

Experimental Investigation on Bio-Enzyme Admixture in Concrete

Sathyakumar N¹, Naveeka Shri K², Pavithra S², Dharini B²

¹Assistant professor, Department of Civil Engineering,

²Students, Department of Civil Engineering,

Sri Shakthi Institute of Engineering and Technology, Coimbatore

Abstract: Concrete properties are significantly influenced by the type of admixtures used, environmental conditions, and material composition. In recent years, the need for sustainable and eco-friendly construction materials has increased due to environmental concerns associated with chemical admixtures. Bio-enzyme derived from natural sources such as banana stem has emerged as a promising alternative. This study focuses on the preparation and application of **banana stem bio-enzyme** as an admixture in concrete. Concrete mixes were prepared with varying percentages of bio-enzyme (0%, 5%, 10%, and 15%) and tested for compressive strength and water absorption. The results indicate that bio-enzyme improves workability, reduces water absorption, and enhances durability. The optimum performance was observed at 10% replacement. This study highlights the potential of bio-enzyme as a sustainable solution for modern construction practices..

Keywords: Bio-enzyme concrete, Banana stem, Sustainable construction, Eco-friendly admixture, Strength, Durability.

I. INTRODUCTION

This invention relates to a comprehensive experimental investigation on the use of banana stem bio-enzyme as a natural admixture in concrete for sustainable construction. The research establishes a systematic methodology for evaluating conventional concrete and bio-enzyme concrete based on engineering, physical, and mechanical properties. The comparative analysis includes parameters such as workability, compressive strength, water absorption, durability, and moisture behavior. These properties are evaluated using standard testing methods such as slump test, compressive strength test using CTM, and water absorption test. The results demonstrate that bio-enzyme concrete improves workability, reduces water requirement, and enhances durability by decreasing permeability. At optimum dosage, it also increases compressive strength due to improved hydration and bonding. Therefore, banana stem bio-enzyme can be effectively used as an eco-friendly alternative to chemical admixtures in concrete, promoting sustainable and green construction practices.

II. OBJECTIVE

The study aims to prepare concrete using banana stem bio-enzyme as a natural admixture and analyze its engineering properties through laboratory tests. The investigation includes evaluating workability using slump test, measuring compressive strength using Compression Testing Machine (CTM), and determining water absorption to assess durability. The bio-enzyme is extracted through a controlled fermentation process and added to concrete in different percentages (0%, 5%, 10%, and 15%). Based on these test results, the performance of bio-enzyme concrete is compared with conventional concrete to determine the optimum dosage and its suitability for sustainable construction applications.



III. METHODOLOGY

Collection of Materials: To collect cement, fine aggregate, coarse aggregate, banana stem, and water required for concrete preparation.

Preparation of Bio-Enzyme: Banana stem is cut into small pieces and fermented under controlled conditions to extract bio-enzyme solution.

Mix Proportioning: Concrete mix is prepared using nominal mix ratio (1:1.5:3) with different percentages of bio-enzyme (0%, 5%, 10%, 15%).

Casting of Specimens: Concrete is poured into cube moulds, compacted properly, and allowed to set.

Curing: Specimens are cured in water for 7 and 14 days.

Testing: Tests such as compressive strength and water absorption are conducted.

Tabulation of Results: Results are recorded and arranged for clear understanding.

Comparison: Performance of bio-enzyme concrete is compared with conventional concrete..

Conclusion: To determine the optimum percentage of bio-enzyme and evaluate its effectiveness.

IV. LITERATURE REVIEW

Study on Bio-Based Admixtures in Concrete

Author: Kidist Bedada et al.

Year: 2023

What they did: Reviewed bio-based admixtures derived from natural sources.

How: Literature review and experimental comparisons on concrete properties.

Result: Bio-admixtures improved workability, hydration, and durability while reducing environmental impact.

Interaction of Admixtures with Cement Hydration

Author: J. Plank et al.

Year: 2015

What they did: Studied the effect of admixtures on cement hydration process.

How: Laboratory analysis of hydration mechanisms and microstructure.

Result: Admixtures significantly influence strength development and concrete performance.

Eco-Friendly Natural Admixtures in Concrete

Author: A. Sharma et al.

