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Effects Of Natural And Glass Fibers In Concrete: A Detailed Study

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Concrete, though strong in compression, suffers from low tensile strength and brittle failure. Modern research focuses on incorporating fibers into the concrete matrix to improve toughness, ductility, crack resistance, and overall performance. This research paper provides a complete experimental and analytical review of the mechanical behavior of concrete reinforced with coconut fiber, jute fiber, glass fiber, and coconut shell aggregate. Additionally, hybrid concrete with mineral admixtures such as metakaolin and alccofine is analyzed. The findings reveal that while natural fibers improve ductility and crack control, glass fibers significantly enhance compressive, flexural, and tensile strength. Coconut shell aggregate serves well for lightweight concrete applications. Hybrid fiber and admixture-based concrete shows the highest performance across all properties.

1. INTRODUCTION

Concrete is the backbone of modern infrastructure but is inherently weak in tension. Microcracks develop early during curing and propagate quickly under loading. Fiber reinforcement has emerged as a proven method to control cracking, improve strength, and enhance post-crack behavior. Fibers bridge cracks, delay crack widening, and improve toughness. Natural fibers like jute and coconut are cost-effective, eco-friendly, and widely available, while synthetic fibers like glass provide superior mechanical strength.

2. LITERATURE REVIEW

A comprehensive review of existing research on fiber-reinforced concrete reveals significant contributions from multiple authors who investigated natural, synthetic, and hybrid fiber systems. Their studies collectively highlight improvements in mechanical performance, crack resistance, durability, and post-cracking behavior.

1. Upendra Varma & A. D. Kumar

These authors investigated the mechanical behavior of Glass Fibre Reinforced Concrete (GFRC) across various grades of concrete. Their experimental program incorporated alkali-resistant glass fibers at a fixed dosage of 0.03% and evaluated compressive, split tensile and flexural strengths. The results demonstrated a consistent increase of 10–20% in compressive strength, along with significant enhancements in tensile and flexural capacities. The authors also observed that the inclusion of glass fibers reduced bleeding and improved surface integrity, while causing only a slight reduction in workability. Their findings confirm that glass fibers are highly effective in improving both strength and durability characteristics of concrete.

2. Bharti Sharma , Vijay kumar Shukla, Amarnath Gupta (Coconut–Jute Fiber reinforced Concrete)

They examined the joint incorporation of coconut fiber and jute fiber in concrete to enhance ductility and crack resistance. The study employed fiber dosages ranging from 0.5% to 2% and reported that an optimum dosage of around 1% resulted in the highest mechanical improvement. Both fibers contributed to higher flexural and split tensile strengths due to their ability to bridge micro-cracks. The author noted that although strength properties improved, the workability of concrete decreased significantly because of the water absorption characteristics of natural fibers. Overall, the study established that hybrid natural fiber reinforcement can effectively improve toughness and ductility in concrete.

3. Bharti Sharma, Vijay kumar Shukla, Amarnath Gupta (Coconut Shell Aggregate in Concrete)

These authors explored the potential of using coconut shell (CS) as a partial replacement for coarse aggregate at levels between 5% and 30%. Their study revealed that coconut shell concrete exhibited 10–12% reduction in density, demonstrating its suitability as a lightweight concrete. However, the reduction in density was accompanied by a corresponding decrease in compressive strength as the replacement level increased. Despite this, the authors argue that coconut shell concrete is appropriate for applications where reduced weight is beneficial, such as non-structural elements and low-load components.

4. R. Sethunarayanan, S. Chocklimgam, and R. Ramnathan (Natural Fiber Reinforced Concrete)

Sethunarayanan and colleagues conducted an extensive investigation into concrete reinforced with natural fibers such as coconut and jute. Their work highlighted improvements in impact resistance, energy absorption, and post-cracking toughness. The study emphasized that the addition of natural fibers enhances the tensile and flexural strengths of concrete by controlling micro-crack propagation. They observed that an optimum fiber content of around 1% produces the best mechanical response, whereas higher percentages lead to fiber agglomeration and reduced compaction, ultimately lowering strength. The authors concluded that natural fibers are a viable, eco-friendly alternative for improving concrete ductility and toughness.

