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Experimental Study of Compressive Strength of 8m Geoploymer Mortar for Different Combinations of Eucalyptus-Ash with Ggbs(45μ)

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ABSTRACT

Concrete is the material which is unstintingly used in the construction sector and the product of cement is one among the reason for global warming due to release of carbon dioxide, to minimize its effect on nature we must use artificial by- product as an indispensable material. Among artificial by- product, operation of cover ash is more.

The geopolymer mortar made by the using cover- ash set sluggishly in ambient temperature and needs heat curing. To overcome this limitation, Ground Granulated Blast Furnace Sediment(GGBS) grease paint is used as a cementious material which shows considerable gain in strength. In this paper, we delved the parcels of geopolymeric binder prepared using the Ground "Granulated Blast Furnace Sediment"(GGBS) and eucalyptus ash without using conventional cement. The individual parcels of the GM for 1:3 rate, similar as compressive strength test were determined as per applicable Indian norms. cells of size (70.6x70.6x70.6) mm were casted and cured in ambient condition for molarity 8M with different rates and different temperatures.

After the trials, compressive strength is increased for adding number of days of curing. Also compressive strength dropped for adding Na_2SiO_3/ NaOH rates and adding roaster curing temperatures.

Keywords: Geoploymermortar, GGBFS, coalash, 8M(Molarity)

1. INTRODUCTION

The development of country is depending upon the infrastructures and in every infrastructure the concrete plays major role, we cannot imagine the world without a concrete. The cement is the main constituent of manufacturing of concrete. Use of concrete is thesecond largest consumption after the water the production of cement increases as per theincrease in demand of concrete. The total consumption of concrete in worldwide is estimated about to the11.5 billion tons of concrete per year and18billion tons of concrete expect in the year of 2050

Construction actions include the production of concrete, mortar, bricks, blocks etc.Major articles include cement, fine aggregates like sand, coarse aggregates, bricks, blocks,steel etc. Among this cement production more than 70% of carbon dioxide and other harmful gases will be generated and enters the atmosphere. This will damage the ozone layer. Hence it is necessary to reduce the production and consumption of cement

As a solution, it is necessary to use alternative building materials which do not create harmful effects for the environment. So many researches have been done on many alternatives for cement, fine aggregates and coarse aggregates. By research work now a day,cement is replaced by fly ash, rice husk ash, slag, bagasse ash, eucalyptus ash, and saw dustash, waste sludge ash etc. by using these alternatives for cement, the consumption of thecement will reduce and the production will defiantly reduce. So up to some extent it may solve the problems arising in the environmental pollution from construction activities

2. MATERIALSANDMETHDOLOGY

The following article deals with the presentation of results obtained from various tests conducted on material as per relevant Indian standardsused for the production of Geopolymer mortar using GGBS as a binding agent and river sand as a fine aggregate.Mixture of sodium hydroxide and sodium silicate is used as alkaline solution which acts as an activator.

2.1 Materials

The following are the various materials which were going to be used in this project

1. Cementitious material(GGBS)
2. Fine aggregate(sand)
3. Eucalyptus ash
4. Alkaline activator solution(SS+SH+WATER)

2.1.1GRONDGRANULATEDBLASTFURNACESLAG:

Ground granulated blast furnace slag (GGBS or GGBFS) is obtained by quenchingmolten iron slag (is a by-product of iron and steel manufacturing) from a blast furnace inwater or stream, to produce a glassy, granular product that is then dried ground into finepowder. The main components of blast furnace slag are CaO (30-50%), SiO_2, Al_2O_3 (8-24%) and MgO (1-18%).

