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To Study the Strength Characteristics of Concrete Using Mineral Admixture

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Abstract

Aside from the combustion of fossil fuels, the cement making business emits carbon dioxide. The global cement industry accounts for around 7% of greenhouse gas emissions into the earth's atmosphere. To address the environmental impacts connected with cement manufacturing, alternative concrete binders must be developed. Another important environmental concern is the extraction of natural resources such as sand from river bottoms. As a result, substantial study into the use of cement substitutes, including several waste materials and industrial byproducts, is continuing. Bamboo leaf ash was utilised as a partial replacement for cement and fenugreek as an addition in this study, and it was compared to standard concrete. The considered bamboo leaf ash was 5%, 10%, 15% by weight of cement for M25 grade concrete and 5% of fenugreek powder as additive for every mix [1]. Additionally, an experimental investigation of the effects of using bamboo leaf ash in place of some of the cement and fenugreek powder as an additive on the performance of concrete in terms of compressive strength and flexure strength. Concrete is cast for the experimental study, and cement is partially substituted with bamboo leaf ash by weight of cement and fenugreek powder as an addition. Because the inclusion of bamboo leaf ash and fenugreek powder works as a binding ingredient in the concrete, the compressive and flexural strength increases. Finally, the compressive and flexural strengths for the combination of bamboo leaf ash as a partial replacement and fenugreek powder as an addition powder in concrete are investigated for the best results obtained from the aforementioned experiment.

Keywords: *Compressive strength, Flexural strength, Bamboo Leaf Ash (BLA).*

1. Introduction

Cement is a substance composed of numerous different components, including a binding base with embedded particles of aggregate fragments. Cement, aggregates, chemical admixtures, mineral admixtures, and water make up concrete. Concrete consumption and manufacture on our planet Earth account for billions of metric tonnes of CO2 emissions every year, posing environmental problems [1]. Pozzolans are a large class of siliceous or siliceous and aluminous minerals that, at room temperature, chemically react with calcium hydroxide (CaOH2) when finely divided and in the presence of water to generate compounds having cementitious characteristics [2]. The pozzolanic activity of a pozzolan is a measure of its ability to react with water and calcium hydroxide. Natural volcanic pozzolans are called pozzolanas. The name "pozzolan" encompasses a vast range of materials with widely varying origins, compositions, and qualities. Pozzolanic activity can be found in both natural and artificial (man-made) materials, which are used as supplemental cementitious materials [3]. Utilising locally obtainable resources in place of cement will partially offset energy consumption and mitigate environmental effects. Utilising plant residue, an industrial byproduct, and agricultural waste in place of Portland cement is a clever way to save raw material consumption, save the environment, and enhance cement quality [11]. In the process of making concrete, pozzolanic waste

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material is sometimes used in place of some of the cement. A growing amount of attention is currently being paid to certain agricultural wastes and byproducts because of their pozzolanic composition and potential application as additives in commercial Portland cement. Concrete usually performs better during the hydration phase of the pozzolanic reaction [4]. Worldwide, a number of studies have been carried out on the application of bamboo leaf ash (BLA) as a pozzolanic ingredient in the manufacturing of concrete. Bamboo leaf ash was shown to be an appropriate pozzolanic material that forms calcium silicate hydrate when combined with calcium hydroxide. With time and temperature, bamboo leaf ash's pozzolanic activity rises [5]. Properties of Cement and BLA & Physical Properties are shown in Table 1 & 2.

The Main Objectives of This Research Are as Follows:

- To study the Strength properties of concrete when bamboo leaf ash is used as partial replacement of cement and Fenugreek as additive at various percentages are using.
- To find the physical properties of bamboo leaf ash.
- To determine workability of concrete with compaction factor test and slump cone test.

2. Experimental Work

Entire experimental work carried out is briefly explained as follows.

