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Comparative Study of Compressive Strength of Bitumen Ferrocement with Admixture

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ABSTRACT

Ferrocement is relatively new material consisting of wire meshes and cement which was developed by P.L. Nervi, an Italian Architect and Engineer in 1940 [1]. It is basically considered as a type of thin reinforced concrete construction where cement mortar matrix is reinforced with many layers of continuous and relatively small diameter wire meshes. While mortar provides the mass, the wire mesh imparts the tensile strength and ductility to the material. In terms of structural behavior ferrocement exhibits very high tensile strength to weight ratio and superior cracking performance. [2] Ferrocement is boon for maintain the ecological balance as it does not requires timber formwork. Bitumen ferrocement is new type of ferrocrete in which wire reinforcement replaced by bitumen coated wire mesh. Due to use of bitumen and admixture in ferrocement, structure not only carries increased compressive strength but also becomes impervious. Thus this material can be used in construction of swimming pools, retaining walls, small arch dams, water tanks and also in construction of road pavements. The present investigation, highlights on ten different cases of wire mesh combination with one additional case as mortar control specimen which does not contain any type of reinforcement. The concrete cubes were casted with single and double layers of wire mesh placed in horizontal, vertical and diagonal orientations. It reveals from the result of investigation that the vertical orientation offers more compressive strength than horizontal orientation for bitumen ferrocement while using admixture.

Key Words: Bitumen, ferrocement, square mesh, reinforcement orientation, admixture.

I.INTRODUCTION

Ferrocement or ferrocrete is a system of reinforced mortar or plaster applied over layers of such as chicken wire or woven or expanded metal mesh or fibers and possibly closely spaced small diameter steel rod such as rebar. It is a versatile material which is less pollutant and also not requires skilled labours and constructed with locally available materials, so it reduces the cost of construction. Wire mesh used in ferrocement may be steel or galvanized and available in different shapes such as square, hexagonal, diamond shape. The committee 549 of American Institute for concrete submitted the following definition of Ferrocement as, "Ferrocement is a type of reinforcement concrete in thin elements, currently constituted by micro- concrete of hydraulic cement, reinforced with thick layers of continuous netting, in wire, with relatively small diameter. The net may be metallic or in other material." In 1848, fibrocement first used for construction of small boat by Frenchman

Joseph Louis Lamboat. Then it was used during Second World War for construction of boats and slowly it is used by worldwide in much application. Compressive strength is the capacity of material or structure to withstand loads tending to reduce size. The compressive strength of ferrocement is governed by volume fraction of reinforcement. The volume fraction of reinforcement is the volume of reinforcement per unit volume of ferrocement. The compressive strength also depends on the specific surface which is bonded surface area of ferrocement per unit volume of ferrocement. The orientation of reinforcement which is the angle in degree between the reinforcement mesh and the direction of applied stress has also a significance related to compressive strength of ferrocement. So there is need of using ferrocement mix for water tightening structures like swimming pool, water tank, retaining wall etc. therefore, in presence study bitumen has been used in ferrocement to improve imperviousness without compromising compressive strength of ferrocement mix.

II. LITERATURE REVIEW

Ferrocement covers all dimensions of sustainability and also durable material. It has better crack arrest mechanism and efficient autogenesis healing of micro cracks, fire resistant, damage being negligible and easily repairable. Ferrocement can be used in various applications such as housing application rural application such as water tank, grain silos, canal lining, and some special applications as precast sandwich wall, ferrocement water filters, ferrocement segmental shells etc. [5] Paper state the effect of orientation of wire mesh on ferrocement. The conclusion arises from the study that compressive strength of ferrocement increases with increase in total volume fraction of reinforcement (%) and specific surface of reinforcement (mm2/mm3) for horizontal and vertical orientation of hexagonal mesh; the orientation of reinforcement i.e. transverse to axis of loading offers more compressive strength than that of vertical orientation i.e. parallel to axis of loading. [6] The effect of wire mesh orientation on the strength of stressed beams retrofitted with ferrocement jackets has been studied. The results show that the per cent increase in load carrying capacity for beam retrofitted with ferrocement jackets with wire mesh at 0, 45, 60 degree angle with longitudinal axis of beam, varies from 45.87 to 52.29 per cent. Also a considerable increase in energy absorption is observed for all orientations. [7] The results of testing folded and flat ferrocement panels reinforced with different number of wire mesh layers were presented in this paper. [8]The main objective of these experimental tests is to study the effect of using different numbers of wire mesh layers on the flexural strength of folded and flat ferrocement panels and to compare the effect of varying the number of wire mesh layers on the ductility and the ultimate strength of these types of ferrocement structure. The experimental results show that flexural strength of the folded panels increased by 37% and 90% for panels having 2 and 3 wire mesh layers respectively, compared with that having single layer. This paper conducted research work is to maintain the eco-balance by preventing the open site dumping of the Blast furnace slag (BFS). This replacement has been found to improve the strength characteristics of ferrocement and also makes it lightweight. Replacement of BFS helps in reducing weight of the structure and thus improving its earthquake resistance. Marginal decrease in ultimate strength with increase in mesh content has been observed and this may be due to bulking of small diameter wires of mesh. [9] Many researchers were used another materials other than wire mesh or with combination of it such as steel fibers, styrene butadiene rubber latex, scrap tyre, fly ash, BFS, Rise Husk, Coconut fibers etc. for construction of ferrocement structures. However there is no reported