Fig 2.1:ground granulated blast furnace slag

2.1.2 PHYSICAL AND CHEMICAL PROPERTIES OF GGBS AND SODIUM HYDROXIDE PELLETS

Table3.1: Physical properties of GGBS

Sl. No.	Physical requirements	Requirement as per BSEN15167-1:2006	Test results
1	Colour	-	Offwhite
2	Specific gravity	-	2.83
3	Particlesize	-	45µ passing
4	Initial setting time(min)	-	135
5	Final setting time(min)	-	550

6	Soundness	Lessthan 10mm	passed
7	Fineness(M^2/kg)	275(min)	382

Table2.2: Chemical properties of GGBS

Sl. No.	Chemical requirements	Requirement as per BSEN15167-1:2006	Testresults
1	Magnesia content(%)	18.0 (max)	7.63
2	Sulphide sulphur(%)	2.00 (max)	0.47
3	Sulphite content(%)	2.50 (max)	0.30
4	Loss on ignition(%)	3.00 (max)	0.18
5	Chloride content (%)	0.10 (max)	0.009
6	Glass content (%)	-	91
7	Moisture content (%)	1.0 (max)	0.11

Table2.3: Properties of sodium hydroxide pellets

Sl. No.	Characteristics	Test results
1	Sodium hydroxide	99.79%
2	Sodium carbonate	0.177%
3	Sodium sulphate	0.005%
4	Sodium chloride	0.017%
5	silicate	0.001%
6	Iron	4.0 ppm
7	Copper	2 ppm
8	manganese	1 ppm
9	Water insoluble in water	0.005%

2.2 EUCALYPTUSASH

The eucalyptus ash is produced in the brick industries usually the eucalyptus woodand their leaves used as burning fuels in brick manufacturing kilns. This ash is obtained from the brick industry in Malur taluk, Kolar district.

Figure2.2:Eucalyptus ash

2.2.1PROPERTIESOFEUCALYPTUS ASH

Table 2.4: Properties of Eucalyptus ash

Sl. No.	Properties	Eucalyptus ash
1	Specific gravity	2.38
2	Standard consistency(%)	28
3	Initial setting time	160
4	Final setting time	900
5	Compressive strength of pozzolana cement(N/mm^2) 3D 7D 28D	 5.15 7.62 9.52

2.3 FINE AGGREGATE (NATURAL SAND):

In this project natural sand is used as a fine aggregate which is obtained from locallyavailable natural sources, the specific gravity of the sand and fineness modulus of sand andgrading zone are determined as per IS383-1976 and the physical properties of natural sand is tabulated below

Figure 2.3: River Sand

2.3.1 PHYSICAL PROPERTIES OF FINE AGGREGATE

Table 2.5: Physical Properties of sand

Sl. No.	Properties	Test Result	STANDARDS[IS:383-1970]
1	Specific Gravity	2.80	_
2	Bulk Density[kg/m^3] a. Loosely packed b. Compacted	1.470 1.585	_
3	VoidRatio	0.475	_
4	Grading Zone	Zone II	Zone I-IV
5	Bulking[%]	35.29	_

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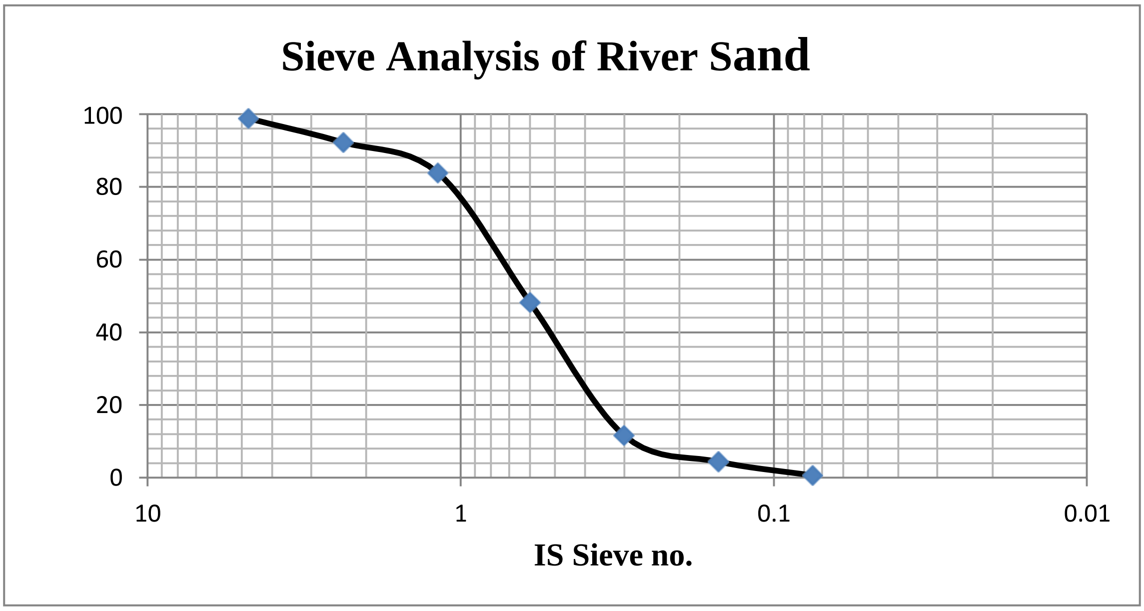
2.3.2 SIEVE ANALYSIS OF RIVER SAND

