Creating Environmentally Friendly Concrete by Substituting Some of The Portland Cement With Corn COB and Banana Leaf ASH

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Abstract

Cement is an essential ingredient in concrete. The cement industry is a major source of greenhouse gas emissions worldwide. Using cement in concrete as efficiently as possible without compromising quality is the simplest way to address this. Numerous materials that can partially replace cement in concrete are the subject of extensive research. The selection of the concrete's constituent materials to minimize adverse environmental effects is the primary component in the creation of sustainable concrete. Due to its enhanced performance and advantages, the use of natural supplemental cementitious materials from new sources is becoming more and more important in contemporary construction methods. India is producing more and more agricultural waste every day. These agricultural wastes can naturally break down in open areas. One possible tactic to support sustainable development in both urban and rural contexts is to construct buildings using materials that are produced locally. The world is currently paying attention to alternative material sources that are less detrimental to the environment.

The study's goal is to determine the effects of using "banana leaves ash" and "corn cob ash" as cement substitutes by evaluating their pozzolanic properties when mixed with concrete. These materials are widely used because they offer several benefits, such as lifespan, energy efficiency, low maintenance costs, cost-effectiveness, fire resistance, excellent thermal properties, and versatility. Corn cob ash, a byproduct of the maize industry, has shown promise as a sustainable and versatile building material, according to research that is currently being published. This research employed banana leaf ash and corn cob ash as partial cement substitutes. The specific mix design is M25. Samples were made by replacing cement with 5%, 10%, 12.5%, and 15% corn cob ash. If the ideal percentage of corn cob ash replacement is maintained, additional cement can be substituted with 2.5%, 5%, 7.5%, and 10% banana leaf ash. The compressive, tensile, and flexural strengths of banana leaf ash and corn cob ash were tested after 7, 14, and 28 days of curing. The results were compared to those of ordinary concrete.

Keywords— Corn cob ash, Banana leaf ash, Mechanical properties, sustainable concrete.

I. INTRODUCTION

1.1 General

Concrete is a common building material because of its strength, adaptability, and durability. Cement, water, and aggregates—which might be sand, gravel, or crushed stone—are the three primary components of concrete. The usage and production of concrete have a significant detrimental impact on the environment, mostly due to the carbon dioxide emissions produced during the cement manufacturing process. In addition to using a significant amount of energy, the manufacture of cement releases a lot of greenhouse gases, like CO2, which makes global warming worse. Additionally, ecosystems, landscapes, and natural habitats may suffer if raw materials like sand and gravel-which are necessary to create concrete—are removed. By creating more ecologically friendly production methods and including alternative elements like GGBS, fly ash, slag, glass powder, and wollastonite powder, scientists are attempting to address these issues and lessen the environmental impact of concrete. Additionally, using concrete in construction can help the environment by prolonging the lifespan and energy efficiency of buildings and infrastructure. As the demand for sustainable construction increases, it is becoming increasingly important to develop ecologically friendly concrete production and use techniques.

1.2 Overview

By 2050, the cement and concrete sectors aim to become net carbon neutral. The production of Portland cement clinker results in a considerable quantity of greenhouse gas emissions (GHG). The manufacture of concrete is linked to these pollutants. Concrete may be made to have a lower carbon footprint using two main methods:

1. Prevention

Goal: Reduce the amount of cement in each volume of concrete.

Implementation:

• Mix Optimization: Modify the concrete mixture to boost volume, reduce cementitious component concentration, and maintain freshness and coolness.

• Performance-Based Design: Instead of supporting smaller cementitious components, design concrete based on performance.

2. Replacement:

• Goal: To substitute another material for Portland cement, either whole or in part.

• Materials: Fly ash, slag, and silica fume are examples of Supplementary Cementitious Materials (SCM). The two novel materials used in this paper are CORN-COB ASH (CCA) and BANANA LEAF ASH (BLA).

An innovative substitute for conventional concrete is Alternative Cementitious Materials (ACM). And an innovative tool that integrates with existing infrastructure is Alternative SCM (ASCM).