significant work on effect of orientation of reinforcement on compressive strength of bitumen ferrocement. Also there is no significant literature on bitumen ferrocement. Hence the present study attempts to investigate the effect of bitumen content on compressive strength of ferrocement and effect of bitumen-wire mesh reinforcement on compressive strength of ferrocement.

Although other forms of ferrocement may have existed earlier, credit for using it should go to Joseph Louis Lamboat in France, who constructed a rowing boat from a net of wires and thin bars, and filled with cement mortar. Lambot applied for patent in year 1855 for his invention with name „Ferciment" Sharma et.al (2013) [4] reported ferrocement covers all dimension of sustainability and also durable material. It has better crack arrest mechanism and efficient autogenesis healing of micro cracks, fire resistant, damage being negligible and easily repairable. Ferrocement can be used in various applications such as housing application rural application such as water tank, grain silos, canal lining, and some special applications as precast sandwich wall, ferrocement water filters, ferrocement segmental shells etc. Kute et.al (2013)[6] studied the effect of orientation of wire mesh on ferrocement. The conclusion arises from the study that compressive strength of ferrocement increases with increase in total volume fraction of reinforcement (%) and specific surface of reinforcement (mm2 /mm3) for horizontal and vertical orientation of hexagonal mesh; the orientation of reinforcement i.e. transverse to axis of loading offers more compressive strength than that of vertical orientation i.e. parallel to axis of loading. Bansal et.al (2004) [7] reported effect of wire mesh orientation on the strength of stressed beams retrofitted with ferrocement jackets has been studied. The results show that the per cent increase in load carrying capacity for beam retrofitted with ferrocement jackets with wire mesh at 0, 45, 60 degree angle with longitudinal axis of beam, varies from 45.87 to 52.29 per cent. Also a considerable increase in energy absorption is observed for all orientations.

The results of testing folded and flat ferrocement panels reinforced with different number of wire mesh layers were presented by Mohamad Mahmood (2008)

III.EXPERIMENTAL PROGRAM

Constituents of Ferrocement: the main constituents of ferrocement are Matrix and reinforcement. In which matrix contains cement and sand and reinforcement contains square wire mesh. Ordinary Portland cement of grade 53 was used in experimental program. Sand used for investigation was locally available and confirming to I.S. 383:1970. All necessary primary tests were taken on both cement and sand. Water used for mixing and curing should be potable water which is free from salts, alkalis, acids etc. The square mesh of spacing 0.5 cm with wire diameter of 0.6096 mm was used. The weight of mesh per unit area was 2.29 x 10-3 kg/m2. The mesh was provided in the size of 70 mm x 70 mm in the cube moulds in single and double layer of different orientations. The specific surface for this layer was as 0.0123 and 0.0246 respectively. Bitumen used for this investigation was of industrial grade having specific gravity 1.01. The ferrocement mix was prepared with cement: sand proportion of 1:3 by weight. The water cement ratio adopted was 0.45. All the cubes were de-moulded after 24 hours after casting and placed in Accelerated Curing Tank having potable water at 550C for 19 hours and then cubes were keeping in room temperature for next 20 hours before testing.

3.1 Asphalt Admixture:

Asphalt paste (AP) made according to Polish Patent No. 136449 was used in this investigation for chemical modification of concrete microstructure. It is a solution of industrial asphalt (Ps 85/25) in high boiling organic solvent (technical kerosene with additions). It is a homogenous, black mass with consistency of dense honey, specific gravity 1.030 kg/dm3.

3.1.1 Composition and preparation of specimens:

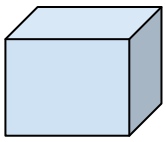
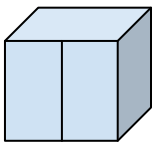
Investigation proved usefulness of vibro-pressing technique for concrete mix consolidation for prefabricated products with high corrosion resistance.

