IJETST- Vol.||03||Issue||03||Pages 3744-3758||March||ISSN 2348-9480 2016

Open access Journal International Journal of Emerging Trends in Science and Technology

Impact Factor: 2.838 DOI: http://dx.doi.org/10.18535/ijetst/v3i03.21

An Experimental Study of Geogrid in Ferrocement Panels

Authors

S.Jaganathan[1], P.Sudharsanamurthy[2]

[1]Civil Engineering, B.E Student, Jaya Sakthi Engineering College

[2]Guide- M.B.A, M.Plan, M.Tech (Structural)

ABSTRACT

The construction industry is seeing a boom as the infrastructure development has increased too many folds. The existing materials used in construction, pollute the environment as well as leads to global warming. The needs of innovation in construction to necessitate the future requirements make us to revolutionize the conventional system. One such conventional system we overviewed is FERROCEMENT CONSTRUCTION.

Definition of ferrocement by ACI Committee 549, 1988

"Ferrocement is a form of reinforced concrete using closely spaced multiple layers of mesh and /or small diameter rods completely encapsulated in mortar. The most common type of mesh used is steel mesh. Other materials such as selected organic, natural or synthetic fibers may be combined with metallic mesh."

It is very well known that one ton of cement produces one ton of CO_2. The increase in percentage of CO_2 results in global warming and for this reason the manufacture of cement must be minimized. The only component which can partially replace the cement is flyash. Flyash is one of the residues from thermal power plant, which when partially replaced with cement can be used as a construction material.The rise in cost of river sand used as fine aggregate in concrete have increased the cost of construction significantly in the past few decades. The increase in the cost of river sand is due to dwindling natural resources as well as the concern to prevent further environmental degradation. These problems have led to the search for alternative materials for fine aggregates that are eco-friendly besides being inexpensive. The quarry dust, which is available abundantly from crusher units at a low cost in many areas, provides a viable alternative for river sand in concrete.

Quarry dust being inexpensive and ecofriendly is been proposed for partially replacing sand.

Steel mesh provided in the ferrocement construction has a serious disadvantage whenever the corrosion property is concerned. So in order to compensate the strength and durability of ferrocement panels, present study has been made to replace steel mesh with HDPE – geogrid mesh for different proportions of cement and flyash and partial replacement of sand with quarry dust. An optimum proportion has been arrived taking into account the social responsibility to bring out the product that could be economic, efficient and eco-friendly.

INTRODUCTION

GENERAL

With the advancement of research technology, use of thin cement composite elements made of cement mortar and layers of continuous and relatively small sized mesh is increasing day by day. Ferrocement is one of the most popular thin cement composite and is especially suitable for spatial structures such as shell and folded plate elements.

Ferrocement is a building material with some similarities to reinforced concrete. Indeed, both materials have the same source. Ferrocement is produced by applying cement mortar composed of fine aggregate and cement on the wire reinforcement using plastering techniques. As a result the property of ferrocement distinguishes it from reinforced concrete. While of similar durability, it is more elastic than reinforced concrete.

History of ferrocement reveals that, A Frenchman, Joseph Monier (1823 - 1906), produced flower pots made of cement mortar reinforced with chicken wire and showed this product at the world exhibition held in Paris in 1867. J. Monier is the father of reinforced concrete. In 1847, another Frenchman, Joseph-Luis Lambot, filed a patent for producing a cement boat, wire-reinforced, not long after the development of Portland cement. Which of the two men first had the idea of combining wire with cement mortar is of no interest. Probably the discovery technique happened by chance. At that time, the commonly known chicken wire was a handmade product and therefore soon too expensive in the fast growing industrial era.

But the knowledge of the steel-concrete combination resulted in the development of reinforced concrete using large steel rods. During the First and also later during the Second World War, the technique of Lambot's ferrocement boat was remembered in the U.S. and the U.K. and shipbuilders were encouraged to construct barges. Although some of the boats built during the Second World War had an amazingly long life span, the technique did not really became widespread.

It was the famous Italian engineer and architect, Pier Luigi Nervi, who first undertook real research into ferrocement technology. He observed that reinforcing concrete with layers of wire mesh resulted in a material with high impact resistance properties. This material differed from reinforced concrete in its flexibility and elasticity. After the Second World War, Nervi built a 165-ton motor sailor. This ship, "Irene", proved to be seaworthy. Similar ships were built in the U.K., New Zealand and Australia, and one circumnavigated the world without problems. But Nervi would not have been a structural engineer and architect if he had not also used this material for building construction.

In 1947, he first built a storehouse of ferrocement. Later he combined reinforced concrete with the ferrocement technique and constructed the famous Turin Exhibition Hall with a roof system which spans 91 m. Nervi's work proved that ferrocement is a high quality construction material. The question remains why ferrocement is relatively seldom used as a building material in industrial countries. The answer lies in the process of industrialization of construction work. As a result, working processes have been mechanized wherever possible. In this context the possibilities for mechanizing ferrocement is dealt. A high percentage of labor cost will always characterize this technology. While this is considered to be a disadvantage for industrialized countries, it is a positive factor in developing countries where the labor market is in need of progress. It has therefore to be emphasized that ferrocement is by no means a second-class technology, but rather highly appropriate especially for countries with high rates of unemployment.