3. *New Materials Criteria:*

• Compatibility: Requires prior knowledge of SCM and cement distribution infrastructure.

• Application: Ideal for batch processing, shipping, and processing.

• Strength, duration, and action duration are performance parameters.

Reasonably priced: competitive.

• New materials must have competitive prices in order to be adopted.

• It is crucial to strike a balance between environmental benefits and economic viability.

1.3 Why is Banana Leaf Ash (BLA) used as a filler in concrete?

• In the production of concrete, banana leaf ash has gained interest as a sustainable alternative. Let's look at its advantages and why it is chosen:

• Garbage usage: Banana leaves are among the many types of agricultural waste produced in India. These leaves are often discarded, which causes environmental problems. Banana leaf ash offers a way to make useful use of this waste. We produce a useful material by burning dry banana leaves and gathering the ash.

• Pozzolanic reaction: The pozzolanic reaction that banana leaf ash causes is similar to that of cement.

• It increases the strength of concrete when used in place of some of the cement.

• Environmental benefits: Because the production process of banana leaf ash has a significant impact on the environment, using it replaces the need for traditional cement.

• We help reduce waste and protect the environment by using banana leaf ash in place of some of the cement.

1.4 Corn Cob Ash

Corncob ash is a crop deposit and agricultural waste consequent from the maize crop. A study showed, that of the 750 Tg of biomass burnt across Asia, 250 Tg (33.4%) originated from open-field incineration. The main donors were India (84 Tg) and China (10 Tg). CCA is an agricultural deposit product derived from maize, the highly significant grain crop in Sub-Saharan Africa. The Food and Agriculture Organization estimated that 589 million tons of maize was prepared worldwide. The US was the crest maize maker, secretarial for 43% of global output. Africa accounted for 7% of global maize production. With 4.62 million tons, Nigeria was Africa's second-highest producer of maize. South Africa has the biggest output (8.04 million tons). Corncob is typically discarded as rubbish in disadvantaged nations. Therefore, it stops sewers, drains and pollutes the atmosphere via combustion, generating substantial socioeconomic and health losses.

Maize cob ash is a secondary cementitious material (SCM) that has recently gained a lot of attention as it has exhibited pozzolanic capabilities in a number of tests on the purpose of CCA as a partial substitution in concrete instead of OPC. A study indicated that the leaching technique greatly increased the physical and chemical features of maize straw ash, resulting in reduce in the amount of portlandite. The study also revealed that chemical compounds (CaO and MgO) on fly ash surfaces may permit the pH of the fly ash and leaching. The chemical components (CaO and MgO) on fly ash surfaces may affect the pH of the fly ash and leaching. Stabilization improves soil strength while dropping plasticity and declining or sometimes expanding permeability, leading to top soil strength, reduced volume changes due to moisture variations, and greater soil workability.

Clay soil can be categorized as having low, medium, high, or very high expansion potential based on the Index, characteristics limit value, and gradation test. In general, soils classified as CH by USCS A-7-5 and A-7-5 may be referred to as expansive soils in accordance with AASHTO classification standards. The pozzolanic movement or cationic substitution of the stabilizer chemically stabilizes clay soil. A chemical component called pozzolanic reacts chemically with calcium hydroxide, which is created when Portland cement hydrates at room temperature, to form compounds with cementitious qualities when they are slightly mixed and there is moisture present.

1. Alumina (Al_2O_3), silica (SiO_2), and ferrite (Fe_2O_3) oxides make up at least 70% of the final weight of pozzolanic materials. Power is increased by adding pozzolanic, which decreases porosity and pore diameter.

2. Pozzolanic reactions are silica reactions that, when calcium hydroxide and water are present, produce calcium silicate hydrates (C-S-H).

3. An excessive dependence on industrially manufactured soil-improving additives, such cement, lime, and others, has kept the cost of building stabilized roadways high.

