https://doi.org/10.46335/IJIES.2022.7.1.4 **eISSN: 2456-3463**
Vol. 7, No. 1, 2022, PP. 16-22

International Journal of Innovations in Engineering and Science, www.ijies.net

Effect of Geopolymer Mortar in Ferrocement

M D Ahirrao[1], DR. S.L. Hake[2]

[1]*PG Scholar,Department of Civil Engineering,*
Dr. V.V.P College of Engineering, Savitribai Phule Pune University, Ahmednagar, Maharashtra, India.
mdahirrao24@gmail.com
[2]*PG Guide, Department of Civil Engineering,Dr. V.V.P College of Engineering*
Savitribai Phule Pune University, Ahmednagar, Maharashtra, India.
drsandeephake@gmail.com

***Received on**: 15 December,2022* ***Revised on**:11 January,2022* ***Published on**: 13 January,2022*

Abstract – *Globally, Cement production contributes about 1.6 billion tons of CO_2 or about 7% of global loading of CO_2 into the atmosphere. The manufacture of Cement releases Carbon dioxide that is significant contributor of Green house gas emissions to the atmosphere. So there was a need to develope and use eco-friendly material having similar properties as like of cement mortar. 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 a composite material formed by closely spaced wire mesh which uses wire meshes as reinforcement and filled with rich 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, tensile testing was done on Geo-ferrocement specimens of size 750 x 60 x 30 mm reinforced with single, double, triple layer using variation in meshes of different sizes. Similarly, compression testing of cubical specimens of side 70 mm reinforced with single, double, triple layer of meshes significant increase in tensilestrength and compressive strength of specimens with increase in number of layer of meshes. Test results also provided the most suitable combination and size of mesh to be used for obtaining the maximum strength .of different sizes was done.*

Keywords- Ferrocemnt, Geopolymer, Flyash,Tensile trength , Compressive strength.

I- INTRODUCTION

The rate of production of carbon dioxide released to the atmosphere during the production of Portland cement and fly ash, a by-product from thermal power stations worldwide is increasing with the increasing demand on infrastructure development, and hence needs proper attention and action to minimize the impact on the sustainability of our living environment. De-carbonation of limestone in the kiln during manufacturing of cement is responsible for the liberation of one ton of carbon dioxide to the atmosphere for each ton of Portland cement, as can be seen from the following reaction equation :
$5CaCO_3 + 2SiO_2\ 3CaO.SiO_2 + 2\ CaO.SiO_2 + 5\ CO_2$ .The current contribution of green house gas emission from the Portland cement production is about 1.35 billion tons annually or about 7% of the total greenhouse gas emissions to the earth's atmosphere[1]. Furthermore,

Portland cement is also among the most energy-intensive construction materials, after aluminum and steel. Geopolymer concrete is a 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. Geopolymer is produced without the presence of Portland 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. The Geopolymer concrete possesses high strength, undergoes very little drying shrinkage and moderately low creep, and shows excellent resistance to sulphate attack[3][4][5].

Ferrocement is a material of construction having great variety, which possesses unique structural properties. It is a composite formed with closely wire mesh tightly wound round skeletal steel and filled with rich cement mortar. Welded mesh, mild steel angles or bars are used for forming skeleton, while chickenmesh, square mesh or expanded metal are used as mesh reinforcement. Mortar mix may be (1:1.5) to (1:4) by volume[2]. It combines the properties of thin sections and high strength of steel, mouldability of concrete, lightweight and eases of working of timber, high tensile strength capacity of prestressed concrete and crack control of fiber reinforced concrete. Ferrocement can replace all these materials. In addition it needs no formwork or shuttering for casting. Ferrocement has applications in all fields of civil construction, including water and soil retaining structures, building components, space structures of large size, bridges, domes, dams, boats, conduits, bunkers, silos, treatment plants for water and sewage and chimneys partially.

II - LITERATURE REVIEW

Experimental investigation has been carried out by **Patankar et al (2015)** for the gradation of Geopolymer concrete and a mix design procedure is proposed on the basis of quantity and fineness of fly ash, quantity of water, grading of fine aggregate, and fine to total aggregate ratio. 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 constant throughout the experiment.

