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Experimental Investigation on Flexural Behaviour of Ferrocement Laminates Using Different Forms of Meshes

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Abstract: The present study describes the results of testing ferrocement panels reinforced with of different types of meshes. The main objective of the study was to investigate the effect of different types of meshes as reinforcement in thin mortar specimen and select the best suitable mesh for further work. Types of meshes were used expanded metal mesh, galvanized woven mesh and welded mesh has a diameter of 1.58 mm. Size of openings are 20x35 mm, 10x10 mm and 15x15 mm. Panels of a size of 560x150x35 mm were reinforced with three layers of wire mesh. Panels were casted with mortar of mix proportion 1:2 and water cement ratio 0.40. The four specimens were tested under four-point loading system on universal testing machine after curing period of 7 days and eight specimens after curing period of 28 days. Test results shows that the flexural strength of the specimen with welded mesh exhibits greater flexural strength than other two types of meshes.
Keywords: ferrocement, mortar, reinforcing material, deflection, flexural strength, M30 grade.

I. INTRODUCTION

The initial definition of ferrocement can be drawn from a patent application submitted by Joseph-Louis Lambot of France in 1852. The patent of “fer-ciment,” which translates into “iron-cement”. Ferrocement can be considered as the first application and the very origin of Reinforced Concrete. The technology of the second part of the 19th century could not accommodate the efficient production of meshes, and small diameter wires were much more expensive than larger diameter rods. Therefore larger diameter iron or steel rods were increasingly used, leading to a shift from ferrocement to standard reinforced concrete construction. Thereafter, reinforced concrete became the material of choice. A.E.Naaman (2001) describes that, in thin concrete products, ferrocement plays the link between reinforced concrete fiber reinforced concrete. Ferrocement is an excellent construction material, for the past and future, from self-help construction to advanced prefabrication. Ferro cement is a highly versatile form of R.C.C possessing unique properties of strength and durability. It is made up of rich cement mortar and wire mesh reinforcement. It has higher ratio of cement mortar. Cement mortar fails when tensile load is applied. In order to withstand the tensile load wire mesh is used. In this project we are going to use different forms of meshes to investigate the tensile strength of the Ferro cement for different meshes. The concept of industrialization of the construction technology has emerged as well accepted and preferred option in the field of building construction now a days in order to reduce in-situ construction up to maximum extent. This could be achieved by employing a number of strategies including the application of newly developed cement-based composites for structural applications. Cement based composites perform better than conventional plain concrete. The development of new construction materials and technology can partly relieve pressures on the existing building material supply and help to arrest the rise in cost of these materials and also may reduce in-situ construction activities Ferrocement is one of the relatively new Cementitious composites considered as a construction material. Ferrocement is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small size wire mesh. The mesh may be made of metallic or other suitable material such as fibre reinforced plastic and woven fabric [1-3]. Compared to reinforced concrete, ferrocement has homogenous-orthotropic properties in two directions. It exhibits high tensile strength, high modulus of rupture and superior cracking performance. In addition, because of high specific surface of ferrocement meshes, larger bond forces develop with matrix resulting in smaller crack spacing and width. The availability of material in most countries, and no skilled labour required and it being suitable for both prefabrication and self-help construction could lead ferrocement to become one of the most inexpensive and alternative technique for strengthening and rehabilitation of existing and damaged concrete structures. The typical application of ferrocement construction includes water tanks, boats, roofs, silos, pipes, floating marine structures and low-cost housing [3-7].

