

DESIGN OF RESIDENTIAL BUILDING USING FERROCEMENT TECHNOLOGY.

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Abstract – Ferrocement is a composite material made up of cement mortar and reinforcement in the form of layer of mesh. A composite material is a formed that behaves differently from reinforced concrete. There is some similarity between the reinforced concrete and ferrocement materials; differences are there, indicating that ferrocement requires a separate study to establish its structural performances. Ferrocement, a thin element, is used as a building construction as well as a repair material. This review from the past experience present the results of experimental and analytical studies on ferrocement members and bring out the salient features of construction, material properties and the special techniques of applying cement mortar on to the reinforcing mesh. This study brings out the importance of using ferrocement in swimming pools and water tanks, silos, corrugated roofs, slab panels, shell and dome structures by using available mechanized production methods and proper choice of reinforcements.

Keywords- Cement Mortar, Ferrocement, Wire Mesh

1.INTRODUCTION

Plain concrete has low tensile strength, ductility, and resistance to crack propagation. Flaws or micro cracks exist in the material even before any load is applied, because of its inherent microstructure and volumetric changes during manufacturing.

However, the present trends towards more economical designs, pressed for higher working stresses. Serviceability criteria become more critical than the strength consideration. The concrete technologist faced with the problem of improving the inherent weak properties of concrete in order to cater for the designer's requirements. A repair good improve the function and performance of structures, restore and increase its strength, provides water tightness and prevent against aggressive environment to steel surface durability .Corrosion of R.C.C structures takes

place in the main reinforcement in slab, beam and the stirrups, where cover is not provided well. To overcome such problem material having good properties has to search out. To encourage the search for new materials to partially replace reinforced concrete. It is under such circumstances that ferrocement, among other materials, has emerged. The reinforcement of ferrocement consists of several layers of relatively fine wire mesh packed together with or without steel bars in the middle. Cement mortar is used to fill the gaps between the meshes and provide the cover for the reinforcement.

1.1 Constrution procedure

The construction procedure of the ferro cement construction are different from regular building work.

Foundation

First excavation is done at a depth foundation and footing is a R.C.C structure of small thickness at the foundation ISA are provided and in between then M.S Flat bars are provided at a regular interval and chicken mesh are provided as a wrapping around it and cement mortar of specific ratio is applied. Earthwork is done inside it compaction was done and cement mortar is applied at the top.

Wall

Firstly from the foundation work the ISA angles are extended to the required height. Then in between these steel bars of 6mm or 8mm diameter are placed horizontally and vertically at a specific distance and a layer of weld mesh and some layer of chicken mesh are wrapped around and inside of this frame work. Then the cement mortar of desired grade is applied around it.



Fig. 1.1 frame work of wall construction.

Roof

The ferrocement roof comes mostly come precast. They come in two types in which one is inverted u shaped roof top. Inside of it there will be chicken mesh

layers and they are placed directly over the walls. The other one is small thickness precast ferrocement slabs with chicken mesh only inside it. They are placed above ferrocement beams of large and small dimensions which are placed perpendicularly. Then the gaps between the slabs are filled with cement mortar and chicken mesh layers are placed over it and cement mortar is applied over it.



Fig. 1.2 ferrocement roof tops.

2.OBJECTIVES

- To study ferrocement technology & its applications.
- To design a residential building using ferrocement technology
- To estimate the quantity used in this type construction.
- To find the material cost of this type construction.

3.METHODOLOGY

- Properties of ferrocement construction is studied.
- Properties of materials used in ferrocement technology is studied.
- A residential building is considered and different loads

acting on it which using ferrocement technology is calculated.

- The residential building designed according and its safety is checked.
- Estimation of the building is done.