The experimental investigations of the resistance of Geopolymer mortar slabs to impact loading has been carried out by **S. Nagan & R. Mohana (2014)**. For this, specimens of size 230mmx230mmx25mm with 4 layers of chicken mesh 2 layers of rectangular weld mesh and combination of single layer of weld mesh and four layers of chicken mesh were cast and subjected to impact loading by drop weight test. It was concluded that the increase in volume fraction of reinforcement Vr, increases the energy absorption.

The synthesis of high-strength geopolymer using fine high-calcium fly ash was studied by **Chindaprasirt et al (2011)**. The effect of fineness of fly ash on the setting time of geopolymer paste, workability, strength development, and drying shrinkage of geopolymer mortars made from classified fine high-calcium fly ash was investigated. The results indicate that the setting time of paste decreases with an increase in fly-ash fineness. The flow, strength, and drying-shrinkage characteristics of mortars were improved using fine fly ash. Geopolymer mortars with high 28-day compressive strength of 86.0 MPa were obtained

Effect of reinforcement orientation on compressive strength of ferrocement and bitumen Ferrocement was studied by **Mitlali Patil et al (2015)**.The present investigation, highlights on ten different cases of wire mesh combination with one additional case as mortar control specimen which does not contain any type of reinforcement. The concrete cubes were casted with single and double layers of wire mesh placed in horizontal, vertical and diagonal orientations. It reveals from the result of investigation that the vertical orientation offers more compressive strength than horizontal orientation for bitumen ferrocement.

Tensile Strength of Ferrocement with respect to Specific Surface has been studied by **Swayambhu Bhalsing et al (2014)**. The study reported herein investigates 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. Behavior of such ferrocement is studied which includes mechanical properties for determining the relations between the tensile strength of ferrocement with respect to the specific surface sing various combination of meshes which is to be used in Ferrocement

Effect of Mesh Orientation on Tensile Response of Ferrocement was studied by **Abdullah and M.A. Mansur (2001)**. The author studied about the behavior of ferrocement elements subjected to direct tension. Twelve specimens, divided into three groups, were prepared. The major variables studied are the orientation of wire mesh to the direction of tension, sizes of wire mesh and the spacing of transverse mesh. Test results indicate that the first crack and ultimate strength and the effective modulus and efficiency of ferrocement elements decrease as the angle of wire mesh orientation increases from 0 to 45 degrees. It is also found that an increase in the spacing of transverse reinforcement leads to a higher first crack strength, but fails at a lower ultimate strength.

III OBJECTIVES OF INVESTIGATION

- To study the effect of various combination of meshes in Geo-Ferrocement and ordinary Ferrocement.
- To study the effect of different mesh sizes reinforced with different layers on Geo-Ferrocement specimens and ordinary Ferrocement specimens in Tensile, Compressive.

.

IV- MATERIALS

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. Fineness modulus was found to be 2.76, Specific gravity was 2.59.

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 flakes form is used. In this investigation the sodium hydroxide of 13M concentrations is used.
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: 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. Tension Test Mould: The mould has been prepared by using ISA 30 X 30 x 3 mm, Two angles of 750mm length are placed on metal sheet with screw arrangement so as the spacing between faces of these angles remains equal to the width of specimen i.e. 60mm.The size of mould used in this project is 750 x 60 x 30 mm. Total 6 numbers of Moulds are prepared for casting.

9. Compression Test Mould: Cubical moulds of size 70 x 70 x 70 mm were used to conduct compression test. Total 6 numbers of moulds were used for casting of specimens.

