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Ferro Cement as a Cost Effective Alternative to RCC

[1]Ar. Laxmi Salgia, [2] Ar. Aparna Panganti
[1] Dr. D.Y.Patil College of Architecture, Sector 29, Pradhikaran, Pune 411044
[2] Dr. D.Y.Patil College of Architecture, Sector 29, Pradhikaran, Pune 411044
Email: laxmisalgia@yahoo.com , aparnapanganti@gmail.com

Abstract: ***Concrete and steel are the basic construction materials, which are being used with different concepts for construction such as RCC, Pre stressed and Ferro cement. Ferro cement is an innovative technology and has several advantages. This paper is an attempt to promote extensive use of Ferro cement components as an alternative to conventional concrete components for application in low-rise housing by doing a comparative study of cost analysis of Ferro cement and RCC.***

OBJECTIVE

- Studying the properties of Ferro cement
- Design methods and Fabrication
- Its advantages and limitations
- Comparative analysis of cost of construction including material and labor

I. INTRODUCTION

Ferrocement is a form of reinforced concrete that consists of closely spaced, multiple layers of mesh or fine rods completely embedded in cement mortar. It is a composite material that can be formed into thin panels, less than 1 in. (25 mm) thick, with only a thin mortar cover over the outermost layers of reinforcement.

II. APPLICATION OF FERROCEMENT COMPONENTS

a. Small capacity water tank
b. Roof , walls and staircase elements
c. Toilet component
d. Benches, Furniture, book store units etc.
e. Boats and water troughs
f. Soil retaining structures

III. PROPERTIES OF FERROCEMENT

- Has increased bond strength
- Can undergo large deformations before collapse
- High surface area imparts ductility
- Ferro cement more homogenous and improves the properties of tension, flexure, impact resistance and crack resistance.
- Closely spaced wires act as crack arrestors
- Equal strength in both directions

IV .CONSTITUENTS OF FERROCEMENT

1. Cement

The cement is fresh, uniform consistency and free from lumps and foreign matter. Generaly Portland cement of 43 or 53 grade is used.

2. Aggregate

Well graded and washed river sand passing 2.36mm IS sieve. Size of aggregate depends on size of mesh and spacing between mesh. For 13 mm mesh opening max size of aggregate 3.25mm, 1/4th its opening size. The fine aggregate should be clean, free from organic matter

3. Clean water

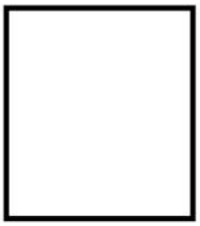
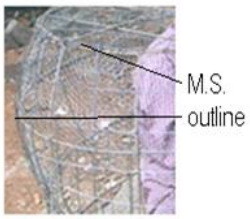
In Ferro cement, the water used should be fresh, clean and fit for construction purposes; pH equal or greater than 7 and free from organic matter

4. Steel

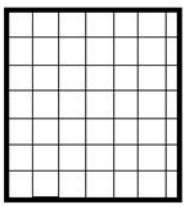
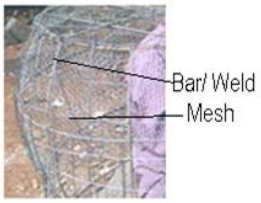
Three basic types of meshes are Weld mesh, Fine wire mesh in form of woven square mesh and interlocked hexagonal wire mesh, expanded metal and Crimped wire mesh

The steps in making a Ferro cement structure are

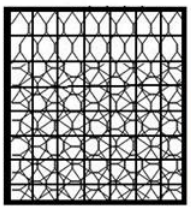
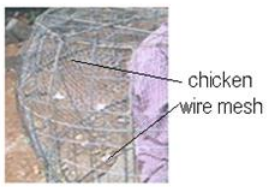
a. Planning the work
b. Fabricating Skeleton of the Structure

c. Tying the weld mesh and wire mesh to bars

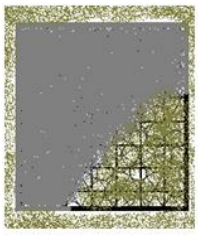



d. A chicken wire mesh layer is attached to this outline.

e. **Mortaring the meshes**

The mortar is to be applied under pressure into the layers of mesh in such a way as to impregnate and encase them completely.

