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A STUDY ON DURABILITY OF FERROCEMENT

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Abstract: Ferrocement is made of cement mortar reinforced with steel wire mesh that is spaced close to form a thin section with high serviceability. The present study investigates the performance of ferrocement mainly focused on the durability properties. The structures are needed to be durable in order to ensure that the service life intended is achieved. To evaluate the durability criteria of the ferrocement, series of cubes and cylinders were casted in this experiment using a mortar mix of ratio 1:3 & water cement ratio of 0.40 was adopted. The curing period adopted were 28, 56, & 90 days. The impact resistance of the ferrocement was determined in accordance with the ACI 544.2R-89. After performing the Impact Test, the energy absorbed was observed to be 5.13, 5.40 & 5.58 Joules for 28, 56, and 90 days respectively. Water Absorption test was performed in accordance with ASTM C 642, to determine the porosity of the ferrocement. After performing the test, it was observed that the average percentage of absorption was 5.89%, 5.41%, & 5.53% for 28, 56, and 90 days respectively. The carbonation resistance of concrete is an important parameter which is needed to be measured to check corrosion of reinforcement occurred by Carbon di Oxide. The results of carbon penetration measured after the following exposure periods: 56th, 63rd, and 70th day were 4.9mm, 6.08mm & 8.2mm respectively.

Keywords: Durability, Ferrocement, Wire Mesh, Impact Test, Accelerated Carbonation, Water Absorption.

1. INTRODUCTION:

A thin-walled reinforced concrete known as Ferrocement is reinforced by interlocking layers of relatively thin wire mesh placed tightly together. It is usually made of cement mortar. Grid may be metal or other suitable material. It consists of multiple layers of thin, closely spaced strips or mesh in cement mortar. It is possible to develop a composite material that differs from conventional reinforced concrete in terms of strength, deformation and application prospects. It can be made into sheets, which are simply a thin layer of mortar over the outer layer of rebar, less than 1 inch (25 mm) thick. In diversities, the use of non-metallic mesh is under study. This mesh features natural organic bamboo or jute materials, organic fabrics and alkali resistant woven glass. Welded mesh offers the best performance in almost all areas because it has two directions of reinforcement of equal strength. Although this type of mesh is superior to the expanded metal, it is weaker in the 45° direction [24], The durability of ferrocement compounds

can be described as its ability to resist cracking, weathering, chemical attack, abrasion, and any other form of damage. Ferrocement which is like a delicate cementitious material is changed in to a versatile composite fabric due to the homogeneously and closely-spaced lean wire work in it. This exchange the ferrocement into profoundly adaptable development materials compared to fortified concrete in its toughness counting warm and acoustic execution [10]. Ferrocement was created by Joseph Lambot in 1847 as an elective to watercraft development. It could be a exceedingly flexible sort of fortified concrete composed of cement, sand, water and steel work. Nowadays, ferrocement is used in an assortment of applications. It could be a polytrophic fabric with unmistakable properties, making it a commendable competitor within the development industry few applications reasonable for developing nations with creating economies. It can be adjusted to a wide extend of development strategies since of its flexibility, environment-friendly and promptly accessible crude materials, ease of transportation and fabric dealing with, and does not require any specific method or extraordinary expertise [39]. The sum of steel and cement utilized whereas development by this strategy is distant less than the conventional strategy. To install certainty within the industry almost the uses of ferro cement, increasingly considers got to be conducted and more enhancements have to be done. [40]

2. MATERIAL AND METHODS:

2.1 Materials:

The materials used for the experimental work are Cement, Sand, Superplasticizer & water. Cement of OPC GRADE 53 confirming to BIS 1489-199 was used. Sand selected is Crushed sand which is conforming to zone 2 and potable water is used. Along with cement and sand, Perma Plast SF 34 superplasticizer is used. The proportion of the mix is 1:3 and superplasticizer taken as 2% of the weight of cement. For Compression test, cubes of 150*150*150mm were casted and cured for 28, 56, & 90 days and the results observed were 35.23 MPa, 35.93 MPa & 36.02 MPa respectively. Table 1 & Table 2 gives detail of the properties of cement and sand respectively.

