Outcome of Variation of Number of Meshes and Size of Meshes in Geo-Ferrocement

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***Abstract* - Normally, conventional concrete is manufactured with Portland cement, which acts as a binder. The production of cement releases approximately an equal amount of $C0_2$ into the atmosphere.In view of this, there is a need to develop sustainable alternativesto Portland cement utilizing the industrial by products such as fly ash, ground granulated blast furnace slag which are Pozzolonic in nature. Geopolymer is produced without the presence of cement as a binder; instead, the base material such as fly ash, that is rich in Silicon (Si) and Aluminium (Al), is activated by alkaline solution to produce the binder. Hence Geopolymer mortar can be used instead of Cement mortar which will have no adverse effect on our environment. Ferrocement is an emerging technology that differs from conventional reinforced concrete by the manner in which the reinforcing elements are dispersed and arranged. It consist of closely spaced, multiple layers of wire mesh embedded in cement mortar. Experimental investigation was carried out to study the effect of Geopolymer mortar in Ferrocement for variation in mesh size and number of layers. For this, Flexure testing was conducted on Geo-ferrocement panel of 750 mm X 120 mm X 30 mm (thickness). Square slabs of dimension 230 x 230 x 30 mm were subjected to impact testing to observe the effect of reinforcement of mesh in different layers on impact energy absorption of slabs. Flexural strength of specimen with triple layer mesh is increased by around 190% than specimen with single layer mesh. From test results it was found that due to incorporation of mesh the impact resistance of the slab has increased as compared to slab without any mesh.**

Keywords—Ferrocemnt, Geopolymer, Flyash,Flexure strength , Impact strength

I. INTRODUCTION

The production of cement generates large amount of carbon dioxide. Carbon dioxide could be reduced if the production of cement could be reduced as well. Concrete is the most versatile and widely used construction material in view of its wide ranging performance, suitability, applicability and cost effectiveness. Normally, conventional concrete is manufactured with Portland cement, which acts as a binder. The production of cement releases approximately an equal amount of CO_2 into the atmosphere. It is also energy intensive and consumes significant amount of natural resources, leading to its depletion in due course of time. In view of this, there is a need to develop sustainable alternatives to Portland cement utilizing the industrial by products such as fly ash, ground granulated blast furnace slag which are Pozzolonic in nature. Further, environmentally compatible disposal of waste materials by appropriate technologies is of increasing concern and imposes interesting technical challenges.

Construction industry is the one where bulk utilization of waste materials can be effectively done without any compromise on quality and performance. It has been established that fly ash can replace cement partially. However, efforts are on to replace Portland cement completely by synthesizing alternative binder (which later became to be known as Alkali Activated Cement) by alkali activation of many marginal materials such as fly ash and ground granulated blast furnace slag which are rich in silica and alumina. Such an effort leads to dual goals of utilizing the marginal materials advantageously rather than just disposal and conservation of resources for sustainable development. Scientists have been doing research and development for more than 20 years on a new material called “Geopolymer” to replace the use of cement .The amorphous to crystalline reaction products resulting from the synthesis of alkali alumino- silicates and high alkaline solution is generically known as “Geo-Polymer”. This material is made basically with the mixture of sodium hydroxide and sodium silicate solution and when it is combined with certain powder material such as fly ash results in a material with cementitious properties similar to Portland cement paste. The three components can vary a great deal, from the concentration of sodium hydroxide and sodium silicate to the ratio of the two solutions to the composition of the fly ash and there is a general consent that the reaction producing the Geopolymer is in the form of polymerization.

Ferrocement is an emerging technology that differs from conventional reinforced concrete by the manner in which the reinforcing elements are dispersed and arranged. It consist of closely spaced, multiple layers of wire mesh embedded in cement mortar.

II. LITERATURE REVIEW

Davidovit[1] proposed that binders could be produced by a polymericreaction of alkaline liquids with the silicon and the aluminium in source materials of geological origin or by-product materials such as fly ash and rice husk ash. He termed these binders as geopolymers.

Gourley[2] carrired out research on Low-calcium fly ash is preferred as a source material to High fly ash. The presence of calcium in high amount may interfere with the polymerisation process and alter the microstructure.

Noor Ahmed Memon et al[3] investigated the performance of high workability mortar mix, applicable for the casting of thin Ferrocement elements by using slag as cement replacement and super plasticizer as water reducing agent.

Md. Zakaria Hossain et al[4] in his research, sixteen specimens were prepared and tested. From the flexural behavior in the form of load-deflection relationships, and first crack and ultimate loads.

