Examine the Impact of Utilizing Jute Fiber and Fly Ash as Partial Replacement for Cement in the Properties of M25 Grade Concrete

Khyati Varshney, Divyanshu Dev, Rohit Ralli, Shobha Ram

Abstract Because regular concrete uses a lot of cement and emits a lot of CO2, it has an adverse effect on the environment. This makes it necessary to look into sustainable alternatives. This study looks into improving the mechanical qualities of M25 grade concrete while lessening its environmental impact by partially replacing cement with fly ash and jute fiber. Jute fibers and fly ash, a pozzolanic byproduct of burning coal, were added in different amounts to test the strength, durability, and microstructural qualities of the finished concrete. The mechanical properties of concrete mixtures with different fly ash and jute fiber ratios were the subject of experimental study. The best mixture, which included 5g of jute fiber and 30% fly ash, outperformed regular concrete by achieving the highest compressive strength at 28 days (34.28 MPa). The identical combination captured the most elevated tensile strength (4.32 MPa) and flexural strength (5.35 MPa) after 28 days. The maximum compressive strengths of the concrete with 15% fly ash and 7.5g of jute fiber were 28.86 MPa and 22.20 MPaat 14 and 7 days, respectively. The tensile strength of the concrete showed continuous improvements, reaching its peak at 28 days (3.82 MPa). Tests for resistance to sulfate attack and chloride permeability further validated the modified mixes' enhanced performance. According to the study's findings, the ideal mixture of 70% cement, 30% fly ash, and 5g jute fiber significantly improves compressive, flexural, and tensile strength, offering a viable substitute for the manufacturing of concrete in a sustainable manner.

Keyword: Cement, Jute fiber, Fly Ash, Different Test, Different types of Strength (Compressive Strength, Tensile strength, Flexural Strength, etc.

I. INTRODUCTION

Due to their potential to enhance the characteristics of concrete, the use of fly ash and jute fiber as cement substitutes in M25 grade concrete has generated significant interest in the construction materials market.

Manuscript received on 05 October 2024 | Revised Manuscript received on 27 October 2024 | Manuscript Accepted on 15 November 2024 | Manuscript published on 30 November 2024.
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Numerous studies have examined the effects of these components on the characteristics of concrete, shedding light on its robustness, longevity, and durability [1]. The material most frequently utilized in the construction of civil engineering constructions. Because of the negative environmental effects of the concrete, the cost is really high. About 65% of global warming is caused by greenhouse gases, of which CO2 is one. Typically, Portland cement contributes 1.35 billion tons each year to emissions of greenhouse gases, or almost 7% of all greenhouse gas emissions to the atmosphere of the earth. rising home demand as well as and the quick growth of infrastructure has resulted in a shortage and increase in the price of building materials. The majority of the garbage generated by destroyed buildings is dumped as land fill.

It turns into Because of the environmental element, it is vital to employ all of these demolition wastes. When flying jute fiber and ash in place of cement, hence the same characteristic was destroyed Natural stone aggregate can be substituted with aggregates [1]. This will lower the price as furthermore advantageous to the environment.The desire for environmentally friendly building materials has raised awareness of the benefits of adding natural fibers and industrial waste to concrete. The mechanical qualities of concrete are improved by fly ash, a byproduct of burning coal, while the tensile strength and ductility are enhanced by jute fiber. This study investigates how different amounts of jute fiber (5g and 7.5g) and fly ash (15% and 30%) affect the mechanical characteristics of concrete at various curing ages. The mixture containing 5g of jute fiber and 30% fly ash had the best flexural strength (5.35 MPa) and the highest compressive strength (34.28 MPa) at 28 days, according to the results. This mixture also has the maximum tensile strength (4.32 MPa), according to the data. In the meantime, the mixture of 7.5g jute fiber and 15% fly ash shows steady increases in tensile strength. Overall, the results point to the best mixture for increasing compressive, flexural, and tensile strengths and encouraging more environmentally friendly building methods as being 70% cement, 30% fly ash, and 5g jute fiber [2].