Table 1 CEMENT PROPERTIES

Properties	Values
Specific Gravity	3.18
Standard consistency	36%
Initial Setting time	42 mins
Compressive Strength	52.69 N/mm2

Table 2 SAND PROPERTIES

Specifications	Values
Specific Gravity	3.18
Fineness modulus	2.36mm
Zone	II

2.2 Experimental Methods:

1. Drop Weight Impact Test:

The impact resistance of the specimens was determined in accordance with the ACI 544 2R-89. The impact test was conducted on 150mm (diameter) X 60mm(length) concrete cylindrical discs. Cylindrical disc specimens were tested to obtain average number of blows required to cause first crack and ultimate failure at 28, 56 & 90 days of curing. The impact load was applied with 4.45kg repeatedly from a height 300 mm on to steel ball of 63.5 mm steel ball, which was located at the center of the top surface of concrete disc. Figure 1 shows the
Impact Testing Apparatus.

Figure 1. IMPACT TEST APPARATUS

The impact energy absorbed by the specimen for each blow is calculated as follows-
Static Energy = Mx g x H x N

Where,

M– drop hammer mass
H – height of drop mass
N – number of blows at

RESULT AND DISCUSSION:

The Results of Impact Test are discussed below in Figure 2 & Figure 3. Figure 4 shows the specimens after testing.

