

EXPERIMENTAL INVESTIGATION ON CONCRETE WITH METAKAOLIN AND TAMARIND KERNEL SHELL

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ABSTRACT

Concrete is a composite material made of cement, aggregates (sand and gravel or crushed stone), and water, which hardens over time to form a durable, rock-like mass. It is the most widely used man-made building material globally due to its versatility and strength. Metakaolin (MK) is a highly reactive pozzolanic material obtained by calcining kaolin clay. When used as a partial replacement for cement, it reacts with calcium hydroxide produced during cement hydration, forming additional calcium silicate hydrate (C-S-H) gel. This leads to a denser microstructure, improved compressive strength, reduced permeability, and enhanced durability of the concrete. Tamarind kernel shell powder (TKS) can be incorporated into concrete mixes as an additive to enhance its properties. Derived from agricultural waste, TKS offers an eco-friendly and cost-effective alternative in construction. The optimal replacement percentage is determined through compressive strength tests and split tensile strength for 7 and 28 days.

KEYWORDS: Metakaolin, Tamarind Kernel Shell, Pozzolanic, Agricultural waste Compressive strength and Split tensile strength.

1. INTRODUCTION

Concrete, the world's most ubiquitous building material, is an indispensable and versatile composite that forms the backbone of modern infrastructure. It's primarily composed of cement, aggregates, and water, transforming into a durable, stone-like material through hydration. Its widespread adoption is driven by exceptional strength, adaptability, and cost-effectiveness. However, ongoing research continually seeks to enhance its sustainability and properties in response to environmental concerns stemming from cement production. Consequently, concrete remains fundamental to global development, constantly evolving to meet contemporary demands.

Metakaolin (MK) is an amorphous, calcined form of kaolin clay, produced by heating kaolinite to temperatures typically between 600°C and 800°C. This thermal treatment dehydroxylates the clay, transforming it

into a highly reactive aluminosilicate material. It acts as a pozzolan, meaning it reacts with calcium hydroxide (a byproduct of cement hydration) to form additional calcium silicate hydrate (C-S-H) gel, which is the primary binder in concrete. Metakaolin has finer particles than cement, contributing to a denser and less permeable microstructure. It is widely used as a supplementary cementitious material (SCM) to enhance the strength, durability, and chemical resistance of concrete, while also contributing to sustainability by reducing cement content.

Tamarind Kernel Shell (TKS), derived from the combustion of tamarind seed shells, can be effectively utilized as an additive in concrete. Its pozzolanic properties allow it to react with calcium hydroxide in the cement paste, forming additional binding compounds and contributing to enhanced strength. This agricultural waste, when finely ground, can improve the packing density of the concrete mix, leading to a denser microstructure.

2. OBJECTIVES

1. To investigate the effect of various percentages of metakaolin as a partial cement replacement on the compressive and split tensile strength of concrete at different curing ages.
2. To evaluate the influence of varying percentages of tamarind kernel ash as an addition on the compressive and split tensile strength of concrete, both independently and in conjunction with metakaolin replacement.
3. To determine the optimal combination of metakaolin partial cement replacement and tamarind kernel ash addition that maximizes the compressive and split tensile strength of concrete.

3. MATERIALS

3.1 Cement: More than just a binder, cement acts as the crucial chemical activator within concrete. Upon hydration with water, it undergoes a complex series of chemical reactions, creating a microscopic, crystalline network of calcium silicate hydrates and other compounds.

3.2 Fine aggregate: Rather than just "sand," fine aggregate functions as the essential granular filler material in concrete. Its finely graded particles occupy the voids between the coarser aggregates, contributing to the mix's workability and preventing segregation of the larger particles.

3.3 Coarse aggregate: These larger, robust particles provide the bulk and structural integrity, transferring compressive forces through their direct interparticle contact. Their shape, texture, and strength critically influence the concrete durability by resisting deformation.

3.4 Water: water is the indispensable chemical catalyst that initiates and sustains the hydration process in cement. It's the medium through which the chemical reactions occur, allowing the cement compounds to dissolve and reform into the hardened paste. Beyond its chemical role, water also provides the necessary workability, allowing the fresh concrete to be placed, compacted, and finished before it sets, influencing the final density and strength of the cured material.