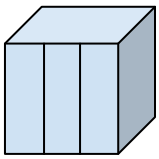
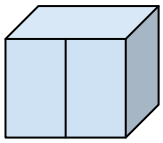
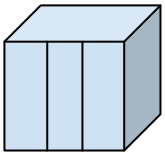
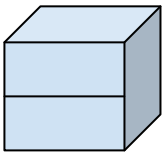
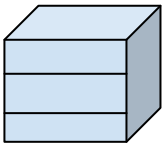
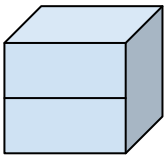
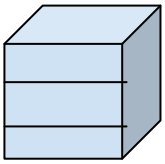
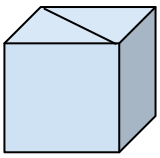
Table 3.1 Concrete compositions

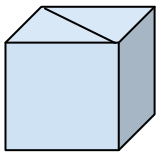
Sr. No.	Concrete	Cement	Asphalt Paste	Standard Sand	Water
1	C0	500	-	824	150
2	C2	500	10	818	150
3	C4	500	20	811	150

IV.SPECIMENS AND TESTING DETAILS

The table 4.1 shows the different ten designation of ferrocement with one additional control specimen.

Sr. No.	Designation	Orientation of mesh	Particulars
1	MCS		Mortar Control Specimen.
2	C1V		One mesh, vertical at centre.

3	E2V		Two meshes, vertical at equal distance.
4	B1V		One bitumen mesh, vertical at centre.
5	B2V		Two bitumen mesh at equal distance.
6	C1H		One mesh, horizontal at equal distance.
7	E2H		Two meshes, horizontal at equal distance.
8	B1H		One bitumen mesh, horizontal at centre.
9	B2H		Two bitumen mesh horizontal at equal distance.
10	D1		One mesh, diagonal.

11	BD1		One bitumen mesh, diagonal.

All cured specimens have been tested in compression testing machine. The % volume of mesh reinforcement and specific surface of all the specimens were noted. The % volume of mesh reinforcement and specific surface of all the specimens have been noted

V. RESULTS AND CONCLUSIONS

The result of various tests conducted on cement, sand, cement mortar, bitumen ferrocement, and ferrocement are given and discussed in following sections. The results of physical properties of cement and sand shown in table 2 and table 3 respectively.

Table 5.1: Physical Properties of Cement

Sr. No.	Particulars	Requirements as per I.S. 12269:1987	Test Results
1	Fineness	Min 0.1	0.13
2	Initial Setting Time	Min 30 minutes	75 minutes
3	Final Setting Time	Min 60 minutes	380 minutes
4	Soundness by Le Chatelier	Max 10 mm	8 mm
5	Specific Gravity	3.15	3.15
6	Standard Consistency	-	29

Table 5.2: Physical Properties of Fine Aggregate

Sr. No.	Particulars	Test Results
1	Specific Gravity	2.80
2	Fineness Modulus	3.03
3	Water Absorption	0.45%

All cured specimens were tested in compression testing machine. The % volume of mesh reinforcement and specific surface of all the specimens were noted. Table 4 shows the results of compressive strength of ferrocement and bitumen ferrocement boxes of 70 x 70 x 70 mm size with various combination of wire mesh.

Table 5.3: Results of Compressive Strength

Sr. No .	Desig nation	Specific Surface mm2/m m3	Compressi ve strength	Compressive strength using Admixture
1	MCS	-	28.02	28.92
2	C1V	0.0131	31.57	32.09
3	E2V	0.0252	31.68	32.65
4	B1V	0.0131	38.98	39.46
5	B2V	0.0252	40.12	40.32
6	C1H	0.0131	28.76	29.37
7	E2H	0.0252	29.27	30.48
8	B1H	0.0131	29.02.	30.02
9	B2H	0.0252	29.58.	30.79
10	D1	0.157	27.08	27.89
11	BD1	0.157	27.97	28.25

The compressive strength increases for horizontal orientation in case of both single and double layer reinforcement, for vertical orientation in ferrocement and bitumen ferrocement with both reinforcement.

In case of diagonal orientation for bitumen ferrocement with respect to mortar control specimen compressive strength increases.

Compressive strength decreases for horizontal orientation of bitumen ferrocement. The horizontal orientation for bitumen ferrocement does not take much load in both cases.

The compressive strength increased significantly for vertical orientation in case of bitumen ferrocement as compare to mortar specimen control. It increased by 31.68 % and 32.85 % for single layer and double layers of reinforcement respectively.

For diagonal orientation it increased by 19.94 %.

In vertical orientation compressive strength increased by 17.58 % for single layer reinforcement as compare to single layer vertical oriented ferrocement and for double layer reinforcement it increased by 17.85 %.

