ABSTRACT

Geopolymers, a novel class of inorganic polymers, are new promising binders. They are manufactured by the activation of a solid state alumino-silicate with a highly alkaline activating solution using thermal energy. In the past few decades, Geopolymer binders have emerged as one of the most powerful solutions to cement binders attributed to its high mechanical properties and environmental friendliness. The performance of this alumino-silicate concrete is promising in some aggressive environments where cement concrete is found vulnerable. Out of many supplementary cementitious materials available in India, precipitated coal fossil burnt flyash, a by-product obtained from Thermal Power Stations, is rich in Silica. Flyash, once considered waste material and found no place for disposal, is very much suitable to produce Geopolymer concrete and Geopolymers. However the caveat is, a high volume of flyash could be used in Geopolymer concretes but not in ordinary cement concretes. Though Portland cement concrete is the most widely used material in the construction industry, the quantity of cement required throughout the world is quite alarming and while producing huge quantity of cement, nearly, 80% of that quantity of CO$_2$ would be emitted into the atmosphere leading to Global warming.

Many researchers have already studied about the mechanical properties of Geopolymer concrete, its applications in construction industry. Although there are many studies that have been reported by investigators from other countries on the behavior of Geopolymer concrete, not much research has been carried out concerning the strengthening of reinforced Geopolymer concrete. This research was performed to generate specific experimental data on the potential use of GFRP sheets as strengthening agent for reinforced Geopolymer structural element.
This research work mainly consists of eight main categories. Geopolymer concrete was used to determine various mechanical properties. This research, reports the properties of Geopolymer concrete and also strengthened Geopolymer columns with GFRP sheets in which GFRP sheets were used as a strengthening element. Geopolymer concrete was prepared for compressive strength of 30 MPa and 50 MPa each with 8 molarity and 12 molarity of NaOH concentration. The behavior of Geopolymer concrete, reinforced Geopolymer short columns and reinforced Geopolymer long columns was found by conducting tests under following categories.

i. Tests on setting time of geopolymer.

ii. Tests on fresh Geopolymer concrete.

iii. Tests on strength of hardened Geopolymer concrete.

iv. Tests on durability of Geopolymer concrete specimens.

v. Tests on Geopolymer G30 short columns (Unwrapped and Wrapped).

vi. Tests on Geopolymer G50 short columns (Unwrapped and Wrapped).

vii. Tests on Geopolymer G30 long columns (Unwrapped and Wrapped).

viii. Tests on Geopolymer G50 long columns (Unwrapped and Wrapped).

The casting and testing of fly ash based geopolymer concrete was done according to the specifications followed for ordinary Portland cement. Initially testing the consistency of flyash based geopolymer binding materials was carried out as specified by the IS: 4031 (PART IV)-1988, initial and final setting time were calculated as per IS: 4031 (PART V)-1988 by vicat apparatus confirming to IS: 5513-1976. The mortar cubes of size 70.6mm x 70.6mm x 70.6mm confirming to IS : 10080-1982 was tested for compressive strength. Test procedures for the compressive strength of mortar cubes as per IS: 4031 (PART VI)-1982 was followed. The slump value and flow value of fresh flyash based geopolymer concrete were tested in accordance with ASTM – C 143 and ASTM – C 1362 – 09 respectively. Compressive strength of
150mm x 150mm x 150mm geopolymer concrete cubes was ascertained by testing as per the procedures stipulated in strength test was conducted on 150mm diameter and 300mm height cylinder cast with geopolymer concrete and tested in accordance to IS: 5816 – 1999. Geopolymer concrete beams of standard size 750mm x 150mm x 150mm confirming to IS: 516 – 1959 was used for evaluating flexural strength of plain geopolymer concrete (prism). Durability tests on flyash based geopolymer concrete cubes were conducted according to ASTM - C 642 and the results were compared. The ultrasonic pulse velocity test was conducted as per the procedure given in IS: 13311-1992. Geopolymer concrete disc of size 90mm diameter and 35mm thickness has been developed to measure the rate of transport of chloride ions into the concrete by rapid chloride penetration test (RCPT) as per ASTM – C 1202 94. The geopolymer short columns were cast to a height of 800mm with a diameter of 100mm. The geopolymer long columns were cast to a height of 1420mm with a diameter of 100mm. The glass fibre reinforced polymer (GFRP) sheets with scattered pattern were used for wrapping the columns in single and double layers to strengthen the members. These columns were tested in a column tester of capacity 2000kN and 3LVDT’s were positioned at selected locations to monitor the lateral deflections and axial deformations of the column.

From the entire test data’s it was found that Geopolymer columns both short and long had greater strength increase, when these columns were strengthened with two layers of GFRP sheets. It was also evident from the study that the bond between structural element and GFRP sheets were good in Geopolymer concrete when compared with OPC concrete.