International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 9 Issue 5 ǁ 2021 ǁ PP. 49-53

Review on Properties and Various Elements of Ferrocement

R Sivasankari[1] and E Mohammed Najeeb[2]
[1]*Post graduate student, Government College of Engineering, Thirunelveli.*
[2]*Assistant Professor, Government College of Engineering, Thirunelveli.*
Corresponding Author: R Sivasankari

ABSTRACT
Ferrocement has various advantages in the field of construction like cost effective, construction without formwork, earthquake resistant properties etc. This paper is to review about experimental work and numerical analysis done so far to enhance the properties of the ferrocement element, how retrofitting work done in structural elements like slab, beam, column, beam column joints, domes and shells using ferrocement and the increase in capacity of these elements are tested. Many researches have been done which proposes the use of ferrocement in various structural elements and throw light on how ferrocement enhance its properties and its advantages over RCC. This review paper aim in presenting the advantages of ferrocement material through various literature journals.

KEYWORDS: *Review on ferrocement properties and elements, researches on ferrocement.*

Date of Submission: 27-04-2021 Date of acceptance: 11-05-2021

I. INTRODUCTION

Ferrocement is the composite of Ferro (Iron) and cement (cement mortar). Ferrocement can be considered as a type of thinwalled reinforced concrete construction in which small-diameter wire meshes are used uniformly throughout the cross section instead of discretely placed reinforcing bars and in which Portland cement mortar is used instead of concrete. In ferrocement, wire-meshes are filled in with cement mortar. It is a composite, formed with closely knit wire 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. 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.

The current paper aim in reviewing the properties of ferrocement and its enhanced application in various structure like slabs, wall panels, columns, beams, beam column joints and domes etc through various journal paper.

II. LITERATURE REVIEW

STUDY ON PROPERTIES

Sneha et al [1] concluded that provision of a corrosion prevention strategy can adversely affect the load carrying capacity of the ferrocement. The better corrosion resistant behaviour was exhibited by CPC coated weld mesh in cement mortar with corrosion inhibitor (CPC CI) specimens, followed by normal weld mesh in cement mortar with corrosion inhibitor (WM CI) and CPC coated weld mesh in normal cement mortar (CPC) specimens. Incorporating Corrosion Inhibitor as well as providing anti corrosive coatings can increase the useful life of ferrocement. Combining both methods can decrease the corrosion more predominantly. By considering both strength and durability aspect, use of corrosion inhibitor is proved to be the better option as there is only little reduction in load carrying capacity while providing better corrosion resistance.

Danial et al [3] found that the addition of nano-TiO_2 (NT) may lead to improve the microstructural and durability properties of cementitious composites in ferrocement. Finally, it can be concluded that the NT was found to be effective in improving the compressive strength and corrosion resistance properties of ferrocement composites exposed under tap water, saline water and sulphuric acidic solution environment. The strength of the NT admixed mortar specimens was found to be significantly higher than that of ethanolamine (EA) admixed specimens. Optimum content of EA was 3%. The optimal effectiveness was found at 5% content of NT. Besides, the corrosion inhibition efficiency of NT was found to be quite comparable to the EA.

Jalawi et al [4] produced a new type of ferrocement plate characterized by its lower density, enhanced thermal insulation and high-performance using local raw materials and studied their physical properties. It was found that the optimum mix is by using cement with the fine aggregate Recycle Thermestone ratio of 1:1 and the ratio of water to cement is 0.4. Compressive strength of the optimum mixture 25 MPa. The compressive strength for the mixture with chemical admixture and feldspar to reference mix was increased by 38.8 and 40% at 28 and 90 days respectively.

Sahooa et al [5] concluded that the rate of increase of compressive and flexural strength is higher for cement mortar replaced with PVC fibers waste in ferrocement than the normal mortar cement casting. The strength is increased with increase in curing period for entire casting of PVC waste ferrocement. 0.2% and 0.4% of replacement gives the advantage for long term rate of strength gain. At all curing period, flexural strength of ferrocement with PVC waste up to 15 to 20% higher than normal ferrocement. Fibres with good bond characteristics and high specific surface are very effective in controlling both deflection and cracking width.

