



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 15, Issue 3, March 2026

Laboratory Evaluation of Concrete Prepared with Bamboo Char Aggregates and Mango Seed Ash Cementitious Matter

Shaik Alifisha¹, Ediga Sisindri²

P.G. Scholar, Department of Civil Engineering, Dr. K. V. Subba Reddy Institute of Technology, Kurnool, AP, India¹

Assistant Professor, Department of Civil Engineering, Dr. K. V. Subba Reddy Institute of Technology, Kurnool, AP, India²

ABSTRACT: The increasing demand for sustainable and environmentally friendly construction materials has sparked interest in utilizing renewable and agricultural by-products within concrete technology. This research looks into the mechanical properties and strength of concrete that uses charred bamboo aggregates as a partial substitute for coarse aggregate and mango seed ash (MSA) as a partial substitute for cement by using M40 grade of concrete.

Charred bamboo aggregates, created by carefully carbonizing bamboo at moderate temperatures, serve as a lightweight and stable alternative aggregate that has lower water absorption and improved resistance to biological decay. Mango seed ash, derived from the high-temperature calcinations of dried mango seed shells, is abundant in silica and shows some pozzolanic activity, allowing it to enhance the cement matrix. Various experimental mixes were developed with different levels of bamboo aggregate replacement (0%, 10%, 20%, 30%, and 40%) and MSA (0%, 5%, 10%, 15% and 20% based on cement weight) by using M40 grade of concrete. Assessments for workability, compressive strength, split tensile strength and water absorption were carried out at different curing periods.

Initial findings suggest that moderate amounts of these replacements achieve satisfactory mechanical strength while notably decreasing the use of natural aggregates and cement. This research showcases that combining charred bamboo aggregates and mango seed ash could lead to the creation of lightweight, sustainable, and eco-friendly concrete composites ideal for both non-structural and semi-structural uses.

KEYWORDS: Charred bamboo aggregates, Mango seed ash, Sustainability, pozzolanic activity.

I. INTRODUCTION

Because of its versatility, longevity, and capacity to be formed into a variety of structural shapes, concrete continues to be one of the most crucial materials used in modern construction. Concrete has become the backbone of global development as a result of its widespread use in infrastructure systems, pavements, bridges, and buildings. Cement, natural aggregates, and water are traditionally used to create concrete, but the widespread usage of these ingredients has caused major environmental issues. The constant extraction of natural aggregates results in resource depletion and ecological imbalance, while the manufacture of cement alone accounts for a significant portion of worldwide carbon dioxide emissions.

Terminologies

Bamboo Char Aggregates

Bamboo char aggregates are lightweight, porous aggregates made by carbonizing bamboo biomass in an environment with little to no oxygen. Bamboo is a viable replacement for traditional mineral aggregates used in building and environmental applications since it is a readily accessible and quickly renewable natural resource. Pyrolysis transforms bamboo into charcoal with a low density, a large specific surface area, and a highly porous internal structure, making it ideal for a variety of applications.

Because of these qualities, bamboo char aggregates are becoming more popular in soil improvement, water treatment systems, and lightweight concrete, and cementitious composites. They can lower self-weight, improve thermal insulation, and aid internal curing by storing and slowly releasing moisture in building materials. Their high carbon content may also have positive effects, such as better durability, carbon capture, and the absorption of hazardous chemicals.

Mango Seed Ash

A material made from agricultural waste, mango seed ash (MSA) is produced by carefully burning mango seeds, a byproduct of the mango processing and food industry. The disposal of mango seeds, which are produced in large quantities every year, notably in tropical and subtropical areas, poses environmental and economic problems

The high concentration of siliceous and aluminous components in mango seed ash allows it to display pozzolanic properties when finely processed. Because of this, there has been research focus on using MSA as a partial substitute for cement in cementitious systems. Its usage can make concrete more sustainable by lowering carbon dioxide emissions from cement manufacturing and reducing cement use.

When utilized in the right ratios, mango seed ash can improve some qualities of concrete, such as its microstructure, permeability, and long-term durability, in addition to its environmental advantages.



Objectives

- ✚ To get better understanding of the bamboo char aggregates and mango seed ash as a construction material.
- ✚ To know the properties of bamboo char aggregates and mango seed ash.
- ✚ Study of compressive strength, flexural strength, split tensile strength of concrete by conducting different tests on cement, fine aggregate, coarse aggregate.
- ✚ To prepare the cubes, cylinders, beams of concrete by bamboo char aggregates and mango seed ash.

