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GEOPOLYMER CONCRETE WITH LIME ADDITION AT NORMAL ROOM TEMPERATURE

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ABSTRACT:

The development of infrastructure is increasing rapidly with an increase in the demand if concrete, where the primary binding material is cement. There are many adverse environmental issues caused by the production of cement. There is a need of finding alternatives for cement which also works like a binder. Geopolymer has been introduced in the research fields with an urge to overcome the demerits and adverse environmental issues caused by conventional concrete. This paper makes an effort to achieve the desired strength of Geopolymer concrete at normal room temperature by addition of Lime in the geopolymer concrete. In this experimental investigation Geopolymer concrete is produced for two different grades with fly ash as the binding material, Sodium Hydroxide and Sodium Silicate as the activators with 16Mole, aggregates and fine sand similar to that used for conventional concrete, adding Lime powder which when reacts with water produces an additional amount of heat (process being exothermic) which will help the polymerization process to develop at lower temperatures. Specimens casted with the mention specifications will be curing at normal room temperature.

KEYWORDS: Fly Ash, Geopolymer concrete, Lime

INTRODUCTION:

The challenge amongst the researchers is finding an appropriate alternative for eliminating the environmental hazard caused due to production of cement. A very prominent research by Davidovits in 1978, was introducing Geopolymer concrete which is cement free concrete. This attracted a lot of attentions where fly ash replaced cement for 100%. It had its own identity and left a remarkable impression in the research studies. Geopolymer exhibits similar properties to that of conventional concrete the only difference being its cement free-100%. But challenging human tendency of having blind faith for the years, over cement for its strength and durability is an uprising challenge. Building faith and trust for the use of Geopolymer Concrete over conventional concrete is a huge task and requires testing of Geopolymer concrete against conventional concrete. Not only the elimination of CO2 emission can be avoided there are lot many reasons for Geopolymer Concrete to be eco-friendly.

The most eye catching reason being the use of Fly Ash which has its own which had its own dumping issues earlier and was of scarce uses. Previous investigations on Geopolymer concrete have succeeded to achieve the desired strength but with the curing done at elevated temperatures, setting its applications and uses limited with no practical use on site. By adding an optimum percentage of Lime powder an additional amount of heat will be produced, when mixed with water the reaction being exothermic that can be used as an alternative for the elevated curing temperatures, thereby achieving the desired strength by curing done at normal room temperature giving it a wide scope and various practical applications and uses.

LITERATURE REVIEW:

Debabrata Dutta et.al [1] studied the Pore sizes get reduction after addition of Lime stone dust into geopolymer paste sample. This phenomena influences water absorption and compressive strength. Incorporation of Lime stone dust up to 15% increases the compressive strength of paste specimens about 44%. The reduction in compressive strength due to lower curing temperature may be compensated by incorporation of calcium compound which can accelerate the rate of geopolymerisation even at low temperature.

B. Vijaya Rangan[2] investigation depicts that the compressive strength increased with age in the order of 10 to 20 percent when compared to the 7th day compressive strength. Geopolymer concrete offers several economic benefits over Portland cement concrete. The cost of one ton of fly ash or blast furnace slag is only a small fraction of the cost of one ton of Portland cement.

Kolli Ramujee et.al [3] studied that the decrease in water content favors the formation of geopolymerisation process, which demands for increase of concentration of Sodium hydroxide and sodium silicate. Hence increase in concentration of NaOH results in increase of compressive strength .Hence it is recommended 16M concentrations for medium grade.

Prakash R. Vora et.al [4] studied that with increase in the curing temperature in the range of 60^0C to 90^0C, the compressive strength of the geopolymer concrete also increases. The compressive strength of the geopolymer concrete increases with increase in the curing time. However, the increase in strength beyond 24 hours is not much significant. 1 day rest period increases the compressive strength of the geopolymer concrete as compared to that for the concrete without the rest period.

A. Palomo et.al [5] studied the significant factors affecting the mechanical strengths are always the temperature and the longer the time of curing, the higher the average strength is. NaOH as an activator gives much better results than KOH. The longer the time of curing, the higher the average strength is.

