Influence of Metakaolin And Arecanut Husk Fiber in Strength of Concrete

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Abstract- *The utilization of alternative materials in construction has gained significant attention due to the need for sustainable and eco-friendly practices. This project focuses on the potential of two such materials, metakaolin and arecanut fiber, in enhancing the strength and properties of concrete. Metakaolin is a pozzolanic mineral admixture, while areca nut fiber is a natural fiber extracted from the areca palm's husk. The experimental phase of this project involves preparing concrete specimens with varying proportions of metakaolin in 10%, 20%, 30% is added. 1%, 2%, 3% of arecanut fiber is added to the optimum strength obtained from different proportions of metakaolin. The concrete grade of M30 was developed. Tests were conducted to evaluate the compressive strength, flexural strength, and split tensile strength of the concrete.*

Keywords- Metakaolin, Arecanut husk fiber, compressive strength, Split tensile strength, Flexural strength.

I. INTRODUCTION

Concrete is one of the important materials in construction field. The utilization of supplementary cementitious materials and natural fibers in concrete has gained significant attention in recent years due to their potential to enhance various properties of concrete, including strength, durability and sustainability.Conventional concrete production is associated with significant environmental drawbacks, including high carbon emissions and resource depletion. Recognizing this the global construction industry seeks eco-friendly alternatives to traditional practices. Focuses on exploring the influence of metakaolin, a pozzolanic material, and areca nut husk fiber, a natural reinforcement, in concrete mixtures.

Metakaolin, a pozzolanic material derived from the calcination of kaolin clay, is known for its pozzolanic reactivity. When metakaolin reacts with calcium hydroxide produced during cement hydration, forming additional cementitious products. This can contribute to improved strengthen properties of concrete.

Areca nut husk fiber, a natural and abundant agricultural byproduct, into the concrete mix. Areca nut husk fibers possess unique characteristics that make them suitable for enhancing the mechanical properties of concrete. Areca fiber is an attractive reinforcement for concrete.

The experimental approach involves designing and testing various concrete mixtures with different proportions of metakaolin and areca nut husk fiber. Compressive strength tests, split tensile strength and flexural strength test will be conducted to evaluate the performance of these mixtures in comparison to conventional concrete.

II. LITERATURE REVIEW

Dhananjay B P et al., (2023) The authors conducted compressive strength. Metakaolin added in 0%,10%, 30%,50%, 70% and compared strength for 7 and 28 days. The study found that use of metakaolin improves strength up to 30% conventional cement replacement. Very effective in gaining higher early strength and helps in production of abrasion resistant concrete.

Bharath et al., (2023) Investigation done on various concrete mixtures were prepared by replacing cement with granite powder and add areca fiber in proportion of 0.5%. the study found that the compressive strength of concrete achieved about 65% for 7 days of curing.

J S R Prasad et al., (2018) Metakaolin, an admixture can be used in concrete in place of cement. 10% can be replaced by cement with metakaolin. The compressive, flexural and split tensile strength for 7 and 28 days is observed. Percentage of metakaolin increases, workability and strength increase and also good correlation between nondestructive test and destructive test is founded.

Ana Maria E et al., (2020) Paper presents a review of the engineering properties of metakaolin based concrete exposed to chloride attack. Workability decreases as the metakaolin replacement increased and also the mechanical properties improved as the metakaolin content increased. Durability properties also improved.

III. MATERIALS AND METHODOLOGY

3.1 MATERIALS USED

3.1.1 Ordinary Portland Cement

Ordinary Portland Cement (OPC) is a common type of cement used in construction, made primarily from limestone and clay. 53 Grade ordinary Portland cement is used. This provides high strength and durability to structures because of its optimum particle size distribution and superior crystallized structures.

Table 1: physical properties of cement

SI no	Properties	Result
1	Fineness	7%
2	Consistency	30
3	Initial setting time	30 min
4	Final setting time	410 min

3.1.2 Fine aggregate

M- sand is used as fine aggregate. M-Sand is artificial sand manufactured from crushing hard gravel into minor sand-sized angular molded units, wash away as well as excellently graded to be used as building aggregate.

