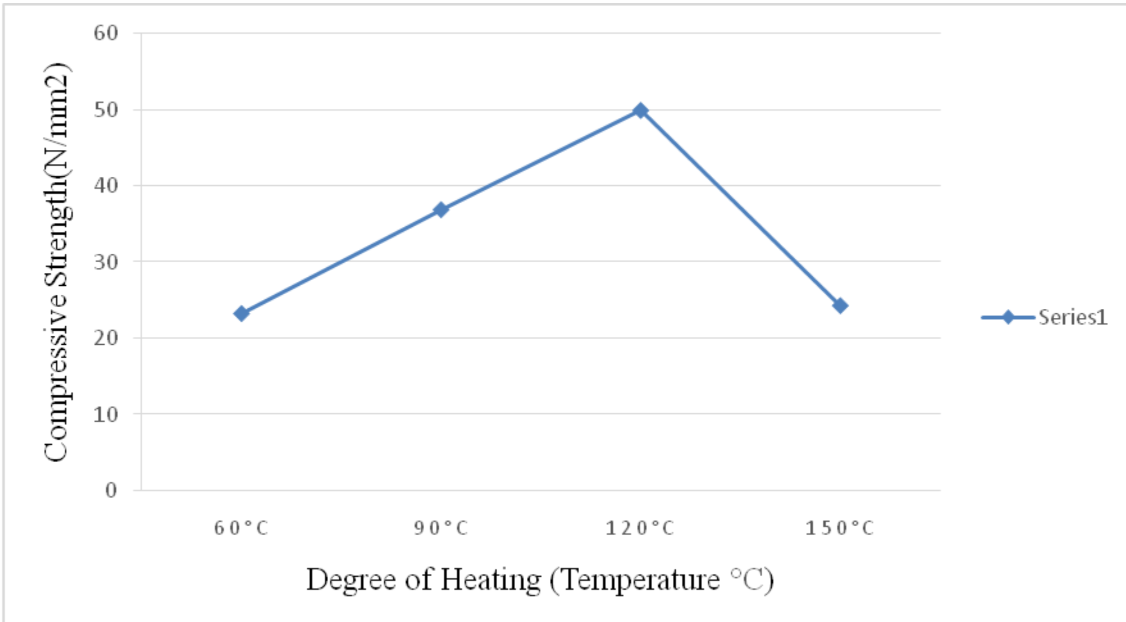


4.2. Effect of Flex and Pallets form of Sodium Hydroxide

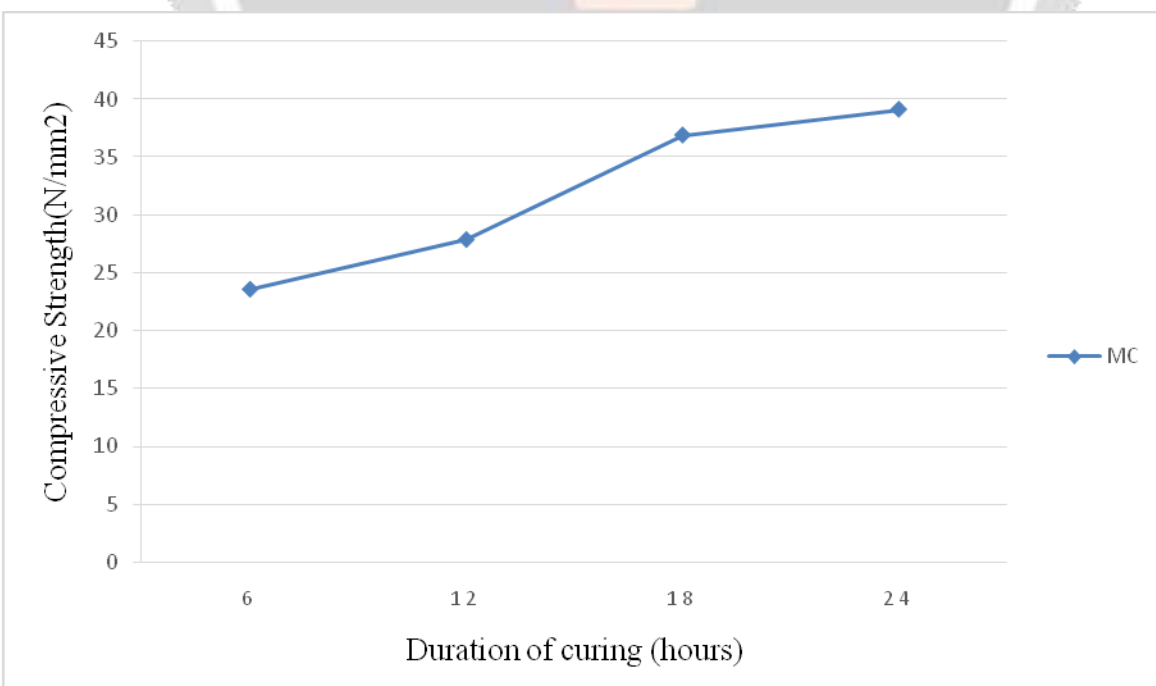
a. Effect of Flex Form of Sodium Hydroxide



