



Article Title: Improved OFDM System with Electromagnetic Wave Disturbances using LDPC Coding

Behaviors of palm fiber reinforced Ferro Cement Slabs

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ABSTRACT

This project focuses on enhancing Ferrocement slab panels using palm fiber as an additional reinforcement material. Ferrocement Panels: These are thin composite materials made from a cement-based mortar matrix, reinforced with layers of small-diameter wire mesh. In developing countries like India, Ferrocement panels (50mm to 150mm thick) are gaining popularity for slab and roof construction due to their ease of construction, lightweight, speed, and cost-effectiveness. Introduction of Palm Fiber: The study explores the addition of palm fiber to Ferrocement slabs to further improve their properties. Palm fiber is incorporated in varying amounts (1%, 2%, 3%, 4%, and 5% by weight of cement), and its impact on the physical properties of the materials is tested. Compressive Strength and Load-Carrying Capacity: Panels of size 600mm x 450mm x 50mm are cast and cured with these varying percentages of palm fiber. Load-carrying capacity tests using loading frame equipment show that adding 1% to 3% palm fiber results in a 9% to 30% increase in load capacity. Optimal Palm Fiber Usage: The study finds that the optimal palm fiber percentage is 3%, offering the best balance between increased strength and material efficiency. This use of palm fiber enhances the mechanical properties of Ferrocement panels, making them a more efficient and durable option for fast and cost-effective construction projects.

1 Introduction

Ferrocement is a thin, lightweight composite material made from a cement-based mortar matrix reinforced with closely spaced layers of small-diameter wire mesh. Invented by Italian engineer Pier Luigi Nervi in the 1940s, it is a highly versatile form of reinforced concrete that consists of wire mesh, sand, water, and cement. Ferrocement offers several advantages, especially in developing countries, due to its cost-effectiveness and the simplicity of construction, which can be handled by unskilled labor. Materials such as sand, cement, and water are locally available. The reinforcing material (wire mesh, steel rods, chicken wire, or expanded metal) is inexpensive. Requires no heavy machinery or welding, simplifying the construction process.

Versatility: Can be shaped into any form, including thin sections of less than 2.5 cm. Lightweight but dense and durable, resistant to rot, vermin, worms, and water penetration. More versatile than traditional reinforced concrete, able to form complex curves.

Applications are commonly used in the construction industry, irrigation, water supply, and sanitation. In construction, Ferrocement is often used for load-bearing wall panels, roofs, and



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other structural elements. Investigation on Ferrocement with Palm Fiber focuses on testing Ferrocement slabs reinforced with hexagonal wire mesh and palm fiber to analyze their strength and durability under flexural load. The objective is to explore the load-carrying capacity of these panels when palm fiber is added as a secondary reinforcement. The use of palm fiber, along with hexagonal mesh layers, enhances the performance of Ferrocement panels, making them more efficient for construction where light weight, flexibility, and durability are essential.

2 Materials and Methods

53-grade cement conforming to IS: 12269 standards is used to prepare Ferrocement panels. Materials and their properties: Cement: Type: 53-grade cement. Conformity: IS: 12269. Fineness: 6%. Consistency: 36%. Setting Time: Initial setting time: 35 minutes. Final setting time: 540 minutes. Condition: Fresh, of uniform consistency, and free of lumps and foreign matter. Aggregate (River Sand): Type: River sand, passed through a 4.75mm IS sieve. Properties: Clean, hard, strong, free of organic impurities and deleterious substances. Relatively free from silt and clay. Specific Gravity: 2.65. Reinforcement (Chicken-Wire Mesh) Mesh Size: 10mm opening. Wire Diameter: 0.5mm. This chicken-wire mesh acts as the primary reinforcement material in the Ferrocement panels, providing strength and support. Palm Fiber Development: For the first time, Egyptian researchers have developed high-performance sustainable textile fibers from date palm by products, such as fronds, leaves, leaflets, rachis, etc. Extraction Process: A combined alkaline-mechanical process was used to extract fibers. Research Objective: To identify the physiochemical, morphological, and mechanical properties of the extracted fibers. This research aims to assess the potential of integrating date palm fibers into construction materials like Ferrocement, contributing to more sustainable building practices. The use of palm fiber as reinforcement in Ferrocement could enhance its mechanical properties while making use of agricultural by products, promoting sustainability in construction.