4.CASE STUDY

4.1 Ferrocement Expansion Work

The site location is Poomala, Thrissur. The existing old structure is about 750sq feet. The foundation provided is rubble masonry of 0.6m foundation, the basement is about 0.45m. The brick used is regular red brick. The roof of the house is made of ferrocement structure, the is inverted u shaped precast roof of 0.05m

The expansion work is about 165 sq feet consisting of a bed room (3×3m), attached bathroom of (2.1×1.75m), a work area (1.5×1.75m). The foundation is made of ferrocement and R.C.C. The ferrocement wall is provided above the R.C.C raft foundation, raft thickness is about 60cm width and 10cm depth. The ferrocement foundation depth is same about the existing building. The ISA angle section used here is 35×35×5mm. between these ISA section M.S Steel bars of 20×6mm is provided at a spacing of 30 center to center distance. The chicken mesh of 0.5mm dia and 10mm openings is used. Two layer of chicken mesh is provided inside and one layer is provided inside. In the walls in between the ISA angle section 6mm dia steel bars is used at 30cm center to center horizontally and vertically. Chicken mesh is applied with two layer outside

and one layer inside along with one layer of weld mesh of 19 gauge. The cement mortar used here is 1:3 ratio. The roof top is of R.C.C. structure.



Fig.4.1.ferrocement expansion work

4.2 Multi-storied Building

The site location is Athani, Thrissur. The building is G+4 structure. The foundation is R.C.C raft foundation. The roof slabs are also of R.C.C. There are R.C.C columns provided as usual and also at the lift room area. All the partition walls are made of ferrocement. The steel rods used here are 8mm dia at a 30cm center to center distance horizontally and vertically. Chicken mesh of 0.5mm dia and 10mm openings is used which is provided two layers outside and one layer inside along with one layer of weld mesh of 19 gauge. The cement mortar used here is 1:3 ratio. The stair steps and landing are also ferrocement structure which comes as precast and directly installed at site.



Fig.4.2 ferrocement multi-storied building

4.3 Residential building

The site is located at mulakunathukavu, Thrissur. The building is a single storied structure fully constructed by ferrocement components. The building is about 1800 sq feet. The foundation is R.C.C raft foundation of 65cm width and 10cm thickness. The ferro cement of foundation is below 60cm from the ground level the basement height is about 50 cm. ISA angle section used is 35× 35×5cm and the M.S flat bar used is about 20× 6 cm. The chicken mesh used is 0.5mm dia and weld mesh used is 19 gauge size. The mix ratio adopted is 1: 3 with water cement ratio as 0.3. the steel bars used here is 6mm dia bar. The roof is ferro cement. The precast ferrocement beams are of sizes 10× 5cm and 2.5×2.5 cm which are placed perpendicularly to each other at a spacing of 40cm center to center distance. Above it ferro cement precast

slabs are placed, then pointing is done by the cement mortar and three layer of chicken mesh is placed above it and cement mortar is applied above it.



Fig.4.3 ferrocement residential building

5.DESIGN OF FOUNDATION

5.1 Plan of the building

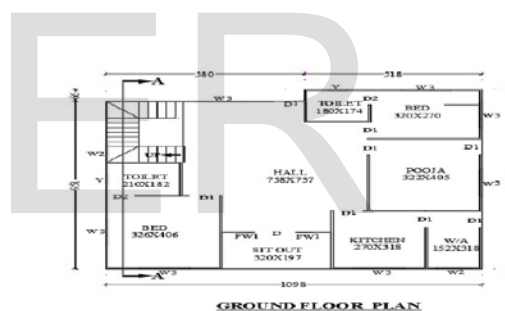


Fig.5.1 Ground floor plan

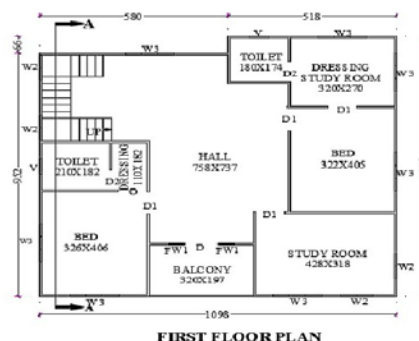


Fig.5.2 First floor plan

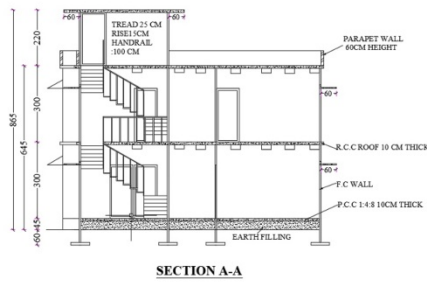


Fig.5.4. Section of a building

Slab is taken as one way slab

Also thickness of slab = 10 cm = 0.1m

Self weight of slab for 1m³ = volume x density

$$= (1 \times 1 \times 0.1) \times 20 = 2 \text{ kN/m}^2$$

Floor finish = (1 x 1 x 0.5) x 20 = 1 kN/m²

Live load = 2 kN/m²

Total load of slab per unit area = 2 + 1 + 2 = 5 kN/m²

-Tensile force on slab

Foundation is taken for the highest load of the slabs provided in our case highest load is acting in the roof of hall, since the area is more dead load will be high so considering hall.