5 Dr. K.Chandramouli, J.Sree Naga Chaitanya, Dr.N.Pannirselvam, Dr D Vijaya Kumar, Pathan Arif Khan (Jute Fiber with Metakaolin and Alccofine)

They conducted a detailed study on jute fiber reinforced concrete enhanced with mineral admixtures, specifically metakaolin (MK) and alccofine (AF). Their results indicated that the addition of metakaolin significantly increased compressive and flexural strengths due to its pozzolanic reaction and pore-refining capability. Alccofine contributed to improved workability and early strength. The hybrid mix of jute fiber with MK and AF delivered the highest overall mechanical performance, reaching compressive strengths exceeding 60 MPa at later ages. This study demonstrated that combining natural fibers with mineral admixtures can produce high-performance concrete with enhanced strength and durability.

6. T. Sai Vijaya Krishna, B. Manoj Yadav (Jute Fiber Reinforced Concrete)

Vijaya Krishna and B. Manoj Yadav evaluated the effects of incorporating jute fibers at dosages of 1–2% into concrete. They reported that 1% jute fiber resulted in notable improvements in split tensile strength and impact resistance due to the fiber's high elongation capacity. However, increasing the fiber content to 2% led to reduced compressive strength and poor workability, mainly due to fiber entanglement and inadequate compaction. Their work highlights the importance of identifying an optimum fiber dosage to achieve balanced mechanical properties.

3. MATERIAL AND MEHOD

3.1 Materials

The materials used include OPC 43/53 grade cement, natural river sand, 20 mm coarse aggregate, coconut coir fiber (3 cm length), jute fiber (25–30 mm), steel fiber, glass fiber (12 mm), metakaolin, alccofine, and water.

3.2 Mix Proportions

Concrete grades used include M20, M30, M40, and M60.

Fiber dosage ranges:

Coconut and jute fibers: 0.5%–2%

- Glass fibers: 0.03%–0.5%
- Coconut shell aggregate: 5%–30%

3.3 Testing

Tests conducted: slump test, compressive strength, flexural strength, and split tensile strength test as per IS codes.

4. VARIOUS TEST RESULTS

There are some experimental data from various references

4.1 Slump test result with jute fiber

Sl. No.	Percentage of fiber (%)	Slump value (mm)	Reference
1	0	55	From -References Paper Sr. No. 01
2	0.5	50	
3	1	46	
4	1.5	35	
5	2	27	

Sl. No.	Percentage of fiber (%)	W/C ratio	Slump value (mm)	Reference
1	0	0.5	62	From - References Paper Sr. No. 02
2	0.5	0.5	48	
3	1	0.5	45	
4	2	0.5	42	

4.2 Compressive strength

Table no 4.2.1 Compressive strength of coconut jute fiber reinforced concrete

Sl. No.	Percentage of fiber (%)	Density (kg/m^3)	Compressive strength (N/mm^2)	Reference
1	0	2500.67	23.55	From - References Paper Sr. No. 01
2	0.5	2471	23.99	
3	1	2432	24.29	
4	1.5	2420	25.33	
5	2	2383	21.036	

Table no 4.2.2 Compressive strength of jute fiber reinforced concrete

Sl. No.	Percentage of fiber (%)	Compressive strength (N/mm^2)		Reference
		7 days curing	28 days curing	
1	0	20.88	29.48	From -References Paper Sr. No. 02
2	0.5	17.06	28.44	

3	1	14.31	26.66	
4	2	13.6	24.88	

Table no 4.2.3 Compressive strength of jute fiber reinforced concrete with admixture Metakaolin (MK) and Alccofine 1203 (AF)

Sl. No.	Percentage of fiber And admixture (%)	Compressive strength (N/mm^2)		Reference
		28 days curing	56 days curing	
1	0	38.85	41.99	From -References Paper Sr. No. 03
2	3%MK+0.3%AF+1% JF	43.40	46.95	
3	6%MK+0.6%AF+1% JF	47.05	50.97	
4	9%MK+0.9%AF+1% JF	49.7	53.97	
5	12%MK+1.2%AF+1 %JF	52.14	56.78	
6	18%MK+1.5%AF+1 %JF	50.07	54.57	

Table no 4.2.4 compressive strength of glass fiber reinforced concrete

Sl. No.	Grade of concrete	Compressive strength (N/mm^2)		Reference
		Without fiber	With fiber	
1	M20	34.12	40.46	From -References

