

Effect of Alkaline Solution on Different Types of Fly Ash of GPC.

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Abstract: Cement industry plays major role for emission of greenhouse gasses. So, there is need for manufacturing of environmental friendly concrete. Geopolymer concrete helps in reduce global warming as well as fly ash disposal problem. This paper presents study the effect of types of curing, temperature, curing time and rest period. These parameters were studies like one variable parameter and other three are fixed parameter. One by one these parameters were finalize. The types of curing analyze with temperature optimization, rest period and curing time of geopolymer concrete. The type of curing like oven, accelerated, membrane, steam, wet and natural sun light (room temperature). The temperature differs like 60⁰C, 90⁰C, 120⁰C and 150⁰C. Once the temperature for type of curing is lock then proceed to curing time i.e. 6, 12, 18 and 24 hours. At the end temperature, type of curing and curing time finalize then optimize the rest period or testing age of concrete. The rest period differ like 1, 3, 7, 14, 21, 28, 56 days. In this study these variable are to be analyze with the help of compressive strength of geopolymer concrete.

Keywords: Geopolymer concrete, type of curing, temperature, fly ash, curing time, rest period.

1. INTRODUCTION

In the geopolymer concrete, cement is totally replaced by fly ash (pozzolanic material) that is rich in silica and alumina and activated by alkaline liquids like sodium hydroxide and sodium silicate. Fly ash used as binder material of concrete. For the infrastructure development require huge quantity of concrete. It is well known fact that the production of OPC not only consumes significant amount of natural resources and energy but also releases huge quantity of carbon dioxide to the atmosphere. Therefore, it is necessary to find alternatives to make the concrete environment friendly with consideration of natural resources and atmospheric pollution.

Annually more than 100 million tons of fly ash is produced in India. The hectares of land required for dumping of wastage fly ash. On the other hand CO₂ emission causes greenhouse gasses. Cement industries emits more CO₂ in environment. If we use geopolymer concrete as an alternative to ordinary concrete which reduce greenhouse gasses as well fly as disposal problem. In geopolymer 100% fly ash used as binding material. For polymerization of geopolymer concrete require heat, due to this it is needy to study the types of curing and temperature variation of geopolymer concrete.

2. RESEARCH REVIEW

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 temperatures effect observed at 60⁰ C, 90⁰ C, 120⁰C and 150⁰C. The different type of curing i.e. Oven, Accelerated, Membrane and Steam curing were study and optimize. (Sandeep L. Hake et al, 2015).

The behavior of Fly ash based Geopolymer Concrete Solid Blocks and its Durability, the size of the block were adopted was 200mm x 200mm x 400mm. The brick were cast with fly ash to river sand,

M-sand and eco-sand (silica sand) with the ratio of 1:2.5 by weight. Sodium hydroxide and Sodium silicate solution were used as the alkaline activators in geopolymer concrete. The binder solution consists of a combination of NaOH and Na₂SiO₃ solution in the ratio of 1:2.5. The water/binder ratio is the ratio of solution (NaOH, Na₂SiO₃ and water) to fly ash. Totally 60 blocks were casted in this study under ambient curing. The blocks were cast with different types of sand with river sand, M-sand and eco-sand (silica sand). The experimental results obtained were compared with locally available Cement Solid Blocks (Sayyad and Patankar, 2013).

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 40⁰C, 60⁰C, 90⁰C, and 120⁰C for each period of 8, 12 and 24 hours of oven heating and tested after a rest period of 1, 2, 3, 7 and 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 (Subhash V. Patankar, 2013)

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 60⁰C, 90⁰C and 120⁰C 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 hours (R. Anuradha, 2012).

The ratio for alkaline solution increases, the workability of mix goes on increasing. The study showed that the strength of geopolymer concrete can be improved by decreasing the water/binding and aggregate/binding ratios. It was observed that water influences the Geopolymerization process and the hardening of concrete. Inclusion of increased binder content enhances the Geopolymerization and affects the final strength. The optimum dosage for alkaline solution, which is used a geopolymer binder can be considered as 2.5, because for this ratio, the GPC specimens of any grade produced maximum strength results with compression and tension. The fly ash can be used to produce geopolymer binder phase which can bind the aggregate systems consisting of sand and coarse aggregate to form geopolymer concrete (GPC). Therefore these concretes can be considered as eco-friendly materials (Shankar H. Sanni et.al, 2013)