$$\text{Tensile force} = 4.32 \times 7.42 \times 5 = 160.7 \text{ kN}$$

$$\text{Factored load} = 160.7 \times 1.5 = 240.4 \text{ kN}$$

Load for 1m of slab

$$\text{Self weight} = 1 \times 2.16 \times 0.1 \times 20 = 4.32 \text{ kN/m}$$

$$\text{Floor finish} = 1 \times 2.16 \times 0.05 \times 20 = 2.16 \text{ kN/m}$$

$$\text{Live load} = 2.16 \times 2 = 4.32 \text{ kN/m}$$

$$\text{Total load} = 10.8 \text{ kN/m}$$

$$\text{Factored total slab load} = 16.2 \text{ kN/m}$$

For wall

For Ground floor

$$\text{Height of wall + foundation} = 340.45 + 6.6 = 4.05 \text{ m}$$

$$\text{Load in 1m of wall} = (4.05 \times 1 \times 0.05) \times 20 = 4.05 \text{ kN/m}$$

For 1st floor

$$\text{Load 1m of wall} = (3 \times 1 \times 0.05) \times 20 = 3 \text{ kN/m}$$

$$\text{Total load from wall} = 7.05 \text{ kN/m}$$

$$\text{Factored load from wall} = 10.5 \text{ kN/m}$$

For foundation

Assume 60x10cm

$$\text{Self weight} = (0.1 \times 0.6 \times 1) \times 25 = 1.5 \text{ kN/m}$$

$$\text{Factored load} = 1.5 \times 1.5 = 2.25 \text{ kN/m}$$

For stairs and landing

Assume

$$\text{Riser} = 15 \text{ cm} \ \& \ \text{Tread} = 25 \text{ cm}$$

$$\text{Height between floors} = 3 \text{ m}$$

$$\text{ie; Total no of risers} = 300 / 15 = 20 \text{ Risers}$$

Three landing provided (u shaped)

$$\text{ie; Total no of steps} = 20 - 3 = 17 \text{ Steps}$$

$$\text{Size of room} = 2.1 \times 3.46 \text{ m}$$

Size of landing= 0.85x0.85 m

= 4.25 kN/m

To calculate no of steps in

Factored load = 6.3 kN/m

(a) First landing = $(2.1-0.85) / 0.25 = 5$ Steps

Total factored load of 2 landing = 12.6 kN/m

(b) Second landing = $(1.76/.25)= 7$ Steps

$(3.46-0.85-0.85= 1.76 \text{ m})$

ie; Total factored load of entire structure = 2 slab + foundation + wall = $2 \times 16.2 + 10.5 + 2.25 = 45.15 \text{ kN/m}$

(c) Third landing is same as of first landing.

ie; Total factored load of entire structure = 2 Stair + landing + wall+ foundation

Total no of steps = 17 Steps

= $2 \times 28.8 + 12.6 + 10.5 + 2.25$

For one step

= 82.95 kN/m

Dead load of step = $R/2 \times 20$

= $(0.15/2) \times 20$

Taking maximum load value

= 1.5 kN/m²

Depth of foundation by Rankines formula

Floor finish = 1kN/m²

$D = (q/w) \times [1 - \sin\theta / 1 + \sin\theta]^2$

Live load = 2kN/m²

Taking

Total load = 4.5 kN/m²

$\theta = 30^\circ$

= 4.5×0.25

q = bearing capacity = 150 KN/m²

= 1.13 kN/m

w = 20 kN/m²

Total factored load of one step = 1.7 kN/m

$D = (150/20) \times [1 - \sin 30 / 1 + \sin 30]^2$

D=0.83m

ie; Total factored load for 17 steps = 28.8 kN/m

Provided Foundation=0.45+0.6+0.1

= 1.15 m > 0.83m

Load of one landing

It is safe.

