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PERFORMANCE AND OPTIMIZATION OF METAKAOLIN GEOPOLYMER CONCRETE SUBJECTED TO ELEVATED TEMPERATURE

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Abstract: Shelter is one of the basic needs of human being. But more than 80 developing countries in the world suffer from housing shortages resulting from population growth, internal migration, war, natural disaster, to mention a few. Housing units constructed using ferrocement panel (bamboo mesh) produced with mortar mixes. This will definitely prove to be economical and safe. This research is to conduct a study on flexural and bending behaviour of ferrocement panels and also on strength. Ferrocement is such a material that is slim and slender but at the same time strong and elegant which provides a potential solution to the above problem. Ferrocement has a very high tensile strength-to-weight ratio and superior cracking behaviour in comparison to conventional reinforced concrete. This means that thin ferrocement structures can be made relatively light and watertight. Hence, ferrocement is an attractive material for the construction of prefabricated housing units. An efficient and eco-balancing revolution of ferrocement technology has been developed, which overcomes the drawbacks of the traditional methods. The results obtained from the experimental study shows that bamboo mesh strength near the strength of tor steel. Study the flexure and bending behaviour of ferrocement panels from which the bamboo mesh panels strength near to the strength of tor mesh panels. Find out the flexure and bending ultimate load for varying fly ash, sodium hydroxide &sodium silicate. From the ultimate load for bending and flexure for 10-100% fly ash, for 50% fly ash re-place as cement which gives the maximum load hence optimum value of fly ash for bamboo meshes 50%.Phenolphthalein used for carbonation test. Concrete panel it shows light pink colour. Various methods exist for inhibiting corrosion. But yet a permanent solution for corrosion is not prescribed as far as ferrocement technology is concerned. Fulfill the demand of low cost houses by replacing cement as fly ash & steel as bamboo

Keywords: *Metakaolin, Geopolymer , Concrete, Elevated Temperature.*

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I INTRODUCTION

In most developing countries, the technology for construction of houses depends on imported building materials to a large extent. With the rapid increase in the demand for housing, the existing stock of conventional building materials like cement, steel etc. would fall short of the demand, if it is consumed indiscriminately. In order to provide basic infrastructure facilities as proper dwelling units to the millions of homeless people, low cost building materials has become an important issue. Researchers suggest that ferrocement can be an alternative material for roof, wall as it is economical. American Concrete Institute ACI 549 de-veloped a report on ferrocement in 1988 and consecutively a guide for the design, construction and repair in 1989. There is a need to achieve the alternative building materials like fly ash as partial replacement of cement, and bamboo for steel bars, a costly building material. This gives considerable savings in consumption of cement and steel. If bamboo can be cured to not absorb water, pre-served, and then be coated to adhere to cement well, bamboo would be better than steel in concrete for poor countries lacking a cheap source of steel. In this context, this research work has been undertaken in the laboratory to develop cheap building elements using locally available bamboo as the main structural element.

Ferrocement is a construction material that proved to have superior qualities of crack control, impact resistance, and toughness, largely due to the close spacing and uniform dis-persion of reinforcement within the material. One of the main advantages of ferrocement is that it can be constructed with a wide spectrum of qualities, properties, and cost, according to customer's demand and budget

Ferrocement is an innovative construction technology which is widely adopted throughout the world. Ferrocement is a type of thin walled reinforced concrete construction in which small-diameter steel wire or other material mesh are used uniformly throughout the cross section instead of discretely placed reinforcing bars and in which Portland cement mor-tar is used instead of concrete. In ferrocement, wire or bamboo meshes are filled in with ce-ment mortar. It is a composite, formed with closely knit wire or bamboo mesh; tightly wound round skeletal steel and impregnated with rich cement mortar.

With Ferrocement it is possible to fabricate a variety of structural elements, may be used in foundations, walls, floors, roofs, shells etc. They are thin walled, lightweight, durable and have high degree of impermeability. It combines the properties of thin sections and high strength of steel. In addition it needs no formwork or shuttering for casting.