Ferrocement has been developed mainly during the past thirty years and yet has reached a very advanced stage in technique and design. A considerable amount of laboratory testing research and prototype constructions have been completed at the Building and Construction Engineering Department of University of Technology, Iraq for the production of ferrocement members that would be used in the roof /floor/wall of building/housing.

Ferrocement is a thin construction element with thickness in the order of 10 -50 mm and uses rich cement mortar; no coarse aggregate is used; and the reinforcement consists of one or more layers of continuous/ small diameter steel wire/ weld mesh netting. It requires no skilled labor for casting, and employs only little or no formwork.

Ferrocement is very adequate to resist the impact, due to its higher ability of absorbing impact energy as compared with the conventional reinforced concrete, and the damage is localized at the impact zone. Tests were carried out at the laboratory of Civil Engineering Department at the University of Nottingham, U.K. The ferrocement building components can withstand direct fire with a temperature values up to 756^{o} C for a period of 2½hours with no segregation in the surface of the elements facing the fire. Tests were carried out at ferrocement victory, Baghdad, Iraq.

In order to prevent loss and damage to property and loss of invaluable lives, construction of Ferrocement Structures should be taken up immediately. The strong earthquakes that occurred in Mexico in 1999 twice richer scale 7.2 & 7.4. These earthquakes destroyed thousands of houses, hundreds of schools and churches and took many lives. The Ferrocement structures such as school, all houses, the class room laboratory, the largest auditorium, all the bridges and small dams that have been designed and constructed were untouched. The above single reason should be sufficient to begin with the Ferrocement constructions in Earthquake Zone.

NEED FOR THE STUDY

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. 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 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.

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, because of two-dimensional reinforcement of the mesh system. So it undergoes a large deformation before cracking or high deflections before collapse.

Ferrocement is being explored as building materials substituting stone, brick, RCC, steel, prestressed 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.

OBJECTIVE

The project aims in the complete experimental study of the existing ferrocement art to that of a proposed innovative system. The proposed innovative system deals with the analysis and comparative study of the strength and flexural properties of steel wire mesh and geogrid in cement sand mortar with three different mortar mixes with partial replacement of cement with flyash and sand with quarry dust in different proportion.

The proposed system thus replaces steel wire mesh with geogrid mesh. Apart from its excellent binding property, cement being a large scale producer of CO_2 is been partially replaced with flyash in the proposed system and sand is been proportionally replaced with inexpensive and eco-friendly quarry dust.

The project aims indirectly in pointing out the possibility of producing high strength, more eco-friendly and highly economical geogrid panels for modular housing units along the coastal region.

It is also a part of objective to innovatively produce geogrid panels with more corrosion resistance and higher strength.

Scaled down panels were prepared and were been tested for its material strength at different loading conditions. The crack distribution and flexural properties of the panels were examined carefully. A comparative study is to be made initially for different mortar combination and using steel wire mesh and geogrid mesh as reinforcement respectively.

And thus arriving at a proposal that can nullify the limitations of ferrocement technology to an extent for aiding its application.

SCOPE OF THE WORK

Ferrocement construction can be divided into four phases: fabricating the skeletal framing system, applying rods and mesh, plastering, and curing. Note that special skills are required for Phases 1 and 3 while Phase 2 is very labor intensive, a possible shortcoming for industrially developing countries but an advantage for countries where unskilled labor is relatively abundant.

The housing units in our country along east coastal belt are mostly huts and thatched roof houses which are affected during monsoon season. This has increased two folds after Tsunami which swiveled the coastal regions.

Housing units constructed using geogrid panels produced with mortar mixes as defined earlier in the objective can be a better alternate to presently existing housing units along the coastal regions since precast houses are more trustworthy to the conditions prevailing there. This will definitely prove to be economical and safe and earthquake resistant.

The panels are tested for flexure and a comparative study is made between ferrocement panels and geogrid panels for different combination of mortar material. An optimum mix is suggested for housing units.

Scaled down models of housing units using the geogrid panels can be made and tested and the technology can be used for constructing housing units along coastal areas.

LITERATURE REVIEW

INTRODUCTION

This part discusses the background and previous literature regarding ferrocement technology.

LITERATURE REVIEW

Sakthivel P.B, et.al presented a paper on “Ferrocement Construction Technology and its Application”. Ferrocement construction technology is quite popular throughout the world. Ferrocement, a thin element, is used as a building construction as well as a repair material. This paper attempts to review the literature on ferrocement and bring out the salient features of construction, material properties and the special techniques of applying cement mortar on to the reinforcing mesh. This study brings out the importance of using ferrocement in swimming pools and water tanks, silos, corrugated roofs, shell and dome structures, and also in the repair of old/ deteriorated RCC structures. The study concludes that ferrocement will certainly be one of the best structural alternatives for RCC in the future.

They Concluded That

1. Ferrocement elements undergo high deformations before collapse. It has high level of impact and cracking resistance, toughness and ductility.
2. The ferrocement structures are thin and light-weight compared to conventional reinforced concrete. Hence there is considerable reduction in self-weight of the structure and saving in foundation cost. Transportation cost is also less.
3. Ferrocement can be fabricated into any desired shape or configuration. Precasting is suitable for thin ferrocement elements, and mechanised methods can be adopted in case of mass production of ferrocement components.
4. Partial or complete elimination of formwork is possible. Hence there is considerable saving in the cost of formwork, particularly for curved or complicated/ complex shapes/ structures, which is not possible with RCC construction.
5. Ferrocement is most suitable for water-retaining structures due to water-tightness and impermeability.
6. Ferrocement structures can be easily maintained, and also repaired in the event of structural damage without any major problems.

