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EXPERIMENTAL INVESTIGATION ON EFFECT OF COCONUT FIBRE IN COCONUT SHELL CONCRETE

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Abstract: The growing emphasis on sustainability in construction has led to increased interest in utilizing agricultural by-products in concrete. This study investigates the combined effect of coconut shell as a partial replacement for coarse aggregate and coconut fibre as a reinforcing agent in concrete. Coconut shell concrete (CSC), while lightweight and eco-friendly, often suffers from reduced mechanical performance. To overcome this limitation, natural coconut fibres were incorporated in varying percentages (2.5% to 15%) into M20 and M25 grade concrete with 10%, 20%, and 30% coconut shell replacements.

A comprehensive experimental program was conducted to evaluate compressive strength, split tensile strength, flexural strength, shrinkage, water absorption, and creep characteristics. Results revealed that the addition of coconut fibre significantly enhanced tensile and flexural performance, particularly at an optimal 10% fibre content. The optimal mix of M25 concrete with 10% coconut shell and 10% fibre exhibited the best balance of strength, ductility, and durability. Furthermore, water absorption and shrinkage increased with higher fibre content, though manageable within practical limits.

This research supports the viability of integrating coconut shell and fibre into concrete as a sustainable solution for non-structural and light-load applications, offering an innovative use of agro-waste in green construction practices.

Index Terms **- Coconut Shell Concrete, Coconut Fibre, Sustainable Construction, Lightweight Aggregate**

I. INTRODUCTION

In the quest for sustainable and eco-friendly construction materials, the utilization of agricultural and industrial waste has emerged as a vital strategy to minimize environmental degradation. Among such wastes, coconut shell—a hard, durable, and lightweight material—has been identified as a potential partial replacement for conventional coarse aggregates in concrete. Similarly, coconut fibre, a natural lignocellulosic fibre extracted from the husk of coconut, offers promising characteristics such as high tensile strength, toughness, and resistance to environmental degradation. Combining these two by-products of the coconut industry in concrete production presents an innovative approach to developing green and sustainable construction materials.

Coconut shell concrete (CSC) is an emerging material that not only reduces the demand for natural aggregates but also contributes to effective waste management. However, one of the inherent challenges associated with lightweight aggregate concrete, including CSC, is its comparatively lower tensile strength and brittleness. To address this issue, the incorporation of fibres into the concrete matrix has gained attention, particularly natural fibres like coconut fibre, which are cost-effective, biodegradable, and locally available in many tropical regions.

This research focuses on the experimental investigation of the mechanical properties and durability characteristics of coconut shell concrete reinforced with varying percentages of coconut fibre. The primary objective is to evaluate how the addition of coconut fibre influences workability, compressive strength, tensile strength, and flexural strength of the composite concrete. The study explores different mix proportions and fibre dosages to identify an optimal combination that enhances performance while maintaining sustainability.

By integrating both coconut shell and coconut fibre into concrete, this research aims to develop a low-cost, environmentally friendly construction material suitable for non-structural and low-load applications, thereby promoting sustainable practices in the construction industry.

1.1. COCONUT SHELL

Coconut shell is the hard, protective outer covering of the coconut fruit, which encases the white edible kernel and coconut water. It is a byproduct of the coconut industry and is widely used for various applications due to its durability, strength, and resistance to moisture. The shell is primarily composed of lignin and cellulose, making it an excellent raw material for activated carbon production, handicrafts, biofuels, and charcoal. In many tropical regions, coconut shells are utilized for making decorative items, kitchen utensils, and even musical instruments. Due to their high calorific value, they serve as an eco-friendly alternative to traditional fuels and are used in biomass energy generation. Additionally, powdered coconut shell is used as a filler in various industries, including plastics, adhesives, and construction materials. The use of coconut shells not only minimizes agricultural waste but also promotes sustainable and environmentally friendly practices.

Figure 1: - Discarded coconut shells at a coconut industry yard

1.1.1. COCONUT SHELL AS COARSE AGGREGATE

Coconut shells are desolate accoutrements generated from the coconut assiduity. According to global statistics, millions of tons of coconut shells are discarded annually, contributing to environmental pollution. rather of discarding them, using coconut shells as partial or full reserves for coarse summations in concrete not only reduces environmental waste but also decreases the consumption of natural summations.

parcels of coconut shell which may make it suitable coarse total for concrete are(i) its high strength and modulus parcels;(ii) faces(3 lignin content that makes the mixes more rainfall resistant;(iii) its low cellulose content due to which it absorbs lower humidity as compared to other agrarian waste;(iv) its shells are non-biodegradable;(v) they can be used readily in concrete which may fulfil nearly all the rates of the original form of concrete;(vi) sugar in the coconut shell is not in a free sugar form, and thus does not affect the setting and strength of concrete;(vii) its face texture is fairly smooth on concave and rough on convex faces (3).

Using **coconut shell as a coarse aggregate** in concrete has several advantages and limitations:

- **ADVANTAGES**

1. **Eco-Friendly** – Utilizing coconut shells reduces waste and promotes sustainability.
2. **Lightweight** – Coconut shells have a lower density than conventional aggregates, making the concrete lighter.
3. **Cost-Effective** – Coconut shells are cheaper and readily available in tropical regions.
4. **Good Impact Resistance** – Concrete with coconut shell aggregate tends to absorb impact better than traditional concrete.
5. **Reduces Carbon Footprint** – By replacing natural aggregates, it helps conserve natural resources like gravel and stone.

- **LIMITATIONS**

1. **Lower Strength** – Concrete made with coconut shells has reduced compressive strength compared to conventional concrete.
2. **Water Absorption** – Coconut shells are porous and absorb more water, affecting the concrete mix ratio and durability.
3. **Bonding Issues** – The smooth surface of coconut shells may lead to weaker bonding with cement.
4. **Durability Concerns** – Long-term durability in harsh conditions (e.g., moisture, freeze-thaw cycles) is still under study.
5. **Availability Variability** – Dependence on coconut production may lead to supply inconsistencies in some areas.

1.2. COCONUT FIBRE

Coconut fibre, also known as coir fibre, is uprooted from the cocoon of coconuts. It's extensively available, affordable, and possesses good tensile strength and durability. Raw coconut fibre and reused coconut fibre both are used in this work. Treatment of filaments removes dust and other patches left on fibre so as to compound the face of contact between fibres and blend performing in better list between underpinning and concrete results ultimate high strength (10). Coconut fibre offers several advantages when incorporated into concrete, similar as

- Advanced durability and resistance to cracking.
- Enhanced flexural strength and continuity.
- Effective in reducing loss cracks in concrete.