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f. **Testing**

The wall panels constructed in Ferro cement are removed from tank after curing of 28 days. Testing was carried under UTM machine for flexure test.

Two Point Loading System

Next the panels were loaded UTM Machine for under two point loading and load and deflections

g. **Precautions about curing**

Though Ferro cement structures gain sufficient strength in one weeks' time, curing should be done for about 26 days.

V. ADVANTAGES AND DISADVANTAGES OF USING FERROCEMENT

Limitations

- The common causes of failure of ferrocement are steel corrosion and incomplete mortar penetration.
- The need of a casting space and working area to prefabricate the elements.
- The need for a properly applied curing method
- If the elements are not manufactured on the site transportation may add to the cost.

Advantages

- Given a large impact or point load, shell will deform and resulting in cracks, however structure will remain intact.
- Less use of cement and steel for any given section compared with RCC
- Reduction in self weight.
- Reduction in cost compared to RCC
- Requires only semi-skilled labor
- Requires neither scaffolding, shuttering, concrete mixer or vibrator
- High degree of impermeability and resistance to cracking
- Economical compared to components built with steel, concrete

VI. BOOK CASESTUDY

CASE STUDY 1 – ALL IN ONE FARM HOUSE BUILDING by Dr. B.N.Divekar

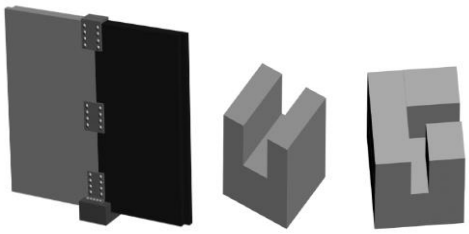
The built up area of the farmhouse is 111.60 sq.m

1. Materials of construction of walls, floor panels, beams and columns are the same.
2. Paneled cavity walls and box sectioned hollow floors reduce the dead weight of the structure to one third.
3. Ferro cement has high energy absorbing capacity, ideal for resisting earthquake forces.
4. Cavity walls and hollow floors provides insulation against sound and heat.
5. The material consumption and labor involved is reduced to large extent
6. Use of bricks, stones, aggregates, timber is eliminated.

CASE STUDY 2 - Low Cost Earthquake Resistant Ferro cement Small House by Saleem Asraf

It consists of Ferro cement panels placed side by side connected with steel plate fixtures using bolts. The panels are lightweight, which are easy to cast, transport and assemble. The system has been designed with the doit-yourself concept in mind. As the wall panels are thin therefore some suitable heat insulation sheets can be used to cope up with the winter conditions of northern Pakistan.

Size of House = 3.25m x 3.25m
Panel Size = 1.10m x 3.25m
Panel Thickness =25mm



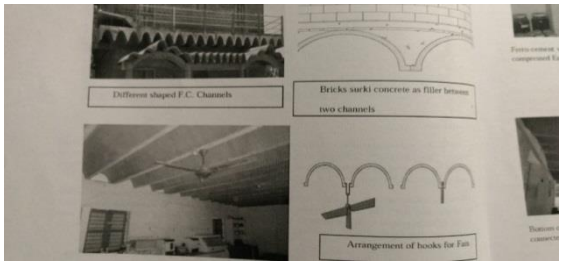
Panels with bolted connection details **Side and Corner Foundation Blocks**

Foundation is proposed as 300mm x 300mm pre-cast Ferro cement block with 150mm total thickness. It has a 75mm deep grove to accommodate Ferro cement panels.

