To Increase Compressive Strength of Ferrocrete Block

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Abstract- *The purpose of this paper is to explore the effect of orientation of mesh reinforced cement on compressive strength of Ferrocrete. Ferrocrete involves the use of conventional cement with fine aggregates and several layers of steel, with the advantage of higher strength than conventional reinforced concrete, limited form work and thinner sections. In addition to basic statement on effect of orientation due to mesh reinforce cement on compressive strength of Ferrocrete , the report draws attention to crack pattern during failure , slowly and with plenty of warning of breaking of structure and strong bonding with in structure due to mesh reinforcement. This report must be considered preliminary. as new advances are made in the technology of Ferrocrete it is likely to became rapidly, absolute unless continually brought up to date.*

Keywords- Welded mesh, mortar, Ferrocrete block, compressive strength

I. INTRODUCTION

Ferrocrete is a versatile material of construction, which possesses unique structural properties. It is a composite formed with closely knit wire mesh tightly wound round skeletal steel and impregnated with rich cement mortar.
Welded mesh, mild steel angles or bars are used for forming skeleton, while chicken mesh, square mesh or expanded metal are used as mesh reinforcement. Mortar mix may be (1:1.5) to (1:4) by volume. With Ferrocrete it is possible to fabricate the variety of structural elements, may be used in foundations, walls, floors, roofs, shells etc. They are thin walled, light-weight, durable and have high degree of impermeability.
It combines the property of thin sections as well as it provides the strength of steel, mouldability of concrete, it is light-weight and provides ease of working, it has high tensile strength capacity of prestressed concrete and crack control. Ferrocrete needs no formwork or shuttering for casting.

Ferrocrete has converted the heterogeneous brittle material like RCC into a homogeneous, ductile, and composite. This is due to a small change of replacing steel bars by continuous meshes of fine steel wires. It has increased the bond between wires and mortar to such an extent that intension wires break but won't get pulled out of the matrix.Upto the yield point of steel, the steel and mortar remain bonded

Ferro-cement has achieved recent popularity as a withstanding construction technique and, as a result of some of its successful applications in construction, commercial builder have shown great interest. The popular list of advantages of Ferro-cement is long and the casual observer might well expect that Ferro-cement should replace all traditional technique in building construction. Of late, independent researchers have started to investigate the behavior of Ferro-cement. Basic material properties are being established in many parts of the world, however, rationalization of the reported information is difficult as methods of testing, type and size of sample, mesh configuration and degree of interconnection, preparation of mix, etc are not to generally agreed standards as no such standards exist. One can summarize the existing state of the art in Ferrocement as follows:

i) Methods of construction and techniques for providing good finishes have been developed to a high art.
ii) Inflated claims have been made for the advantages of Ferro-cement.
iii) Few standards exist for the fabrication of Ferrocement and its testing.

This state of affairs is rapidly changing as more interest is being shown by competent engineers, researchers and agencies for the rational development of Ferro-cement.

II. CHARACTERISTICS OF FERROCRETE

1.2.1 Increase in bond strength:

In RCC construction, the two ingredients, cement concrete and steel reinforcement share the load. The transfer of load from steel to concrete and vice versa takes place through bond between two materials. The bond depends upon the bond stress of concrete and the area of contact between the steel and concrete. The bond can be substantially increased if the contact area between steel and mortar is increased. In Ferrocrete it is achieved by use of small dia. Wires in place of steel bars. Increase in bond area will result in more adhesion between steel and concrete, making it behave more like a homogeneous material and which has become very strong intension due to increase ion bond. The bond increases to such an extent that in direct tension test, the Ferrocrete specimen fails by yielding of steel wires and not by cooling them out. Bond area increase by use of small wire is illustrated.

1.2.2 Dispersion of steel wire:

Ferrocrete is formed by tying together a no. of layers of continuous wire meshes. Volume of steel Per cent is very large, may be up to 8%. Also the mortar cover over the meshes is hardly 3-5 mm. Hence throughout the body of the composite, the wire reinforcement is fully dispersed. This leads ferrocrete4 to become more homogeneous. It results in improving the properties of Ferrocrete in tension, flexure, impact resistance and crack resistance.

