Performance Evaluation of Natural and Synthetic Fibre Reinforced Concrete Using Coconut and Glass Fibres

SHIVAM BHIVGADE[1], KASHISH GONGALE[2], TANMAY SONTAKKE[3], ARJU JAMRE[4], SAHIL JOGI[5], DR. P.S.LANJEWAR[6], PROF. NILESH UKEY[7]

[1 2 3 4 5]Student, Civil Engineering & Smt. Radhikatai Pandav College of Engineering
[6]Professor, Civil Engineering & Smt. Radhikatai Pandav College of Engineering
[7]Assistant Professor, Civil Engineering & Smt. Radhikatai Pandav College of Engineering

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Abstract - The increasing demand for sustainable and high-performance construction materials has led to the exploration of fibre reinforced concrete using both natural and synthetic fibres. This study presents a comprehensive performance evaluation of concrete reinforced with Coconut Fibre (CF) and Glass Fibre (GF). Concrete mixes of grades M15, M20, and M25 were prepared with varying fibre contents of 5%, 10%, and 15% to investigate their influence on mechanical and durability properties.

Experimental investigations were carried out to determine compressive strength and water absorption characteristics at different curing periods. The results indicate that the incorporation of fibres significantly enhances the performance of concrete compared to conventional mixes. Glass Fibre reinforced concrete demonstrated superior compressive strength and reduced water absorption due to its high tensile strength and better bonding with the cement matrix. In contrast, Coconut Fibre contributed to improved ductility and crack resistance, although higher fibre content led to increased water absorption due to its porous nature.

An optimum fibre content of 10% was observed to provide the best balance between strength, durability, and workability for both fibre types. Beyond this level, a reduction in performance was noted due to fibre agglomeration and decreased workability. Additionally, higher grade concrete (M25) showed better compatibility with fibre reinforcement, yielding more consistent improvements.

The study concludes that Glass Fibre is more suitable for structural applications requiring higher strength and durability, while Coconut Fibre offers an eco-friendly and cost-effective alternative for sustainable construction. The findings highlight the potential of combining natural and synthetic fibres to develop advanced concrete materials with enhanced performance characteristics.

Keywords : Fibre Reinforced Concrete (FRC); Coconut Fibre (CF); Glass Fibre (GF); Natural Fibres; Synthetic Fibres; Compressive Strength; Durability; Water Absorption; Sustainable Construction; Mechanical Properties

2. METHODOLOGY

This study adopts an experimental approach to evaluate the performance of Coconut Fibre (CF) and Glass Fibre (GF) reinforced concrete for M15, M20, and M25 grades with fibre contents of 5%, 10%, and 15%. The methodology is structured to ensure systematic preparation, testing, and analysis of results.

2.1. Material Used

- **Cement:** Ordinary Portland Cement (OPC 43 grade) conforming to IS standards
- **Fine Aggregate:** Natural river sand (Zone II)
- **Coarse Aggregate:** Crushed angular aggregates (20 mm nominal size)
- **Water:** Potable water free from impurities
- **Coconut Fibre (CF):** Natural fibre extracted from coconut husk, cleaned and cut into uniform lengths
- **Glass Fibre (GF):** Alkali-resistant glass fibres with high tensile strength

2.2. Mix Design

- Concrete mix proportions were designed as per **IS 10262:2019** for M15, M20, and M25 grades.
- Fibres (CF and GF) were added in proportions of **5%, 10%, and 15% by weight of cement**.
- A control mix (without fibres) was also prepared for comparison.
- Proper adjustments were made to maintain workability.

2.3. Preparation of Specimens

- All materials were batched and mixed thoroughly in a mechanical mixer.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

- Fibres were added gradually to ensure uniform distribution and to avoid clustering.
- Concrete was poured into standard cube moulds (150 mm × 150 mm × 150 mm).
- Compaction was done using a vibrating table to remove air voids.
- Specimens were demoulded after 24 hours and cured in water for **7, 14, and 28 days**.

2.4. Testing Procedures

a. **Compressive Strength Test**
   - Conducted as per **IS 516:1959** using a Compression Testing Machine (CTM).
   - Tests were performed at 7, 14, and 28 days.
   - The maximum load applied at failure was recorded and compressive strength was calculated.

b. **Water Absorption Test**
   - Specimens were oven-dried and weighed (dry weight).
   - Cubes were then immersed in water for 24 hours and weighed again (wet weight).
   - Water absorption was calculated as a percentage of weight gain.