M. A. Saleem, et.al, (January 2008) presented a paper on “Low Cost Earthquake Resistant FerrocementSmall House”. This research work is mainly focused on developing a design of small size, low cost and earthquake resistant house. Ferrocement panels are recommended as the main structural elements with lightweight truss roofing system. Earthquake resistance is ensured by analyzing the structure on ETABS for a seismic activity of zone 4. The behaviour of structure is found satisfactory under the earthquake loading. An estimate of cost is also presented which shows that it is an economical solution.

They Concluded That

1. Based on the analysis and experience it can be confidently stated that this type of structure (ferrocement House) will not only be suitable for temporary use but for permanent construction as well.
2. Its behaviour under a major seismic activity is satisfactory.
3. It can bear the shock with little or no damage.
4. Catastrophic failure will be avoided in any case thus minimizing the loss of life and property.

Hoe I. Ling, et.al (August 1998) presented a paper on “Tensile Properties of Geogrid Under Cyclic Loadings”. The tensile behaviour of three commonly used polymeric geogrids (polypropylene, polyester and high-density polyethylene)under cyclic loading was investigated. The tests were strain controlled and were conducted for 100 cycles at different load ratios. The stiffness and damping ratios of geogrids at all load cycles were compared with primary loading curve. The stiffness increased while the damping ratio decreased with more loading cycles at any load ratios. A higher load ratio decreased the stiffness ratio and increased the damping ratio. The strength of prestressed and virgin specimens were also compared. Negligible strength reduction resulted from short term cyclic loading. The strength obtained from static tests appears reasonable when used for design considering short term cyclic loading. An empirical relationship is proposed to determine the strain accumulated from cyclic loading under different load ratios.

They concluded that

1. The strength of polypropylene geogrid was not affected significantly by cyclic loading.
2. Whereas, the strength of polyester and polyethylene geogrids was increased by cyclic loading and also increased by load ratios.

3. HDPE geogrid performs well than other two types of geogrid.

Md. Zakaria Hossain, et.al (August 2005) presented a paper on "Flexural Behavior of Cement CompositesPanels Reinforced with Different Types of Meshes". An experimental investigation on the flexural behavior of thin cement composite plates reinforced with welded square geogrid mesh and chicken wire mesh with varying number of mesh layers as well as varying percentage of effective reinforcement is presented. A comparison of the load-deflection relationships between the geogrid and chicken mesh composite with 20 and 30 mm thickness is reported. Load carrying capacity of the cement composite elements containing both types of meshes at first crack and ultimate loads is also compared. It is concluded that the first crack and ultimate loads increase with the increase in number of mesh layers for both types of meshes. The load-deflection relationships fluctuate for chicken-mesh-cement composites whereas it is almost smooth pattern for geogrid-mesh-cement composites with any number of mesh layers.

They Concluded That

1. The bearing capacity of the cement composite elements at first crack and ultimate loads is more for specimens with larger thickness irrespective of reinforcement.
2. The bearing capacity at first crack and ultimate loads of the cement composite elements in flexure increases with the increase in percent effective reinforcement for both the geogrid and chicken meshes irrespective of thickness.
3. The increment rate of the first crack and ultimate loads is conspicuously higher for cement composite element containing chicken mesh than that of the cement composite containing geogrid mesh. This line of thinking is completely opposite for cement composite with square steel mesh

METHODOLOGY

MATERIALS

The materials used for this experimental study were deeply analyzed and quality measures were taken in proper execution .The project consumes materials which are inert and available easily in abundance thus making it cost efficient with the caliber to withstand the constructional challenges faced in ferrocement art.

Materials Used

Cement

Ordinary Portland Cement of grade 53 is used.

Flyash

The flyash used in this project is "Class F" flyash sourced from the coal fired from North Chennai thermal power station.

Sand

River sand passing through 2.36mm sieve is used.

Quarry dust

The quarry dust was obtained from the local crusher at Tambaram, Kancheepuram District. The moisture content of quarry dust was found to be lesser than the sand properties.

Geogrid mesh

Geogrid made ofHigh Density Polyethylene (HDPE) of ultimate tensile strength of 12.30kN and maximum deflection 87mm is used in this project.

Chicken wire mesh

Hexagonal steel wire mesh of 0.5mm diameter, Young's modulus 104kN/mm^2 and Poisson's ratio 0.3 was used in this project (ref 1)

Water

A tap water available in the concrete laboratory was used in casting process. The quality of water samples were tested and found potable. The pH of water was found to be less than 7, and it was colourless, odourless and free from salts.

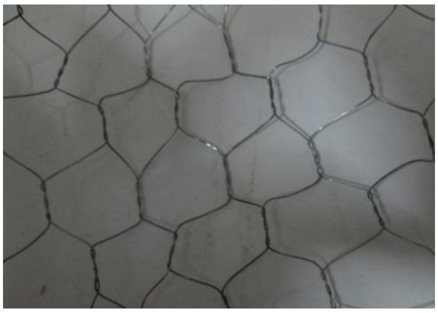
 

CEMENT **FLYASH**

SAND **QUARRY DUST**

GEOGRID MESH



STEELWIRE MESH

Figure 3.1 Materials Used

MATERIAL TESTING

Cement

1. Fineness of cement

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat.