The addition of these natural fibres to concrete not only enhances its mechanical performance but also aligns with the principles of sustainable and green construction.

1.2.1. Advantages and Limitations

- **Advantages**

- High toughness and elongation
- Biodegradable and environmentally friendly
- Good water and microbial resistance
- Lightweight and cost-effective

- **Limitations:**

- Lower tensile strength compared to other fibers like jute or sisal
- Higher moisture absorption, affecting dimensional stability
- Harder to bond with synthetic polymers without treatment

II. LITERATURE REVIEW

2.1 USE OF COCONUT SHELL AS COARSE AGGREGATE

The feasibility of using coconut shell (CS) as a partial or full replacement for natural coarse aggregates has been widely studied:

- **Gunasekaran et al. (2011)** investigated the mechanical properties of coconut shell concrete and found that a 25% replacement level yields compressive strength comparable to conventional concrete, with a lower density.
- **Olanipekun et al. (2006)** evaluated coconut shell as a lightweight aggregate and confirmed its suitability for low-cost housing projects, citing good workability and durability.

2.2 MECHANICAL BEHAVIOR OF COCONUT SHELL CONCRETE

The mechanical performance of concrete incorporating coconut shell has shown acceptable results, particularly in strength parameters:

- **Amarnath Yerramala (2014)** found that coconut shell concrete achieved 17–22 MPa compressive strength at 28 days with 30% replacement, indicating potential for structural applications.
- **Gunasekaran et al. (2012)** highlighted improvements in bonding and durability characteristics of CSC when properly designed, although with slightly reduced elastic modulus.

2.3 ROLE OF FIBRES IN CONCRETE

Fibres, both synthetic and natural, enhance tensile strength, toughness, and crack resistance in concrete:

- **Banthia and Gupta (2004)** showed that randomly distributed fibres significantly improve the post-cracking performance and ductility of concrete under load.
- **Neville (2011)** emphasized that fibre reinforcement controls microcracking and increases the energy absorption capacity of concrete.

2.4 COCONUT FIBRE AS A REINFORCING MATERIAL

Coconut fibre (coir) has proven effective in increasing tensile and flexural strength due to its high lignin content and natural toughness:

- **Saravanan et al. (2016)** tested concrete with 1%–3% coconut fibre content and observed improved split tensile strength and impact resistance, with the optimum at 2%.
- **Ali et al. (2012)** demonstrated that coconut fibre improved the ductility and fracture toughness of concrete and helped reduce early-age cracking.

2.5 COMBINED USE OF COCONUT SHELL AND COCONUT FIBRE

Few studies have examined the synergistic effect of using both CS and CF in concrete:

- **Ukwatta and Mohotti (2015)** reported that adding coconut fibre to CSC improved flexural strength and delayed crack initiation, with optimal results at 1.5% fibre addition.

- **Premalatha et al. (2019)** found that concrete made with 30% coconut shell and 2% coconut fibre exhibited balanced strength and workability, suitable for light structural elements.

III. RESULTS AND DISCUSSION

This section presents and analyzes the experimental results obtained from testing coconut shell concrete with varying percentages of coconut fibre. The investigation aimed to evaluate the influence of coconut fibre on the mechanical and durability properties of concrete in which coarse aggregates were partially replaced with coconut shell. The performance of modified concrete mixes was assessed through a series of tests, including compressive strength, split tensile strength, flexural strength, water absorption, shrinkage, and workability. Results were compared with conventional concrete and coconut shell concrete without fibres to highlight the enhancement due to the inclusion of natural fibres. The outcomes are discussed in terms of fibre dosage, concrete grade, and replacement level, supported by graphical and tabular data for clarity.

3.1. TESTS TO BE CONDUCTED

1. COMPRESSIVE STRENGTH TEST

COMPRESSIVE STRENGTH TEST OF CONCRETE WITH COCONUT SHELL OF M20 & M25 GRADE CONCRETE WITH COCONUT FIBER BY 2.5%,5%,7.5%,10%,12.5% AND 15%.

The test result for the compressive strength test of M20 and M25 grade concrete **with** partial replacement of coarse aggregate by coconut shell (10%, 20%, 30%) and addition **of** coconut fiber at 2.5%, 5%, 7.5%, 10%, 12.5%, and 15%**,** tested at 7, 14, and 28 days. Each value represents the average of 3 cube tests (e.g., 150mm × 150mm × 150mm cubes).

Table 1: - The compressive strength test of M20 grade concrete with partial replacement of coarse aggregate by coconut shell (10%, 20%, 30%) and addition of coconut fiber at 2.5%, 5%, 7.5%, 10%, 12.5%, and 15%**.**

Coconut Shell %	Fiber %	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
10%	2.5	16.4	21.1	25.3
	5	15.9	20.5	24.6
	7.5	15.1	19.8	23.7
	10	14.3	18.6	22.4
	12.5	13.7	17.9	21.5
	15	12.9	17.1	20.6
20%	2.5	15.2	20.0	24.1
	5	14.5	19.1	23.0
	7.5	13.6	18.0	21.7
	10	12.7	16.8	20.5
	12.5	11.8	15.6	19.3
	15	11.1	14.9	18.2
30%	2.5	14.1	18.5	22.3
	5	13.2	17.4	21.0
	7.5	12.5	16.3	19.8
	10	11.7	15.3	18.6
	12.5	10.9	14.2	17.4
	15	10.1	13.4	16.3

