"EVALUATION OF COMPRESSIVE STRENGTH GEO-POLYMER FOAMED CONCRETE"

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Abstract - *Foamed concrete is the future commercial material in construction industry due to its light weight nature The physical and mechanical properties of foamed concrete varies from type of mixture and its composition Fly ash and grounded granulated blast furnace slag are industrial waste and generally used as mineral admixture in concrete blend to enhance the property of hardened concrete. In our work we have used fly ash, grounded granulated blast and alkaline solution which acts as an activator is used to develop foamed geopolymer concrete and parameters effecting compressive strength of the foamed concrete were studied. Fly ash is used as fine aggregate and grounded granulated blast furnace slag helps in improving strength of concrete. Rice husk ash and micro silica are also used to improve the density and strength of our concrete Compression strength test was conducted to study the mechanical strength of concrete and water absorption test was also carried out. Trial and error approach is used and every mix proportion of material and quantity of foam is varied.*

Key Words: Fly ash, Foamed Concrete, GGBS, Compressive strength, Geo-polymer Concrete, Rice Husk.

1. INTRODUCTION

1.1 General

After water, concrete is the most widely used material by the community and in the construction world, around 15 billion tonnes of concrete is used annually. Ordinary Portland Cement (OPC) is primarily used binder for production of concrete, there is environmental issue for the production of OPC, we burn $CaCO_3$ in kiln at temperature of about 1400 C0 during this lime (Cao) and CO_2 is produced by process called calcination. $5CaCO_3+SiO_2 \rightarrow (3CaO, SiO_2)\ (2CaO, SiO_2) + 5CO_2$

In this process CO_2 is emitted in the atmosphere which is a greenhouse gas. India is contributing 7.1% of total greenhouse gas emission Olivier and peters,2018) [24]. Silica containing material is added to the lime which produces an intermediate product called clinker then clinker is cool and small amount of gypsum is added to produce ordinary Portland cement. For production of OPC, fossil fuel generally coal is used which produces CO_2 .1 ton of cement produces around 0.95 tonnes CO_2 (Davidov its, 2015) [8].

Development in infrastructure leads to rise in demand of cement concrete. Global production of concrete is approximately 15 Billion tonnes and 1 cubic meter per person per year is already achieved (Gartner, 2004)[10]. India is second largest manufacturer of cement after China and produces around 330 million tonnes cement (Government of India, 2017)[11].We can reduce the GHGs emission by using supplementary cementitious material such as fly ash, blast furnace slag, silica fume etc

In India coal based thermal power plant is used for electricity generation, which produces waste material fly ash as by product of burning coal. Fly ash is effectively used for making cement concrete, by using this waste, reduces environmental impact and increases the technical property of concrete .Other waste material like rice husk, Ground Granulated Blast Furnace Slag (GGBFS) by product of iron and steel making. It can be blended with Portland cement which increase concrete workability, durability, density, and resistance to alkali silica reaction.

2. OBJECTIVES

There are two main constituent of geopolymer concrete source material and alkaline solution .Source material should be enrich with Silicon (Si),Aluminium (Al).These can be by-product such as fly ash ,GGBFS, Silica fume, rice husk ash ,red mud etc. and can be natural mineral like clay, kaolinite. Selection of material depends upon the availability, cost, type of application, and specific demand of end user .The most commonly used alkaline solution are sodium hydroxide (NaOH), potassium hydroxide (KOH), and sodium silicate (Na_2SiO_3),potassium silicate (K_2O_3Si).

- Slag based geopolymer concrete: In this concrete, blast furnace slag is used as secondary binder and silica fume as primary binder with alkali activator.
- Rock based geopolymer concrete: The materials used in this concrete are crushed volcanic tuff (type of volcanic rock ejected from volcanic eruption), and mine tailing (left over material from mines) with silica fume and alkali activator.
- Fly ash based geopolymer concrete: Fly ash from thermal power plants is used as primary binder with furnace slag as secondary binder is used and alkali activator. Recent studies have shown that this concrete can be made by 100% fly ash as binder.

- Ferro-isolate based geopolymer concrete: This concrete is similar to rock based concrete, but the rocks used have higher iron oxide content. Thus polymer formed in this concrete have iron (Fe) atoms.

