International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Planning and Analysis of a Hospital Building Using the Developed Fibre Reinforced Concrete

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Abstract:
This study investigates the incorporation of nylon and coir fibres in concrete to improve its performance for hospital building design. Nylon fibres were added at 0.5%, 0.75%, and 1% by volume, demonstrating notable improvements in tensile strength and reduced crack formation, particularly at the 0.75% dosage. This enhancement is crucial for meeting the structural integrity and durability requirements of healthcare facilities, where safety and resilience are paramount.
Coir fibres were introduced at 1%, 2%, and 3%, effectively increasing the ductility and energy absorption characteristics of the concrete. The optimal performance was observed at the 2% dosage, which not only contributed to better structural performance but also promoted sustainability through the use of natural fibres. Overall, the synergistic effects of both nylon and coir fibres in concrete demonstrate their potential to significantly enhance the mechanical properties and longevity of materials used in the construction of hospitals, supporting the need for innovative and durable building solutions in healthcare environments.

Keywords: Nylon Fibre, Coir Fibre, Concrete, Mechanical Properties.

1. Introduction:

Concrete is renowned for its compressive strength, but it is inherently weak in tension, which can lead to cracking and structural failure. To address these limitations, the addition of fibres has gained popularity as a method to enhance the mechanical and durability properties of concrete. This introduction examines the effects of nylon and coir fibres when added to concrete at specified volume.

Nylon Fibers in Concrete:

Nylon fibres are synthetic fibres characterized by high tensile strength, flexibility, and resistance to wear and chemical degradation. When incorporated into concrete at volume fractions of **0.5%, 0.75%, and 1%**, nylon fibres provide several benefits:

- **Crack Control**: The addition of nylon fibres helps to reduce the size and frequency of cracks by bridging gaps and enhancing the tensile strength of the concrete matrix.
- **Improved Ductility**: Nylon fibres increase the ductility of concrete, allowing it to deform under stress without sudden failure, which is particularly beneficial in seismic regions.
- **Durability**: Their resistance to moisture and chemicals contributes to the longevity of concrete structures, especially in harsh environments.

As the volume of nylon fibres increases, the improvements in tensile strength and toughness become more pronounced, with the 1% mix often showing the most significant enhancements.

Coir Fibers in Concrete:

Coir fibres are natural fibres obtained from coconut husks. Their incorporation into concrete at volume fractions of **1%, 2%, and 3%** not only contributes to the mechanical properties but also supports environmental sustainability:

- **Sustainability**: Coir is a renewable resource, making it an eco-friendly alternative to synthetic fibres. Its use helps reduce waste and promotes sustainable construction practices.
- **Mechanical Properties**: The addition of coir fibres enhances the impact resistance and flexural strength of concrete. Studies show that coir fibres can effectively improve the energy absorption capacity of concrete, making it more resilient to dynamic loads.
- **Water Retention and Workability**: Coir fibres can enhance the water retention capability of the concrete mix, which may improve workability and reduce segregation during mixing.

As the volume of coir fibres increases, the impact on the mechanical properties tends to vary. Typically, a 2% volume fraction strikes a balance between enhancing performance and maintaining workability, while the 3% mix may lead to increased fibre clumping, which could negatively affect concrete consistency.

2. Currently using Fibres:

Nylon fibre: It is a synthetic polymer, first introduced in the 1930s, that revolutionized the textile industry. Developed by chemist Wallace Carothers and his team at DuPont, nylon was the first entirely synthetic fibre, made from petrochemicals. Its unique properties—such as high strength, elasticity, and resistance to abrasion—made it an ideal material for a wide range of applications, from clothing and hosiery to industrial products.

Nylon fibre is increasingly recognized for its role as an innovative additive in concrete production. This synthetic fibre enhances the mechanical properties of concrete, providing benefits such as improved tensile strength, durability, and resistance to cracking. When incorporated into concrete mixes, nylon fibres help to distribute stress more evenly throughout the material, reducing the likelihood of micro-cracks forming and propagating.

One of the key advantages of nylon fibre in concrete is its ability to improve impact resistance and toughness, making concrete structures more resilient to dynamic loads and environmental stressors. Additionally, nylon's lightweight nature contributes to the overall reduction of weight in concrete applications, which can be beneficial in construction and structural design. Nylon fibre is also resistant to moisture and chemical degradation, making it suitable for various applications, including precast concrete elements, pavements, and shotcrete. As the construction industry seeks to improve the longevity and performance of concrete structures, the incorporation of nylon fibre represents a promising advancement in material technology, enhancing both functionality and sustainability.