The cost is roughly Rs 275/- per square foot

CASE STUDY 3 - GREEN BUILDING WITH FERROCEMENT By V. Ramakrishnan

- Roofing channel of different parabolic shapes
- Chicken mesh (22gauge soft) was used for one layer for entire section and another layer at the sides and at the center.
- Channels are of 35 ft length. 20mm MS rods were used at two sides and 6mm MS rod has been used on top to give strength..
- One layer of chicken mesh was used to join the channels as well as for avoiding the leakage
- Precast staircase with handrail
- All doors and window frames made in Ferro cement
- Circular shaped cost effective toilet has been constructed with Ferro cement channels.



Parabolic channels used in roofing

VII .LIVE CASE STUDY

CASE STUDY 1-Thermally Insulated House with Ferro cement All-in-One Technique Bhalerao farmhouse 150 sq.m

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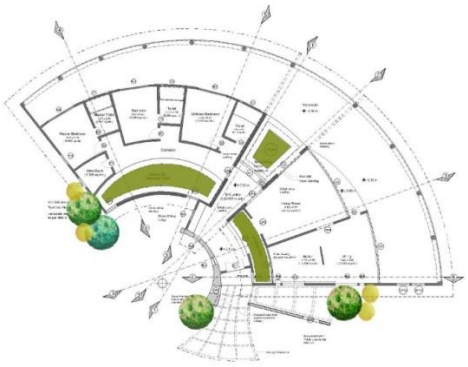
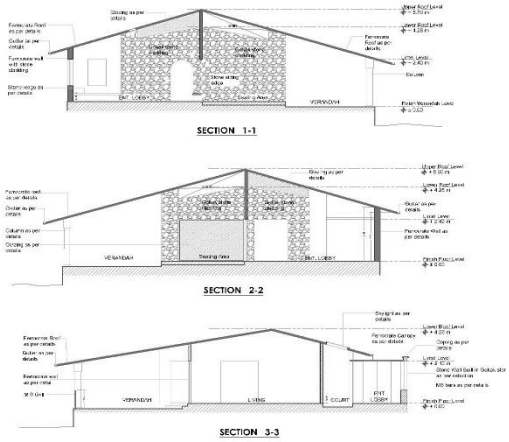


Ground Floor Plan of Bhalerao Farmhouse

The plan is complicated. The shape was geometrical. One side of sloping roof became frustum of cone while other side became sector of soccer. There are cut outs in the roof for light. These are of varying size and shape.
The roof and walls are done with Ferro cement. The slab is designed as grid slab. It is totally of 180 mm thickness. There are two layers of Ferro cement. Each one is of 40 mm thick and in between two layers there is Thermacoal of 100 mm thickness. The two layers are connected to each other by ribs. The ribs are placed at 1050 mm c/c. while the Thermacoal is of 1.0 m x 1.0m. size. All the ferrocement walls are resting on rubble masonry walls. R.C.C.

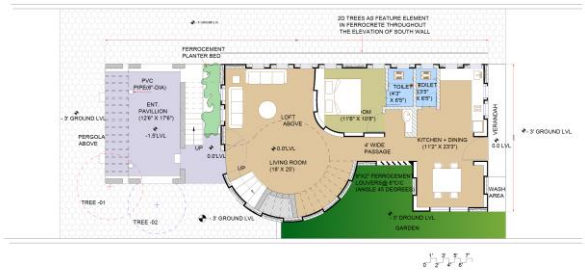


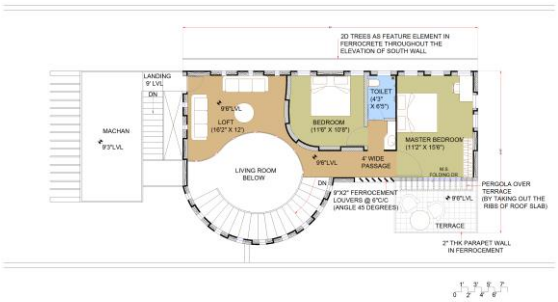
Section of Bhalerao Farmhouse

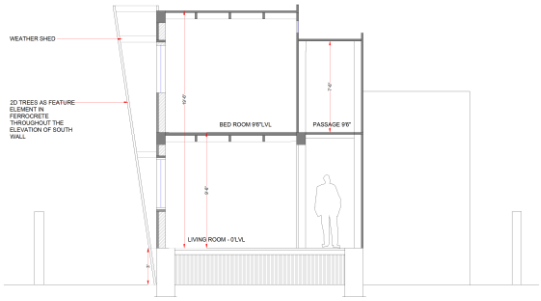
CASE STUDY 2 - NANDKUMAR JADHAV FARMHOUSE