B.Sivagurunathan, Dr.B.Vidivelli[5] were investigates the flexural behaviour of reinforced concrete beams strengthened by ferrocement laminates. The aim of this project is to bond ferrocement laminates to reinforced concrete beams and strengthen it against flexure.

V.Sreevidya, R.Anuradha et al[6], studied to assess the Acid resistance of fly ash based Geopolymer mortar with a ratio of fly ash to sand as 1:3.The various ratio between NaOH and Na_2SiO_3 solution to fly ash were used. Study indicate that Geopolymers are highly resistance to sulfuric acid and hydrochloric acid.

Bhalsing S., Sayyed Shoaib, Autade P[7]., investigated the increase in tension due to increase in contact area between wire meshes and mortar, i.e. increase in specific surface of ferrocement. For achieving higher values of specific surface, No. of Layers of meshes needs to be increased.

Dr. A. S. Kasnale. S. Yedshikar[8] studied the effect of different volume fraction percentage of steel mesh on compressive strength and split tensile strength of Ferrocement and Geopolymer mortar. Activated liquid to fly ash ratio of 0.6 by mass was maintained in the experimental work on the basis of past research. Sodium silicate solution with Na_2O = 16.37%, SiO_2 = 34.35% and H_2O = 49.28% and sodium hydroxide solution having 13M concentration were maintained throughout the experiment. Geopolymer mortar cylinders of 150 x 300 mm size were cast. The temperature of heating was maintained at 900C for 8 hours' duration after demoulding.

III OBJECTIVES OF INVESTIGATION

- To study the suitability of the meshes for use in Ferrocement.
- To study Flexure characteristics of Geopolymer based Ferrocement samples of chosen size reinforced with different layers.
- To study the effect of layers of meshes on toughness of Geo-Ferrocement specimens and ordinary Ferrocement specimens.

IV. MATERIALS

The present research work is experimental and requires preliminary investigations in a methodological manner.

1 Cement: The cement used in this experimental work is "ACC 43 grade Ordinary Portland Cement". All properties of cement are tested by referring IS 8112 - 1989 Specification for 43 Grade Ordinary Portland Cement.

2 Fine aggregate: Locally available river sand conforming to Grading zone II of IS: 383–1970.

3 Fly ash-Fly Ash is available in dry powder form and is procured from Dirk India Pvt. Ltd., Nashik. It is available in 30Kg bags, color of which is light gray under the product name "**Pozzocrete 63**" Confirming to IS: 3812 Part 1-2003 as mineral admixture in dry powder form.

4 Water: Potable water available in laboratory is used.

5 Sodium hydroxide: Sodium hydroxide available in pellet form and it is packed in 50 Kg bag. The physical and chemical properties of Sodium hydroxide are listed in following tables.

Table I PHYSICAL PROPERTIES OF NAOH

Property	Information
Molecular Weight	39.997g/mol
Appearance (solid)	White Crystalline Substance
Transparent	Only in liquid form
Odour	None
Density	2.13g/cm³
Boiling Point	1390°C
Melting Point	318°C
Freezing Point	14°C
Specific Gravity (20°C)	1.52g/ml
Flammable	No
Vapour Pressure (0.2 kPa, 20°C)	1.5mmHg

Table II CHEMICAL PROPERTIES OF NAOH

Chemical Formula	**Information**
Acidity	NaOH
Basic Type	Very Low (13-14 pH)
Corrosive	Caustic Metallic Base
Reactivity	High
Hygroscopic	Medium
Solubility (20°C)	Yes
Soluble (in)	1110g/L

6 Sodium Silicate: Sodium silicate available in liquid (gel) form.

Table III Properties of Sodium Silicate

Property	**Information**
Molecular Weight	122.06 g/mol
Appearance (viscous)	Yellowish
Transparent	Not Transparent
Odour	None
Density	2.4g/cm³
Melting Point	1088°C

7 Wire meshes: Weld meshes generally used in ferrocement structures are having opening sizes in mm as 25 X 25,50 X 50, 75 x 75, 100 x 100, and 150 x 150.The wire gauges may vary from 10 to 18.

8 Flexure Test mould: Sample mould for specimen castingwas prepared having dimensions 750mm X 125mm with 30mm thickness.

Figure I: Flexure Test moulds

9 Impact Test Mould: Moulds has been prepared of size 230 mm X 230 mm X 30 mm in size, two angles are placed on metal sheet with screw arrangement.