Fig. No: 01, Nylon Fibre.

Coir Fibre: It is a natural, eco-friendly product derived from the fibrous husk of coconuts. Primarily sourced from the coconut palm (Cocos nucifera), coir is an abundant and sustainable material, widely recognized for its versatility and durability. There are two main types of coir fibres: brown coir, extracted from mature coconuts, and white coir, obtained from younger coconuts.

Coir fibre is increasingly being recognized as a valuable additive in concrete, enhancing its properties and promoting sustainable construction practices. Derived from the husk of coconuts, coir fibres are biodegradable and abundant, making them an eco-friendly alternative to synthetic fibres commonly used in concrete.

When incorporated into concrete, coir fibre can improve various characteristics, such as tensile strength, ductility, and resistance to cracking. Its natural properties help to mitigate shrinkage and enhance the overall durability of the concrete mix. Coir fibres also contribute to better workability and can reduce the weight of concrete, making it easier to handle and apply. As the construction industry increasingly prioritizes green materials, coir fibre presents an innovative solution that aligns with eco-conscious building practices, contributing to the development of more sustainable infrastructure. Overall, the integration of coir fibre into concrete formulations not only enhances material performance but also supports environmental stewardship in construction.

Fig. No: 02, Coir Fibre.

3. Results:

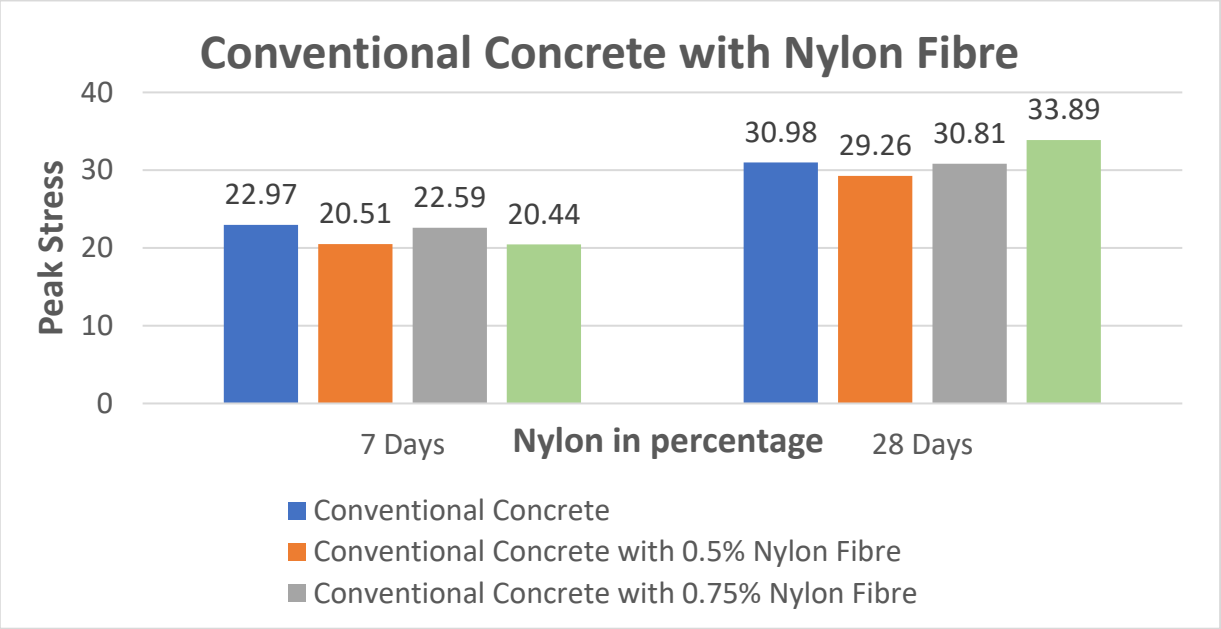
3.1. 7-Day Compressive Strength of Nylon Fibre Reinforced Concrete:

At 7 days, the addition of 0.75% nylon fiber to conventional concrete achieves a compressive strength of 22.59 MPa. This result suggests that a small percentage of nylon fiber can enhance early-age compressive strength by improving crack resistance and overall stability of the mix.

3.2. 28-Day Compressive Strength of Nylon Fibre Reinforced Concrete:

At 28 days, the optimal nylon fiber content was found to be 1%, yielding a compressive strength of 33.89 MPa. This indicates that increasing the fiber content further strengthens the concrete over a longer period, enhancing its structural integrity and durability.