2.1 Materials

- **Cement:** OPC 43 grade cement which was having a specific gravity of about 3.15.
- **Bamboo leaf ash:** Class – Bamboo leaf ash was used in this study.
- **Coarse Aggregate:** The size of the aggregate is 10mm and the specific gravity is 2.74.
- **Fine Aggregate:** River sand was used and its specific gravity is 2.64
- Water

Table 1 Chemical Properties of Cement and BLA

Chemical composition	SiO_2	Al_2O_3	Fe_2O_3	Cao	MgO	Na_2O	K_2O
OPC	21.40	5.03	4.40	61.14	1.35	-	0.48
BLA composition	65.66	6.41	4.28	15.22	2.48	2.76	4.84

Table 2 Physical Properties of BLA

Parameters	Result
Color	Dark grey
Specific Gravity	2.33
Fineness	7%
Density	1217 kg/m^3

2.2 Fenugreek

Trigonella foenum-graecum, an organic additive commonly called as fenugreek [9,10]. Mineral additives are identified as supplementary cementitious material (Pozzolana) is a finely ground siliceous material which, as such, does not possess cementitious properties itself, but react with chemically with calcium hydroxide released from the hydration of the Portland cement at normal temperature to form low solubility having cementitious properties [6-9].

3. Methodology

Concrete mix design calculation for M25 Grade concrete (Table 4). Material Quantities is shown in Table 3.

Table 3 Material Quantities

	Cement (Kg/m^3)	FA (Kg/m^3)	CA (Kg/m^3)	Water (Kg/m^3)
Quantity	394	730	1003	197

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Table 4 Mixes and Percentages of Materials
MIX RATIO = 1: 1.8:2.5

Mix	FA (%)	CA (%)	BLA (%)	Cement (%)	Fenugreek (%)	Water (%)
M_1	100	100	0	0	5	100
M_2	100	100	5	95	5	100
M_3	100	100	10	90	5	100
M_4	100	100	15	85	5	100

3.1 Observation of Specific Gravity of BLA

Formula: (Table 5)

$$G = \frac{w2-w1}{(w2-w1)-(w3-w4)}$$

Where G is specific gravity

W1 = Mass of empty density bottle

W2 = Mass of bottle and bamboo leaf ash

W3 = Mass of bottle, bamboo leaf ash and water

W4 = Mass of bottle and water

Table 5 Observation of Specific Gravity of BLA

	W1 (kg)	W2(kg)	W3(kg)	W4(kg)
T1	0.0612	0.0812	0.162	0.1508
T2	0.0612	0.0815	0.163	0.1504
T3	0.0612	0.0812	0.163	0.1508
Average	0.0612	0.0813	0.162	0.1504

Specific Gravity, G = 2.31

Table 6 Fineness Test of Bamboo Leaf Ash Calculations

	W1(gm)	W2(gm)	Fineness (%)
T1	100	8	8%
T2	100	7	7%
T3	100	9	9%

Formula Fineness of bamboo leaf ash (Table 6)

$$= \frac{w1}{w2} * 100$$

Where, w1 = weight of bamboo leaf ash taken as test sample.

w2 = weight of sample retained on 90-micron sieve.

$$\text{Fineness of bamboo leaf ash} = \frac{8}{100} * 100 = 8\%$$

Table 7 Observation of Slump Test and Compaction Test

Mix	Slump	Compaction
M1	6cm	0.96
M_2	5.5cm	0.95
M3	5cm	0.94
M4	4cm	0.92

Observation of Slump Test and Compaction Test is shown in Table 7.

Table 8 Comparison of Compressive and Flexure Strength at 7days

Mix	Compressive strength(MPa)	Change in strength	Flexure strength	Changein strength
M1	16.8	-	2.7	-
M2	20.10	+3.3	3.2	+0.5
M3	18.36	-1.74	2.83	-0.37
M4	16.73	-1.63	2.64	-0.19

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At Mix2, Target strength is arrived with 5% of Bamboo leaf ash as partial replacement and 5% of fenugreek as additive. The strength is increased at mix2 and from Mix3 it is decreasing gradually [7]. Comparison of Compressive and Flexure Strength at 7,14,28 Days reports are shown in Table 8,9 and 10.

