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MECHANICAL PROPERTIES OF KEVLAR FIBER CONCRETE WITH ROBOSAND AND TAMARIND KERNEL SHELL POWDER

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ABSTRACT

Concrete remains the most widely used construction material worldwide, with ongoing research focused on enhancing its sustainability and performance through innovative material modifications. In this study, natural fine aggregate is partially replaced with Robo sand to improve workability and strength. Tamarind kernel powder is utilized as a partial cement replacement to explore its potential as a supplementary cementitious material. Additionally, Kevlar fibers are incorporated into the concrete mix to enhance crack resistance, ductility, and overall toughness.

Concrete cubes and cylinders are cast using these modified materials and cured under controlled conditions. Compressive strength tests are conducted at 28, 56, and 90 days to evaluate the long-term load-bearing capacity. Similarly, split tensile strength tests are performed at the same intervals to assess resistance to tensile stresses. The mechanical performance of the modified concrete is then compared with that of conventional concrete to determine improvements.

The results reveal a synergistic effect of Robo sand, tamarind kernel powder, and Kevlar fibers on concrete performance. Overall, the experimental findings demonstrate the development of a sustainable, high-strength concrete mix with enhanced durability and long-term mechanical properties.

KEYWORDS: Robo sand, Tamarind kernel powder, Kevlar fiber, High strength, Compressive strength and Split tensile strength

1. INTRODUCTION

Concrete is the most widely used construction material globally, valued for its strength, durability, and versatility. It is a composite material composed of cement, fine aggregate, coarse aggregate, and water. When mixed, cement undergoes a chemical reaction with water known as hydration, which binds the aggregates together to form a solid mass. One of concrete's key advantages is its ability to be molded into virtually any shape before setting, making it suitable for a wide range of structural applications. Its high compressive strength, long service life, and resistance to

environmental degradation make it an essential material in modern construction.

However, conventional concrete production consumes large quantities of cement and natural aggregates, contributing significantly to environmental issues such as CO₂ emissions and depletion of natural resources. In response to these challenges, researchers are increasingly investigating sustainable alternatives to improve the environmental footprint and performance of concrete.

Robo sand, also known as manufactured sand (M-sand), is one such alternative. It is produced by mechanically crushing hard stones into fine particles, offering a sustainable substitute for natural river sand, which is becoming scarce due to over-mining and environmental restrictions. Robo sand has a uniform grading and angular particle shape, which enhances interlocking among particles, leading to improved strength and durability. Its consistent quality helps reduce voids in the concrete matrix and ensures good workability. Partial replacement of natural sand with Robo sand has been shown to yield comparable or even higher compressive and tensile strengths while minimizing environmental impacts such as riverbed degradation. Thus, Robo sand presents a cost-effective and eco-friendly solution for sustainable construction.

Tamarind kernel powder (TKP) is a natural biopolymer derived from the seeds of the tamarind fruit. It can be used as a partial replacement or additive to cement in concrete to enhance its workability and mechanical properties. TKP has demonstrated potential in improving early and long-term strength, reducing shrinkage cracks, and increasing overall durability when used in small dosages. As a renewable and biodegradable material, TKP offers a sustainable alternative to synthetic chemical admixtures. Its use supports environmentally responsible construction without compromising structural performance.

Kevlar fibers are high-performance synthetic fibers known for their exceptional tensile strength and impact resistance. When added to concrete, they act as micro-reinforcement, bridging cracks and enhancing the material's ductility and toughness. Kevlar fibers improve resistance to impact, tensile stresses, and long-term degradation, contributing to more durable and resilient structures. Being lightweight, chemically inert, and highly stable, these fibers provide long-lasting benefits in demanding construction environments. The incorporation of Kevlar fibers aligns with modern engineering goals of developing safer, more durable, and high-performance concrete composites.

2. OBJECTIVES

1. To assess the effect of Robo sand as a partial replacement for fine aggregate on the compressive strength and split tensile strength of concrete.
2. To examine the influence of Tamarind Kernel Powder (TKP) as a partial replacement for cement on the strength, durability, and crack resistance of concrete.
3. To evaluate the role of Kevlar fibers as an additive in improving the ductility, toughness, and overall structural performance of concrete.

3. MATERIALS

1. Cement: Cement is a fine binding material widely used in construction. When mixed with water, it undergoes hydration, setting, and hardening to hold aggregates together in concrete or mortar. The most commonly used type is Ordinary Portland Cement (OPC).

2. Fine Aggregate: Fine aggregate consists of natural sand or crushed stone particles that pass through a 4.75 mm sieve. It fills the voids between coarse aggregates, enhancing the strength, density, and workability of concrete.

3. Coarse Aggregate: Coarse aggregate includes gravel, crushed stone, or similar materials retained on a 4.75 mm sieve. It provides bulk, strength, and dimensional stability to concrete.