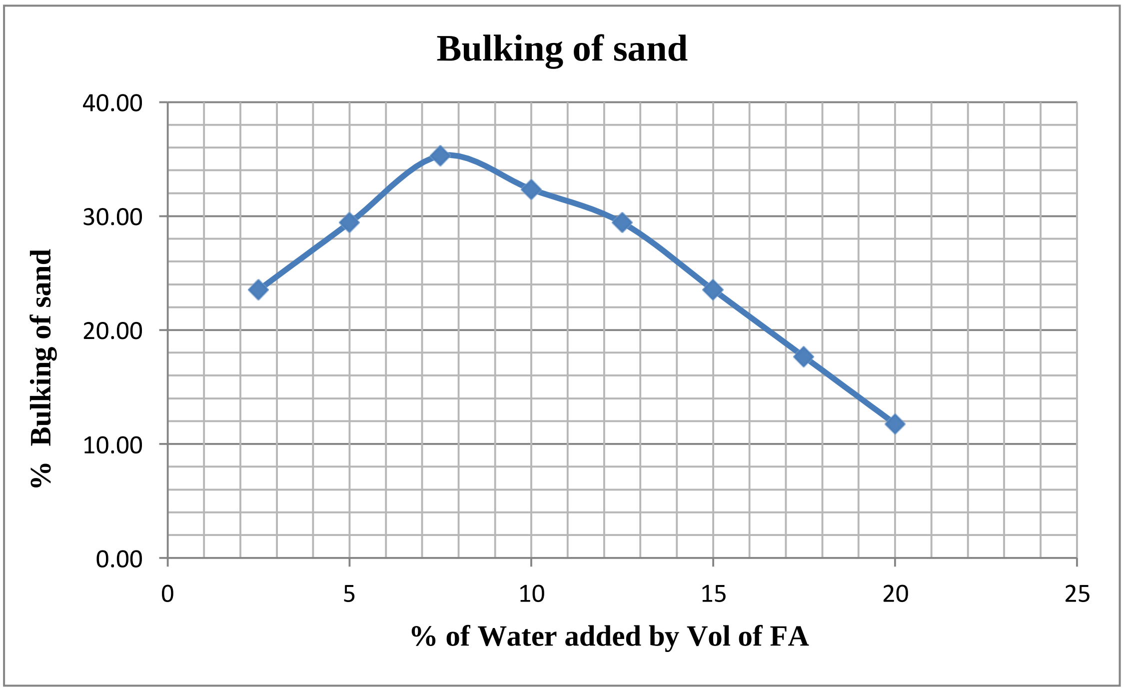
Table 2.6: Sieve analysis of river sand

Weight of River sand taken = 500 grms					
Sl. No.	**IS-SIEVE(MM)**	**WT. RETAINED(GM)**	**% RETAINED**	**% PASSING**	**CUMULATIVE % RETAINED**
1	4.75	6	1.2	98.8	1.2
2	2.36	33	6.6	92.2	7.8
3	1.18	42	8.4	83.8	16.2
4	600µ	178	35.6	48.2	51.8
5	300µ	183	36.6	11.6	88.4
6	150µ	36	7.2	4.4	95.6
7	Pan	22	4.4	0	100
	Total	500		SUM	360.4
				FM	3.60

According to IS 383:1970, the percentage passing of fine aggregates confirm to Zone-II classification.