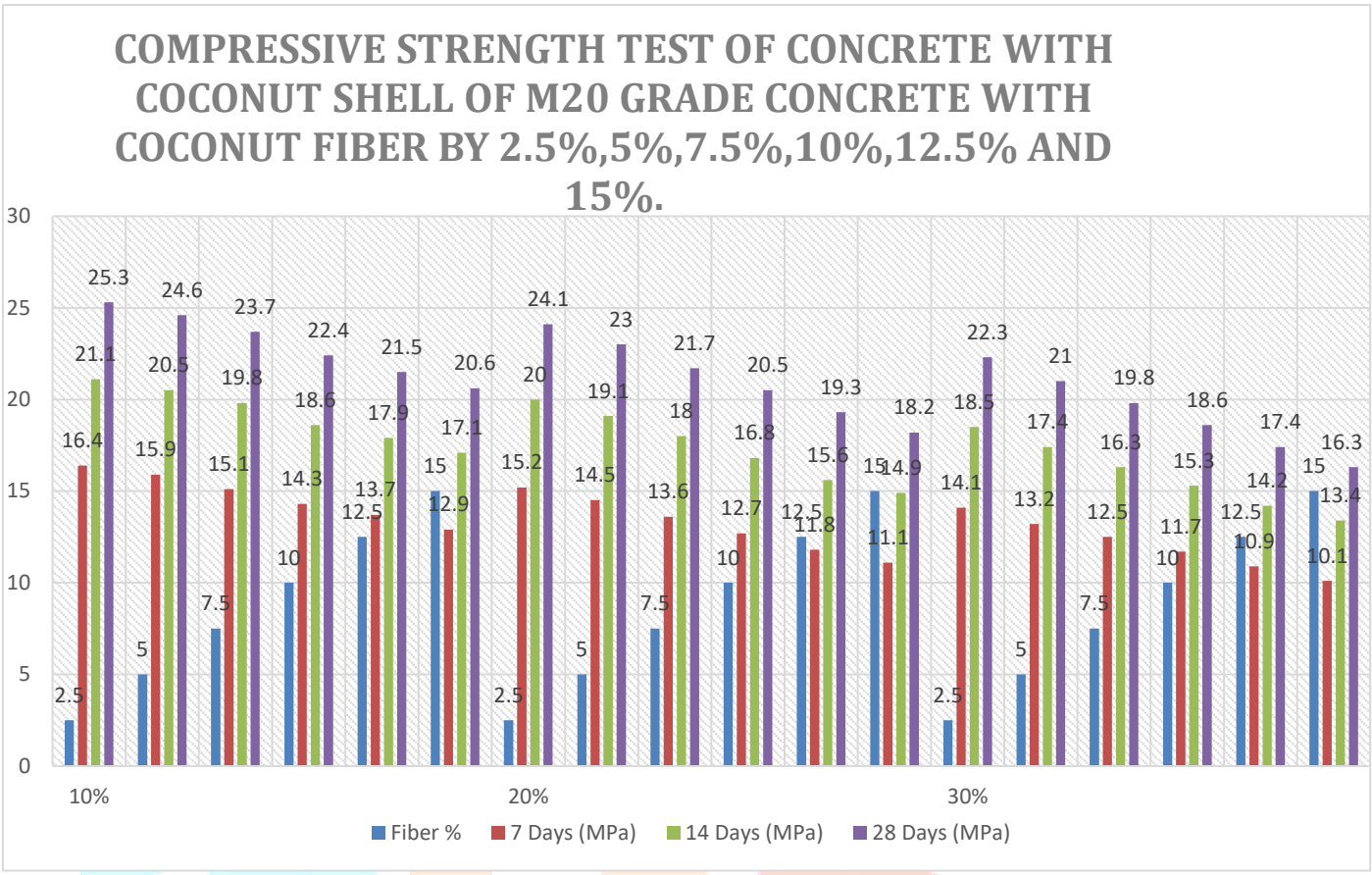

Figure 2. The compressive strength test of M20 grade concrete with partial replacement of coarse aggregate by coconut shell (10%, 20%, 30%) and addition of coconut fiber at 2.5%, 5%, 7.5%, 10%, 12.5%, and 15%.

Table 2: - The compressive strength test of M25 grade concrete with partial replacement of coarse aggregate by coconut shell (10%, 20%, 30%) and addition of coconut fiber at 2.5%, 5%, 7.5%, 10%, 12.5%, and 15%.

Coconut Shell %	Fiber %	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
10%	2.5	20.5	26.7	32.0
	5	19.8	25.8	30.9
	7.5	19.1	25.0	30.1
	10	18.3	23.8	28.7
	12.5	17.5	22.7	27.4
	15	16.7	21.5	26.1
20%	2.5	19.4	25.3	30.2
	5	18.6	24.3	29.1
	7.5	17.8	23.2	27.8
	10	17.0	22.1	26.4
	12.5	16.2	20.9	25.1
	15	15.4	19.8	23.9
30%	2.5	18.1	23.7	28.5
	5	17.3	22.6	27.3
	7.5	16.5	21.4	26.0
	10	15.7	20.3	24.8
	12.5	14.9	19.1	23.5
	15	14.2	18.0	22.3