Figure 3.2 90 micron sieve

100g of OPC of grade 53 is taken and it is sieved on 90 micron sieve for 15 minutes by giving 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).

Fineness of the OPC used was found to be *0.5%*

2. Normal consistency

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

Figure 3.3 Vicat apparatus

500g of cement is taken and it is made into paste with a weighed quantity of water (say 24% by weight of cement) for first trial. Then this paste is filled into the vicatmould within 3-5minutes. And the mould is shaked to expel the air. The standard plunger is brought down to touch the surface of the paste and then it is quickly released allowing it to sink into the paste by its own weight. Reading is noted by observing the depth of penetration of the plunger. The above process is repeated for 25, 26, 27%... of water content such that the depth of penetration is 33-35mm from the top of the mould.

The normal consistency of the cement used was found to be *29% weight of cement.*

3. Initial setting time

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

500g of cement is taken and made into a paste by adding 0.85 times the water required to produce cement paste of standard consistency (i.e.0.85P).This paste is filled into the Vicatmould within 3-5minutes. Stop watch is started at the moment when the water is added. Needle is brought in contact with the surface of the sample then it is released quickly. Initially the needle is completely pierced through the test block. But due to lose of plasticity, the needle starts penetrating only to a depth of 33-35mm from the top. The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35mm from the top is taken as initial setting time.

The initial setting time was found to be*28 minutes*.

4. Specific gravity test

Specific gravity is the ratio of the mass of a solid or liquid to the mass of an equal volume of distilled water at 4°C (39°F) or of a gas to an equal volume of air or hydrogen under prescribed conditions of temperature and pressure.

Specific gravity bottle of 100ml capacity is taken and it is cleaned and weighed (W1). A sample of cement is placed upto half of the flask (about 50g) and it is weighed with its stopper (W2). Kerosene is added to cement in the flask till it becomes half full. Thorough mixing is done with glass rod to remove the entrapped air. Continuous stirring is done and more kerosene is added until it touches the graduated mark and it is weighed (W3). Then it is cleaned and filled with kerosene upto graduated mark and weighed (W4).

Figure 3.4 Specific gravity bottle

Specific gravity G is determined by

$$G = \frac{W2 - W1}{\{(W2 - W1) - (W3 - W4)\}\, X\, 0.79}$$

Specific gravity of OPC grade 53 was found to be *3.15*

Flyash

Flyash is been prescribed in this project for replacement of cement. So the basic amenities for this replacement were checked. And comparatively similar results if arrived have been checked.

1. Fineness of flyash

Fineness of flyash was found following the same procedure as cement and checked so that it can be satisfactorily replaced.

The fineness of flyash was found to be *7.5%*

2. Specific gravity test

Specific gravity of flyash was found following the same procedure as cement and checked so that it can be satisfactorily replaced.

The specific gravity of flyash was found to be 2.24

Sand

1. Particle size distribution (Sieve analysis)

Particle size distribution is the fundamental property to consider as for as sand is concerned. The percentage of various sizes of particles in a given dry soil sample is found by particle analysis (i.e) the separation of a soil into its different size fractions.

1kg of fine grained soil passing through 2.36mm sieve was taken. And a set of sieves ranging from 1.18, 0.6, 0.3, 0.15, 0.075mm, pan were arranged. The Soil sample was placed in top sieve, then the entire set up was placed in a sieve shaking machine and it was allowed to shake for 10minutes.The portion of soil retained on each sieve was weighed. The percentage of soil retained on each sieve was calculated on the basis of the total mass of the soil sample taken.

Figure 3.5 Sieve shaker

From these results, percentage passing through each sieve is calculated (cumulative % finer). Then the curve was plotted in semi log graph for the sieve size and cumulative % finer. The curve was found to be in "S" shape which shows the distribution of particles as per standards of soil codes. The graph is shown as follows.

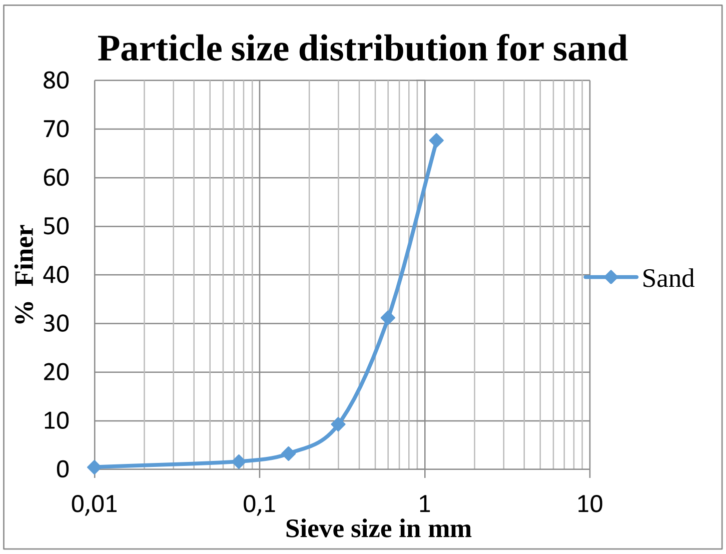


Figure 3.6 Particle size distribution curve for sand

2. Specific gravity test (Pycnometer)

Specific gravity G is defined as the ratio of the weight of a given volume of soil solids at a given temperature to the weight of an equal volume of distilled water at that temperature, both weights being taken in air.