Table 2: Physical properties of fine aggregate

Sl no	Properties	Result
1	Specific gravity	2.51
2	Fineness modulus	4.96

3.1.3 Coarse aggregate

Crushed stones are used as coarse aggregate. Aggregate passing through IS 20mm sieve are used.

Table 3: Physical properties of coarse aggregate

Sl no	Properties	Result
1	Specific gravity	2.81
2	Fineness modulus	5.98

3.1.4 Metakaolin

Metakaolin is the calcined form of the clay mineral kaolinite.Particle size of metakaolin is smaller than cement particles. It is produced by calcining kaolinite clay at temperatures between 500°C and 800°C. Metakaolin is an admixture used in concrete to partially replace cement.

Table 4: Physical properties of metakaolin

Ph [10% suspension]	5.5-6.5
Bulk Density [Kg/ Litre]	0.4-0.5
Specific Surface Area m2/g [BET]	10-12
Oil Absorption g/100g	45-55
Specific gravity	2.6
RET. on 500 Mesh	0.05%

3.1.5 Arecanut fiber

Arecanut fiber (ANF) is a natural fiber obtained from the areca palm tree. It act as a light weight composite material.

Fig 3.1: Arecanut fiber

3.1.6 Water

Potable tap water is used for mixing.

3.2 METHODOLOGY

3.2.1 Mix design

M30 grade mix has been designed and mix proportions are given in Table 5.

Table 5: Quantity of materials required per cubic meter for M30 grade concrete

Cement	Fine aggregate	Coarse aggregate	water
387.5 kg/m^3	663.33 kg/m^3	1178.77 kg/m^3	193.85 kg/m^3

3.2.2 Experimental progress

The experimental phase focuses on the partial replacement of cement with metakaolin and adding arecanut fiber as reinforcement.Casting conventional concrete specimens such as cube, cylinder and beams for finding compressive strength, split tensile strength and flexural strength.

Metakaolin is the anhydrous calcined form of the clay mineral kaolinite. The particle size of metakaolin is smaller than cement particles. It is produced by calcining kaolinite clay at temperatures between 500°C and 800°C, which results in the dihydroxylation of the clay mineral. Metakaolin has high pozzolanic activity and reactivity, which makes it an effective pozzolanic material for use in concrete.Casting concrete specimens by replacing cement with metakaolin in different proportions 10%, 20% and 30% for finding its optimum strength.

Arecanut fibers has been collected and cleaned. After the extraction of fibers, the fibers has been mixed with the concrete in ratios 1%, 2% and 3% of mass of cement and metakaolin with optimum value 10%.

3.2.3 Casting of specimens

Casting specimens such as cubes, cylinders and beams for finding the compressive strength, split tensile strength and flexural strength.

Size of cube – 150 × 150 × 150 mm
Size of cylinder – 150mm diameter and 300mm height
Size of beam – 100 × 100 × 500 mm
The specimens are casted and cured for 7 and 28 days. Determine the strength after 7 days and 28 days curing period.

Fig 3.2 moulds for casting

Fig 3.3 casting of specimens

3.2.4 Tests for concrete

Compressive Strength Test of Cubes

The compressive strength of concrete specimen is calculated by formula

$$F_{ck} = P/A$$

Where, P = failure load in compression (N)
A = Area of cross section (mm^2)
F_{ck} = Compressive strength (N/mm^2)

Split Tensile Strength Test of cylinders

The split tensile strength was calculated by formula

$$F_{sp} = 2P / (\pi dl)$$

Where, F_{sp}= Split tensile strength (N/mm^2)
P = Maximum applied load (N)
L = Length of cylinder (mm)
d = Diameter of cylinder (mm)

Flexural Strength Test of beams

The flexural strength was calculated by formula

$$F_b = PL/bd^2$$

Where, f_b = Flexural strength (N/mm^2)
P = Maximum applied load (N)
L = Length of cylinder (mm)
d = height of cylinder (mm)
b = width of specimen (mm)

IV. RESULTS

The mechanical properties such as compressive strength, split tensile strength and flexural strength by replacing cement with metakaolin is determined.

