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" To Overcome Construction Industry Obstacles using Ferrocrete for Time and Cost Analysis"

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Abstract—
It's a lightweight construction material made up of tiny portions of cement mortar strengthened by many layers of steel wire mesh positioned closely together. Ferro-cement is widely used in the building sector due to its low self-weight, lack of trained labour, and lack of formwork. Ferro-cement is commonly used in structural repair, strengthening, and retrofitting.
Hexagonal wire meshes, welded wire meshes, woven wire meshes, expanded metal meshes, and three-dimensional meshes are all employed in Ferro-cement. A multi-layered chicken wire construction can be used to create the desired shape, which can then be reinforced with steel wire or steel bars if necessary. A suitable mixture of cement, sand, and water is spread over the completed framework. The Ferro-cement is kept moist throughout hardening to ensure that it sets and hardens properly. In comparison to R.C.C., the quantity of Ferro-cement used in building construction is substantially less. As a result, using ferrocement wall we can save 16% in cost compared with conventional brick wall and 30% of cost reduction using ferrocement roofing over RCC flat roof slab.

Keywords— Ferro-cement, wire mesh, Brickwork, lightweight, low self-weight.

1. INTRODUCTION

Ferrocement may well be a skinny slab of cement mortar reinforced with wire mesh. Ferro-cement may be considered a sort of thin ferro concrete construction which consist of large amounts of small-diameter wire meshes that are used uniformly throughout the cross section rather than discretely placed reinforcing bars and within which hydraulic cement mortar is employed rather than concrete. Metallic mesh is the most typical style of reinforcement. Meshes manufactured from alkali-resistant glass fibres, and woven fabric made from vegetable fibres like jute-burlap and bamboo, have also been tried as reinforcement. The ferrocement sections thickness may vary from 10mm to 40mm. It requires minimum of skilled labour and utilizes readily available materials for construction.
The mesh is produced from steel or various appropriate materials to come up with parts of little thickness, resilience and excessive robustness, and rigidity and high strength are accomplished once correctly shaped. Ferro-cement is believed to be one in every of the distinctive techniques of construction that are now used throughout the world. it's the cement material manufactured from tightly spaced mesh layers within which the reinforcement is provided evenly throughout the fabric of Ferro-cement making it ductile from fragile. Ferro-cement encompasses a high strength and serviceability that acts as an artifact for several purposes. Compared to RCC, it functions as a homogeneous material having comparable characteristics all told directions. The mesh extent in Ferro-cement is extremely large, which enables the mortar to properly bond with it, leading to lesser cracks, exhibiting greater durability due to the identical. It also incorporates a much greater lastingness and rupture module that helps to avoid cracks. Similar skinny artifact offers characteristics that don't match Ferro-cement's characteristics like strength, toughness, water tightening, lightness, and sturdiness. Ferrocement is defined as 'Cement mortar strongly bonded and encased in layers of fine wire meshes making it a homogeneous and ductile composite'.[1] consistent with Naval Ship R&D Center, 'Ferrocement contains several layers of wire mesh reinforcing mortar of sand and Portland cement'.[2]

Figure 1 Typical cross section of ferrocement structure

1.1 Constituents of Ferrocement

The constituents of ferrocement includes thick cement mortar planned as per the quality mix design procedures for mortar and concrete which incorporates cement, sand, wire mesh, water and admixtures.
Cement: The cement to use is sometimes ordinary Portland cement. However, rapid hardening hydraulic cement could also be employed in cold climates. Sometimes a sulphate resistant cement is employed, either wholly or partly mixed with ordinary Portland against sulphate attack. If the cement is employed with admixtures, care should be exercised in compatibility.
Water: Water should be potable, clean, and free from harmful salts or foreign materials which can impair the strength and resistance of the mortar.
Fine Aggregates: The importance of excellent, clean, well graded sand can't be over emphasized if one is to create the high-grade impervious mortar required.
Skeleton steel: it's provided to supports the steel wire mesh. the dimensions of Skeleton steel are generally 6 to 8 mm of Fe 500 bars were used.
Wire mesh: Consists of galvanized steel wires of diameter 0.5 to 1.5 mm, spaced at 5 to 20 mm center to center welded wire mesh has openings either hexagonal or rectangular
Admixtures: admixtures are could also be utilized in ferrocement for improvement in impermeability, water reduction, air entrainment, which increases resistance to thawing and freezing.

1.2 Related Work

“Ferro cement is a type of thin wall reinforced concrete construction where usually hydraulic cement is reinforced with layers of continuous and relatively small diameter mesh”.

Joseph Aspdin introduced to the world Portland cement and patented it during 1824.Subsequent developments in material, higher burning temperature, continuous process rotary kiln etc., drastically improved the material and reduced the cost. A spate of buildings erected from 1835 onwards was of concrete but the concept of reinforcing the material was hardly around this period (John E Morgan 1998).