4. Since most highways are inaccessible to rural residents, who comprise a significant section of the population, the cost of constructing them has skyrocketed in emerging nations.

5. Construction costs will be greatly decreased by the possible utilization of agricultural wastes such corn cob ash (CCA).

Applications

Corn cob ash has several interesting applications (CCA). We'll now look at a few of them:

1. Corn cob ash (CCA), an inorganic or heterogeneous residue of burning corn cobs at high temperatures, is the cementitious material used in concrete. Its hues might vary from brown to grey.

2. Its chemical composition may give it pozzolanic qualities. Studies have been done on CCA as a cement alternative for concrete.

3. While it influences the density, ultrasonic pulse velocity, thermal conductivity, and compressive strength of hardened concrete at room temperature, extended curing times and thermal treatment (calcinations) increase compressive strength because of their increased surface area and silica content. Ingredients for Filler for Asphalt Concrete.

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4. The use of CCA as filler in asphaltic concrete for intensively trafficked roadways can be advantageous.

5. In addition to improving the properties of asphalt concrete, this application aids in the solution of the agricultural waste disposal issue.

6. There is a lot of promise for using corn cob, which can be turned into CCA, in place of fine aggregate in concrete.

7. With nations like the US producing about 50 million tons of maize a year, using corn cob waste as CCA might be beneficial for the environment.

1.5 Objectives

The main objective is to gain a better understanding of CCA and BLA as construction materials.

1. We want to learn about the features of BLA and CCA.

2. Tests are conducted on cement, fine aggregate, and coarse aggregate to study the compressive, flexural, and split tensile strength of concrete.

3. We will prepare concrete cubes, cylinders, and beams using these materials.

4. The aim is to create a cost-efficient and environmentally friendly block material that supports a sustainable society.

5. Therefore, the key focus of this research is to find out how using Corncob ash and banana leaf ash as partial substitutes for cement affects the properties of concrete, such as consistency, setting time, slump for workability, compressive strength, water absorption, and microstructure.

Significance of the Study

1. The fast-growing population in India is leading to a quick rise in the need for buildings, homes, and various types of infrastructure. This, in turn, increases the demand for raw materials and energy sources.

2. The cost of construction is quite high because it involves hiring engineers and laborers, as well as purchasing materials like bricks, cement, steel, timber, plastics, and glass.

3. Moreover, the cost of transporting these materials depends on how far the construction site is from the source. Also, factories that make steel and cement release harmful substances into the environment.

4. It's true that there are other sources of pollution, but it's also true that these issues can be reduced. One effective way is to use corn cobs ash and banana leaf ash as an additive in cement.

1.6 MANUFACTURING PROCESS OF CONVERTING CORN COB INTO ASH:

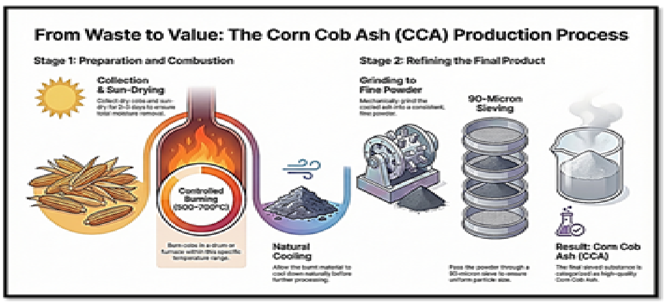


Fig 1: The procedure of manufacturing Ash from CCA

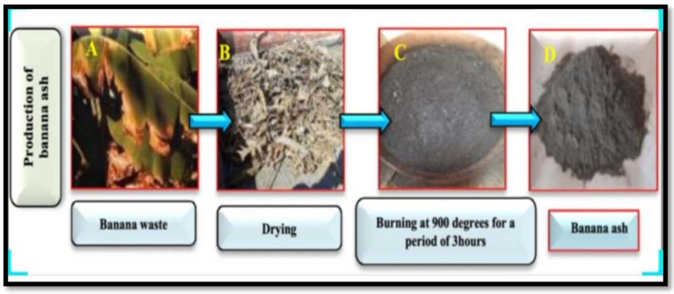


Fig 2: Flowchart of extracting Banana Leaf Ash (BLA)