3. LITERATURE REVIEW

Mohd & Samidi, 1997 Aerated concrete can be classified based on curing method and based on pore formation method. So based on curing method aerated concrete can be classified as autoclaved aerated concrete (AAC) and non-autoclaved aerated concrete (NAAC). similarly based on pore formation method it can be classified as “gas concrete” and “foamed concrete”

Zhang, Liu, Yan, Qin, 2016 We produced geopolymer foamed concrete by entraining air into it. When the air content varies 2 to 6 % the number closed micro pores in the hardened concrete increases space between air void and diameter of void decreases so providing good frost resistance property

Rashad, A. (2014) The development of new binders, as an alternative to Portland cement (PC), by alkaline activation, is a current researchers interest. Alkali-activated fly ash (AAFA) binder is obtained by a manufacturing process less energy-intensive than PC and involves lower greenhouse gasses emission. Utilizing AAFA system as binder material can limit the consumption of virgin materials (limestone and sand) required in PC manufacture. AAFA belongs to be prospective material in the field of Civil Engineering where it can resist aggressive acids, resist sulfate attacks, resist aggregate alkali reaction, and resist elevated temperatures. Researchers have employed different fibers, chemical admixtures, mineral admixtures, additives and other materials in AAFA system aiming to modify special properties of this system

Ali Hansberger et al (2012) Globally, the cement industry accounts for approximately 5 percent of current anthropogenic carbon dioxide (CO2) emissions. World cement demand and production are increasing significantly, leading to an increase in this industry’s absolute energy use and CO2 emissions. Development of new energy-efficiency and CO2 emission- reduction technologies and their deployment in the market will be key for the cement industry’s mid- and long-term climate change mitigation strategies.

3. MATERIAL AND METHODS

3.1 **Ordinary Portland Cement (OPC)**

Ordinary Portland cement (OPC) of “ULTRATECH” branded of grade 53 confirming to IS:12269 was used for our study. It was kept in a dry environment with proper storage facility 53 grade of OPC is used because of its optimum particle size distribution and superior crystallized structure offers a strong and durability of structure. It has high early strength as compared to any other grade of cement but because of early strength it does not increase much after 28 days.

3.2 Fly Ash

Low Calcium Class F fly ash used for our work. fly ash was obtained from the Spat Thermal power plant at Bilaspur India and it is used as basic material for making concrete. The physical properties of fly ash are according to IS 1727 (1967).

3.3 Micro silica

Micro silica used for this study has been obtained from Nagpur. It is known to be extremely pozzalanic in nature and is used as concrete additive .Addition of micro silica to concrete and geopolymer have shown better packing ability and improve the strength . It is also known as silica fume and is obtained as by product of silicon or ferro-silicon alloy development from electrical arc furnace (EAF).

3.4 Grounded Granulated Blast Furnace Slag

GGBFS used in our work was obtained from Uttam Galva,Wardha . It is used in combination with standard Portland cement or other pozzolanic materials to produce durable concrete structures. GGBS based concrete sets slower than concrete made of ordinary Portland cement It reduces hydration and lower temperatures making it easier to avoid cold joints but also effects building schedules where fast setting is required. It also reduces the risk of alkali-silica reaction offers higher chloride intrusion resistance and reduces the risk of corrosion reinforcements and offers greater resistance to sulphate and other chemical attacks

3.5 Rice Husk Ash (RHA)

Rice husk ash used in this project is obtained from Nagpur. It is produced from rice milling industry as agro-industrial waste. Burning process and temperature affect the chemical composition of RHA. The amount of silica increases when temperature is increased. RHA contains amorphous and very cellular silica with a surface area of 50-1000 m2/g. It has been observed that use of RHA reduces heat development, thermal cracking and plastic shrinkage also increases strength of hydrated cement paste which modifies pore structures and blocking the large voids in the pozzolanic reaction. Indian standard IS 456:2000 recommends the use of RHA in concrete and reinforced concrete but does not specify the quantity which can be used in mixed design.