4. Water: Water is a vital component in concrete, essential for the chemical reaction of hydration with cement. It imparts workability for mixing, placing, and compaction. Only clean, potable water free from salts, oils, and organic matter should be used to ensure durability.

5. RoboSand: RoboSand is a manufactured sand obtained by crushing hard stones, typically granite, into sand-sized particles. It serves as an eco-friendly substitute for natural river sand, improving strength characteristics and minimizing voids in concrete and mortar.

6. Tamarind Kernel Shell Powder (TKSP): TKSP is a byproduct derived from the outer shells of tamarind seeds after processing. When ground into a fine powder, it can be used as a supplementary material in cement or concrete. It enhances binding properties and promotes sustainable, eco-friendly construction practices.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength:-In this test, standard concrete cubes of 150 mm × 150 mm × 150 mm are cast and cured. After 28, 56 and 90 days of curing, the cubes are tested in a compression testing machine, where load is applied gradually until failure. The maximum load at failure is then used to determine the compressive strength.

Table 1: Compressive strength results of concrete Robo sand as partial replacement of fine aggregate.

Sl.no	% of Robosand	Compressive Strength Results, N/mm ²		
		28 days	56 days	90 days
1	0%	32.57	35.18	37.79
2	25%	35.13	37.94	40.75
3	50%	37.54	40.53	43.55
4	75%	35.62	38.46	41.32

Table 2: Compressive strength results of concrete addition of tamarind kernel shell powder in cement.

Sl.no	% of Tamarind Kernel Powder	Compressive Strength Results, N/mm ²		
		28 days	56 days	90 days
1	0%	32.57	35.18	37.79
2	0.25%	37.45	40.54	43.48
3	0.5%	42.89	45.46	48.82
4	0.75%	36.33	39.24	42.15

Table 3: Compressive strength results of concrete by addition of kevlar fiber .

Sl.no	% of Kevlar fibers	Compressive Strength Results, N/mm ²		
		28 days	56 days	90 days
1	0%	32.57	35.18	37.79
2	0.5%	37.86	40.87	43.91
3	1%	40.99	44.26	47.54
4	1.5%	38.82	41.92	45.03

Table 4: Compressive strength results of Combined replacement of 50% of RS+0.5% of TKP+1% of KF in concrete.

Sl.no	50% of RS+0.5% of TKP+1% of KF	Compressive Strength Results, N/mm ²		
		28 days	56 days	90 days
1	0%	32.57	35.18	37.79
2	50% RS+0.5%TKP+1% KF	49.85	53.84	57.63

4.2 Split tensile strength :-The split tensile strength test is an indirect method used to determine the tensile resistance of concrete, as it is naturally weak in direct tension. In this test, a cylindrical specimen is placed horizontally, and a compressive load is applied along its diameter. This loading generates tensile stresses within the cylinder, leading to its splitting along the loaded diameter. The test is typically conducted after 28, 56 and 90 days of curing to assess the cracking behavior and the development of tensile strength in concrete.

Table 5: Split tensile strength results of concrete Robo sand as partial replacement of fine aggregate.

Sl.no	% of Robosand	Split tensileStrength Results, N/mm ²		
		28 days	56 days	90 days
1	0%	3.28	3.54	3.81
2	25%	3.47	3.78	4.02
3	50%	3.75	4.05	4.36
4	75%	3.53	3.86	4.14

Table 6: Split tensile strength results of concrete addition of tamarind kernel shell powder in cement.

Sl.no	% of Tamarind Kernel Powder	Split tensile Strength Results, N/mm ²		
		28 days	56 days	90 days
1	0%	3.28	3.54	3.81
2	0.25%	3.71	4.01	4.32
3	0.5%	4.33	4.67	5.02
4	0.75%	3.59	3.86	4.16

Table 7: Split tensile strength results of concrete by addition of kevlar fiber .

Sl.no	% of Kevlar fibers	Split tensile Strength Results, N/mm ²		
		28 days	56 days	90 days
1	0%	3.28	3.54	3.81
2	0.5%	3.73	4.02	4.34
3	1%	4.22	4.56	4.89
4	1.5%	3.84	4.15	4.56

Table 8: Split tensile strength results of Combined replacement of 50% of RS+0.5% of TKP+1% of KF in concrete.