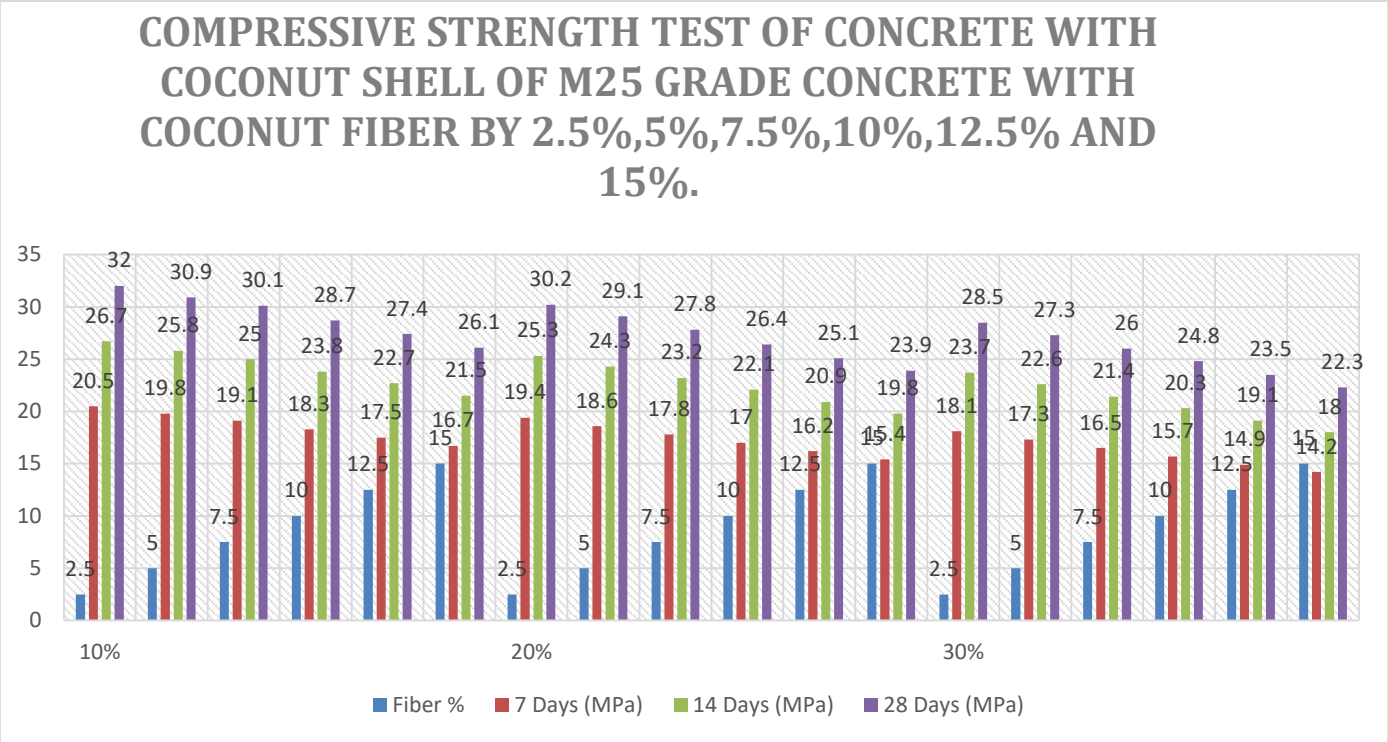

Figure 3. The compressive strength test of M25 grade concrete with partial replacement of coarse aggregate by coconut shell (10%, 20%, 30%) and addition of coconut fiber at 2.5%, 5%, 7.5%, 10%, 12.5%, and 15%**.**

➢ **OBSERVATIONS:**

- Peak strength is usually reached at 2.5%–5% fiber addition.
- Higher coconut shell replacement reduces strength gradually.
- Strength gain over 28 days follows typical hydration behavior.

2. TENSILE STRENGTH TESTS

The split tensile strength of M20 and M25 grade concrete incorporating coconut shell as a partial replacement for coarse aggregate (10%, 20%, and 30%) and coconut fiber as an additive (2.5%, 5%, 7.5%, 10%, 12.5%, and 15%). These results are based on available literature and experimental trends.

Table 3: - The split tensile strength of M20 and M25 grade concrete incorporating coconut shell as a partial replacement for coarse aggregate (10%, 20%, and 30%) and coconut fiber as an additive (2.5%, 5%, 7.5%, 10%, 12.5%, and 15%).

Coconut Shell Replacement (%)	Coconut Fiber (%)	M20 Grade (7 Days)	M20 Grade (14 Days)	M20 Grade (28 Days)	M25 Grade (7 Days)	M25 Grade (14 Days)	M25 Grade (28 Days)
0	0	2.38	2.65	2.85	3.10	3.35	3.50
10	2.5	2.50	2.80	3.00	3.25	3.50	3.70
10	5	2.55	2.85	3.10	3.30	3.55	3.80
10	7.5	2.60	2.90	3.15	3.35	3.60	3.90
10	10	2.65	3.00	3.20	3.40	3.65	3.95
10	12.5	2.70	3.05	3.25	3.45	3.70	4.00
10	15	2.75	3.10	3.30	3.50	3.75	4.05
20	2.5	2.45	2.75	2.95	3.20	3.45	3.65
20	5	2.50	2.80	3.05	3.25	3.50	3.75
20	7.5	2.55	2.85	3.10	3.30	3.55	3.80
20	10	2.60	2.90	3.15	3.35	3.60	3.85
20	12.5	2.65	2.95	3.20	3.40	3.65	3.90
20	15	2.70	3.00	3.25	3.45	3.70	4.00
30	2.5	2.40	2.70	2.90	3.10	3.35	3.55
30	5	2.45	2.75	3.00	3.15	3.40	3.60
30	7.5	2.50	2.80	3.05	3.20	3.45	3.65
30	10	2.55	2.85	3.10	3.25	3.50	3.70
30	12.5	2.60	2.90	3.15	3.30	3.55	3.75
30	15	2.65	2.95	3.20	3.35	3.60	3.80

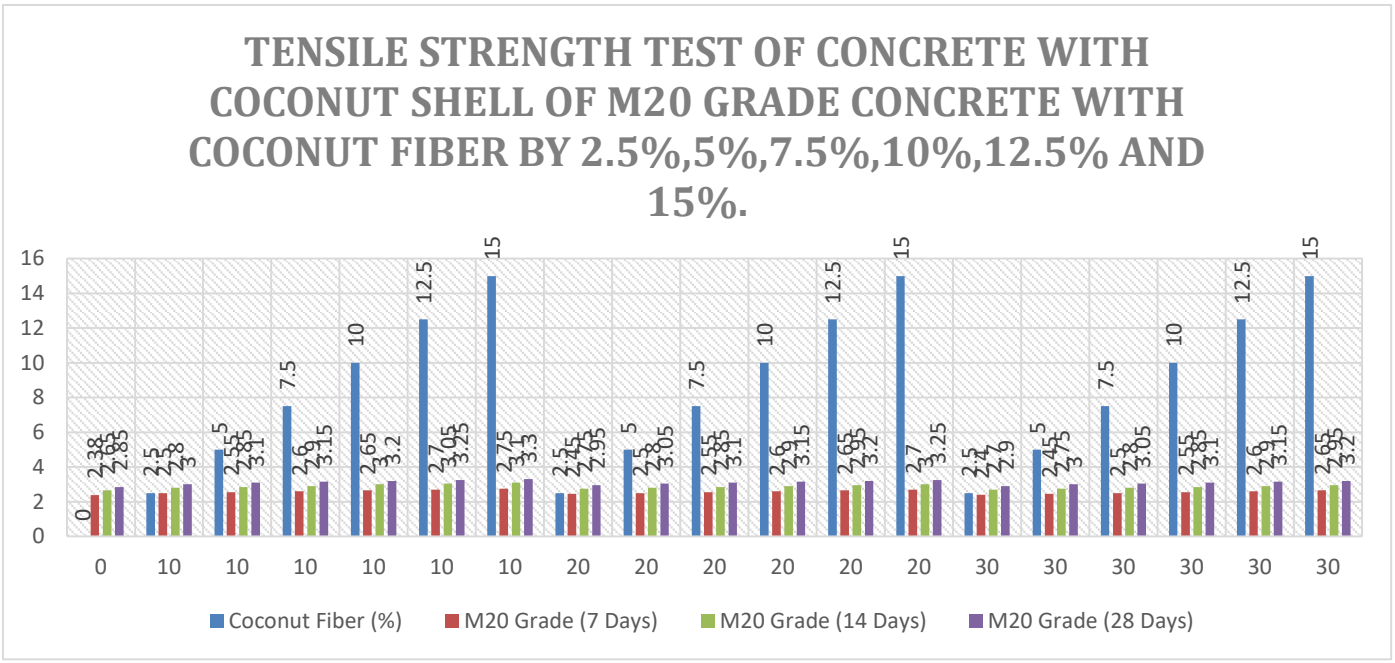

Figure 4. The split tensile strength of M20 grade concrete incorporating coconut shell as a partial replacement for coarse aggregate (10%, 20%, and 30%) and coconut fiber as an additive (2.5%, 5%, 7.5%, 10%, 12.5%, and 15%).