Dayer et al [6] developed a light weight composite plates which has superior deformations, high ductility and energy absorptions properties which are very useful for dynamic applications. This plate have the advantages of heat isolation and sound isolation. The developed light weight composite plates are economic and saving in cost reached 40% compared to conventional concrete plates. Using expanded steel mesh with mild steel bars in reinforcing ferrocement plates results in markedly higher energy absorption than that obtained, when using mild steel bars only. Welded meshes have a higher modulus and hence higher stiffness which leads to smaller crack widths in initial portion of the load – deformation curve. This leads to a higher stiffness of the tested specimen.

Sharma [14] concluded that, at varied water cement ratio the compressive strength of Vinyl acetate-ethylene (VAE) polymer modified mortars decreases but the compressive strength of Styrene butadiene (SBR) polymer modified mortars increases both after 7 and 28 days. The flexure strength of both VAE and SBR modified mortars increases but after 15 % the flexure strength of VAE modified mortars starts decreasing. Modulus of elasticity of SBR modified mortars increases with increasing in polymer content up to 10 % and then starts decreasing but modulus of elasticity of VAE modified mortars decreases with increase in polymer content in mortar. The tensile strength of both VAE and SBR modified ferrocement samples increases with increase in polymer content. Finally, it is found that SBR modified ferrocement beams take more load than VAE for both flexure and tensile strength.

Batra et al [18] studied different properties of the Ferrocement like tensile behaviour, cracking, compression, fire resistance and impact Resistance. Based on Tests performed, various applications and its benefits over normal cement is found. He concluded that Ferro-cement should not been seen as competitor to RCC or complement to it. Study on use of reinforced plastic meshes and high performance cementitious matrices are carried out with the help of which improved structural performance at low cost can be obtained in future.

Patil et al [19] concluded that the compressive strength of bitumen ferrocement increases with increase in total volume fraction of reinforcement and specific surface of reinforcement for vertical orientation of square mesh. Vertical orientation and diagonal orientation of bitumen ferrocement offers more compressive strength than same orientation of ferrocement. The application of bitumen ferrocement is swimming pool. Due to use of bitumen ferrocement material becomes watertight. Also, it can be used for construction of road pavement, construction of small arch, bandharas and retaining walls.

Bhikshma et al [23] concluded that the coefficient of permeability of modified ferrocement decreases with the increase in polymer cement ratio upto 12.5% and flyash replacement levels upto 30%. The time taken for initiation of crack for ordinary ferrocement specimens is less compared to that of polymer and flyash specimens. The time taken for initiation of crack in flyash modified ferrocement is more in case the replacement of cement by flyash by 0% to 30%, when compared to the addition of polymer by 0% to 12.5% in polymer modified ferrocement. As the percentages of polymer (0% to 12.5%) and flyash (0% to 30%) increased, the resistance to current of ferrocement elements increased.

STUDY ON BEAM

Hussein et al [2] concluded that Composite timber-ferrocement beams (FTC) exhibited high increase of section capacity as compared with timber beams. The composite sections overall stiffness and strength increase with a high ratio. FTC exhibited high increase of section capacity as compared with timber beams. The addition of steel wire mesh to the ferrocement slab can delay the initiation of crack and led to a significantly increasing of ultimate carrying capacity, ductility and energy absorption of specimens.

Erfan et al [13] concluded that the use of welded and expanded wire meshes show multiple features over steel reinforcement, especially for structures with complex shapes and curvatures, because they are lighter, easier to handle, easier to cut, and easier to bend than steel reinforcement. Ferrocement concrete specimens reinforced by expanded or welded steel wire mesh exhibit superior ultimate loads compared to the control ones under flexural loadings. Welded wire mesh contributed to increase load carrying capacity, deflection shear stresses, stiffness & toughness higher than expanded wire mesh. Finally, it is concluded that the use of wire mesh in place of shear reinforcement in beams tends to improve the shear resistance properties of the beam.