Kolli. Ramujee et.al [6] studied the development of the mix design for Geo-polymer concrete in different grades of concrete that are low, medium and higher grades. They have considered the design parameters as alkaline liquid to fly ash ratio and water to geo polymer solids ratio. Seven different mixes for each grade is casted, tested and optimized. Based on results they have suggested water to binder ratio of 0.27, 0.21 & 0.158 and alkaline to binder ratios of 0.5, 0.40, and 0.35 are suggested for M20, M40, & M45 respectively.

M.I. Abdul Aleem et.al [11] attempted to find out an optimum mix for the Geo-polymer concrete and they have casted concrete cubes of size 150 x 150 x 150 mm and cured under Steam curing for 24 hours. The compressive strength was found out at 7 days and 28 days. The results are compared. The optimum mix is Fly ash: Fine aggregate: Coarse aggregate (1:1.5:3.3) with a solution (NaOH& Na_2SiO_3 combined together) to fly ash ratio of 0.35. High and early strength was obtained in the Geo-polymer concrete mix.

Madheswaran C.K et.al [7] studied the variation of strength for different grades of geo polymer concrete by varying the molarities of sodium hydroxide. Different molarities of NaOH (3M, 5M, and 7M) are taken to prepare different mixes and cured in the ambient temperature. GPC mix formulations with compressive strength ranging from 15 to 52 M pa have been developed. The specimens are tested for their compressive strength at the age of 7 and 28 days. The compressive strength of GPC increased with increasing concentration of NaOH.

Mohamed Aquib Javeed et.al [8] studied that sustainable Geo-polymer concrete has been achieved in a sequential procedure starting with the trial mixes designed by the Rangan method of mix design which is regarded as a simple mix design. Rangan method gives the calculation of quantity of materials used in the mix design but the dosage of super plasticizer are finalized using trial and error. Compressive strength of concrete increases with increasing the concentration of sodium hydroxide.

EXPERIMENTAL PROGRAM:

The experimental program included the preparation of geopolymer concrete, the casting of specimens, curing to be done at normal room temperature. The preparation of geopolymer concrete is very similar to that of conventional concrete. Mixing of all the materials was done in the laboratory at normal room temperature. Fly ash and aggregate (65%-CA-I-35%-CA-II) weighed according to the mix design, were mixed together in a concrete mixer. This mixing was allowed to continue for about 3 to 4 minutes. After ensuring proper mixing weighed quantity of Cement was added in the mixer and allowed to mix for the next 2 minutes. NaOH solution which was prepared one day prior to the casting was then mixed with Na_2SiO_3 and the extra water; all weighed as per the mix design were stirred thoroughly to ensure proper mixing. This alkaline solution prepared was then added to the mix in the concrete mixer in three stages to ensure proper mixing. After the liquid was introduced to the mixture the mixing was continued for about 2 minutes. The fresh geopolymer concrete thus prepared was casted into the moulds immediately. For compaction, specimens were vibrated using vibration table for another 10 to 15 seconds. After the casting, the moulds were left at room temperature for 24 hours. Then, the moulds were remolded and cured to the required temperature in an oven for the specified time. In this experimental program specimens were casted for compression test of two grades i.e. M30 & M45. The percentages opted for the trial mix for addition of Lime were 5%, 10%,15%,20% & 25%.The optimum percentage of Lime addition was investigated by trial mixing and was concluded to be 10% for M30 as well as M45 grade of Geopolymer Concrete. Curing was done at normal room temperature for varied rest period i.e. 7, 14, 21 & 28days where the temperature was recorded as 28°C (Temperature in the morning was recorded as 27°C and in the evening it was recorded as 29°C).The specimens were tested for compression under a compression testing machine of capacity 3000KN after the completion of specified curing period.