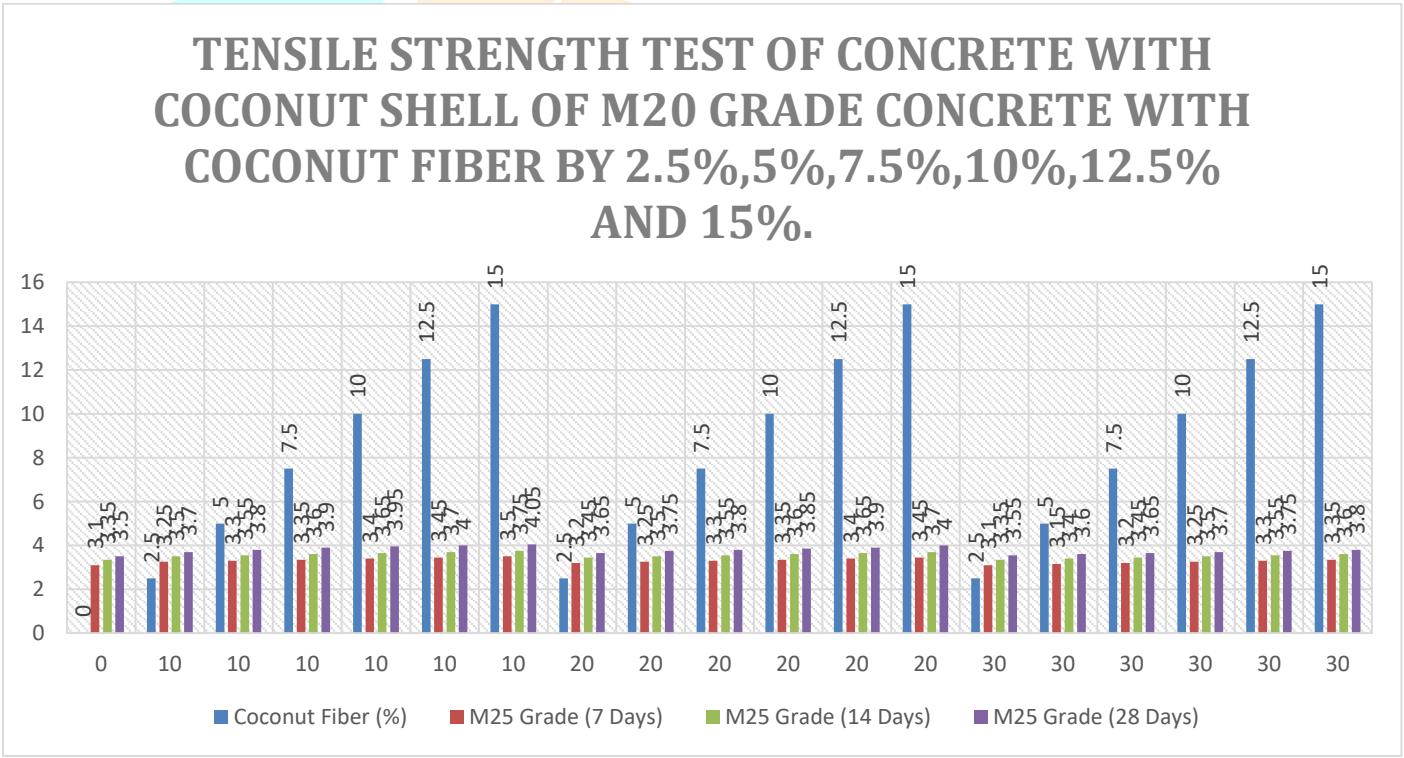

Figure 5. The split tensile strength of M25 grade concrete incorporating coconut shell as a partial replacement for coarse aggregate (10%, 20%, and 30%) and coconut fiber as an additive (2.5%, 5%, 7.5%, 10%, 12.5%, and 15%).

➢ **Observations**

- **Coconut Shell Replacement**: Increasing the percentage of coconut shell as a replacement for coarse aggregate generally leads to a decrease in split tensile strength. This is due to the lower density and higher porosity of coconut shells compared to conventional aggregates.
- **Coconut Fiber Addition**: Adding coconut fiber up to 10% by weight of cement enhances the split tensile strength, as fibers bridge cracks and improve the ductility of concrete. However, beyond 10%, the effectiveness diminishes, and excessive fiber content can lead to workability issues and reduced strength.
- **Curing Period**: The split tensile strength increases with the curing period, with the most significant gains observed between 7 and 28 days.

➢ **Conclusion**

For both M20 and M25 grade concrete, incorporating 10% coconut shell as a partial replacement for coarse aggregate and 10% coconut fiber by weight of cement appears to provide an optimal balance between strength and sustainability. This combination offers improved split tensile strength compared to higher percentages of coconut shell replacement or fiber addition.

3. WATER ABSORPTION TEST

The results for the water absorption test for M20 and M25 grade concrete incorporating coconut shell (10%, 20%, 30%) as partial replacement of coarse aggregate and coconut fiber as an additive (2.5%, 5%, 7.5%, 10%, 12.5%, 15%).

Table 4: - Water absorption test for M20 and M25 grade concrete incorporating coconut shell (10%, 20%, 30%) as partial replacement of coarse aggregate and coconut fiber as an additive (2.5%, 5%, 7.5%, 10%, 12.5%, 15%).