II. LITERATURE REVIEW

1) Manish Hajare, Dr. M. B. Varma et.all, The present study describes the results of testing ferrocement panels reinforced with of different types of meshes. The main objective of the study was to investigate the effect of different types of meshes as reinforcement in thin mortar specimen and select the best suitable mesh for further work. Types of meshes were used expanded metal mesh, galvanized woven mesh and welded mesh has a diameter of 1.58 mm. Size of openings are 20x35 mm, 10x10 mm and 15x15 mm. Panels of a size of 560x150x35 mm were reinforced with three layers of wire mesh. Panels were casted with mortar of mix proportion 1:2 and water cement ratio 0.40. The four specimen were tested under four point loading system on universal testing machine after curing period of 7 days and eight specimen after curing period of 28 days. Test results shows that the flexural strength of the specimen with welded mesh exhibits greater flexural strength than other two types of meshes.
2) Randhir J. Phalke, Darshan G. Gaidhankar et.all, The present study describes the results of testing flat ferrocement panels reinforced with different number of wire mesh layers. The main objective of this work is to study the effect of using different no of wire mesh layers on the flexural strength of flat ferrocement panels and to compare the effect of varying the no of wire mesh layers and use of steel fibers on the ultimate strength and ductility of ferrocement slab panels. Slab panels of size (550*200) with thickness 25 mm are reinforced with welded square mesh with varying no of layers of mesh. Panels were casted with mortar of mix proportion (1:1.75) and water cement ratio (0.38) including super plasticizer (Perma PC-202) with dosage of 1% of total weight of cement. Some panels were casted with steel fibers (0.5%) of total volume of composite and aspect ratio (l/d) =57. Panels were tested under two point loading system in UTM machine after curing period of 28 days. Test result shows that panels with more no of layers exhibits greater flexural strength and less deflection as that compared with panels having less no of layers of mesh.
3) Sandeep Sathe, Rajshekhar G Rathod et.all The present study describes the results of testing flat ferrocement panels reinforced with different number of wire mesh layer and variation in panel thickness. The main objective of these experimental tests is to study the effect of using different numbers of wire mesh layers and thickness variation on the flexural strength of flat ferrocement panels and to compare the effect of varying the number of wire mesh layers on the ductility and the ultimate strength of this type of ferrocement structure. In this study, all the specimens were divided into four groups to investigate the strength and behaviour of ferrocement flat panels subjected to two-point loading. Forty-eight ferrocement elements were constructed and tested. The used number of wire mesh layers is single, two, three and four layers; also, thicknesses of panels are 20mm, 30mm, 40mm and 50 mm.
4) Sridhar Jayaprakash , Jegatheeswaran Dhanapal , Vivek Deivasigamani et.all, Bending tests were conducted on ferrocement laminates containing chicken mesh and steel slag. The fundamental goal of the examination was to investigate the effects of partial substitution of fineaggregate by steel slag in cement mortar combining chickenmesh of different volume fractionsas reinforcement in thin ferrocement laminates.The following variables were investigated:(a) volume fraction of chicken mesh as 0.94%, 1.88%, 2.82%, and 3.77% and (b) level of steel slag substitution from 0% to 50% by weight fine aggregate. Results show that ferrocement laminates with chicken mesh of volume fractions of 3.77% and 30% substitution of fine aggregate with steel slag display better performance in terms of load deflection behaviour, first crack load, ultimate load, energyabsorption, and ductility ratio when related with other specimens. Ananalytical model has been proposed to predict the ultimate moment carrying capacity of ferrocement laminates flexure to validate the experimental results.
5) Dr.Amartya Kumar Bhattacharya, Dr.Bruce M. McEnroe, Dr.Hongying Zhao, Debasish Kumar, Sandip Shinde et.all,This research is an investigation of a spatially distributed unit hydrograph model. The ModClark model (Peters and Easton, 1997) is an adaptation of Clark's unit hydrograph technique to accommodate gridded NEXRAD precipitation data. In this study, two features were added to the ModClark model: a spatially distributed loss model and a spatially distributed velocity field. A new formula to calculate the spatially distributed velocity field was derived. Maps of spatially distributed runoff curve numbers for Kansas and Oklahoma were developed. The improved ModClark model was applied to 25 storm events on six watersheds. The calibration results are excellent. Two global parameters, the time of concentration and the storage coefficient, were calibrated for each event. Based on the calibration results, two equations to estimate the time of concentration and the storage coefficient were developed. This model and the equations for the two parameters were applied to simulate four storm events on two watersheds.
6) Tahmina Tasnim Nahar, Md. Motiur Rahman, Md. Rashedul Haque, Ashish Kumer Saha et.all, "Effect of wire mesh on the strength of R.C.C. beams repaired using ferrocement layers" Ferrocement, a thin element is used in building construction as well as a repair material. Here an experimental investigation on ferrocement performance for repairing of RCC beam is presented. Three set RCC beams of the same dimension (width 4″ , thickness 6″ and span 5.5′) are tested up to ultimate load by

one point loading system as a simply supported beam. After testing of beams BN-1.1, BN- 1.2 and BN-1.3 are repaired by 0.5 inch ferrocement layer on three sides. The Beams BN-2.1, BN-2.2, BN-2.3 are subjected to two layers of ferrocement on the bottom of thickness 1 inch and only one layer in a two sides. And another three beams of BN-3.1, BN-3.2, BN-3.3 are surrounded by total 1 inch ferrocement layer on three sides. Then they are verified again. A comparison has been made on cracking load, ultimate load and deflection between the normal beams and repaired beams. The study also represents performance of beam sets according to their different layer by graphical representation. From this paper, we can understand that the beams of bottom two layers ferrocement overlay (repairing) give comparatively good performance.