II. LITERATURE SURVEY

Performance Optimization and Carbon Reduction Potential of Bamboo Biochar for Lightweight Artificial Aggregates

To realize the efficient utilization of biochar and construction solid waste in building materials production, a novel core-shell aggregate concept is proposed, in which artificial aggregates are prepared by encapsulating coarse-particle bamboo biochar (C-BB) with concrete slurry waste (CSW), calcium carbide slag (CCS), and fine-particle bamboo biochar (F-BB).

The results showed that the best engineering properties of the artificial aggregates were achieved when the F-BB content was about 6%, with crushing strength, water absorption, and bulk density values of 4.7 MPa, 14.3%, and 796 kg/m³, respectively. In addition, the artificial aggregates have promising potential for CO₂ uptake under a CO₂ curing system and can achieve 5.72% (by mass) uptake when the F-BB content is 6%. This performance is attributed to the formation of well-developed CO₂ transport channels in the shell matrix by the F-BB particles. In summary, the novel core-shell aggregate not only has better engineering properties than commercial lightweight aggregates but also offers significant potential for CO₂ sequestration, opening new opportunities for the efficient application of biochar in construction materials with both engineering and environmental benefits.

Evaluating the Strength Property of Concrete by Partially Replacing Cement with Mango Seed Ash

This study aims to investigate the compressive strength of concrete produced with partial replacement of cement with mango seed ash (MSA). The oxide composition analysis of MSA indicates that the Ash is pozzolanic in nature and contains about fifty-eight (58.26%) percent of SiCO₂. Consistency, setting times, compressive, Slump, Compacting Factor test were carried out on both the fresh and hard concrete. Mix ratio 1:2:4 was used in preparing each of the samples from which nine concrete cubes were cast at each replacement levels of; 0%, 5%, 10%, 15%, 20%, 25%, and 30%. Compressive strength test performed on the cubes at 7days, 14days, and 28days curing periods showed that the strength of the test cubes decreases with an increase in MSA content. The 28days compressive strength of cement-MSA concrete cubes was observed to have attained its highest compressive strength of 23.70N/mm² at 5% replacement level.

III. METHODOLOGY

Cement

The cement used in this investigation was Ordinary Portland Cement (OPC) Grade 43 conforming to Bureau of Indian Standards specifications under IS 8112. The specific gravity of cement was found to be 3.12. ACC Cement was used for the preparation of concrete mixes in this project. The cement was fresh, free from lumps, and stored in dry conditions to prevent moisture contamination.

All preliminary tests such as fineness test, standard consistency test, initial and final setting time tests, and specific gravity test were conducted in Dr. KVSr Civil Engineering Laboratory as per relevant IS codes. The test results confirmed that the cement satisfied the required standards and was suitable for construction purposes

Fine Aggregate

Fine aggregate utilized in this study was composed of clean, well-sorted natural river sand. This sand did not contain any organic matter, silt, clay, or other harmful substances.

The fine aggregate met the criteria set by the Bureau of Indian Standards as specified in IS 383. According to IS guidelines, this sand fell into Zone II grading.

Coarse Aggregate

Use 20 mm crushed stone with a specific gravity of 2.45 & a density of 1389 kg/m³ as coarse aggregate. Smaller sized aggregates make higher concrete strength. Regularly an aggregate with specific gravity more than 2.55 and absorption less than 1.5% (except for light weight aggregates) can be regarded as being of excellent quality. Where aggregates strength is higher, concrete strength is also higher.

Bamboo Char Aggregates

Bamboo char aggregates were utilized as a partial substitute in this study. The bamboo char was created through a regulated burning process (carbonization) of dried bamboo in an environment with limited oxygen. After carbonization, the charred material was ground and sifted to achieve the desired aggregate size.

Initial assessments including specific gravity tests, water absorption tests, and sieve analyses were performed at the Dr. KVSr Civil Engineering Laboratory according to relevant IS guidelines.

S.No.	state	Bamboo area	uses
1	Madhya Pradesh	18,394	Furniture, paper industry
2	Andhra Pradesh	6,104	Rural construction, furniture
3	Telangana	4,555	Rural crafts
4	Karnataka	8,624	Mats, crafts, furniture

Mango seed ash:

In this study, Mango Seed Ash (MSA) served as an additional cementitious substance. Prior to being burned in a regulated environment to produce ash, the mango seeds were carefully gathered, cleaned, and dried. After that, the ash was ground and sieved through a 90-micron sieve to get the necessary fineness. To increase sustainability and lower cement usage, it was employed as a partial cement replacement in concrete mixtures. Dr. KVSr Civil Engineering

Laboratory carried out preliminary tests in accordance with the appropriate protocols, including fineness tests, chemical composition analysis, and specific gravity.

