North Asian International Research Journal of Sciences, Engineering & I.T.

IRJIF. I.F. : 3.821

ISSN: 2454-7514 Vol. 8, Issue-8, August-2022

Index Copernicus Value: 52.88 Indian Citation Index Thomson Reuters ID: S-8304-2016

A Peer Reviewed Refereed International Journal

STRENGTH STUDIES ON ABACA FIBER CONCRETE WITH HYPOSLUDGE AND QUARRY DUST

[1]J.SREE NAGA CHAITANYA, [2]DR.K.CHANDRAMOULI, [3]SK.SAHERA,[4]PEEKE ANJAIAH

[1,3] Assistant Professor,[2]Professor & HOD,[4]B. Tech Student
[1,2,3,4] Department of Civil Engineering, NRI Institute of Technology, Visadala (V), Medikonduru (M), Guntur, Andhra Pradesh, INDIA .
Email:jarugumillichaitanya1989@gmail.com, koduru_mouli@yahoo.com

ABSTRACT

This research explores the formulation of sustainable concrete by judiciously incorporating industrial by-products and natural fibers. It investigates the efficacy of partially replacing natural fine aggregate with quarry dust and cement with hyposludge, a paper mill waste. Furthermore, the study examines the beneficial impact of adding abaca fibers to the concrete mix. This multi-pronged approach aims to enhance mechanical properties, reduce reliance on virgin materials, mitigate environmental pollution from waste disposal, and ultimately contribute to greener construction practices. The objective is to achieve concrete with comparable or superior performance, promoting resource efficiency and a reduced carbon footprint in the construction industry.Test for compressive strength and split tensile strength for 7 and 28 days.

KEYWORDS:Quarry dust,Hyposludge, Abaca fibre,Waste disposal, Compressive strength and Split tensile strength

1. INTRODUCTION

Concrete is a foundational and ubiquitous construction material, second only to water in global consumption. This composite, formed by combining cement, aggregates (like sand and gravel), and water, undergoes a process of hydration where the cement and water react to create a hardened paste. This paste then binds the aggregates into a durable, stone-like mass. Its exceptional versatility, strength, and longevity make concrete indispensable for modern infrastructure, providing the structural integrity for everything from skyscrapers and roads to bridges, dams, and residential buildings. The ability to be molded into any shape when fresh, coupled with its resistance to heavy loads, fire, and harsh environmental conditions, is crucial to its widespread use.

In response, there's a growing need to identify sustainable and economical alternative materials. Quarry dust, a finely crushed rock byproduct generated in vast quantities during stone crushing activities, presents a promising solution. Currently, a significant amount of this material is simply discarded, leading to disposal challenges and environmental pollution. Utilizing quarry dust as a partial replacement for fine aggregate in concrete offers a dual benefit: it reduces the demand for natural sand, thereby conserving natural resources, and provides an effective waste management strategy for an otherwise problematic industrial byproduct. Research aims to confirm its suitability and optimize its inclusion to maintain or even enhance concrete's performance.

Cement production is a highly energy-intensive process, contributing significantly to global carbon dioxide emissions and the depletion of natural resources. This environmental burden necessitates the exploration of sustainable alternatives. Hypo sludge, a substantial waste product from the paper manufacturing industry, poses a significant disposal challenge, consuming vast landfill space and potentially polluting ecosystems.However, hypo sludge exhibits promising characteristics, including the presence of silica and calcium, which are crucial components in cement. This makes it a potential supplementary cementitious material. By partially replacing cement with hypo sludge, the construction industry can achieve a dual benefit: reducing its environmental footprint by lowering cement consumption and simultaneously addressing the waste management issues associated with paper mills. This research aims to investigate the feasibility and efficacy of incorporating hypo sludge as a partial cement replacement in concrete, thereby promoting resource efficiency and a circular economy approach in construction.

Plain concrete, while possessing excellent compressive strength, is inherently brittle and exhibits low tensile strength and limited ductility.This susceptibility to cracking under tensile stresses and sudden failure under overload remains a critical challenge in concrete applications.The incorporation of fibers has long been recognized as an effective method to enhance these properties, transforming concrete into a more ductile and crack-resistant material.Among various fiber options, natural fibers are gaining increasing attention due to their eco-friendliness, renewability, and cost-effectiveness. Abaca fiber, derived from the Musa textilis plant, stands out for its remarkably high tensile strength, stiffness, and durability, even in harsh environments.

2. OBJECTIVES

1. To evaluate the optimal percentage replacement of natural fine aggregate with quarry dust that maximizes the compressive and split tensile strength.

2. To investigate the impact of partially replacing cement with varying proportions of hyposludge on the compressive and split tensile strength of concrete, aiming to identify a mix that maintains or enhances these mechanical properties.

3.To determine the effect of incorporating different dosages of abaca fibers on the compressive and split tensile strength of concrete, assessing their ability to improve the ductile behavior and crack resistance of the material.

3. MATERIALS

3.1 Cement: Cement is a fine, powdery binding agent that, when mixed with water, undergoes a chemical reaction (hydration) to form a hardened, stone-like substance. Its primary function in construction is to bind various aggregates, such as sand and gravel, into a cohesive and durable mass, most commonly known as concrete.

3.2 Fineaggregate: Fine aggregate consists of inert granular material, typically natural sand or crushed stone, with particles generally smaller than 4.75 mm. Its primary role in concrete is to fill the voids between coarse aggregates, contributing to workability, density, and a smooth finish. It also influences the overall strength and durability of the hardened concrete.

3.3 Coarse aggregate: Coarse aggregate consists of larger, inert granular materials like gravel or crushed stone, with particles typically retained on a 4.75 mm sieve. It acts as the primary skeletal filler in concrete, providing bulk, enhancing compressive strength, and reducing drying shrinkage. Its presence significantly contributes to the overall structural integrity and durability of the hardened mix.