7) Pavithra Chandramouli, Dinesh Muthukrishnan , Venkatesh Sridhar , Veerappan Sathish Kumar, Gunasekaran Murali and Nikolai Ivanovich Vatin et.all, Flexural Behaviour of "Lightweight Reinforced Concrete Beams Internally Reinforced with Welded Wire Mesh" LECA possess internal curing properties as any other lightweigh taggregate due to their pore structure and higher water absorption capacity. In this work, experimental and analytical behaviour using LECA as a 100% replacement for coarse aggregate to make lightweight concrete (LWC) beams was studied. The LWC beams were compared to the conventional concrete beams in load-deflection, energy absorption capacity, and ductility index. Internal mesh reinforcement using welded wire mesh (WWM) was provided to enhance the load-carrying capacity of the LWC beam without increasing the dimensions and self-weight of the beams.. The internal reinforcement of WWM is provided to make steel rebars, and WWM works monolithically while loading; this will reduce the stress on tension bars and increase load-carrying capacity. Finally, the generated analytical findings agreed well with the experimental data, demonstrating that the analytical model could mimic the behaviour of LWC beams with WWM.
8) J.C. Walraven• and S.E.J. Spierenburg et.all, "Behaviour of Ferrocement with Chicken Wire Mesh Reinforcement" An analysis of the behaviour of ferrocemenl reinforced with chicken wire (hexagonal) mesh is presemed. The analysis concerns the behavinur in the uncracked and the cracked state, both in pure tension and bending. A series of 32 bending tests have bee11 carried out on thin slab eleme111s. The variables were the mesh aperture and wire thickness, the orientation, the number of layers, the strengrh of the concrete and the influence of spacers, aiming to create an enlarged inner lever arm. Comparisons berween theory and experiment show that the behaviour can be predicted sufficiently well.
9) K.Ranjitha, S.Sowmya , R.Manojguru et.all, Construction trade is developing quickly all over the world. Concrete and steel are the basic construction materials which are being used with different concepts for construction such as Reinforced concrete, Prestressed and Ferrocement. Ferrocement is an innovative technology and it is composed of mortar and galvanized steel wire mesh. This paper is aimed to present the research made continuously to improve the ferrocement properties and performance and its uses in the different application and to encourage practical application of ferrocement especially in developing countries. This paper covers the theoretical and experimental studies conducted by several researchers to investigate the mechanical and structural properties of ferrocement. The aim of this paper is to summarize presented literature on the use of ferrocement and to talk about new application of ferrocement.
10) Darshan. G. Gaidhankar, Dr. Ankur. A. Kulkarn et.all, "Experimental Investigation of Ferrocement Panel Under Flexure By Using Expanded Metal Mesh" Volume 5, Issue 4, April-2014 ISSN 2229-5518. The present study describes the results of testing flat ferrocement panels reinforced with different number of wire mesh layer and variation in panel thickness. The main objective of these experimental tests is to study the effect of using different numbers of wire mesh layers and thickness variation on the flexural strength of flat ferrocement panels and to compare the effect of varying the number of wire mesh layers on the ductility and the ultimate strength of this type of ferrocement structure. In this study, all the specimens were divided into four groups to investigate the strength and behavior of ferrocement flat panels subjected to two-point loading. Forty eight Ferro-cement elements were constructed and tested. The used number of wire mesh layers is single, two, three and four layers; also thicknesses of panels are 20mm, 30mm, 40mm.

III. FERROCEMENT INGREDIENTS

The ingredients of ferrocement include cement, sand, water and reinforcing mesh.

A. Cement

Ordinary Portland cement is used in making of mortar. The cement should fresh and free from lumps.

B. Aggregates

Normal-weight fine aggregate is the most common aggregate used in ferrocement. The aggregate consists of well graded fine aggregate that passes a 2.34 mm sieve; and since salt-free source is recommended, sand should preferably be selected from river-beds and be free from organic or other deleterious matter and relatively free from silt and clay. Good amount of consistency and compaction is achieved by using a well-graded, rounded, natural sand having a maximum top size about one-third of the small opening in the reinforcing mesh to ensure proper penetration (ACI Committee 549R-97). The moisture content of the aggregate should be considered in the calculation of required water.