Dead load of one slab = $D \times 20 = 0.1 \times 20 = 2 \text{ kN/m}^2$

To find width of foundation

Finish load = 1 kN/m²

W= (Total load / bearing capacity)

Live load = 2 kN/m²

= $(82.95/150) = 0.55 = 55 \text{ cm}$

Total load = 5kN/m²

We provided 60 cm

= 5×0.85

It is safe.

6.ESTIMATION

Sl no	Description	No	L (m)	B (m)	H (m)	Quantity(m ³)
1	Earthwork in foundation	1	82.34	0.6	0.7	34.6
2	RCC work in foundation	1	79.09	0.6	0.1	4.74
3	Ferrocement work					
	(a) Foundation walls	1	78.69	.05	1.05	4.13
	(b) Ground floor walls	1	78.69	.05	3	11.8
	Deductions:-					
	Door D	1	1	.05	2.1	0.105
	Door D1	8	.9	.05	2.1	0.756
	Door D2	2	.8	.05	2.1	0.168
	Ventilator, V	2	1	.05	.4	0.04
	Window W1	2	.5	.05	2.1	0.105
	Window W2	2	1	.05	1.5	0.15
	Window W3	7	1.5	.05	1.5	0.788
						2.11
						11.8 -
						2.11 =
						<u>9.7</u>
	(c) First floor walls	1	78.74	.05	3	11.81
	Deductions:-					
	Door D	1	1	.05	2.1	0.105
	Door D1	4	.9	.05	2.1	0.378
	Door D2	2	.8	.05	2.1	0.168
	Ventilator, V	2	1	.05	0.4	0.04
	Window W1	2	.5	.05	2.1	0.105
	Window W2	4	1	.05	1.5	0.3
	Window W3	7	1.5	.05	1.5	0.787
	Opening	1	1	.05	2.1	0.105
						1.98
						11.81 -
						1.98 =
						<u>9.83</u>
	(d) Stair case top floor walls	1	11.56	.05	2.2	1.27
	Deductions					
	Door D2	1	0.9	.05	2.1	0.09
	Window W2	2	1	.05	1.5	0.15
						0.24
						1.27 -
						.24 =
						<u>1.03</u>
	(e) Steps					
	(i) Tread	17	.25	.85	.05	0.18
	(ii) Riser	20	.1	.85	.05	0.085
	(f) Landing	2	.85	.85	.05	.072
	(g) Roof slab ground floor	1	103.5		.1	10.35
	(h) Roof slab first floor	1	103.5		.1	10.35
	(i) Roof slab stair case room	1	8.02		.1	0.802

	(j) parapet	1	30.82	.05	.08	1.23
	(K) Roof beams (0.1x0.05)					
	Stair case room	10	1.78	0.1	.05	0.089
	Top floor and ground floor					
	Bed room	24	2.76	0.1	.05	0.33
	Toilet	14	1.32	0.1	.05	0.09
	Sitout	18	1.72	0.1	.05	0.15
	Hall	40	6.87	0.1	.05	1.37
	Kitchen	18	2.2	0.1	.05	0.198
	Work area	18	1.02	0.1	.05	0.091
	Pooja room	22	2.72	0.1	.05	0.29
	Bed room	18	2.2	0.1	.05	0.198
	Toilet	12	1.24	0.1	.05	0.07
						<u>2.87</u>
	(L) Roof beams (0.025x0.025)					
	Stair case room	4	3.02	.025	.025	.75x10 ³
	Top floor and ground floor					
	Bed room	16	3.56	.025	.025	0.035
	Toilet	8	1.6	.025	.025	8x10 ⁻³
	Sitout	8	2.7	.025	.025	0.013
	Hall	36	7.08	.025	.025	0.16
	Kitchen	12	2.68	.025	.025	0.02
	Work area	6	2.68	.025	.025	0.01
	Pooja room	14	3.55	.025	.025	0.031
	Bed room	14	2.7	.025	.025	0.023
	Toilet	8	1.24	.025	.025	6.2x10 ⁻³
						<u>0.0306</u>
4	Chicken mesh					
	Walls and foundation	3	219	7.05		4631.8 m ²
	Stair case room	3	10.66	3		95.4 m ²
	Roof slab floors	8	207			1656 m ²
	Roof slab of stair case room	8	8.02			64.16 m ²
	Steps and landing					
	Tread and landing	4	17.85	.85		60.69 m ²
	Riser	4	9	.85		30.6 m ²
						<u>6600 m²</u>
4	Weld mesh					
	walls	1	219	6		1314 m ²