Pycnometer of 900ml capacity, with a conical brass cap screwed at its top was taken. It was cleaned and weighed with the brass cap (M1). 200 to 400g of oven-dried soil was taken and it was placed in the Pycnometer. Then the weight of Pycnometer plus soil was taken (M2). After that Pycnometer was filled with distilled water to its half of the height. It is mixed thoroughly with glass rod. Then more water is added and it is stirred. Screw top is replaced and Pycnometer flush is filled with hole in conical cap. Then it is weighed (M3). After that the Pycnometer is emptied and it is cleaned thoroughly. Then the distilled water is filled to the hole of the conical cap and it is weighed (M4).

Figure 3.7 Pycnometer

Specific gravity G is determined by

$$G = \frac{M2 - M1}{(M2 - M1) - (M3 - M4)}$$

Specific gravity of sand was found to be 2.64

Quarry dust

Quarry dust is prescribed in this project for replacement of sand. So the basic for this replacement was checked. Same experiments as that of sand was done and analyzed for comparatively similar results to aid in partial replacement.

1. Particle size distribution (Sieve analysis)

It is carried out similar to that of sand and graph for particle size distribution of quarry dust is shown below.

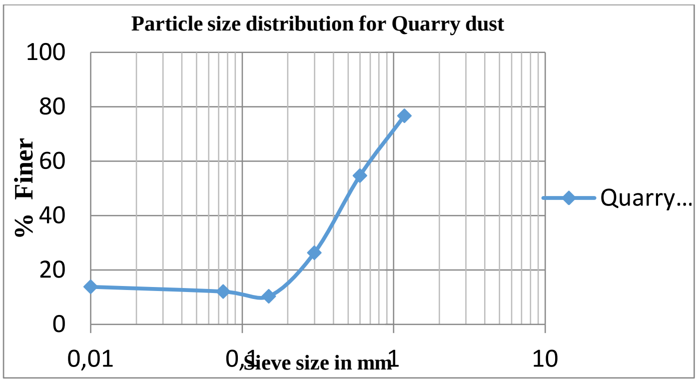


Figure 3.8 Particle size distribution curve for quarry dust

The particle size distribution graph obtained for a mixture of sand and quarry dust (0.5 kg each) is shown below.

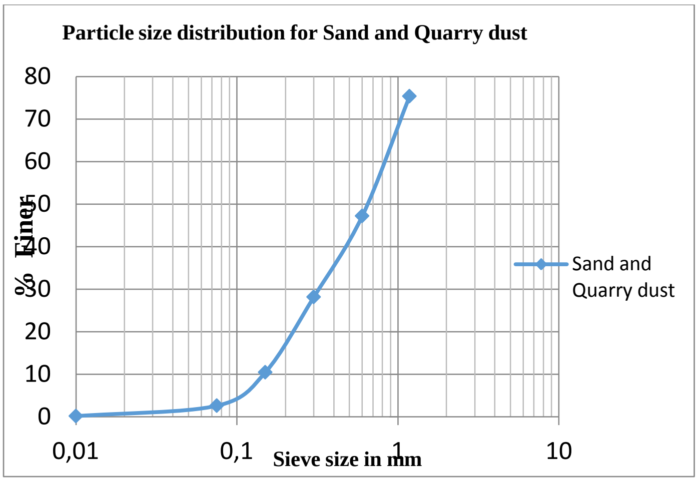


Figure 3.9 Particle size distribution curve for sand & quarry dust

2. Specific gravity test (By Pycnometer)

Specific gravity of quarry dust is found out similar to that of sand.

Specific gravity of sand was found to be 2.62

MIX PROPORTIONS

Based on the limited research on ferrocement mortar system, three new mortar mixes were decided.In the existing ferrocement system the ingredients of the mortar are cement and sand in the ratio 1: 2. In this project we are incorporating two additional ingredients to partially replace the earlier with flyash and quarry dust. The different mixes are,

1. Mix A – C : S = 1:2
2. Mix B – C : F : S = 0.7 : 0.3 : 2
   (i.e 30% replacement of cement with flyash)
3. Mix C – C : S : QD = 1 : 1 : 1
   (i.e 50% replacement of sand with quarry dust)
4. Mix D – C : F : S : QD = 0.7 : 0.3 : 1 : 1
   (i.e 50% replacement of sand with quarry dust along with 30% replacement of cement with flyash)

SELECTION OF MORTAR MIX

To analyze the strength of each mortar mix, specimens like cubes, cylinders and beams were casted and tested for compression, tension and flexure respectively after 28 days of curing. The mix satisfying the strength requirement in all the three aspects was used in casting panels.

Compression test on cube

Nine cubes each of size 70mm×70mm×70 mm were casted and cured. The compression test of the specimens were conducted on 7th, 14th, 28th day in the compression testing machine.

Compressive strength in N/mm^2 = $\frac{\text{Load}}{\text{Area}}$

The compression strength values are detailed in table 3.1.

Figure 3.10 Casting and testing of cube

Split tensile strength of cylinder

Nine cylinders each of size 100mm diameter and 200mm height were casted and cured. The split tensile strength test of the specimens were conducted on 7th, 14th, 28th day.