3.3.Nylon Fibre 7- and 28-days Results:



Fig, No: 03, Comparison of Conventional Concrete with Nylon Fibre.

3.4. 7-Day Compressive Strength of Coir Fibre Reinforced Concrete:

At 7 days, the addition of 2% coir fiber to conventional concrete yields a compressive strength of 22.20 MPa. This demonstrates that coir fiber can improve the early-age strength of concrete, likely due to its ability to resist microcracking and enhance the internal bonding of the mix.

3.5. 28-Day Compressive Strength of Coir Fibre Reinforced Concrete:

After 28 days, the compressive strength of concrete with 2% coir fiber reaches 37.5 MPa. This significant increase in strength indicates that coir fiber contributes positively to the long-term performance of concrete, enhancing its durability and load-bearing capacity.

3.6. Coir Fibre 7- and 28-days Results:

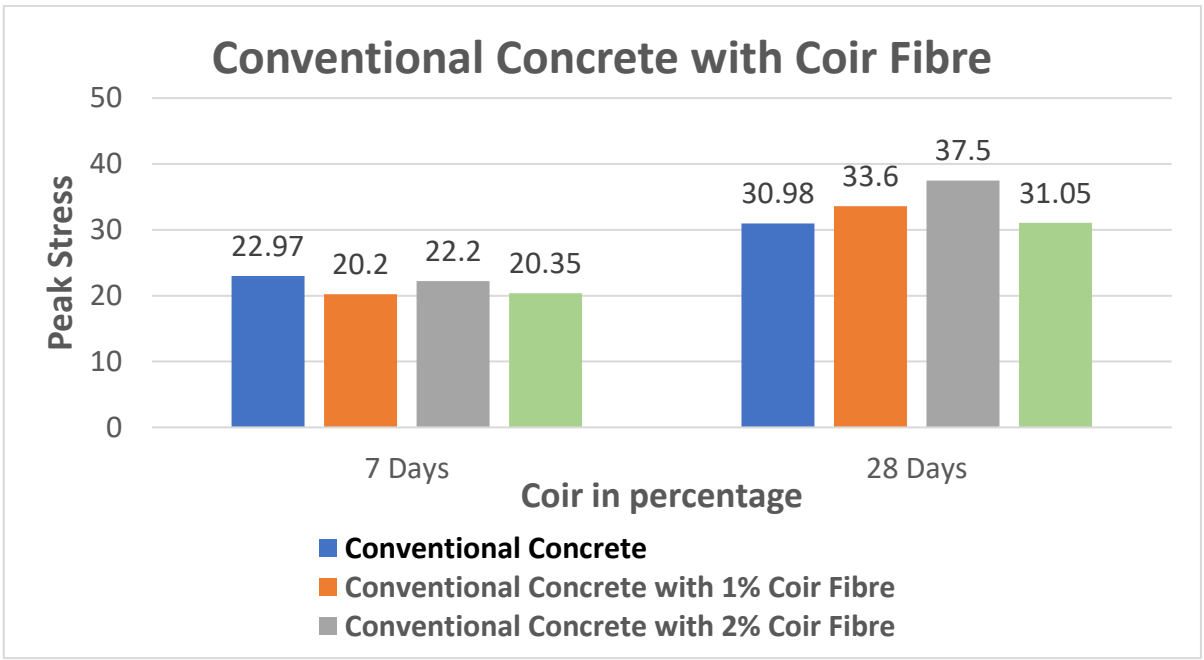


Fig. No: 04, Comparison of Conventional Concrete with Coir Fibre.

4. Proposed Plan Details:

Table. No: 01, represents the plan details.

Sl. No	Building Type	Commercial Building
1	Construction purpose	Multispecialty Hospital Building
2	Total plot size	35*60m.
3	Area to be constructed	30*55m
4	Number of stores	G + 2
5	Total area	1650 sq.m
6	Floor area ratio	1.27

4.1. Cost Estimation:

Table. No: 02, represents the cost estimation of a proposed Hospital Building.

	Cement(Kg)	Coarse Aggregate(Kg)	Fine Aggregate(Kg)	Steel(Kg)
Column	7450.38 x 3 = 22351.14	17605.35 x 3 = 52816	11532.78 x 3 = 34598.34	3338.2 x 3 = 10014.6
Beam	35635 x 3 = 106905	84207.6 x 3 = 252622.8	55162.08 x 3 = 165486.24	12773.2 x 3 = 38320.56
Slab	108405 x 3 = 325215	256162.5 x 3 = 768487.5	167805 x 3 = 503415	19428.75 x 3 = 58286.25
Total	**4,54,471**	**10,73,926.3**	**7,03,499.58**	**1,06,621.41**

Table. No: 03, represents the cost estimation of the materials used.