Fig. 1 - Tension Test Mould

Fig. 2 - Tension Test Setup

V- METHODOLOGY

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.

https://doi.org/10.46335/IJIES.2022.7.1.4 eISSN: 2456-3463
Vol. 7, No. 1, 2022, PP. 16-22

International Journal of Innovations in Engineering and Science, www.ijies.net

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.
    - Preparation of Binder Solution

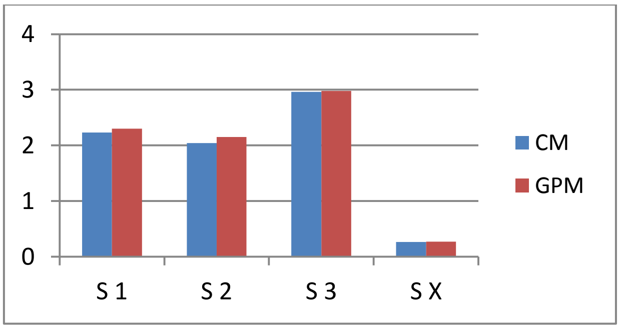
Binder solution plays a vital role in the binding of the fly ash based geopolymer mortar. Binder solution is a mixture of Sodium Hydroxide and Sodium Silicate. In this investigation
the sodium hydroxide pellets in 13 molar concentrations were used. Binder solution is mixed 24 hours prior to the mixing of mortar.

VI - TESTING PROGRAM

Tensile Strength Test (IS 516-1959): All the specimens were tested on Universal Testing Machine. In order to test the specimen, tensile test setup was prepared. Gauge lengths were marked on the each specimen and for proper arrangement rubber grip were used. Load was applied gradually through a hydraulic system and displacements were recorded.

Table 1 - Single Mesh Tensile Strength

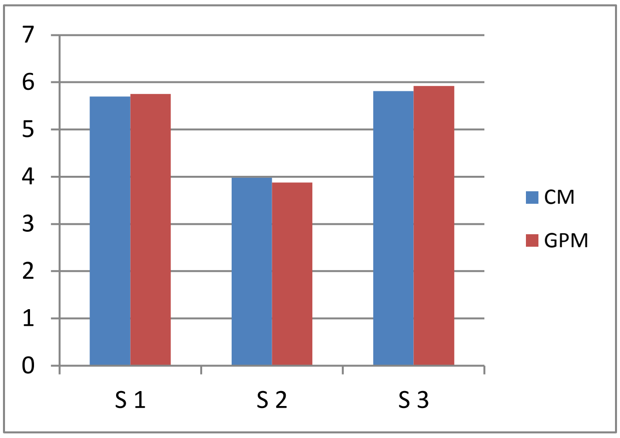
Sample	Notation	Opening Size of Mesh (in x in)	Mortar Materi al	Tensile Strength (N/mm^2)
1	S X	-	CM	0.264
2	S 1	0.50 x 0.50	CM	2.23
3	S 2	0.75 x 0.75	CM	2.04
4	S 3	1.0 x 1.0	CM	2.96
5	S X	-	GPM	0.271
6	S 1	0.50 x 0.50	GPM	2.30
7	S 2	0.75 x 0.75	GPM	2.15
8	S 3	1.0 x 1.0	GPM	2.98



Graph 1 - Single Mesh Tensile Strength

Table 2 – Double Layer Mesh Tensile Strength

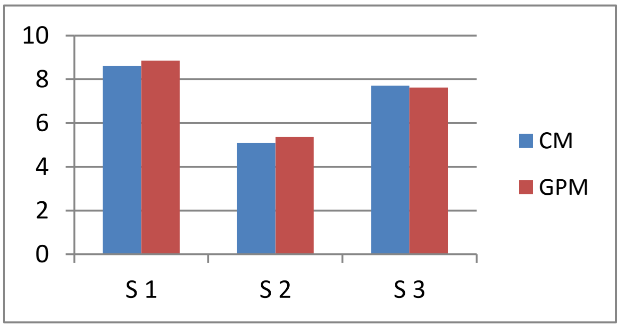
Sample	Notation	Opening Size of Mesh (in x in)	Mortar Materi al	Tensile Strength (N/mm^2)
1	S 1	0.50 x 0.50	CM	5.70
2	S 2	0.75 x 0.75	CM	3.98
3	S 3	1.0 x 1.0	CM	5.81
4	S 1	0.50 x 0.50	GPM	5.75
5	S 2	0.75 x 0.75	GPM	3.88
6	S 3	1.0 x 1.0	GPM	5.92