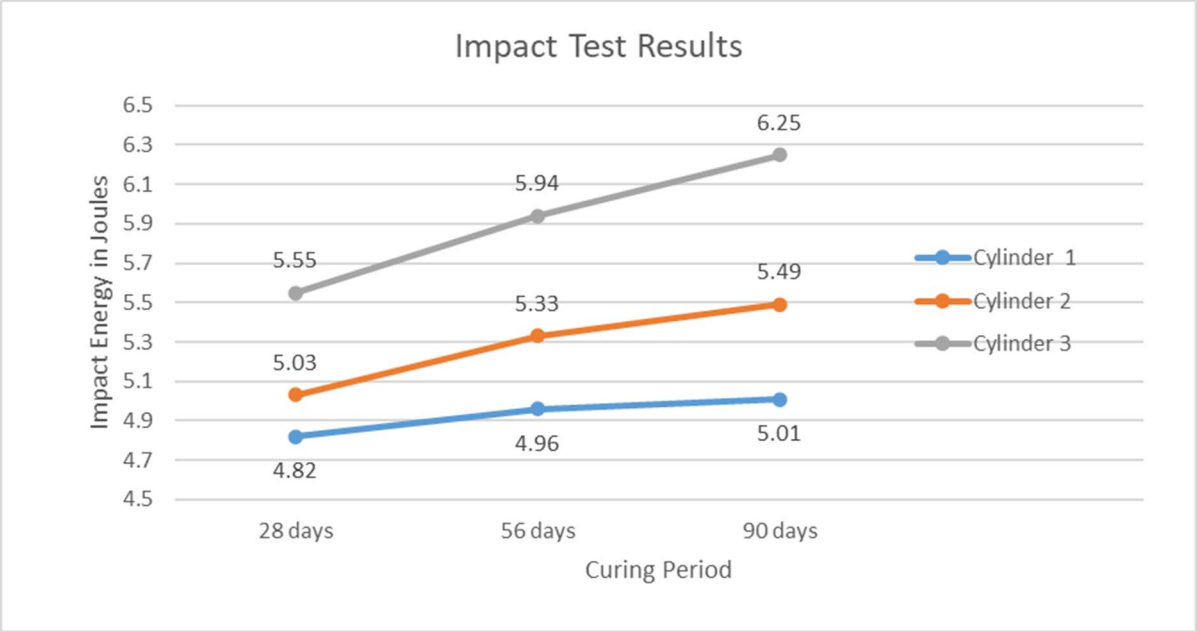

Figure 2. IMPACT TEST RESULTS

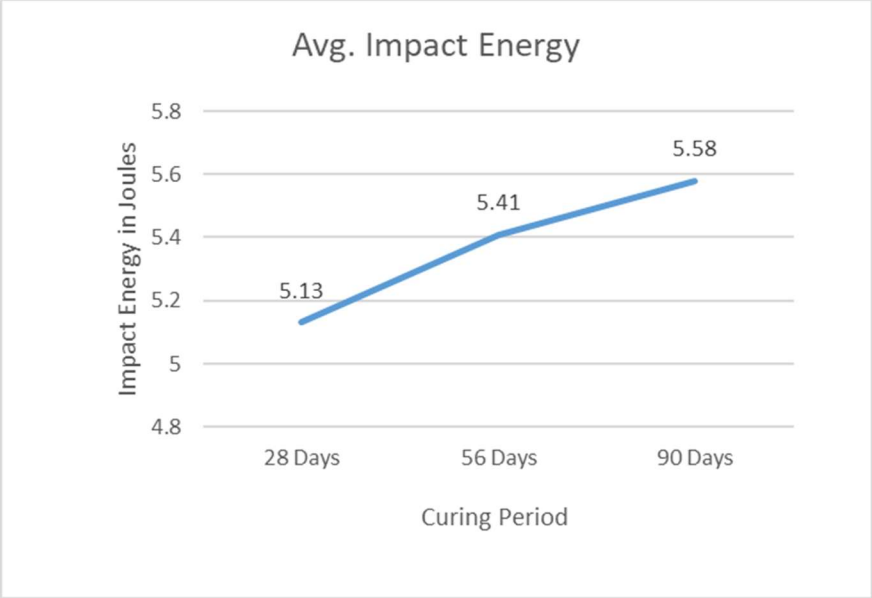

Figure 3 IMPACT TEST RESULTS SPECIMENS

Figure 4 IMPACT TEST

2. Water Absorption Test:

The core of the structure is known to be of high importance for the durability of the material. A characterization of this core structure by means of a simple test is often investigated, in order to find a very simple compliance criterion with respect to durability. With the use of ASTM C642 13, the water absorption by immersion is considered to be a relevant parameter. This test method covers the determination of the Percentage of Absorption. For this test specimens of 150*150*150 mm were cast and cured for 28, 56, & 90 days. After the curing period, all the Masses required for the calculations were measured.

All the Masses are mentioned below.

a) Oven Dry mass- The specimens were kept in the oven for 48 hrs at a temperature of 1100C. After 48 hrs the specimens are removed from the oven and kept in the open environment, allowing them to cool to a temperature of 200C to 250C and after that, the mass of the specimen was determined. The mass was designated as A. Figure 5 shows the specimens placed in oven.

b) Saturated mass after immersion- After removing specimens from the water tanks, they were surfaced and dried with the help of a towel, and the mass was determined. The mass was designated as B.

c) Saturated mass after boiling- The specimens were placed in a metal container and were boiled in normal tap water for 5 hrs. After the boiling process was complete the specimens were allowed to cool down. The surface moisture was removed with a towel and the mass was determined. The mass was designated as C

Formula:

1. Absorption after immersion (Ai)=((B-A)/A) x100
2. Absorption after Immersion and Boiling (Ae)=((C-A)/A) x100

Figure 5. SPECIMENS IN OVEN

RESULT AND DISCUSSION:

Figure 6 shows the results of Water Absorption Test.