Ferrocement have 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.

Ferrocement is defined in different ways by different organizations.

1. According to United Nations High Commissioner for refugees (UNHCR), ferrocement is defined as 'A thin walled construction, consisting of rich cement mortar with uniformly dis-tributed and closely spaced layers of continuous and relatively small diameter mesh (metallic or other suitable material).
2. ACI committee-549 describes it- 'Ferrocement is a form of reinforced concrete using closely spaced multiple layers of mesh and/or small diameter rods completely infiltrated with, or encapsulated, in mortar. The most common reinforcement is steel mesh' (reference – ACI 549.1R-93- Guide for the design, construction and repair of ferrocement).
3. Ferrocement is a construction material consisting of wire meshes and cement mortar. Ap-plications of ferrocement in construction are vast due to the low self weight, lack of skilled workers, no need of framework etc.

Comparison of RCC and Ferrocement

Ferrocement composite has different features than Reinforced cement concrete. Fea-tures like thickness of products, matrix used in products, reinforcement, strength, structural behaviour etc. on which they are differentiated, is given in table 1.1.

Table 1. 1 Comparison of RCC and Ferrocement

1	Thickness	Minimum 75 mm	Thin walled, 25 to 50mm.
2	Matrix Material	Cement	Rich Cement Mortar
3	Reinforcement	Steel bars > 6mm diameter	Continuous fine wire mesh
		spaced distance apart	dispersed throughout the
			body of the structure
4	Casting process	Formwork and shuttering	Tightly tied wire meshes act
		are quite essential. Due to	as supporting mortar casting.
		forms honeycombing is	Filling is dense and compact,
		likely to occur	no honeycombing
5	Structural behaviour	Rigid	Non rigid

Scope of work

Housing units constructed using ferrocement panel (bamboo mesh) produced with mortar mixes. This will definitely prove to be economical and safe.A comparative study between ferrocement panels of bamboo mesh & wire mesh for mortar material. It will suggest an optimum mix for housing units.This research is to conduct a study on flexural and bending behaviour of ferrocement panels and also on strength.

II NEED FOR THE STUDY

Shelter is one of the basic needs of human being. But more than 80 developing coun-tries in the world suffer from housing shortages resulting from population growth, internal migration, war, natural disaster, to mention a few. Most dwellings in rural areas are made of cheap local materials including low quality wood (which is easily attacked by termites), scrap metal, thatch and/or earth products (like clay, mud, sand, rock/ stone) which are temporary and unsafe. There is an urgent need to explore a building material that is structurally efficient but at the same time, should be lightweight, eco-friendly, cost effective and especially the ones that can perform the desired functions.

Ferrocement is such a material that is slim and slender but at the same time strong and elegant which provides a potential

solution to the above problem. Ferrocement has a very high tensile strength-to-weight ratio and superior cracking behaviour in comparison to con-ventional reinforced concrete. This means that thin ferrocement structures can be made rela-tively light and watertight. Hence, ferrocement is an attractive material for the construction of prefabricated housing units.

In India especially in and around the coastal region the requirement of slum clearance is high. The bearing capacity of these regions generally being lower compared to urban areas and may require suitable ground improvement techniques which may not be cost effective. In such cases ferrocement technology is very much helpful for constructing the houses (since it is light weight) without incorporating any ground improvement technique to improve the bearing capacity.

In ferrocement, cement matrix does not crack since cracking forces are taken over by wire mesh reinforcement immediately below the surface. Ferrocement has a high tensile strength and stiffness and a better impact and punching shear resistance than reinforced concrete, be-cause of two-dimensional reinforcement of the mesh system. So it undergoes a large defor-mation before cracking or high deflections before collapse.