II. THE PURPOSE OF THE RESEARCH

The following summarizes the thesis's primary goals:

A- create the fly ash concrete blend percentage with jute fibers.

B-To calculate the water-to-binder ratio in order to create a design mix with the right strength and workability.

C-To examine the impact of fly ash on tensile, flexural, and compressive strengthusing jute fiber.

D-Examining and contrasting the effects of varying fly ash and jute fiber quantities intraditional concrete.

E-Based on these findings, a formula was created that enables us to use the formula to directly calculate the compressive strength in a single step.

III. MATERIALS USED

A. Cement: The material utilized was Ordinary Portland Cement (OPC) 53 grade, which is made up of argillaceous, siliceous, and calcareous components [3]. Because it develops its strength more quickly, this kind of cement is recommended. Specific gravity (Fig.1), compressive strength (43 MPa at 28 days), and setting periods of 30-45 minutes for the initial setting and 600 minutes for the final setting are important characteristics [4].

B. Fly Ash: Class F fly ash was utilized. It is a byproduct of burning coal and mostly consists of silica (20–60%) and alumina (5–35%) [5]. By using less cement, it improves the durability, workability, and sustainability of concrete (fig-2,3,4)

C. Aggregates: Fine aggregate, categorized in accordance with IS 383:1970, guarantees concrete's workability and consistency. Based on IS: 2386-1963, coarse aggregate (12.5 mm and 20 mm sizes) was used, which had an impact on the workability and strength of the mix (fig-5 and fig.6)

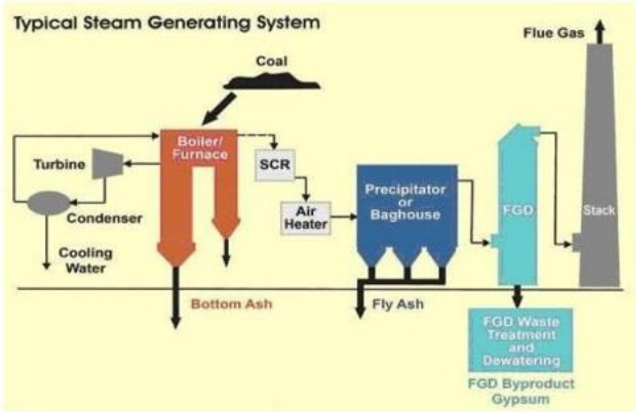
D. Jute fiber: which has a tensile strength of 1100 MPa and a fiber length of 50 mm, was utilized. Jute fiber is well-known for its strength and longevity. It enhances concrete's mechanical qualities (fig- 7)

E. Water: To ensure the quality of the concrete, potable tap water free of chemicals or salts was utilized for mixing and curing.

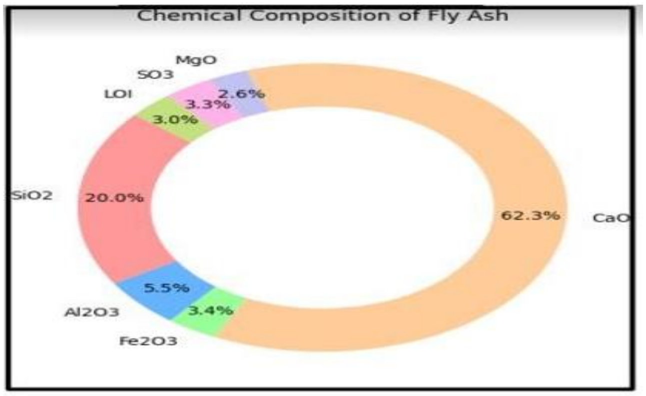
	Property	Value
0	Fibre Length	50 mm
1	Fibre Diameter	1.0 mm
2	Aspect Ratio	5
3	Tensile Strength	1100 MPa
4	Deformation	Continuously deformed
5	Appearance	Bright and clean wire

[Fig.1: Cement]

[Fig.2: Fly Ash]



[Fig.3: A Typical Layout of Fuel Furnace and Fly Ash Collection System]