Graph 2 - Double Mesh Tensile Strength

Table 3 - Triple Mesh Tensile Strength

Sample	Notation	Opening Size of Mesh (in x in)	Mortar Material	Tensile Strength (N/mm^2)
1	S 1	0.50 x 0.50	CM	8.02
2	S 2	0.75 x 0.75	CM	5.08
3	S 3	1.0 x 1.0	CM	7.71
4	S 1	0.50 x 0.50	GPM	8.26
5	S 2	0.75 x 0.75	GPM	5.36
6	S 3	1.0 x 1.0	GPM	7.62

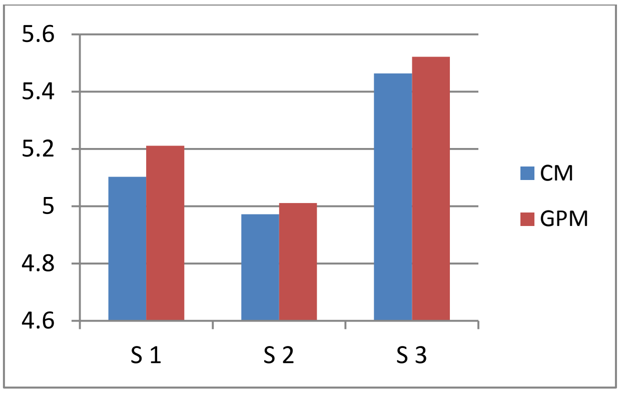


Graph 2 - Triple Mesh Tensile Strength

https://doi.org/10.46335/IJIES.2022.7.1.4 eISSN: 2456-3463
Vol. 7, No. 1, 2022, PP. 16-22

Table 4 – Combined Mesh Tensile Strength

Sample	Notation	Opening Size of Mesh (in x in)	Mortar Material	Tensile Strength (N/mm^2)
1	S 1	1.0 x 1.0 + 0.75 x 0.75	CM	5.102
2	S 2	0.75 x 0.75 +0.50 x 0.50	CM	4.972
3	S 3	1.0 x 1.0 + 0.50 x 0.50	CM	5.463
4	S 1	1.0 x 1.0 + 0.75 x 0.75	GPM	5.211
5	S 2	0.75 x 0.75 +0.50 x 0.50	GPM	5.011
6	S 3	1.0 x 1.0 + 0.50 x 0.50	GPM	5.521



Graph 4 - Combined Mesh Tensile Strength

Compressive Strength Test (IS 516-1959): For compressive strength test, Cubical specimens of dimensions 70 x 70 x 70 mm were casted . All cured specimens have been tested in compression testing machine as per the guidelines mentioned by **(IS 516:1959)**. After the age 7th,14th & 28th days curing, these cubes were tested on Universal testing machine

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

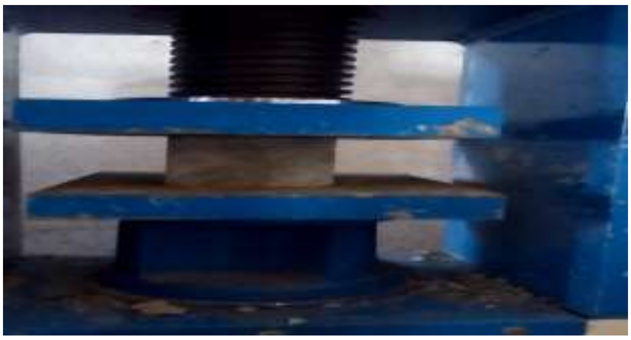
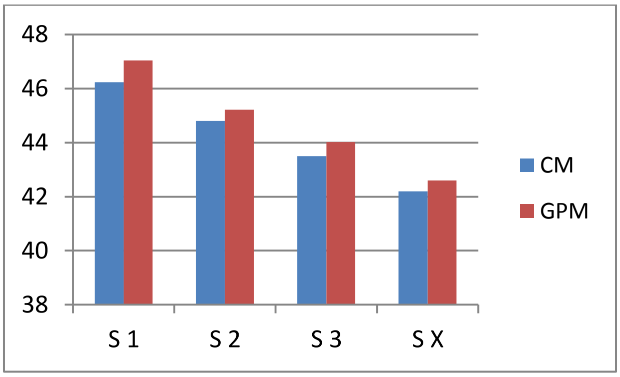