Ferrocement is being explored as building materials substituting stone, brick, RCC, steel, pre-stressed concrete and timber and also as structural components—walls, floors, roofs, beams, columns and slabs, water and soil retaining wall structures. Ferrocement can be fabricated into any desired shape or structural configuration that is generally not possible with standard masonry, RCC or steel. Since the ferrocement uses layers of steel mesh as reinforcement (2 to 8%), the specific surface of reinforcement is considerably higher for ferrocement than for RCC. Also, the reinforcing steel wire mesh has openings large enough for adequate bonding; the closer distribution and uniform dispersion of reinforcement, transforms the brittle mortar into a high performance material which is completely different from reinforced concrete. So it is seen that, ferrocement provides better results in all aspects that R.C.C.

III METHODOLOGY

The project study involved three stages. The primary data was gathered through a Literature survey targeted by web searches and review of eBooks, manuals, codes and journal papers. After that casted and tested, final take the result. This project execution follows the flow chart given below:

Materials:

Cement:

The cement used is fresh and without any lumps.Cement is the most impor-tant ingredient used. One of the important criteria for the selection of cement is its ability to produce improved microstructure. The cement should be fresh of uniform consistency and free of swellings and external matter and of the nature or grade depending on the application. Cement is a Binding Material . Using Ordinary Portland cement(OPC) of Grade 53 con-forming to IS: 8112

Figure 3. 1 90 micron sieve for fineness test.

100g of OPC of grade 53 is taken and it is sieved on 90 micron sieve for 15 minutes by giv-ing circular and vertical motion. And the residue on sieve is weighed and checked so that it is not more than 10% of the original weight taken (i.e. 10g).

Figure 3. 2Vicat Apparatus for Consistency, IST, FST.

Normal consistency

The standard consistency (Normal consistency) of cement paste is defined as that consis-tency which will permit a Vicat plunger having 10mm diameter and 50mm length to pene-trate to a depth of 33-35mm from the top of the mould. This apparatus is called Vicat Ap-paratus. This Apparatus is used to find out the percentage of water required to produce a cement paste of standard consistency.

Initial setting time

The time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity.

Final setting time

The time lapsed between the mixing of water, till the standard Vicat needle for final setting makes an impression on top surface of test block, but the annular attachment fails to do so. Thus, the final setting time is determined.

Concrete Mix Design

Table 4. 1Concrete Mix Design

W/GPB	Fly Ash (Kg)	NaOH (Gram)	Na_2SiO_3 (Gram)	Aggregate		Lime (Kg)	Aggregate Quantity of Water (Kg)
				Fine (Kg)	Coarse (Kg)		
0.35	4.79	840	840	7.66	14.70	0.479	0.690

Compressive Strength of Processed Fly Ash(Pellets Form)

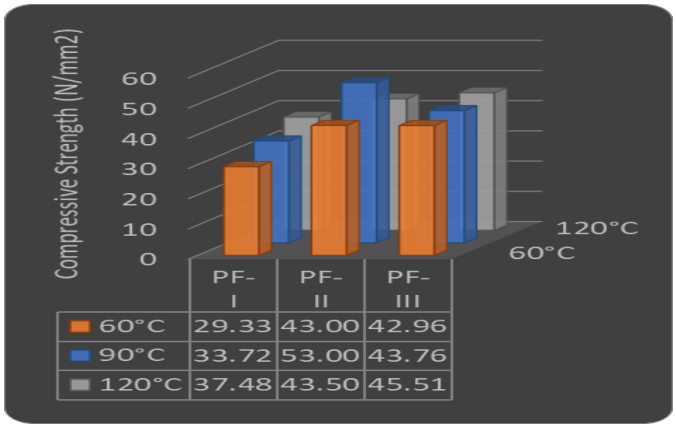
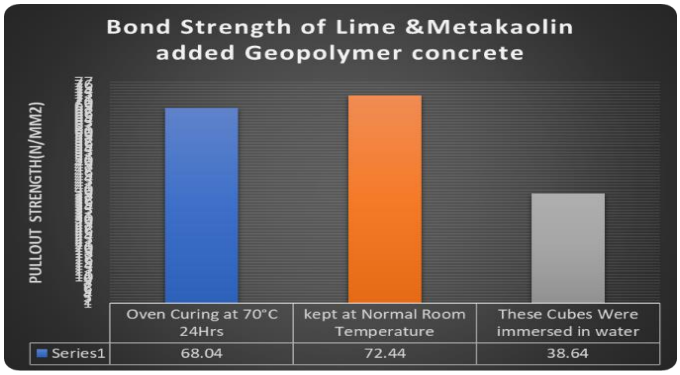


