

EXPERIMENTAL INVESTIGATION ON BEHAVIOUR OF FLY ASH BASED GEOPOLYMER MORTAR AT ELEVATED TEMPERATURE

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Abstract - This paper presents results from experimental studies on thermal behavior of geopolymer mortar, prepared by alkaline solution of sodium silicate, potassium hydroxide and fly ash blend. To produce the geo-polymer mortar the Portland cement is fully replaced with fly ash and the river sand is used as fine aggregate and alkaline liquids are used for the binding of materials. The alkaline liquids used in this study for the polymerization are the solutions of Potassium hydroxide (KOH) and sodium silicate (Na_2SiO_3). Different molarities of sodium hydroxide solution namely 10M, 12M and 14M are used and the compressive strength is found out for each of the molarity. The cube specimens are taken of size 70.6mm x 70.6mm x 70.6mm. The Geopolymer mortar cube specimens are tested for their compressive strength at the age of 7 days, mixes of varying potassium hydroxide molarities i.e. 10M, 12M and 14M are prepared and they are cured by oven curing at 70°C and strengths are calculated for 7 days. The result shows that the strength of Geopolymer mortar is increasing with the increase of the molarity of potassium hydroxide at elevated temperature.

Key Words: Geopolymer mortar, Sodium silicate, Potassium hydroxide, Fly ash, Portland cement, Elevated temperature, Compressive test.

1. INTRODUCTION

In 1978, Joseph Davidovits coined the term Geopolymer to represent a wide range of materials which are characterized by chains or networks of inorganic molecules. The chemical reaction that takes place in geopolymers is the polymerization process. Geo-polymers, generally have their chemical composition equivalent to Zeolites. However, they can be formed as an amorphous structure. He also suggested the use the term 'polysialate' for the chemical designation of geopolymers based on silico-aluminate.

1.1 Preparation of conventional mortar

The materials used for the preparation of conventional mortar include cement and sand in an optimized water cement ratio. A number of conventional mortar cubes have

been casted to test their characteristics with that of geopolymer mortar cubes. The standard mortar mould size of 70.6mmX70.6mmX70.6mm are being used for casting of conventional mortar. Conventional mortar are placed in a curing pot at an interval of 7 and 28 days and are taken out for further testing process at elevated temperature and the strength results are compared with the geopolymer mortar cube strength.

1.2 Mix design of Geopolymer mortar

The mix design in the case of geo-polymer mortar is based on conventional mortar with some modification. In case of conventional mortar the material proportion can be found out for the required strength by using the code, but in the case of geo-polymer mortar there is no design method or provisions from code book. Here by means of trial and error method optimized mixes are being produced. The geo-polymer mortar is wet-mixed for five minutes and cured at 70°C for 24 hours in hot air oven after casting. The quantities of all ingredients are kept constant except the molarity of KOH is changed in the each mix for strength determination.

2. FIRE EXPOSURE AND RESULTS

To find the thermal behavior of geopolymer mortar or its strength under elevated temperature, the cube specimens have been exposed to 600°C for about 2 hrs. The temperature up to 600°C is obtained at a gradual incremental rate of approximately 5°C/min from room temperature. As soon as the target temperature was attained, it was maintained for an additional 120 min before the furnace was shut down to allow the specimens in the furnace to cool down to room temperature. The cooling process usually takes more than 12 hours.

Table -1: Geopolymer mortar cube strength after fire exposure at 600°C

MOLARITY OF KOH USED	SPECIMEN USED	LOAD AT FAILURE (kN)	COMPRESSIVE STRENGTH AFTER FIRE EXPOSURE(N/mm ²)
10M	GP1	130	26.1
	GP2	127	25.5
	GP3	136	27.2
12M	GP1	145	29.1
	GP2	156	31.3
	GP3	143	28.7
14M	GP1	119	23.8
	GP2	128	25.6
	GP3	131	26.3

Compressive strength is the capacity of a material or structure to withstand axial forces. Cubes of 70.6mmX70.6mmX70.6mm were casted and compressive strength test was conducted on specimens at 7 days after fire exposure. To conduct the test the specimens are placed in a compression testing machine and the load is applied to the cube and the load at failure is noted as failure load.

$$f_{ck} = P_c / A$$

Where,

P_c=load at failure in N

A=loaded area of cube in mm².



Fig -1: Testing compressive strength of geopolymer mortar after fire exposure

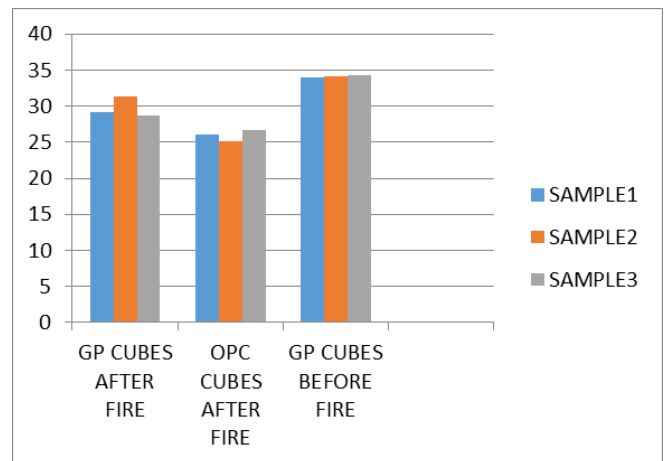


Chart 1: Compressive strength of conventional mortar and 12M of geopolymer mortar before fire exposure and after fire exposure at 600°C

3. CONCLUSIONS

Geopolymer mortar cube attains higher strength at increased temperature of oven curing. Geopolymer mortar sample cubes are more resistant to fire than the conventional mortar cubes. From the results it can be inferred that Geopolymer mortar with 12M of Potassium Hydroxide has higher compressive strength after Fire exposure. There is considerable loss of strength in case of conventional mortar during the fire exposure in a short period of time. Whereas the geopolymer mortar holds good in this case. The fresh flyash-based geo-polymer mortar is easily handled up to 120 minutes without any sign of setting and without any degradation in the compressive strength. The geopolymer mortar shows better fire endurance than ordinary Portland cement mortar. This is due to the fact that the matrix of geopolymer mortar are stable than the matrix of ordinary Portland cement mortar.

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