Gaidhankar et al [15] concluded that the load carrying capacity and flexural strength of ferrocement channel section reinforced with welded square mesh is found to be more than that of ferrocement channel section reinforced with woven square mesh through analysis using ANSYS. Flexural strength and load carrying capacity increases when the number of mesh layers increases. The proposed finite element model can be used efficiently in characterizing the behaviour of ferrocement channel section under the flexural behaviour.

Surya Kumar et al [27] found out the experimental deflection values of 28 ferrocement beams and compared with deflection values obtained using ACI and CEB Code formulae for prediction of short term deflections of reinforced concrete members in the working load range. The agreement between the experimental and code values is observed to be quite satisfactory. Thus, ACI and CEB formulae seem to be quite suitable for prediction of effective flexural rigidity of ferrocement in cracked stage.

STUDY ON WALL AND ROOF PANEL

Herrera et al [7] presents the results drawn from cycling loading tests carried out on ferrocement walls, in order to determine their strength, hysteretic behaviour, ductility, energy dissipation capacity, equivalent viscous damping, and damage limit states. To assess their seismic performances for the DBE and the MCE earthquake hazard levels, a nonlinear dynamic analysis methodology based on the Performance-Based Seismic Design philosophy. The walls have a 100% probability of incurring no damage limit state for the DBE and the MCE earthquake hazard levels.

Grija et al [20] concluded that the ferrocement wall panel with cross rib shows maximum value in terms of load, deflection, strain distribution and ultimate load when compared to walls without cross rib. Ferro cement wall panels were analysed using finite element method using ABAQUS to check the compressive stress under cracking load. The experimental ultimate loads were found to be 6.3% and 9.1% higher than those estimated analytically. The weight of Ferro cement wall panel was 66.66%, 54.9%, 49.12%, 37.33% and 31.11% lower than the light weight brick masonry, fly ash brick masonry, concrete brick masonry, hollow block masonry and solid block masonry. From cost analysis it has been proved that the cost of thin ferrocement wall panel was 78. 21% lower than the cost of brick masonry wall.

Naseer et al [24] concluded that the shear strength of the ferrocement retrofitted masonry was significantly increased due to which the damage mechanism transformed from mixed compression-flexural-shear mode to a more stable flexural rocking mode. The lateral stiffness and the lateral load capacity were significantly increased by 129% and 107% respectively after retrofitting. The deformation capacity of the test structure was found to be decreased after retrofitting by 26%.

Saleem et al [26] 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. Catastrophic failure will be avoided in any case thus minimizing the loss of life and property.

STUDY ON SLAB

Jaafer et al [8] investigated the applicability and performance of a new strengthening method for concrete slabs, intended to increase their punching resistance using combination layers of steel wire mesh with epoxy attached to the concrete slab's tension face. The 45 skewed configuration strengthening composite was the most efficient among the strengthened slabs investigated in this study. The maximum percentage of reserve shear attained by this configuration increased to 44% compared with the reference slab.

El-Shami et al [25] presented the experimental models of ferrocement slabs with and without steel sheeting and their numerical models using ANSYS. The analytical results compared well with the experimental for the ferrocement slabs without steel sheeting. For those specimens with steel sheeting, the comparison was good until the failure of the bond between the slabs and the steel sheeting. Further experimentation is required to better understand the role ferrocement slabs might play.

STUDY ON COLUMN

Anandan et al [10] performed experimental study on the increase in the load carrying capacity of conventional ferrocement wrapped columns and silica fumes and flyash modified ferrocement columns. The specimens were subjected to axial compressive load till Failure. The results indicated that the increase in load carrying capacity of Column wrapped with conventional ferrocement is about 79.60% over control specimen that of column wrapped with modified ferrocement is about 89.80% over control specimen. Hence it is concluded that modified ferrocement jackets can be effectively used for strengthening of columns.