Fig.3 - Compression Testing

Table 5 - Single Mesh Compressive Strength

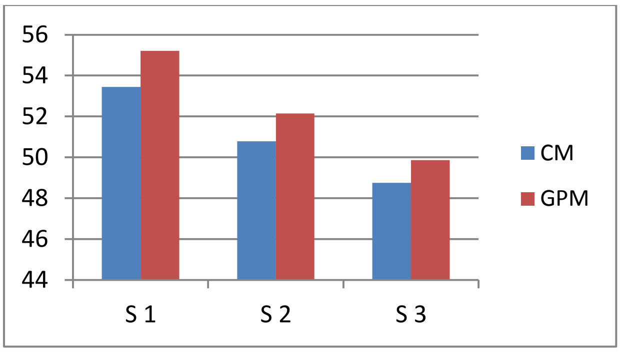
Sample	Notation	Opening Size of Mesh (in x in)	Mortar Material	Compressive Strength (N/mm^2)
1	S X	-	CM	42.2
2	S 1	0.50 x 0.50	CM	46.23
3	S 2	0.75 x 0.75	CM	44.8
4	S 3	1.0 x 1.0	CM	43.5
5	S X	-	GPM	42.6
6	S 1	0.50 x 0.50	GPM	47.04
7	S 2	0.75 x 0.75	GPM	45.21
8	S 3	1.0 x 1.0	GPM	44.02



Graph 5 - Single Mesh Compressive Strength

Table 6 – Double Layer Mesh Compressive Strength

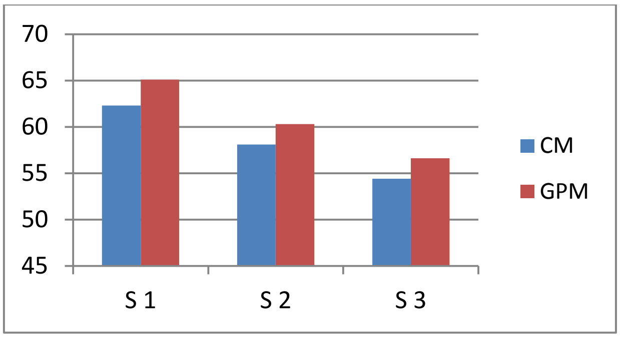
Sample	Notation	Opening Size of Mesh (in x in)	Mortar Material	Tensile Strength (N/mm^2)
1	S 1	0.50 x 0.50	CM	53.45
2	S 2	0.75 x 0.75	CM	50.78
3	S 3	1.0 x 1.0	CM	48.75
4	S 1	0.50 x 0.50	GPM	55.21
5	S 2	0.75 x 0.75	GPM	52.14
6	S 3	1.0 x 1.0	GPM	49.86



Graph 6 - Double Layer Mesh Compressive Strength

Table 7 – Triple Layer Mesh Compressive Strength

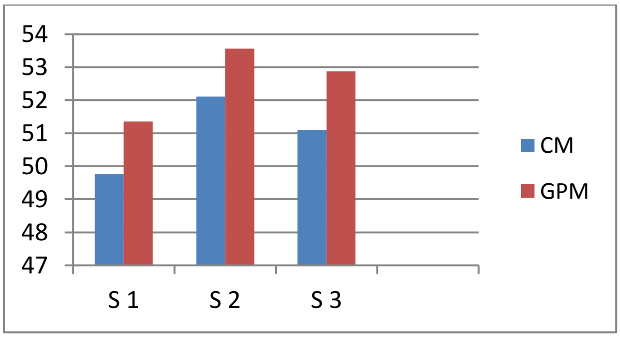
Sample	Notation	Opening Size of Mesh (in x in)	Mortar Material	Tensile Strength (N/mm^2)
1	S 1	0.50 x 0.50	CM	62.3
2	S 2	0.75 x 0.75	CM	58.1
3	S 3	1.0 x 1.0	CM	54.4
4	S 1	0.50 x 0.50	GPM	65.1
5	S 2	0.75 x 0.75	GPM	60.3
6	S 3	1.0 x 1.0	GPM	56.6