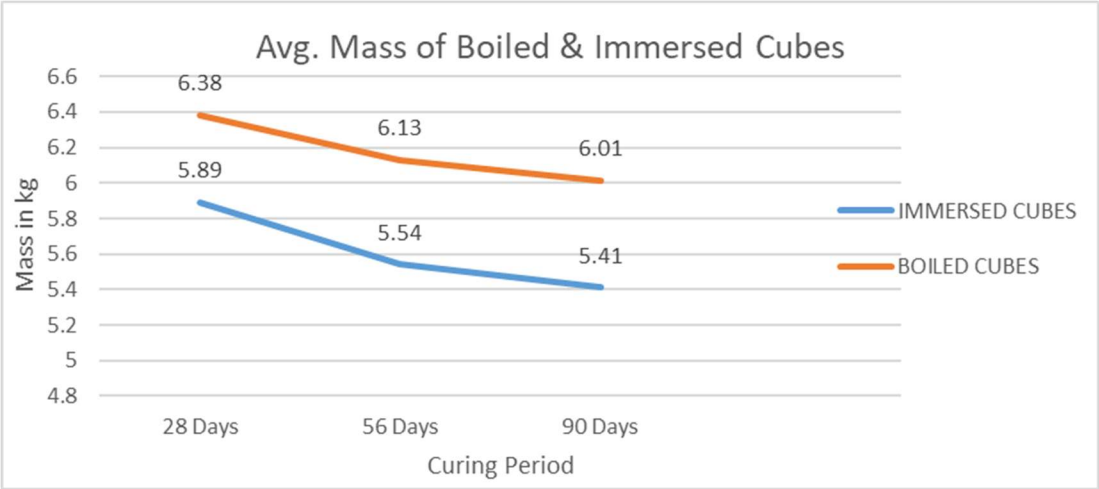

Figure 6 AVERAGE MASS OF SPECIMENS

3. Accelerated Carbonation Test:

Carbonation is a process in which carbon dioxide from the atmosphere diffuses through the porous cover concrete and may reduce the pH to 8 or 9, at which the passivating/oxide film is no longer stable. Carbonation process involves the following two stages: First, the atmospheric carbon dioxide (CO_2) reacts with water in the concrete pores to form carbonic acid (H_2CO_3). Along with that carbonic acid reacts with calcium hydroxide [$Ca(OH)_2$] to form calcium carbonate ($CaCO_3$). This process leads to cause a reduction in the pH value of the pore solution from 12.5 to 13.5 to around 8 to 9, Two concrete prisms were casted in accordance with ISO - 1920 part 3 as per required grade. Exposure Condition in Chamber A storage chamber with a carbon dioxide concentration at (3,0 ± 0,5) % by volume, temperature at (22 ± 2) °C, and a relative humidity at (55 ± 5) %. In locations where the climate is hot and humid, the temperature in the storage chamber should be (27 ± 2) °C and relative humidity should be (65 ± 5) %.

Measuring the depth of carbonation:

Carbonation depth was measured at 10 points on each prism after each exposure period & an average value was taken. The depth was measured at 5 points on both side of prism at equal lengths. The carbonation depth was measured on the broken side of the prisms and measuring a total of 20 measurements points. Figure 7 & Figure 8 shows the Depth of Carbonation for 56th, 63rd, & 70th day. Figure 9, Figure 10, Figure 11 shows the specimen after testing.

RESULT AND DISCUSSION:

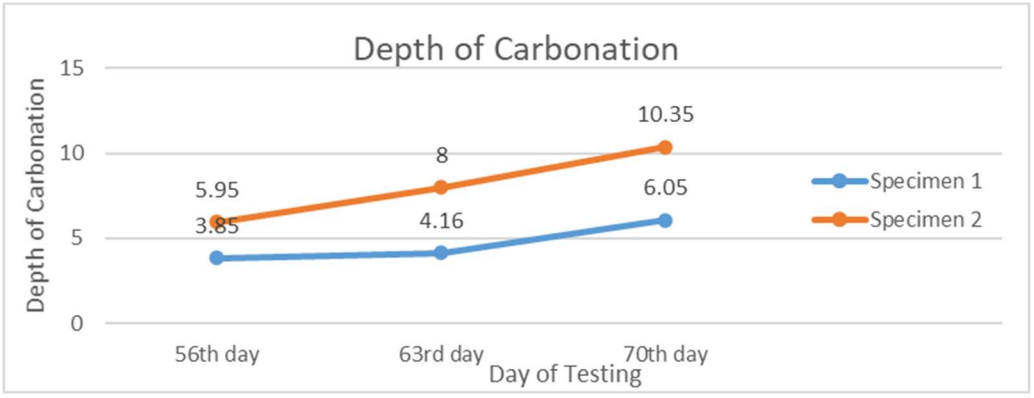

Figure 7. DEPTH OF CARBONATION

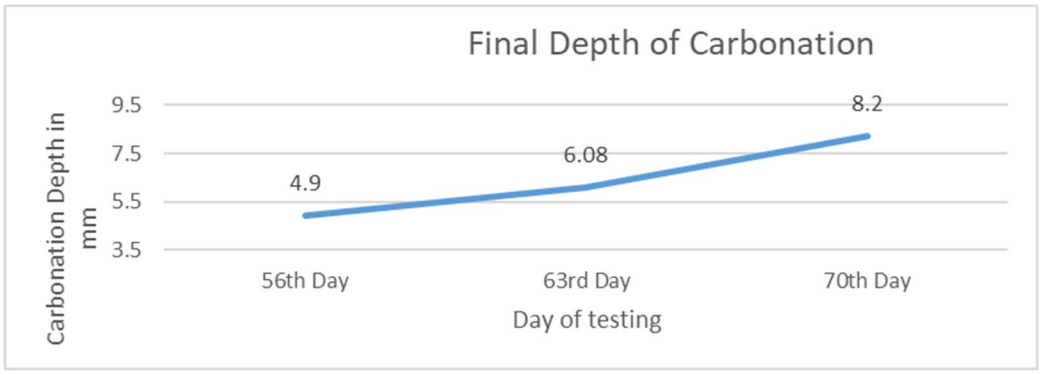

Figure 8. FINAL DEPTH OF CARBONATION

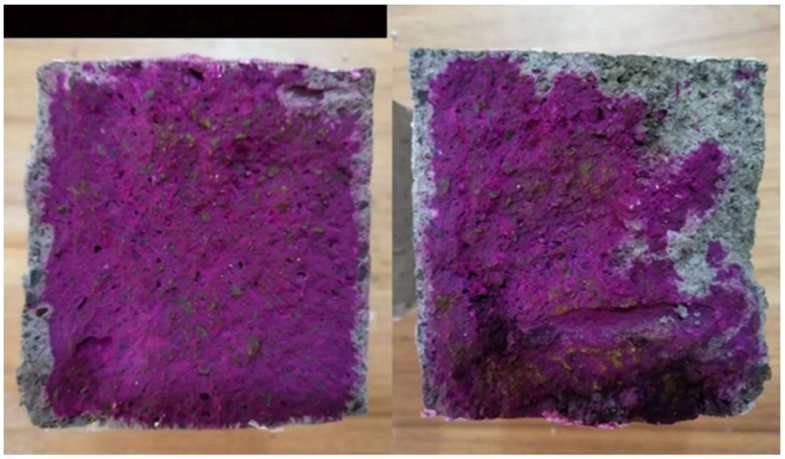

Figure 9. CARBONATION RESULT FOR 56TH DAY

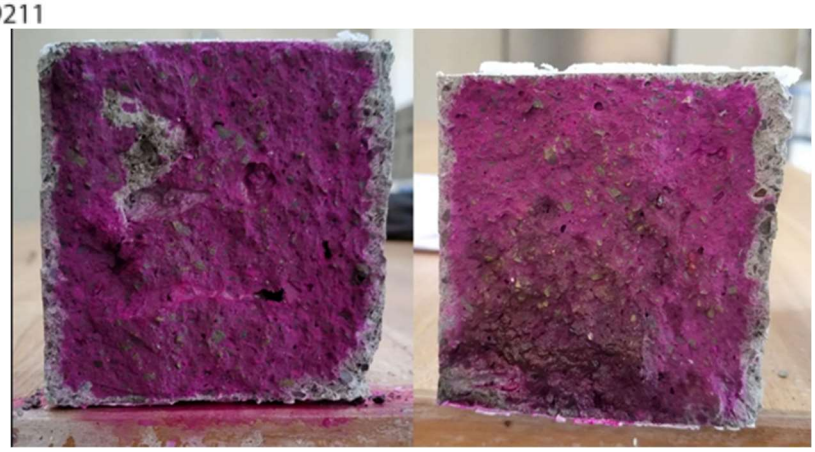

Figure 10. CARBONATION RESULT FOR 63TH DAY

Figure 11. CARBONATION RESULT FOR 70TH DAY

4. CONCLUSION:

From the test results & the analysis of the experimental work carried during the research, the following are the conclusions-

After performing the Impact Test, the results obtained were 5.13, 5.41 & 5.58 Joules for 28, 56, and 90 days respectively. The average number of blows required for the specimens to crack were convincing & energy absorbed by the specimen which was transferred by the impacting hammer was also similar, which concludes that the specimens has absorbed almost all the energy while impacting from which we can conclude that ferrocement can be used for structures carrying less load. After performing the Water Absorption Test, Percentage Absorption after Immersion was 5.89%, 5.41%, & 5.53% for 28, 56, and 90 days respectively. It can be reduced by adding Fly ash, Silica fumes etc. After the test it was observed that, Immersed mass & Boiled mass were not having any significant difference. The results of Accelerated Carbonation Test observed at 56th, 63rd & 70th day were 4.9mm, 6.08mm & 8.2mm respectively, it can be reduced by practicing proper compaction using equipment, by obtaining a clean and pore free outer surface.