[Fig.4: Constituents of Fly Ash]

[Fig.5: Fine Aggregate]

[Fig.6: Coarse Aggregate]

Retrieval Number: 100.1/ijse.A132004021124
DOI: 10.54105/ijse.A1320.04021124
Journal Website: www.ijse.latticescipub.com

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[Fig.7: Jute Fibre]

IV. EXPERIMENTAL PROGRAM

The cube specimen (150*150*150 m3) was cast and tested as part of the experiment.size with various concrete mixtures by adjusting the fly ash percentage using the quantity of jute fiber and a cast beam specimen measuring 100 by 100 by 700 mm3 for tensile testing using M25 concrete grade and cast cylindrical specimens (150*300 mm) for flexural strength [3]. The compressive, flexural, and tensile strengths of concrete specimens have all undergone testing. This study's primary goal is to examine the compressive, flexural, and tensile strength tests of M25 gradeconcrete conducted on various days.

A. Nomial Design of M-25 Grade of Concrete: -(M-25=1:1:2)

i.Calculation -Wet volume = (0.15)^3

= 0.003375m^3
Dry volume =1.54*0.003375
=0.0051975m^3
Proportion of Cement:
m^3 = 0.0051975*1/4
= 0.001299375m3
kg = 0.001299375*density of cement
= 0.001299375*1440
= 1.8711kg
Total cement used for the preparation of cubes=1.8711*15=28.0665kg
Proportion of Sand:
m^3 =0.0051975*1/4
=0.001299375m3
kg=0.001299375*density of sand

=0.001299375*1602
=2.08159875kg
Total sand used for the preparation of cubes=2.08159875*15=31.22398125kg

Proportion of Aggregate:
m^3 =0.0051975*2/4
=0.00259875m3
kg=0.00259875*density of aggregate
=0.00259875*2400
=6.237kg

Total Aggregate used for the Preparation of cubes=6.237*15=93.555kg

ii.New Concrete

Every material is weighed using the nominal mix design as a guide. In a concrete mixer, dry ingredients (cement, sand, and aggregates) are combined for two minutes. Water is then added, and the mixture is stirred for three more minutes.

iii.Samples Curing and Casting

Using a vibrating table, concrete cubes measuring 150 x 150 x 150 mm are formed, filled with new concrete, and compacted. After being cured for 24 hours in the air, the specimens are moved to a water tank and left there until the test days (7, 14, and 28 days) ,showing in the below figure.

iv.Method of Testing

A variety of specimens, including cubes, beams, and cylinders, underwent compressive, flexural, and tensile strength tests at 7, 14, and 28 days.

v.Test of Compressive Strength

The compressive strength of concrete cubes is tested. A record of the failure load is made.and the formula for compressive strength is

$$P=L/A$$

Where,
P= Compressive strength (Mpa)L=Failure load (KN)
A=Cross Sectional area (mm2)
Test of Flexural Strength
Flexural strength of concrete beams (100x100x700 mm) is measured under third-point loading. After noting the failure load, the flexural strength is computed as follows: The formula for calculating the elasticity strength (MPa) is Strength(Mpa) =

$$(3P*L)/(2b*d2)$$

Where ,
P= failure load (KN)
L=centre to centre distance b/w the support(mm)b=width of specimen(mm)
d=depth of specimen(mm)
Test for Split Tensile Strength
The tensile strength of 150x300 mm concrete cylinders is tested. Tensile strength is computed as follows when the failure load is noted:
Tensile strength is equal to strength=

$$(2*P)/(\pi*L*D)$$

Where ,
P=Failure load(KN) L=Length of specimen(mm)
D=Diameter of the specimen(mm).