Figure 1. Specimen with Lime addition cured at normal room temperature

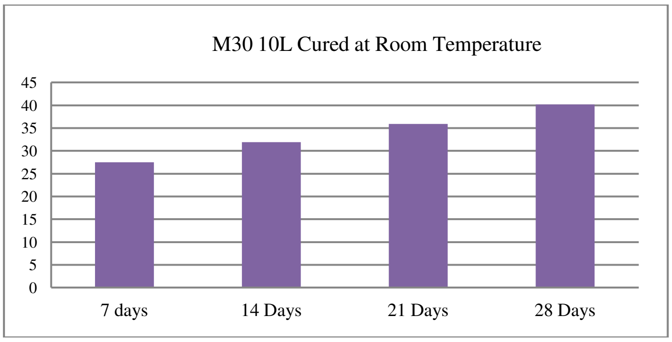
RESULTS:

Specimens were casted of size 150mm x 150mm x 150mm of grade M30 & M45 having alkaline solution ratio as 2.5 and were cured at normal room temperature with an addition of 10% Lime. These specimens were kept at normal room temperature for a rest period of 07, 14, 21 and 28 days after which the specimens were tested for compression on a compression testing machine of capacity 3000KN. The readings were recorded in the below tables to know the effect on strength of GPC cured at normal room temperature.

Table 1. Compressive strength of geopolymer concrete of grade M30 for 10% Lime addition and cured at normal room temperature with varied rest period

SR No.	Specimen	Rest Period (Days)	Peak Load (KN)	Compressive Strength (MPa)	Average Compressive Strength (MPa)
1	RMT10L1	7	646.8	28.75	27.5
2	RMT10L2		605	26.89	
3	RMT10L3		601.9	26.75	
4	RMT10L4	14	721.6	32.07	31.9
5	RMT10L5		713	31.69	
6	RMT10L6		716.66	31.85	
7	RMT10L7	21	806.1	35.83	35.9

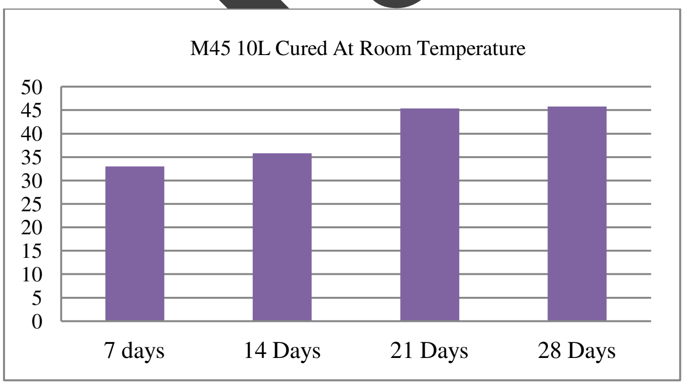
8	RMT10L8		811	36.04	
9	RMT10L9		809	35.96	
10	RMT10L10	28	902.1	40.09	40.2
11	RMT10L11		909.4	40.42	
12	RMT10L12		905	40.22	



Graph No.1 Compressive Strength of M30+10L Cured at Normal Room Temperature.

Table 2. Compressive strength of geopolymer concrete of grade M45 for 10% Lime addition and cured at normal room temperature with varied rest period

SR No	Specimen	Rest Period (Days)	Peak Load (KN)	Compressive Strength (MPa)	Average Compressive Strength (MPa)
1	45RMT10L1	7	698.1	31.03	33.0
2	45RMT10L2		788.8	35.06	
3	45RMT10L3		741.3	32.95	
4	45RMT10L4	14	800	35.56	35.8
5	45RMT10L5		803	35.69	
6	45RMT10L6		811	36.04	
7	45RMT10L7	21	1022	45.42	45.4
8	45RMT10L8		1016	45.16	
9	45RMT10L9		1028.9	45.73	
10	45RMT10L10	28	1038	46.13	45.8
11	45RMT10L11		1029	45.73	
12	45RMT10L12		1026	45.60	



Graph No.2 Compressive Strength of M45+10L Cured at Normal Room Temperature.

CONCLUSION:

1. The compressive strength goes on increase with the increase in the rest period of geopolymer concrete (M30 & M45) with addition of 10% of Lime when cured at normal room temperature
2. The maximum compressive strength was achieved at the completion of 28 days of rest period thereby giving it a wide scope.
3. The compressive strength achieved by grade M30 of geopolymer concrete cured at normal room temperature at a rest period of 7days is higher than the compressive strength achieved by ordinary concrete for similar rest period.
4. Performance in terms of compressive strength of M30 10L cured at normal room temperature is better than performance of M45 10L.
5.

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