II. LITERATURE REVIEW

The objective of literature review is to collect published information from numerous study publications. We choose valuable data for research investigations using

- Nusrat Jahan Mim a, Md Montaseer Meraz et.al;[1] Journal of Building Engineering Volume 64, 1 April 2023, 105581. The high cement content and requirement for several additives in self-consolidating concrete (SCC) result in high yields but also significant cement consumption, which restricts its application in building. Thus, it is advisable to think about several approaches to create an efficient SCC while lowering the environmental influence. Thus, the goal of this work is to find the ideal BLA ratio by examining the mechanical, structural, and microbiological characteristics as well as the environmental impacts of self-compacting concrete (SCC) mixed with banana leaf ash (BLA). Investigated were concrete mixtures with 10%, 20%, and 30% OPC substitution. The test findings revealed that every novel combination performed within the parameters advised by EFNARC (2002). Though the mechanical characteristics deteriorated with increasing BLA concentration, BLA strength up to 20% produced strength comparable to that of the control mixture. Furthermore, the permeability of chloride ions rises up to 4%; 20% of BLA replenishment falls into the intermediate permeability zone. Lastly, the low global warming potential (GWP) is indicated by the low CO_2-eq per MPa (up to 29.13% decrease). https://doi.org/10.1016/j.jobe.2022.105581
- Vishal Gadgihalli, MeenaY.R et,al;[2] International Journal of Research –GRANTHAALAYAH ISSN(O) 2350-0530 Vol. 5 No. 11 (2017): Volume 5 Issue 11 - November, 2017 Ingredients other than cement, water, and aggregates that impart special qualities to plastic (fresh) or hardened (ASTMC 496) concrete mixes are termed concrete admixtures. In this work, we analyze the behavior of concrete utilizing banana peel as an additive and discover the strength and release qualities of concrete due to its chemical interaction with regular Portland cement. Banana peels are abundant in fiber and a popular source of potassium. By utilizing banana peel powder as an additive, the compressive strength of concrete rose, but the compressive strength increased dramatically. Reduced transition

temperature ratio and temperature decline time. Therefore, it is obvious that the exterior reactivity of concrete was minimized by utilizing dry banana peel powder as an additive.

https://doi.org/10.29121/granthaalayah.v5.i11.2017.2367

- Asha Oak, Abhishek Namdev Dalve [3] Cement is the most commonly used construction material in the world, second only to water in terms of consumption. As the population grows, the need for cement has increased to support development. However, producing cement requires a lot of energy, which leads to about 7-10% of global emissions and has harmful effects on the environment. It's also costly. This study looked at using Corn Cob Ash (CCA) as a substitute for some of the cement. CCA was used in mixes that replaced cement in ratios of 0%, 10%, 15%, and 20%. The results were compared with regular concrete made entirely from cement. The study found that CCA can be a good alternative to cement in making concrete and for building walls and other light construction projects. Tests like the Impact Test, Crushing Test, and Shape Test were done on the aggregates and they all showed good results.
- Shiva Kant, Janvijay Singh et.al;[4] International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 09 Issue: 10 | Oct 2022. Conclusion of this study: - The swelling resistance, contraction, and separation of the concrete are altered by replacing a portion of the cement. Concrete loses compressive strength when the percentage of banana leaf ash is increased. Concrete may become stronger and its expenses can be lowered by combining the replacement portion mentioned above. Thus, the material will be stronger and more reasonably priced when the two components are combined. A banana leaf ash pozzolanic material is produced by the combination of finer particles with larger surface area per particle with pozzolanic chemicals mandated by standards. The strength characteristics of concrete somewhat drop when the amount of banana leaf ash is increased above ordinary concrete. Apart from that, its strength rises with age because to pozzolanic processes. Therefore, the use of banana leaf in concrete helps to turn it from an environmental issue into a practical component for the creation of very successful substitute concrete materials. The stronger and more resilient concrete is produced when banana leaf ash is used in place of cement.