Figure 1: *Date palm tree and fiber*

2.1 Physical and Mechanical Properties of Date Palm Fiber

The date palm fiber, produced from by products such as fronds, leaves, and rachis, offers a sustainable alternative to synthetic fibers and does not contribute to deforestation or food crises.



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Sustainability: Eco-friendly: Since the fiber is derived from the by-products of date palms, which are already grown for agricultural purposes, no additional resources or land are required. This reduces environmental impact and promotes sustainable practices. **Biodegradability:** The fiber is 100% biodegradable and compostable, making it an environmentally responsible alternative to non-degradable materials. **High Tensile Strength:** The fiber's tensile strength is 5 times higher than steel, putting it on par with other high-strength natural fibers like flax and sisal. **Thermal Insulation:** The fiber exhibits thermal insulation properties superior to carbon fiber, making it suitable for applications requiring heat resistance and energy efficiency. The quality and performance of natural fibers like date palm fiber depend on several variables: **Structure:** The internal arrangement of cells and fibers influences the mechanical properties. **Micro-fibril Angle:** The orientation of the micro-fibrils within the fiber affects its strength and flexibility. **Chemical Composition:** The presence of cellulose, lignin, and other chemical compounds influences durability and structural integrity. **Cell Dimensions:** The size and arrangement of cells within the fiber impact its mechanical properties. **Defects:** Imperfections in the fiber, such as breaks or weak spots, can weaken its overall performance. These properties make date palm fiber a promising material for various industrial applications, including natural fiber composites, where its strength, sustainability, and thermal insulation capabilities can be effectively utilized. This innovation in natural fiber technology highlights the potential for replacing non-renewable materials with sustainable alternatives in construction and other industries.

Table 1. Properties of Palm fiber

Length	Density	Diameter	Specific Modulus	Thermal conductivity	Tensile strength	Elongation At Break
20-250mm	0.9to 1.2g/cm ³	100to 1000µm	7	0.083W/mK	58to203 MPa	5to10%

2.2 Sources of Date Palm Fiber

There are more than 140 million date palms in the Middle East and North Africa. Egypt is currently the largest producer of dates, as are Iran, Saudi Arabia, UAE, Pakistan, and Sudan. More than 48.8 million tons of waste is generated every year by pruning date palms for agriculture. So, the production of date palm fiber is currently a big success. Sustainable textile fibers are found in all these countries from date palm by products such as fronds, leaves, leaflets, rachis, fruit branches, etc.



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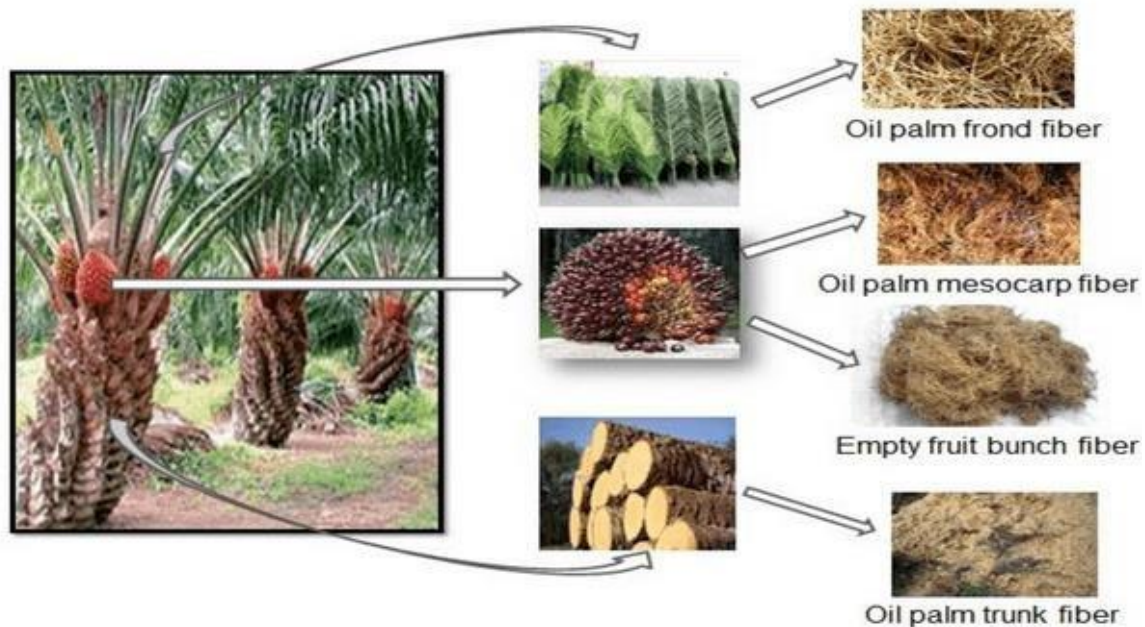


