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Geoplymer Concrete

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Abstract: Concrete is the world's most versatile, durable and reliable construction material. Next to water, concrete is the most used material, which required large quantities of Portland cement. Ordinary Portland cement production is the second

Only to the automobile as the major generator of carbon di oxide, which polluted the atmosphere. In addition to that large amount energy was also consumed for the cement production. Hence, it is inevitable to find an alternative material to the existing most

Expensive, most resource consuming Portland cement. Geopolymer concrete is an innovative construction material which shall be produced by the chemical action of inorganic molecules. Fly Ash, a by- product of coal obtained from the thermal power

plant is plenty available worldwide. Flyash is rich in silica and alumina reacted with alkaline solution produced alumina & silicate gel that acted as the binding material for the concrete. It is an excellent alternative construction material to the existing plain

cement concrete. Geopolymer concrete shall be produced without using any amount of ordinary Portland cement. This project reviews the constituents of geopolymer concrete, its strength and potential applications. The experimental conducted on processes flyash based geopolymer concrete in which ash is use as a source material instead of cement & two types of alkaline

activators (NaOH solution of concentration of 13 moles & Na 2 SiO 3 solution) were used in geopolymer concrete cube of size 150x15x150 mm, cylinder 150 mm diameter &300 mm height, beam 750x150x150mm were casted by varying water to geopolymer binder ratio from 0.30, 0.35,0.40. With incremental of 0.05. The geopolymer concrete cube, cylinder, beam were cured in oven curing. In oven curing it was kept under 90 0 C for 24 Hours duration. Then it was tested for 7, 14, 28 days for compressive strength, flexural strength & indirect split tensile strength are conducted on each of 3 mixes. It was observed that water to cementious material of 0.30 the result are promising. The detailed investigation conclusion drawn from experimental work have been highlighted in this dissertation.

***Index Terms* -** Flyash, Geopolymer Concrete, Heat –Cured, Alkaline Activators, Polymerization.

I. Introduction

Production of Portland cement is increasing due to the increasing demand of construction industries. Therefore, the rate of production of carbon dioxide released to atmosphere during production of Portland cement is also increasing.

Now a days, Portland cement (PC) concrete is the most popular and widely used building materials, due to its availability of the raw materials over the world, its ease for preparing and fabricating in all sorts of conceivable shapes. The applications of concrete in the area of infrastructure, habitation, and transportation have greatly prompted the development of civilization, economic progress, and stability and of the quality of life. However, due to the restriction of the manufacturing process and the raw materials, some inherent disadvantages of Portland cement are still difficult to overcome. There are two major drawbacks with respect to sustainability. About 1.5 tonnes of raw materials is needed in the production of every tonne of Portland cement, at the same time about one tonne of carbon dioxide (CO_2) is released into the environment during the production. Therefore, the production of PC is extremely resource and energy intensive process. On the other hand, the global warming also can occur because of the greenhouse gases such as carbon dioxide to the atmosphere. A need of present status is, should we build additional cement manufacturing plants or find alternative binder systems to make concrete? On the other scenario huge quantity of fly ash are generated around the globe from thermal power plants and generally used as a filler material in low level areas. Alternative binder system with fly ash to produce concrete eliminating cement is called “Geopolymer Concrete”.

The main object of this project is to develop the geopolymer concrete using processed flyash as source material instead of cement. It intended to develop geopolymer concrete using optimized use of alkaline activators like sodium silicate and sodium hydroxide with a view to minimize cost. To increase the use of conventional residual product, that is fly ash

To use the residual product from other industries not traditionally used in concrete that is fly ash form bio fuels and sewage sludge from sewage treatment plant. To establish the economical, technological and environmental benefits of geopolymer binders over Ordinary Portland Cement. To verify the improvement of properties like compressive strength, tensile strength, flexural strength with respect to water binder ratio.

II. METHODOLOGY:

- Design Steps

1. Target mean strenght(Fck) for Mix design

   $Fck = Fck' + 1.65 * S$

   $= 20 + 1.65 * 4$ …. As per IS 456-2000 Page no. 23 Table no. 8

   $Fck = 26.6$ MPA

2. Selection of quantity of Fly-ash for Figure-1

   The quantity of Fly-ash is required is 300 kg/m^3 for Target mean strenght 26.6 MPA at solution to Fly-ash ratio 0.30 and for 439 m^3/kg Fineness of Fly-ash.