It was in the middle of the 19th century when the Frenchman Joseph-Louis Lambot came up with an idea that was to become ground-breaking for concrete as a building material. By combining steel and concrete, he was the first to produce a watercraft in concrete construction. The way there was marked by countless attempts. At the family home in Miraval in southern France, Joseph-Louis Lambot first began to produce concrete barrels or containers with steel inserts

There was very little application of true ferrocement construction between 1888 &1942 when Pier Luigi Nervi began a series of experiments on ferrocement. He observed that reinforcing concrete with layers of wire mesh produced a material possessing the mechanical characteristics of an approximately homogeneous material capable of resisting high impact. After the Second World War Nervi demonstrated the utility of ferrocement as a boat building material.

Sr. No.	Title	Author /Publication	Detail of Paper
1.	Study on performance of prefabricated Ferro- and technology	Lakhan Murari and Elson John IJERST (2016)	• In this paper they studied about performance of fabricated Ferro-cement column and wall panels. • It was concluded that the prefabricated Ferro-cement columns and wall panels may be used for the construction of low-rise buildings and it is also cheaper compared to RCC elements of similar size.
2.	Ferro-cement Construction Technology and its Applications-A Review	A.S. Burakale, P. M. Attarde, Mayuri D.Patil IRJET (2020)	• This is only a review study and experimental research on new building materials for use in Ferro-cement construction or combinations of meshes and fibres are needed. The standard methods of Ferro-cement construction and effect of shape due to which novel forms are generated have to be researched upon and benefits brought out. • This study recommends Ferro-cement as the best alternative material to RCC and also a construction material of the future due to its properties/ advantages. And also recommended that Ferro-cement also use for repair work.

Sr. No.	Title	Author /Publication	Detail of Paper
3.	Ferro-cement an effective alternative for construction industry	Kavita V. Desai and Dr. Deepa A. Joshi IJIET (2015)	• Ferro-cement application started with boats and now, various structures such as building, retaining wall, swimming pools, water tanks, domes, corrugated roof, etc. are being built with it. Ferro-cement has another important advantage of reduction in CO2 emission. For sustainable development and prevention of environment, this feature of Ferro-cement, makes it more suitable for construction.
4.	Study and Cost Analysis of Ferro-cement Panel for Affordable Housing	Ganesh A. Choughule And N. N. Morey Journal of Basic and Applied Engineering Research, Volume 3, Issue 10 (2016)	• Result shows that panels with more no of layers having higher flexural strength and less deflection compared with panels having less no of layers of mesh and construction of Ferro-cement structure is rapid and economical as compared with conventional material for affordable housing.

1.3 Problem Definition

The use of Ferro-cement and their factors affecting the construction sector in India not so much data available for study.
This study attempted to determine how much profit and efficiency of construction projects could be increased using Ferro-cement. This study also explored and evaluated differences between constructions in India, by analysing the traditional material like RCC over Ferro-cement. We reduce the cost and get more benefits using Ferro-cement.

1.4 Aims And Objectives

The main aim of this study is analysis of cost saving using Ferro-cement in comparison with reinforced cement concrete.

- To compare the costs of ferro-cement and rcc construction projects in order to discover any price discrepancies.
- To investigate the environmental factors affecting ferro-cement and determine the time required to finish a project utilizing ferro-cement material and rcc.
- Specific construction wastes should be linked to waste generated by the construction industry, using ferrocement materials.
- To study Effect on total project cost and benefits using Ferro-cement material.

2. METHODOLOGY

Research Methodology will be designing a questionnaire survey by which we can find out the factor affecting the construction cost which directly related with material use in construction projects.

2.1 Formation of questionnaire

For this particular project, a questionnaire survey approach has been adopted to find the impact of various factors affecting the cost of project. The design philosophy of the questionnaire was based on the fact that it had to be simple, clear and understandable for the respondents and at the same time it should be interpreted well by the researcher.

2.2 Through literature survey

It has been seen that a significant amount of research has already been done in perspective of structure. The use of Ferro-cement and their factors affecting the construction sector in India not so much data available for study. And hence, preliminary research through various literatures throughout the globe led to the formation of a preliminary list consisting of factors affecting the project cost and time.

2.3 Through preliminary survey of the sites

After recognizing the basic factors through the literature survey, preliminary survey of various sites led to the understanding the nature and relative importance of those factors in the Indian working conditions. The survey co-related the effectiveness of

global factors with respect to the Indian sites and also gave us and practical insight adding a few more factors, though they are area specific.

2.4 By talking to local experts

Due to varying environmental, social and economic changes, the effectiveness of the factors may also vary over the period of time, and due to the time constraint of the project, it's not feasible to cover all the aspects. And hence by talking to local experts, who are equipped with the practical knowledge of the situation, information required to verify the importance of a particular factor with respect to Indian working conditions can be achieved.