Figure 2: Sources of Date Palm Fiber

Table 2. Chemical Composition (%) of Date Palm Fibers

Constituents	Cellulose	Hemicelluloses	Lignin	Ash	Extractive
Leaflet	40.21	12.80	32.2	10.54	4.25
Leaf	54.75	20.00	15.30	1.75	8.20
Rachis	38.26	28.17	22.53	5.96	5.08

Date palm fibers, like other natural fibers, have a complex structure that contributes to their mechanical properties. Their primary cell walls and secondary walls are composed of helically wound micro-fibrils formed from long-chain cellulose molecules. These micro-fibrils play a crucial role in determining the fiber's strength, flexibility, and overall performance.

Composition of Cell Walls in Date Palm Fibers:

Cellulose: The primary structural component in the cell walls, providing tensile strength and stability to the fiber. Resistant to hydrolysis and attacks from strong alkali and oxidizing agents.

Degradation: Cellulose can degrade to some extent under chemical treatments, which might reduce its mechanical properties if not managed properly.

Hemicelluloses: These are polysaccharides that bind with cellulose fibers, playing a role in maintaining cell wall structure and flexibility. Properties: Hemicelluloses are more easily hydrolyzed than cellulose and contribute less to mechanical strength but play a significant role in fiber flexibility.

Lignin: Function: Lignin is a complex hydrocarbon polymer that provides rigidity to plant structures and helps in water transportation through the plant. Adds stiffness to the fiber. Resistant to



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microbial attack and environmental stress, contributing to the fiber's durability. While lignin increases the fiber's rigidity, it can reduce flexibility, making it important in determining the balance between strength and pliability. The helical arrangement of micro-fibrils within the fiber walls determines the mechanical properties such as tensile strength and elasticity. The angle of these micro-fibrils influences how the fibers will behave under stress. A smaller angle typically results in greater tensile strength, while a larger angle allows for more flexibility. The combination of cellulose, hemicelluloses, and lignin in the date palm fiber's cell walls gives the fiber its desirable mechanical properties. The rigidity from lignin and the tensile strength from cellulose create a material that is both strong and versatile, making it suitable for various applications, particularly where strength, rigidity, and environmental sustainability are essential.

3 Experimental Method

Table 3. Details of the material quantity of one cubic

Materials	Std. panel	1%Palm fiber	2%Palm fiber	3%Palm fiber	4%Palm fiber	5%Palm fiber
Cement	270g	270g	270g	270g	270g	270g
Sand	540g	540g	540g	540g	540g	540g
Palm fiber	-	2.7g	5.4g	8.10g	10.8g	13.5g
Water	135g	135g	135g	135g	135g	135g



Figure 3: Casting of slab panel

The experiment was designed to check the behavior of Ferrocement panels in axial compressive loading. For this purpose a total of 18 Ferrocement slab panels are cast of size 600mm x 450mm x 50mm with Chicken wire mesh of 10mm mesh opening and 0.5mm wire diameter are used for this work.



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The panels are of the following four types.