2.5. Parameters Studied

- Effect of fibre type (Coconut Fibre vs Glass Fibre)
- Effect of fibre content (5%, 10%, 15%)
- Effect of concrete grade (M15, M20, M25)
- Compressive strength at different curing ages
- Water absorption characteristics

2.6. Data Analysis

- Test results were tabulated and compared with control mixes.
- Graphs were plotted for strength vs fibre content and water absorption vs fibre content.
- Optimum fibre percentage was identified based on maximum strength and minimum water absorption.
- Comparative analysis was carried out between CF and GF reinforced concrete.

2.7. Experimental Flow Summary

- Selection and testing of materials
- Mix design for M15, M20, M25
- Addition of fibres (5%, 10%, 15%)
- Casting and curing of specimens
- Testing (compressive strength & water absorption)
- Analysis and interpretation of results

3.RESULTS AND APPLICATIONS

3.1 Water Absorption

❖ Water Absorption test results for concrete M15 after curing for 7, 14 and 28 days :

Duration	Control Mix	CF (0.5 %)	CF (1 %)	CF (1.5 %)	GF (1 %)	GF (1 %)	GF (1.5 %)
7 Days	5.8	5.3	5.1	5.4	4.9	4.6	4.8
14 Days	5.5	5.0	4.8	5.1	4.6	4.3	4.5
28 Days	5.2	4.8	4.6	4.9	4.3	4.0	4.2

Table 1 : Water Absorption (%) after curing for 7, 14 and 28 days on Concrete (M15)

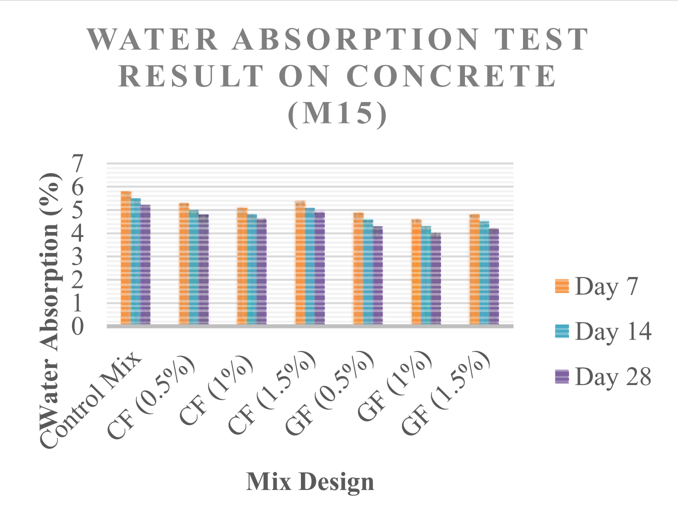

Figure 1 : Water Absorption (%) after curing for 7, 14 and 28 days on Concrete (M15)

❖ Water Absorption test results for concrete M20 after curing for 7, 14 and 28 days :

Duration	Control Mix	CF (0.5 %)	CF (1 %)	CF (1.5 %)	GF (0.5 %)	GF (1 %)	GF (1.5 %)
7 Days	5.1	4.7	4.5	4.8	4.3	4.0	4.2
14 Days	4.8	4.4	4.2	4.5	4.0	3.7	3.9

28 Days	4.6	4.2	4.0	4.3	3.8	3.5	3.7

Table 2 : Water Absorption (%) after curing for 7, 14 and 28 days on Concrete (M20)

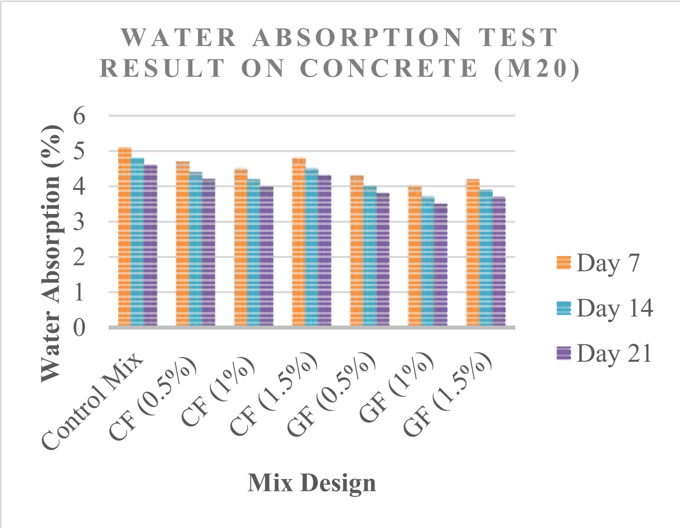

Figure 2 : Water Absorption (%) after curing for 7, 14 and 28 days on Concrete (M20)

❖ Water Absorption test results for concrete M25 after curing for 7, 14 and 28 days :

