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Investigation of Experimental Study on Flexural Behaviour of Alkali Activated Geopolymer concrete by Using Fly Ash and Paper Sludge Ash

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ABSTRACT: The present experimental program is conducted to study the structural behavior of reinforced Geopolymer concrete beams under two points loading. Geoploymer concrete mixtures are prepared by varying the percentage of fly ash and paper sludge ash content and experimental study carried on strength parameters, the best suited mixtures based on the optimal strength of compression and flexure was selected for manufacture of beam. Investigation is confined to find Moment of resistance of the beam and compared with the conventional concrete beam analysis as per IS 456-2000 code of practice. Deflections, stiffness and crack patterns are also studied in the investigations. Experimental investigations of moment of resistance of the beams are validated over the analysis results. The defalcation, stiffness and crack patterns are found similar to conventional concrete beam.

Keywords: Structural behavior, Fly Ash, Paper sludge Ash, Geopolymer Concrete Beams.

I. INTRODUCTION

Geopolymer are inorganic polymer binder with chemical composition similar to zeolite but with amorphous microstructure. This technology was first introduced by Dr. Joseph Devidovit and he coined the name GEO-POLYMERS. The Geopolymer concrete is not containing any cement and it is manufactured by using activated pozzolanic materials and aggregates. Unlike ordinary Portland cement Geopolymer donot form calcium silicate hydrates for matrix formation but it forms by polycondensation of aluminium and silica activated by alkali materials. Significant research work has been carried to study the behavior of the geopolymer concrete under structural application and the results of which shows the effective durability and strength over conventional ordinary Portland cements concrete. The behavior of the concrete depends upon the source materials or pozzolanas and activator solution or alkaline solution. This research work is carried to study the flexural behavior of beam under the application of load and substantiate the previous research significations.

II MATERIALS

Following are the basic materials used for the preparation of Geopolymer concrete

a) Fly ash & PSA (source material)
b) Aggregates (Coarse and Fine aggregate)
c) Alkaline solution (Activators)
d) Water
e) Plasticizers

2.1 FLY ASH

Fly ash is the alumina-silicate source material used for the synthesis of geo-polymeric binder. Fly ash obtained from the Mettur Thermal Power Station, was used for the experimental work. The fly ash was of low calcium fly ash which confirms to class F of ASTM standards. The percentage of fly ash passing through 45µm IS sieve was found to be 95% and its specific gravity was 2,20.

2.2 PAPER SLUDGE ASH

Paper sludge ash used for geopolymer concrete, which obtained from SPB Paper mill, Pallipalayam. The percentage of paper sludge ash passing through 45µm IS sieve was found to be 95% and its specific gravity was 2.29. Here Hydrochloric acid(1.5M) used for decrease the amount of calcium from the ash and increasing the amount of silica.

2.3 FINE AGGREGATE

Locally available river sand is used as fine aggregate. The sieve analysis is conducted .The fine aggregate test conforms to Zone-II as per IS: 383-1970. Fineness modules and Specific

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gravity of fine aggregate were 2.61 and 2.64, respectively.

2.4 COARSE AGGREGATE

Locally available crushed(angular) granite coarse aggregate passing through 12.5 mm sieve size and retained on 10 mm sieve are used .The Coarse aggregate tested confirms to the size of 12.5 mm graded aggregate of nominal size as per IS 383 – 1970 code of practice. Specific gravity and water absorption of the aggregates were 2.62 and 0.3%, respectively

2.5 ALKALINE SOLUTION

A combination of sodium silicate solution and sodium hydroxide solution was used to react with the aluminium and the silica in the fly ash. Flake form sodium hydroxide with 97% purity and sodium silicate from local supplier was used for the present study. The chemical composition of sodium silicate solution are Na2O=14.74%, SiO2=31.45%, and water content equal to 33.75% by mass. The molarity of the solution is kept 16 M for throughout experimental work.

2.6 WATER

Clean portable water is used for solution preparation. The total water in the solution is considered as added water plus the water content in the sodium silicate

2.7 SUPER PLASTICIZERS

Poly carboxylic ether based high performance super plasticizers of the brand name Glenium B233 confirmed with IS 9103: 1999, from BASF construction chemicals was used for all the experimental mix. The dosage applied in the range of 1% to 2% of cementitious material (FA & PSA) by mass for better workability.

III EXPERIMENTAL PROCEDURE

This investigation has to study the flexural behaviour and strength properties of concrete with the addition of the FA & PSA. Specimens were casted at different percentages. Initially the mould is oiled to ease the removal of specimen from the mould. The specimens were casted in a way that the specimens were free from voids. The top surface are smoothened and kept undisturbed for 24 hours. Cubes are casted for compression test , cylinders are casted for tensile strength and prisms were tested for flexural strength.