1.2.3 Crack control:

Closely spaced fine wires, very near to the surface of Ferrocrete, act as crack arrestors. In conventional reinforced concrete the bars are spaced some distance apart and the concrete in between them is prone to temperature expansion and contraction. This tendency is overcome by the tension taking member fully bonded to mortar and spaced very to the surface of Ferrocrete.

1.2.4 Equal strength in both directions:

The continuity and placement of equal mesh reinforcement in both directions make Ferrocrete to achieve equal strength in two direction and become strong in resisting diagonal tensions due to shear.

1.2.5 Containment off mortar matrix in mesh layers:

In Ferrocrete, layers of wire meshes tightly tied together are impregnated with cement mortar. The matrix is held by the meshes in between and is contained by them. In RCC, steel bars are encased in concrete while in Ferrocrete layers of wire meshes encase the mortar and hold it bonded strongly. Thus there would not be sudden brittle failure of Ferrocrete element. In case of test up to failure or in the case of sudden shock loading like earthquake, the member will undergo large deflection with adequate warning.

1.2.6 Formless construction:

Tightly tied meshes in Ferrocrete can hold wet cement mortar when it is press filled in them. The consistency of cement mortar is very thick with very low water cement ratio. It won't out of the meshes. Thus casting of Ferrocrete does not need any formwork or shuttering. The other advantage of this aspect is that no honeycombing in press filling as the mortaring is done in front of your eyes.

1.2.7 Self quality conscious material:

If the mesh is tied loosely or water cement ratio is not maintained to thick consistency, or over sanding is, the mortar will flow down and will not be held by the meshes. Thus the Ferrocrete may be characterized as a self quality conscious material and will not allow less cement, more sand or more water in the mortar mix.

1.2.8 Strength through shape:

Ferrocrete structure is thin walled and may be hardly 25 to 50mm in thickness. Hence to take care of slenderness and buckling, Ferrocrete is shaped in different forms to achieve its strength.

1.3 RAW MATERAILS, SKILLS AND TOOLS

1.3.1 Ferrocement as a material of construction:

Ferrocrete is an ideal material of construction, as it gives maximum strength with the minimum energy input. It is really optimized material. It needs only three raw materials, only three steps of construction, only three types of skills and no special machinery for fabrication and casting.

1.3.2 Raw material in forming Ferrocrete structure:

This material is as follows:

a) Skeletal Steel in form of angles, steel bars, welded wire fabrics or pipes.
b) Steel Wire meshes for forming cages.
c) Rich cement mortar, as matrix in form of micro concrete.

1.3.3 Standard method of construction:

Steps in Ferrocrete construction are as follows:

i) Welding skeletal steel formwork. A skeleton of steel bars is welded to the exact geometrical shapes and sizes of the structure. This provides a rigid framework of the exact line, level and size.
ii) Tying mesh reinforcement tightly over it to form cage. Weld mesh and fine wire chicken mesh are tied over this welded skeleton. Tightly tying meshes' is the key point in Ferrocrete constructions
iii) iii) Impregnating the mesh cage with rich cement mortar, finishing and curing the stiff cement mortar is filled in the mesh layers by press fill method by using a vibro-press.

1.3.4 Skeletal steel:

As the name implies is generally used to give basic shape and size to the structure. If used only to give the form to the structure, the steel rods may be spaced wide apart, say even up to 500mm, when they are not treated as structural reinforcement. They also act as spacers to the layers of meshes. In highly stressed structures, where the skeletal steel acts also as reinforcement, its spacing will be as per the structural design of the structure. Steel size of 4 to 10mm dia. is generally used.

1.3.5 Skeleton of steel bars:

Steel bars are welded to form skeleton of the shape and size of the structure element. Spacing of bars may be 75x75 mm to 500x500 mm c/c both ways. Generally square grid pattern is adopted .