Retrieval Number: 100.1/ijse.A132004021124
DOI: 10.54105/ijse.A1320.04021124
Journal Website: www.ijse.latticescipub.com

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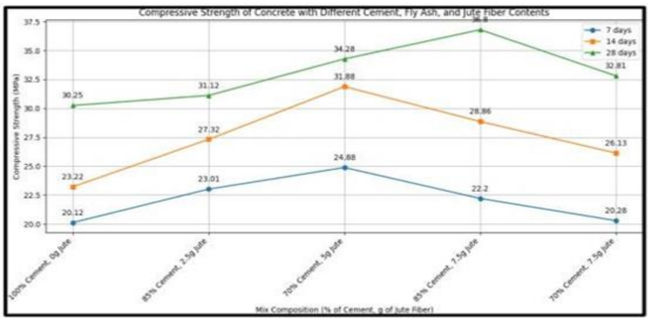
V. RESULTS AND DISCUSSION

A. Compressive Strength

According to IS-516-1959, [4] compressive tests have been used to determine the compressive strength of different fly ash compositions added to concrete as well as fly ash fiber reinforced concrete. Table 1 lists the compressive strengths of fly ash with jute fiber reinforced concrete and ordinary concrete.

Table 1: Compressive Strength Tests Results for M-25 Concrete Grade

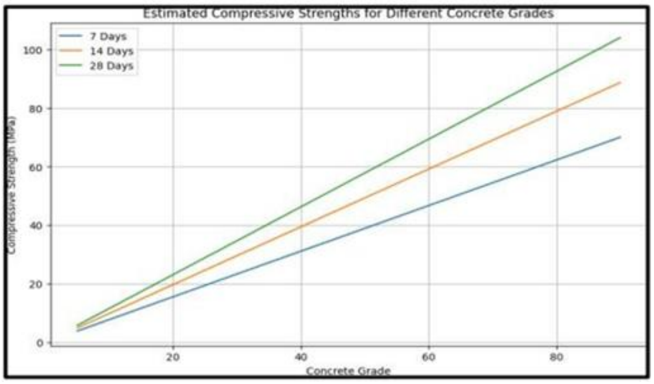
% of Cement	% of Fly Ash	Jute (gm)	Compressive strength (7 days)	Compressive strength (14 days)	Compressive strength (28 days)
100	0	0	20.12	23.22	30.25
85	15	2.5	23.01	27.32	31.12
70	30	5	24.88	31.88	34.28
85	15	7.5	22.20	28.86	36.80
70	30	7.5	20.28	26.13	32.81



[Fig.8: Compressive Strength Test Results of Concrete with Different Percentage of Jute Fibre and Fly Ash]

Table 2: Compressive Strength of Different Grades of Concrete (Using Python)

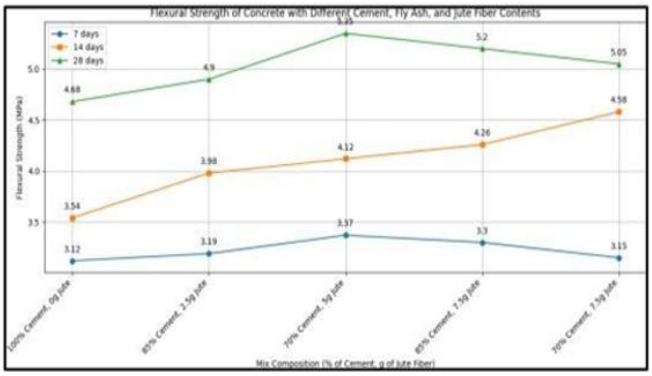
Grade	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
M5	3.89	4.93	5.78
M10	7.78	9.86	11.56
M15	11.67	14.78	17.34
M20	15.56	19.71	23.12
M25	19.45	24.64	28.9
M30	23.34	29.57	34.68
M35	27.23	34.5	40.46
M40	31.12	39.42	46.24
M45	35.01	44.35	52.02
M50	38.9	49.28	57.8
M55	42.79	54.21	63.58
M60	46.68	59.14	69.36
M65	50.57	64.06	75.14
M70	54.46	68.99	80.92
M75	58.35	73.92	86.7
M80	62.24	78.85	92.48
M85	66.13	83.78	98.26
M90	70.02	88.7	104.04



[Fig.9: Compressive Strength for Different Grades of Concrete (Using Python)]