3.4 Water: Water serves as a crucial component in concrete, initiating the chemical reaction (hydration) with cement that leads to hardening and strength development. Beyond its role in hydration, it also acts as a lubricant, enabling the mix's workability so it can be effectively placed, compacted, and finished. The precise amount of water, typically expressed as the water-to-cement ratio, significantly influences the final strength, durability, and porosity of the hardened concrete.

3.5Quarry Dust: Quarry dust is a finely crushed rock byproduct generated during the aggregate crushing process. It consists of inert, non-volatile waste particles typically smaller than 4.75 mm. This material is a sustainable alternative to natural sand in concrete, addressing both resource depletion and waste disposal.

3.6 Hyposludge: Hypo sludge is a waste product from the paper manufacturing industry, primarily composed of lime and silica. Its characteristics make it a potential supplementary cementitious material. Utilizing it can reduce cement consumption and mitigate environmental pollution from paper mill waste.

3.7 Abaca Fiber: Abaca fiber is a natural, high-strength fiber extracted from the leaf stalks of the Musa textilis plant. Known for its exceptional tensile strength and durability, it serves as an effective reinforcing agent in brittle materials like concrete. Its inclusion enhances flexural strength, toughness, and crack resistance.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength:-Compressive strength measures a material's capacity to withstand forces that attempt to crush or compress it. This is typically done by gradually applying force to a standardized specimen cube in a testing machine for 7 and 28 days.

Table 1: Compressive strength results of concrete with different percentages of Quarry dust used as a partial replacement of fine aggregate.

Sl.no	% Of Quarry Dust	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	32.52	49.43
2	10%	35.89	53.41
3	20%	38.84	56.96
4	30%	41.92	59.72
5	40%	41.13	58.85

Table 2: Compressive strength results of concrete with different percentages of Hyposludge used as a partial replacement of Cement.

Sl.no	% Of Hyposludge	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	32.52	49.43
2	5%	39.61	57.46
3	10%	45.48	64.78
4	15%	41.25	59.21

Table 3: Compressive strength results of abaca fiber concrete.

Sl.no	% Of Abaca fiber	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	32.52	49.43
2	0.25%	37.38	55.45
3	0.5%	40.52	58.82
4	1%	36.59	52.36

Table 4: Compressive strength results of Combined replacement of 30% QD+10% HS+0.5% AF in concrete.

Sl.no	30% QD+10% HS+0.5% AF	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	32.52	49.43
2	30% QD+10% HS+0.5% AF	50.44	73.21

4.2 Split tensile strength

Split tensile strength is an indirect measure of concrete's resistance to tensile forces, as concrete is weak in direct tension. It involves placing a cylindrical specimen horizontally and applying a compressive load diametrically along its length, causing the cylinder to split along the loaded diameter due to induced tensile stresses. To cracking in concrete constructions for 7 and 28 days.

Table 5:Split tensile strength results of concrete with different percentages of Quarry dust used as a partial replacement of fine aggregate.

Sl.no	% Of Quarry Dust	Split tensile Strength Results, N/mm²	
		7 days	28 days
1	0%	3.11	4.81
2	10%	3.24	4.94
3	20%	3.86	5.66
4	30%	4.24	6.08
5	40%	3.96	5.72

Table 6:Split tensile strength results of concrete with different percentages of Hyposludge used as a partial replacement of Cement.

Sl.no	% Of Hyposludge	Split tensile Strength Results, N/mm²	
		7 days	28 days
1	0%	3.11	4.81
2	5%	3.55	5.68
3	10%	4.42	6.53
4	15%	4.04	5.79

Table 7: Split tensile strength results of Abaca fiber concrete.

Sl.no	% Of Abaca fiber	Split tensile Strength Results, N/mm²	
		7 days	28 days
1	0%	3.11	4.81
2	0.25%	3.64	5.47
3	0.5%	3.95	5.78
4	1%	3.59	5.19

Table 8: Split tensile results of combined replacement of 30% QD+10% HS+0.5% AF in concrete.

Sl.no	30% QD+10% HS+0.5% AF	Split tensile Strength Results, N/mm²	
		7 days	28 days
1	0%	3.11	4.81
2	30% QD+10% HS+0.5% AF	5.29	7.31

5. CONCLUSION

1. Normal concrete achieved a 28-day compressive strength of 49.43 N/mm².
2. Quarry dust replacement showed optimal strength of 59.72 N/mm² at 30% QD, a ~20.8% increase over normal concrete.
3. Hypo sludge replacement reached a peak strength of 64.78 N/mm² at 10% HS, a ~31.1% improvement.
4. Abaca fiber addition gave the highest strength of 58.82 N/mm² at 0.5% AF, a ~19.0% increase.
5. Combined replacement of 30% QD + 10% HS + 0.5% AF resulted in 73.21 N/mm², a ~48.1% increase over normal concrete.
6. All partial replacements improved compressive strength, with the combined mix delivering the maximum enhancement.
7. Normal concrete achieved a 28-day split tensile strength of 4.81 N/mm².
8. Quarry dust replacement showed optimal strength of 6.08 N/mm² at 30% QD, a ~26.4% increase over normal concrete.
9. Hyposludge replacement reached a peak strength of 6.53 N/mm² at 10% HS, a ~35.7% improvement.
10. Abaca fiber addition gave the highest strength of 5.78 N/mm² at 0.5% AF, a ~20.2% increase.
11. Combined replacement of 30% QD + 10% HS + 0.5% AF achieved 7.31 N/mm², a ~52.0% increase over normal concrete.
12. All partial replacements improved split tensile strength, with the combined mix showing the maximum enhancement.

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