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Experimental Study on Strength Properties of Flyash Based Geopolymer Light Weight Aggregate Concrete

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Abstract:
The development of concrete led to the evolution of light weight geopolymer concrete which is eco-friendly in nature. It uses fly ash obtained as industrial by-product and alkaline solution (sodium hydroxide and sodium silicate combination), which undergoes polymerization reaction togetherly constitute binder material in GPC. In alkaline solution sodium hydroxide of 10M is prepared and mixed with sodium silicate solution, the combination of mixture is left for one day and then it is used in the mix. Usage of cinder as coarse aggregate reduces the weight of concrete, which is obtained from steel industry as waste product. Preliminary tests on cinder is carried to know the property of material, the results satisfied the limiting value of IS codes. Ambient curing method is adopted were specimen are subjected to sun dried curing with optimum temperature of 30 to 40^0C. Compressive and tensile strength test is carried on light weight GPC and satisfactory results were found at the end of 28days for prepared mix design of M30 grade

Key Words: Alkaline solution, Cinder, Ambient curing.

1. INTRODUCTION

The word 'Geopolymer' was primarily coined by Davidovits in the year 1978, the name geopolymer explains mineral binders which is having chemical composition likely same as that of zeolite mineral, having amorphous nature with microstructure characters. Adding value to the GPC, alternative for conventional quarry aggregate can be obtained with some of the natural available light weight materials which not only provides light weight character but also strength to the concrete. The light weight concrete will be having low density, water absorption capacity and less weight loss as compared to conventional type of concrete. Light weight aggregates can be got naturally or through by-product of some manufacturing mechanism, some of commonly available forms of light weight aggregates are scoria, volcanic cinder, pumice, clay and shale.
Cement and concrete uses large quantity of water which is potable in nature, this creates serious issue of water crisis and also results in depletion of resources that are available naturally. In order to avoid this social disastering action utilization of water recycling and improvement techniques to be used or else alternative source to be considered in place of water for purpose of construction (manufacturing concrete). Waste processing can be effectuated via twain physical and chemical action. Waste treatment and stabilization can be done either independently, or in association with physical outline. While chemical processing may deliver the waste itself chemically inert and will not release toxins as a outcome of leeching, physical processing concentrates on separating the wastes from interacting with ground water and surface water. There are many agents available that can stabilize the action of toxic waste. The key purpose of current research work is to evaluate the behaviour of such stabilizing agent known as geopolymer, which is inorganic in nature.

2. LITERATURE REVIEW

[1] N Manoj kumar, P Hanitha: In this case concrete was prepared by using material like flyash, GGBS, alkaline solutions. Study on behaviour of GPC was made and it has been compared with ordinary concrete, it was found that concrete made with flyash and GGBS tends to produce satisfying properties as compared to ordinary concrete mix. Mix design was prepared for ordinary concrete and GPC M20 grade, consisting of coarse aggregate of down sizes 20mm and 10mm, fine aggregate of 4.75mm down grade. The mixture has been bonded by considering sodium hydroxide and sodium silicate solution (alkaline solution) along with water reducing superplasticizers. Compressive strength test was performed , it was observed GPC showing 34.36 MPa on 28 days. Split tensile value and flexural strength value was found more than that of ordinary kind which was of 4.33 N/mm and 6.5 N/mm respectively. Resistance to acid action where conducted, it was observed that GPC is highly resistant against HCL and slightly to the H_2SO_4, overall it showed great response against acid behaviour. GPC gives less water absorbing capacity at the end of 56 days in comparison with normal type which is of 22.52 value.

[2] Neethu Susan Mathew, S. Usha In this study comparison of durability, strength and bond strength of GPC containing fly ash and GGBFS with OPC with M30 grade. GPC of mix proportion 1:1.5:2.5 was taken, in which fly ash to GGBFS was taken in the ratio 50:50, also activator compound to binder ratio considered to be 0.35. Compressive strength test was performed at 7 days and 28 days, it was note that compressive strength value of 20% rise in GPC relative to OPC M30 grade. There was 10.2% ascend in split tensile value in GPC. Beam mould of size 100mmX100mmX500mm were used for casting and tested for flexure strength, it gives 4.7% inflated value than ordinary M30, pull out test was conducted in order to check bond strength for the sample of cube 100mm bearing 12 mm diameter bars, strength between two GPC specimen shows even distribution at early failure stage. Sorptivity test was carried to check water absorption, obtained results was GPC found to have less water absorbing capacity than ordinary type. The variation in the water absorbing percentage was seen with

the difference of 58%. Overall GPC showed satisfying results as compared to ordinary M30 grade concrete.