2	M30	40.30	46.04	Paper Sr. No. 04
3	M40	49.25	56.26	
4	M60	66.92	74.55	

4.3 Flexural Strength –

Table 4.3.1 Flexural strength of coconut jute fiber reinforced concrete

Sl. No.	**Percentage of fiber (%)**	**Flexural strength (N/mm^2)**	**Increase of flexural strength by inclusion of fiber (%)**	**Reference**
1	0	3.42	-	From -References Paper Sr. No. 01
2	0.5	4.79	40.058	
3	1	4.32	26.32	
4	1.5	3.53	3.21	
5	2	3.27	-	

Table no 4.3.2 Flexural strength of jute fiber reinforced concrete

Sl. No.	**Percentage of fiber (%)**	**Flexural strength (N/mm^2)**		**Reference**
		7 days curing	**28 days curing**	
1	0	3.2	4.4	From –References Paper Sr. No. 02
2	0.5	3.4	4.6	
3	1	3.6	4.8	
4	2	3.2	4	

Table no 4.3.3 Flexural strength of glass fiber reinforced concrete

Sl. No.	Grade of concrete	Flexural strength (N/mm^2)		Reference
		Without fiber	With fiber	
1	M20	3.56	4.08	From -References Paper Sr. No. 04
2	M30	4.12	4.85	
3	M40	4.86	5.72	
4	M60	6.37	7.12	

4.4 Split Tensile strength –

Table no 4.4.1 Split tensile strength of jute fiber reinforced concrete

Sl. No.	Percentage of fiber (%)	Split tensile strength (N/mm^2)		Reference
		7 days curing	28 days curing	
1	0	1.98	3.34	From -References Paper Sr. No. 02
2	0.5	2.26	3.42	
3	1	2.39	3.55	
4	2	2.08	3.25	

Table no 4.4.2 Split tensile strength of jute fiber reinforced concrete with admixture Metakaolin (MK) and Alccofine 1203 (AF)

Sl. No.	Percentage of fiber And admixture (%)	Split tensile strength (N/mm^2)		Reference
		28 days curing	56 days curing	

1	0	3.76	4.06	From -References Paper Sr. No. 03
2	3%MK+0.3%AF+1%JF	4.30	4.65	
3	6%MK+0.6%AF+1%JF	4.63	5.01	
4	9%MK+0.9%AF+1%JF	4.92	5.36	
5	12%MK+1.2%AF+1%JF	5.20	5.66	
6	18%MK+1.5%AF+1%JF	5.05	5.50	

Table no 4.4.3 Split tensile strength of glass fiber reinforced concrete

Sl. No.	Grade of concrete	Flexural strength (N/mm^2)		Reference
		Without fiber	With fiber	
1	M20	3.62	4.30	From -References Paper Sr. No. 04
2	M30	4.36	5.12	
3	M40	4.79	5.65	
4	M60	5.72	6.86	

5. RESULTS DISCUSSION

5.1 Workability

Fiber addition reduces workability due to water absorption and surface roughness. Glass fibers cause minimal reduction.

5.2 Compressive Strength

Glass fibers enhance compressive strength significantly (10–20%). Jute and coconut fibers show
improvement at optimum dosage but reduce strength when used excessively. Coconut shell aggregate reduces compressive strength due to lower density.

5.3 Flexural Strength

All fibers increase flexural strength. Glass fibers provide the highest gain due to high tensile strength and modulus. Coconut fiber improves flexural toughness.

5.4 Tensile Strength

Jute fiber significantly improves split tensile strength at 1% dosage. Glass fibers provide maximum
tensile performance.

5.5 Durability

Glass fibers enhance durability under chemical exposure. Natural fibers may degrade unless treated. Hybrid mixes demonstrate excellent durability.

6. COMPARATIVE ANALYSIS

A comparative analysis shows:
1. Glass fibers offer the best mechanical improvement.
2. Jute fibers provide balanced performance and sustainability.
3. Coconut fibers focus on crack resistance.
4. Coconut shell aggregate reduces weight but reduces compressive strength.

8. APPLICATION –

Fiber reinforced concrete is used for industrial floors, pavements, precast panels, earthquake-resistant structures, lightweight blocks, and low-cost housing.

10. CONCLUSIONS

This detailed research demonstrates the effectiveness of various fibers in improving concrete performance. Glass fibers are best for structural applications, while natural fibers offer economical and eco-friendly solutions. Hybrid mixes show maximum strength, durability, and performance benefits.

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