5	Painting interior	2	117.3	3		703 m ²
	Painting exterior	2	42.04	3		252.2 m ²
						955 m ²

S l no	Description	No	L (m)	Total Length (m)	Wt of bar (kg/m)	Total Weight (kg)
6	ISA (35×35×5) mm					
	(a) Foundation	36	1.05	37.5	2.18	82.4
	(b) Ground floor	36	3.1	111.6	2.18	243.2
	(c) First floor room	36	3.1	111.6	2.18	243.2
	(d) Stair case room	4	3	12	2.18	26.16
						595kg
7	Steel rod 6mm dia					
	Horizontally placed					
	(a) Stair case room	10	10.6	106	0.22	23.32
	(b) Ground floor	10	75.9	759	0.22	166.98
	(c) First floor	10	75	750	0.22	165
	Vertically placed					
	(a) Stair case room	35	3.1	108.5	0.22	23.87
(b) Ground floor	253	3.1	784.3	0.22	172.5	
	(c) First floor	250	3.1	775	0.22	170.5
						723kg
8	M.S Flat bar (20×6)mm	263	1.05	276	0.94	260kg

7.MATERIAL COST

(i) The cement mortar ratio is taken as 1:3 and water cement ration is 0.3.

Quantity, Q = 1+3=4

Wet to dry ratio taken is 1.56.

Then,

The ratio of cement = (1÷4)×1.56= 0.39 per m³

For 51m³ ratio of cement = 51×0.39 = 19.8m³ ~ 20m³

Wt of 1m³ of cement = 1440kg

Then, for 20m³ wt of cement = 20×1440= 28800kg

1 bag cement = 50kg

ie;

Number of bags = (28800÷50)= 576 bags

Rate of 1 bag cement= 410 rupee

Total cost for cement = 2,36,000/- Rupees

(ii) Ratio of fine aggregate = (3÷4)× 1.56=1.17 per m³

For 51m³ ratio of fine aggregate = 1.17 ×51= 59.67m³ ~ 60m³

For M sand rate = 62 rupee per cubic feet

1 m³ = 35.31 cubic feet

So 60 m³ = 2118.8 cubic feet ~ 2120 cubic feet

For 2120 cubic feet M sand cost = 131440/- Rupees

(iii) Cost of 6mm diameter bar = 62 Rupee per kg

ie;

Total cost of 6mm diameter bar = $62 \times 723 = 44800/-$ Rupees

(iv) Cost of M.S Flat bar (20 × 6)mm = 57 Rupee per kg

ie;

Total cost of M.S Flat bar (20 × 6)mm = $57 \times 260 = 14820/-$ Rupees

(v) Cost of ISA angle section = 42 Rupee per kg

ie;

Total cost of ISA angle section = $42 \times 595 = 24990/-$ Rupees

(vi) Cost of one roll chicken mesh (L=3m,H=0.8m) = 460/- Rupees

Number of chicken mesh roll required = $(6600 \div (30 \times 0.80)) = 275$ rolls

Total cost required for chicken mesh = 126500/- Rupees

(vii) Cost of one roll weld mesh (L=15m,H=1.5m) = 2500/- Rupees

Number of weld mesh roll required = $(1314 \div (15 \times 1.5)) = 59$ rolls

Total cost required for weld mesh = 147500/- Rupees

(vii) Cost of painting = 21 per m²

Total cost for painting full structure = 20055/- Rupees

The total material cost for the entire structure is 716050/- Rupees

8.RESULT AND DISCUSSION

Total factored load in the structure is 82.95 kN/m. The foundation provided is 60 cm in width and a depth of 1.15m. The total material cost for the entire structure is 716050/- Rupees. Safety of the structure is checked and all the components are designed using ferrocement technology

9.CONCLUSION

Ferro cement technology is very suitable to design the residential building. We designed a residential building which all components using ferrocement, It is economic compared to R C C and fire resistant. Hence this can be adopted in future.

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