Split tensile strength in N/mm^2 = $\frac{2P}{\pi DL}$

where P is the load in N

D is the diameter of cylinder in mm

L is the height of cylinder in mm

The test results are detailed in table 3.1.

Figure 3.11 Casting and testing of cylinder

Flexural test on beam

Flexural tests were conducted in the mortar specimens, to get a better view about the mortar proportion when they are casted into panels. Beam moulds of size 40mm×40mm×160mm pertaining to RILEM standards were used and nine specimens for each mix proportions were casted and cured. The flexural test of the specimens were conducted on 7th, 14th and 28th day.

Flexural strength in N/mm^2 = $\frac{PL}{BD^2}$

where P is the load in N

L is the length of the beam in mm

B and D are width and depth of the beam respectively in mm

The results are detailed in table 3.1.

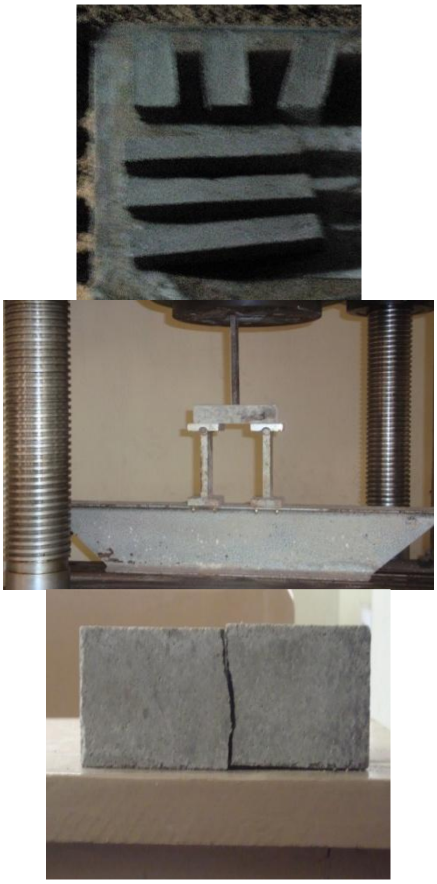


Figure 3.12 Casting and testing of beam

Table 3.1 Test results on cube, cylinder and beam

Mix	Compressive strength (N/mm^2)			Split Tensile strength (N/mm^2)			Flexural strength (N/mm^2)		
	7th day	14th day	28th day	7th day	14th day	28th day	7th day	14th day	28th day
A	34.03	37.65	41.22	1.56	1.70	2.42	4.63	4.88	5.38
B	27.43	34.69	38.78	1.02	1.29	1.85	3.75	4.25	5.25
C	36.19	42.45	49.93	2.05	2.26	2.58	5.13	5.63	6.63
D	24.9	29.66	39.39	1.62	1.8	2.16	4.38	4.63	5.13

3.5 CASTING OF PANELS

Based on the results of compression test, tensile test and flexural strength test panels were casted with Mix A (C: S), Mix C (C: S: QD), Mix D (C: F: S:QD) with 20% and 10% replacement of cement with flyash using chicken wire mesh and geogrid mesh separately for the comparative study.

3.5.1 Panel specifications

Wooden panel moulds of sizes 500mm×200mm and 30mm thick were used for casting panels. A clear cover of 5mm was maintained at the bottom (tension) and top (compression) sides. This panel size was recommended after a thorough study of ferrocement documents.

Figure 3.13 Placing of steel wire mesh

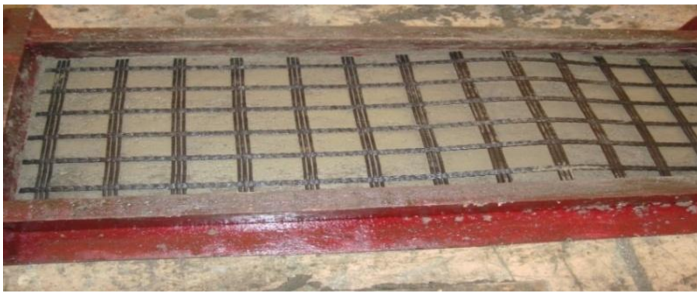


Figure 3.14 Placing of geogrid mesh

Figure 3.15 Casted panel

3.6 CURING OF PANELS

The samples were cured for 28days and it was allowed to air dry for 48hours in room temperature of about 10^0 C and then the test was performed.

3.7 TESTING OF PANELS

All the elements were tested with their two edges simply supported over a span of 450mm under two points loading. The distance between the two loading points is 150mm with moment arms of 150mm at both sides of the loading points. The test was performed in universal testing machine and the readings were taken at an interval of 0.2kN and the corresponding deflections were noted. Before testing, all the elements were painted white so that the cracks could be easily observed and clearly photographed. The ultimate load and the corresponding deflection is noted.

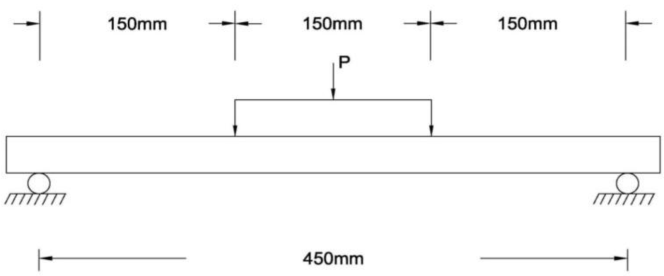


Figure 3.18 Test setup

Figure 3.19 Testing of panel

RESULTS AND DISCUSSION

4.1TEST RESULTS OF PANELS

The results of the tested specimens in flexure are listed in the table as follows.

