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Characteristics and application of ferrocement A Review

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Ferrocement was invented by Joseph Louis Lambot in 1948 and firstly used by pier Luigi Nervi for construction in the 19th century by considering ferrocement as homogeneous and efficient material for his complex architectural shapes [1,2,3].
Ferrocement is a highly versatile material possessing a degree of roughness, ductility, durability, strength, crack resistance that is greater than that found in other forms of concrete construction [4,5,30].
One of the disadvantages of ferroconcrete construction is the skill labor cost of it, which makes it expensive for industrial application in the western world but suitable for Romania [6].
As we all know very well that fire is one of the serious potential risks to structures [7]. Hence the use of fire protection materials like cementitious and composite material is increased. As ferrocement is cementitious material of mortar and reinforcement , it is used as fire protective material also [8]. Since mortar is a good insulator and the reinforcing wire mesh can reduce surface spalling better than plain concrete, the application of ferrocement jacketing for other structural components like reinforced concrete, prestressed concrete, or steel can protect these structural members from fire. Further to this ferrocement provides more additional confinement [9-12].When a column retrofitted with ferrocement jacket and tested it was found that shear strength and ductility capacity enhanced significantly. It was also observed that expanded mesh were more effective than ties in shear strengthening of concrete columns. Reduction in shear cracking was also observed due to use of ferrocement jackets [13].
When wire mesh was used for jacketing of lightweight web sandwich panels (LWSP), increase in ductility of the panels was observed [14]. One of the applications of ferrocement jacket as an alternative repair/strengthening technique for increasing the axial load carrying capacity and ductility of tied reinforced concrete columns. It was observed that with two layers of WWM ferrocement jackets showed about 33% and 26% increase in axial load carrying capacity and stiffness respectively [15].
Orientation of wire mesh plays an important role in retrofitting. When beams are retrofitted with wire mesh oriented at zero degree they were the most efficient as their cost to strength ratio is lowest [16].
Similarly orientation of wire mesh with 45 degree showed very poor result because of the lowest volume fraction of wire mesh in the direction of loading at this orientation [17].The structural behavior of lightweight ferrocement (LWF) sandwich composite beams is investigated and found that LWF beams exhibit better performance and have a more favorable advantage in achieving the improvements on pre-cracking stiffness, load carrying capacity, energy absorption capacity, ductility index and a higher ultimate flexural load-to-weight ratio compared with RC beams [18].
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 designed and strengthened to prevent local failure, Shear behaviour of ferrocement plates (SBFP) [19].
Ferro cement specimens indicate that the tensile strength depends on both matrix strength and wire mesh ratio [20].
The concrete beams incorporating permanent ferrocement forms, irrespective of the type of the steel mesh and number of layers in the ferrocement laminate, have high strength, crack resistance, and energy absorption properties relative to conventional reinforced concrete beams of the same dimensions and total reinforcing steel content. In fact, the beams incorporating ferrocement forms have less steel weight but attains higher first crack load, service load, and ultimate load in comparison to the control beams [21].
By providing external confinement at plastic regions or over the entire reinforced columns, the strength and ductility can be enhanced. It is observed by the author that a circular ferrocement jacket can be an effective alternative material to strengthen reinforced concrete columns with inadequate shear resistance [22].
Ferrocement laminates are introduced to enhance the overall performance of structures, such as composite bridge decks, beams, bearing walls, etc. Beam specimens with square mesh exhibited better cracking capacity than the control beam as well as beams with hexagonal mesh. Full composite action between both layers can not be attained based on rough surfaces without shear studs. It was observed that a minimum number of five studs is needed to provide full composite action between both layers. Beams having shear studs with hooks exhibited better pre-cracking stiffness as well as cracking strength than those with L-shaped studs [23].