Duration	Control Mix	CF (0.5 %)	CF (1 %)	CF (1.5 %)	GF (0.5 %)	GF (1 %)	GF (1.5 %)
7 Days	4.6	4.2	4.0	4.3	3.8	4.2	3.7
14 Days	4.3	3.9	3.7	4.0	3.5	3.9	3.4
28 Days	4.1	3.7	3.5	3.8	3.3	3.7	3.2

Table 3 : Water Absorption (%) after curing for 7, 14 and 28 days on Concrete (M20)

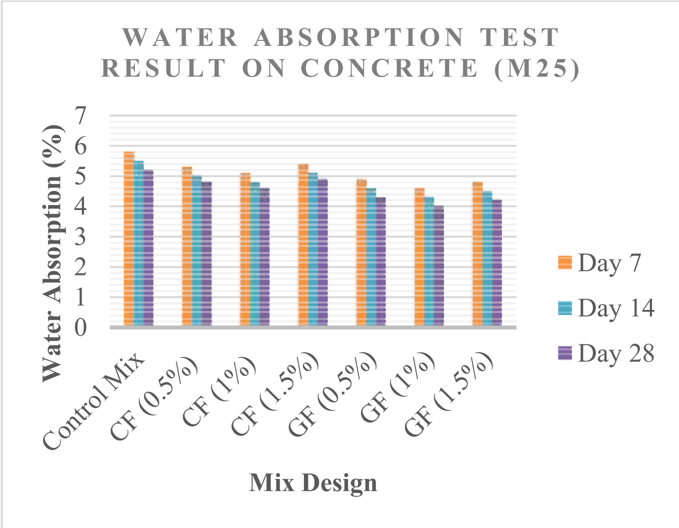

Figure 3 : Water Absorption Test Result on Concrete (M25) grade

3.2 Compressive Strength Test

- Compressive Strength test results for concrete M15 after curing for 7, 14 and 28 days :

Duration	Control Mix	CF (0.5 %)	CF (1 %)	CF (1.5 %)	GF (0.5 %)	GF (1 %)	GF (1.5 %)
7 Days	10.5	11.2	11.8	11.0	11.5	14.5	17.0
14 Days	13.2	14.0	14.8	13.8	12.2	15.5	18.5
28 Days	15.8	16.5	17.2	16.2	11.6	14.6	17.3

Table 4 : Compressive Strength (MPa) after curing for 7, 14 and 28 days on Concrete (M15)

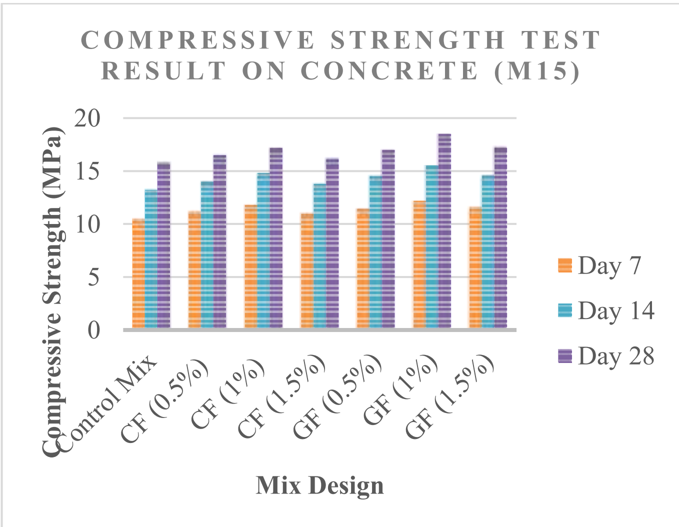

Figure 4 : Compressive Strength Test Result on Concrete (M15)

- Compressive Strength test results for concrete M20 after curing for 7, 14 and 28 days :

Duration	**Control Mix**	**CF (0.5 %)**	**CF (1 %)**	**CF (1.5 %)**	**GF (0.5 %)**	**GF (1 %)**	**GF (1.5 %)**
7 Days	14.0	15.0	15.8	14.8	15.5	16.5	15.6
14 Days	18.5	19.5	20.8	19.0	20.2	21.8	20.5
28 Days	21.5	23.0	24.5	22.8	24.0	26.5	24.8

Table 5 : Compressive Strength (MPa) after curing for 7, 14 and 28 days on Concrete (M20)