3. METHODOLOGY

The geopolymer concrete was design for characteristics strength of M30 grade. The mix proportion for M30 grade (R. Anuradha, 2012). The cement is totally replaced by Pozzocrete fly ash P60. For the mixing of solution to fly ash ratio maintained as 0.35 for all types of curing. The alkali activators ratio i.e. sodium silicate to sodium hydroxide solution ratio is 2.5. The rest period for GPC is of 7 days and curing time for concrete 18 hrs. The optimization of curing time and rest period was also study in this paper. The different types of curing were studied oven, steam, membrane, wet, natural sun light and accelerated curing. In this study, the fresh geopolymer concrete were found by proper mixing of dry solid and activators. The geopolymer concrete is made up of using fly ash, fine aggregate, coarse aggregate and alkaline liquid. The Pozzocrete P60 fly ash obtained from India Dirt Pvt. Ltd. The alkaline liquids are Sodium hydroxide (NAOH) and Sodium Silicate (Na₂SiO₃). The sodium silicate to sodium hydroxide ratio used is 2.5 and the solution to fly ash ratio is 0.35. The pallets form of sodium hydroxide lab grade was obtained from market. The sodium silicate obtained from market in the liquid form. For preparation of 1M solution 40 grams of sodium hydroxide pellets of solid form was used. While we mix 40 grams pellets in one liter solution then we get 1M sodium hydroxide solution. Similarly, we prepare 16 M solution for geopolymer concrete by adding 16 X 40 = 640 grams sodium hydroxide pellets then we get 16 M one liter 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.

In the laboratory, the dry mix of fly ash and aggregate were mixed in pan mixer. Then, required quantity of Sodium Hydroxide solution and sodium silicate solution with extra water 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 various methods are adopted for Oven, Steam, Accelerated and Membrane Curing at various temperatures like 60⁰C, 90⁰C, and 120⁰C. These cubes were placed at room temperature after curing up to the testing age. The testing age for cube will be assumed as 7 day which was fixed from past literature review. The processed and unprocessed types of fly ash analyze with the pallet and flex form of sodium hydroxide and sodium silicate. The processed fly ash contain the silicon and aluminum oxides in the low-calcium fly ash reacts with the alkaline liquid to form the geopolymer paste that binds the loose coarse aggregates, fine aggregates, and other un-reacted materials together to form the geopolymer concrete. The flex and pallets form of sodium hydroxide plays important role in polymerization the bond strength of flex form is less as compare to pallets form [14].

4. RESULT AND DISCUSSION

The initial parameters for geopolymer concrete were analyzing with the type of fly ash and the type sodium hydroxide activators. The unprocessed and processed fly ashes are optimizing with flex and pallets form of sodium hydroxide solution (Sandeep L. Hake, 2016). Then rest period, curing time, temperature and different curing condition of concrete were analyzed. This parameter were optimize one by one. While studying one parameter other two parameter lock with reference of past literature survey. Once the rest period lock then go for the curing time. The rest period and curing time optimize then study for temperature of geopolymer concrete.

4.1. Analysis of fly ash with Pallets form of Sodium Hydroxide and Silicate

The compressive strength for processed fly ash was study with temperature variation. It is observed that the strength for P100 is much higher than other but the cost of the P100 processed fly ash is much higher than other. As we consider for economy the characteristics strength of M30 grade concrete obtained for P60 grade of processed fly ash, so for the further study the P60 grade processed fly ash was used. As well unprocessed fly were analyze with pallets form of sodium hydroxide and procured from bhusawal, nashik & beed thermal power plant at different temperature 80⁰C, 100⁰C and 120⁰C in figure 1.

