STUDY ON FLEXURAL BEHAVIOUR OF GEOPOLYMER FERROCEMENT SLAB

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ABSTRACT

Geopolymers are one of the recently used advanced construction material for binding instead of cement. Geopolymers are inorganic binders consisting of two components: a very fine and dry powder, and a syrupy, highly alkaline liquid. Ferrocement is a form of reinforced concrete that differs from conventional reinforced or prestressed concrete primarily by the manner in which the reinforcing elements are dispersed and arranged. It consists of closely spaced, multiple layers of mesh or fine rods completely embedded in cement mortar.

In this work, cement is replaced by geopolymer mix to bind the ferrocement skeletal and its flexural behavior is studied. The flexural behavior of geopolymer ferrocement slabs of dimension 1000 x 200 x 25 mm are tested and reported for different molarities of the alkaline solution and for various volume fractions.

The parameters of the study include initial crack load, ultimate crack load, ultimate flexural strength, crack behavior and load deformation behavior.

Ferrocement slab: *Flexural behavior of ferrocement Slab*

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1. FERROCEMENT

The term ferrocement is most commonly applied to a mixture of Portland cement and sand reinforced with layers of woven or expanded steel mesh and closely-spaced small-diameter steel rods rebar. It can be used to form relatively thin, compound curved sheets to make hulls for boats, shell roofs, water tanks, etc. It has been used in a wide range of other applications including sculpture and prefabricated building components.

1.1 Properties of Geopolymer

Compressive strength depends on curing time and curing temperature. As the curing time and curing temperature increase, the compressive strength increase, normally it varies between 400-500 kg/cm^2 (19). *Curing* of geopolymer specimens are performed at an elevated temperature in the range of 60^{0}C-90^{0}C because the energy required for dissolution of fly ash is an endothermic process and the curing time elapses between 24hr.-72hr. *Resistance to corrosion*, since no limestone is used as a material, geopolymer cement has excellent properties within both acid and salt environments. It is especially suitable for tough environmental conditions. Sea water can be used for the blending of the geopolymer cement. This can be useful in marine environments and on islands short of fresh water. Less *shrinkage and permeability* shows its better performance than the conventional cement. Geopolymer specimens are possessing better *durability* and *thermal stability* characteristics

1.2 Applications of Geopolymer

There is a great potential for geopolymer applications in bridges, such as precast structural elements and decks. Structural retrofits using geopolymer fiber composites. There is a potential near-term application for precast pavers and slabs for paving. Geopolymer technology is most advanced in precast applications due to the relative ease in handling sensitive materials. Replacement of current building component such as bricks, ceramic tiles and cement could be possible by using geopolymer. The durability attributes of geopolymer make them attractive to use in severe-environment applications such as bridges, marine structures and acid storage tanks.

2. REINFORCEMENT

For the purpose of reinforcing the geopolymer ferrocement slab two different type of meshes are Chicken mesh and weld mesh. The wire woven **chicken meshes** (Fig.10) with a hexagonal opening of size 12 mm a wire thickness of 0.72 mm (20 gauges) are used. For attaining 2 % volume fraction four layers of chicken mesh can be used. The machine welded **weld mesh**(Fig.11) having a rectangular grid opening of size 76.2 mm x 38.1 mm, with a thickness of 2.45 mm in transverse direction and 3.45 mm in longitudinal direction are used.

Fig -1 Chicken Mesh

Fig-2 Weld mesh

2.1 Mould Preparation

A rectangular slab mold of dimension 1000 x 200 x 25 mm (Fig.4) is prepared for studying the flexural behavior of the geopolymer ferrocement structural element. For each specimen type 6 mortar cubes of size 70.6 x 70.6 x 70.6 mm are cast to test the characteristic strength of the mortar mix. Totally five type of specimens are studied including cement for control specimen, 8, 10, 12 and 14 molarity for geopolymer specimen. For 2% volume fractions, four layers of chicken mesh and one layer of weld mesh are used and the specific surface area for 2% volume fraction arrangement is 7.74%.

