MECHANICAL PROPERTIES OF PALM FIBER CONCRETE PRODUCED WITH PALM OIL FUEL ASH

[1] Dr. K.Chandramouli, [2] J.Sree Naga Chaitanya, [3]Ravi Sinha

[1]Professor & HOD, [2]Assistant Professor, [3]PG Student
[1,2,3]Department of Civil Engineering, NRI Institute of Technology, Visadala (V), Medikonduru (M), Guntur, Andhra Pradesh, INDIA

---***---

Abstract: - With the rapid expansion of construction activities, the environmental impact of traditional concrete technology has become a growing concern. To tackle this issue, researchers have developed innovative concrete solutions, including admixtures that enhance strength properties while minimizing ecological harm. This study examines the mechanical and physical properties of composites reinforced with palm fibers and produced with palm oil fuel ash (POFA). Cement was partially replaced with POFA at varying percentages of 10%, 20%, 30%, and 40%, and each batch was further modified with palm fibers at different percentages of 0%, 0.5%, 1%, 1.5%, and 2% by weight of cement. The aspect ratio of palm fibers was kept at 50. The effects of POFA replacement and palm fiber addition on the properties of composites were evaluated. The results demonstrated notable improvements in mechanical and physical properties with the inclusion of palm fibers. The optimal replacement percentage of POFA and palm fiber content was determined. Compressive and split tensile strengths were evaluated at 7 and 28 days.

Keywords: Palm oil fiber, Palm oil fuel ash, Environmental, Admixtures, Compressive and Split tensile Strength.

1. INTRODUCTION

Concrete is inherently brittle, possessing low tensile strength, limited ductility, and minimal resistance to cracking. Micro-cracks are present within the concrete, and its poor tensile strength is attributed to the propagation of these micro-cracks, resulting in the brittle nature of concrete. In plain concrete and similar brittle materials, structural cracks can develop even before loading due to drying shrinkage and other causes. When a load is applied, the internal cracks propagate and expand due to stress, leading to the formation of additional cracks. The development of these cracks is responsible for the inelastic deformation in concrete.

Palm oil fiber (POF) serves as a sustainable and eco-friendly reinforcement material. Derived from palm oil empty fruit bunches, POF offers a unique combination of strength and durability. In concrete applications, POF can enhance mechanical properties and reduce shrinkage. Additionally, POF is a cost-effective alternative to traditional steel reinforcement, promoting a greener and more sustainable construction industry.

Palm oil fuel ash (POFA) is a by-product of palm oil mill boilers and can be used as a supplementary cementitious material (SCM) in concrete. Replacing cement with POFA reduces greenhouse gas emissions and conserves natural resources. POFA also enhances concrete's workability and durability, making its use in concrete a sustainable and environmentally friendly option.

2. MATERIALS

Cement: Cement is a fine powder that acts as the primary binding agent in concrete. It is composed of limestone, clay, sand, and other minerals. When mixed with water, cement forms a paste that hardens over time, binding aggregate particles together and creating a strong, durable structure. It is a crucial component in construction, used in buildings, roads, and infrastructure projects.

Fine Aggregates: Fine aggregate refers to smaller-sized particles of aggregate, typically passing through a 4.75mm sieve. It consists of natural sand, crushed stone, or a combination of both. Fine aggregate plays a critical role in concrete by filling the gaps between coarse aggregate particles, thereby improving the workability, density, and overall strength of the concrete.

Coarse Aggregates: Coarse aggregates, obtained by crushing gravel, are used to add strength to concrete compositions. Typically, the maximum size of these aggregates is restricted to 20mm. The 12.5mm aggregates, derived from natural rocks, inherit properties such as hardness and stability from their parent rock, ultimately enhancing the overall durability of the concrete.

Water: Water is an essential component in construction, serving as a mixing agent for cement mortar and a curing medium. It facilitates the formation of a binding matrix between cement and aggregates, enabling the development of concrete's strength and durability. For optimal results, the pH level of surface water should range from 6.5 to 8.5, while groundwater should fall between 6 and 8.5.

Palm Oil Fuel Ash (POFA): POFA is a by-product of palm oil mill boilers and acts as a pozzolanic material that can partially replace cement in concrete. It reduces greenhouse gas emissions and conserves natural resources. POFA enhances concrete's workability and durability, making it a sustainable cement replacement material.

Palm Fiber: Palm fibers are natural, sustainable, and biodegradable materials. They can be used as reinforcement in concrete, improving its mechanical properties. Palm fibers can partially replace cement, reducing the environmental impact of concrete. Their use in concrete promotes eco-friendliness and sustainability.

