Analysis of Cementless/Geopolymer Concrete Properties with Change in Molarity and Varied Proportions of Fly Ash and GGBS.

Shivam Soni[1]

[1]*Shivam Soni, Student, CEPT University, Faculty of technology, Ahmedabad.*

Abstract - *This study aims at investigating the factors that affect certain fresh and hardened properties of Cementless (geopolymer) concrete. The major inclination of the study is based upon the properties like settling time, workability, and the compressive strength of the Cementless concrete. The research shall also investigate the curing methodology of Cementless concrete which is heat/oven curing and the aim will also be to develop a recipe that eliminates the need for heat curing in Cementless concrete. The development of Cementless concrete is based on the process called Geopolymerization. All the factors affecting the properties of the Cementless concrete listed above will be analyzed and will be followed by a conclusion.*

Key Words: Cementless concrete, Geopolymerization, Geopolymer concrete, Green concrete, Greencrete

1.INTRODUCTION

Carbon emissions across the world have been increasing and have become a topic of concern. Climate change and global warming are the results of the rapid increase in carbon emissions. According to the GCCA (GCC Association) Concrete is the most used man-made material on the planet and the second most used material after water on earth, cement is the major component in the manufacturing of concrete as a material. Cement manufacturing is one of the major industries contributing to the increase in carbon emissions. Cementless concrete/Geopolymer concrete is the need of the hour as it is concrete which is free from cement and has constituents like Fly ash which is an industrial by-product along with G.G.B.S which is also an industrial by-product, these materials are mixed with alkali activators along with coarse aggregates and fine aggregates to get a material called as Cementless concrete/Geopolymer concrete. The curing process of cementless concrete is something that is a challenging task and it is also considered as a drawback of the cementless concrete or the process of geopolymer concrete. The molarity of the alkaline solutions also plays an important role in the strength of cementless concrete. Through this research and study on the material, an effort has been made to minimize the limitations associated with cementless concrete/geopolymer concrete of heat curing and settling time of the concrete.

1.1 Designation of mix proportions

The given designations were adopted and given to the mixture proportions for further reference. **%F%GXM** which stands for % of fly ash (F) + % of GGBS (G) + 'X' Molarity of the alkaline solution. For example, **60F40G8M** says **60% fly ash + 40% GGBS with an 8 molarity concentration** of the alkaline solution (Aanal shah).

1.2 Trial mix for pilot study

The application determines the performance standards for a geopolymer concrete mixture. The performance criteria are chosen to be the compressive strength of hardened concrete and the workability of fresh concrete for simplicity. The alkaline liquid-to-fly ash ratio by mass, water-to-geopolymer solids ratio by mass, wet-mixing time, heat-curing temperature, and heat-curing duration are chosen as parameters to achieve these performance standards (Rangan and Lloyd)(2010, pp. 1–13).

A total of 16 trial mixes were prepared to understand how the concrete is mixed and casted. Cementless concrete had different workability for each trial mix, some mixes were too stiff whereas some were equivalent to the self-compacting nature of concrete. Each and every material added into the mix had its own behavior and it reacted within the concrete to give different workability and settling times.

2. MATERIAL PROPORTIONING AND OBSERVATIONS

A total of 4 mix proportions were finalized to be cased and do analysis on. The mixes were finalized as follows:

1. 90F10G8M
2. 100F0G12M
3. 75F25G8M
4. 50F50G8M

Table -1: *Material quantities and proportions for cementless concrete.*

MATERIAL NAME / CATEGORY	QUANTITY (Kg/m³)
SOURCE MATERIAL 1	532.8
SOURCE MATERIAL 2	59.2
ALKALI ACTIVATOR SOLID	92
ALKALI ACTIVATOR LIQUID	475
COARSE AGGREGATES	1188
FINE AGGREGATES	504
WATER / SOLIDS RATIO	0.29

The first mix proportion casted was **90F10G8M** which had certain properties as follows:

- The mix got set within 14-16 hours of casting.
- The mix was observed to be moderately viscous
- The casted concrete cubes were put under heat curing at a controlled temperature of 90 degrees Celsius.
- The target grade of concrete was decided to be M25 but the strength gained at the test done on day 3 after casting was 30.81 N/mm². This proves that the strength was gained after only 3 days of heat curing of the concrete cubes.

The second mix proportion casted was **100F0G12M** which had certain properties as follows:

- The mix got set within 22-24 hours of casting.
- The mix was observed to be moderately viscous
- The casted concrete cubes were put under heat curing at a controlled temperature of 90 degrees celsius.

The target grade of concrete was decided to be M25 and the strength gained at the dest done on day 3 after casting was 21.42 N/mm². This proves that the strength was not gained after only 3 days of heat curing of the concrete cubes which was the case for Mix 1, here the strength gained after 7 days is 22.7 N/mm².

The third mix proportion casted was **75F25G8M** which had certain properties as follows:

- The mix got set within 6-8 hours of casting.
- The mix was observed to be highly viscous
- The casted concrete cubes were put under heat curing at a controlled temperature of 90 degrees Celsius.
- The target grade of concrete was decided to be M25 and the strength gained at the dest done on day 3 after casting was 27.37 N/mm². This proves that the strength was gained after only 3 days of heat curing.

The fourth mix proportion casted was **50F50G8M** which did not have to undergo heat curing at it showcased the following properties:

- The mix got set within 45-60 minutes of casting.
- The mix was observed to be extremely viscous.
- The casted concrete cubes were not put under heat curing.
- The target grade of concrete was decided to be M35 and the strength gained at the dest done on day 3 after casting was 33.005 N/mm² and the strength gained after 7 days was 38.19 N/mm².

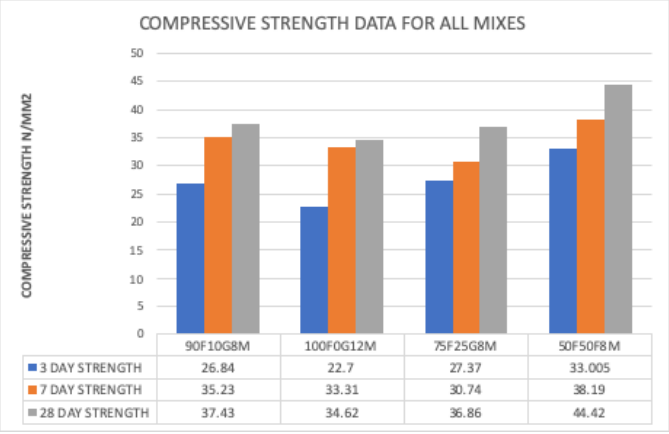

Chart -1: Strength gained for all specimen

3. CONCLUSIONS

There are two major factors leading to the change of fresh and hardened properties of concrete. The foremost property is the settling time of the concrete which increases gradually as the quantity of Fly ash increases into the mixture and decreases with an increase in quantity of GGBS which is a major factor to be considered if the mix is to be designed

with a specific settling time of the concrete. The second most important factor is the molarity of the alkaline solution, the compressive strength increases with an increase in the molarity of the alkaline solution. Moreover the need for heat curing is a major issue in the process of geopolymerization, but it can be concluded with reference to mix 4 that if equal quantities of Fly ash and GGBS are mixed into the concrete then there is nor requirement of heat curing for Cementless concrete.

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BIOGRAPHY

Shivam soni- currently pursuing bachelor's of construction tecnlology at CEPT University, Ahmedabad.