4. METHODOLOGY

4.1 Preliminary Laboratory Work

There is no standard available for making geopolymer foamed concrete, so trial and error method is adopted and numerous sample were made. Identifying the appropriate quantity of foamed, proportion of various filler material and their effect on fresh and hardened properties, air void characteristics of foamed concrete were dealt. There is very few study available on use of geopolymer foamed concrete so present study was focused on this. Preliminary work was done to know the effect of foaming agent on geopolymer foamed concrete as there is very less study available with foam and geopolymer. Proportion of various constituents material like fly ash, GGBFS, lime, rice husk were determined and behaviour with geopolymer solution were studied for making the various trial mixes.

4.2 Mixing of Geopolymer Solution

At beginning geopolymer solution was prepared 1 day before to give maturity of 24 hour. NaOH is used in pallets form. According to the molarity of geopolymer solution mass of NaOH is selected and mass of Na2SiO3 is selected according to ratio of NaOH: Na2SiO3. Then NaOH and Na2SiO3 is added in water. This solution is kept for one day and next day used for preparation of foamed concrete. For some trial foamed was generated in water and added into the solution and for some trial foamed is generated in geopolymer solution.

Foam is generated by using hand mixer with rpm (Revolution per Minute) 1000 as foam generator machine was not available in laboratory. Then foaming agent quantity was selected according to volume of geopolymer solution. Consistency of foam get changed if mixing time is vary, so to get a proper consistency of foam, it is mixed for a specified time so that every time we get same consistency. If we mixed the foam for more time air induced in it will increases, however longer mixing lead to air loss by lowering the air content. After some trial maturity period given to solution was removed insist of it after adding the constituents solution was mixed by hand mixer until it get turned brownish.

4.3 Specimen Preparation

Hand mixer was used to produce geopolymer foamed concrete in laboratory as the volume is less but in commercial practice volume will be high for that rotary drum can be used for production, both the cases mixing procedure will be same. For preparation of specimen first all the dry constituents like fly ash, GGBFS, lime, rice husk, cement and other fine material is collected. Then according to required proportion each is mixed in a container. For getting homogeneous mixed of this dry constituent, it is mixed by hand mixer for 1-2 minute. Geopolymer solution is prepared according to point and according to volume of it foaming agent quantity is mixed in solution. To get required consistency foaming agent is mixed for 10-15 minutes. If foam is generated in water, then it is mixed in dry constituent and mixed for 2-3 minutes until foam get uniformly distributed, incorporated, which we can notice during mixing. To increase the workability of concrete we can use superplasticizer. After that in dry constituent this prepare solution is mixed until we get required consistency then concrete mix is poured in moulds of 100*100*100. After 24-hour demoulding was done and concrete cube is kept for curing either oven curing or water curing.

5. EXPERIMENTAL WORK

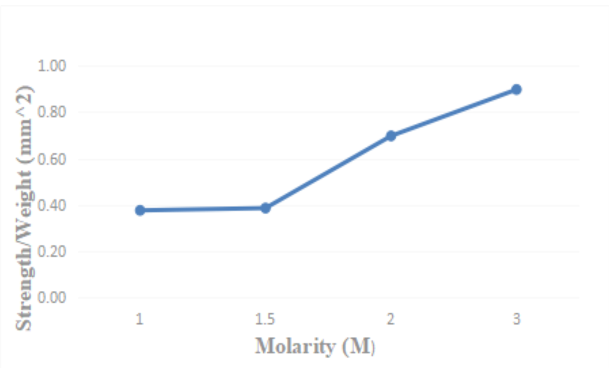
The test results are presented and discussed in this chapter. Each data point for the compressive strength test shown in different graphs or in different tables corresponds to the mean compression value. the effect of different parameters on the compressive strength of geopolymer foamed concrete is discussed. Along with compressive strength, other parameters like water absorption, and efflorescence values of the concrete are also discussed. The parameters considered are as follows:

- Ratio of sodium hydroxide solution to sodium silicate solution
- Curing time (oven heating)
- Molarity of the alkaline solution
- Mixing time
- Concentration of foam in mix
- Effect of GGBS in compressive strength
- Variation of compressive strength with dry density

