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Investigation of the Behaviour of Geopolymer Mortar with Fly-Ash under High Temperature

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Abstract: ***Geopolymers belong to a range of inorganic polymeric materials formed by activating silica aluminium rich minerals. Silica-aluminium rich industrial wastes like fly ash etc. are activated with alkaline or alkaline-silicate solution at ambient or higher temperature to get Geopolymers. The objective of the present research is to investigate the effect of different synthesizing parameter on the hardened properties fly ash based geopolymer mortar exposed to different Elevated temperature level. An experimental investigation on low calcium fly ash based geopolymer mortar, was undertaken. Percentage of Na2O was taken 8 % and 10 %. SiO2 / Na2O ratio was varied from 1 to 1.6. Sand to Fly ash ratio was kept 2:1, 1:1, and 1:2.Curing temperature and curing time were 800C and 72 hours respectively. After seven days, specimens were heated in oven at 2000C , 4000C & 5500C for four hours and then kept in air for cooling. The effect of various synthesizing parameters at different temperature exposure on different properties such as Compressive strength, workability test & Apparent porosity have been studied and the results were presented in the tabular form. It was observed that the geopolymer mortar is quite temperature resistant & some reduction in compressive strength was observed.***

Keywords: compressive strength test, Workability test, Apparent porosity

1. Fly Ash

Fly ash is brought from Ramagundem Thermal power station was used as a source material.along with a mixture of sodium hydroxide and sodium silicate solution as alkaline activator.Here fly ash is used in place of cement as a binder.

Lab testing: The following are the test conducted on the concrete cube samples are as follows

1. Compressive strength by CTM
2. Workability test
3. Apparentporosity

2. Compressive strength by CTM

The compressive strength at 3 days of normal curing temperature & after 7 days heated at a temperature of 200°c, 400°c & 550°C are as follows

Compressive strength(MPa)(3days)	Compressive strength(MPa)200°c	Compressive strength(MPa)400°c	Compressive strength (MPa)550°c	%Na_2o	Sand/flyash ratio	Sio_2/Na_2o ratio
28.10	25.36	22.46	18.52	8	1:2	1.6
26.32	23.42	18.4	16.32	8	1:1	1.6
24.31	13.8	13.4	9.64	8	2:1	1.6

Compressive strength(MPa)(3days)	Compressive strength(MPa)200°c	Compressive strength(MPa)400°c	Compressive strength (MPa)550°c	%Na_2o	Sand/flyash ratio	Sio_2/Na_2o ratio
25.6	22.4	20.54	12.91	8	1:2	1.3
30.64	25.56	13.56	13.46	10		
22.4	19.5	14.6	9	8	1:1	1.3
26.3	23.18	17.66	12.6	10		
17.2	13.6	6.4	5.74	8	2:1	1.3
22.12	16.16	13.26	9.4	10		

Compressive strength(MPa)(3days)	Compressive strength(MPa)200°c	Compressive strength(MPa)400°c	Compressive strength(MPa)550°c	%Na_2o	Sand/flyash ratio	Sio_2/Na_2o ratio
24.3	18.36	15.3	9.42	8	1:2	1
25.36	21.12	16.2	11.28	10		
18.9	15.3	10.32	6.23	8	1:1	1
21.4	13.28	10.28	9.4	10		
12.6	8.69	4.3	1.12	8	2:1	1
17.78	14.68	9.16	8.16	10		

3. Workability Test

The Workability test at different mix proportions are as follows

Workability (mm)	Sio_2/Na_2o ratio	Sand/flyash ratio	$\%Na_2o$
141	1	2:1	8
188	1.3	1:1	8
215	1.6	1:2	8
130	1	2:1	8
175	1.3	1:1	8
186	1.6	1:2	8
119	1	2:1	8
135			10
167	1.3	1:1	8
178			10
174	1.6	1:2	8
191			10

4. Apparent Porosity

The Apparent porosity at 3 days of normal curing temperature & heated at a temperature of 200°c, 400°c & 550^{0}C are as follows

Apparent porosity (%)	Apparent porosity (%)(200^{0}c	Apparentporosity (%)400^{0}c	Apparentporosity (%)550^{0}c	$\%Na_2o$	Sand/flyash ratio	Sio_2/ Na_2o ratio
21.23	21.68	22.9	25.8	8	1:2	1
17	18.4	20.73	22.93	10		
18.87	19.3	20.62	23.9	8	1:2	1.3
17.8	18.13	18.7	20.6	8	1:2	1.6

Apparent porosity (%)	Apparentporosity (%)(200^{0}c	Apparentporosity (%)400^{0}c	Apparentporosity (%)550^{0}c	$\%Na_2o$	Sand/flyash ratio	Sio_2/ Na_2o ratio
19.8	20.54	22.3	23.1	8	1:1	1
12.58	13.86	15.71	17	10		
17.15	18.57	20.23	21.12	8	1:1	1.3
15.9	16.9	17.6	18.6	8	1:1	1.6
Apparent porosity (%)	Apparentporosity (%)(200^{0}c	Apparentporosity (%)400^{0}c	Apparentporosity (%)550^{0}c	$\%Na_2o$	Sand/flyash ratio	Sio_2/ Na_2o ratio
16	17.4	18.2	19.35	8	2:1	1
12.58	13.86	15.71	17	10		
14.9	15.87	17.16	18.254	8	2:1	1.3
14.174	14.835	15.253	15.93	8	2:1	1.6

5. Conclusion

- Fly ash to Sand ratio at different elevated temperature (200^{0}C, 400^{0}C & 550^{0}C) plays a vital role in compressive strength development. Increase in sand to fly ash ratio decrease the strength of the Geopolymer mortar.
- The preparation of Geopolymer mortar has been accomplished by mixing of allumino-silicate source material fly ash with an activating solution that contains sodium hydroxide and soluble sodium silicate. Study on workability of the fly ash based Geopolymer mortar result shows that the percentage of Na2O, SiO2 / Na2O ratio and Sand to fly ash ratio affects the mortar flow. Increasing the Sand to fly ash ratio mixture become stiffer and workability become low. Increase the alkali (% Na2O) content and silicate ratio (SiO2 / Na2O) increase the workability of the Geopolymer mixture
- Silicate ratio (SiO2 / Na2O) was also found to be crucial factor affecting the compressive strength of the Geopolymer mortar. The high reactive silica content involved in the formation of high amount of alkali alumina-silicate gel, resulting in high compressive strength. Compressive Strength loss at higher elevated temperature was less for higher SiO2 /Na2O ratio
- The alkali content (% Na2O) was also important parameter affecting compressive strength of Geopolymer mortar. Increasing alkali concentration in Geopolymer system increased bulk concentration of hydroxide ions, resulted in increase of the dissolution rate of Si and Si-Al phase of fly ash. For alkali content (8 % Na2O), the unexposed and exposed compressive strength was found to be 25.6 MPa and 20.54 MPa respectively. When alkali content was increased from 8 % to 10 %, the unexposed and exposed compressive strength was found to be 30.64 MPa and 13.56 MPa respectively
- Apparent porosity was found to decrease with increase in Sand to Fly ash ratio, SiO2 / Na2O ratio and percentage of Na2O for both normal and elevated temperature condition.

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