III. STEEL FINE WIRE MESH REINFORCEMENT

Fine wire mesh reinforcement is the most basic element of Ferrocrete, because it controls the specific surface, which is an important factor in design. The no. of layer if meshes, decided the thickness of composite. Three basic types of meshes are in use

a) Weld mesh
b) Fine wire mesh in form of woven square mesh and interlocked hexagonal mesh
c) Expanded metal
d) Crimped wire mesh

Sr No.	Sample	Type of Block	Orientation of Mesh	No. Of Layers	No. of Blocks
1.	Non-Reinforcement	Cube	NR	-	3
2.	Non-Reinforcement	Cylinder	NR	-	3
3.	Reinforcement	Cube	Horizontal	3	3
4.	Reinforcement	Cube	Horizontal	6	3
5.	Reinforcement	Cube	Vertical	3	3
6.	Reinforcement	Cube	Vertical	6	3
7.	Reinforcement	Cylinder	Spiral	3	3

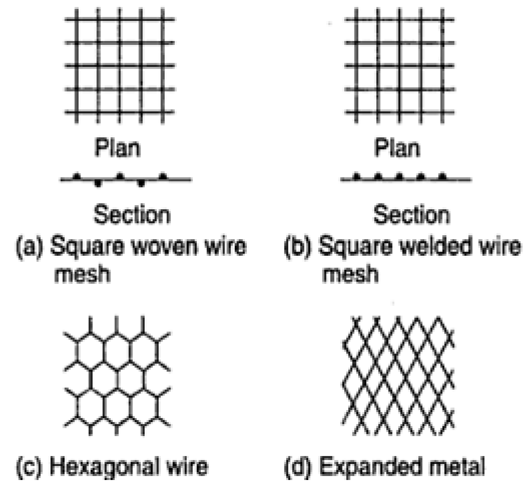


Figure 1.3.6.1: Mesh Configuration

IV. DESIGN ASPECT

Tests carried out on materials for Ferrocrete:-

1. Fineness of cement

Reference: IS 8112:1989 Specifications of Ordinary Portland cement 43 grade.

Table No. 3.8.1

Test	Results
Fineness of cement	4%

2. Standard Consistency of cement

Reference: IS 5531:1976 Specification for Vicat's apparatus.

Table No. 3.8.2

Test	Results
Standard Consistency of cement	32%

3. Specific Gravity of fine aggregate

Reference: IS:2386 (part III) – 1963

Table No. 3.8.3

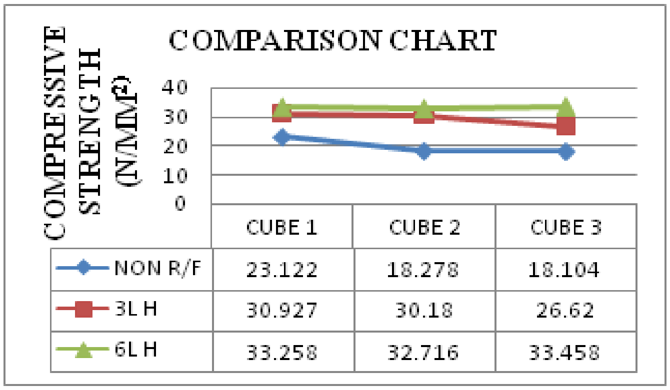
Test	Results
Specific Gravity of fine aggregate	2.4%

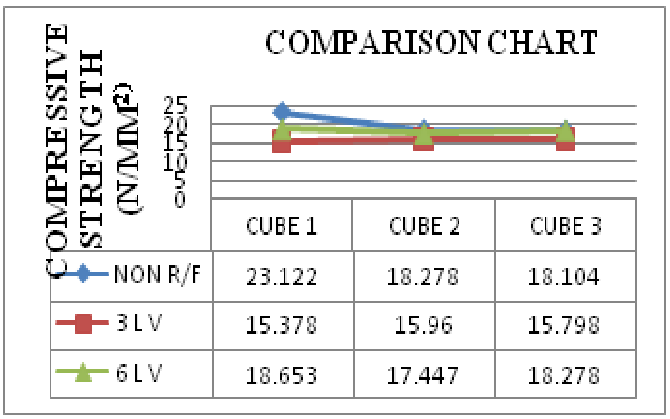
4. Surface moisture content of fine aggregate