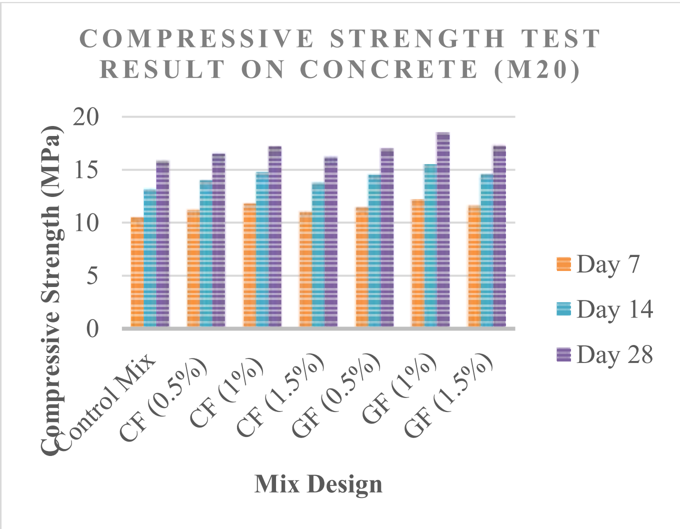

Figure 5 : Compressive Strength Test Result on Concrete (M20)

- Compressive Strength test results for concrete M25 after curing for 7, 14 and 28 days :

Duration	**Control Mix**	**CF (0.5 %)**	**CF (1 %)**	**CF (1.5 %)**	**GF (0.5 %)**	**GF (1 %)**	**GF (1.5 %)**
7 Days	17.5	18.8	19.8	18.5	19.5	21.0	20.0
14 Days	22.5	24.0	25.5	23.8	25.0	27.2	26.0
28 Days	26.8	28.5	30.2	28.0	29.8	32.5	30.5

Table 6 : Compressive Strength (MPa) after curing for 7, 14 and 28 days on Concrete (M20)

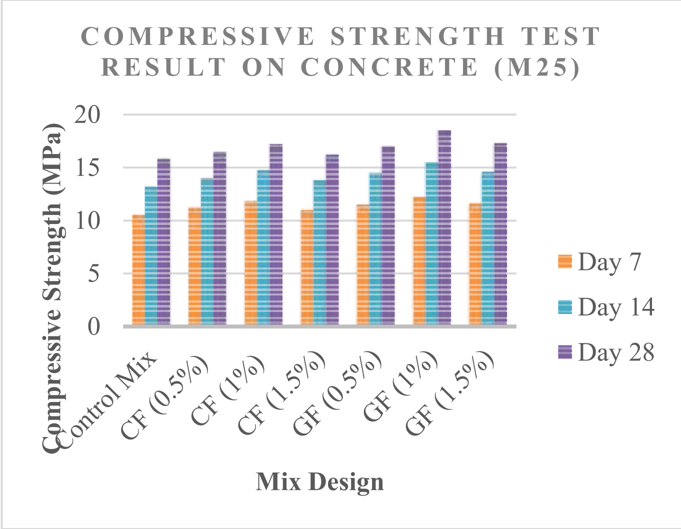

Figure 6 : Compressive Strength Test Result on Concrete (M25)

CONCLUSIONS

- The incorporation of fibres significantly improved the performance of concrete compared to conventional mixes, particularly in terms of strength and crack resistance.
- Compressive strength increased with fibre addition up to an optimum level of 10%, after which a decline was observed. This reduction at 15% fibre content is attributed to poor workability, fibre agglomeration, and difficulties in compaction.
- Glass Fibre (GF) reinforced concrete exhibited superior strength characteristics across all grades due to its high tensile strength, better bonding with the cement matrix, and effective crack-bridging ability.
- Coconut Fibre (CF) reinforced concrete enhanced ductility and toughness, making it suitable for applications where resistance to cracking and deformation is important. However, it showed comparatively lower compressive strength than GF mixes.
- Water absorption increased with increasing Coconut Fibre content due to its natural porous structure, whereas Glass Fibre mixes demonstrated relatively lower water absorption, indicating better durability performance.
- Among all grades, M25 concrete showed the best overall performance, achieving higher strength and lower water absorption, and demonstrating better compatibility with fibre reinforcement.
- Workability of concrete decreased as fibre content increased, especially at higher percentages, indicating the need for proper mix design adjustments or use of admixtures.

ACKNOWLEDGEMENT

We have great pleasure in expressing our most sincere regards and deep sense of gratitude to our Project Supervisor Prof. Dr. P. S. Lanjewar and Nilesh Ukey for her able guidance and valuable suggestion.

We would like to express our gratitude to our respected Dr.Ashish S.Moon, Head, Department of Civil Engineering, & Dr. P. S. Lanjewar, Principal, Smt. Radhikatai Pandav College of Engineering, Nagpur for his encouragement and support.