Sl.no	50% of RS+0.5% of TKP+1% of KF	Split tensile Strength Results, N/mm ²		
		28 days	56 days	90 days
1	0%	3.28	3.54	3.81
2	50% RS+0.5%TKP+1% KF	5.01	5.43	5.89

5. CONCLUSION

1. The normal concrete without any replacement achieved a compressive strength of **32.57 N/mm² at 28 days, 35.18 N/mm² at 56 days and 37.79 N/mm² at 90 days.**
2. The use of **robosand as a partial replacement of fine aggregate** showed the optimum strength at **50% replacement**, reaches **37.54, 40.53 and 43.55 N/mm² at 28, 56 and 90 days.**
3. The addition of **tamarind kernel shell powder** showed maximum improvement at 0.5% addition achieving **42.89, 45.46 and 48.82 N/mm² at 28, 56 and 90 days.**
4. The addition of **Kevlar fibers** showed maximum improvement at **1% addition**, achieving **40.99, 44.26 and 47.54 N/mm² at 28, 56 and 90 days.**
5. The **combined replacement of 50% RS+0.5%TKP+1% KF** gave the highest strength, reaching **49.85, 53.84 and 57.63 N/mm² at 28, 56 and 90 days.** which is significantly higher than normal concrete.

6. The normal concrete without any replacement achieved a split tensile strength of **3.28 N/mm² at 28 days**, 3.54N/mm² at 56 days and 3.81N/mm² at 90 days.
7. The use of **robosand as a partial replacement of fine aggregate** showed the optimum strength at **50% replacement**, reaches **3.75,4.05 and 4.36 N/mm² at 28, 56 and 90 days**
8. The addition of **tamarind kernel shell powder** showed maximum improvement at 0.5% addition achieving 4.33,4.67 and 5.02N/mm² **at 28, 56 and 90 days**.
9. The addition of **Kevlar fibers** showed maximum improvement at **1% addition**, achieving**4.22, 4.56 and 4.89N/mm² at 28, 56 and 90 days**.
10. The **combined replacement of 50% RS+0.5% TKP+1% KF** gave the highest strength, reaching 5.01, 5.43 and 5.89 N/mm² **at 28, 56 and 90 days**, which is significantly higher than normal concrete.

6. REFERENCES

1. Li, Y.-F., et al. (2023). Comparing mechanical characterization of Carbon, Kevlar and hybrid fiber-reinforced concretes. Buildings — static and dynamic mechanical characterization of Kevlar-fiber concrete (tests include compressive & split tensile).
2. DR.K.CHANDRAMOULI, J.SREE NAGA CHAITANYA, .M.CHAITANYANAVA KUMAR AND Y.PREM NIKHIL.An Experimental Investigation on Concrete by Zeolite Powder as Partial Replacement of Fine Aggregate and Coarse Aggregate With Bamboo Chips.North Asian International Research Journal of Sciences, Engineering & I.T,9(10),October-2023.
3. Li, Y.-F. (2023). A study on mechanical behavior of Kevlar fiber reinforced concrete (quasi-static & dynamic tests).
4. J. SREE NAGA CHAITANYA, DR.K. CHANDRAMOULI, SK.SAHERA,DR.D.VIJAYAKUMAR,5M. SIREESHA.STRENGTH STUDIES ON GRAPHENE OXIDE AND METAKAOLIN AS PARTIAL REPLACEMENT OF CEMENT AND QUARRY DUST AS PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE,North Asian International Research Journal of Sciences, Engineering & I.T,9(5),May-2023.
5. Al-Daraji, M. (2024). The effect of Kevlar fibers on the mechanical properties of lightweight concrete — reports improvements in compressive and tensile strengths with different Kevlar contents.
6. K.Chandramouli , N.Pannirselvam ,J.Sree Naga Chaitanya, and G.Hymavathi.Experimental Investigation on Self Compacting Concrete with Silica Fume,International Conference on Smart Materials and Structures(ICSMS),2810(1),June 22 2023.
7. (Conference/paper) An experimental study on mechanical properties of Kevlar fiber in concrete, IJERT (2019) — practical experimental data on strength and toughness improvements.
8. J. Sree Naga Chaitanya; Dr. K. Chandramouli; Dr. D. Vijaya Kumar; N. Varalakshmi, Investigation on Concrete by Using Carbon Fibers and Partial Replacement of Sand with Copperslag and Cement with Metakaolin, *Gis Science Journal*, Volume 9, Issue 7, 2022, **Pages:** 1308–1310.
9. Study on Mechanical Properties of Concrete by using RoboSand (IJAMTES) — experimental report showing increases in split-tensile and flexural strength for certain replacement levels.
10. Experimental studies indicating RoboSand improves concrete strength and durability compared with natural sand (various conference papers & technical reports).

11. Assessment papers replacing river sand with RoboSand and adding other supplementary materials (useful for methodology).
12. Study on strength parameters of concrete added with tamarind kernel powder (ResearchGate / conference paper) — reports optimal TKP addition (~0.5–1.0% by cement weight) that increased compressive and split tensile strength.
13. Study on effects of fly ash and tamarind kernel powder in concrete (IJERT) — combined TKP with fly ash, shows influence on workability and strength.
14. IRJET / IRJET-type project reports on TKP as an additive (compressive strength and durability tests). These are useful for experimental parameters and mix proportions.
15. North Asian Int. Res. Journal — partial replacement studies using tamarind kernel shell in combination with other SCMs; useful for durability/chemistry discussions.