3. Calculation of the quantity of Alkaline activators

   Calculation the quantity of Alkaline activators and considering solution / Fly-ash ratio by mass = 0.30

   i.e Mass of (Na_2SiO_3+NaOH) / Fly-ash=0.30

   i.e (Na_2SiO_3+NaOH)/300 = 0.30

   Mass of (Na_2SiO_3+NaOH) = 90 kg/m^3

   Take the Na_2SiO_3 to NaOH ratio by mass of 1

   Mass of NaOH Solution = 45 kg/m^3

   Mass of Na_2SiO_3 Solution = 45 kg/m^3

4. Calculation of total solid content in Alkaline solution

   Solid content in Sodium Silicate solution = 50.32/100*45

   = 22.644 kg/m^3

   Solid content in Sodium Hydroxide solution = 38.50/100*45

   = 17.325 kg/m^3

   Total Solid content in both Alkaline solution = 39.97 kg/m^3

5. Selection of water content for medium degree of workability and fineness of Fly-ash of 439 m^2/kg water content per cubic meter Geopolymer concrete is selected from table no.2

   Water content = 110 kg/m^3

6. Adjusment in water content for sand conferming to gtading zone 2nd, there will be no correction from table no 3.

   Water content in alkaline solution = 90 - 39.97

   = 50.03 kg/m^3

7. Calculation of additional quantity of water = (Total quantity of water - Water present in alkaline solution)

   = 110 - 50.03

   = 59.97

   = 60 kg/m^3

8. Selection of weight Density of Geopolymer concrete from fig 3. of weight Density of Geopolymer concrete to 2538 kg/m^3 for the Fineness of Fly-ash of 439 m^3/kg

9. Selection of fine to total aggregate content – Now from figure 2, Fine to total aggregate content is 32.5 % for fineness modulus of sand of = 2.71

10. Calculation of fine and course aggregate content

    Total aggregate content = (weight of G.P.C)-(Quantity of Fly-ash + Quantity of both solution + Extra water if any)

    = 2538-(300+90+60)

    = 2088 kg/m^3

    Sand content = (Fine to total aggregate content in %) * (Total quantity of all in aggregate)

    = 32.5/100*2088

    = 678.6 kg/m^3

    Course aggregate content = (Total quantity of all in aggregare)-(Sand content)

    = 2088-678.6

    = 1410 kg/m^3

Table No.1.Mix Design M20 for One Cubic Meter

Water/G.P.B.	G.P.B.($NaOH+ Na_2SiO_3$) (Kg)	Sand (Kg)	C.A. (Kg)	Extra Water (liter)
0.30	390	679	1410	60
	1	1.74	3.615	0.154
0.35	405	674.25	1400.37	51.628
	1	1.66	3.46	0.127
0.40	420	674.280	1400.37	43.292
	1	1.60	3.33	0.103

Table No.2.Quntity Of Material Required For M20 Grade 0.30 Gpc For 9 Cubes,9 Cylinders And 9 Beams In Kg

Type	W/GPB (Kg)	Fly ash (Kg)	NaOH (Kg)	Na_2SiO_3 (Kg)	F.A (Kg)	C.A (Kg)	Water (liter)
Cube	0.30	8.60	2	2	22	45	2
Beam	0.30	15.30	8	8	88	180	8
cylinder	0.30	12.15	2.83	2.83	31.23	63.9	5

III. RESULT

Compressive Test:

Compressive are kept for oven curing 24 hours at 90°C for specified duration and result are obtained as follows-

Table No. 3. Compressive Strength for 7 Days

Sr.No.	Identification Mark	Water/ geopolymer binder ratio.	Compressive strength (N/mm^2)	Average Compressive strength (N/mm^2)	Remark
1	CUBE 1	0.30	17.78	18.09	In oven curing at temperature of 90°C for duration of 24 hours.
2	CUBE 2		18.01		
3	CUBE 3		18.50		
4	CUBE 1	0.35	17.25	17.07	
5	CUBE 2		16.77		
6	CUBE 3		17.21		
7	CUBE 1	0.40	14.98	14.84	
8	CUBE 2		15.22		
9	CUBE 3		14.22		

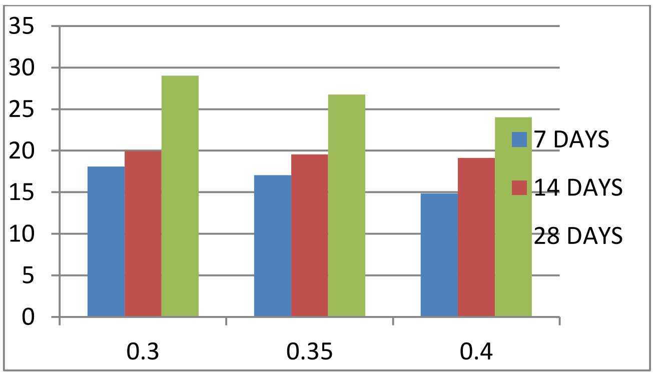
Table No. 4 Compressive Strength for 14 Days