It has niched cavity wall for thermal and sound insulation.
A 2" Ferro cement staircase, and ribbed slab. Total built up area 240 sq.m. It was constructed in a rural setting, which had shortage of labor and material. Strength has been achieved by niched wall.

- PCC in weld mesh
- UCR masonry (1.5' thk) for foundation and plinth
- Laying of steel in plinth beams
- Leaving out bars from plinth beam for wall of ground floor
- The reinforcement of walls of ground floor is assembled and welded at side, then placed at position and welded to the bars left out from plinth beams.
- Then weld mesh of 100mm x 100mm x11 gauge is tied to main reinforcement from outside
- GI Chicken mesh is fixed from inside and outside
- Rough casting of walls







Ground, First Floor &Section of Jadhav Farmhouse

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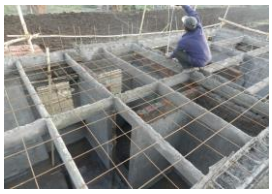

Niched walls and ribbed slab

VIII. DATA ANALYSIS

1. **Cost analysis of RCC Vs Ferro cement structure in Divekars Farmhouse 111.60 sq.m**

	CONVENTIONAL RCC			FERROCEMENT		
MAT.	QTY	RATE	AMT	QNTY	RATE	AMT
Brick	38000 nos	5/ brick	1,90,000	------	------	-------
Cement	565 bags	280/ bag	1,58,200	295 bags	280/ bag	82,600
Sand	53.80 Cu.m	1200/ cu.m	64,560	29.30 cu.m	1200/ cu.m	35,160
Metal	22.10 cu.m	600/ cu.m	9000			
Steel	2400 kg	48 /kg	1,15,200	2610 kg	48 /kg	1,25,280
Weld mesh	------	------	-------	550 sq.m	158 / sq.m	86,900
Chicken mesh	------	------	-------	1430 sq.m	36 /sq.m	51,480
Material cost 70%			5,36,960			3,81,420
Labor cost 30%			2,30,130			1,63,470
Total			7,67,090			5,44,890

NET SAVINGS IN TOTAL COST = Rs 2,22,200

2. Cost analysis of RCC Vs Ferro cement structure in Bhalerao Farmhouse 150 sq.m

	CONVENTIONAL RCC			FERROCEMENT		
Mat.	Qty	Rate	Amt	Qty	Rate	Amt
Brk	47,075 nos	5/ brick	235,375	------	------	-------
Cement	1250 bags	280/ bag	3,50,000	690 bags	280/ bag	1,93,200
Sand	70 cu.m	1200 /cu.m	84,000	90 cu.m	1200 /cu.m	1,08,000
Metal	30 cu.m	600 /cu.m	18000	------	-------	-------
Steel	3000 kg	48 /kg	1,44,000	2570 kg	48 /kg	1,23,360
Weld mesh	------	------	-------	1500 sq.m	158 / sq.m	2,37,000
Chicken mesh	------	------	-------	350 sq.m	36/ sq.m	12,600
Material cost 70%			8,31,375			6,74,160
Labor cost 30%			2,49,413			2,02,248
Total			10,80,788			8,76,408