4.1 compressive strength Test

Table 6: Compressive strength Test Result

S.no	Mix (%)	7 Days	28 Days
1	M30+0%MK	17.3	30.17
2	M30+10%MK	20.0	31.21
3	M30+20%MK	18.21	31.16

4.2 Split Tensile Strength Test

Table 7: Split Tensile strength Test Result

S.no	Mix (%)	7 Days	28 Days
1	M30+0%MK	1.72	2.1
2	M30+10%MK	1.80	2.58
3	M30+20%MK	1.76	2.28

4.3 Flexural strength Test

Table 8: Flexural strength Test Result

S.no	Mix (%)	7 Days	28 Days
1	M30+0%MK	2.6	4.03
2	M30+10%MK	3.66	5.0
3	M30+20%MK	2.8	4.25

Replace cement by metakaolin in various proportions. Mechanical properties were determined by conducting tests such as compressive strength test, split tensile strength and flexural strength. The optimum strength is obtained at the mix of replacing cement with 10% of metakaolin.

Adding arecanut fiber in 1%, 2% and 3% alongside the 10% metakaolin in the concrete mix.

4.4 Compressive strength Test

Table 9:Compressive strength TestResult

S.no	Mix (%)	7 Days	28 Days
1	M30+0%MK+0%AF	17.3	30.1
2	M30+10%MK+1%AF	20.1	30.8
3	M30+10%MK+2%AF	22.3	31.9
4	M30+10%MK+3%AF	18.2	24.1

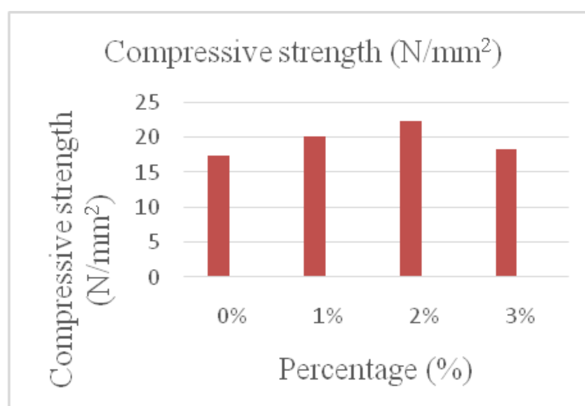

Fig 4.1: Compressive strength after 7 days

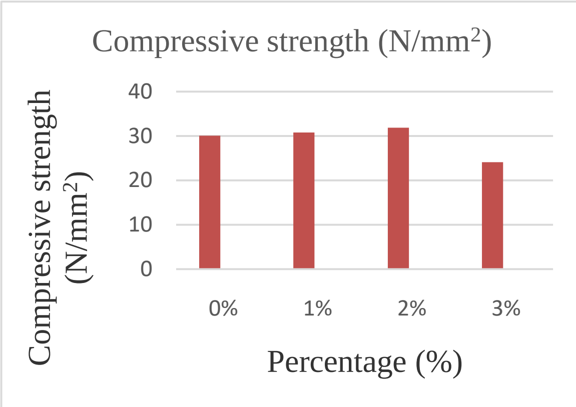

Fig 4.2: Compressive strength after 28 days

4.5 Split tensile strength Test

Table 10: Split tensile strength Test Result

S.no	Mix (%)	7 Days	28 Days
1	M30+0%MK+0%AF	1.72	2.1
2	M30+10%MK+1%AF	1.75	2.21
3	M30+10%MK+2%AF	1.90	2.75
4	M30+10%MK+3%AF	1.69	1.7