Sr.No.	Identification Mark	Water/ geopolymer binder ratio.	Compressive strength (N/mm^2)	Average Compressive strength (N/mm^2)	Remark
1	CUBE 1	0.30	20.12	19.93	In oven curing at temperature of 90°C for duration of 24 hours.
2	CUBE 2		19.17		
3	CUBE 3		19.91		
4	CUBE 1	0.35	19.37	19.57	
5	CUBE 2		20.22		
6	CUBE 3		19.12		
7	CUBE 1	0.40	19.52	19.13	
8	CUBE 2		18.68		
9	CUBE 3		19.21		

Table No. 5 Compressive Strength For 28 Days

Sr.No.	Identification Mark	Water/ geopolymer binder ratio.	Compressive strength (N/mm^2)	Average Compressive strength (N/mm^2)	Remark
1	CUBE 1	0.30	28.12	29.01	In oven curing at temperature of 90°C for duration of 24 hours.
2	CUBE 2		29.34		
3	CUBE 3		29.58		
4	CUBE 1	0.35	26.92	26.75	
5	CUBE 2		27.01		
6	CUBE 3		26.33		
7	CUBE 1	0.40	24.28	24.03	
8	CUBE 2		25.25		
9	CUBE 3		22.61		

Graph No. 1.Effect Of Various Water / Geopolymer Binder Ratio On Compressive Strength



Flexural Test -

Beams are kept for oven curing 24 hours at 90°C for specified duration and result are obtained as follows

Table No.6. Flexural Strength For 7 Days

Sr.No.	Identification Mark	Water/ Geopolymer Binder Ratio.	Flexural Strength (N/Mm²)	Average Flexural Strength (N/Mm²)	Remark
1	BM1	0.30	4.52	4.60	In oven curing at temperature of 90°C for duration of 24 hours.
2	BM2		4.43		
3	BM3		4.87		
4	BM1	0.35	3.82	3.69	
5	BM2		3.27		
6	BM3		3.98		
7	BM1	0.40	3.28	3.44	
8	BM2		3.54		
9	BM3		3.50		

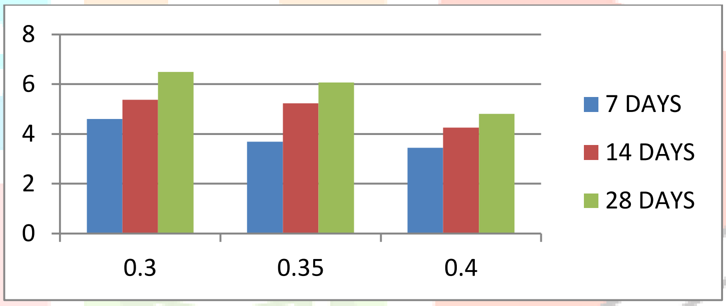
Table No. 7. Flexural Strength For 14 Days

Sr.No.	Identification Mark	Water/ Geopolymer Binder Ratio.	Flexural Strength (N/Mm²)	Average Flexural Strength (N/Mm²)	Remark
1	BM1	0.30	4.98	5.37	In oven curing at temperature of 90°C for duration of 24 hours.
2	BM2		5.26		
3	BM3		5.87		
4	BM1	0.35	4.76	5.23	
5	BM2		5.24		
6	BM3		5.67		
7	BM1	0.40	3.85	4.25	
8	BM2		4.73		
9	BM3		4.18		

Table No. 8 Flexural Strength For 28 Days

Sr.No.	Identification mark	Water/ geopolymer binder ratio.	Flexural strength (N/mm^2)	Average Flexural strength (N/mm^2)	Remark
1	BM1	0.30	6.36	6.49	In oven curing at temperature of 90°C for duration of 24 hours.
2	BM2		6.87		
3	BM3		6.25		
4	BM1	0.35	5.97	6.06	
5	BM2		6.29		
6	BM3		5.76		
7	BM1	0.40	4.59	4.81	
8	BM2		5.21		
9	BM3		4.64		

Graph No. 2. Effect Of Various Water / Geopolymer Binder Ratio On Flexural Strength



IV. Conclusion

1. Geopolymer concrete is more environmentally friendly and has the potential to replaced ordinary cement concrete in many applications such as precast unit.
2. Compressive strength of geopolymer concrete will be increase if reduce the water to geopolymer binder ratio.
3. It has observed that slightly more cost required for preparation of GPC concrete.
4. So use of product like geopolymer concrete, green concrete etc in future will reduce the emission of CO_2 in environmental point of view.
5. As the flyash is the byproduct of coal which is produce during combustion of coal thus the problem of disposal of by product get solved. Hence geopolymer concrete is thus not harm to environment and it is environment friendly.
6. It required temperature curing and hence it required energy for curing.
7. Geopolymer concrete requires special handling needs and is difficult to create.It requires the use of chemicals, such as sodium hydroxide, that can be harmful to human.
8. The flexural strength of geopolymer concrete will be increases if reduces the water to binder ratio

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