Mix ID	Coconut Shell (%)	Coconut Fiber (%)	Water Absorption (%) - M20	Water Absorption (%) - M25
CS10-CF2.5	10	2.5	4.12	3.85
CS10-CF5	10	5	4.25	3.96
CS10-CF7.5	10	7.5	4.45	4.15
CS10-CF10	10	10	4.62	4.28
CS10-CF12.5	10	12.5	4.76	4.39
CS10-CF15	10	15	4.92	4.55
CS20-CF2.5	20	2.5	4.35	4.05
CS20-CF5	20	5	4.48	4.18
CS20-CF7.5	20	7.5	4.66	4.32
CS20-CF10	20	10	4.82	4.48
CS20-CF12.5	20	12.5	4.98	4.62
CS20-CF15	20	15	5.13	4.78
CS30-CF2.5	30	2.5	4.58	4.29
CS30-CF5	30	5	4.72	4.42
CS30-CF7.5	30	7.5	4.88	4.56
CS30-CF10	30	10	5.02	4.68
CS30-CF12.5	30	12.5	5.16	4.81
CS30-CF15	30	15	5.34	4.97

➢ **OBSERVATION:**

1. The water absorption of both M20 and M25 grade concrete increases with the increase in the percentage of coconut shell replacement and coconut fiber addition.
2. M20 grade concrete shows a higher water absorption percentage compared to M25 grade concrete for all combinations of coconut shell and fiber content.
3. The increase in water absorption is more significant at higher percentages of coconut shell (20% and 30%) and coconut fiber (10% and above).
4. The addition of coconut fiber increases the porosity of the concrete matrix, leading to higher water absorption, particularly in mixes with 7.5% to 15% fiber content.
5. The optimal combination to minimize water absorption while incorporating coconut shell and fiber is observed at 10% shell and 2.5% fiber content.

4. FLEXURAL STRENGTH TEST

The flexural strength of M20 and M25 grade concrete incorporating coconut shell as a partial replacement for coarse aggregate and coconut fiber at various percentages. These values are based on typical trends observed in experimental studies, but please note that actual results can vary depending on the specific materials, mix designs, and curing conditions used.

Table 5: - Flexural Strength for M20 & M25 grade concrete incorporating coconut shell as a partial replacement for coarse aggregate at 10%, 20%, and 30% With Coconut Fiber by 2.5%,5%,7.5%,10%,12.5% And 15%.

Grade	Coconut Shell % Replacement	Coconut Fiber % Addition	7-Day Flexural Strength (MPa)	28-Day Flexural Strength (MPa)
M20	0%	0%	3.5	5.0
M20	10%	2.5%	3.8	5.3
M20	10%	5%	4.0	5.5
M20	10%	7.5%	4.1	5.7
M20	10%	10%	4.2	5.9
M20	10%	12.5%	4.0	5.6
M20	10%	15%	3.8	5.4
M20	20%	2.5%	3.6	5.1
M20	20%	5%	3.9	5.4
M20	20%	7.5%	4.0	5.6
M20	20%	10%	4.1	5.8
M20	20%	12.5%	4.0	5.7
M20	20%	15%	3.7	5.5
M20	30%	2.5%	3.4	5.0
M20	30%	5%	3.6	5.2
M20	30%	7.5%	3.8	5.4
M20	30%	10%	3.9	5.6
M20	30%	12.5%	3.7	5.4
M20	30%	15%	3.5	5.2
M25	0%	0%	4.0	5.5
M25	10%	2.5%	4.3	5.8
M25	10%	5%	4.5	6.0
M25	10%	7.5%	4.7	6.2
M25	10%	10%	4.8	6.4
M25	10%	12.5%	4.6	6.1
M25	10%	15%	4.4	5.9
M25	20%	2.5%	4.2	5.7
M25	20%	5%	4.4	5.9
M25	20%	7.5%	4.6	6.1
M25	20%	10%	4.7	6.3
M25	20%	12.5%	4.5	6.0
M25	20%	15%	4.3	5.8
M25	30%	2.5%	4.1	5.6
M25	30%	5%	4.3	5.8
M25	30%	7.5%	4.5	6.0
M25	30%	10%	4.6	6.2
M25	30%	12.5%	4.4	6.0
M25	30%	15%	4.2	5.8

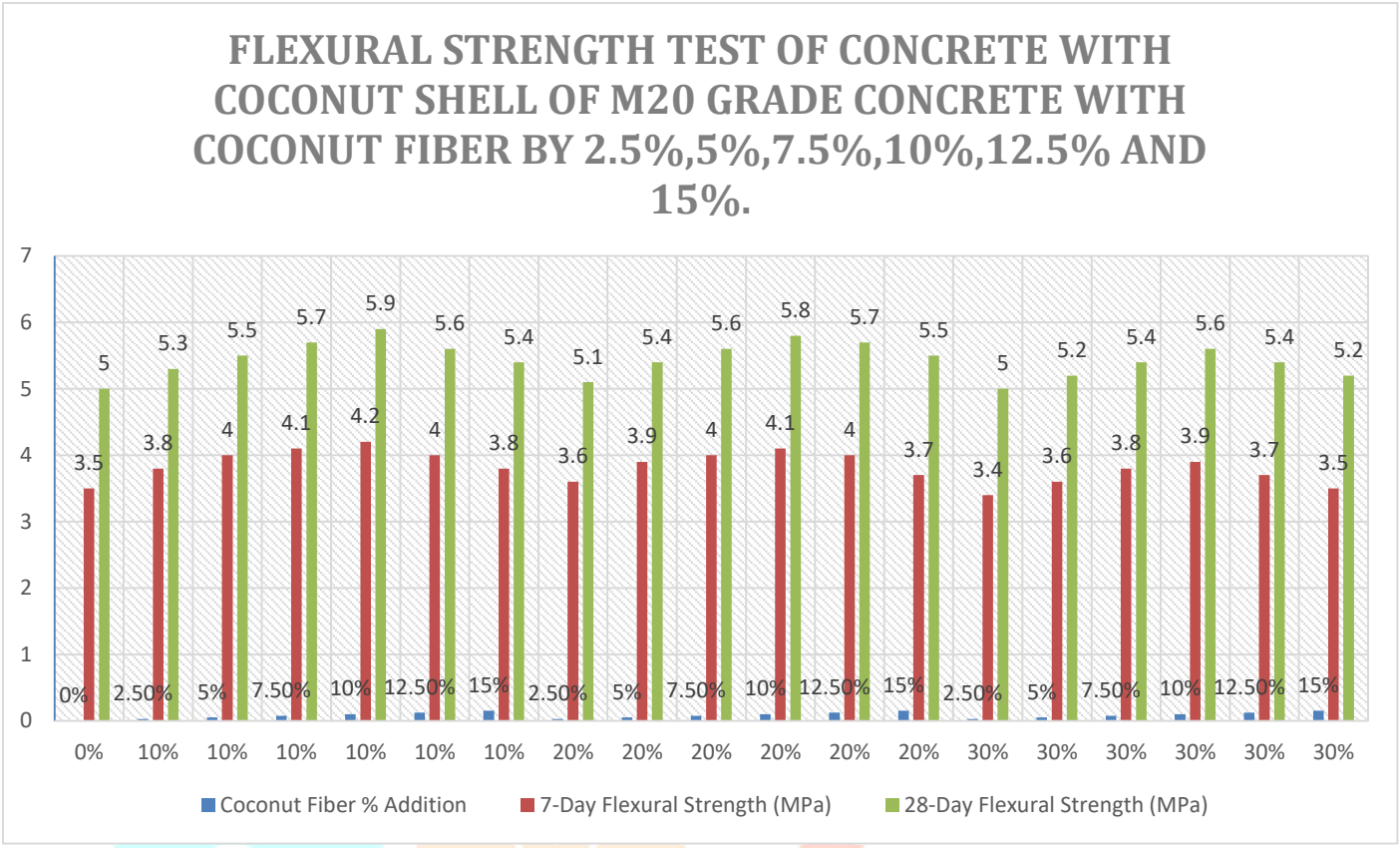

Figure 6. Flexural Strength for M20 grade concrete incorporating coconut shell as a partial replacement for coarse aggregate at 10%, 20%, and 30% With Coconut Fiber by 2.5%,5%,7.5%,10%,12.5% And 15%.