And hence, the factors affecting the construction cost and time were identified through the literature based on previous research, site survey and with input, revision and modifications by local experts.

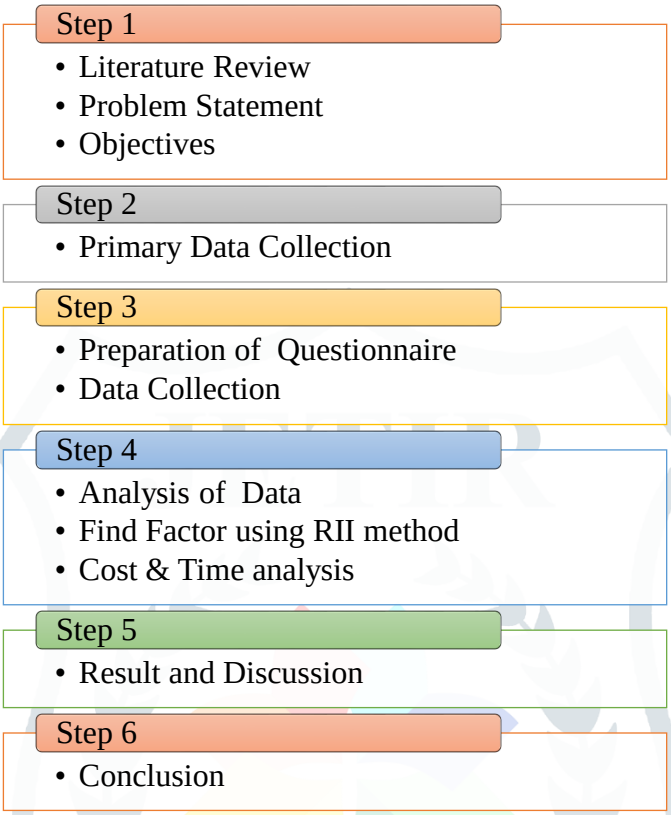


Figure1: Methodology chart

3. FERROCEMENT CONSTRUCTION PROCESS

Making skeletal frame and placement of wire mesh:

The Ferro-cement structures were fabricated in the Concrete and Material Testing Laboratory. As per dimensions of the structures, the amount of longitudinal and transverse steel was calculated for various segments. After all the steel has been cut to the required length, the skeletal frame was constructed according to the shapes of the structures. Welding was used to connect between steel bars. Following the shape of the structures, two layers of wire mesh - one inside and one outside of the steel frame, were placed and tied with steel wire maintaining the thickness as minimum as possible.

Preparation of mortar:

It is utmost important that the mixing of mortar should be done in such proportions as to give consistently the desired strength. The proportion of cement to sand generally varies from 1:1.5 to 2 parts of sand by weight. The proportion of cement to sand by weight used in the mix was 1:2. The water-cement ratio used was in the order of 0.5 depending upon the dryness of the sand. In the mixing process, sand and cement were firstly mixed uniformly. Water was added part by part in order to obtain required workability of the mortar mix.

Plastering:

The strength and durability of a Ferro-cement structure largely depend on the plastering work. Before plastering a structure, it was ascertained that the reinforcing rods and wire meshes were in proper position; and all the reinforcement was brushed off if there were rust, grease or any other contaminants. The plastering technique employed here was a one-stage method that refers to a single monolithic application of mortar to fill up the wire mesh, finishing both inside and outside surfaces at the same time before the initial set of cement has taken place.

For stiff mixes, mortar normally remains in position after placing. For straight and vertical structure like canal/drain lining, plank of wood was used.

Curing:

The objective of curing is to keep the mortar saturated and to promote the hydration of cement. There are several methods of curing of which moist curing i.e., covering the structures by wet jute mats was followed for about one week.

Roofing Applications

The mould made of steel is lightly coated with waste engine oil. After those newspapers are laid on mould. the entire amount of mortar required is ready with ratio of water/ cement/ sand as 0.45:1:2 the primary layer of mortar mix is applied on top of the mould already coated with waste engine oil and newspaper. This mortar mix is evenly opened up over whole surface of the mould. The prepared steel and mesh frame is placed on the primary layer of cement mortar. The second and final layer of cement mortar is applied over the steel and mesh frame. Several irregular lines are made on the lower portion of either side of roofing channel so as to facilitate the bonding process with the concrete mix while joining the channel together. If the channel is employed as roof, some final polishing is completed with the mason's trowel. this is often not necessary just in case roof channel is employed as floor or filled up for warmth insulation. After the casting of the channel, it is left for four days on mould. The demoulding of the roof channel is completed after 48 hours. this purpose, the specially made small gaps within the bottom of the mould for a simple grip during the demoulding. A curing period of minimum 7 days to maximum 10 days is usually recommended. The channels are placed next to every other and also the valley between these channels is full of concrete mix 1:2:4 and finishing is completed. Proper curing practice or method should be applied a minimum of 7 days since the structure must function as roof, proper curing of the joined channels is that the most vital

Ferrocement Confinement

Ferrocement confinement is done around defective circular or square/rectangular RCC columns in order to enhance the strength, ductility and energy absorption capacity of existing concrete columns. A jacketing layer of 30 mm is created around the RCC columns with ferrocement is done in order to increase its load carrying capacity.