[3] A. Suriya prakash, G. Senthil kumar: In current instance, complete replacement of OPC is made with alkaline solution to flyash balance of 0.45 and steel fibers variations are made in the value of 0.5%, 1.0% and 1.5% by concrete volume, flyash of class-f is used which contains low calcium. Here 15 specimen of size 150mmX150mm cube were casted, also same number of cylinder of dimension 300mm height and 150mm dia and 100mmX100mmX500mm prism were casted and they are subjected to heat curing for the period of 24 hours at the temperature of 80 ^{0}C. It was observed, the rise of compressive strength of 8.2% and 25.9% for GPC1 and GPC2 mix, also decrease in value of 18.1% of GPC3 in compared to GPC2. Hence keen observation has been made that GPC with 1% steel fibre gives 5% increase in strength value. Split tensile strength value of specimen with fibre and without fibre was found rise by 26.9% and 57.4% for GPC1 and GPC2 and falling value of about 44.26% for GPC3 with GPC2 mix. Thus GPC having 1% fibre generates 5% peak in split tensile strength. Therefore, finally it was concluded that 1% of steel fibre concentration is ideal for GPC in order to get effective results in the current study.

3. MATERIAL AND METHODS

3.1 FLY ASH

Fly ash is the extremely obtainable product on earth and broadly used as a substitute for cement. It is gained as outgrowth from coal production. Coal which are achieved from natural resources have some impurities like organic substances on its facade. To take out those impurities coal is subjected to combustion. At the time of burning phenomenon compounds having more weight settle downs and particles with light weight fly in the air. this flying matters are gathered and hence we obtain fly ash. Fly ash is is rich in alumino silicate source which will be helpful in formation of geopolymeric binder, fly ash used is of low calcium type having specific gravity 2.4 and passing through IS Sieve 45µm.

3.2 FINE AGGREGATE (FA)

Natural sand is consumed as fine aggregate, which passes 4.75 mm Indian Standard sieve as per codal provision IS 383-1970. In the case when natural sand is not available crushed stones can be used as fine aggregate.

3.3 COARSE AGGREGATE (CA)

Coarse mixture (CA) or rock chips make up the fundamental part of any concrete. They supply institution to the concrete, moderate shrinkage, and effect economic system. Their effect on numerous bodily characteristics and residences of concrete is big. To recognize greater approximately any concrete its miles very vital that one need to recognize extra about the ca. It should be strong enough as it provides strength to concrete and occupies major portion in aggregates unit. Here we have adopted light weight aggregate named as cinder, in which down size of 16mm is used for mix proportioning.

3.4 CINDER

Cinders are extrusive igneous rocks. Cinders are akin to pumice, which has so many voids, causing its low-density of zero.641g/cm^3 that lets in it to uniform drift on water. Cinder is the kind of mineral which is obtained as by product of steel industry, cinder aggregate is normally having rough and highly porous surface due to its mineral structure, these cinder material vividly ranked as possessing 100% crushed face. Cinder is characteristically brown, black, or pink depending on its chemical content. “a extra present day name for cinder is scoria”.

3.5 WATER: IS 456 Recommends that water used for mixing and curing concrete have to be ideal and unfastened from harmful measures of oils, acids, antacids, salts, sugar, natural materials or special substances that might be malicious to cement or metallic. Consumable water is for the most element concept to be appealing for mixing and curing concrete. Mixing or curing of cement with ocean water isn't prescribed in mild of the nearness of hurtful salts in ocean water. In the present paintings consuming water accessible inside the region of the lab changed into utilized for purchasing geared up and curing the SCC blends and examples.