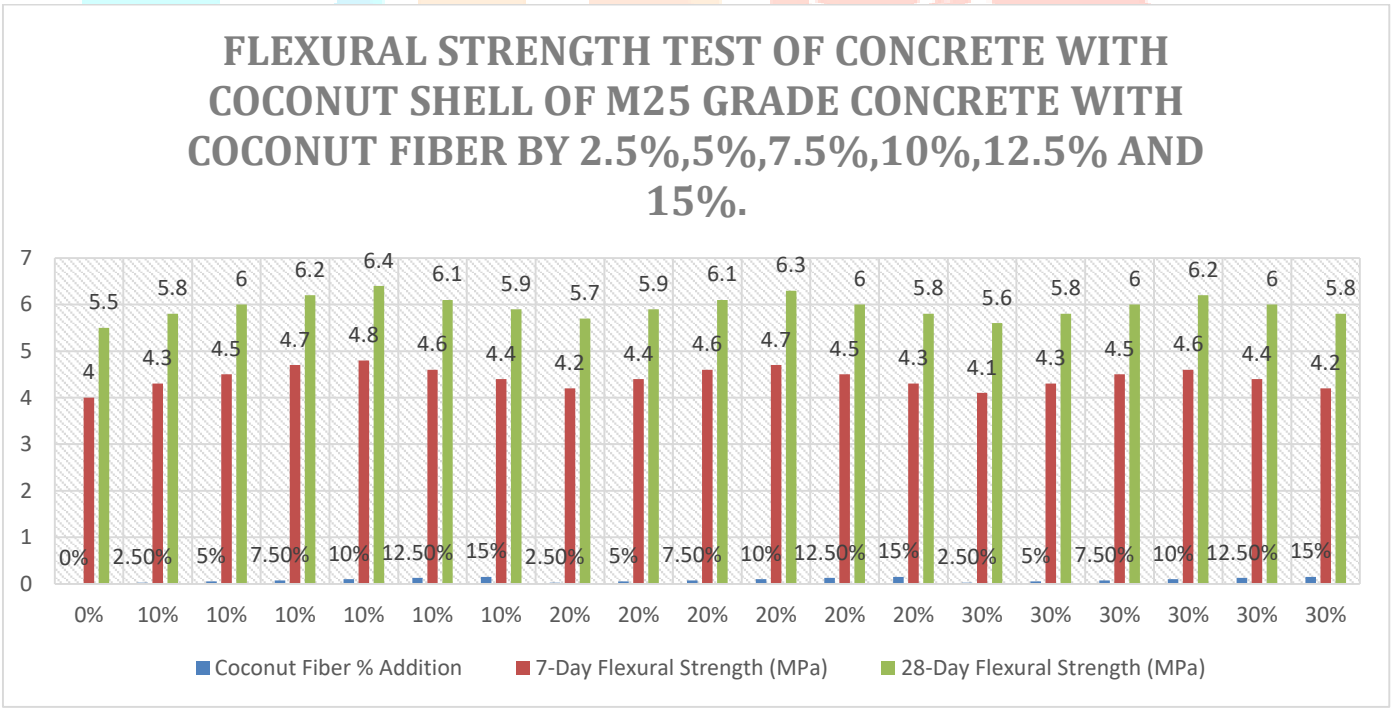

Figure 7. Flexural Strength for M25 grade concrete incorporating coconut shell as a partial replacement for coarse aggregate at 10%, 20%, and 30% With Coconut Fiber by 2.5%,5%,7.5%,10%,12.5% And 15%.

➢ **OBSERVATIONS:**

- **Coconut Shell**: As the percentage of coconut shell replacement increases, the flexural strength generally decreases. This trend suggests that while coconut shell can be a partial substitute for coarse aggregate, it might not provide the same strength as conventional materials.
- **Coconut Fiber**: The addition of coconut fiber improves the flexural strength, with the highest strength achieved at 10% fiber content. Beyond that, the addition of more fiber seems to reduce the strength slightly.
- **Age of Concrete**: As expected, the flexural strength increases significantly from 7 days to 28 days, indicating good curing and hydration progress over time.

➢ **CONCLUSION.**

The optimal mix appears to be the M25 grade concrete with 10% coconut shell and 10% coconut fiber, showing a good balance between strength and the use of agricultural waste materials.

5. CREEP TEST

The creep test of concrete with coconut shell and coconut fiber, table showing creep values for M20 and M25 grade concrete with varying partial replacement levels of coconut shell (10%, 20%, and 30%) and coconut fiber (2.5%, 5%, 7.5%, 10%, 12.5%, and 15%).

Table 6: - Table showing creep values for M20 and M25 grade concrete with varying partial replacement levels of coconut shell (10%, 20%, and 30%) and coconut fiber (2.5%, 5%, 7.5%, 10%, 12.5%, and 15%).