Graph 2.1Sieve Analysis of Riversand



Graph 2.2 Bulking of river sand

2.4 ACTIVATOR SOLUTION

The alkaline activator solution used for experimental investigation is a combination of sodium silicate solution and sodium hydroxide solution, the sodium hydroxide used for investigation is flaky and pellets form the geopolymer with sodium hydroxide exhibit better zeolitic properties also that addition of sodium silicate solution to sodium hydroxide enhance the reaction between source material and alkaline solution, the solution must be prepared before 24 hours.

NaOH Pellets

Sodium silicate solution

Water

Figure 2.4: Materials used in alkaline activator solution

2.5 METHODOLOGY

2.5.1 Mix design

The ratio of binder to sand is 1:3 Molarity=8M
Solution/binder = 0.5 Sand = 600 gm SS/SH=1.5
Oven curing temperature =60°C and 100°C
Density of GPM =2200 kg/m3
Total mass =density*volume of cubes
=2200*3.518*104
=0.775 kg
= 775 gm
Binder =775/1+3
=195gm
Binder= 200gm
Binder=200gm ash(for 100%ash)
Binder=40 gm ash +160g ggbs (for 20% ash and 80% ggbs) Binder =80 gm ash+120g ggbs (for 40% ash and 60% ggbs) Binder =120gm ash+80g ggbs (for 60% ash and 40% ggbs) Binder =160 gm ash+40g ggbs (for 80% ash and 20% ggbs) Binder=200gm ggbs (for100%ggbs)
Solution=0.5*200
Solution=100gm
Solution = NaOH+Na_2SiO_3 = 100 gm NaOH = 100/1+1.5= 40 gm Na_2SiO_3 =100-40
Na_2SiO_3 = 60 gm
NaOH = include both water and pellets=40g
1m = 40g of NaOH pellets for1000ml=1040 gm
8M = 8*40=320 gm of NaOH pellets 1000ml =1320 gm Water=(1000/1320)*40
Water=30.3 gm
NaOH= (320/1320)*40
NaOH pellets = 9.70 gm

Typical mix design:

Molarity	8 M			10 M			12 M		
Na_2SiO_3/NaOH	**1.5**	**2**	**2.5**	**1.5**	**2**	**2.5**	**1.5**	**2**	**2.5**
Water(gm)	30.3	25.25	21.64	28.57	23.80	20.4	27.02	22.52	19.30
NaOH Pellets(gm)	9.7	8.08	6.92	11.43	9.53	8.17	12.97	10.81	9.26
Na_2SiO_3 solution(gm)	60	66.67	71.43	60	66.67	71.43	60	66.67	71.43

Table 2.7: Typical mix design

2.52 PREPARATIONOFALKALINEACTIVATORSOLUTION

- The calculation is made for the required molarities
- The portable water is used for preparation of NaOH solution
- Sodium hydroxide is measured according to the molarity required which is a available in pellets

form

- The sodium hydroxide solution is prepared by proper stirring,
- Then sodium silicate solutions are weighed and pour into the sodium hydroxide solution and stir well.
- The high temperature is generated due to chemical action
- This solution is kept for 24 hours to complete the reaction

Weighing of NaOH pellets

Mixing with water

Dissolving of NaOH with water

Mixing of NaOH solution with Na_2SiO_3

Figure 2.5: Preparation of alkaline activator solution

2.53GEOPOLYMERMORTARPREPARATION

- To prepare Geopolymer mortar, at least one day earlier alkaline activator solution is to be prepared. According to mix proportion (Molarity) sodium hydroxide pellets are dissolved in water and mixed with sodium silicate solution, to make alkaline activator.
- The various constituents of GPM are weighed properly according to mix design.
- Binder materialGGBSand fine aggregatesaremixed properly togetuniformdrymix.
- Transfer Geopolymer mortar mix into steel mouldsof si (cube70.6mm x70.6mm x 70.6mm) in 3 layers with good compaction.
- After 24hours, specimens are demoulded and Kept for oven drying at temperature of 60°C and 100°C for next 24 hours.