STUDY ON DOME AND SHELL

Kadam et al [9] compared an inverted umbrella roof shell with quadrilateral rectangular plate by using two different material like reinforcement and Ferrocement by using ANSYS software. It is concluded that both in static and regression analysis ferrocement shell and plate produce less deformation compared to RCC. The shell structure seems to perform better than the plate. It is concluded that ferrocement material is better than the RCC.

Sekar et al [12] concluded that in dome structure, ferrocement has made it possible to construct a light but strong, durable weather resistant shell with a weight reduction to almost 1/10th of the convectional material. Structures are highly waterproof and higher strength to weight ratio than R.C.C. This method has provided a solution where by air supported forms may be used for such large concrete domes. The overall cost of dome project using air supported forms is very efficient.

Rasheed et al [17] performed research on estimating of the structure performance of reactive powder concrete (RPC) hemispherical ferrocement domes and the effects of the changing of its thickness and steel fiber ratio on structural behaviour. The increase in ultimate load for RPC is about 100%, for an increase in thickness from 15 mm to 20 mm. The increase in ultimate load for RPC is about 309%, for an increase in concrete strength from (40 to 195) MPa for dome. The first crack load and ultimate load increases for ferrocement dome reinforced with 2 layer of welded wire mesh by about 50% and 57% respectively compared to dome with one layer of wire mesh. The most important conclusion of this work is the efficiency of using reactive powder concrete in construction of ferrocement hemispherical domes by plastering.

Shaheen et al [21] conducted research in estimating the structure performance of ferrocement domes reinforced with welded wire mesh, glass fiber mesh and polyethylene mesh. It is concluded that dome with welded wire mesh exhibits highest ductility ratio and energy absorption and with polyethylene exhibit lowest ductility ratio and energy absorption. The ferrocement dome reinforced with two layers of fiberglass mesh gave the highest failure load and service load. The width of cracks increased by replacing the welded wire meshes by fiberglass meshes and polyethylene meshes.

Rifaie et al [22] proposed an experimental study for the effect of both skeletal reinforcement and thickness on the strength capacity and behaviour of thin ferrocement dome structures under uniformly distributed load. A decrease in skeletal steel reinforcement tends to decrease the initial cracking and ultimate loads and is more significant in cracked stage than in the un-cracked stage. As skeletal steel content is reduced, the failure became more severe and sudden. An increase in the dome thickness plays the dominant role in increasing the initial cracking and ultimate loads. During testing as cracks appear in the sides and crown of the domes due to an increase of the load beyond the first cracking loads, the remaining parts of the dome were cracked continuously.

STUDY ON BEAM COLUMN JOINT

Shaabanaet al [16] studied the experimental behaviour of full-scale beam-column space (three-dimensional) joints retrofitted by ferrocement layers under displacement-controlled cyclic loading. The studied variables were the number of layers, orientation angle of expanded wire mesh per layer, and presence of steel angles in the corners of joint specimen prior to wrapping with ferrocement layers. The joints retrofitted by ferrocement layers showed higher ultimate capacity, higher ultimate displacement, resisted larger number of cycles prior to failure. It is recommended to retrofit exterior joint specimens by at least two ferrocement layers in addition to steel angles inserted in the corner of the joint specimens. It is worth mentioning that orientation angle for expanded wire mesh should be taken into consideration.

Shaabanaet al [11] after the experimental work for the behaviour of strengthening beam column joints in building frames using ferrocement, they decided to further study such joints using finite element modelling using ANSYS by including more variables. The application of non-linear finite elements model presented in this study yielded satisfactory prediction of load-carrying capacity and load-deflection response for experimentally tested specimens strengthened by ferrocement layers.

III. CONCLUSION

1. The review has explained about how various additives like nano-Tio_2, PVC, polymers, fly-ash, reactive powder, glass fibers, etc enhance the mechanical, corrosion, durability, permeability and strength of ferrocement.
2. The slabs made or retrofitted by ferrocement seems to have good thermal properties, punching shear capacity and earthquake resistant.
3. Strengthening of beams, columns and beam column joints using ferrocement seems to provide good strength in experimental and numerical studies.

