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COMPARATIVE STUDY OF GEOPOLYMER FERROCEMENT WITH CONVENTIONAL FERROCEMENT

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ABSTRACT:

Production of cement generates large quantity of carbon dioxide nearly 6 to 7 in percentage of total 9.795 Gigatonnes of CO_2 emission. There is a need to extend sustainable substitute to Portland cement utilizing the industrial by-products such as fly ash, ground granulated blast furnace slag which are Pozzolanic in nature. An experimental analysis on the Compressive, flexural and split tensile behavior of Geopolymer mortar as well as Conventional mortar reinforced with rectangular welded with varying number of mesh. Specimen are casted using cement mortar and Geopolymer mortar separately. The specimens are tested under flexural, compressive and Split tensile loading. 750 x125 x 35 in mm size of the mould is prepared for flexural specimens. Samples are prepared like panels for flexural testing and cylinders for Compressive and Split tensile testing. The sample specimens from the mould will be demoulded and kept for curing. Then the samples tested on UTM and CTM and observations were recorded to draw results and conclusions.

KEYWORDS: Ferrocemnt, welded meshes, Geopolymer, Flyash, Flexural Strength,Compressive strength, Split tensile strength

INTRODUCTION:

The production of cement generates large amount of carbon dioxide. Emission of carbon dioxide in atmosphere can be reduced with the reduction of production of cement. Concrete is the most adaptable and extensively used construction substance in view of its extensive ranging recital, aptness, applicability and cost effectiveness. Normally, conventional concrete is manufactured with Portland cement, which acts as a binder. The manufacturing of cement discharges about an equal amount of $C0_2$ into the atmosphere. It is also energy exhaustive and consumes major quantity of natural resources, leading to its depletion in due course of time.

Construction industry is the one where bulk utilization of waste materials can be effectively done without any compromise on quality and performance. 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 base material such as fly ash results in a material with cementitious properties similar to Portland cement paste. The three components i.e. solution to fly ash ratio, Sio_2/Na_2O and $Na_2Sio_3/NaOH$ ratio can have great impact on results obtained.

LITERATURE REVIEW:

Davidovit[1] proposed that binders could be produced by a polymeric reaction 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] carried 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 indicates 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 = 16.35%, 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 80°C for 8 hours duration after demoulding. Test results show that compressive strength and split tensile strength of Geopolymer mortar increases with increase in volume fraction percentage and specific surface of steel mesh as compare to ferrocement mortar.

MATERIALS AND SPECIFICATION:

In this present study following materials are used for casting the specimen.

1. Cement: The cement used in this experimental work is tested by referring IS 8112 - 1989 Specification for 43 Grade Ordinary Portland Cement. Cement is used only for conventional Specimen.
2. Fine aggregate: Locally available river sand conforming to Grading zone II of IS: 383–1970
3. Water: Potable water.
4. Sodium hydroxide (NaOH): The sodium hydroxides are available in solid state by means of pellets and flakes. In this investigation the sodium hydroxide pellets of 13 molar concentrations were used.
5. Fly ash: Class F fly ash is used in dry powder form provided by DIRK India Pvt. Ltd
6. Sodium Silicate (Na_2SiO_3) Sodium silicate also known as water glass or liquid glass, available in liquid (gel) form. In present investigation sodium silicate in gel form is used.
7. Wire meshes: Square welded meshes are used. Specimen 1, 2 & 3 consist of mesh with opening sizes 13x13, 19 x19 and 25 x 25 for mortar ratio 1:2. The welded meshes are used for the ferrocement construction was tested as per the Guide for Design, Construction and Repair of Ferrocement Reported by ACI Committee 549 (ACI 549.1R-88).
8. Sample mould: Sample mould for specimen casting was prepared having dimensions 750mm X 125mm with 35mm thickness. Sample mould is shown in figure

Figure 1-Prepared Specimen Moulds for Flexural Strength

EXPERIMENTAL PROGRAMME AND RESULTS:

Geopolymer concrete is a new material that does not need the presence of Portland cement as a binder. Instead, the source of materials such as fly ash, that are rich in Silicon (Si) and Aluminium (Al), are activated by alkaline liquids to produce the binder. Hence, concrete with no cement.