Table 9 Comparison of Compressive and Flexure Strength at 14days

Mix	Compressive strength (MPa)	Change in strength (%)	Flexure strength	Change in strength (%)
M1	20.62	-	3.1	-
M2	24.22	+3.6	3.8	+0.7
M3	23.07	-1.15	3.4	-0.4
M4	21.34	-1.73	3.14	-0.26

At Mix2, Target strength is arrived with 5% of Bamboo leaf ash as partial replacement and 5% of fenugreek as additive. The strength is increased at mix2 and from Mix3 it is decreasing gradually [8]. Comparison of Compressive Strength & Flexural Strength results are shown in Figure 1 and 2.

Table 10 Comparison of Compressive and Flexure Strength at 28 Days

Mix	Compressive strength (MPa)	Change in strength (%)	Flexure strength	Change in strength (%)
M1	24.43	-	3.49	-
M2	28.97	+4.54	4.3	+1.01
M3	26.12	-2.85	3.75	-0.75
M4	23.30	-2.82	3.43	-0.32

At Mix2, Target strength is arrived with 5% of Bamboo leaf ash as partial replacement and 5% of fenugreek as additive. The strength is increased at mix2 and from Mix3 it is decreasing gradually [9].

4. Analysis

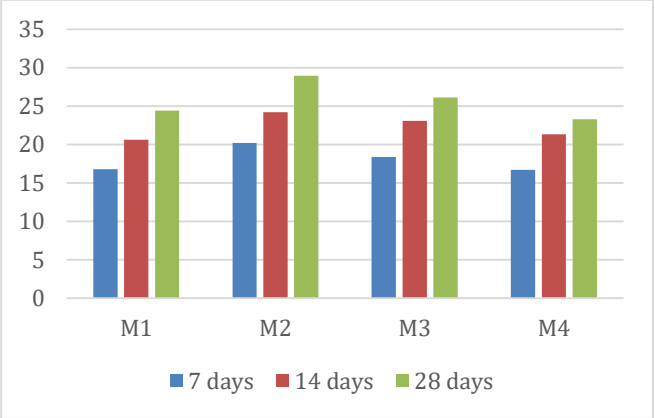

Figure 1 Comparison of Compressive Strength at 7,14,28 Days

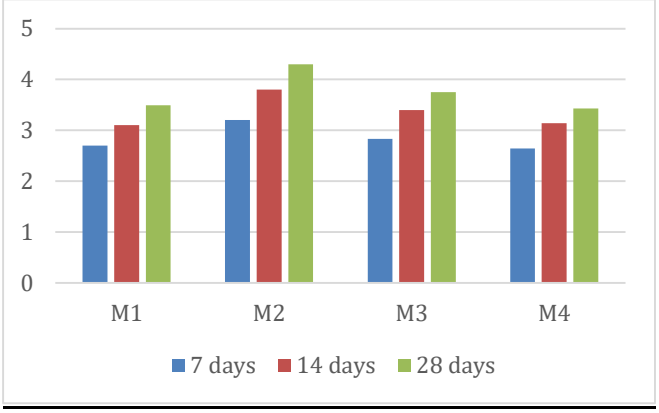

Figure 2 Comparison of Flexural Strength at 7,14,28 Days

Conclusion

On the basis of results obtained, following conclusions can be drawn:

- By replacement, the strength also increased at 5% replacement. From 10% replacement the strength decreased.
- 5% partial replacement of cement by and cement by bamboo leaf ash and fenugreek as additive showed 3.3% increase in compressive strength at 7 days, 3.6% increase at 14 days and 4.54% increase at 28 days.
- In flexure test at 5% replacement, 0.5% increase in flexure strength at 7days, 0.7% increase at 14 days and 1.01% increase at 28 days.

- The fineness of bamboo leaf ash is 7% which is more like cement.
- Use of bamboo leaf ash in concrete is proved to be much economical though it is non- useful waste and free of cost.
- Use of bamboo leaf ash in concrete will eradicate the disposal problem of waste and prove to be environment friendly thus paving way for greener concrete
- Use of bamboo leaf ash in concrete will helps to replace the cement partially and thus make concrete construction industry sustainable.

Bamboo leaf ash potentially substitutes cement up to 5%**.** The outcome of the study will balance the cement price escalation and increase housing affordability without compromise in quality

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