NET TOTAL SAVINGS IS RS. 2,04,380/-

3.Cost analysis of RCC Vs Ferro cement structure in Jadhav Farmhouse 240 sq.m

	CONVENTIONAL RCC			FERROCEMENT		
Mat.	Qty	Rate	Amt	Qty	Rate	Amt
Brk	75,320 Nos	5 /No.	3,76,600	------	------	-------
Cement	2000 Bags	250/Bag	5,00,000	1100 bags	250/ bag	**2,75,000**
Sand	110 Cu.M	1200/Cu.M	1,32,000	141 cu.m	1200/cu.m	1,40,000
Metal	43.60Cu.M	600/ Cu.M	26,160	------	------	-------
Steel	4800 Kg	48/Kg	1,82,400	4100 Kg	48/Kg	1,96,800
Weld mesh	------	------	-------	2400 sq.m	158 / sq.m	3,79,200
Chicken mesh	------	------	-------	558 sq.m	36/ sq.m	20,088
Material cost 70%			12,17,160			10,11,088
Labor cost 30%			3,65,148			3,03,326
Total			15,82,308			13,14,414

NET SAVINGS IS RS 2,67,893

4.Cost Comparison of Labor in RCC and Ferro cement

LABOUR	FERROCEMENT	RCC
Mesh fitting+casting	25 / Sf	-----
Fabricating	25 / Sf	-----
Mortaring	60 / Sf	-----
Shuttering+Concreting	-----	120 / Sf
Brick work +plaster	------	75 / Sf
TOTAL	110 / Sf	200 / Sf

NET SAVINGS IN LABOUR + SHUTTERING = 90 / SF

5. Construction rate comparison per area

	WITH FINISHES	**WITHOUT FINISHES**
FERROCEMENT	Rs 1262/Sf	Rs 656/Sf
RCC	Rs 1800/Sf	Rs 1050/Sf
NET SAVINGS	RS. 538/ Sf	RS. 394 / Sf

IX.FINDINGS AND OBSERVATIONS

- No formwork, no bricks no stone aggregate, no door window frames are required.
- Foundation design becomes lighter and cheaper
- Plastering time is saved.
- Structures have good earthquake resistance.
- Almost 15% to 18% saving.

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- Lesser use of material
- More carpet area is achieved
- Less cracking.
- Less differential settlement.
- The structure is such that it will not break or crack or fall down, but will just warp or bend at its position.
- No special labor is required.
- Complicated shapes and design possible
- Strength is achieved through shape and not size

X. PROPOSALS AND RECOMMENDATIONS IN FERROCEMENT

1. Ferro cement technology can be used in all fields of construction including buildings, industrial structures, water retaining structures, earth retaining structures, space structures, precast concrete products
2. It is cost effective to use Ferro cement in low rise mass housing than RCC
3. Proposed where shapes are complicated and shuttering is not possible
4. Ideal for housing in earthquake zones.
5. Ideal for use in remote locations which has shortage of material and skilled labor.
6. Ideal for structures which require reduced load on foundation
7. Ideally used in areas which has shortage of material like brick, wood and stone aggregate.
8. Soundproof, heat proof and waterproof structure
9. Fabricate factory made modular panels

XI. CONCLUSION

Areas where there is labor shortage, complicated shapes and material shortage it is always cost effective to replace RCC with Ferro cement in low-rise buildings.

XII. AKNOWLEDGEMENT

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XIII.REFERENCES

i. *Ferrocrete Technology a construction manual by Dr. B.N. Divekar*
ii. *Ferro cement Super-Insulated Shell House Design and Construction-JAN LUGOWSKI*
iii. *Guide for Design, Construction and Repair of Ferro cement- ACI Committee 549*
iv. *State-of-the-Art Report on Ferro cement- ACI Committee 549*
v. *Low Cost Earthquake Resistant Ferro cement Small House -M. A. Saleem and M. Ashraf - Pak. J. Engg. & Appl. Sci. Vol. 2 Jan 2008*
vi. *Shah, S. P., "Ferro cement in Construction," Journal of the American Concrete Institute, May 1974.*
vii. *Vivekananda Kendra NARDEP- www.vknardep.org*
viii. *Ferrocement.com - www.ferrocement.com/*