3.1 COMPRESSIVE STRENGTH

The compressive strength test is conducted 150x150x150 mm concrete cubes. Three no of cubes prepared on each mixtures specified in Table 2 and tested through compressive testing machine. Table 1 shows the compressive strength of the specimens.

Mixtures with %	Density (KN/ mm$^{3)}$	Load(KN)	Avg comp strength (N/ mm$^{3)}$
FPGC-M1-15%	23.50	405	17.48
FPGC-M2-17%	23.33	430	19.92
FPGC-M3-19%	23.57	590	26.59
FPGC-M4-21%	23.66	630	28.44
FPGC-M5-23%	23.69	725	31.55

Table 1 Compressive strength Result

3.2 FLEXURAL STRENGTH TEST

The Geopolymer concrete mixtures FPGC1-M1, FPGC2-M2, FPGC3-M3 (Optimal compressive strength mixtures) were used for the flexural strength. Tests carried on 100 X 100 X 500 mm specimens according to IS: 516-1959, the tests results are shown in Table 2. Based on test data the higher values of compressive and flexure strength found at FPGC-M3, are selected to manufacture the beam specimens to study the flexure behavior of beams. Three Number of beams are manufactured in each tensile reinforcement.

Mixure	Load P(KN)	Avg Flexural strength(N/mm^2)
FPGC-M1	10	4.26
	11.5	
FPGC-M2	11	4.46
	12	
FPGC-M3	10.5	4.13
	11	

Table 2 Flexural strength Result

3.3 GENERAL BEHAVIOR OF BEAM

As the load increases beam starts to deflect in the direction of load and cracks are developed along the tension face of the beam specimens, eventually all the beam specimens failed in a typical flexure mode. The load-deflection curves indicate distinct events that were taking place during the test. These events are identified as first cracking, yield of the tensile reinforcement, crushing of concrete at the compression face associated with Spalling of concrete cover and disintegration of the compression zone.

3.4 CRACK PATTERNS AND MODE OF FAILURE

All the beam specimens were failed in same mode, as the load increases the flexure cracks initiates in the pure bending zone. As the load increases, existing cracks propagated and new cracks developed along the span. The cracks at the mid-span opened widely near failure, the beams deflected significantly, thus indicating that the tensile steel must have yielded at failure. The final failure of the beams occurred when the concrete in the compression zone crushed, accompanied by buckling of the compressive steel bars. The failure mode was typical of that of an under-reinforced concrete beam.

3.5 CRACKING MOMENT

The load at which the first flexural crack was visibly observed was recorded. From the available test data theoretical cracking moments were determined according to the IS: 456-2000. Both the experimental and theoretical test results were compared, the test result shows the experimental first crack moment is much higher than the theoretical cracking moment. The results are given in Table 3 and Figure 1 shows the variation of moment at first crack with % of tensile reinforcement. The load at which the first flexural crack was visibly observed was recorded. From the available test data theoretical cracking moments were determined. The Figure 1 shows the Moment at first crack increases with increase in % of tensile reinforcement as the percentage of tensile reinforcement increases from 0.74 to 1.16 the increase in cracking moment is 29.63%, further increase in tensile reinforcement from 1.16 to 1.67 the increase in cracking moment is about 10.53%.

IV DEFLECTIONS

The deflections were measured at mid span and at 1/6th of span from both sides. The deflections were recorded up to failure load and compared with test values. The Load versus mid-span deflection curves of the test beams are presented in Figure 2 shows average mid span deflections. our effort to utilize red mud and steel

V CONCLUSION

The flexural strength of FA & PSA based Geopolymer concrete is a fraction of the compressive strength, as in the case of Portland cement concrete. The measured values are higher than recommended values in IS: 456-2000. As compressive strength increases the flexural strength also increases in Geopolymer concrete. This behavior is similar to the OPC concrete. All the beams were failed in flexural mode, the cracks are initiated in the tension face of the beam and cracks are propagate towards compression face as the load increases, followed by the crushing of concrete in compression face. As the tensile reinforcement ratio increases the first crack load is also increases. The cracking moment is calculated according to the IS: 456-2000 and compared with the tested results it shows the all the results are within the range specified in the codal provisions. The flexural capacity of the beam increases with the increase in longitudinal tensile reinforcement ratio, the tested ultimate moment capacity of beams were found 1.35 times more than theoretical ultimate moment capacity. The measured service load deflections of test beams were compared with the values calculated with the IS: 456-2000. All the measured deflection were within the permissible limit. Stiffness of the beam increase with increase in percentage of tensile reinforcement, this behavior is similar to the reinforced OPC concrete beams.

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