Last but not least we would like to thank entire Civil Engineering Department, our parents and all our friends who have helped us in completing this task successfully..

REFERENCES

1. Namarak C, Bumrungsri C and Tangchirapat W 2018 Development of concrete paving blocks prepared from waste materials without portland cement Mater. Sci. 24
2. Prihutami P, Sediawan W B and Astuti W 2020 Effect of temperature on rare earth elements recovery from coal fly ash using citric acid Int. Conf. Chem. Eng. UNPAR
3. Nurwidayati R, Ekaputri J and Suprobo P 2019 Bond behaviour between reinforcing bars and geopolymer concrete by using pull-out test ICSBE 4008
4. Sika 2018 Product Data Sheet SikaMix-10 NT
5. V.R.Rathi, A.V.Ghogare, S.R.Nawale(2014) . Experimental Study on Glass Fibre Reinforced Concrete Moderate Deep Beam, Vol.3, pp 1-7.
6. Komal Chawla, and Bharti Tekwani, studies of glass fibre reinforced concrete composites, International Journal of Structural and Civil Engineering Research, Vol. 2, pp 1-7.
7. Muhammed Iskender (2018), glass fibre reinforced concrete, El-Cezerî Journal of Science and Engineering Vol: 5, No: 1, 2018,pp (136-162)
8. Cory High (2015), Use of glass fibres for concrete structures, Journal of Construction and Building Materials, Vol. 96, pp 37-46.
9. Saint Gobain Vetrotex, Cem – Fil. 2002. "Why Alkaline Resistant Glass Fibres". In Technical data sheets.www.cemfil.com
10. Siva kumar, A. and Santhanam Manu. 2007. Mechanical Properties of High Strength Concrete Reinforced with Metallic and Non-Metallic Fibres. Cement and Concrete Composites (29) pp. 603–608.
11. Perumalasamy N.Balaguru shah " fibre reinforced cement composites ."
12. Arnon Bentur and Sidney Mindess, "Fibre Reinforced Cementitious Composites", Second Edition 2007, Chapter 8, (pp 278)
13. Alan J. Brookes, "Cladding of Buildings", Third Edition Published 2002, (pp 82).
14. U. M. Ghare, "Manufacture of Glass Fibre Reinforced Concrete Products", Unit 1, Division of YOGI group UAE, August 2008.
15. A Avinash Gornale, B S. Ibrahim Quadri and C Syed Hussaini (2012), Strength
16. aspect of Glass fibre reinforced concrete, International journal of Scientific and Engineering research, vol,3, issue 7.
17. A Dr. Srinivasa Rao, B Chandra Mouli K. and C Dr. T. Seshadri Sekhar (2012), Durability studies on Glass Fibre Reinforced Concrete, International Journal of civil engineering science, vol.1, no-1-2.
18. A G. Jyothi Kumari, B P. Jagannadha Rao and C M. V. Seshagiri Rao (2013), Behavior of concrete beams reinforced with glass fibre reinforced polymer flats, international journal of research in engineering and technology, Vol.2, Issue 09.
19. A Kavita S. Kene, B Vikrant S. Vairagade and C Satish Sathawane (2012), Experimental study on behavior of steel and glass fibre Reinforced concrete composite, Bonfring International Journal of Industrial Engineering and Management studies, Vol. 2, No-4.
20. A S. H Alsayed, B Y.A. Al-Salloum and C T. H. Almusallam (2001), Performance of glass fibre reinforced plastic bars as a reinforcing material for concrete structures, Journal of Science and Technology.
21. A Yogesh Murthy, B Apoorv Sharda and C Gourav Jain (2012), Performance of glass fibre reinforced concrete, International journal of engineering and innovative technology, vol.1, issue 6.
22. S.Harle, Prof.R.Meghe (2013). "Glass Fibre Reinforced Concrete & Its Properties" International Journal of Engineering and computer science, Volume-2, Issue-12, PP-3544-3547, December 2013.
23. Chandramouli.K, Srinivasa.R.P, Pannirselvam.N, Sekhar.T (2010) "Strength Properties of Glass Fibre Concrete" ARPN Journal of Engineering and Applied Sciences, vol-5, No-4, April 2010.
24. Murthy.I.Y, Sharda.A, Jain.G (2012) "Performance of Glass Fibre Reinforced Concrete" International Journal of Engineering and Innovative Technology,Volume-1, Issue-6, June 2012.
25. D.D.Paradava, Prof. J.Pitroda (2013) "Utilization of Artificial Fibres in Construction Industry: A Critical Literature Review " International Journal of Engineering Trends and Technology, Volume-4 Issue- 10 October 2013.