3.6 SUPER PLASTICIZER: Conplast SP430 is used as super plasticizers which is Sulphonated Napthalene Polymers and prepared and supplied as a brown liquid. Conplast SP430 specially used to give high reduction of water upto 25% without causing depletion of workability. In order to gain the fresh workable concrete, high-range water-reducing naphthalene based admixture Conplast SP-430 was incremented to the mixture

4.0 PREPARATION OF ALKALINE SOLUTION

The pellets of sodium hydroxide is dissolved in water. The amount of sodium hydroxide required depends on concentration of solution need to be prepared which is expressed as molar value M. For instance, NaOH solution with a concentration of 10M consisted of 10x40=400 grams of NaOH solids (in flake or pellet form) per liter of the solution is prepared, here the molecular weight of NaOH is 40. The sodium silicate solution and the prepared sodium hydroxide solution were blended together at least one day earlier to use in concrete mix. On the casting day of specimen the alkaline liquid which is prepared before 24 hours was mixed with the superplasticizer as well as extra water is added to the mixture if necessary.

5.0 MIX DESIGN PROCEDUREAND RESULTS

5.1 RANGAN'S METHOD

Mix design of M30 grade GPC for the 50% replacement of cinder
Aggregate size = 16 mm size aggregate
Specific gravity of coarse aggregate = 2.7
Specific gravity of cinder = 1.844
Bulk density of coarse aggregate = 1500 Kg/m^3
Bulk density of cinder =1100kg/m^3
Specific gravity of fine aggregate = 2.6
Bulk density of fine aggregate = 1410 Kg/m^3
Specific gravity of cement = 3.15

Step 1: Volume of cube

Volume of cube = 0.15X0.15X0.15
= 0.0033 m^3

Step 2: Mass of aggregate

Total 78% of composite
Unit weight of concrete =2400 Kg/m^3
Density of aggregate =1872 Kg/m^3
(78% consideration)
Mass = Density X Volume
= 1872 X 0.0033

Mass of combined aggregate = 6.227 Kg
Mass of coarse aggregate =0.7X6.227 =4.37 Kg
(70% of combined aggregate)
Mass of normal aggregate =0.5X4.34 =2.17 Kg
(50% of total coarse aggregate)
Mass of cinder (16mm) =0.25X4.34 =1.086 Kg
(25% of total coarse aggregate)
Mass of cinder (12mm) =0.25X4.34 =1.086 Kg
(25% of total coarse aggregate)
Mass of fine aggregate (sand) =0.3X6.22 =1.86 Kg
(30% of combined aggregate)

Step 3: Mass of fly ash and alkaline liquid
Ratio of alkaline liquid to fly ash =0.45
(From Rangan's table, for high workability)
Density of alkaline liquid =552 Kg/m^3
Mass of fly ash =552/(1+0.45)
=380.69X0.0033
=1.28 Kg

Mass of alkaline liquid =0.45X1.282 =0.577 Kg

Step 4: Mass of sodium hydroxide and sodium silicate solution
Ratio of Na_2SiO_3 to NaOH =2.5
(From Rangan's table)
Mass of NaOH solution =0.577/(1+2.50)
=48.95X0.0033
=0.164 Kg
Mass of Na_2SiO_3 solution =2.50X0.164 =0.41 Kg

Step 5: Quantity of materials
Mass of fly ash =1.28 Kg
Mass of normal aggregate =2.17 Kg
Mass of cinder(16mm) =1.08 Kg
Mass of cinder(12mm) =1.08 Kg
Mass of fine aggregate =1.86 Kg
Mass of alkaline liquid =0.577 Kg
Mass of superplasticizers =0.015X1.28 =0.0192 Kg
(1.5% mass of fly ash)

5.2 MIX PROPORTION FOR VARYING CINDER PERCENTAGE

Materials		Mass (kg/m^3)				
Cinder percentage		30%	40%	50%	60%	100%
Normal weight aggregate	20 mm	905.5	776.16	646.8	517	0
Light weight cinder	16 mm	195	258.72	323.4	388	646.8
	12 mm	195	258.72	323.4	388	646.8
Fine sand		554.40	554.40	554.40	554.40	554.40
Fly ash		380.89	380.69	380.69	380.69	380.69
Sodium hydroxide solution (NaOH)		48.95	48.95	48.95	48.95	48.95
Sodium silicate solution (Na_2SiO_3)		122.36	122.36	122.36	122.36	122.36
Super Plasticizer (1.5% of flyash)		5.71	5.71	5.71	5.71	5.71