4. The use of ferrocement in dome structure has made it very easy to construct the dome without formwork and has properties like earthquake resistance, cost effectiveness. Ferrocement dome has become the ideal structure to build lowcost dwellings.

REFERENCES

[1]. Sneha S S , KarthikaSoman, C Prajith , Aiswaria K Davis and B S Dhanya (2020), 'Study of the mechanical and corrosion resistance properties of ferrocement', IOP Conf. Series: Earth and Environmental Science ,doi:10.1088/17551315/491/1/012033.

[2]. Abdulkhaliq A. Jaafer and Karrar K. Abdul Hussein (2020), 'Experimental investigations of the structural behaviour of simply support ferrocement-timber composite beams', IOP Conference Series: Materials Science and Engineering, 888 (2020) 012014, doi:10.1088/1757-899X/888/1/012014.

[3]. Danial.M.D ,SabihAkhtari , AmerAzam and ShahidUl Islam (2020), 'Effect of ethanolamine and nano-TiO2 on the properties of ferrocement composites under different exposure environments', Sadhana (2020)45:86 ,Indian Academy of Sciences https://doi.org/10.1007/s12046-020-01324-2.

[4]. Nada Mahdi Fawzi A. Jalawi (2020), 'Quality Control of Production Lightweight Ferrocement Plate Using Sustainable Materials', Key Engineering Materials,ISSN: 1662-9795, Vol. 857, pp 10-14.

[5]. Sahooa. D, S.K. Nayakb& S. Panda (2020), 'An Experimental Investigation on Ferrocement: Comparative Study', Journal of Shanghai Jiaotong University, Volume 16, Issue7, July - 2020, Page No:780.

[6]. Yousry B. Shaheen, Fatma M. Eid and Manar A. Sayer Dayer (2020), 'Developing of light weight ferrocement composite plate', AICSGE-10, Page no: 862.

[7]. Juan P. Herrera, Daniel Bedoya-Ruiz, Jorge E. Hurtado (2020), 'Performance-based seismic assessment of precast ferrocement walls for one and two-storey housing', Engineering Structures 214, 110589.

[8]. Abdulkhaliq A. Jaafer , Raid AL-Shadidi and Saba L. Kareem(2019),'Enhancing the Punching Load Capacity of Reinforced Concrete Slabs Using an External Epoxy-Steel Wire Mesh Composite', Fibers 2019, 7, 68; doi:10.3390/fib7080068 by the authors, Licensee MDPI, Basel, Switzerland.

[9]. Kadam. S.S, G. R. Gandhe2, D. H. Tupe (2019), 'Advanced Modelling and Analysis of Plate and Inverted Umbrella Roof Shell Using Ansys', International Journal of Science and Research, Volume 8 Issue 2, February 2019, ISSN: 2319-7064.

[10]. V Anandan, S Senthamilkumar, V Sundararajulu, S Gunaselvi and M Jeganathan (2019), 'Comparative Study on the Behavior of Conventional Ferrocement and Modified Ferrocement Wrapped Columns', International Journal of Advanced Research in Engineering and Technology, 10 (6), 2019, pp 22-29.

[11]. Ibrahim G. Shaaban and Mohamed Said (2018), 'Finite Element Modeling of Exterior Beam-Column Joints Strengthened by Ferrocement under Cyclic Loading', Case Studies in Construction Materials,https://doi.org/10.1016/j.cscm.2018.02.010.

[12]. Sekar.S, R. Tamilarasi, C. Vino, R. Jhansi (2018), 'Experimental study on ferrocement dome by using chain mesh',Technical Research Organisation India, ISSN (Print): 2393-8374, (Online): 2394-0697, Volume-5, Issue-4, 2018.

[13]. Taha A. El-Sayed and Abeer M. Erfan (2018), 'Improving shear strength of beams using ferrocement composite', Construction and Building Materials 172, 608–617.

[14]. Er. Kartik Sharma (2018), 'Mechanical properties of polymer modified ferrocement', International Research Journal of Engineering and Technology, vol 5 issue 9.