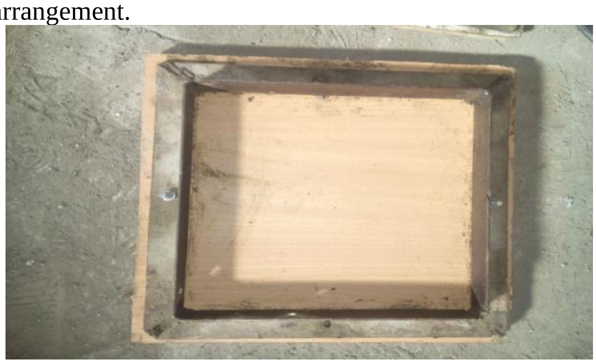


Figure II: Impact Test moulds

V. METHODOLOGY

The fresh fly ash-based geopolymer mortar was dark in colour (due to the dark colour of the fly ash), and was cohesive. Davidovits (2002) suggested that it is preferable to mix the sodium silicate solution and the sodium hydroxide solution together at least one day before adding the liquid to the solid constituents.

1. Mix sodium hydroxide with water at least one day prior to adding the liquid to the dry materials.
2. Mix all dry materials in the pan mixer for about three minutes. Add the liquid component of the mixture at the end of dry mixing, and continue the wet mixing for another four minutes.

Ratio of sodium silicate solution-to-sodium hydroxide solution, by mass, can be used inI the range of 0.4 to 2.5. But this ratio was fixed at 1 for most of the mixtures because the sodium silicate solution is considerably cheaper than the sodium hydroxide solution.

- Preparation of Binder Solution

Binder solution plays a vital role in the binding of the fly ash based geopolymer mortar. Binder solution is a mixture of Sodium Hydroxide and Sodium Silicate. In this investigation the sodium hydroxide pellets in 13 molar concentrations were used.

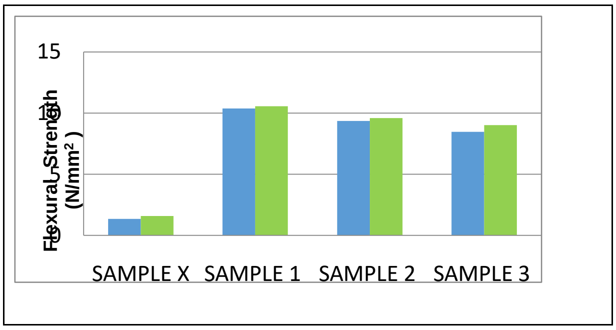
VI. TESTING PROGRAM

Flexural Strength (IS 516:1959): As per provision of testing of flexure member in **IS 516:1959** we have tested our sample for flexure and calculated flexural strength .

Figure III: Flexural test on specieme

TABLE IV- Single Mesh flexure strength

Sr No	Specimens	Opening Size of Mesh (mm x mm)	Mortar Material	Flexural Strength (N/mm^2)
1	Sample X	No Mesh	CCM	1.371
2	Sample 1	13 x 13		10.38
3	Sample 2	19 x 19		9.36
4	Sample 3	25 x 25		8.46
5	Sample X	No Mesh	GM	1.606
6	Sample 1	13 x 13		10.57
7	Sample 2	19 x 19		9.6
8	Sample 3	25 x 25		9.01



Graph 1-Single Layer Mesh Flexural Strength

Table V-Double Layer Mesh Flexural Strength

Sr. No	Specimens	Opening Size of Mesh (mm x mm)	Mortar Material	Flexural Strength (N/mm^2)
1	Sample 1	13 x 13	CCM	15.98
2	Sample 2	19 x 19		15.51
3	Sample 3	25 x 25		14.85
4	Sample 1	13 x 13	GM	17.12
5	Sample 2	19 x 19		16.04
6	Sample 3	25 x 25		15.47

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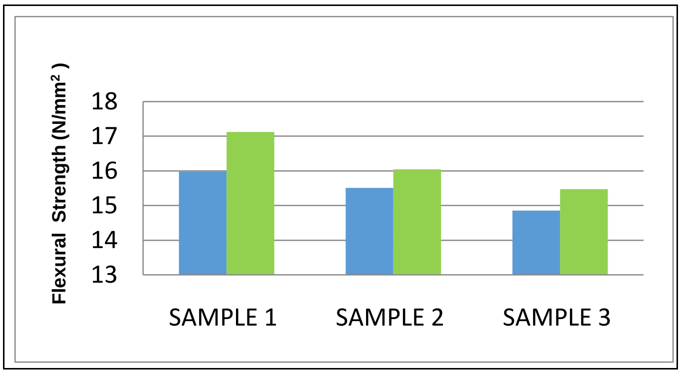