3.5 Metakaolin: An amorphous, high-reactivity aluminosilicate material produced by calcining kaolin clay. It acts as a pozzolan, reacting with calcium hydroxide to form additional C-S-H gel, enhancing concrete strength and durability.

3.6 Tamarind kernel shell powder: A fine powder derived from the waste shells of tamarind seeds. When added to concrete, it can act as a filler or binding agent, potentially improving workability, strength, and contributing to sustainable waste utilization.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength

The compressive strength test measures the maximum axial load a material, like concrete, can withstand before it fails under Compression. This is commonly performed by applying gradual force to a standardized cube specimen in a testing machine, typically at **7 and 28 days** to assess its strength development.

Table 1: Compressive strength results of concrete with Metakaolin used as a partial replacement of cement.

Sl.no	% of MK	Compressive Strength Results, N/mm ²	
		7 days	28 days
1	0%	33.87	49.67
2	5%	36.43	52.73
3	10%	38.19	55.19
4	15%	39.92	57.42
5	20%	38.35	54.87

Table 2: Compressive strength results on concrete by addition of Tamarind Kernel Shell Powder by weight of cement.

Sl.no	% of TKS	Compressive Strength Results, N/mm ²	
		7 days	28 days
1	0%	33.87	49.67
2	0.25%	38.78	57.12
3	0.5%	45.21	65.63
4	0.75%	38.27	54.75

Table 3: Combined Compressive strength of concrete with 15% of MK+0.5% of TKS

Sl.no	15% of MK+0.5% of TKS	Compressive Strength Results, N/mm ²	
		7 days	28 days
1	0%	33.87	49.67
2	15% of MK+0.5% of TKS	48.23	69.51

4.2 Split tensile strength

Split tensile strength is an indirect method for determining the tensile strength of concrete, which is typically very weak in direct tension. The test involves placing a cylindrical concrete specimen horizontally and applying a

compressive load along its diameter plane until it splits into two halves, typically at **7 and 28 days** to assess its strength development.

Table 4: Split tensile strength results of concrete Metakaolin used as a partial replacement of cement.

Sl.no	% of MK	Split tensile Strength Results, N/mm ²	
		7 days	28 days
1	0%	3.24	4.83
2	5%	3.52	5.17
3	10%	3.73	5.42
4	15%	3.97	5.68
5	20%	3.91	5.59

Table 5: Split tensile strength results on concrete by addition of Tamarind Kernel Shell Powder by weight of cement.

Sl.no	% of TKS	Split tensile Strength Results, N/mm ²	
		7 days	28 days
1	0%	3.24	4.83
2	0.25%	3.82	5.61
3	0.5%	4.51	6.49
4	0.75%	3.78	5.42

Table 6: Combined Split tensile strength of concrete with 15% of MK+0.5% of TKS

Sl.no	% of MK+0.5% of TKS	Split tensile Strength Results, N/mm ²	
		7 days	28 days
1	0%	3.24	4.83
2	15% of MK+0.5% of TKS	4.83	6.91

5. CONCLUSION

1. The normal concrete compressive strength results for 7 and 28 days is 33.87 and 49.67 N/mm².
2. At 15% partial replacement of cement with metakaolin which gives compressive strength result for 7 and 28 days is 39.92 and 57.42 N/mm².
3. At 0.5% addition of cement with Tamarind Kernel Shell Powder which gives compressive strength result for 7 and 28 days is 45.21 and 65.63 N/mm².
4. Compressive strength result for combined replacement of 15% partial replacement of cement with metakaolin and 0.5% addition of cement with Tamarind Kernel Shell Powder which gives compressive strength result for 7 and 28 days is 48.23 and 69.51 N/mm².
5. The normal concrete split tensile strength results for 7 and 28 days is 3.24 and 4.83 N/mm².
6. At 15% partial replacement of cement with metakaolin which gives split tensile strength result for 7 and 28 days is 3.97 and 5.68 N/mm².

7. At 0.5% addition of cement with Tamarind Kernel Shell Powder which gives split tensile strength result for 7 and 28 days is 4.51 and 6.49 N/mm².
8. Split tensile strength result for combined replacement of 15% partial replacement of cement with metakaolin and 0.5% addition of cement with Tamarind Kernel Shell Powder which gives compressive strength result for 7 and 28 days is 4.83 and 6.91 N/mm².

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