In this work sodium hydroxide is used as the alkali powder. The atomic weight and the molar mass details are given. For preparing 8 molarity sodium hydroxide solutions, 8 times the molar mass of sodium hydroxide powder is taken and mixed with 1 liter water in a beaker and similarly other molarities can be prepared. Similarly for preparing different molarity solutions the amount of sodium hydroxide to be taken are given in the table 5.

Normally the ratio of Sodium silicate to sodium hydroxide varies between 0.4 to 2.5.In this work the ratio 1:1 is adopted for both control specimen mortar mix and geopolymer mortar mix preparation. For the control specimen a water/cement ratio of 0.3 is adopted and for geopolymer specimens 2% to 5% of water is added as suggested by Davidovis.

Specimen	Cement	8-Molarity	10- Molarity	12- Molarity	14- Molarity
No. of Specimens	3	3	3	3	3
Cement(Kg.)	18.94	-	-	-	-
Sand(Kg.)	18.94	18.94	18.94	18.94	18.94
Flyash(Kg.)	-	14.15	14.15	14.15	14.15
Sodium hydroxide	-	2.29	2.29	2.29	2.29
Sodium silicate(Kg.)	-	2.29	2.29	2.29	2.29
Water	0.3	0.02	0.03	0.04	0.05
Super Plasticizer	-	-	-	0.01	0.01

Table -1 Mortar Mix Detail

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2.2 Testing of Specimens

The variation in the compressive strength for the concentration of 8M, 10M, 12M, 14M geopolymer mortars with respect to cement mortar is shown in table 6. The results clearly show that the compressive strength of geopolymer mortar increased with increase in the concentration of sodium hydroxide compared to cement mortar. The percentage increase in compressive strength compared to control specimen for 8M, 10M, 12M, 14M geopolymer mortars are 9%, 36%, 59%, 83% respectively.

S. No.	Specimens	Failure load (tons)	Avg. load(tons)	Compressive strength(N/mm^2)
1	Cement	18.0	16.625	32.72
		16.0		
		14.0		
		18.5		
2	8-molarity	15.0	18.125	35.67
		18.5		
		20.0		
		19.0		
3	10-molarity	22.0	22.625	44.53
		24.0		
		21.5		
		23.0		
4	12-molarity	30.0	26.425	52.01
		25.5		
		24.2		
		26.0		
5	14-molarity	30.5	30.50	60.02
		31.0		
		28.5		
		32.0		

Table -2 Test Results

3. FLEXURAL STRENGTH

The variation in flexural strength of the ferrocement and geopolymer ferrocement elements is shown in table 7. From the results it can be clearly observed that the first crack load of geopolymer ferrocement elements increase with increase in molar concentration compared to control specimen. The ultimate strength of the geopolymer specimens also follow the similar pattern but the ultimate strength of the 14M specimen slightly minimizes when compared to the 12M specimens.

This phenomenon is identified due to the improper replacement of the calcium ions in the fly ash by the sodium ions in the geopolymer solution. The percentage increase in first crack strength compared to control specimen for 8M, 10M, 12M, 14M geopolymer mortars are 8.3%, 70.8%, 166.7%, 179.17% respectively. Similarly the percentage increase in ultimate strength compared to control specimen for 8M, 10M, 12M, 14M geopolymer mortars are 1.2%, 28.4%, 64.2%, 38.3% respectively.