Table 4.1 Load and displacement values of panels

Load in kN		0.2	0.4	0.6	0.8	1.0	4.2	1.4	1.6	1.8	2.0	2.2	2.4
		Displacement in mm											
Mix A	S	0.07	0.12	0.21	0.28	0.35	0.42	0.49	0.59				
	G	0.15	0.30	0.43	0.54	0.62	0.82	0.97	1.05	1.18			
Mix C	S	0.09	0.16	0.24	0.32	0.40	0.46	0.52	0.60				
	G	0.06	0.11	0.17	0.24	0.30	0.39	0.47	0.55	0.69			
Mix D (20%flyash)	S	0.07	0.14	0.20	0.26	0.31	0.36	0.36	0.42	0.47	0.52	0.59	
	G	0.13	0.22	0.33	0.41	0.45	0.50	0.56	0.62	0.69	0.77	0.83	
Mix D (10%flyash)	S	0.08	0.13	0.18	0.24	0.29	0.35	0.41	0.49				
	G	0.06	0.10	0.18	0.24	0.3	0.36	0.42	0.48	0.55			

4.2 LOAD DEFLECTION CURVES

The load deflection relationship for specimens reinforced with two layers of geogrid wire meshes and chicken wire meshes are analyzed and presented herein individually.

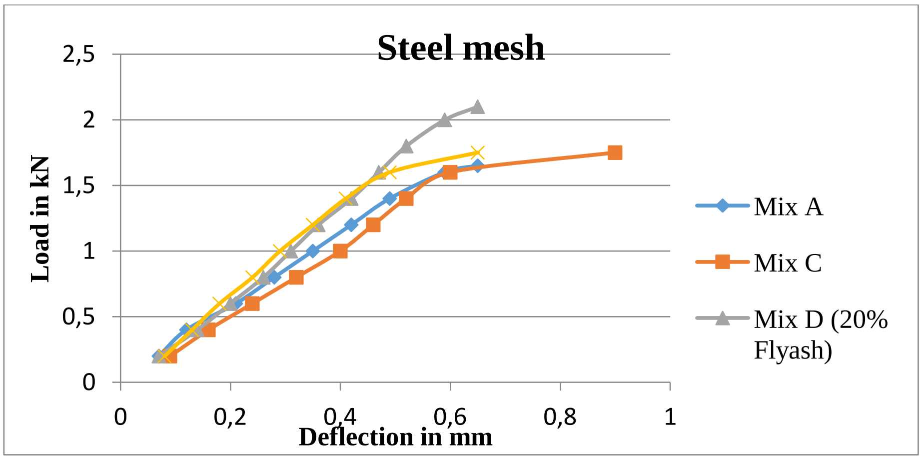


Figure 4.1 Load deflection curve for Steel mesh panels

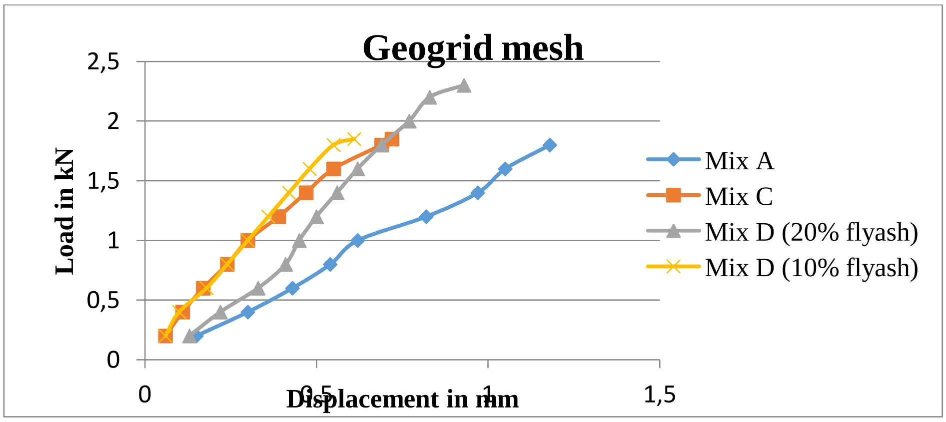


Figure 4.2 Load deflection curve for Geogrid panels

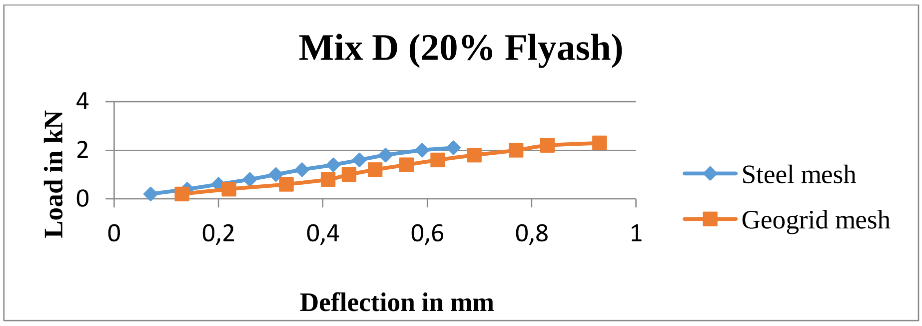


Figure 4.3 Load deflection curve for Mix D with 20% flyash panels

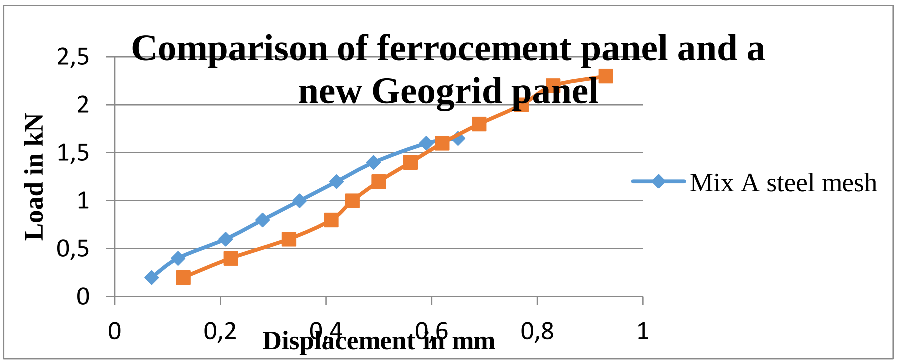


Figure 4.4 Load deflection curve for Mix A (steel mesh) panel and Mix D (20% flyash) Geogrid panel

4.3 FAILURE PATTERN OF PANELS

It is found that there is a complete collapse at ultimate load in ferrocement panel with steel mesh. But in geogrid panel the crack is initialized at ultimate load and bending occurs without complete collapse of panel.

Figure 4.5 Failure of steel wire mesh panel

Figure 4.6 Failure of Geogrid mesh panel

4.3 COMPARITIVE STUDY OF PANELS

The ultimate load and the corresponding displacements of all panels with steel and geogrid reinforcement were studied and the details are given below.

Table 4.2 Ultimate load values of panels

Type of Mix		Ultimate load in kN	Displacement in mm
Mix A	Steel mesh	1.65	0.65
	Geogrid mesh	1.8	1.20
Mix C	Steel mesh	1.75	0.80
	Geogrid mesh	1.85	0.72
Mix D with 20% flyash	Steel mesh	2.10	0.65
	Geogrid mesh	2.3	0.93
Mix D with 10% flyash	Steel mesh	1.75	0.65
	Geogrid mesh	1.85	0.61

From the above table the ultimate load of the panel casted with Mix D (20% flyash) and geogrid mesh is found to be more than the ultimate load of the panel casted with Mix A and steel mesh.

CONCLUSION

An efficient and eco-balancing revolution of ferrocement technology has been successfully developed, which overcomes the drawbacks of the traditional methods. The results obtained from the experimental study shows that geogrid can successfully replace the chicken wire mesh without sacrificing the strength aspects of chicken wire mesh.