6. RESULTS

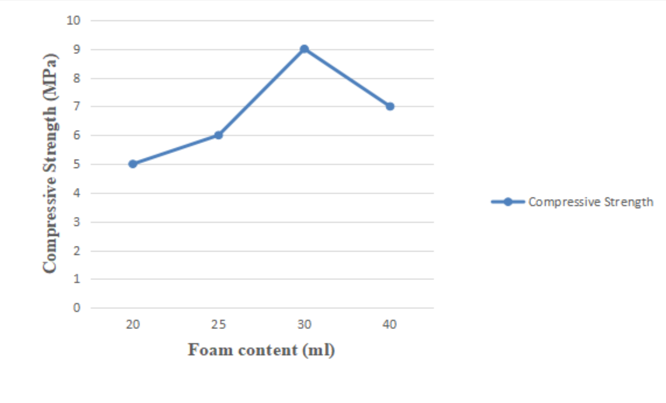
6.1 Variation of compressive strength with molarity

It is observed that compressive strength of geopolymer NAAC is proportional to the molarity of solution and it can be ascertained that molarity is the function of compressive strength. Higher the molarity higher will be the compressive strength. On higher molarity free Si molecules are produced which increases C-S-H gel is produced which gives strength to the concrete. Also workability of concrete decreases as more C-S-H gel is produced. Trials of higher molarity which were cured in oven showed increase in compressive strength after one day of demoulding. Instead of taking compressive strength directly, compressive strength to weight of the cube is taken because strength is directly proportional to weight.



6.2 Variation of compressive strength with foam content.

It is observed from the graph initially compressive strength of foam concrete increases uptoa certain point and then decreases the strength of block so optimum content is chosen which is shown in graph



6.3 Trial mixes and compressive strength

TRIAL 1										
Sampl e no.	Ceme nt	GGB S	Flyas h	Foa m	Aura+T E A+SP5 0 0+	Molar i ty	Age at test	Compr es sive strengt h	dry dens i ty	mea n dens i ty
	(gm)	(gm)	(gm)	(ml)	HVF (ml)	(M)	(day)	(Mpa)	(kg/ m3)	(kg/ m3)
1	600	600	1800	15	3+3+3 +3	1	After demou ld ing	1.8	1087	1029
2							3	3.1	1040	
3							7	3.8	962	

7. FUTURE SCOPE OF WORK

In this chapter future scope of work is discussed in line with present work. As we know that cement industry contributes more in greenhouse gas emission, so in present work cement should be completely remove from the GFC As we know that density of GFC depend on quantity of foam content and properties of foam content, in this work protein based foaming agent is used in future work different type of foaming agent with different quantity should be try, this area needs to be explored more. Strength of foamed content depends on GGBFS content so more investigation should be done to find out the optimum quantity of GGBFS and also investigate the potential use of fibre in aerated concrete to overcome the problem of reinforcement. To confirm the long term use of foamed concrete, in future work more test should be done to test the durability.

8. CONCLUSION

Aim of this project was to create a geopolymer lightweight foamed concrete alkaline solution as an activator that will address environmental issues and retain their structural properties. Maximum compressive strength 9 MPa was noted at density 1324 Kg/M3 at following percentage of content 10% cement, 20% GGBFS, 60% fly ash, 5% rice husk 5% lime, 2M alkaline solution Efflorescence test was also conduct on GFC, result of this test was Nil. The production process of GFC differ from production process of bricks, blocks in which controlling factor is water/cement ratio whereas GFC is divided into several sub-tasks, main controlling factor was mean target density therefore so there is need to develop design mix strategy for aerated block with air entraining agent. Certain consistency in terms of water content is required for air-entraining otherwise bubbles of foam will reach the surface and escape out or it can be broken during mix phase. The main controlling factor that influences the design mix are GGBFS, Fly ash, foam content, and plasticizers Due to complex nature of air entrainment trial and error method was adopted foam content was chosen such that it will give target density, during trial-and-error procedure it was found that if we generate foam in water it does not give good consistency but when it is mixed with alkaline solution good consistency was found and compressive strength results was also good. Mixing time of foaming agent plays an important role more time mixing produces more foam content so in this test mixing time was kept constant as for as possible It was found that compressive strength of GFC is function of alkaline solution (NaOH) higher the molarity higher compressive strength was observed. Second aim of was to analyse the effect of properties GGBFS, lime and rice husk on density and compressive strength of GFC.

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