1. Mix the Water and the sodium hydroxide solution together at least one day before adding the liquid to the solid constituents to avoid hazards caused due to excessive heat generated.
2. Mix sodium hydroxide solution and sodium silicate solution together at least 2 hours before adding to the dry materials. Mix all dry materials in the pan mixer for about three minutes.
3. Add the liquid component of the mixture at the end of dry mixing, and continue the wet mixing for another four minutes.
4. Ratio of sodium silicate solution to sodium

hydroxide solution, by mass, is fixed at 1 in this research because sodium silicate solution is considerably cheaper than the sodium hydroxide.

5. In this research, molarity of Alkaline Solution is 13M

- Specimen Preparation

The size of mould which we have utilized in this project is 750 x 125 x 35 mm.

For Compressive and split tensile test standard moulds of dimensions 300 x Φ150 in mm are used. As shown in figure

Figure 2-Specimen Moulds for Compressive and Split tensile Strength

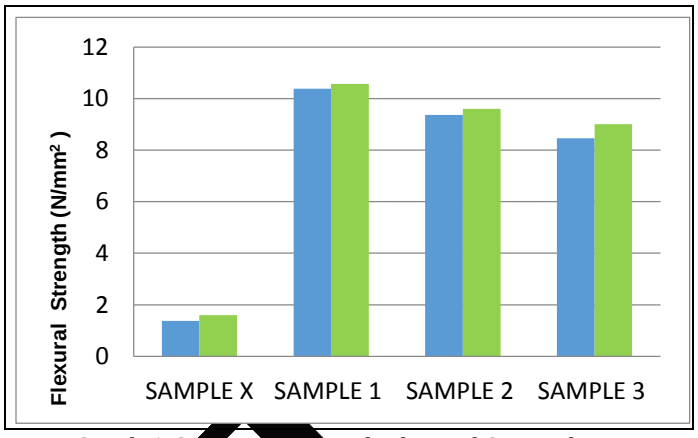
FLEXURAL STRENGTH TEST- IS 516(1959):

The panels were tested under flexural testing machine with loading cell of 100 KN capacity. The specimen was placed for uniform loading. The load was applied to uppermost part of specimen along with two loading points. For applying loads two steel rollers were used in the assembly. In Bar Charts Blue Colour represents Conventional Cement Mortar and Green Colour represent Geopolymer Mortar.

Figure 3-Flexural testing of Specimen

Table 1- Single Layer Mesh Flexural Strength

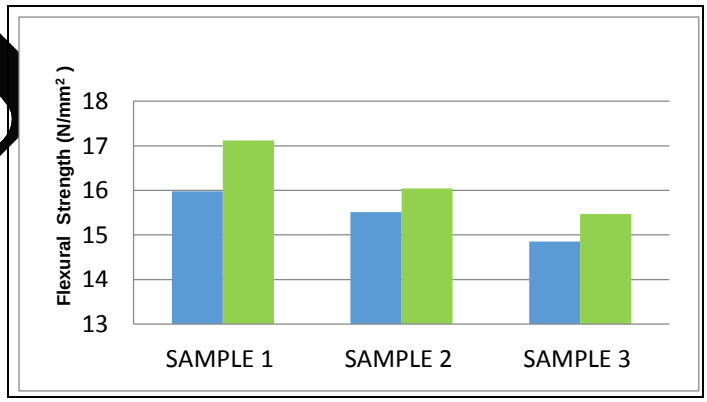
Sr No	Specimens	Opening Size of Mesh (mm x mm)	Mortar Material	Flexural Strength (N/mm²)
1	Sample X	No Mesh	CCM	1.371
2	Sample 1	13 x 13		10.38
3	Sample 2	19 x 19		9.36
4	Sample 3	25 x 25		8.46
5	Sample X	No Mesh	GM	1.606
6	Sample 1	13 x 13		10.57
7	Sample 2	19 x 19		9.6
8	Sample 3	25 x 25		9.01



Graph 1-Single Layer Mesh Flexural Strength

Table 2-Double Layer Mesh Flexural Strength

Sr. No	Specimens	Opening Size of Mesh (mm x mm)	Mortar Material	Flexural Strength (N/mm²)
2	Sample 1	13 x 13	CCM	15.98
3	Sample 2	19 x 19		15.51
4	Sample 3	25 x 25		14.85
6	Sample 1	13 x 13	GM	17.12
7	Sample 2	19 x 19		16.04
8	Sample 3	25 x 25		15.47