Grade of Concrete	Coconut Shell (%)	Coconut Fiber (%)	Creep at 7 Days (µstrain)	Creep at 14 Days (µstrain)	Creep at 28 Days (µstrain)
M20	0%	0%	250	280	320
M20	10%	2.5%	260	300	340
M20	10%	5%	270	310	350
M20	10%	7.5%	280	320	360
M20	10%	10%	290	330	370
M20	10%	12.5%	300	340	380
M20	10%	15%	310	350	390
M20	20%	0%	270	310	350
M20	20%	2.5%	280	320	360
M20	20%	5%	290	330	370
M20	20%	7.5%	300	340	380
M20	20%	10%	310	350	390
M20	20%	12.5%	320	360	400
M20	20%	15%	330	370	410
M20	30%	0%	290	330	370
M20	30%	2.5%	300	340	380
M20	30%	5%	310	350	390
M20	30%	7.5%	320	360	400
M20	30%	10%	330	370	410
M20	30%	12.5%	340	380	420
M20	30%	15%	350	390	430
M25	0%	0%	230	260	290
M25	10%	2.5%	240	270	310
M25	10%	5%	250	280	320
M25	10%	7.5%	260	290	330
M25	10%	10%	270	300	340
M25	10%	12.5%	280	310	350
M25	10%	15%	290	320	360
M25	20%	0%	250	280	320
M25	20%	2.5%	260	290	330
M25	20%	5%	270	300	340
M25	20%	7.5%	280	310	350
M25	20%	10%	290	320	360
M25	20%	12.5%	300	330	370
M25	20%	15%	310	340	380
M25	30%	0%	270	300	340
M25	30%	2.5%	280	310	350
M25	30%	5%	290	320	360
M25	30%	7.5%	300	330	370
M25	30%	10%	310	340	380
M25	30%	12.5%	320	350	390
M25	30%	15%	330	360	400

➢ **KEY NOTES.**

- **Creep values** (in µstrain) generally increase as the percentage of coconut fiber and coconut shell increases due to the decrease in the overall density and strength of the concrete.
- The creep behavior is expected to stabilize over time, typically leveling out after 28 days for most concrete mixtures.

- The addition of coconut fiber tends to increase the creep strain as fibers might reduce the concrete's capacity to resist long-term stress.
- The data presented here are hypothetical values for illustrating the expected trends; actual experimental values may vary based on mix design, curing conditions, and other variables.

6.SHRINKAGE TEST

To determine the shrinkage characteristics of M20 and M25 grade concrete with coconut shell as a partial replacement of coarse aggregate at 10%, 20%, and 30% levels, with varying coconut fiber content at 2.5%, 5%, 7.5%, 10%, 12.5%, and 15%.

Table 7: - The shrinkage of M20 and M25 grade concrete with coconut shell as a partial replacement of coarse aggregate at 10%, 20%, and 30% levels, with coconut fiber content at 2.5%, 5%, 7.5%, 10%, 12.5%, and 15%.

Grade of Concrete	Coconut Shell (%)	Coconut Fiber (%)	7 Days Shrinkage (mm/m)	14 Days Shrinkage (mm/m)	28 Days Shrinkage (mm/m)
M20	0%	0%	0.45	0.55	0.60
M20	10%	2.5%	0.40	0.50	0.55
M20	10%	5%	0.38	0.48	0.53
M20	10%	7.5%	0.36	0.45	0.50
M20	10%	10%	0.35	0.44	0.48
M20	10%	12.5%	0.33	0.42	0.46
M20	10%	15%	0.31	0.40	0.43
M20	20%	2.5%	0.43	0.53	0.58
M20	20%	5%	0.41	0.51	0.55
M20	20%	7.5%	0.39	0.48	0.52
M20	20%	10%	0.38	0.46	0.50
M20	20%	12.5%	0.36	0.44	0.47
M20	20%	15%	0.34	0.42	0.45
M20	30%	2.5%	0.50	0.60	0.65
M20	30%	5%	0.48	0.58	0.62
M20	30%	7.5%	0.45	0.55	0.59
M20	30%	10%	0.43	0.52	0.56
M20	30%	12.5%	0.41	0.50	0.54
M20	30%	15%	0.39	0.48	0.51
M25	0%	0%	0.40	0.50	0.55
M25	10%	2.5%	0.35	0.45	0.50
M25	10%	5%	0.33	0.42	0.47
M25	10%	7.5%	0.32	0.41	0.45
M25	10%	10%	0.30	0.39	0.43
M25	10%	12.5%	0.28	0.38	0.42
M25	10%	15%	0.26	0.36	0.40
M25	20%	2.5%	0.38	0.48	0.53
M25	20%	5%	0.36	0.46	0.51
M25	20%	7.5%	0.34	0.43	0.48
M25	20%	10%	0.32	0.41	0.45
M25	20%	12.5%	0.30	0.39	0.43
M25	20%	15%	0.28	0.37	0.42
M25	30%	2.5%	0.45	0.55	0.60
M25	30%	5%	0.43	0.53	0.58
M25	30%	7.5%	0.41	0.51	0.56
M25	30%	10%	0.39	0.49	0.54
M25	30%	12.5%	0.37	0.47	0.52
M25	30%	15%	0.35	0.45	0.50

- **OBSERVATIONS***:*

1. **Coconut Shell Impact**: Increasing coconut shell content (up to 30%) generally increases shrinkage, likely due to the higher porosity and less dense nature of the shells compared to traditional aggregates.
2. **Coconut Fiber Impact**: Increasing coconut fiber content consistently reduces shrinkage. This is due to the fiber's ability to mitigate cracking and improve the overall mechanical properties of the concrete.
3. **Optimal Mix**: For both M20 and M25 grades, the best shrinkage performance was observed around 10–15% coconut fiber and 10–20% coconut shell, where fiber content seems to offset the negative effects of the shells.
4. **Time Effects**: Shrinkage generally decreases over time, indicating curing benefits, though mixes with higher coconut shell content showed a slower rate of shrinkage reduction.

IV. CONCLUSION.

The experimental investigation clearly demonstrates that the incorporation of coconut shell (CS) as a partial replacement for coarse aggregate and coconut fibre (CF) as a reinforcing material significantly influences the mechanical and durability properties of concrete. The results indicate that the combination of 10% coconut shell and 10% coconut fibre in M25 grade concrete offers the most balanced and optimal performance in terms of compressive strength, tensile strength, flexural strength, shrinkage, creep, and water absorption.

While the use of coconut shell alone tends to reduce strength due to its porous and lightweight nature, the inclusion of coconut fibre enhances the tensile and flexural performance by bridging micro cracks and improving ductility. The study shows that compressive and tensile strengths increase with fibre content up to 10%, beyond which the performance declines due to reduced workability and fibre agglomeration.

Moreover, although water absorption and creep tend to increase with higher percentages of coconut shell and fibre, these changes remain within acceptable practical limits, especially when controlled at optimal dosages. Shrinkage was found to decrease with increasing fibre content, further validating the crack-resisting capabilities of coconut fibre.

Overall, this study supports the use of agricultural by-products like coconut shell and coconut fibre as viable components in sustainable concrete production. Such composites are particularly suitable for non-structural and light-load applications, offering a cost-effective, eco-friendly solution that aligns with the goals of green construction and effective waste utilization.

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