Ferrocement can be used effectively and efficiently for confinement of concrete. Ferrocement jacketing or confinement provides much better strengthening result in lower grade of concrete, as the grade of concrete increases strength after confinement with ferrocement decreases [24,31]. Due to the occurrence of much more cracks in the mortar layer of ferrocement including steel bars (FS} confined columns, the ductility of FS confined columns is obviously higher than those of bar mat-mortar (BM), FS, and fibre reinforced polymer (FRP) confined columns [25]. It was observed that unreinforced masonry columns when encased by ferrocement then load carrying capacity, ductility and serviceability of unreinforced masonry columns can be enhanced [26]. Ferrocement jacketing may be used as an alternative technique to strengthen RC columns with inadequate shear strength [27]. Column when wrapped with a ferromesh jacket gives additional strength about 20% and apart from this ductility is also enhanced [28]. Effect of column retrofitted with ferrocement and non retrofitted can be investigated in different phases as: The initial portion of the load-deflection curve of the conventional column is almost the same for jacketed columns. The later portion of the load-deflection curve of the Retrofitted column clearly shows the effect of confinement. In general, it is concluded that the RC Jacketing technique is one of the efficient techniques for repair and rehabilitation of the damaged RC columns [29].
To evaluate the tensile reinforcement for ferrocement channel with various spans as per its usage an experimental and finite element analysis is done by the researcher and concluded that a combination of meshes (expanded metal lath with wire mesh) with water/cement = 0.5 and Torbat cement provided a better design for construction[32].
Ferrocement due to its characteristics of uniform distribution and high surface area-to-volume ratio of the reinforcement (wire mesh) with which such composites behave like the crack-arrestor , can be called as ideal material for repairing and strengthening old and deteriorated structures or structural members [33]. To minimize the cost of building using local material like Bamboo, Flyash and chicken wire mesh an experiment conducted by the researcher on bamboo based ferrocement slab panels and found that ultimate load to be about doubled the first crack loads and all slabs exhibited large ductility before final failure in flexure [34]. The confinement effectiveness and hence load carrying capacity of columns improved with the number of layers of wrapping but reduced with increase in aspect ratio and preloading rates [35].

REFERENCES

[1] Di Prisco M., Ferrara L., Concrete and Construction Technology – the Fiber Reinforced Concrete Experience. FIB Symp., Prague, 2011, 253-268.
[2] Saleem. A., Ashraf M., Low Cost Earthquake Resistant Ferrocement Small House. Pak. J. Engg. & Appl. Sci., 2 (2008).
[3] Seraj S.M., Ahmed K.I., A Model of Calamity-Resistant Rural Hut with Ferro-Concrete Thin Shell Roof. Proc. of H&H 2000 Conf., Dhaka & Exeter, 2000, 195-206.
[4] Naaman AE. Ferrocement and laminated cementitious composites. Ann Arbor, Michigan, USA: Techno Press 3000; 2000, ISBN -0-9674939-0-0, 370pp.
[5] Memon NA, Salihuddin RS. Ferrocement: a versatile composite structural material. Mehran University Research Journal of Engineering and Technology 2006;25(1):9–18.
[6] Letitia Nadasan and Traian Onet, possible use of ferrocement in Romania, February11, 2013.
[7] Chan SYN, Peng G-F, Chan JKW. Comparison between high strength concrete and normal strength concrete subjected to high temperature. Mater Struct 1996;29:616–9.
[8] Naaman AE. Ferrocement and laminated cementitious composites. Michigan, USA: Techno Press 3000; 2000.
[9] Kodur VKR et al. Effect of strength and fiber reinforcement on fire resistance of high-strength concrete column. J Struct Eng 2003;29(2): 253–9.
[10] Kodur VKR. Fire performance of high-strength concrete structural members. Constr Technol 1999;31:1–4.
[11] Kodur VKR. Fire resistance evaluation of large scale structural system. In: Proceedings of fire resistance determination and performance prediction research needs workshop, 2002. NISTIR 6890.
[12] Vatwong Greepala , Pichai Nimityongskul, Structural integrity of ferrocement panels exposed to fire, Cement & Concrete Composites 30, (2008), pp.419-43.
[13] Mohammad Taghi Kazemi , Reza Morshed, Seismic shear strengthening of R/C columns with ferrocement jacket, Cement & Concrete Composites 27, 2005, pp. 834-842.
[14] Nahro Radi Husein, V. C. Agarwal, Anupam Rawat, An Experimental Study on Using Lightweight Web Sandwich Panel as a Floor and a Wall, International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-3, Issue-7, December 2013, pp. - 2278-3075.
[15] S.M. Mourad and M.J. Shannag, Repair and strengthening of reinforced concrete square columns using ferrocement jackets, Cement & Concrete Composites 34, 2012, PP.288 – 294.
[16] Prem Pal Bansal, Maneek Kumar, S.K. Kaushik, Effect Of Wire Mesh Orientation On Strength Of Beams Retrofitted Using Ferrocement Jackets, International Journal of Engineering, Volume (2), Issue (1).
[17] Mohammed Arif , Pankaj, Surendra K. Kaushik, Mechanical behaviour of ferrocement composites: an experimental investigation, Cement & Concrete Composites 21, 1999, PP.301-312.
[18] Naveen G.M, Suresh G.S, Experimental study on light weight ferrocement beam under monotonic and repeated flexural loading, INTERNATIONAL JOURNAL OF CIVIL AND STRUCTURAL ENGINEERING Volume 3, No 2, 2012, PP. 294-301.