Methodology

1. Preparation of materials

The rice husks and coconut shells were subjected to sun drying to remove moisture. Then, it was subjected to uncontrolled combustion through an open-air burning and allowed to cool. Then, the materials were sent to the hollow block-making station

2. Sample Preparation

Samples will be prepared for each mix by mixing the materials in the concrete mixer according to the mix design. The samples will be cast in cube molds, cylinders, beams of standard dimensions and cured in water for 7, 14, 28 days.

Preparation of Materials - Cement, Fine aggregate, coarse aggregate and replacement materials

Proportionate Mixing- Cement was partially substituted with MSA (for example, 5%, 10%, and 15% by weight). In some cases, BCA was employed as a partial substitute for large aggregate (for example, 5%, 10%, and 15% by weight). The mix design was made in accordance with IS 10262 rules, taking into consideration the necessary grade of concrete.

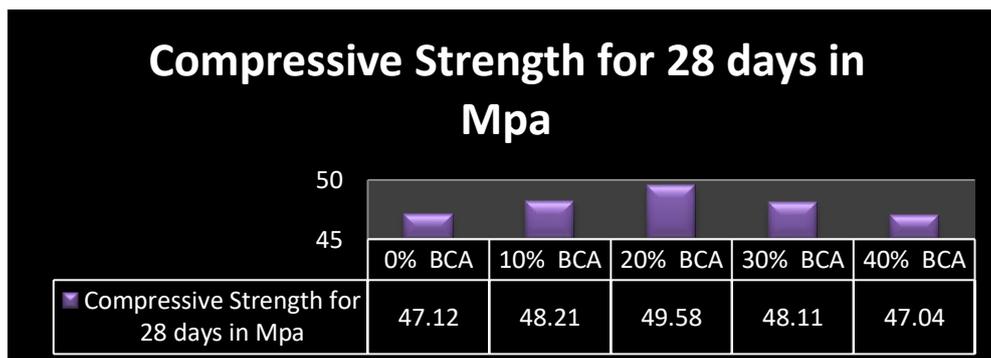
Combination Method- The necessary amounts of cement and Mango Seed Ash were measured and thoroughly dry-blended. Dry fine aggregate and coarse aggregate (including BCA) were added and thoroughly mixed. To keep the intended water-cement ratio, the water was added gradually during the mixing process. The mixing process was maintained until the concrete mixture was consistent and usable.

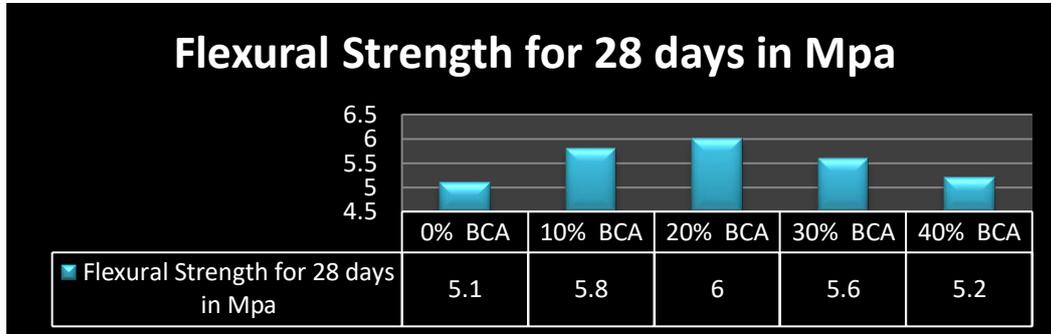
Specimens Casting- Standard cube molds measuring 150 mm by 150 mm by 150 mm were used to pour the concrete. To eliminate air gaps, concrete was compacted using a vibrating table or tamping rod. The upper surface was leveled and had a smooth finish.

Treatment- The samples were removed from the mold after 24 hours. The cubes were cured by soaking them in pure water for 7, 14, and 28 days.

