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Bio-Enzyme Treated Mud Mortar: A Sustainable Approach for Construction

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Abstract: The increasing demand for sustainable and eco-friendly construction materials has led to the exploration of alternative building techniques. Bio-enzyme treated mud mortar is an innovative and sustainable approach that enhances the properties of traditional mud mortar using naturally derived enzymes. This paper discusses the advantages, preparation methods, and potential applications of bio-enzyme treated mud mortar in modern construction. The rapid pace of urbanization and construction has placed significant stress on natural resources and the environment. The conventional cement-based mortars, though strong and durable, are associated with high carbon emissions and resource consumption. This research investigates the potential of bio-enzyme treated mud mortar as an eco-friendly, cost-effective, and sustainable alternative to traditional mortars.

Bio-enzymes, produced by fermenting organic materials such as orange peels, banana peels, jaggery, and yeast, were applied to mud mortar mixes. The study focused on assessing the mechanical and durability properties including compressive strength, water absorption, shrinkage, and erosion resistance. An environmental life cycle assessment and cost analysis were also conducted to evaluate feasibility. Experimental results revealed that the bio-enzyme treated samples demonstrated significantly improved compressive strength (up to 3.05 MPa), reduced water absorption (down by 35%), and minimal shrinkage. These findings support the viability of bio-enzyme stabilization for sustainable construction, particularly in rural and low-income housing sectors.

Keywords: Bio-enzyme, Mud-mortar, sustainable, construction

I. INTRODUCTION

Mud mortar is a traditional building material that is formed by combing soil and water, and occasionally adding additional ingredients to improve its strength and durability, such as sand, husk, coconut coir, jute, straw or cow dung. For generations, it has been an essential component of construction, especially in low-income and rural areas. Mud has been a great material for construction, as evidenced by the creation of mud bricks. In India, around 58 percent of all buildings are made of mud brick, with some of them as many as 100 years old [1]. However, its limited strength prevents it from being widely used in contemporary and modern construction. This may be attributed to some sociocultural and technological factors also. However, there is a dearth of scientific research on such factors influencing the strength and durability of mud mortar.

Bio-enzymes are natural catalysts produced by plant extracts or microbial fermentation. They are essential in changing the soil's chemical and physical characteristics, which improves the soil's ability to bond in mud mortar, a process known as soil stabilization which is commonly used in the construction industry and building quality roads. These plant-based enzymes improve the mixture's density and compaction, which decreases permeability and increases strength. Furthermore, these enzymes also help in the decomposition of organic materials in the soil, and thereby increasing its cohesiveness and durability with time. Bio enzymes are manufactured using a variety of methods, including the extraction of bio enzymes from microorganisms such as fungus and bacteria produced by the fermentation of agricultural plant biomass, vegetable matter, and so on. These bacteria produce a range of exoenzymes, which are readily collected in higher concentrations. Bio-enzyme treated mud mortar is made up of soil, water, plant-based enzymes, and fibres. Soil is the primary component chosen depending on its clay and silt concentration. Natural fibres such as coconut coir or jute is used to improve tensile strength. The preparation involves combining soil, water, and bio-enzyme in specific proportions, followed by a curing period to allow enzyme function. The mixture is then used as mortar for masonry or plaster applications. Bio-enzyme-treated mud mortar offers numerous benefits for sustainable construction. The enzymatic treatment of mortar increases its compactness and tensile strength, extending its lifetime and making constructions more resistant to environmental stress and mechanical pressures. This technique is environmentally favourable since it eliminates reliance on cement-based mortars, resulting in lower carbon emissions. These enzymatic changes also improve water resistance by reducing permeability, and preventing moisture damage.

This approach is also cost-effective because it uses locally available organic raw materials and requires minimal processing and less time consuming than conventional methods, making it a viable alternative to traditional cement-based mortars. The material's inherent porosity promotes thermal insulation, controlling indoor temperatures and lowering energy usage for heating and cooling. It also does not pollute soil like traditional methods such as cement, fly ash, and hydrated lime do. Bio enzymes are organic and have no side effects on the human body, whether inhaled or touched, rather than conventional methods using cement and lime. Furthermore, the improved water retention qualities reduce shrinkage and cracking, resulting in increased structural integrity and lifetime. In construction applications Bio-enzyme-treated mud mortar is highly suitable for rural and low-cost housing projects, providing a sustainable and affordable building solution. It is also an effective material for the restoration of heritage structures, where traditional mud-based construction methods need reinforcement. The material can be widely used in eco-friendly architecture, playing a crucial role in green building initiatives and off-grid housing. Furthermore, it is particularly beneficial in sustainable infrastructure projects, especially in eco-sensitive areas where conventional construction materials may not be viable. Despite its numerous benefits, bio enzyme-treated mud mortar faces challenges such as the need for standardization, acceptance in mainstream construction, and comprehensive long-term durability assessments. Further research is needed to establish its viability as a mainstream construction material. Raising awareness and developing clear guidelines for its use can accelerate its adoption in modern construction practices. This paper discusses the advantages, preparation methods, and potential applications of bio-enzyme treated mud mortar in modern construction.