C. Water

The mixing water should be fresh, clean, and potable.

D. Reinforcement for Ferrocement

Different types of meshes are available almost in every country in the world. Two important reinforcing parameters are commonly used in characterizing ferrocement and are defined as Volume fraction of reinforcement; it is the total volume of reinforcement per unit volume of ferrocement. Specific surface of the reinforcement, it is the total bonded area of reinforcement per unit volume of composite. The principal types of wire mesh currently being used are hexagonal wire mesh, Welded wire mesh, Woven wire mesh, expanded metal mesh and three dimensional meshes.

E. History of Ferrocement

Joseph Louis Lambot a horticulturist experimented with plant pots, seats and tubs made of meshes and plastered with sand and cement mortar replaced his rotting rowing boat. He called this material as “Fercimemt” in a patent which he took in 1852. There was very little application of true ferrocement construction between 1888 &1942 when Pier Luigi Nervi began a series of experiments on ferrocement. He observed that reinforcing concrete with layers of wire mesh produced a material possessing the mechanical characteristics of an approximately homogeneous material capable of resisting high impact. In 1945 Nervi built the 165 ton Motor Yatch “Prune”on a supporting frame of 6.35mm diameter rods spaced 106mm apart with 4 layers of wire mesh on each side of rods with total thickness of 35mm.It weighed 5% less than a comparable wooden hull &cost 40% less at that time. In 1948 Nervi used ferrocement in first public structure the Tutrin Exhibition building, the central hall of the building which spans 91.4m was built of prefabricated elements connected by reinforced concrete arches at the top &bottom of the undulations. In1974 the American Concrete Institute formed committee 549 on ferrocement.ACI Committee 549 first codified the definition of ferrocement in 1980 which was subsequently revised in 1988,1993 and 1997.

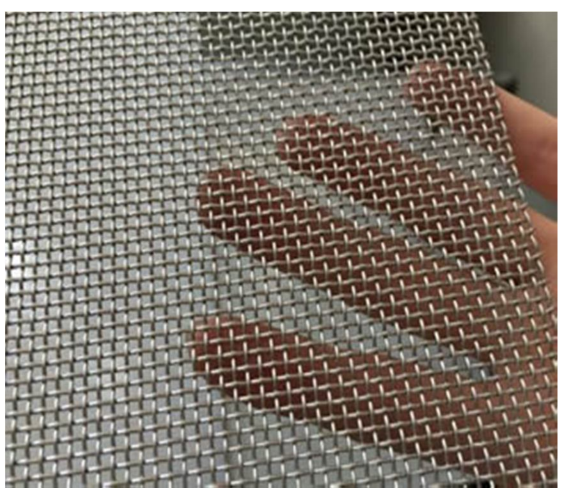

Fig: 1 Plain Weave Mesh

F. Nano Silica

The nano silica of density 2533 kg/m3 of composition with silicon- 46.83% and oxygen-53.33%. The appearance of nano silica is powder form and white in colour.

Nanocrystalline silicon (nc-Si), sometimes also known as microcrystalline silicon (μcSi), is a form of porous silicon. [1] It is an allotropic form of silicon with paracrystalline structure—is similar to amorphous silicon (a-Si), in that it has an amorphous phase. Where they differ, however, is that nc-Si has small grains of crystalline silicon within the amorphous phase. This is in contrast to polycrystalline silicon (poly-Si) which consists solely of crystalline silicon grains, separated by grain boundaries. The difference comes solely from the grain size of the crystalline grains. Most materials with grains in the micrometre range are actually finegrained polysilicon, so nano crystalline silicon is a better term. The term Nano crystalline silicon refers to a range of materials around the transition region from amorphous to microcrystalline phase in the silicon thin film. The crystalline volume fraction (as measured from Raman spectroscopy) is another criterion to describe the materials in this transition zone.