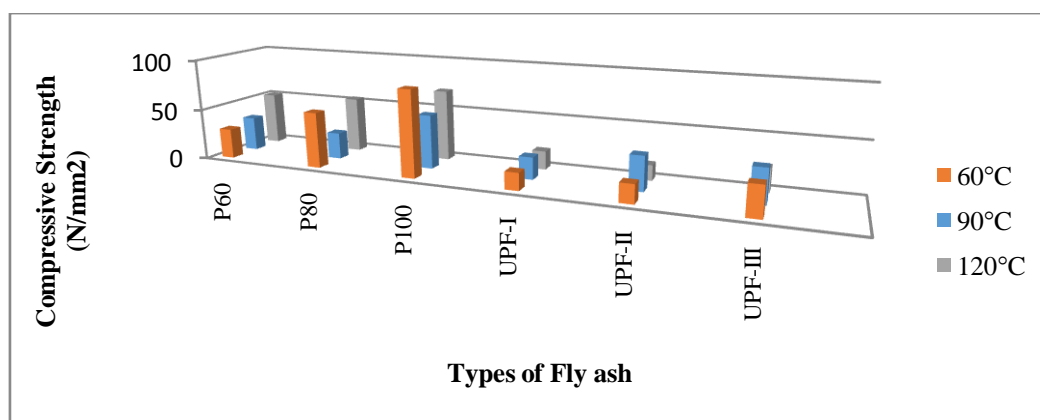


Figure1. Compressive Strength for pallets form of NaOH with types of fly ash

4.2. Analysis of fly ash with Flex form of Sodium Hydroxide and Silicate

The figure 2 shows the compressive strength behavior of processed and unprocessed fly ash. The effect of sodium hydroxide flex form on different types of fly ash was analyzed. As seen the strength for P100 is higher than the other but the cost of the fly ash is more as compare to other types of processed fly ash with consideration of economy the P60 type of processed fly ash is cheaper. These fly ash analyze with different temperature like 60⁰C, 90⁰C and 120⁰C.

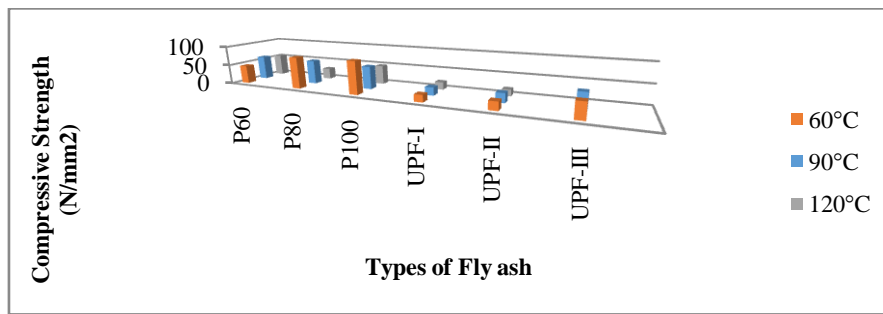


Figure2. Compressive Strength for Flex form of NaOH with types of fly ash

4.3. Analyze Result For Rest Period

The compressive strength of rest period for oven, steam, membrane, accelerated, wet and natural sun light curing at different temperature were analyzed. The rest period analyze for 1, 3, 7, 14, 21, 28 and 56 days. The temperature of oven and membrane curing maintained at 90°C. The temperature for steam curing maintained at 120°C and also for accelerated curing it was maintained at 90°C. The cubes were placed for room temperature for natural sun light curing as well as conventional curing method adopted for geopolymer concrete. As the rest period of concrete increases the compressive strength increases. The compressive strength at 28 and 56 days was not considerable. As we seen in graph 1 the 7 days rest period gives target strength.

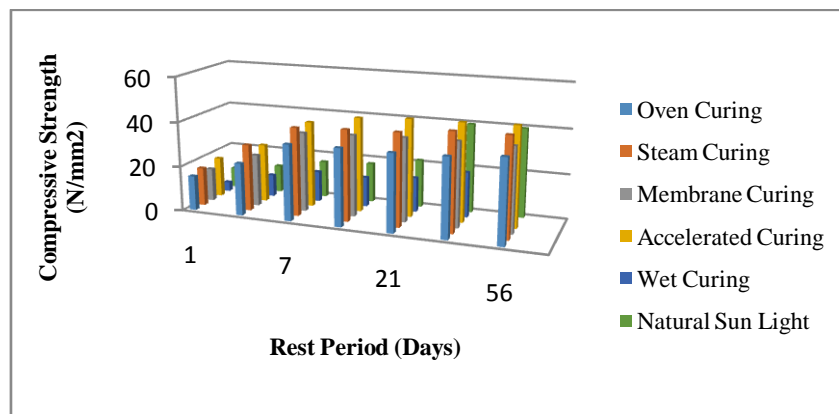


Figure3. Compressive Strength of GPC for curing and Rest Period

4.4. Analyze Result For Curing Time

The Compressive Strength of different types of curing with the help of curing time. The curing time varies with 6, 12, 18 and 24 hours. For higher temperature the curing time reduces. For oven and membrane curing the temperature optimize at 90°C. But in case of steam it was optimize at 120°C and for accelerated curing it was 90°C for these temperatures the curing time optimize at 18 hours of all types of curing.