Table 3: Flexural Strength Tests Results of M25 Concrete Grade

% of Cement	% of Fly Ash	Jute (gm)	Flexural strength (7days)	Flexural strength (14days)	Flexural strength (28days)
100	0	0	3.12	3.54	4.68
85	15	2.5	3.19	3.98	4.90
70	30	5	3.37	4.12	5.35
85	15	7.5	3.30	4.26	5.20
70	30	7.5	3.15	4.58	5.05



[Fig.10: Flexural Strength Test Results of Concrete with Different Percentage of Jute Fibre and Fly Ash]

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Journal Website: www.ijse.latticescipub.com

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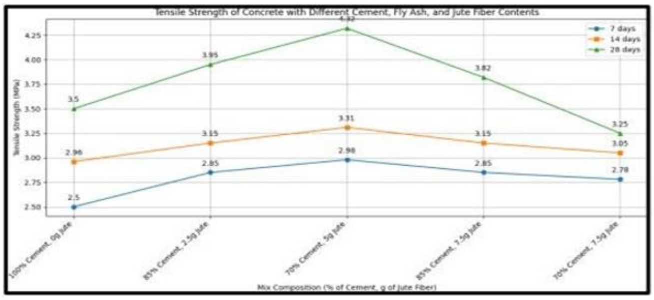
Table 4: Split Tensile Strength Tests Results of M25 grade Concrete

%of Cement	% of Flyash	Jute (gm)	Tensile strength (7days)	Tensile strength (14days)	Tensile strength (28days)
100	0	0	2.50	2.96	3.50
85	15	2.5	2.85	3.15	3.95
70	30	5	2.98	3.32	4.32
85	15	7.5	2.85	3.15	3.82
70	30	7.5	2.78	3.05	3.25



[Fig.11: Tensile Strength Test Results of Concrete with Different Percentage of Jute Fibre and Fly Ash]

VI. CONCLUSION

a)-Concrete with 30% fly ash and 5g of jute fiber achieved the highest compressive strength at 28 days (34.28 MPa), indicating significant improvement over plain concrete.

b)-The inclusion of 15% fly ash and 7.5g jute fiber resulted in the highest compressive strength at 14 days (28.86 MPa) and 7 days (22.20 MPa).

c)-Fly ash and jute fiber reinforcement improved the flexural strength at all test ages. d)-The highest flexural strength at 28 days (5.35 MPa) was observed in concrete with30% fly ash and 5g of jute fiber.

e)-Concrete with 30% fly ash and 7.5g jute fiber showed a significant increase in flexural strength at 14 days (4.58 MPa).

f)-The highest tensile strength at 28 days (4.32 MPa) was recorded for concrete with30% fly ash and 5g of jute fiber.

g)-Concrete with 15% fly ash and 7.5g jute fiber showed consistent improvements in tensile strength across all ages, with the peak at 28 days (3.82 MPa).

h)-The optimal mix for the best compressive and tensile strength improvementsappears to be 70% cement, 30% fly ash, and 5g of jute fiber.

i)-or the highest flexural strength, the same mix of 70% cement, 30% fly ash, and 5g jute fiber was the most effective.

j)-From table 2 and fig 9 we can easily find out the compressive strength of different grades of concrete using python without any experimental work.

ACKNOWLEDGEMENT

As Khyati Varshney and Divyanshu Dev, we thus declare that the study paper we did under the supervision of Drs. Rohit Ralli and Shobha Ram, entitled "Study on the Effects of Using Jute Fiber and Fly Ash as Partial Replacement of Cement in M25 Grade Concrete Properties," is our original work. This work is being submitted in partial completion of M.tech (Structural Engineering) at Gautam Buddha University, with all sources appropriately credited. It's not been turned in anywhere else.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** No organisation or agency has sponsored or funded this article. The independence of this research is a crucial factor in affirming its impartiality, as it has been conducted without any external sway.
- **Ethical Approval and Consent to Participate:** The data provided in this article is exempt from the requirement for ethical approval or participant consent.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Authors Contributions:** The authorship of this article is contributed equally to all participating individuals.

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