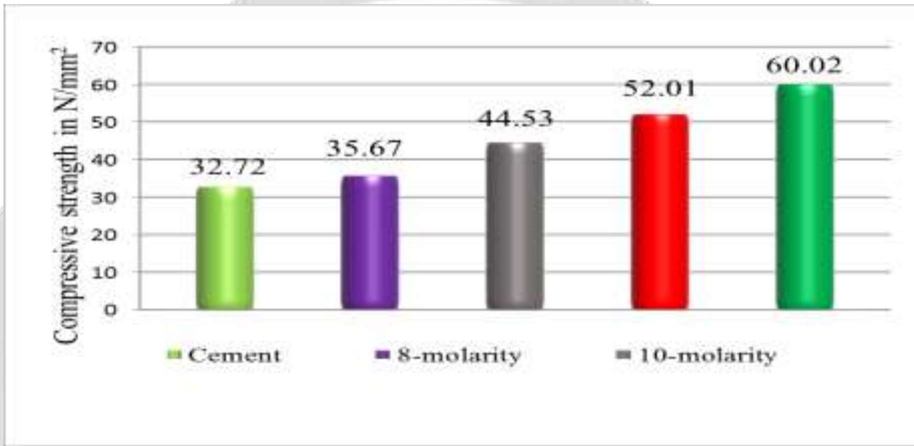

Chart -1 Flexural Strength

3.1 Flexural Strenth

All the slabs exhibit a fairly ductile behavior and the failure pattern (Fig.10).The failure of slab specimen's results from the yielding of wire mesh reinforcement followed by the crushing of mortar. Initially fine flexural cracks appeared at the bottom of the specimen. With further increase in the load, regularly spaced vertical cracks are observed and they extend from the bottom of the specimen towards the top. The load is increased up to ultimate stage and cracking pattern is observed. The cracking of the specimen in the top and bottom surfaces are noted and reported for both the control and geopolymer specimens .

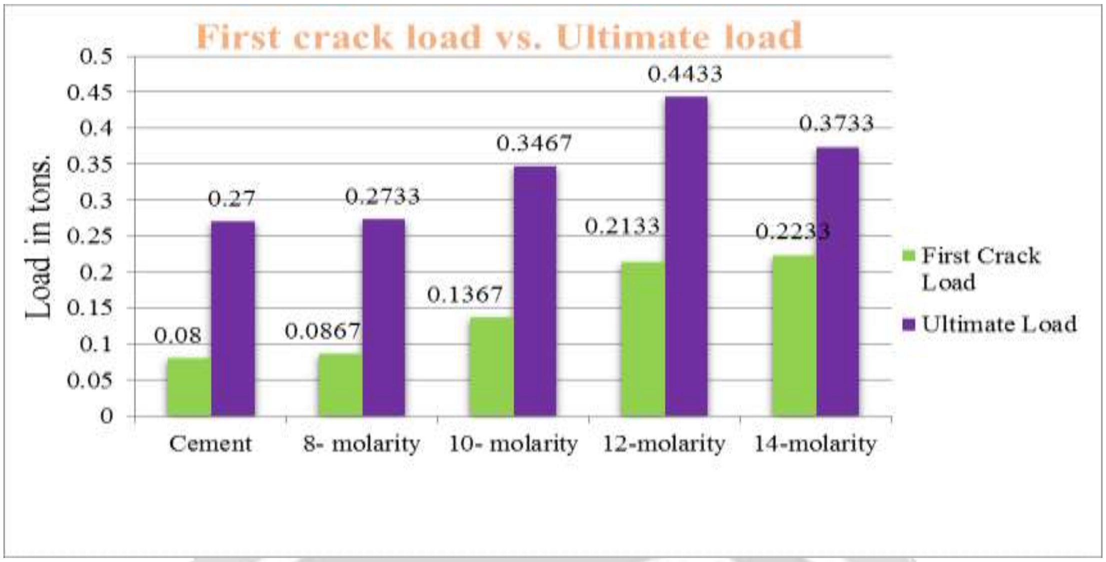

Chart -2 Flexural Load Relationships

4. CONCLUSIONS

While comparing with the control specimen, the compressive strength of the geopolymer specimens increases with increase in the molarity (concentration) of the sodium hydroxide solution. The initial cracking load of the specimens in flexural testing increases with increasing molarity. The ultimate cracking load behavior also follows the initial cracking behavior and the ultimate load of the 14-molarity specimens is smaller than the 12-molarity. Further the plot implies that the 10, 12, & 14 molarity specimens show similar pattern up to their yield load and after yielding the 12- molarity specimen takes ultimate load higher than that of the 14 & 10 molarities. The cracking behavior of the various specimen shows that the number of cracks of the geopolymer specimens are less when compared to the control specimen. Also the cracking region and the cracking space are more in the geopolymer specimens while comparing with the control specimens. The large deflection of the geopolymer specimen shows its good ductile behavior than conventional specimen and in turn implies ample warning before failure.

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