REFERENCES:

[1] K.S.Saranya; Faizuneesa A; Dhilip Kumar;, "Strength and Durability performance of

ferrocement panels with the influence of corrosion inhibitor," International Journal of Engineering and advanced technology, vol. 9, 2019.
[2] Shaikh and F. U. Ahmed, "Review of Mechanical Properties of short fiber reinforced geopolymer composites," Construction and Building Materials, pp. 37-49, June 2013.
[3] Baston and G., "Ferrocemnt and Laminated Cementitious Composites," Material and Structures, vol. 2, March 2000.
[4] A. Masood, M. Arif, S. Akhtar and M. Haquie, "Performance of Ferrocement Panels in different environments," Cement and Concrete Research, 2003.
[5] I.G.Vickridge and A.S.Nakassa, "High Durability Ferrocement," Proceedings of 6th International Symposium on Ferrocemnet, 1998.
[6] ACI, "State of art report on ferrocement," ACI Committee 549R-97, 2000.
[7] ACI, "Report on thin Reinforced Cementitious Products," ACI, 5492R-04,2004.
[8] Muhammad Harunur Rashid; Zahangir Alam; Firoz Mahmud; M.S Anita,"Durability and Performance pf Ferrocement infill wall panel," Civil Engineering Journal, vol. 5, no. 6, June 2019.
[9] M.T.Bassuoni; M.L.Nehdi; T.R.Greenough;, "Enhancing the reliability of evaluating chloride ingress in concrete using ASTM C 1202 Rapid Chloride Penetrability test," Journal of ASTM International , vol. 3, March 2006.
[10] Muhammad Harunur Rashid , Zahangir Alam , Firoz Mahmud , M S Anita ;, " Durability and Performance of Ferrocement Infill Wall Panel," Civil Engineering Journal Vol. 5, No. 6, June, 2019
[11] Letitia Nadasan; Trainan Onet;, "Durability of ferrocement," International Journal of Engineering .
[12] Sabih Akhtar; Mohammed Arif; mumtaz A Quraishi;, "Use of chemical corrosion inhibitors for protection of metallic fiber reinforcement in ferrocement composites," The Arabian Journal for Science and Engineering, vol. 34, December 20019.
[13] Ornela Lalaj; Yavuz Yarim; Salih Yilmaz;, in Recent Prespectives for ferrocement , Research on Engineering Structures and Material, 2015.
[14] M.T.Bassuoni; T.R.Greenough ; M.L.Nehdi;, "Rapid Chloride Penetration Test: A new look," Toronto, Ontario, Canada, June 2005.
[15] V.Bhiksma; Ravandekishore; R.Srinivas;, "Durability of polymer and flyash modified Ferrocement elements," Procedia Engineering, 2011.
[16] S.S.Sneha; Karthika Soman; C.Prajith; Aiswaria.K.Davis;, "Study of the mechanical and corrosion resistance properties of ferrocement," IOP Conf. Series: Earth and Environmental Science 491, 2020.
[17] K.D.Stanish; R.D.Hooton; M.D.Thomas;, "Testing the chloride penetration resistance of concrete: A Literature Review," FHWA Contract DTFH61-97-R-00022.
[18] T.C.Madhavi; S.Annamalai;, "Electrical Conductivity of concrete," ARPN Journal of Engineering And Applied Science, vol. 11, May 2016.
[19] S.A.Tkalich; O.Y.Taratynov;, "Durability prognostication of ferroconcrete structures based on netural indistinct network," IOP Conference Series: Material Science and