III. METHODOLOGY

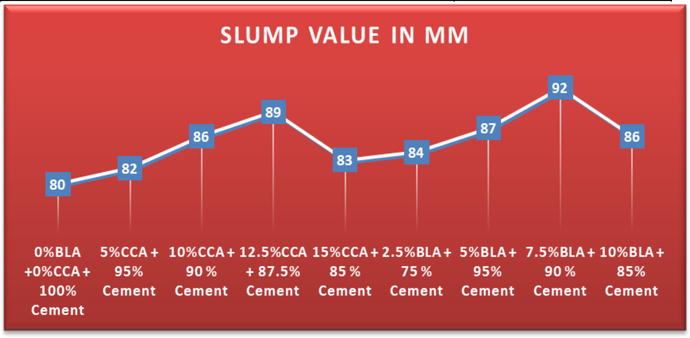
The physical properties of ingredients are assessed as per relevant Indian standards.

- M25 grade concrete mix is designed as per Is 10262:2019 by considering the properties of ingredients.
- Concrete mix design is prepared by replacing at the intervals of 0%, 2.5%, 5%, 7.5%, and 10% and 0%, 5%, 10%, 12.5%, and 15% of cement by partially replacing the Banana leaf ash & Corn cob ash.
- Workability of all the mixes is assessed by conducting slump test
- Compressive strength, split tensile strength & flexural strength of concrete mixes are assessed at 7, 14 & 28 days and also done durability tests.

IV. RESULTS

Table no 1 Slump Cone values

Mix % Replacement	Slump value in mm
0%BLA +0%CCA + 100% Cement	80
5%CCA + 95% Cement	82
10%CCA + 90 % Cement	86
12.5%CCA + 87.5% Cement	89
15%CCA + 85 % Cement	83
2.5%BLA + 75 % Cement	84
5%BLA + 95% Cement	87
7.5%BLA + 90 % Cement	92
10%BLA + 85% Cement	86



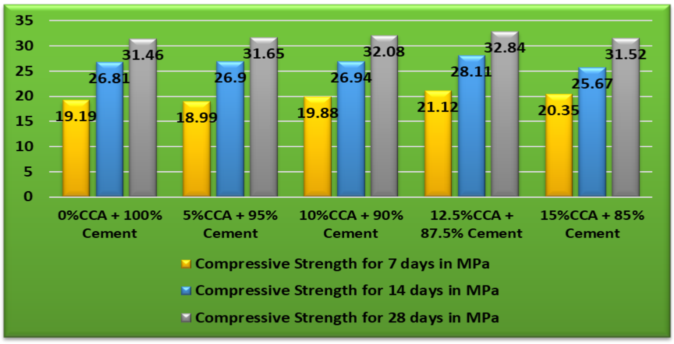
Graph no 1 Slump Cone values

Table no 2: Mix proportion of M25

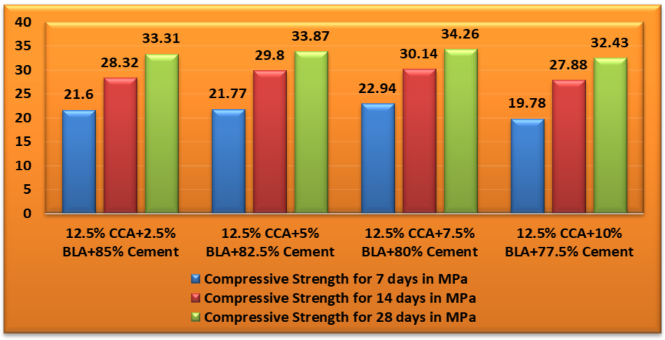
Grade	M25
Proportion	1: 2.3: 4.0
W/C ratio	0.48
Cement	309 Kg/m^3
Fine Aggregate	733 Kg/m^3
Coarse Aggregate	1254 Kg/m^3
Water	148.37 Kg/m^3
Chemical admixture	3.09 Kg/m^3