Year: 2021

What they did: Investigated natural admixtures as alternatives to chemicals.

How: Experimental study on concrete mixes with natural additives.

Result: Improved workability and reduced water demand in concrete.

Use of Agricultural Waste in Concrete

Author: R. Siddique

Year: 2012

What they did: Studied incorporation of agricultural waste in concrete.

How: Experimental evaluation of cement-based materials.

Result: Improved sustainability and reduced environmental pollution.

Agricultural Waste as Construction Material

Author: E. Aprianti

Year: 2017



What they did: Reviewed agricultural waste usage in concrete.
How: Comparative analysis of research studies.
Result: Increased strength, reduced permeability, and lower CO₂ emissions.

Durability of Concrete with Admixtures

Author: G. De Schutter et al.

Year: 2004

What they did: Studied durability performance of admixture-based concrete.
How: Laboratory durability tests under environmental conditions.
Result: Improved resistance to moisture, chloride, and environmental damage.

Shrinkage-Reducing Admixtures in Concrete

Author: S. Güneysi et al.

Year: 2014

What they did: Investigated shrinkage behavior in concrete.
How: Experimental testing of shrinkage-reducing admixtures.
Result: Reduced cracking and improved dimensional stability.

Combined Use of Admixtures in Concrete

Author: S. A. Civjan et al.

Year: 2005

What they did: Studied multiple admixtures in structural concrete.
How: Laboratory experiments using combined admixtures.
Result: Enhanced strength, workability, and durability.

Natural Admixtures in Sustainable Concrete

Author: Twana Othman et al.

Year: 2025

What they did: Reviewed plant-based admixtures in concrete.
How: Systematic literature review.
Result: Improved compressive strength, durability, and sustainability.

Bio-Based Materials in Concrete Systems

Author: Luo et al.

Year: 2017

What they did: Studied biological materials in concrete systems.
How: Experimental analysis using bio-agents.
Result: Improved crack resistance and long-term performance of concrete.

V. SAMPLE COLLECTION AND PREPARATION

This project involves the preparation and testing of concrete using banana stem bio-enzyme as a natural admixture. Proper material selection and preparation ensure that the results are accurate, reliable, and representative of actual performance in concrete.



BANANA STEM BIO-ENZYME (RAW MATERIAL)

Definition:

Banana stem bio-enzyme is a natural liquid obtained by fermenting banana stem waste. It contains organic compounds and enzymes that help improve concrete properties such as workability, durability, and water resistance.

Formation:

It is produced through a controlled fermentation process of chopped banana stem mixed with water and natural sugars. Over a period of days, microbial activity breaks down organic matter and releases bio-enzymes.

Sources (India):

Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Maharashtra, West Bengal, and other banana-cultivating regions.

Chemical Composition:

Rich in organic acids

Natural enzymes (fermentation-based)

Carbon compounds

Moisture content

Minor nutrients and minerals

Engineering Significance:

Improves workability of concrete

Reduces water requirement

Enhances hydration process of cement

Increases durability and resistance to permeability

Acts as eco-friendly alternative to chemical admixtures

VI. BIO-ENZYME PREPARATION (IMPORTANT SECTION)

Materials Required:

Fresh banana stem pieces

Jaggery / Sugar

Clean water

Airtight plastic container

Preparation Process:

Cut banana stem into small pieces.

Add jaggery (natural sugar source) to the container.

Add water in the ratio **1 : 3 : 10** (Jaggery : Banana stem : Water).

Mix the contents thoroughly.

Close the container tightly and keep it in a warm place.

Open the lid daily for the first few days to release gas formed during fermentation.

Allow fermentation for **20–30 days**.

Filter the liquid to obtain clear bio-enzyme solution.

Properties of Prepared Bio-Enzyme:

Colour: Light brown

Odour: Mild fermented smell

pH: Slightly acidic (around 4.5 – 5.5)

Nature: Biodegradable and non-toxic

Purpose of Bio-Enzyme in Concrete:

Acts as natural admixture

Improves bonding between particles

Enhances cement hydration



Reduces permeability
Promotes sustainable construction

CEMENT, SAND & COARSE AGGREGATE (MATERIALS)

Cement:

Acts as the main binding material in concrete. It provides strength and stability through hydration.