Graph 7 - Triple Layer Mesh Compressive Strength

Table 8 – Combined Mesh Compressive Strength

Sample	Notation	Opening Size of Mesh (in x in)	Mortar Material	Tensile Strength (N/mm^2)
1	S 1	1.0 x 1.0 + 0.75 x 0.75	CM	49.76
2	S 2	0.75 x 0.75 +0.50x0.50	CM	52.11
3	S 3	1.0 x 1.0 + 0.50 x 0.50	CM	51.10
4	S 1	1.0 x 1.0 + 0.75 x 0.75	GPM	51.35
5	S 2	0.75 x 0.75 +0.50x0.50	GPM	53.56
6	S 3	1.0 x 1.0 + 0.50 x 0.50	GPM	52.87



Graph 7 – Combined Mesh Compressive Strength

VII- CONCLUSIONS

- For various combination of meshes used in Tension & Compression,the combination of meshes 0.5" x 0.5"+ 0.75" x 0.75" gave more strength as compared to other two combinations of meshes i.e. 1.0" x 1.0" + 0.75" x 0.75" and 1.0" x 1.0" + 0.50" x 0.50.
- For two layers of mesh the increase in tensile strength as compared to single layer mesh is observed to be in the range of 96% - 159%. Further, for 3 layers of mesh increase in tensile strength as compared to single layer mesh is in the range of 172% - 260%.
- Compressive strength also increased with increase in number of layer of meshes. It is increased around 135% for 3 layers as compared to single layer of same size of mesh and is increased by 116% for 2 layers as compared to single layer of same size of mesh. It is concluded that GPM specimens gives more compressive strength as compared to specimen with CM.

ACKNOWLEDGEMENT

Experimental work was carried out using the facilities in Civil Engineering Department laboratory of P.D.V.V.P.COE, Ahmednagar. I wish to thank Dr. S.L Hake, my guide & ME Co-ordinatorfor their valuable Suggestionsand authorities for their kind support. I also wish to thank the laboratory staff for their help and support during experimental work

REFERENCES

[1] Davidovits, J., 1994, 'Properties of Geopolymer Cements', *in First International Conference on Alkaline Cements and Concretes,* SRIBM, Kiev,StateTechnical University, Kiev, Ukraine, 1994.

[2] Gourley, J.T. "*Geopolymers; Opportunities for Environmentally Construction Materials*", Conference: Adaptive Materials for a Modern Society, Sydney, Institute of Materials Engineering Australia, 2003.

[3] A Mohamad N., Mahmood Sura, A. Majeed "*Flexural behaviour of flat and folded Ferrocement panels*" [Al-Rafidain Engineering, Vol.17, No.4, August 2009].

[4] MD. Zakaria Hossain, A Comparison of the Mechanical Properties of Ferrocement in Flexure for Square and Hexagonal Meshes, *Journal of Ferrocement, International Ferrocement Information Center*.ISSN: 0125-1759 28(2) 111-134 1998.

[5] Sivagurunathan.B, Vidivelli.B, 'Strengthening of Predamaged Reinforced Concrete Beams by Ferrocement Plates' "*International Journal of Current Engineering and Technology*' Vol.2-2012, pp 340 – 344.

[6] V. Sreevidya, R. Anuradha, R.Venkatasubramani and S. Yuvaraj, "Flexural Behavior of Geopolymer Ferrocement Elements", *asian journal of civil engineering (bhrc) vol. 15, no. 4 (2014)*PAGES 563-574.

[7] Dr. B.N. Divekar, "Ferrocement Technology", A Construction Manual.

[8] Swayambhu Bhalsing, Sayyed Shoaib, Pankaj Autade " Tensile Strength of Ferrocement with respect to Specific Surface".

[9] Niteen Deshpande and Mohan Shirsath, "Comparative study between Bamboo reinforced & Conventional Ferrocement Panels", IJRPET, ISSN 2554-7875, Volume 2, Issue 7, July 2016.

[10] Randhir Phalke & Darshan Gaidhankar, "Flexural Behaviour of Ferrocement Slabs Panels using Welded Square mesh by incorporating Steel Fibers", IJRET, Volume:3 Issue:5, May 2014.