IV. CONCLUSION

1) From the journals, it is evident that the ferrocement laminates will effectively control the cracks as well as the mid span deflection.
2) Galvanized wire mesh performs better than un-galvanized wire mesh.
3) From the experiment, we observe increase in tension due to increase in contact area between wire meshes and mortar i.e., increases in specific surfaces of ferrocement composites with different compositions.
4) For achieving higher values of specific surface, number of layers of meshes needs to be increased and also the opening of meshes should be small.
5) Addition of nano silica increases the compressive strength of the cement mortar. Therefore, it does not increase the flexural property of the laminate.
6) The optimum mix ratio is 1:2 of cement and sand with w/c 0.5 and 30% addition of nano silica with closely spaced mesh.
7) In general, the flexural capacity increases with increase in layers and volume fraction of mesh.

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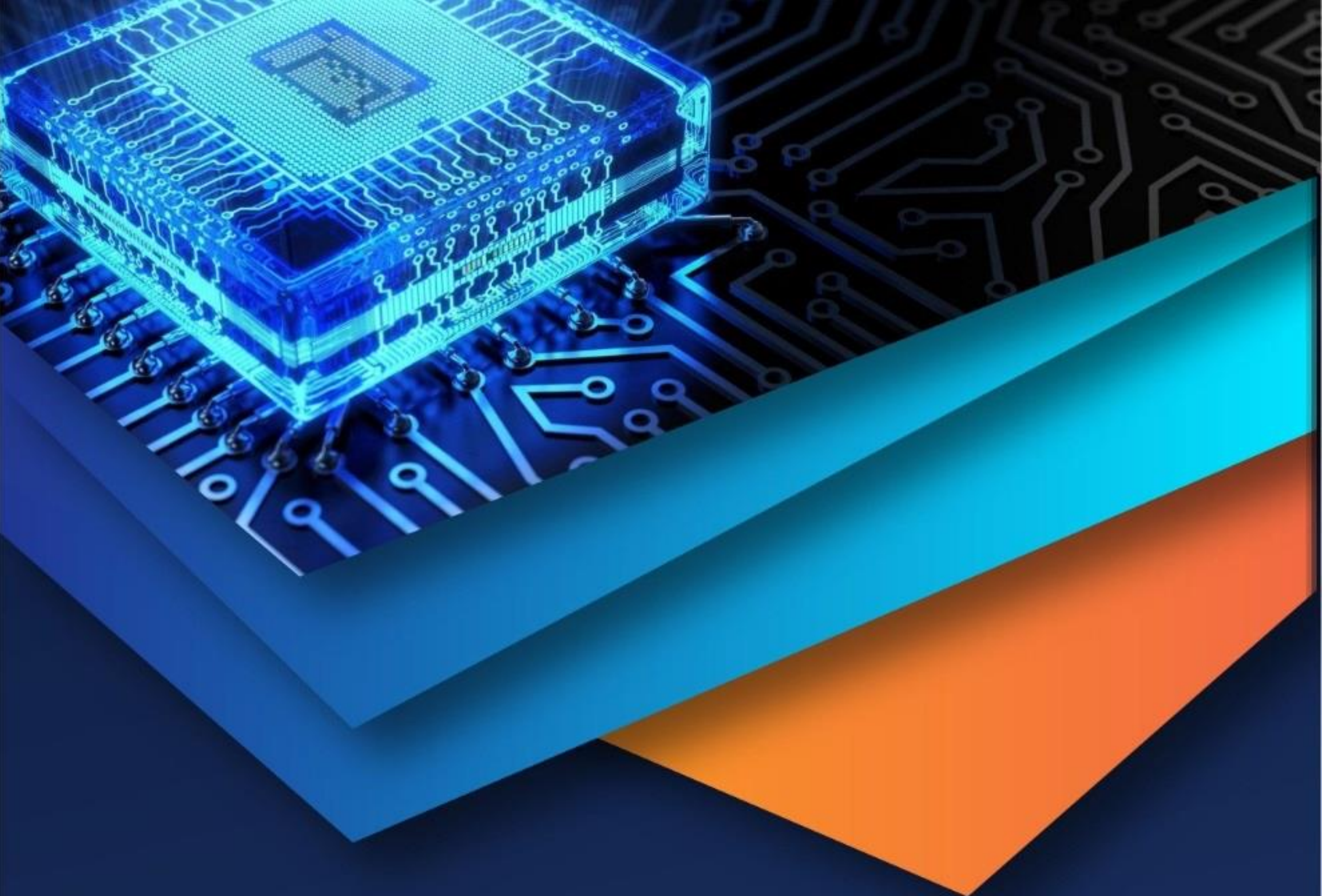

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