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A Review on Experimental Study of Ferrocement Beams in Shear, Deflection and Bending

Prasad Joshi[1], Dipali Yerudkar[2], Minaxi Rai Sharma[3]

Research Scholar, JSPM's Rajarshi Shahu College of Engineering, Pune, Maharashtra, India[1]

Associate Professor, JSPM's Rajarshi Shahu College of Engineering, Pune[2,3]

Abstract:*Rapid construction has led to the use of various new methods in the construction process other than regular concreting. Use of ferrocement technology is one of the rapidly growing methods due to its various advantages like less construction time, cost effectiveness and high strength. In this review, experimental results on various parameters like shear, flexure and bending behavior of ferro cement beams from various journals have been discussed.*

Keywords: Ferrocement, Box Beam, Shear, Flexure, Strengthening, Wire Mesh, Cement,Fine Aggregate, Coarse Aggregate, etc.

I. INTRODUCTION

Ferrocement is a thin construction element with thickness in the order of 10-25 mm (3/8–1 in.) 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 construction technology is being popularized throughout the world in countries like Canada, USA, Australia, New Zealand, United Kingdom, Mexico, Brazil, the former USSR, Eastern European countries, China, Thailand, India, Indonesia, and in other developing countries due to its uniqueness and versatility. 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; other applications include window and door frames and shutters ferrocement can be fabricated into any desired shape or structural configuration that is generally not possible with standard masonry, RCC or steel. (**Mr. A.S.Burakale 2020).**

II. EXPERIMENTAL BEHAVIOUR OF FERROCEMENT BEAM IN SHEAR

Nagesh Hanche (2016): The experimental investigation includes casting and testing of 24 rectangular beams and 8 cubes. The specimens were divided into eight series; A to H according to the volume fraction of reinforcement, compressive strength of the mortar, and amount of reinforcement was varied in Series A to H by varying the number of layers of wire mesh. Specimens in these series were symmetrically reinforced with 4, 6, 8 and 10 layers of wire mesh, respectively, and were lumped together near each face with a clear cover of 5 mm. The parameter investigated in each series was the shear-span-to –depth ratio a/h, which was achieved by varying the shear span to overall depth ratio from 1 to 2 at increments of 0.5 for the sake of simplicity since several reinforcement layers were involved.

Abeer M. Erfan, Taha A. El-Sayed (2019) [22]: This paper presents an experimental and analytical study of the shear strength of ferrocement composite box section concrete beams. The experimental program includes 7 box section concrete beamstesting using two-point loading system. Beam with expanded wire mesh showed an improvement in ultimate failure load, shear capacity and deflection with respect to beams with reference & welded wire mesh.

Md Ihtesham Hussain,VaijanathHalhalli, P.M.B Raj Kiran Nanduri [23]: This present study deals with the behavior of Ferro cement deep beams under central point load. A total of 27 rectangular deep beams have been casted of dimension 125 x 250mm and the lengths of beams have been varied along with the variation of wire mesh and mortar strength. Before testing, the top surfaces of these beams were white washed, to get a clear picture of crack pattern. Along with these beams 27 cubes have been casted with the dimensions 7.06 cm x 7.06 cm x 7.06 cm. the compressive strength of mortar is determined.

Ms. Madhuri N. Savale, Prof. P. M. Alandkar (2013) [11]: In the present study an attempt is made to observe behaviour of ferrocement plate with various mesh patterns. The results give that Increasing the volume fraction (VF) of the wire mesh layer subsequently increases the shear carrying capacity of the plate to attain this advantage, supports and loading points should be design and strengthened to prevent local failure, Shear behaviour of ferrocement plates (SBFP).The stress intensity is determined using FEM (Ansys) and compared with the available results. it is observed that stress intensity as well as cracking shear strength of plate depends upon volume fraction the available equations from literature can be used for analysis of mesh plate.

Mr. Sahan A, Mr. Sumanth, Mr. Vachan Shetty, Ms. Vaishnavi T, Mr. Suraj K S, Mrs. Smitha (2018) [24]: In the compressive strength and shear strength, thevalues were found on the 28 days which justifies thatthe value increases and then on further addition offibre it decreases among the two fibres used in this experiment for0.5%, 1% and 1.5% variation, polypropylene of 1% gives high strength in compressive strength.

Manasa B1 et.al(2018) [25]: This work deals with an experimental study on behavior of ferrocement beams. Mix proportions 1:3 i.e., cement: jelly chips with water cement ratio 0.45 were selected. The overall dimensions of beam are 150x150x2000mm and it is reinforced with compressive strength of about 16.32Mpa. Flexural and Impact test was conducted. The cracks were due to loading and failure cracks developed due to ultimate load. Flexural strength of produced specimens was 13.6N/mm2.

Mahmoud Elsayed1 et.al(2018) [26]: In this they investigated the behavior of R.C deep beam with web openings retrofitted by ferrocement laminates. It was observed that the ultimate load carrying capacity was reduced by 31% and 16% due to the existence of opening placed at the shear and flexural span respectively. The results indicated that the ultimate failure load,ductility and uncracked stiffness of strengthened specimen with openings in the shear zone were increased by about 85%.