- Standard panel without the addition of palm fiber - 3nos
- 1% palm fiber added slab panel - 3nos
- 2% palm fiber added slab panel - 3nos
- 3% palm fiber added slab panel - 3nos
- 4% palm fiber added slab panel - 3nos
- 5% palm fiber added slab panel - 3nos

After 28 days of curing and 48 hrs. Drying each panel was moved and placed under the test frame. The test setup is the loading frame equipment to apply compressive load and the panels are placed in such a way that it is uniformly supported. For this, a channel section is provided below the test specimen and load is applied at the top of the panel through 32mm diameter steel rod of the same length as that of the panel to distribute the load equally. The test up is as shown in the figure.



Figure 4: Testing of slab panels

The application of the load is continued till the failure occurs. The first load at which crack and the ultimate load capacity are noted down.

4 Result and Discussion

Eighteen number slab panels were cast, cured, and tested by using loading frame equipment. The first crack load and ultimate loads are represented in Table 4 and graphically shown in Figure 5. 1 to 3% palm fiber added Ferro cement slab load carrying capacity increased compared to the standard slab panel. 3% palm fiber Ferro cement slab load-bearing capacity 30% increased compare to standard slab panel. The 4% and 5% palm fiber added Ferro cement slab load bearing capacity slightly reduced compared to the 3% palm fiber slab panel. The 4% and 5% palm fiber added Ferro cement slab present air voids due to grouping of fiber so this reason load bearing capacity reduced. The optimum utilization of palm fiber is 3%.



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Table 4. First crack and ultimate load for Ferrocement slab panels

Ferrocement slab panel	First crack load (kN)	Ultimate load(kN)
Std slab panel	96.50	139.33
1% palm fiber slab panel	105.96	152.99
2% palm fiber slab panel	116.34	167.98
3% palm fiber slab panel	127.74	184.44
4% palm fiber slab panel	120.52	174.02
5% palm fiber slab panel	113.72	164.19

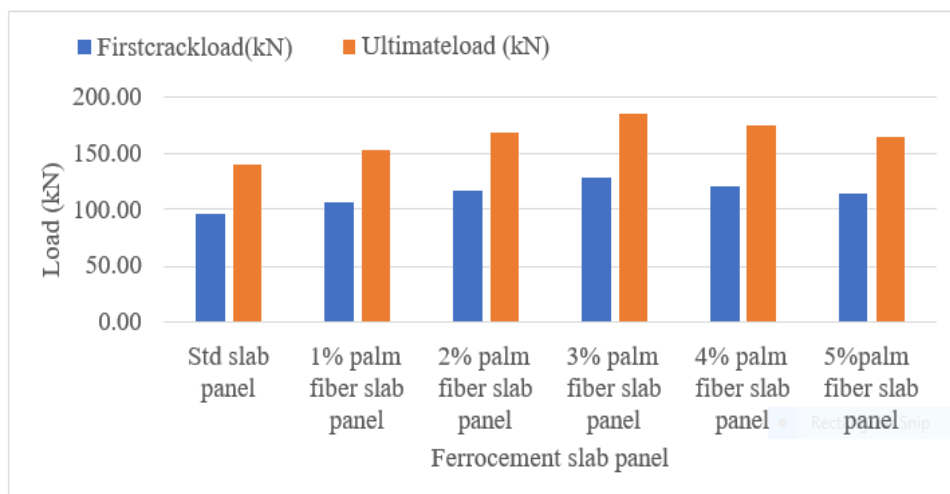


Figure 5: First crack and ultimate load for Ferrocement slab panels

5 Conclusion

The Ferrocement slab panels load carrying capacity is checked by loading frame equipment and its result conclusion are given below. One to three percent of palm fiber added Ferrocement slab loading carrying capacity is 9% to 30% increased. The optimum utilization of fiber percentage is 3%. 4% and 5% palm fiber added Ferrocement slab load bearing capacity slightly reduced compared to 3% palm fiber slab panel. 4% and 5% of palm fiber added Ferrocement slab present some internal air voids, and fiber grouping so this above reason the strength of slab is reduced.

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