This confinement work also protects the existing reinforcement, provides water tightness and prevents ingress of the aggressive species to the surface of original concrete or steel surface. Ferrocement not only increases the performance/ function of structures but also enhances the appearance of the existing RCC structure. The repair in the structural elements using ferrocement can withstand for long years without cracking provided the mortar used is of proper proportion using good quality materials, and the wire mesh is of anti-corrosive coating type.

Properties of Ferrocement

Ferro cement is a type of a reinforced concrete haring large amount of smaller diameter wire meshes are needed, these wires are metal wire and sometimes other type of suitable material can be used sand, cement, mortar mix and quantity of reinforcing material decide the strength of ferro cement.

- It is very Durable, Cheap and versatile material.
- Low W/c Ratio produces an impermeable structure.
- Less Shrinkage and low weight.
- High Tensile strength and stiffness.
- Better impact & punching shear resistance.
- Undergo large deformation before cracking or high Deflections.

Cement: Some Of The Properties Of The Cement Are:
Specific Gravity = 3.15, Standard Consistency =34%, Initial Setting Time = 40mins Compressive Strength = 52.16 N/Mm2

Fine Aggregate: Fine Aggregate Used Are Passing Through 4.75 Mm Is Sieve with A Specific Gravity Of 2.62

Chicken Mesh: Galvanized Chicken Wire Mesh with A Hexagonal Opening of Size 12mm And a Wire Thickness Of1.29mm Is Generally Used.

Water: Potable Drinking Water Was Used for Mixing and As Well As for Curing Other Constituent Elements Are as Follows:

Steel – Generally the Diameter of Steel Used Is From 3 Mm To 10 Mm but Generally 6 Mm Diameter Steel Is Most Commonly Used.

Binding Wire – Binding Wire Of 18 To 24 Gauges Is Used.

Admixtures – For Increasing the Workability, Minimizing Water Use and Reducing the Setting Time of Cement Admixtures Are Added.

Equipment Required for Ferrocement Construction

- Nails
- Hammer
- Plumb Bob
- Misplace
- Steel Cutter

- Chisel
- Wire Brush
- Spade
- Shovel
- Sieve
- Wheel Barrow

Ferrocement as Sustainable Construction Materials:

The low material cost, labor intensity and semi-skilled labor requirements make ferrocement is the most promising alternative materials for housing. The constituent materials of ferrocement are easily available and are quite inexpensive. The fabrication technique of ferrocement is quite easy and common people could be trained in a short time to learn the skill. Advantages of ferrocement as a construction material may be summarized as follow:

1. Very high-quality control.
2. Easy production and installation.
3. Shading devices to provide shading and day lighting to the building (use light weight and low-cost environmental element).
4. Fast construction.
5. Manpower can be easily trained at site.
6. Improved structural performance.
7. Less maintenance.
8. Reduction in dead weight, 50-75% lighter than conventional techniques.

4. CASE STUDY

Structure Type: Residential Building Construction
Construction Type: Ferrocement house
Name of the project: Meerai, Nigdi, Pimpri Chinchwad
Location: Nigdi, Pimpri Chinchwad
Completion period: 8 Months
Construction Type: Ferrocement panel
No. of Floor: Ground only
Contractor Name: Mr. Nitin Tilekar
Authority Engineer: Mr. Arun Purandare
Local Authority: Pimpri Chinchwad Municipal Corporation, Pune

QUESTIONNNAIRE SURVEY:

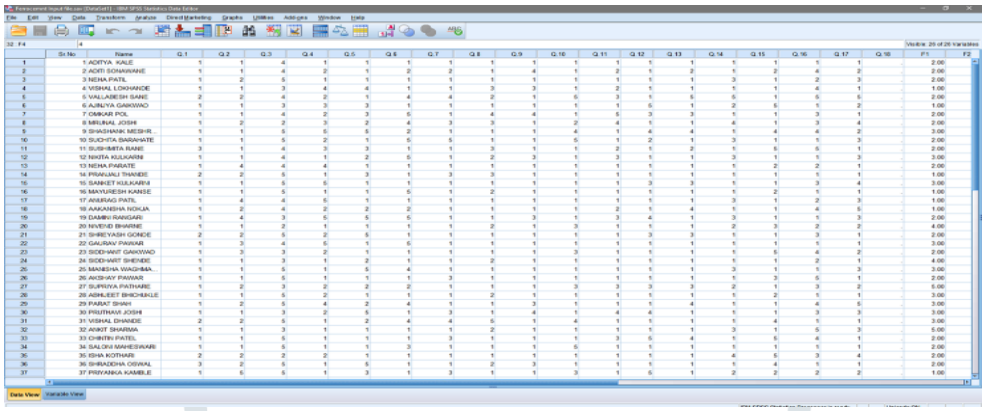
1. Name
2. Designation
3. Gender
4. Email
5. Your position
6. Experience
7. Phone number
8. Do you believe that using ferrocement structure are sustainable structure?
9. Will the Ferrocement structure be environment friendly as it requires much less quantity of cement and steel?
10. Will ferrocement have negative impact on environment compared to RCC?
11. Will the compressive strength of ferrocement be higher than that of typical construction concrete?
12. Are ferrocement structure more durable then RCC structure?
13. Do you think ferrocement consume less energy during construction?
14. Are the materials locally available for construction of ferrocement?
15. Do you think ferrocement is good alternative to RCC when there is high inflation?
16. Does poor labour management contribute to project delays?
17. Do you think poor productivity of labour will have impact on ferrocement construction?
18. Do you believe the project team members are experiencing a lot of uncertainty?
19. Do you believe low quality of material will have an impact?
20. Does a using precast ferrocement panel further reduce the project costs?
21. Does poor material management have an impact on the total project cost and time to completion?
22. Will the use of recycle and reused material reduce the cost of the project?
23. Will the easy of formwork and casting of ferrocement is main factor for usage of ferrocement?
24. Does ferrocement structure have less CO2 emission compared to RCC Structure?
25. Following are the type of waste generated in construction, for ferrocement which waste is generated that have impact on environment?

(Rate according to, 1= Highly Impact, 2= moderate impact, 3= Less impact, 4= little impact, 5= No Impact)

a. Cement Mortar.
b. Steet
c. Wire Mesh
d. Dirt/Earth
e. Paper and Rubber
f. Misc. Waste

SPSS Software Analysis

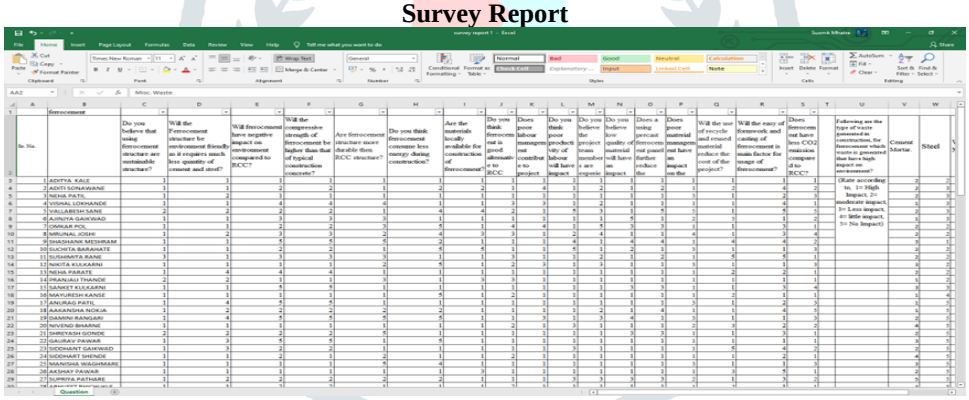
Analysis of the questionnaires survey was done using IBM SPSS Software. SPSS Statistics is a software package used for statistical analysis. The software name originally stood for Statistical Package for the Social Sciences (SPSS), reflecting the original market. It is a Windows based program that can be used to perform data entry and analysis and to create tables and graphs. It is capable of handling large amounts of data and can perform all of the analyses covered in the text and much more.



RII Analysis

Formula: ∑W= 5 x n5 + 4 x n4 + 3 x n3 + 2 x n2 + 1 x n1/ (A x N)

Survey Report



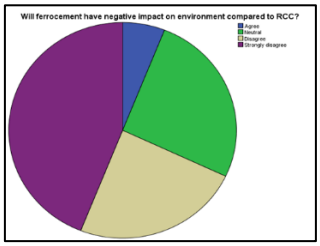
SPSS Results:

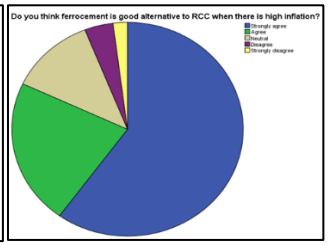
Will ferrocement have negative impact on environment compared to RCC?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	3	6.0	6.0	6.0
	Neutral	13	26.0	26.0	32.0
	Disagree	12	24.0	24.0	56.0
	Strongly disagree	22	44.0	44.0	100.0
	Total	50	100.0	100.0	