[15]. Gaidhankar. D.G, M. S. Kulkarni, Abhay R. Jaiswal (2017), 'Ferrocement composite beam under flexure', International Research Journal of Engineering and Technology, Volume: 04 Issue: 10, Page 117.

[16]. Ibrahim G. Shaaban and Osama A. Seoud (2017), 'Experimental behavior of full-scale exterior beam-column space joints retrofitted by ferrocement layers under cyclic loading', Case Studies in Construction Materials, November2017, DOI:10.1016/j.cscm.2017.11.002.

[17]. Nadiyah KherallahAbd, Dr. Mohammed M. Rasheed, Dr.Layth A. Al-Jaberi (2017), 'Experimental behaviour of RPC hemispherical domes under concentrated load and sitting on 4 support', Journal of Engineering and Sustainable Development, Vol. 21, No.04, July 2017 ISSN 2520-0917.

[18]. Ankit Batra, SumitGhangas, Lalit Kumar and HardikSaxena (2017), 'A Review study of Application of Ferro-Cement', International Research Journal of Engineering and Technology, vol 4, issue 6.

[19]. MitaliPatil, Khandekar S.D, Patil J.R (2015), 'Experimental Study of Compressive Strength of Bitumen Ferrocement', International Journal of Science and Research, Volume 4 Issue 6, June 2015, ISSN (Online): 2319-7064.

[20]. Grija .S , P. Sivakumar , K. N. Lakshmikandhan , R. Ravichandran , B.Karthikeyan (2014) , 'Novel Ferrocement Light Weight Wall Panels', International Journal of Applied Engineering Research, ISSN 0973-4562 Volume 9, Number 18 (2014) pp. 4645-4657.

[21]. Yousry B.I. Shaheen, Boshra A. Eltaly , Amany A. Hanesh (2014), ' Experimental and FE simulations of Ferrocement Domes Reinforced with Composite Materials', Concrete Research Letters, Vol. 5(4) 2014.

[22]. Wail N Al-Rifaie, Azad Ahmed (2013), 'Experimental Investigation on Thin Ferro cement Dome Structures',International Journal of Engineering and Advanced Technology, ISSN: 2249 – 8958, Volume-3, Issue-2, December 2013.

[23]. Bhikshma. V, Ravandekishore and R.Srinivas (2011), ' Durability of Polymer and Fly Ash Modified Ferro Cement Elements', The Twelfth East Asia-Pacific Conference on Structural Engineering and Construction, © 2011 Published by Elsevier Ltd doi:10.1016/j.proeng.2011.07.332 , Page no : 2643.

[24]. Mohammad Ashraf, Akhtar Naeem Khan, QaisarAli, Khan Shahzada and AmjadNaseer (2011), 'Experimental Behavior of Full Scale URM Building Retrofitted with Ferrocement Overlay', Advanced Materials Research Vols. 255-260 (2011) pp 319-323.

[25]. Boshra Aboul-Anen, Ahmed El-Shafey, and Mostafa El-Shami (2009), 'Experimental and Analytical Model of Ferrocement Slabs', International Journal of Recent Trends in Engineering, Vol. 1, No. 6, May 2009

[26]. M. A. Saleem and M. Ashraf (2008), 'Low Cost Earthquake Resistant Ferrocement Small House', pak. J. Engg. & Appl. Sci. Vol. 2 Jan 2008.

[27]. Surya Kumar. G.V, V.K. Gupta and P.C. Sharma (1979), 'Flexural Rigidity of Ferrocement', Journal of Ferrocement: Vol. 9, No. 4, October 1979.

[28]. ACI Committee 549, 'Guide for the Design, Construction and Repair of Ferrocement', 1988, American Concrete Institute.

[29]. ACI Committee 318, 'Building Code Requirements for Structural Concrete', American Concrete Institute.

[30]. Ferrocement technology', WRD Handbook Chapter No. 1, Maharashtra Engineering Research Institute, Nashik First Edition 2018, Government of Maharashtra, Water resource department.

[31]. UNHCR- United Nations High Commissioner for refugees, Large ferrocement Water tank Manual July 2006.