Quarry dust has been found to replace sand efficiently in all aspects. Fly ash at an optimum percentage of replacement gives better results than the cement sand mortar combination of existing ferrocement system. Thus a new mortar mix proportion which is economical, efficient and ecobalancing is been proposed in the project.

A worthy collaboration of this mortar with an excellent material like geogrid, lime lights a better technology to adopt from the results analyzed. Panels casted can be produced based on the scale on which this technique is to be adopted. From the table, which gives the concluded outcomes between steel mesh ferrocement panel system and proposed geogrid ferrocement panel the strength properties namely the bending and durability properties can be very well understood.

Ferrocement construction is usually well known for thin and light weight construction with higher percentage of reinforcement contributing to the strength. A serious limitation of ferrocement is that the steel reinforcement in the existing mortar system is highly prone to corrosion. The effects are even more adverse once the first crack appears in the structure. And this limitation has contributed much to the unawareness of ferrocement technology all these days. And recently this technology has been lime lighted in various research areas.

Various methods exist for inhibitingcorrosion. But yet a permanent solution for corrosion is not prescribed as far as ferrocement technology is concerned. Geogrid suggested in this project for reinforcement has been used to fabricate strong, durable panels which are corrosion resistant to any extend thus giving solution to the limitation.

REFERENCES

1. Flexural behavior of cement composite panels reinforced with different types of meshes, Md.Zakaria Hossain (Mie University), Md.Rokonuzzaman (Mie University), Sohji Inoue (Mie University). 30th conference on OUR WORLD IN CONCRETE AND STRUCTURES (August 2005).
2. Low Cost Earthquake Resistance Ferrocement Small House, M.A.Saleem, Department of Civil and Environmental Engineering, Florida International University, Miami, USA. M.A.Ashraf, Department of Civil Engineering, University of Engineering and Technology, Lahore, Pakistan.
3. Modern Housing System Using Ferrocement as a Sustainable Construction Material, Wail Nourildean Al-Rifaei, Professor of Civil engineering, University of Tikrit, Iraq.
4. Tensile Properties of Geogrid Under Cyclic Loading, Hoe I.Ling, Yoshiyuki Mohri, Toshinori Kawabata (Members of ASCE)
5. Ferrocement, P.J.Nedwell
6. Concrete Technology, M.S.Shetty.
7. SoilMechanics and Foundation Engineering, B.C.Punmia.
8. Website on Ferrocement.com.
9. RILEM standards.