Binder added to fine aggregate


Dry mixing


Adding alkaline solution to dry mix


Final mortar mix


Mortar cubes after filling

Figure 2.6: Preparation of Geopolymer mortar

2.6 TEST CONDUCTED ON GEOPOLYMER MORTAR

2.61 COMPRESSIVE STRENGTH TEST:

Cube specimens of size 70.6mmx70.6mmx70.6mmwere taken out after ambient curing and tested at the ages of 3, 28 and 56 days Specimens are tested as per IS 516-959(part5).While testing the cubes are placed at right angle to that as cast. Without hock the load is applied gradually till the failure of the specimen happens and thus the compressive strength was found. The point at which specimen fails is

considered as maximum load (N), and the surface area exposed to load is cross section of the specimen. Thus, compression strength is calculated by the formula,
Compressive strength=[Load/Area]N/mm^2

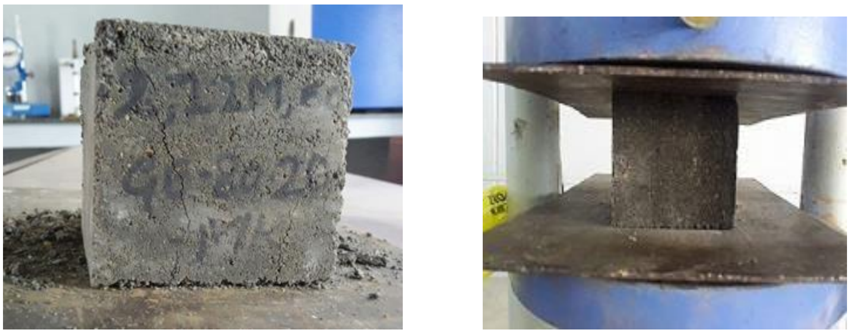
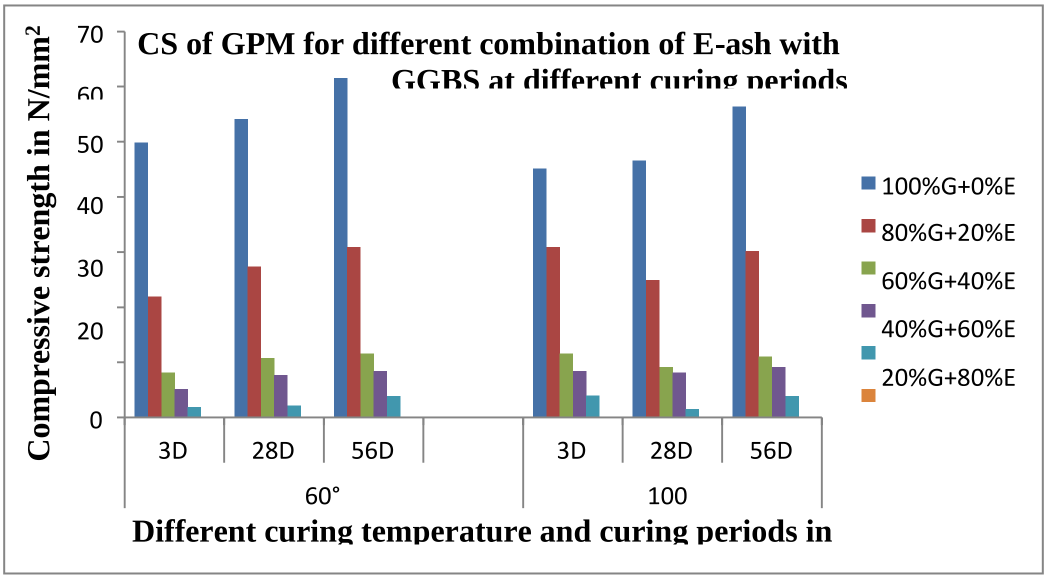