Fine Aggregate (Sand):

Fills voids between coarse aggregates and improves workability and compaction.

Coarse Aggregate:

Provides strength, load-bearing capacity, and structural stability to concrete.

A. MATERIAL SELECTION

Selection of Materials:

Ordinary Portland Cement (OPC 53 grade)

M-Sand or River Sand

20 mm Coarse Aggregate

Banana stem bio-enzyme solution

Clean potable water

B. SAMPLE PREPARATION PROCEDURE

1. Materials Needed:

Cement, fine aggregate, coarse aggregate

Banana stem bio-enzyme solution

Water

Concrete mixer or hand mixing tools

Cube moulds (150 × 150 × 150 mm)

Tamping rod or vibrator

Labels for identification

2. Mix Preparation:

Prepare concrete mix using ratio 1:1.5:3

Add bio-enzyme in different proportions (0%, 5%, 10%, 15%)

Mix thoroughly to ensure uniform distribution

3. Casting Procedure:

Fill concrete into cube moulds

Compact properly to remove air voids

Level the surface

Label each specimen according to mix percentage

4. Curing Process:

Keep specimens in water curing tank

Cure for 7 and 14 days

Maintain proper temperature and moisture conditions

5. Storage:

After curing, specimens are taken for testing

Avoid damage before testing

Keep samples properly labeled



C. TESTING PROCEDURE

Tests Conducted:
Slump Test (Workability)
Compressive Strength Test (CTM)
Water Absorption Test
Density Test

D. SAMPLE IDENTIFICATION

MIX TYPE	Bio-Enzyme Percentage
Control Mix	0%
Mix 1	5%
Mix 2	10%
Mix 3	15%

E. PURPOSE OF SAMPLE PREPARATION

To ensure uniform mixing of materials
To achieve accurate test results
To maintain consistency in concrete specimens
To study effect of bio-enzyme on concrete performance
To avoid errors during testing

VII. NUMBER OF TESTS TAKEN

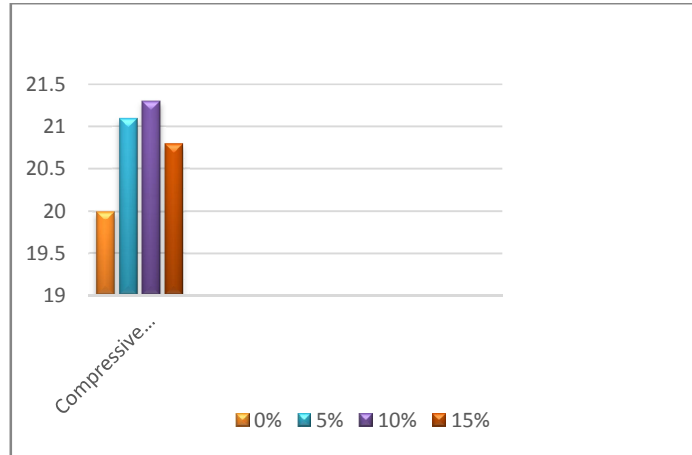
SLUMP TEST (WORKABILITY TEST)
COMPRESSIVE STRENGTH TEST
WATER ABSORPTION TEST
DENSITY TEST
CURING TEST (7 & 14 DAYS)
WORKABILITY OBSERVATION

VIII. COMPARATIVE SUMMARY OF CONCRETE PROPERTIES

COMPRESSIVE STRENGTH TEST

REPLACEMENT (%)	Compressive Strength(N/mm ²)	
	7 DAYS	14 DAYS
0%	20.1 N/mm ²	26.7 N/mm ²
5%	21 N/mm ²	27.8 N/mm ²
10%	21.3 N/mm ²	28.9 N/mm ²
15%	20.8 N/mm ²	28 N/mm ²