Graph 2-Double Layer Mesh Flexural Strength

COMPRESSIVE STRENGTH TEST: (IS 516:1959):

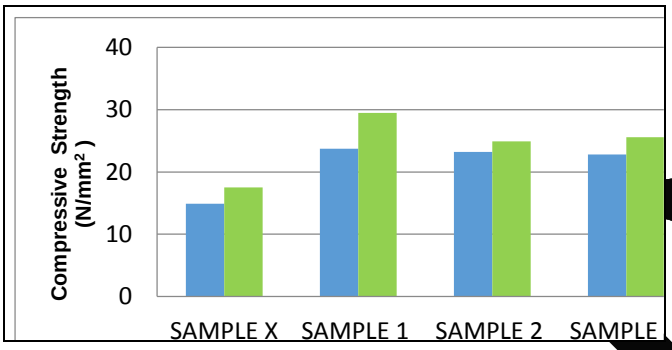
For compressive strength test, Cylindrical specimens of dimensions 300 x Φ150 mm were cast for 1:2 mortar for 13 molarity of solution & Na_2SiO_3/NAOH ratio is 1 & Vibration was given to the molds using table vibrator. The top surface of the specimen was leveled and finished. After 24 hours the specimens were de-molded and were transferred to curing tank wherein they were allowed to cure for 28 days. After the age 3rd, 7th& 28th days curing, these cubes were tested on Universal testing machine. The failure load was noted. The compressive strength was calculated as follows.

In Bar Charts Blue Colour represents Conventional Cement Mortar and Green Colour represent Geopolymer Mortar.

Compressive strength (MPa) = Failure load / cross sectional area

Table 3- Single Layer Mesh Compressive Strength

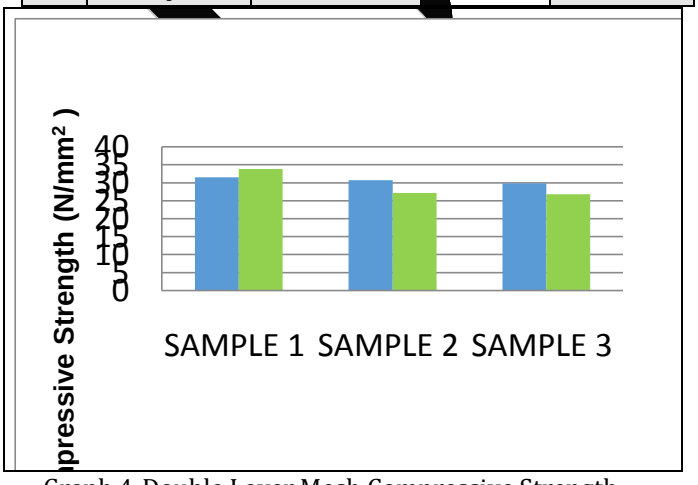
Sr No	Specimens	Opening Size of Mesh (mm x mm)	Mortar Material	Comp. Strength (N/mm²)
1	Sample X	No Mesh	CCM	14.88
2	Sample 1	13 x 13		23.72
3	Sample 2	19 x 19		23.20
4	Sample 3	25 x 25		22.80
5	Sample X	No Mesh	GM	17.52
6	Sample 1	13 x 13		29.44
7	Sample 2	19 x 19		24.89
8	Sample 3	25 x 25		25.58



Graph 3-Single Layer Mesh Compressive Strength

Table 4-Double Layer Mesh Compressive Strength

Sr No	Specimens	Opening Size of Mesh (mm x mm)	Mortar Material	Comp. Strength (N/mm²)
2	Sample 1	13 x 13	CCM	23.72
3	Sample 2	19 x 19		23.20
4	Sample 3	25 x 25		22.80
6	Sample 1	13 x 13	GM	29.44
7	Sample 2	19 x 19		24.89
8	Sample 3	25 x 25		25.58