S.F.Ahmad (1995) [6]: The shear behavior of ferrocement channel beams have been studied by conducting tests under transverse loads for 15 beam specimens. Influence of variation of the dominant parameters were studied through systematic tests. Test results indicate that cracking and ultimate shear strength increases with the increase in the volume of wire mesh and mortar strength, and decreases with the increase in shear span to depth ratio.

Mansur M.A (1991) [4]: An experimental investigation was carried out on a total of 28 simply supported ferrocement I-beams loaded in flexure under two symmetrical point loads. The major parameters considered in the study were the shear span-to-depth ratio, compressive strength of the mortar, and amount of longitudinal and transverse reinforcement. The results of these are presented and discussed. Test results indicate that the beams fail in shear only when the span-depth ratio is less than or equal to 1.5. Beyond this value, failure occurs in flexure. Analyses are presented to predict the cracking and ultimate strengths of such beams in shear as well as flexure. A comparison of theoretical predictions with experimental results shows good agreement.

Shichuan Tian (2013) [13]: This thesis presents the results of an experimental, numerical and analytical study to develop a design method to calculate shear resistance of flanged ferrocement beams with vertical mesh reinforcements in the web. Two groups of full-scale testing were conducted comprising of three I beam and four U beams. The I beam had the same geometry and reinforcement arrangements, but differed in the matrix strength or shear span to depth ratio. The U beams differed in web and flange thickness, reinforcement arrangements, matrix strength and shear span to depth ratio. The experimental data were used for validation of finite element models which had been developed using the ABAQUS software. The validated models were subsequently employed to conduct a comprehensive parametric study to investigate the effects of a number of design parameters, including the effect of matrix strength, shear span to depth ratio, cross sectional area, length of clear span, volume fraction of meshes and amount of rebar.

The main conclusion from the experiments and parametric studies were: shear failure may occur only when the shear span to depth ratio is smaller than 1.5; the shear strength may increase by increasing the matrix strength, volume fraction of meshes, cross sectional area and amount of rebar. The main type of shear failure for I beams was diagonal splitting while for U beams it was shear flexural. Based on the results from the experimental and numerical studies, a shear design guide for ferrocement beams was developed. A set of empirical equations for the two different failure types and an improved strut-and-tie were proposed. By comparison with the procedures currently in practice, it is demonstrated that the methodology proposed in this thesis is likely to give much better predictions for shear capacity of flanged ferrocement beams.

III. EXPERIMENTAL BEHAVIOUR OF FERROCEMENT BEAM IN FLEXURE

Abhishek G B, Dr. R M Mahalingegowda (2020) [27]: The fundamental point of this task is to explore or consider the quality attributes of Ferro-concrete with and without utilizing coir fiber. By differing the level of fiber included (1%, 2% and 3% of concrete). Likewise contrast the quality of Ferro-concrete and single and twofold layer of square wire work.The mechanical test was performed to check the impact of fibers on improving compressive, flexural and split tensile in Ferro-cement. Since fiber go about as optional fortification, it will keep Ferrocement from small scale splitting and engendering break development and builds the quality. After the expansion of coir strands into ferrocement expands the flexural and spilt elasticity consequently it very well may be utilized more as flexural part in development.

Aziz Ibrahim Abdulla, Zainah Ibrahim, Ubagaram Johnson Alengaram(2014) [18]: The flexural performance of beam specimens with wire mesh layers was compared to beam specimens with carbon fibre and a hybrid of wire mesh–epoxy–carbon fibre composite. The test findings demonstrate that using wire mesh with epoxy to improve the flexural performance of concrete beam specimens is a viable option. Increased wire mesh layers improve flexural strength, cracking behavior, and energy absorption capabilities greatly. In terms of flexural strength and ductility, the wire mesh–epoxy composite outperforms carbon fiber.

TahminaTasnim Nahar, Md. Motiur Rahman, Md. Rashedul Haque, Ashish KumerSaha (2014) [17]: In this paper, Wire mesh has an effect on the strength of R.C.C. beams that have been repaired with ferrocement layers.The findings of the tests carried out in this study show that there is a considerable change in ultimate load, cracking load, and deflection. The load-bearing capacity of the beam is reduced as a result of the failure; to ad ess these issues, a ferrocement coating can be applied, resulting in an increase in load carrying capacity and a decrease in deflection.

Yousry B.I. Shaheen, Noha M. Soliman, Ashwaq M. Hafiz (2013) [15]: The structural behavior of ferrocement concrete composite channels reinforced with various types of reinforcing materials was investigated in this articlefind that when compared to all of the evaluated beams, the use of welded steel mesh produced the best results. And The use ofpolypropylene fibres in mortar increases the first crack load, serviceability load, ultimate load, and energy absorption, as well as providing increased stiffness.

H.R. Ronagh, A. Eslami (2013) [12]: In these studies, flexural retrofitting of RC buildings using GFRP/ CFRP is done. Composite sheets are meant to be put at the two end regions of all beams and columns in a feasible flange-bonded system for this purpose. The seismic response of the original structure was compared to the GFRP/CFRP retrofitted structures using a nonlinear pushover analysis with lumped plasticity technique. The nonlinear findings show that both composite materials have a considerable increase in lateral load bearing capability, with the CFRP improvement being twice that of the GFRP. The latter, on the other hand, has a higher ductility.