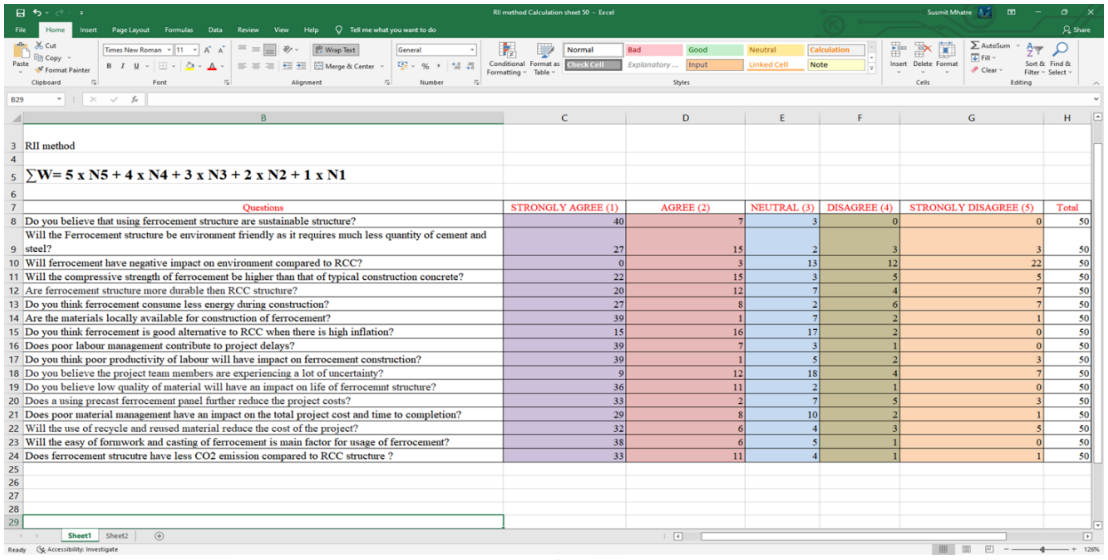
Do you think ferrocement is good alternative to RCC when there is high inflation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	15	30.0	30.0	30.0
	Agree	16	32.0	32.0	62.0
	Neutral	17	34.0	34.0	96.0
	Disagree	2	4.0	4.0	100.0
	Total	50	100.0	100.0	





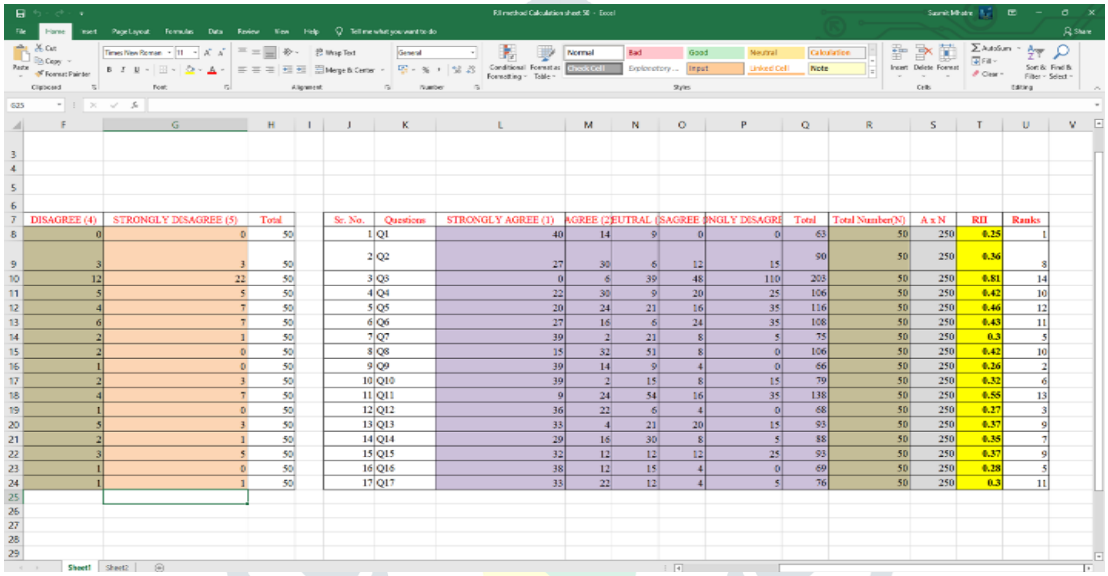
RII Method Result:



RII method

$\sum W = 5 \times N5 + 4 \times N4 + 3 \times N3 + 2 \times N2 + 1 \times N1$

Questions	STRONGLY AGREE (1)	AGREE (2)	NEUTRAL (3)	DISAGREE (4)	STRONGLY DISAGREE (5)	Total
Do you believe that using ferrocement structure are sustainable structure?	40	7	3	0	0	50
Will the Ferrocement structure be environment friendly as it requires much less quantity of cement and steel?	27	15	2	3	3	50
Will ferrocement have negative impact on environment compared to RCC?	0	3	13	12	22	50
Will the compressive strength of ferrocement be higher than that of typical construction concrete?	22	15	3	5	5	50
Are ferrocement structure more durable then RCC structure?	20	12	7	4	7	50
Do you think ferrocement consume less energy during construction?	27	8	2	6	7	50
Are the materials locally available for construction of ferrocement?	39	1	7	2	1	50
Do you think ferrocement is good alternative to RCC when there is high inflation?	15	16	17	2	0	50
Does poor labour management contribute to project delays?	39	7	3	1	0	50
Do you think poor productivity of labour will have impact on ferrocement construction?	39	1	5	2	3	50
Do you believe the project team members are experiencing a lot of uncertainty?	9	12	18	4	7	50
Do you believe low quality of material will have an impact on life of ferrocemnt structure?	36	11	2	1	0	50
Does a using precast ferrocement panel further reduce the project costs?	33	2	7	5	3	50
Does poor material management have an impact on the total project cost and time to completion?	29	8	10	2	1	50
Will the use of recycle and reused material reduce the cost of the project?	32	6	4	3	5	50
Will the easy of formwork and casting of ferrocement is main factor for usage of ferrocement?	38	6	5	1	0	50
Does ferrocement strucutre have less CO2 emission compared to RCC structure ?	33	11	4	1	1	50



DISAGREE (4)	STRONGLY DISAGREE (5)	Total	Sr. No.	Questions	STRONGLY AGREE (1)	AGREE (2)	NEUTRAL (3)	DISAGREE (4)	STRONGLY DISAGREE (5)	Total	Total Number(N)	A x N	RII	Ranks
0	0	50	1	Q1	40	14	9	0	0	63	50	250	0.25	1
3	3	50	2	Q2	27	30	6	12	15	90	50	250	0.36	8
12	22	50	3	Q3	0	6	39	48	110	203	50	250	0.81	14
5	5	50	4	Q4	22	30	9	20	25	106	50	250	0.42	10
4	7	50	5	Q5	20	24	21	16	35	116	50	250	0.46	12
6	7	50	6	Q6	27	16	6	24	35	108	50	250	0.43	11
2	1	50	7	Q7	39	2	21	8	5	75	50	250	0.3	5
2	0	50	8	Q8	15	32	51	8	0	106	50	250	0.42	10
1	0	50	9	Q9	39	14	9	4	0	66	50	250	0.26	2
2	3	50	10	Q10	39	2	15	8	15	79	50	250	0.32	6
4	7	50	11	Q11	9	24	54	16	35	138	50	250	0.55	13
1	0	50	12	Q12	36	22	6	4	0	68	50	250	0.27	3
5	3	50	13	Q13	33	4	21	20	15	93	50	250	0.37	9
2	1	50	14	Q14	29	16	30	8	5	88	50	250	0.35	7
3	5	50	15	Q15	32	12	12	12	25	93	50	250	0.37	9
1	0	50	16	Q16	38	12	15	4	0	69	50	250	0.28	5
1	1	50	17	Q17	33	22	12	4	5	76	50	250	0.3	11

Ranking of Factors considered

Factors Considered	RII Value	Rank
Sustainability	0.25	1
Material Quantity	0.36	8
Impact on Environment	0.81	14
Compressive strength	0.42	10
Durability	0.46	12
Energy Consumption	0.43	11
Material Availability	0.3	5
Inflation	0.42	10
Poor Management	0.26	2
Low Productivity	0.32	6
Project Team Experience	0.55	13
Low Quality	0.27	3
Precast Panels	0.37	9
Poor Material Management	0.35	7
Recycle and Reuse	0.37	9
Easy Formwork	0.28	5
CO2 Emission	0.3	11

Ranking of waste generation factors.

Waste generated	RII Value	Rank
Cement Mortar	0.4	4
Steel	0.78	2
Wire Mesh	0.82	1
Dirt/Earth	0.48	3
Paper and rubber	0.35	6
Misc. Waste	0.38	5

SITE PHOTOS:

Cost Analysis

Cost analysis of ferrocement wall:

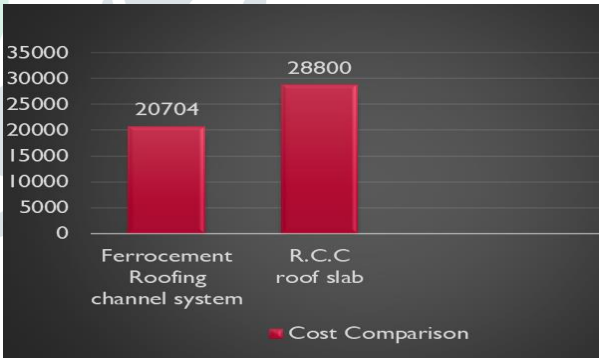
[A] Material					
Sr. No.	Materials	Quantity	Per	Rate	Amount
1	8mm dia. Tor steel bar	17.6	Kg	80	1408
2.	Weld Mesh 100x100	9.45	Sqm	90	850
3.	Chicken Mesh 13x13	31.5	Sqm	50	1575
4.	Binding wire	2	Kg	70	140
5.	Welding rod	L.S.			125
6.	Cement	4.34	Bag	365	1584
7.	Sand	0.175	brass	7000	1225
8.	Additives	L.S.			150
				Total	7057
[B] Labour					
1.	Welder	1	Day	1000	1000
2.	Fitter	1	Day	1000	1000
3.	Mason	2	Day	1100	2200
4.	Helper	8	Day	650	6000
				Total	10200