Compressive strength increased by 25.85 % for bitumen ferrocement of diagonal orientation with respect to diagonal ferrocement.

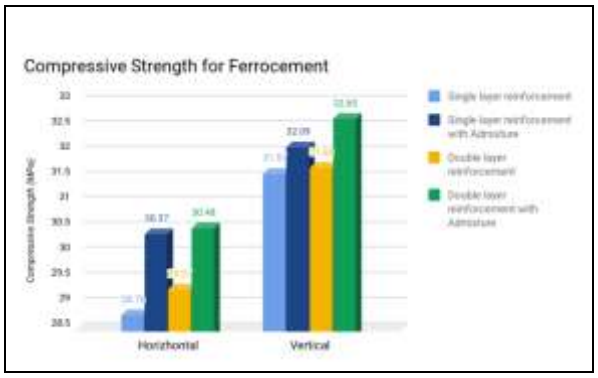


Chart 5.1 : Compressive Strength of Ferrocement

As number of layers increases the compressive strength of ferrocement increase is shown in chart 1 whereas chart 2 describes the compressive strength for bitumen ferrocement. It clearly shows that horizontal orientation does not take much compressive strength but vertical orientation gives significantly more compressive strength. Chart 4 and 5 gives the compression of compressive strength for ferrocement with bitumen ferrocement for horizontal and vertical orientation respectively.

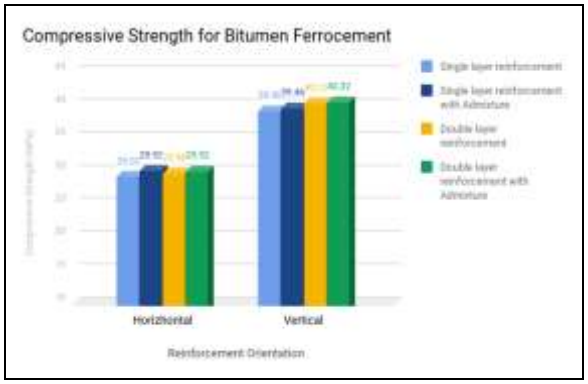


Chart 5.2: Compressive Strength of Ferrocement

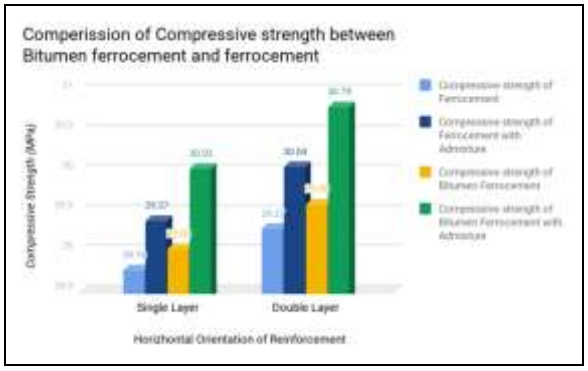


Chart -5.3: Compression of Compressive strength between Bitumen ferrocement and ferrocement

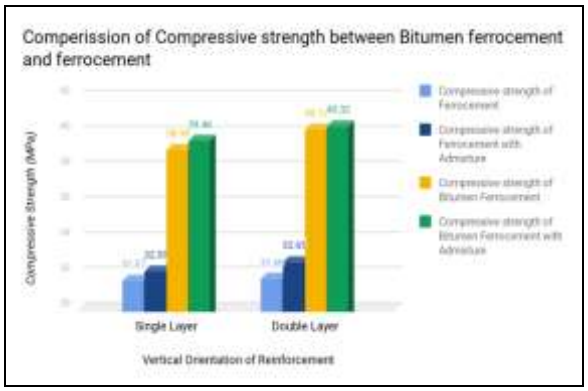


Chart -5.4: Compression of Compressive strength between Bitumen ferrocement and ferrocement

VI. CONCLUSION

In the present study the efficacy of ferrocement and bitumen ferrocement is studied with planned test program on cement mortar cubes with various combinations of mesh bitumen and admixture content. Compressive strength of ferrocement depends on the material used, percentage volume of reinforcement, orientation of reinforcement. Based on study following conclusions are drawn.

1) As number of layers of wire meshes increase, compressive strength of bitumen ferrocement also increases.

2) Vertical orientation in both cases (ferrocement and bitumen ferrocement) offers more compressive strength than horizontal orientation.

3) For vertical and diagonal orientation of bitumen ferrocement offers more compressive strength than same orientation of ferrocement.

4) Compressive strength of bitumen ferrocement also increases with adding admixture along with number of layers of wire meshes increases.

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[11] I. S. 383:1970 for Fine Aggregates.