Figure2 .7: Compression testing method

3. RESULTS AND DISCUSSION

Table 3.1: Compressive strength of 8M, 1.5GPM

Slno.	Combination	pressive strength in N/mm^2 for different Curing Periods in days and different temperature					
		60°C			100°C		
		3D	28D	56D	3D	28D	56D
1	100%G+0%E	49.8	54.1	61.52	45.16	46.58	56.32
2	80%G+20%E	21.9	27.4	30.9	19.00	25.98	29.12
3	60%G+40%E	8.10	10.8	11.58	7.98	9.12	10.88
4	40%G+60%E	5.12	7.65	8.45	4.15	6.86	8.12
5	20%G+80%E	1.9	2.1	3.95	1	1.5	3.10
6	0%G+100%E	0	0	0	0	0	0



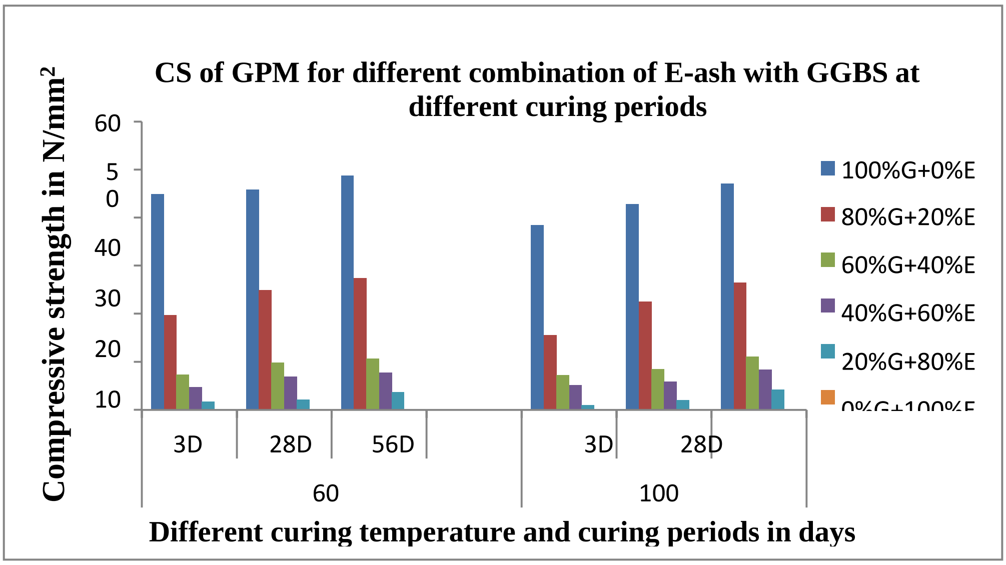
Graph 3.1 : Compressive strength of 8 M,1.5, 60°C and 100°C GPM

OBSERVATION

- From the graph 4.1 it is observed that the compressive strength of GPM decreased with increase in the quantity of Eucalyptus ash.
- During compression testing the cracks were found near the edges due to less geopolymer reaction near the edges of geopolymer mortar.
- The workability of GPM is decreased with the higher replacement of Eucalyptus ash because of higher quantity of ash requires a more solution.
- The geopolymer mortar made with the 0%G+100%E is shows the chipping during the demoulding because of improper reaction with alkaline activator.
- The 56days compressive strength of 100%GGBS GPM is 61.52N/mm^2 which is highest among all combination.

Table3.2:Compressive strength of 8M, 2 GPM

Sl. No.	Combination	Compressive strength in N/mm^2 for different Curing Periods in days and different temperature					
		60°C			100°C		
		3D	28D	56D	3D	28D	56D
1	100%G+0%E	44.9	45.89	48.8	38.45	42.83	47.10
2	80%G+20%E	19.71	24.93	27.38	15.6	22.53	26.47
3	60%G+40%E	7.37	9.75	10.65	7.28	8.5	9.98
4	40%G+60%E	4.57	6.86	7.68	4.16	5.84	7.30
5	20%G+80%E	1.76	2.12	3.62	1.01	1.99	3.23
6	0%G+100%E	0	0	0	0	0	0