Table no 3 Test results of Compressive Strength at 7 days, 14 days & 28 days:

Mix % Replacement	Compressive Strength for 7 days in MPa	Compressive Strength for 14 days in MPa	Compressive Strength for 28 days in MPa
0%CCA + 100% Cement	19.19	26.81	31.46
5%CCA + 95% Cement	18.99	26.90	31.65
10%CCA + 90% Cement	19.88	26.94	32.08
12.5%CCA + 87.5% Cement	21.12	28.11	32.84
15%CCA + 85% Cement	20.35	25.67	31.52
12.5% CCA+2.5% BLA+85% Cement	21.60	28.32	33.31
12.5% CCA+5% BLA+82.5% Cement	21.77	29.80	33.87
12.5% CCA+7.5% BLA+80% Cement	22.94	30.14	34.26
12.5% CCA+10% BLA+77.5% Cement	19.78	27.88	32.43



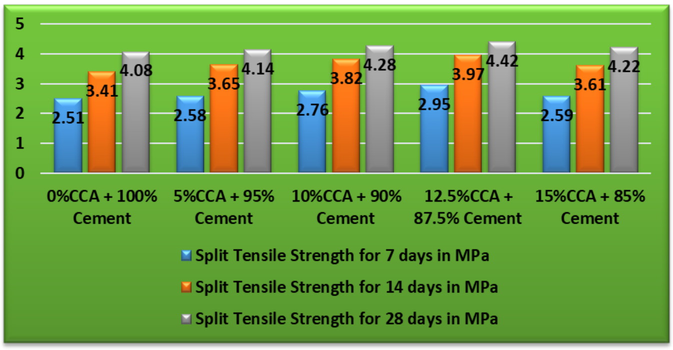
Graph No 2 Development of Compressive strength after curing 7, 14& 28 days for M25



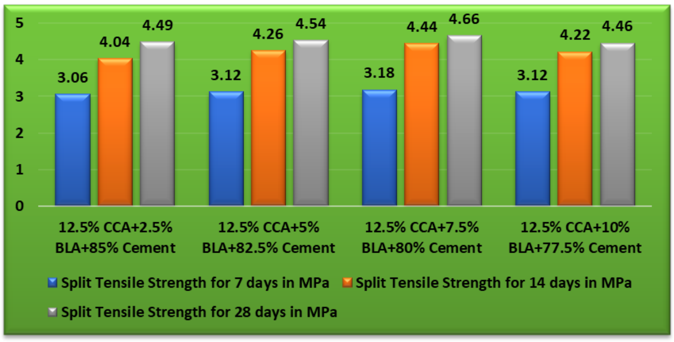
Graph No 3 Relation between optimum Corn cob ash (12.5%) +% Banana leaf ash replacement and Compressive strength

Table no 4 Test results of Split Tensile Strength at 7 days, 14 days & 28 days:

Mix % Replacement	Split Tensile Strength for 7 days in MPa	Split Tensile Strength for 14 days in MPa	Split Tensile Strength for 28 days in MPa
0%CCA + 100% Cement	2.51	3.41	4.08
5%CCA + 95% Cement	2.58	3.65	4.14
10%CCA + 90% Cement	2.76	3.82	4.28
12.5%CCA + 87.5% Cement	2.95	3.97	4.42
15%CCA + 85% Cement	2.59	3.61	4.22
12.5% CCA+2.5% BLA+85% Cement	3.06	4.04	4.49
12.5% CCA+5% BLA+82.5% Cement	3.12	4.26	4.54
12.5% CCA+7.5% BLA+80% Cement	3.18	4.44	4.66
12.5% CCA+10% BLA+77.5% Cement	3.12	4.22	4.46