Chart 4. 1 Compressive Strength of Processed Fly Ash(Pellets Form)

Bond Strength of Lime &Metakaolin added Geopolymer concrete



Bond Strength of Lime &Metakaolin added Geopolymer concrete

Sulphuric Acid Attack of Lime and Metakaolin added GPC

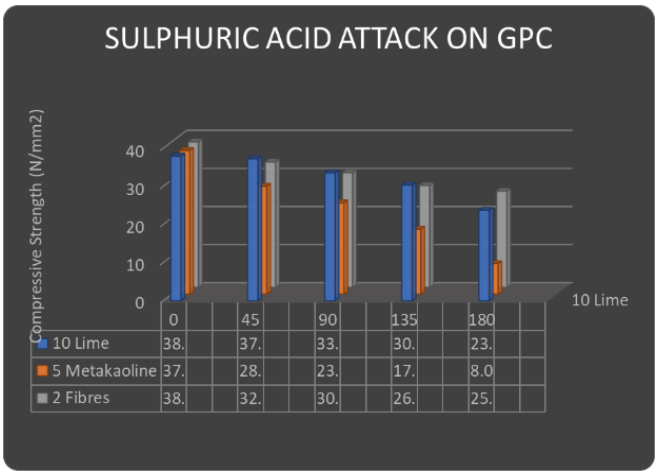


Chart 4. 2Sulphuric Acid Attack of Lime and Metakaolin added GPC

Hydrochloric Acid Attcack of Lime and Metakaolin added GPC

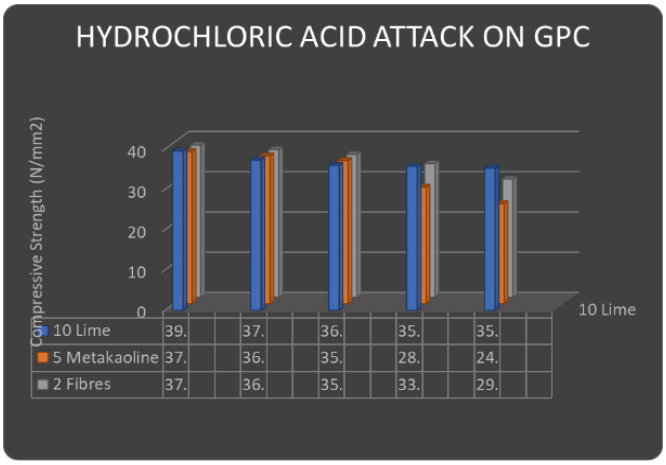


Chart 4. 3Hydrochloric Acid Attcack of Lime and Metakaolin added GPC

Effect of Types of Curing on Lime and Metakaolin Added GPC

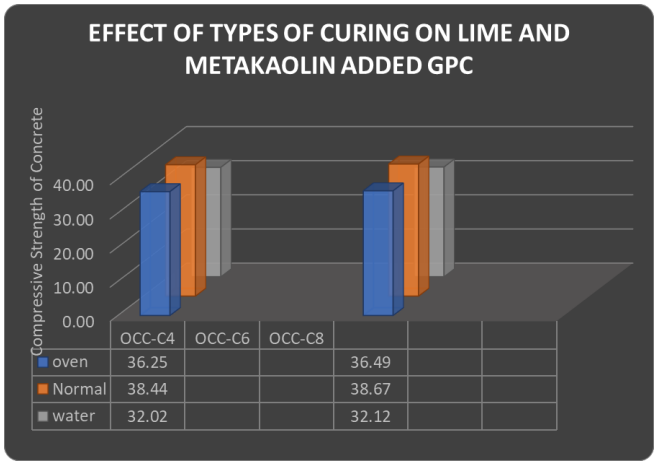


Chart 4. 4Effect of Types of Curing on Lime and Metakaolin Added GPC

NDT test on Lime and Metakaolin Added GPC

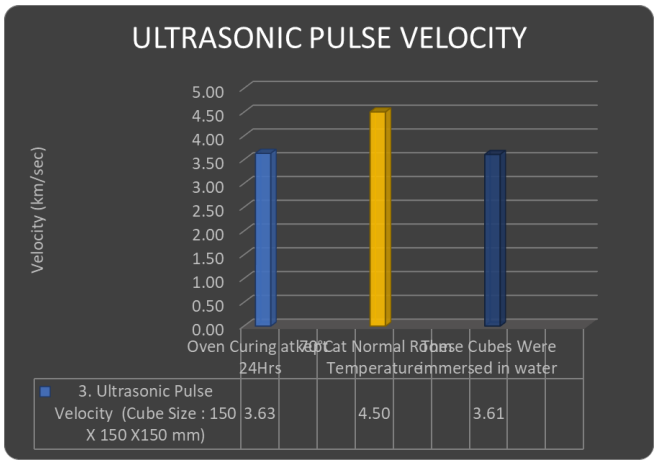


Chart 4. 5NDT test on Lime and Metakaolin Added GPC

Effect of Sea Water on Lime and Metakaolin Added GPC

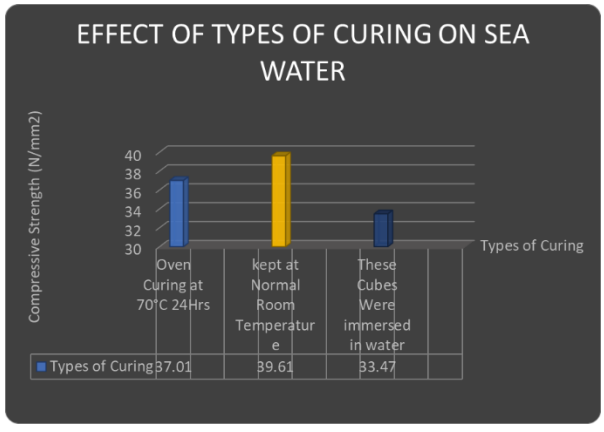


Chart 4. 6Effect of Sea Water on Lime and Metakaolin Added GPC

V CONCLUSION

The following results have been drawn based on the results obtained from present study:

1. An efficient and eco-balancing revolution of ferrocement technology has been developed, which overcomes the drawbacks of the traditional methods. The results obtained from the ex-perimental study shows that bamboo mesh strength near the strength of tor steel.