Engineering.
[20] Piyush Sharma;, "Analytical Research on ferrocemnt: Design, Strength and Serviceability Aspects".
[21] Kondraivendhan.B; Bulu Pradhan;, "Effect of Ferrocement Confinement on Behavior of concrete," Construction and Building Material 23, March 2009.
[22] Masood.A; M.Arif; S. Akhtar; M.haquie;, "performance of ferrocement panels in different environments," Cement And Concrete Research 33, April 2003.
[23] Mansur; P.Paramasivam; T.H.Wee; H.B.Lim;, "Durability of ferrocement -A case study," Journal Ferrocement 26, 1996.
[24] J.J.Nita; M.John Paul;, "Experimental Evaluation on Durability Properties of Geopolymer Ferrocement Slab," International Journal of Innovative Research in Science, vol. 8, 2019.
[25] F.M.Hanafiah; M.Ramli;, "Durability of Ferrocement structure in the aggressive environment," 2004.
[26] D.R.Kumar; B.Vidivelli;, "Acrylic Rubber Latex in Ferrocement for strengthening," American Journal of Engineering And Applied Sciences, 2010.
[27] D.R.Kumar; B.Vidivelli;, "Performance Evaluation of Polymer Modified Ferrocement Mortar," International Journal of Engineering Research, vol. 3, 2017.
[28] M.I.M; Dyana Joseline; Haji Sheik Mohammed;, "Strength, Durability and Thermal Performance of ferrocement panels for use in secondary roofing," International Journal of Applied Engineering Research, vol. 12, 2017.
[29] [29] B.S.J; Dhinesh M; Revathi T;, "Comparative Study on Durability, Mechanical strength of ferrocement," International Journal of Chem-Tech Research, vol. 10, 2017.
[30] Letitia Nadasan; Traian Onet;, "Durability of Ferrocement," International Journal of Engineering, 2013.
[31] W.Du; Canqian Yang; Chong Wang; Yong Pan;, "Flexural Behavior of polyvinyl Alcohol Fiber- Reinforced ferrocement Cementitious Composite," ASCI, vol. 33, 2021.
[32] R.Ravindrarajah; C.T.Tam;, "Watertightness in ferrocement," journal of ferrocement , vol. 14, p. 11, 1984.
[33] [33] Y.Ohama and A.shirai, "Durability of polymer ferrocement," Journal of ferrocement , vol. 22, p. 27, 1992.
[34] D.Alexander;, "The durability of ferrocement and fibrous ferrocement in aggressive environments," Journal of ferrocement, vol. 22, p. 373, 1992.
[35] M.Mathews; Sudhakumar;, "Durability of ferrocement," Journal of Ferrocement , vol. 23, p. 15, 1993.
[36] K.V.Aadithiya; Dr.P.Chandrasekaran;, "Review Paper on the usage of ferrocement panels in lightweight sandwich concrete slabs," International Journal of Engineering and Technology, vol. 4, 2017.
[37] Ankit Batra; Sumit Ghangas; Lalit Kumar;, "A Review study of the application of ferrocement," International Journal of Engineering and Technology, vol. 4, 2017.
[38] N.Jayaramappa;, "Experimental Studies on reinforced concrete and ferrocement

beams," IRA-International Journal of Engineering and Technology, vol. 5, 2016.
[39] [39] Cheryl Lyne; C.Roxas; Ronaldo.S;, "Durability of ferrocement garbage disposal barge," Research Congress, vol. 1, 2013.
[40] Viraj Deshpande; Kaustubh Gore; Komal Gavhane;, "Use of fly ash and copper slag as construction material in ferrocement to make it more sustainable and ecological," IJIRT, vol. 8, 2021.
[41] D.Raj Kumar; B.Vidivelli;, "Performance Evaluation of polymer modified ferrocement mortar," International Journal of Engineering Research and advanced technology, vol. 3, 2017.
[42] J.Jurish Nina; M.Johan Paul;, "Experimental Evaluation on durability properties of geopolymer ferrocement slab with Nani silica," International Journal of innovative research in science, engineering, and technology, vol.8, 2019.
[43] Mohamed Ibrahim M; Dyana Joseline; Haji Sheik Mohammed;, "Strength,Durability and Thermal performance of Ferrocement panels for use in secondary Roofing," International Journal of applied engineering research ISSN 0973-4562, vol. 12, 2017.
[44] Sayyed Wasim Mujammil, “Durability Study of Recycled Aggregates Concrete with Partial Replacement of Cement By Fly” GIS Science Journal, Vol. 8,2021.
[45] Rajat S. Tembhurne, “Strength and Durability Parameter of Recycled Concrete Aggregates” International Journal of Science Technology & Engineering |Journal, Vol. 5,2018.
[46] Yash D.Chhaniyara, “Achieve High Compressive Strength and Durability of Concrete Made from Recycled Concrete Aggregate” International Journal of Innovative Technology and Exploring Engineering Journal, Vol. 8,2019.