3. RESULTS AND DISCUSSIONS

3.1 Compressive strength test: The Compressive Strength Test measures the ability of concrete to withstand compressive loads.It determines the maximum stress that concrete can resist without failing or crushing.The test is typically performed on cube-shaped concrete specimens after a specified curing period.

Table 1: Compressive Strength of Concrete using POFA as partial replacement of cement.

%of pofa	Compressive strength of concrete in N/mm^2	
	7 days	28days
0% POFA	36.4	48.3
10% POFA	38.20	49.46
20% POFA	40.02	54.32
30% POFA	41.45	58.13
40% POFA	39.40	49.30

Table 2: Compressive Strength of Concrete using Palm fiber 50 A.R AND 10% POFA with different % of fibers:

%of fibers	Compressive strength of concrete in N/mm2	
	7 days	28days
0% POFA + 0% fibers	36.4	48.3
10% POFA + 0.5% fibers	36.94	48.52
10% POFA + 1% fibers	37.28	50.21
10% POFA + 1.5% fibers	38.01	51.01
10% POFA + 2% fibers	36.45	49.63

Table 3: Compressive Strength of Concrete using Palm fiber 50 A.R AND 20% POFA with different % of fibers

%of fibers	Compressive strength of concrete in N/mm2	
	7 days	28days
0% POFA + 0% fibers	36.4	48.3
20% POFA + 0.5% fibers	37.2	48.94
20% POFA + 1% fibers	38.59	52.63
20% POFA + 1.5% fibers	39.94	54.04
20% POFA + 2% fibers	38.26	52.05

Table 4: Compressive Strength of Concrete using Palm Palm fiber 50 A.R AND 30% POFA with different % of fibers

%of fibers	Compressive strength of concrete in N/mm2	
	7 days	28days
0% POFA + 0% fibers	36.4	48.3
30% POFA + 0.5% fibers	38.24	49.29
30% POFA + 1% fibers	40.02	54.45
30% POFA + 1.5% fibers	43.51	62.18
30% POFA + 2% fibers	39.78	55.49

Table 5: Compressive Strength of Concrete using Palm fiber 50 A.R AND 40% POFA with different % of fibers

%of fibers	Compressive strength of concrete in N/mm2	
	7 days	28days
0% POFA + 0% fibers	36.4	48.3
40% POFA + 0.5% fibers	36.94	48.14
40% POFA + 1% fibers	38.42	51.04
40% POFA + 1.5% fibers	40.38	58.94
40% POFA + 2% fibers	37.44	50.34

3.2 Spilt tensile strength test: The Split Tensile Strength Test evaluates the tensile strength of concrete by applying a diametrical compressive load.The test measures the resistance of concrete to cracking and failure under tensile stress.It is typically performed on cylindrical concrete specimens to determine their tensile strength.

Table 6: Split tensile Strength of Concrete using POFA as partial replacement of cement.

	Split tensile strength of concrete in N/mm2	
	7 days	28days
0% POFA	3.32	4.76
10% POFA	3.48	4.94
20% POFA	3.75	5.37
30% POFA	4.06	5.88
40% POFA	3.39	4.92

Table 7: Split tensile Strength of Concrete using Palm fiber 50 A.R AND 10% POFA with different % of fibers

%of fibers	Split tensile strength of concrete in N/mm2	
	7 days	28days
0% POFA + 0% fibers	3.32	4.76
10% POFA + 0.5% fibers	3.28	4.77
10% POFA + 1% fibers	3.49	4.96
10% POFA + 1.5% fibers	3.56	5.09
10% POFA + 2% fibers	3.37	4.92

Table 8: Split tensile Strength of Concrete using Palm fiber 50 A.R AND 20% POFA with different % of fibers

%of fibers	Split tensile strength of concrete in N/mm2	
	7 days	28days
0% POFA + 0% fibers	3.32	4.76
20% POFA + 0.5% fibers	3.46	4.84
20% POFA + 1% fibers	3.65	5.23
20% POFA + 1.5% fibers	3.76	5.39
20% POFA + 2% fibers	3.61	5.16

Table 9: Split Tensile Strength of Concrete using Palm fiber 50 A.R AND 30% POFA with different % of fibers

%of fibers	Split tensile strength of concrete in N/mm2	
	7 days	28days
0% POFA + 0% fibers	3.32	4.76
30% POFA + 0.5% fibers	3.35	4.87
30% POFA + 1% fibers	3.78	5.43
30% POFA + 1.5% fibers	4.34	6.21
30% POFA + 2% fibers	3.87	5.53

Table 10: Split Tensile Strength of Concrete using Palm fiber 50 A.R AND 40% POFA with different % of fibers