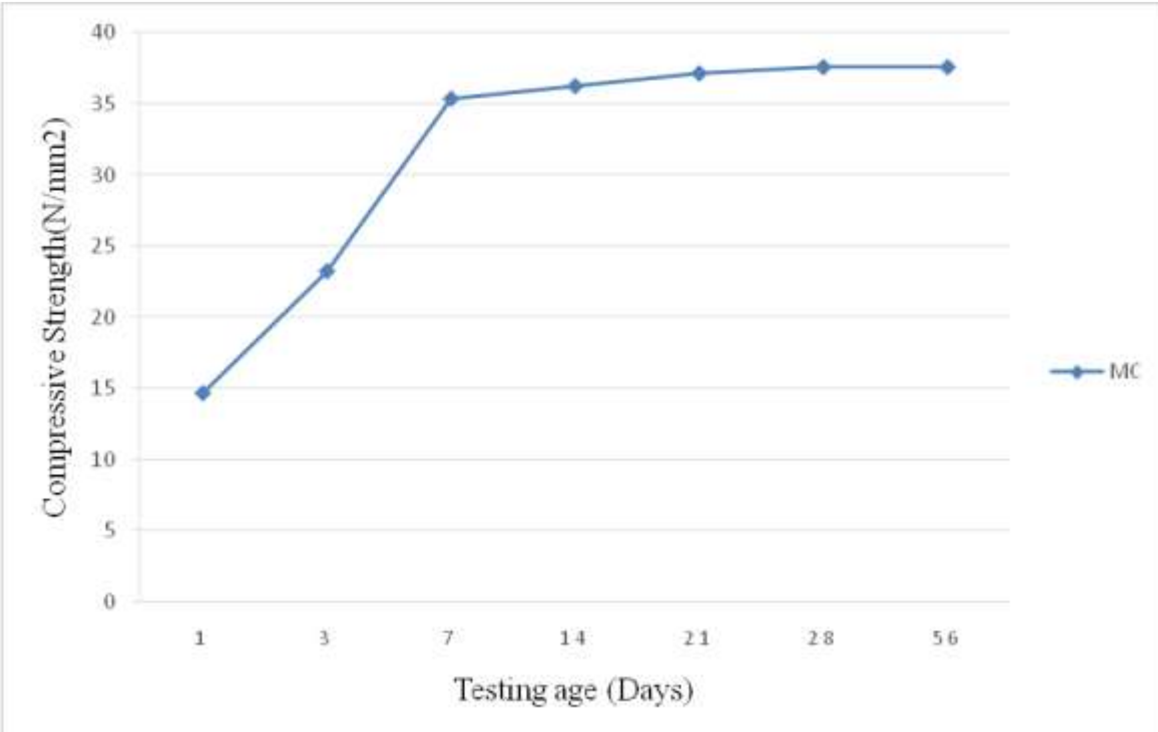
4.3. Effect of Temperature on Membrane cured GPC



4.4. Effect of Duration of curing of membrane cured GP



4.5. Effect of testing age of membrane cured GPC



V. Conclusion

1. The membrane Cured GPC shows the higher strength as compare with oven cured Geopolymer concrete.
2. It is observed that the due to membrane curing the moisture losses is entrapped by polythene bag.
3. The Temperature required for polymerization is less in case of membrane curing.
4. The rate of gain of compressive strength at seven day is high but after that the gradual increasing in strength for membrane cured Geopolymer concrete.

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