Materials	Steel	Cement	Coarse Aggregate	Fine Aggregate
Quantity	1,06,621.41	4,54,471 Kg	10,73,926.3 Kg	7,03,499.58 Kg
Per unit cost	Rs- 48 Per Kg	Rs- 440/-(per bag)	0.8 per Kg	50 per cft
Cost	Rs- 51,17,827.68	Rs- 36,35,600	Rs- 8,59,141.04	Rs- 14,06,999.16
Total Cost				**1,10,19,567.88**

4.3: Calculation of Carbon Emission:

Table. No: 04, represents the carbon emission of a control concrete.

Control Concrete			
Sl. No:	**Materials**	**Carbon Co-efficient($C0_2$/ Kg)**	**Carbon Emission**
1.	Cement	0.73	331763.8
2.	Coarse Aggregate	0.01	10739.26
3.	Fine Aggregate	0.004	2813.998
4.	Steel	1.83	195117.2
5.	**Total Carbon Emission**		**5,40,434.3**

Table. No: 05, represents the carbon emission of a Coir Fibre reinforced concrete.

Fibre Reinforced Concrete			
Sl. No:	**Materials**	**Carbon Co-efficient ($C0_2$/ Kg)**	**Carbon Emission**
1.	Cement	0.73	331763.80
2.	Coarse Aggregate	0.01	10739.26
3.	Fine Aggregate	0.004	2813.99
4.	Steel	1.83	195117.20
5.	Coir Fibre	0.83	1090.88
6.	**Total Carbon Emission**		**5,41,525.13**

Table. No: 06, represents the carbon emission of a Nylon Fibre reinforced concrete.

Fibre Reinforced Concrete			
Sl. No:	**Materials**	**Carbon Co-efficient ($C0_2$/ Kg)**	**Carbon Emission**
1.	Cement	0.73	331763.80
2.	Coarse Aggregate	0.01	10739.26
3.	Fine Aggregate	0.004	2813.99
4.	Steel	1.83	195117.20
5.	Nylon Fibre	0.201	80.53

6.	**Total Carbon Emission**	**5,40,514.78**

5. Results:

- **7-Day Compressive Strength of Nylon Fibre Reinforced Concrete:**
- At 7 days, the addition of 0.75% nylon fibre to conventional concrete achieves a compressive strength of 22.59MPa. This result suggests that a small percentage of nylon fibre can enhance early-age compressive strength by improving crack resistance and overall stability of the mix.
- **28-Day Compressive Strength of Nylon Fibre Reinforced Concrete:**
- At 28 days, the optimal nylon fibre content was found to be 1%, yielding a compressive strength of 33.89MPa. This indicates that increasing the fibre content further strengthens the concrete over a longer period, enhancing its structural integrity and durability.
- **7-Day Compressive Strength of Coir Fibre Reinforced Concrete:**
- At 7 days, the addition of 2% coir fibre to conventional concrete yields a compressive strength of 22.20MPa. This demonstrates that coir fibre can improve the early-age strength of concrete, likely due to its ability to resist microcracking and enhance the internal bonding of the mix.
- **28-Day Compressive Strength of Coir Fibre Reinforced Concrete:**
- After 28 days, the compressive strength of concrete with 2% coir fibre reaches 37.5MPa. This significant increase in strength indicates that coir fibre contributes positively to the long-term performance of concrete, enhancing its durability and load-bearing capacity.

6. Conclusion:

In conclusion, the test results indicate that both nylon and coir fibers can enhance the compressive strength of conventional concrete at different curing stages.

- **Nylon Fiber:** Incorporating nylon fibers at varying percentages improves compressive strength, with 0.75% fiber content being effective at 7 days and 1% fiber content being optimal at 28 days. Nylon fibers are shown to be a reliable additive for increasing both early and long-term strength, making them suitable for applications that require enhanced performance at different stages.
- **Coir Fiber:** The addition of 2% coir fiber also effectively increases compressive strength at both 7 and 28 days, demonstrating its potential as an eco-friendly reinforcement. Coir fiber is particularly beneficial for sustainable concrete applications, contributing to durability and long-term strength, which is ideal for structural applications where extended service life is essential.

Overall, both nylon and coir fibers offer distinct advantages for concrete reinforcement, with nylon fibers improving strength performance over time and coir fibers providing a sustainable option for enhancing durability.

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