%of fibers	Split tensile strength of concrete in N/mm2	
	7 days	28days
0% POFA + 0% fibers	3.32	4.76
40% POFA + 0.5% fibers	3.48	4.82
40% POFA + 1% fibers	3.56	5.06
40% POFA + 1.5% fibers	3.71	5.28
40% POFA + 2% fibers	3.49	4.93

4. CONCUSSION

1. The compressive strength of normal concrete for 7 and 28 days is 36.40 and 48.30 N/mm^2.

2. The optimum compressive strength of 30% POFA is found to be 41.45 and 58.13 N/mm ^{2} for 7 and 28 days respectively.

3. The optimum compressive strength of 30% POFA + 1.5% palm fiber is found to be 43.51 and 62.18 N/mm ^{2} for 7 and 28 days respectively.

4. The split tensile strength of normal concrete for 7 and 28 days is 3.32 and 4.76 N/mm^2.

5. The optimum split tensile strength of 30% POFA is found to be 4.06 and 5.88 N/mm ^{2} for 7 and 28 days respectively.

6. The optimum split tensile strength of 30% POFA + 1.5% palm fiber is found to be 4.34 and 6.21 N/mm ^{2} for 7 and 28 days respectively.

5. REFERENCES

1. Adilah Binti Darsani1, Omar Mohd Faizan Bin Marwah, Potential Behaviour of Oil Palm Empty Fruit Bunch Fibre Reinforced With Polypropelene For 3D Printing Filament Material, International Journal of Engineering Trends and Technology,69(1),2021,PP.194-197.
2. Dr.K.Chandramouli,"Experimental Study on Partial Replacement of Cement with Metakaolin admixture", IJER, Vol.5, Issue.03, May-June, 2017, ISSN: 2321-7758.
3. M.R.M. Asyraf , M.R. Ishak , Agusril Syamsir. Mechanical properties of oil palm fibre-reinforced polymer composites: a review, 11 January 2022.
4. H.P.S. Abdul., Oil Palm Biomass Fibres and Recent Advancement in Oil Palm Biomass Fibres Based Hybrid Biocomposites, Compos. Their Appl.,(2012).
5. J.Sree Naga Chaitanya,"Strengthening Of Fibre Reinforced Concrete With Admixtures And Partial Replacement Of Fine Aggregate By Moorum Soil"---The International journal of analytical and experimental modal analysis,Volume XIII, Issue III, March/2021,ISSN NO:0886-9367.
6. Husain Z, Zainac Z, Abdullah Z. Briquetting of palm fibre and shell from the processing of palm nuts to palm oil. Biomass Bioenergy 2002;22:500e9. https://doi.org/10.1016/ S0961-9534(02)00022-3.
7. Michael Attah Onugba, Enhancing Earth-based Building Materials: Effect of Palm Fibre Reinforcement on Compressive Strength, Journal of Engineering Research and Reports,25(11),2023, PP:55-63.
8. Al Amoudi. O.S.B., Rasheeduzzarfar, Maslehuddin, M., and AI Mana, A.I..(1993). "Prediction of long term corrosion resistance of plain and blended cement concretes" ACI Materials Journal, Vol. 90,No.6,pp.564-570.
9. Yadlapalliadilakshmi and J. sreenagachaitanya"Experimental investigation on recron3s fiber reinforced concrete with partial replacement of cement with metakaolin and fine aggregate with copper slag"The International journal of analytical and experimental modal analysis; Volume XII, Issue VII, July/2020, ISSN NO:0886-93672.
10. Ali, M.B., Saidura, R. and Hossainb, M.S.(2011). "A review on emission analysis in cement industries" Renewable and sustainable Energy Reviews, Vol. 15,Issue 5, pp. 2252-2261.
11. K. Chandramouli, N. Pannirselvam, J. Sree Naga Chaitanya. Experimental Investigation on AR Glass Fiber reinforced concrete with silicafume, Material proceedings, 68(1), 2022,136-138.
12. Yunusa A, Onugba MA, Austyns OA, Ojih CU, Oni AE, The use of waste marble dust as partial replacement for cement in concrete. Current Journal of Applied Science and Technology. 2022; 41(8):3946.
13. Bahar Demirel,Oguzhan Kelestemur. 2010 Effect of elevated temperature on the mechanical properties of concrete produced with finely ground pumice and silica fume, Fire Safety Journal45385-39.
14. 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,* , 040003-1–040003-5,2002.
15. Antara Choudhary, Vineet Shah, Shashank Bishnoi, 2016 Effect of low cost fillers on cement hydration *Construction and Building Materials* 124533-543.