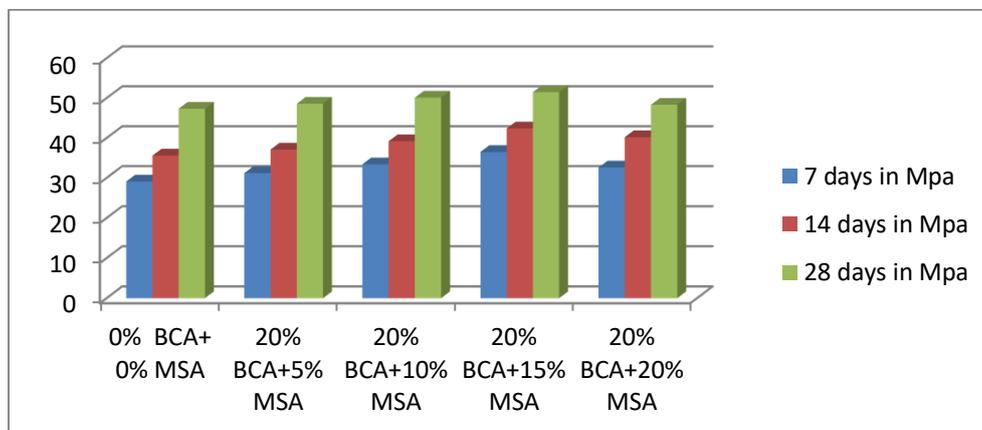
IV. EXPERIMENTAL RESULTS

Mix Replacement %	Compressive Strength for 28 days in Mpa	Flexural Strength for 28 days in Mpa	Split Tensile Strength for 28 days in Mpa
0% BCA	47.12	5.1	4.1
10% BCA	48.21	5.8	4.5
20% BCA	49.58	6	4.9
30% BCA	48.11	5.6	4.7
40% BCA	47.04	5.2	4.4

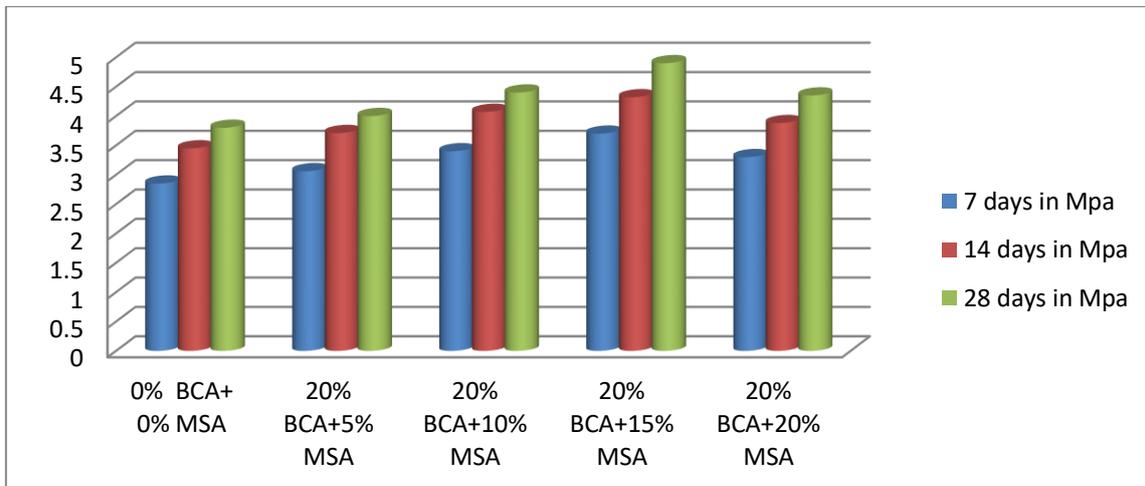




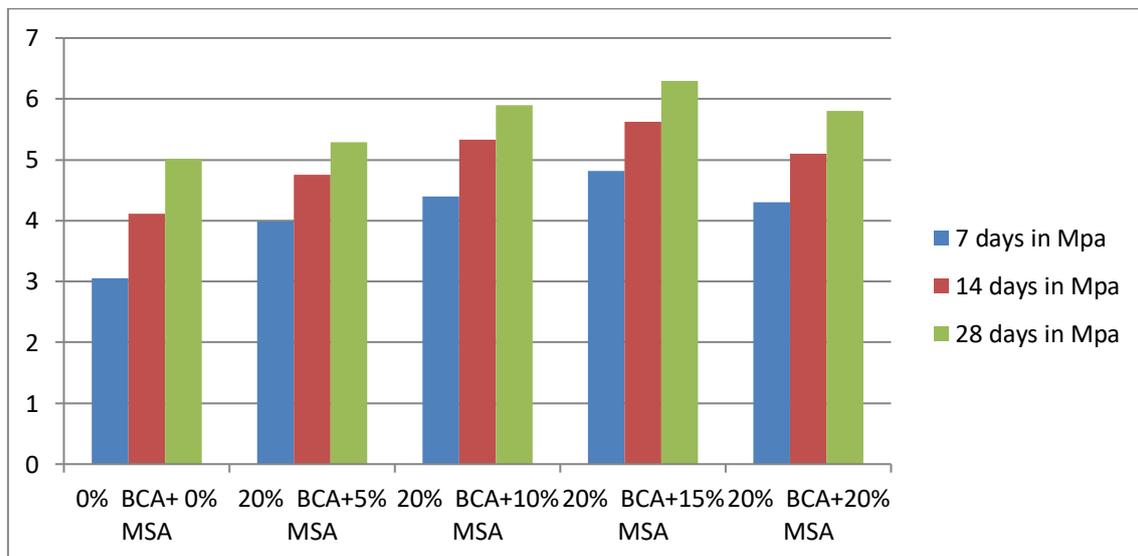
Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0% BCA+ 0% MSA	29.1	35.6	47.34
20% BCA+5% MSA	31.2	37.1	48.6
20% BCA+10% MSA	33.4	39.2	50.12
20% BCA+15% MSA	36.5	42.4	51.5
20% BCA+20% MSA	32.6	40.2	48.33



Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0% BCA+ 0% MSA	2.85	3.45	3.8
20% BCA+5% MSA	3.06	3.71	4
20% BCA+10% MSA	3.4	4.07	4.4
20% BCA+15% MSA	3.7	4.32	4.9
20% BCA+20% MSA	3.3	3.88	4.35



Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0% BCA+ 0% MSA	3.05	4.11	5.02
20% BCA+5% MSA	3.99	4.75	5.29
20% BCA+10% MSA	4.4	5.33	5.9
20% BCA+15% MSA	4.82	5.62	6.3
20% BCA+20% MSA	4.3	5.1	5.8



V. CONCLUSION

According to the experimental study, the ideal mix ratio was obtained by replacing 20% of the BCA with 15% of the MSA. The material at this level demonstrated better mechanical and durability qualities than the other combinations that were tested. According to the findings, this ratio strikes the perfect mix between increased strength, structural integrity, and effective use of resources.

Better particle packing, better interfacial binding, and improved pozzolanic or filler effects may all contribute to the increase in performance at 20% BCA and 15% MSA with 51.5 Mpa of compressive strength, which results in greater compressive strength and general longevity. Same increases in other strengths like split tensile and flexural are greater compared to conventional concrete. Above this proportion, a decrease in strength and performance was noticed, suggesting that over-replacement has a negative impact on the matrix integrity.

By partially substituting traditional materials, this ideal combination improves strength qualities, lowers environmental effect, and encourages efficient waste use, all of which support sustainable building techniques.

Applications

- ✚ A mix proportion of 20% BCA and 15% MSA may be utilized efficiently.
- ✚ Construction of buildings for residential and commercial use paver units and pavement blocks.
- ✚ Concrete components those are semi-structural or non-structural.
- ✚ Structural elements those are low-rise.
- ✚ Projects for construction those are sustainable and ecologically beneficial.

As a result, the 20% BCA + 15% MSA combination is recommended as the ideal replacement level for achieving improved performance while preserving environmental sustainability and structural safety.

REFERENCES

- [1] **Paul, Effects of Bamboo Leaf Ash on Concrete Compressive Strength, Water Absorption and Chloride Penetration**
Journal: Journal of Building Engineering (2024)
Summary: Shows that replacing 15% cement with bamboo leaf ash increased 28-day compressive strength by about 18% and improved durability.
Link:<https://www.sciencedirect.com/science/article/pii/S2352710224025543>
- [2] **Mechanical and Durability Properties of Sustainable Bamboo Leaf Ash in High-Performance Concrete**
Journal: Cleaner Engineering and Technology (2022)
Summary: Studies workability, compressive strength, tensile strength, and water absorption of concrete with 0–15% bamboo ash replacement.
Link:<https://www.sciencedirect.com/science/article/pii/S2666790822001884>
- [3] **Evaluating the Strength Property of Concrete by Partially Replacing Cement with Mango Seed Ash**
Journal: Scientific Journal of Mehmet Akif Ersoy University (2021)
Summary: Mango seed ash contains ~58% silica, indicating pozzolanic behavior; optimum compressive strength was observed at 5% replacement level.
Link:<https://dergipark.org.tr/en/pub/sjmakeu/issue/64747/888531>.
- [4] **Evaluating the Strength Property of Concrete by Partially Replacing Cement with Mango Seed Ash**
Alternate open-access source:<https://openaccess.izmirakademi.org/paper/1927/64747/888531>
- [5] **Mango Seed Derived Hydrochar as Sustainable Additive in Cementitious Materials**
Journal: Materials Letters (2026)
Summary: Hydrochar derived from mango seed improves mortar strength and supports sustainable construction.
Link:<https://www.sciencedirect.com/science/article/abs/pii/S0167577X25015137>



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details