Graph 3.2: Compressive strength of 8M, 2 , 60°C and 100°C GPM

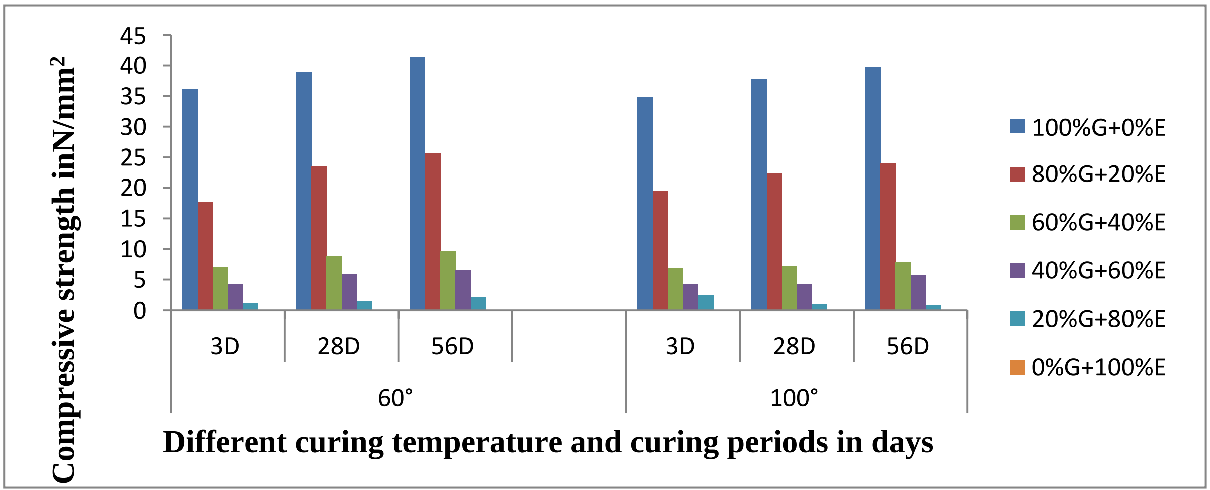
OBSERVATION

- From the graph 4.2 it is observed that compressive strength of GPM increased with increase in the GGBS content.

- The cracks were vertical for all the combinations geopolymer mortar made with Eucalyptus ash with GGBS.
- It observed that the compressive strength increased with increase in the curing period because of increased geopolymerization.
- The 56days compressive strength of GPM increased from 0N/mm^{2}to 48.8N/mm^2.
- The compressive strength of GPM made with100%G+0%E is 48.8N/mm^2 which is highest among all combination.

Table3.3:Compressive strengthof 8M,2.5GPM

Sl no.	Combination	npressive strength in N/mm^2 for different Curing Periods in days and different temperature					
		60°C			100°C		
		3D	28D	56D	3D	28D	56D
1	100%G+0%E	36.23	38.99	41.49	34.89	37.84	39.78
2	80%G+20%E	17.73	23.6	25.68	19.43	22.35	24.12
3	60%G+40%E	7.1	8.94	9.65	6.82	7.21	7.89
4	40%G+60%E	4.23	5.98	6.54	4.30	4.21	5.76
5	20%G+80%E	1.23	1.46	2.18	2.43	1.1	0.96
6	0%G+100%E	0	0	0	0	0	0



Graph 3.3: Compressive strength of 8M, 2.5, 60°C and 100°C

OBSERVATION

- From the graph4.3 it is noticed that the higher compressive strength results for 100%GGBS and gradually reduced with increase in E-ash content.
- The100% replacement of E-ash with GGBS samples shows the no strength results because of in complete geopolymerization process.
- After the failure of geopolymer mortar samples the cracks were developed from the corners of the cubes because of lower polymerization at corners of mortar cube.
- The compressive strength increased from2.18N/mm^{2}to41.49N/mm^{2}for 60°C temperature cured

samples.

- The compressive strength of 100%GGBS with E-ash 41.49N/mm^2 which is highest among all combination.

4. CONCLUSION

- As molarity increased the compressive strength is also increased i.e. as concentration of sodium hydroxide and sodium silicate is more in the alkaline solution results in elevated compressive strength of GPM.
- The GPM made with different combination of E-ash with GGBS Compressive strength is more up to 80% replacement with GGBS but for 100% E-ash based GPM the compressive strength became zero at different curing period.
- The compressive strength gets reduced at 100°C temperature cured geopolymermortar cubes because of condensation reaction was not well established at high temperature.

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