Gangadharappa B M, Prakash K E, Suresh G S and Shesha Prakash M N (2013) [14]: Under monotonic tensile stresses, the impact of % replacement of sand by Blast Furnace Slag (BFS) and reinforcing with meshes is investigated in this article. It has been discovered that replacing BFS boosts ultimate strength up to a point and then declines as replacement rises.

Naveen G.M, Suresh G.S (2012) [10]: In this paper Under monotonic and repetitive flexural loads, experimental research on a low-weight ferrocement beam was conducted. And found that under both monotonic and repetitive stress, lightweight ferrocement beams exhibit a good moment of resistance.

Bong, J.H.L, Ahmed, E., (2010) [9]: The structural short-term behavior of a beam reinforced with ferrocement laminate is described in this research, along with its benefits. A ferrocement laminate-strengthened beam is compared to a control beam to determine the benefits of utilizing ferrocement. In compared to a conventional beam, a beam reinforced with ferrocement has a larger cracking load, ultimate load, and lower deflection, according to the experiment.

M.M. Kamal, Y.B. Shaheen, M.A. Saafan and A.A. Nasser, (2005) [8]: The purpose of this article is to show the various production and installation configurations for various ferrocement units used in home building. Many architectural forms may be achieved by using ferrocement in skeleton parts. Panelized ferrocement homes are a revolutionary prefabricated building method.

Hani H. Nassif, HusamNajm (2004) [7]: The findings of an experimental and analytical investigation on composite beams built of reinforced concrete placed over a thin slice of ferrocement are presented in this work (cement paste and wire mesh). A two-point loading technique is used to evaluate several types of beam specimens with varied mesh types (hexagonal and square). To predict the overall non-linear behavior, the results from experimental data are contrasted to those from nonlinear analysis and finite element research. The suggested composite beam has high ductility, cracking strength, and ultimate capacity, according to the results.

M. A. Mansur, P. Paramasivam (1985) [3]: This paper presents the findings of an experimental study on three ferrocement sections subjected to combined bending and axial stresses. Each piece was the same size, but the volume % of reinforcement was variable. A technique for forecasting the ultimate load capacity and, as a result, the interaction behavior of a ferrocement section is described based on standard reinforced concrete analysis. The experimental findings and theoretical predictions are in good accord.

Balaguru, P.N., A.E. Naaman and S.P. Shah (1977) [2]: This paper's study was carried out to predict deflection and fracture widths in ferrocement constructions that were exposed to flexure, Cracks preferentially form in the transverse wires of the mesh's outermost layer, The specific surface of reinforcement did not appear to have as much of an impact on cracking behavior in flexure as it did in tension. This might be due to the particular surface of the tensile zone of mortar in flexure.

N. Jayaramappa (2016) [21]: In this paper experimental studies are carried out to understand the flexural behaviour of Reinforced concrete beams of grade M20 with HYSD reinforcement and Ferrocement hollow beams of cement to sand ratio of 1:3and water cement ratio of 0.4. A total of four beams were cast in which two are straight beams and another two are arched beams. In that two straight beam, one is reinforced concrete beam with minimum reinforcement and another one is Ferrocement hollow beam and in two arch beams, one is reinforced concrete beam and other is Ferrocement hollow beam. All beams are rectangular in cross-section of size 200 x 200 mm and the span length is 2500 mm. The arch beam is provided with a rise at centre of 0.8 m.

The Ferrocement beam is made of mortar with hollow cross section using hexagonal wire mesh with thickness of 40 mm and all the specimens are cured for 28 days. Flexural tests are carried out on conventional RC beam and Ferrocement hollow beams for simply supported condition. The test results are presented in terms of load deflection behaviour, ultimate load, cracking load and crack pattern with respect to reinforced concrete beam and Ferrocement hollow beam.

IV. CONCLUSION

Following conclusions have been drawn from the experimental study on various ferrocement beam sections:

1. Beam with expanded wire mesh showed an improvement in ultimate failure load, shear capacity and deflection with respect to beams with reference & welded wire mesh.
2. Shear failure may occur only when the shear span to depth ratio is smaller than 1.5; the shear strength may increase by increasing the matrix strength, volume fraction of meshes, cross sectional area and amount of rebar.
3. Cracking and ultimate shear strength increases with the increase in the volume of wire mesh and mortar strength, and decreases with the increase in shear span to depth ratio.
4. Increased wire mesh layers improve flexural strength, cracking behavior, and energy absorption capabilities greatly. In terms of flexural strength and ductility, the wire mesh–epoxy composite outperforms carbon fiber.
5. In compared to a conventional beam, a beam reinforced with ferrocement has a larger cracking load, ultimate load, and lower deflection, according to the experiment.
6. The use of polypropylene fibres in mortar increases the first crack load, serviceability load, ultimate load, and energy absorption, as well as providing increased stiffness.

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