[19] Madhuri N. Savale1, Prof. P. M. Alandkar, Shear behaviour of ferrocement plates, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 2, February 2013, PP.652-656.

[20] Azad A. Mohammed and Dunyazad K. Assi, Tensile Stress-Strain Relationship For Ferro cement Structures, Al-Rafidain Engineering Vol.20 No. 2, 2012, PP.27-40.
[21] Alaa Abdel Tawab, Ezzat H. Fahmy and Yousry B. Shaheen, Use of permanent ferrocement forms for concrete beam construction, Materials and Structures (2012) 45, PP.1319–1329.
[22] Katsuki TAKIGUCHI and ABDULLAH, EXPERIMENTAL STUDY ON REINFORCED CONCRETE COLUMN STRENGTHENED WITH FERROCEMENT JACKET, 12 WCEE 2000, 0689.
[23] Hani H. Nassif , Husam Najm, Experimental and analytical investigation of ferrocement–concrete composite beams, Cement & Concrete Composites 26, 2004, PP.787-796.
[24] B. Kondraivendhan , Bulu Pradhan, Effect of ferrocement confinement on behavior of concrete, Construction and Building Materials 23, 2009, PP. 1218-1222.
[25] G.J. Xiong, X.Y. Wu, F.F. Li, Z. Yan, Load carrying capacity and ductility of circular concrete columns confined by ferrocement including steel bars, Construction and Building Materials 25, 2011, PP.2263-2268.
[26] Jonathan M. Woodsa, Panos D. Kiousisb,_, Mohammad R. Ehsania, Hamid Saadatmanesha, Wolfgang Fritza, Bending ductility of rectangular high strength concrete columns, Engineering Structures 29, 2007, PP.1783- 1790.
[27] P. Rathish Kumar, T. Oshima, S. Mikami and T. Yamazaki, STUDIES ON RC AND FERROCEMENT JACKETED COLUMNS SUBJECTED TO SIMULATED SEISMIC LOADING, ASIAN JOURNAL OF CIVIL ENGINEERING (BUILDING AND HOUSING) VOL. 8, NO. 2 (2007) PAGES 215-22.
[28] Syed wasim nawaz Razvi, M. G. Shaikh, Effect of confinement on behavior of short concrete column, Procedia Manufacturing, volume 20, Elsevier, 2018, PP. 563-570.
[29] K.SENGOTTIAN, K. JAGADEESAN, RETROFITTING OF COLUMNS WITH RC JACKETTING AN EXPERIMENTAL BEHAVIOR, Journal of Theoretical and Applied Information Technology 20th October 2013. Vol. 56 No.2 © 2005 - 2013 JATIT & LLS., ISSN: 1992-8645, E-ISSN: 1817-3195 349.
[30] S. Wasim N. Razvi, Review on ferrocement, Int. J. Innovations Eng. Technol.(IJIET), 2015, PP.338-340.
[31] Mohammed Ishtiyaque, Syed Wasim Nawaz Razvi, Syeda Amrin Jeelani, Effect of Grade of Concrete on Behavior of Short Reinforced Column, Journal of Eng. Science and management education, vol. 9 (III), 2016, PP.192-196.
[32] Hamid Eskandari, AmirhosseinMadadi, Investigation of ferrocement channels using experimental and finite element analysis, Engineering Science and Technology, an International Journal, Volume 18, Issue 4, December 2015, Pp. 769-775.
[33] A.B.M.A.Kaish, M.Jamil, S.N.Raman, M.F.M.Zain, LutfunNahar, Ferrocement composites for strengthening of concrete columns: A review, Construction and Building Materials, Volume 160, 30 January 2018, Pp. 326-340.
[34] S. JeevaChithambaram, SanjayKumar, Flexural behaviour of bamboo based ferrocement slab panels with flyash, Construction and Building Materials, Volume 134, 1 March 2017, Pp. 641-648.
[35] MiniSoman, JebinMohan, Rehabilitation of RC columns using ferrocement jacketing, Construction and Building Materials, Volume 181, 30 August 2018, Pp. 156-162.