Cost analysis of single wall 50mm thick
Total [A] + [B] = 17,257
Add contingency, overheads 18% = 3106.3
Total = 20,363
Add Profit 20% = 4073

- Total cost for single 3m x3m 50 mm thick wall = 24,436
- The cost of construction of 50mm thick wall of 3m X 3m room size = 33.07 X 2715 = Rs 89,785/-
- The cost of construction of 230mm thick brick wall of 3m X 3m room size = Rs 1,07,700/-

Cost analysis for single ferrocement channel:

Item	Qty.	Rate	Amount (Rs.)
Steel	3.55 kg	85/kg	302
Chicken mesh	36 sq. ft.	10/sq. ft.	360
Cement (1:3)	0.6 bag	365/bag	219
Sand (1:3)	0.092 cu. m	7000/brass	162
Labour (skill)	1	500/day.	500
Labour (semi-skill)	2	400/day.	800
Total			2463
Contingencies, Tools and plant charges (Add 2% in total)			2496



Therefore, cost for 3m long and 0.375m wide with 50mm thickness ferrocement roofing channel
Roofing = 2463 Rs.
Consider Room size: 10ft. × 10ft.
No. of ferrocement channel required = 8
Cost of channels required =8×2463 = 19,704 Rs.
Cost of gap filling between channels and installation=1000Rs.
Total cost required for 100sq. ft. = 20,704 Rs.
Therefore, RCC roof slab of 150mm thickness the cost 100 Sq. Ft is 28,800.

where the M20 grade is used and cost for steel, labour, shuttering and material is included.
Total cost using conventional (R.C.C) slab = 288 Rs. /sq. ft
Therefore % saving = 28%

Time analysis:
Time analysis was done by using Gantt Chart method.

a) Time required for Ferrocement farmhouse came to be 25 Days.
b) Time required for Load bearing structure was calculated by previous industry experience which came to be 40 Days.
c) Time required for RCC structure was calculated by previous industry experience which came to be 50 Days.

Advantages of Ferro cement

- Required materials are readily available.
- It can be used for large construction work.
- Minimum skilled labors are required.

- Light weight members due to smaller thickness.
- Most suited for high levels of prefabrication.
- Highly versatile material hence can be fabricated in any desired shape.
- It is having high tensile strength and flexural strength.
- It is highly durable, crack resistant and water resistant.
- Due to its ductile behaviour, it can be used in earthquake resistance.
- Have good impact resistance and toughness.
- Construction with this is easy, less weight and lasts long.
- It requires low maintenance

Disadvantages of Ferrocement

- It fails in compression due to absence of mass concrete.
- Liable to corrosion due to bad compaction.
- Because of distinctive shapes trouble in construction.
- Frequently suffers from intense spalling of matrix cover.
- Delamination of extreme tensile layer.
- Labour demanding therefore excessive labour cost.

CONCLUSION

Wall thickness in ferrocement structure is between 10 to 50mm which is much less compared to brick wall in RCC structure. Thus, material required is less which is major part of construction cost. There is 15-18% of reduction in cost using ferrocement compared to Brick wall.
There is 30% saving with ferrocement roof channels in comparison with RCC roof slab.
In terms of sustainability, steel, plywood, and bricks have the highest embodied energy when compared to ferrocement wall panels and ferrocement roof panels, which are directly related to an increase in carbon dioxide emissions.
Increasing carbon dioxide emissions will result in a higher carbon footprint when traditional materials such as steel, plywood, and bricks are used.
The use of ferrocement technique will help to reduce carbon footprint, making it a sustainable technique.
Ferrocement is an innovative material and has a number of structural applications which includes: Earth Retaining walls, swimming pools, underground and overhead water tanks, corrugated roofs, circular shell structures, domes and housing structures, thin ferrocement elements are used in facades, sunscreens and curtain walls, and for architectural beauty. It is also used as repair works.
Preparation of mix design, selection of rich cement-sand ratio, lower water -cement ratio, application of cement mortar to reinforcing mesh is presently done by confirming to specification of ACI codes. Due to lack of availability of particular IS Code for Ferrocement construction technique in India, ACI code is being used. Hence preparation of IS code can be the further work of study.

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