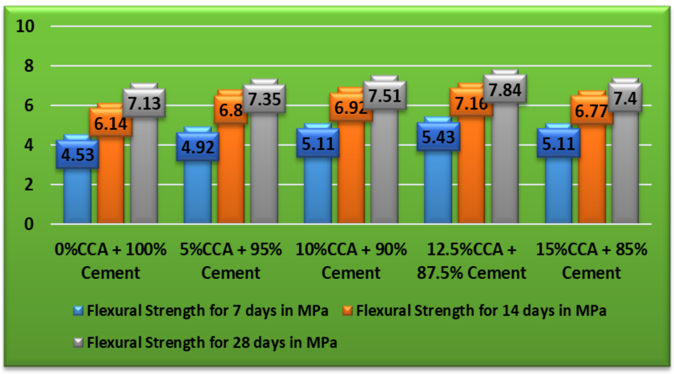
Graph No 4 Development of Split Tensile strength after curing 7, 14 & 28 days for M25



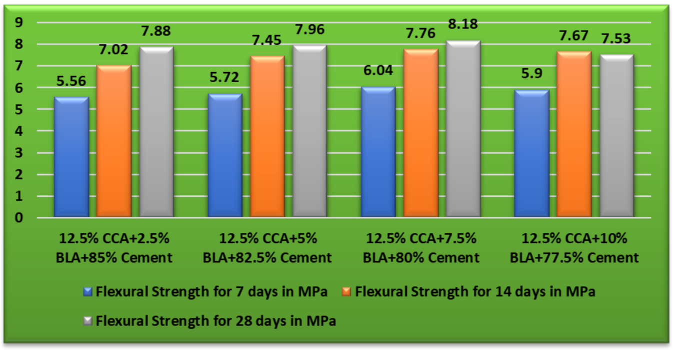
Graph No 5 Relation between optimum Corn cob ash (12.5%) +% Banana leaf ash replacement and Split Tensile strength

Table no 5 Test results of Flexural Strength at 7 days, 14 days & 28 days:

Mix % Replacement	Flexural Strength for 7 days in MPa	Flexural Strength for 14 days in MPa	Flexural Strength for 28 days in MPa
0%CCA + 100% Cement	4.53	6.14	7.13
5%CCA + 95% Cement	4.92	6.80	7.35
10%CCA + 90% Cement	5.11	6.92	7.51
12.5%CCA + 87.5% Cement	5.43	7.16	7.84
15%CCA + 85% Cement	5.11	6.77	7.40
12.5% CCA+2.5% BLA+85% Cement	5.56	7.02	7.88
12.5% CCA+5% BLA+82.5% Cement	5.72	7.45	7.96
12.5% CCA+7.5% BLA+80% Cement	6.04	7.76	8.18
12.5% CCA+10% BLA+77.5% Cement	5.90	7.67	7.53



Graph No 6 Development of Flexural strength after curing 7, 14 & 28 days for M25



Graph No 7 Relation between optimum Corn cob ash (12.5%) +% Banana leaf ash replacement and Flexural strength

V. CONCLUSION

Based on the above research, the following analysis was carried out on artificial concrete in which cement was partially replaced with Corncob Ash and the mineral additive Banana Leaf Ash.

- ✓ It was found that the maximum strength in the total percentage of cement modified with Corncob Ash occurred at 12.5% CCA.
- ✓ Compared to other mixtures, the highest concrete properties were obtained with concrete mixtures containing 12.5% CCA and 7.5% BLA.
- ✓ According to the test results, it was determined that the strength of the concrete combined with Corncob Ash and Banana Leaf Ash increased better than the Corncob Ash concrete mixture.
- ✓ It is seen that the use of 12.5% CCA increases the compressive strength by 4.38%, splitting tensile strength by 8.33% and bending strength by 9.95% compared to conventional concrete.
- ✓ Compared to normal concrete, it is seen that the use of 12.5% CCA and 7.5% BLA increase the compressive strength by 8.90 %, splitting tensile strength by 14.21 % and bending strength by 14.72 %.
- ✓ I Suggest that BLA can be replaced by up to 7.5% and CCA up to 12.5%.

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