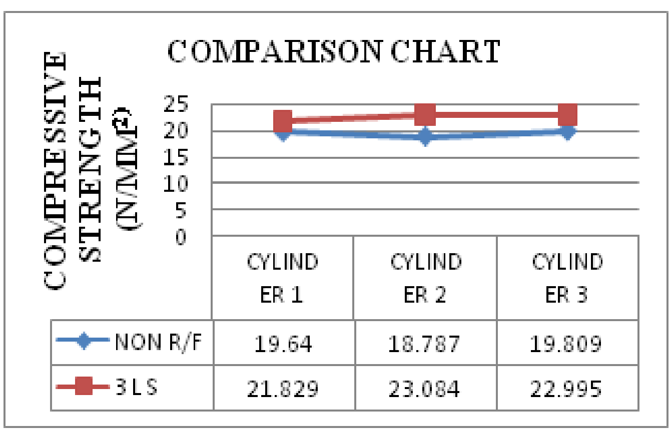
Table No. 3.8.4

Test	Results
Surface moisture content of fine aggregate	0.35%

V. RESULTS AND DISCUSSIONS







VI. CONCLUSION

Chart 1, it can be seen that, when the meshes are oriented horizontally, the compressive strength of the blocks is increased by **47.43%** when 3 meshes are laid if compared with non reinforced block. And when 6 meshes are laid **67.10%**increase in strength can be achieved if compared with non reinforced block.

From Chart 2, it can be seen that, when the meshes are oriented vertically, the compressive strength of the block decreases by **20.78%**when 3 meshes are laid compared with non reinforced block. And when 6 meshes are laid **8.61%** decrease in strength is occurs. The decrease in strength is due failure at cover.

From Chart 3, it can be inferred that, the strength of cylinder increases by **16.60%** due to spiral reinforcement. The failure in non reinforced blocks is sudden and the block bursts while in Ferrocrete the failure of block isgradual and there is no bursting. This can increase Evacuation time of building during any catastrophe.

State of this report It has been the intention of the report to illustrate some of the thinking, procedures and tests which will be necessary to rationalize the design of Ferrocement. There is too much information which is either not freely available or which requires development. On the other hand there is considerable information from other technologies which can be applied at this time. Continued revision and expansion will be necessary in the ensuing years to keep abreast of the technology for this material.

Potential Developments in Ferrocement

As indicated earlier, Ferrocement as it is presently constituted is a long way from being an optimized material. It can be expected that the material will evolve and the requirements for improvements will be: Lighter weight, better utilization of steel content before cracking occurs, improved impact resistance.

REFERENCES

[1] Divekar B.N. 'Ferrocement Technology- Developments in Pune region' Souvenir, Constro 87, Jan, 1987. Pune Construction Engineering Research Foundation, Pune (India)

[2] Morgan, Rowland G. Concrete (London) Vol. 2 No 3, March 1968, Pg No. 128

[3] Nervi, pier Luigi. 'Ferrocement, Its characteristics and potentialities' Library translation No.60, Cement and Concrete Association London. July 1956. Pg No. 17.

[4] National Academy of Sciences, "Ferrocement: Applications in Developing Countries", Washington, February, 1973.

[5] Romualdi, J.P., "Research Needs and the Future of Ferrocement", Ref.71, Pg No.173-177.

[6] ACI Committee 549, "State of the Art", Report on Ferrocement.

[7] Paul,B.K., and Pama, R.P., "Ferrocement" International Ferrocement Centre, IFIC Pub., August, 1978, Pg No.149.

[8] Alwash, A.A., "Flexural Characteristics of Ferrocement", M.Sc. Thesis, College of Engineering, University of Baghdad, Iraq, June, 1974.

[9] Naaman, A.E., and Shah, S.P., "Tensile Tests of Ferrocement", ACI Journal, Vol.68, No.9, Sept. 1971, Pg No.693-698.

[10] Logan, D., and Shah, S.P., "Moment Capacity and Cracking Behavior of Ferrocement in Flexure", ACI Journal, Vol.70, No. 12, December 1973, Pg No.799-804.

[11] Nathan, G.K., and Paramasivam, P., "Mechanical Properties of Ferrocement Material", First Australian Conference on Engineering Materials, Sydney, August 1974, Pg No.309.

[12] Rao, A., and Gowdar, C.S., "A Study of Behavior of Ferrocement in Direct Compression", Cement and Concrete Journal, Vol.10, No. 3, Oct.-Dec. 1969, Pg No.231-237.

[13] Cohen, L.D.G., and Kirwan, R.S., "Some Notes on the Characteristics of Ferrocement", Civil Engineering and Public Works Review, London, Vol.54, No. 631, Feb.1959, Pg No.195-196.