5.3 THE COMPRESSIVE STRENGTH RESULT FOR CUBES

Material replacement	Compressive strength of cubes in kN/mm2 weight in kgs					
Replacement of course aggregate	7 days		14 days		28 days	
	Strength	Weight	Strength	Weight	Strength	Weight
40%Replacement of cinder	21.62	7.21	28.88	7.56	37.71	7.80
50%Replacement of cinder	18.81	6.98	27.11	7.12	35.55	7.35
60% replacement of cinder	14.37	6.76	22.90	6.95	25.03	7.23
70% Replacement of cinder	11.70	6.53	14.96	6.73	18.22	6.98
100% Replacement of cinder	10.96	5.90	13.77	6.20	17.03	6.46

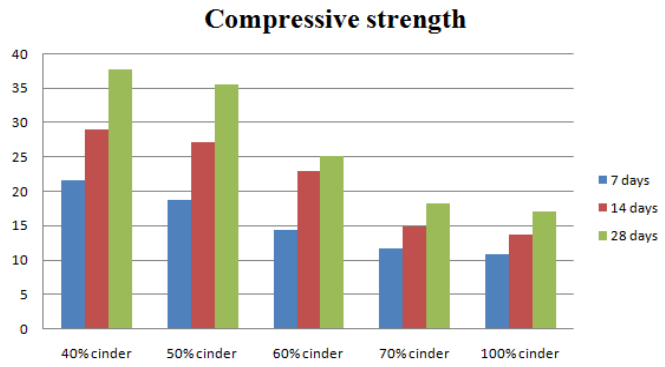

Figure.5.1 Cube Compressive Strength Chart

5.4 SPLIT TENSILE STRENGTH RESULTS OF CYLINDER

Material replacement	Flexural or Compressive strength test of cylinder in N/mm^2	
Replacement of coarse aggregate	7 days	28 days
40%Replacement of cinder	2.96	4.66
50%Replacement of cinder	2.53	4.10
60% Replacement of cinder	2.26	3.39
70% Replacement of cinder	1.55	2.54
100% Replacement of cinder	1.13	1.89

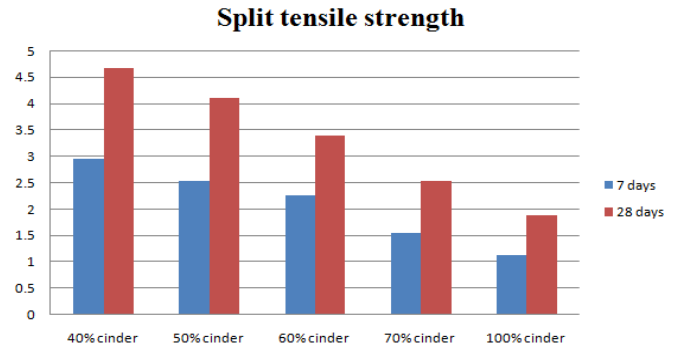

Figure.5.2 Tensile Strength of Cylinder

6. CONCLUSION

1. The heat generated during the process of mixing the sodium hydroxide (in pellets) to the mixer of sodium silicate and water is more compared to sodium hydroxide pellets to the water, and then adds up that solution to sodium silicate solution.
2. GPC with cinder produces weight reduction of upto 27% as compared to that of normal concrete blocks
3. Compressive strength of concrete at 28 days was found to be satisfactory value of 37.71MPa for the prepared mix design of M30 grade.
4. Tensile strength value of 4.66MPa were observed as optimum strength value for light weight cinder based GPC.
5. The GPC put to use the industrial wastes outcome such as fly ash for obtaining the binder element in concrete. Hence these concrete will be considered as eco-friendly materials.
6. As Portland cement is not used in GPC, they are considered as less energy interactive.

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7. REFERENCES

[1] N Manoj Kumar, P Hanitha (Dec 2016) "Geopolymer concrete by using fly ash and GGBS as a replacement of cement" *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).*

[2] Neethu susan Mathew, Usha S "Study on strength and durability of fly ash and GGBFS based geopolymer concrete", *International Research Journal of Engineering and Technology (IRJET).*

[3]. A Suriya Prakash, G Senthil Kumar (March 2015) "Experimental Study on Geopolymer Concrete using Steel Fibres", *International Journal of Engineering Trends and Technology (IJETT).*