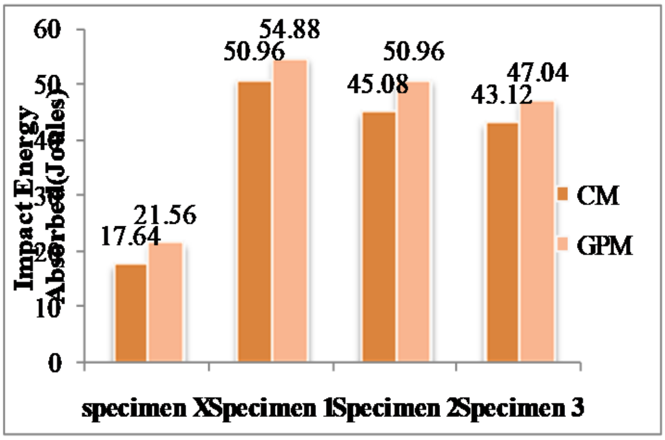
Graph 2-Double Layer Mesh Flexural Strength

Impact Test (ASTM D 2794.): Specimens of size 230 x 230 x 30 mm were placed in their position in the testing frame with the finished face up. The mass 0f 0.5 kg was then dropped repeatedly and the number of blows required to cause first crack was recorded. The number of blows required for failure was also recorded.

Figure IV - Impact testing of specimen

Table VI-Single Layer Mesh Impact Strength

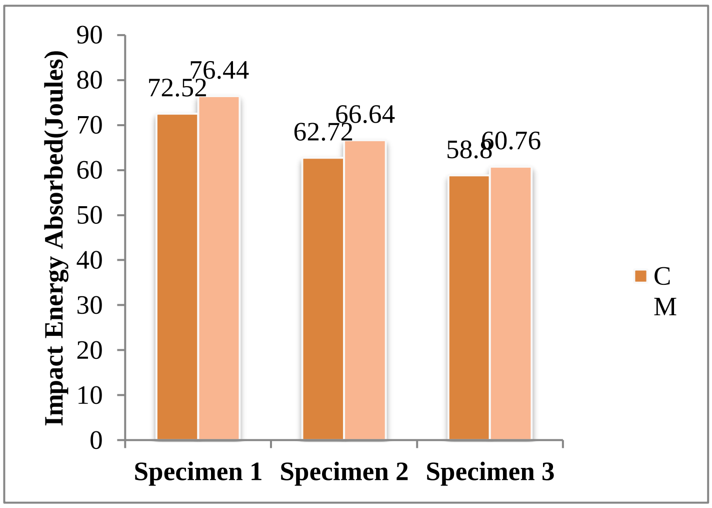
Sr No	Specimens	Opening Size of Mesh (mm x mm)	Mortar Material	Impact Energy (Joules)
1	Sample X	No Mesh	CCM	1.371
2	Sample 1	13 x 13		10.38
3	Sample 2	19 x 19		9.36
4	Sample 3	25 x 25		8.46
5	Sample X	No Mesh	GM	1.606
6	Sample 1	13 x 13		10.57
7	Sample 2	19 x 19		9.6
	Sample 3	25 x 25		9.01



Graph 3-Single Layer Mesh Impact Strength

Table VII-Double Layer Mesh Impact Strength

Sr. No	Specimens	Opening Size of Mesh (mm x mm)	Mortar Material	Impact Energy (Joules)
1	Sample 1	13 x 13	CCM	72.52
2	Sample 2	19 x 19		62.72
3	Sample 3	25 x 25		58.80
4	Sample 1	13 x 13	GM	76.44
5	Sample 2	19 x 19		66.64
6	Sample 3	25 x 25		60.76



Graph 4-Double Layer Mesh Impact Strength

VII. CONCLUSIONS

- It is concluded that Flexural strength of specimen after 28 days of curing with triple layer mesh is increased by around 190% than specimen with single layer mesh & Flexural strength of specimen after 28 days of curing with double layer mesh is increased by around 150% than specimen with single layer mesh
- From test results it was found that due to incorporation of mesh in mortar the impact resistance of the slab has increased as compared to slab without any mesh. It can be thus inferred that meshes used as reinforcement play a major role in improving the impact energy absorption.

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