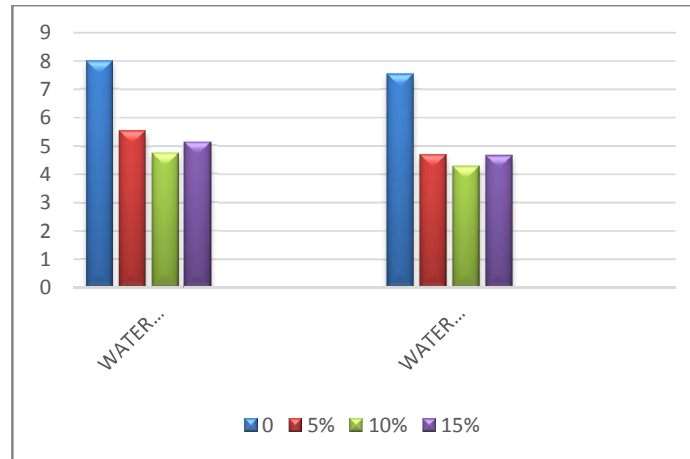


Mixture ID	Load (kN)	Compressive Strength (N/mm ²)	Average
0% (Control Mix)	450	20.0	
	455	20.2	20.1
	452	20.1	
5% Bio-Enzyme	470	20.9	
	475	21.1	21.0
	472	21.0	
10% Bio-Enzyme	480	21.3	
	485	21.6	21.4
	482	21.4	
15% Bio-Enzyme	465	20.7	
	468	20.8	20.8
	470	20.9	

WATER ABSORPTION TEST

REPLACEMENT (%)	WATER ABSORPTION(%)	
	7 DAYS	14 DAYS
0%	8%	7.54%
5%	5.55%	4.70%
10%	4.74%	4.29%
15%	5.12%	4.67%





IX. COMPARISON TABLE

MIX TYPE	Strength	Water Absorption	Suitable
0% Control	Low	High	Base level concrete
5% Bio-Enzyme	Good	Reduced	Improved performance
10% Bio-Enzyme	Best	Lowest	Optimum mix
15% Bio-Enzyme	Slight drop	Slight increase	Not optimal

X.CONCLUSION

The experimental results show that banana stem bio-enzyme significantly improves concrete performance. Workability increases due to better mixing behaviour, while compressive strength improves up to 10% dosage. Water absorption decreases, indicating higher durability and reduced porosity. However, at higher dosage (15%), slight reduction in strength is observed due to excess organic content. Therefore, 10% bio-enzyme is identified as the optimum level for sustainable concrete production. This study proves that agricultural waste like banana stem can be effectively used to develop eco-friendly and cost-efficient construction materials.

REFERENCES

- [1]. Reddy, B.V., et al. (2018). Application of Bio-Enzymes in Concrete Technology. Journal of Sustainable Construction Materials (Explains the use of natural bio-enzymes to improve concrete properties such as strength, durability, and permeability.)
- [2]. Kumar, S., & Mehta, P.K. (2019). Natural Admixtures in Concrete. International Journal of Civil Engineering Research. (Discusses eco-friendly alternatives to chemical admixtures and their effect on workability and strength.)
- [3]. Singh, A., et al. (2020). Utilization of Agricultural Waste in Construction Materials. Construction and Building Materials Journal. (Studies the use of agricultural waste materials for sustainable construction applications.)
- [4]. Prakash, R., et al. (2021). Study on Banana Stem Extract as Concrete Admixture. Materials Today Proceedings. (Analyzes banana stem extract as a bio-additive improving concrete performance.)



- [5]. Ahmed, S., et al. (2022). Durability Performance of Bio-Enzyme Concrete. Journal of Building Engineering. (Investigates long-term durability and permeability reduction in bio-enzyme treated concrete.)
- [6]. Aprianti, E. (2017). A Review on the Use of Agricultural Waste in Concrete. Procedia Engineering. (Provides a review of various agricultural wastes used in concrete for sustainable development.)
- [7]. IS 456:2000. Plain and Reinforced Concrete – Code of Practice. Bureau of Indian Standards. (Standard code for concrete design, durability requirements, and construction practices.)
- [8]. IS 10262:2019. Concrete Mix Proportioning Guidelines. Bureau of Indian Standards. (Provides guidelines for designing concrete mix proportions.)
- [9]. IS 516:1959. Methods of Tests for Strength of Concrete. Bureau of Indian Standards. (Standard method for compressive strength testing of concrete specimens.)
- [10]. Neville, A. M. (2011). Properties of Concrete. Pearson Education. (Explains fundamental behavior of concrete including strength, durability, and water absorption.)