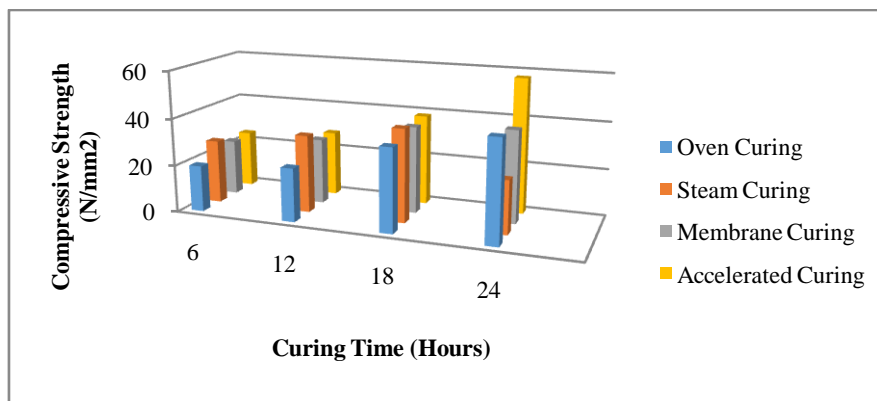


Figure4. Compressive Strength for different curing and its time.

4.5. Analyze Result for Temperature Variation.

Figure 5 shows the effect of temperature variation and different type of curing on geopolymer concrete. In oven heat curing the temperature varies from 60 °C to 150 °C the optimum result we get at 90 °C with consideration of energy for heating.

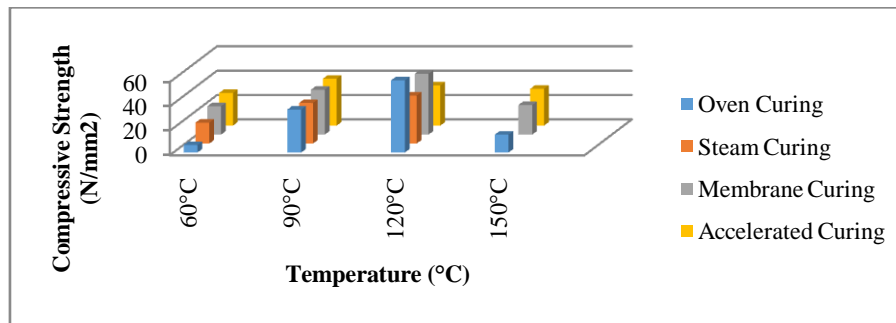


Figure5. Compressive Strength for temperature variation and curing type.

In Accelerated curing the effect of temperature on geopolymer concrete will show the optimum result at 120°C. Also in membrane curing the effect of temperature varies from 60°C to 150°C the optimum result we get at 90°C. In case of Steam curing the temperature optimize at 120°C.

5. CONCLUSION

Based on investigation, the following conclusions have been drawn.

- The effect of pallets and flex form of sodium hydroxide activator on processed and unprocessed fly ash were analyzed and seen that the activators play important role for achieving the strength of geopolymer concrete.
- The types of fly ash specifically fineness affect the compressive strength of geopolymer concrete.
- In geopolymer concrete after 7 days the compressive strength of concrete achieves their target strength.
- It is seen that, in natural sun light curing target compressive strength achieves at 28 days. And also wet curing not suitable for geopolymer concrete.
- The compressive strength of geopolymer concrete achieves at 90°C, 120°C for oven and steam curing as well membrane and accelerated curing respectively.
- In short period of curing time i.e. 18 hrs the polymerization of geopolymer concrete takes place and gives considerable target strength.
- It is observed that, the target compressive strength of concrete achieves at 90°C for oven curing and also after that the strength increases up to 120°C but at 150°C the strength of concrete losses his compressive strength due to overheating.
- In case of steam curing the compressive strength achieved at 100°C after that the strength increases but energy consumption for steam generation is more so it is optimize at 100°C.
- In Accelerated Curing, the optimum result we will get at 90°C in this case the compressive strength suddenly decreases with increase in temperature.
- In case of Membrane curing the target compressive strength obtained at 90°C due to consumption of electricity this parameter optimize at 90°C while considering economy.

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Citation: S. L. Hake et.al, “Effect of Alkaline Solution on Different Types of Fly Ash of GPC.”, *International Journal of Constructive Research in Civil Engineering*, 4(2), pp. 21-26. DOI: <http://dx.doi.org/10.20431/2454-8693.0402004>

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