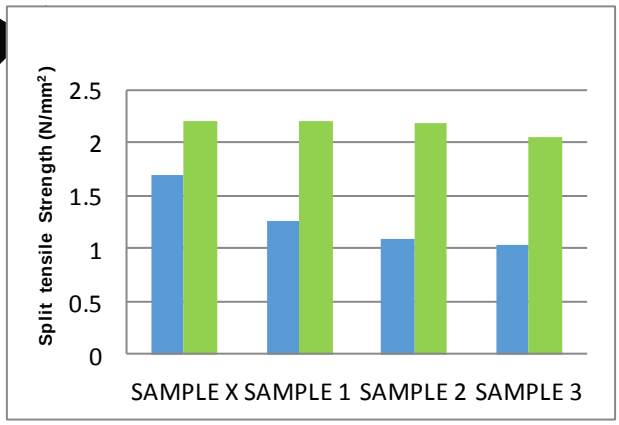
Graph 4-Double Layer Mesh Compressive Strength

SPLIT TENSILE STRENGTH TEST: (IS 5816:1999)

For Split tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens with Conventional Mortar were de-molded after 24 hours of casting and were transferred to curing tank wherein they were allowed to cure for 28 days and specimens with Geopolymer Mortar were de-molded after 24 hours of casting and were transferred to Oven for 1 day. These specimens were tested under compression testing machine. In each category three cylinders were tested and their average value is reported. In Bar Charts Blue Colour represents Conventional Cement Mortar and Green Colour represent Geopolymer Mortar.

Table 5-Single Layer Mesh Split Tensile Strength

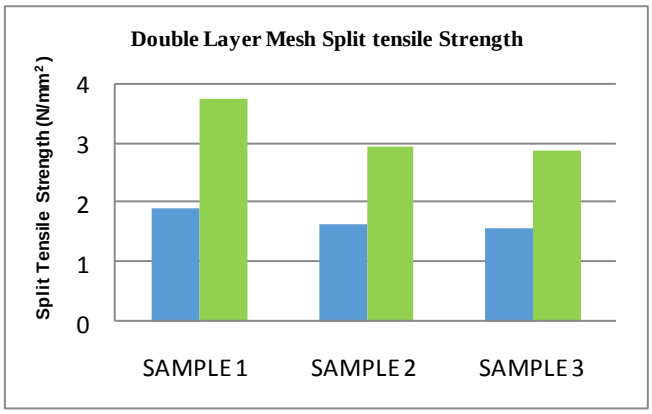
Sr No	Specimens	Opening Size of Mesh (mm x mm)	Mortar Material	Split Tensile Strength (N/mm²)
1	Sample X	No Mesh	CCM	1.70
2	Sample 1	13 x 13		1.26
3	Sample 2	19 x 19		1.08
4	Sample 3	25 x 25		1.03
5	Sample X	No Mesh	GM	2.20
6	Sample 1	13 x 13		2.21
7	Sample 2	19 x 19		2.18
8	Sample 3	25 x 25		2.05



Graph 5-Single Layer Mesh Split Tensile Strength

Table 6-Double Layer Mesh Split Tensile Strength

Sr No	Specimens	Opening Size of Mesh (mm x mm)	Mortar Material	Split Tensile Strength (N/mm²)
2	Sample 1	13 x 13	CCM	1.90
3	Sample 2	19 x 19		1.64
4	Sample 3	25 x 25		1.57
6	Sample 1	13 x 13	GM	3.77
7	Sample 2	19 x 19		2.96
8	Sample 3	25 x 25		2.88



Graph 6-Double Layer Mesh Split Tensile Strength

CONCLUSION:

Increasing the number of welded mesh layers from 1 to 2 caused a substantial increase in flexural strength, compressive strength as well as Split tensile. This is because of the increased percentage of steel meshes in the specimens and the increased depth of mesh layers from the neutral axis. For the same number of mesh layers, it was found that the strongest configuration in both elastic and inelastic ranges results from the smallest spacing because of the increase in volume fraction of the mesh in longitudinal and transverse direction of the specimens. The use of welded mesh in the ferrocement structure gives more strength and significant improvement to the ferrocement. Geopolymer Mortar specimen, it was found that there is sight increase in flexural strength that conventional cement mortar.

Compressive strength of single mesh layer in Geopolymer mortar is greater than single mesh layer in conventional cement mortar by approximately 15 %. For double layer mesh, specimens with Geopolymer mortar shows greater strength than specimens with conventional cement mortar by 16 %.

Split tensile strength of single mesh layer in Geopolymer mortar is greater than single mesh layer in conventional cement mortar by approximately 46 %. For double layer mesh, specimens with Geopolymer mortar shows greater strength than specimens with conventional cement mortar by nearly 57 %. It was also observed that by using Geopolymer mortar cost can be reduced up to 15-20%

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