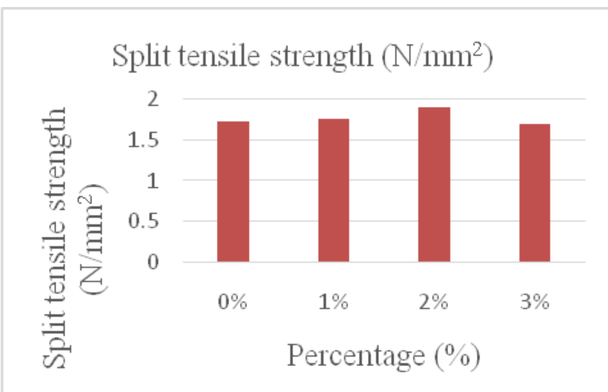

Fig 4.3: Split tensile strength after 7 days

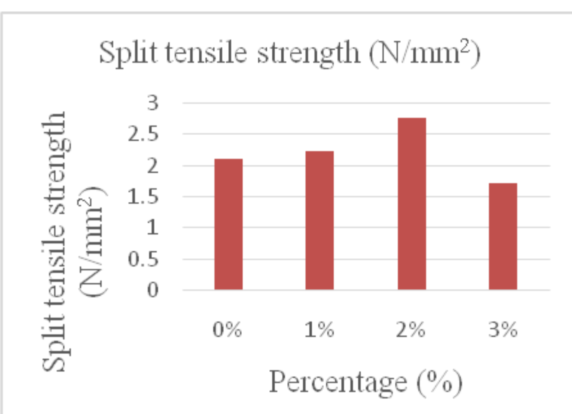

Fig 4.4: Split tensile strength after 28 days

4.6 Flexural strength Test

Table 11: Flexural strength Test Result

S.no	Mix (%)	7 Days	28 Days
1	M30+0%MK+0%AF	2.6	4.03
2	M30+10%MK+1%AF	3.16	4.75
3	M30+10%MK+2%AF	5.10	6.3
4	M30+10%MK+3%AF	4.12	5.16

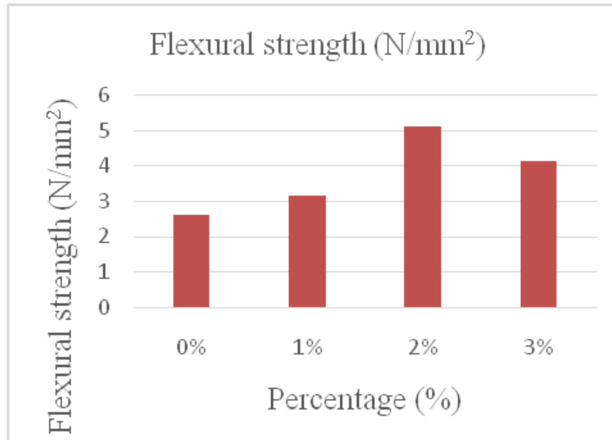

Fig 4.5: Flexural strength after 7 days

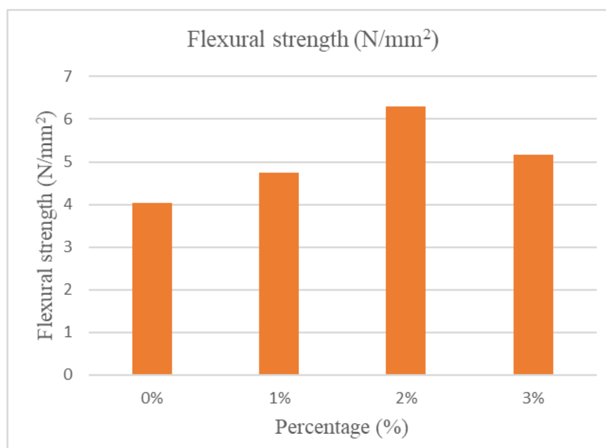

Fig 4.6: Flexural strength after 28 days

V. CONCLUSION

In this paper, we have conducted test on partially replacing cement by metakaolin and adding arecanut fiber as reinforcement in various proportions. We cast conventional concrete specimens with mix proportion of M30 grade concrete and cast concrete specimens by replace cement with metakaolin in various proportions.We got optimum strength at replace 10% cement by metakaolin. The strength determination tests such as compression test, split tensile test and flexural strength test has been conducted by adding arecanut fiber in 1%, 2% and 3% and replace cement by 10% metakaolin. The addition of 2% of arecanut fiber along with metakaolin enhancing the compressive, split tensile and flexural strength. On further adding of fiber, the strength gradually decreases.

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