2. Study the flexure and bending behaviour of ferrocement panels from which the bamboo mesh panels strength near to the strength of tor mesh panels.
3. Find out the flexure and bending ultimate load for varying fly ash, sodium hydroxide &sodium silicate.
4. From the ultimate load for bending and flexure for 10-100% fly ash, for 50% fly ash re-place as cement which gives the maximum load hence optimum value of fly ash for bamboo meshes 50%.
5. Similarly Optimum value of NaoH (sodium hydroxide) which gives maximum load 16 Molar.
6. And for the Na_2siO_3 (sodium silicate), maximum load obtained for 13 Molar. Hence Opti-mum value of Na_2siO_3 (sodium silicate) is 13 molar.
7. Compressive strength of mortar cubes at 7 days, 14 days, and 28 days, 7days-13.18 N/MM2, 14 days-17.77 N/MM2, 28 days- 20.21 N/MM2.
8. Ph of NaoH= 10.52 (7-14) Alkaline.
9. Phenolphthalein used for carbonation test. Concrete panel it shows light pink colour.
10. Various methods exist for inhibiting corrosion. But yet a permanent solution for corrosion is not prescribed as far as ferrocement technology is concerned.
11. Fulfill the demand of low cost houses by replacing cement as fly ash & steel as bamboo.

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