A. Problem Statement

Dry mud is a mixture of soil particles of varied sizes that, when combined with the appropriate amount of water, forms mud mortar. Traditional mud mortar is prone to erosion, cracking, and moisture damage, reducing its long-term performance, durability, and strength. Conventional mud stabilisers such as cement-based mortars and lime mortars, although stronger, contribute significantly to carbon emissions. The purpose of this study is to investigate bio-enzymes as a sustainable alternative to chemical stabilisers in mud mortar, with an emphasis on mechanical qualities, durability, and environmental impact.

B. Objectives

1) To investigate the effect of bio-enzyme treatment on the mechanical properties of mud mortar.
2) To assess the strength, durability, water resistance, and erosion resistance of bio-enzyme stabilized mud mortar.

II. REVIEW OF LITERATURE

Bio enzyme is an organic and environment friendly enzyme formulation which is produced from plant-based and vegetable extracts that improves the strength and durability of the soil. Organic enzymes are usually in a liquid state and are proteins that enhance and speed chemical processes without affecting the end product (Shil et al. 2021). [1] There are different types of bio enzymes such as Terrazyme, Permazyme, Fujibeton etc that have high efficacy in soil stabilization and are found to be cost effective (Vedula et al. 2002). [2] Using bio enzymes in soil stabilization, a short road was made in the campus of the National Council for Cement and Building Materials in Ballabhgarh, India, to test the efficacy of bio enzymes in soil stabilization by suing Fujibeton. The road was opened to traffic in just one day due to faster settling and improved CBR. Fujibeton-stabilized country roads are cost-effective and successful within traffic diversion limits (Vedula et al. 2002). [2] In Ghana mud mortars have, traditionally, been improved by the addition of organic matter such as cow dung and ashes from agro-processing waste. [3] S. Panchal et al. (2017) conducted a study focusing on the use of Terrazyme to improve the CBR in road construction. During the study, various tests were performed on local soil with and without bio enzyme. Ater mixing of Terrazyme, it was observed improvement in consistency limits, dry density, and CBR values. [4] Rastogi et al. (2023) conducted a study discussing the potential of bio enzymes in enhancing soil stability. The study focussed on various soil stabilizing techniques to improve the quality of soil. It was found that bio enzymes have a significant impact on the quality of soil and considering such environment friendly soil stabilizers can be a bigger step over switching from chemical-based methods. [5] Rintu et al. (2017) conducted a study on enzyme-based soil stabilization for unpaved road construction by assessing the efficacy and correct used of new enzyme in the construction of unsealed road. During the study, a series of characterization tests were conducted on several soil types obtained from the proposed sites. A trial road was constructed to investigate the efficacy of enzyme stabilization along with the correct constriction sequence. During the study significant improvement of the road performance was found, as was evidenced from the test results which were based on site soil obtained before and after stabilization. [6] Sreekumar et al. (2012) discovered that adding 0.5% coconut coir increased the compressive strength of stabilised lateritic blocks by approximately 20%. [7]

A study conducted by Ajanta Kalita et al. (2024) on effect of enzyme-based soil stabilization highlighted the improvements in unconfined compressive strength and shear strength due to use of bio-enzyme treatment. The study revealed that bio-enzyme improves UCS strength up to 4.5 times and shear strength from 104.32% to 463.50%, and reducing soil permeability by 0.4 to 0.16 times than the parent strength. The findings in this study represented sustainable solutions for soil stabilization, which engineers or researchers can use for future development and construction. [8]

III. MATERIALS AND METHODS

1) *Soil*: The soil sample was collected from a local site at Pulwama, from a depth of 40 cm below the ground level. It was subjected to colour test, smell test, texture, and adhesion test at site. The results of the material characterisation of soil are mentioned in *Table. A*
2) *Bio-Enzyme:* Bio enzyme was prepared in laboratory using orange peels, banana peels, Jaggary, and yeast powder were fermented for 14 days in plastic container.
3) *Water:* Tap water with TDS 120 was used.
4) *Sand*: Sourced from the local site.
5) *Coconut coir:* Coconut fibre was collected from the local market. The coir was washed and air dried, before using. The coir was cut in lengths of 10 cm.

Table A. Properties of Soil

S. No	Property	Result	Remarks
1	Colour	Light Brown	Suitable for mud construction
2	pH	6.150	5.9-6.5 (moderately acidic)
3	Organic content	0.250%	< 0.5% (low organic content)
4	Specific gravity	2.9	2.6 – 2.7 (for Blocks)
5	Particle size distribution a. Clay b. Silt c. Sand	 a. 25% b. 40% c. 35%	 18%-22% 40%-42% 30%-40% (Mud Mortar)
6	Atterberg Limits a. Liquid limit b. Plastic Limit c. Shrinkage Limit d. Plasticity Index	a. 42% b. 26% c. 5% d. 27%	12-15 (Mud Mortar)

IV. METHODOLOGY

A. Sample Preparation

Soil was dried, sieved, and tested for particle size distribution.

Control sample: Control sample was made with traditional mud mortar by mixing soil, sand and water.

Bio-Enzyme treated sample: This was made by mixing up soil, water, sand, coconut coir, and lab made organic bio enzyme.

Samples were air-cured and tested at 7, 14, and 28 days.

Fig.1: Bio-enzyme Sample Preparation (1a and 1b)

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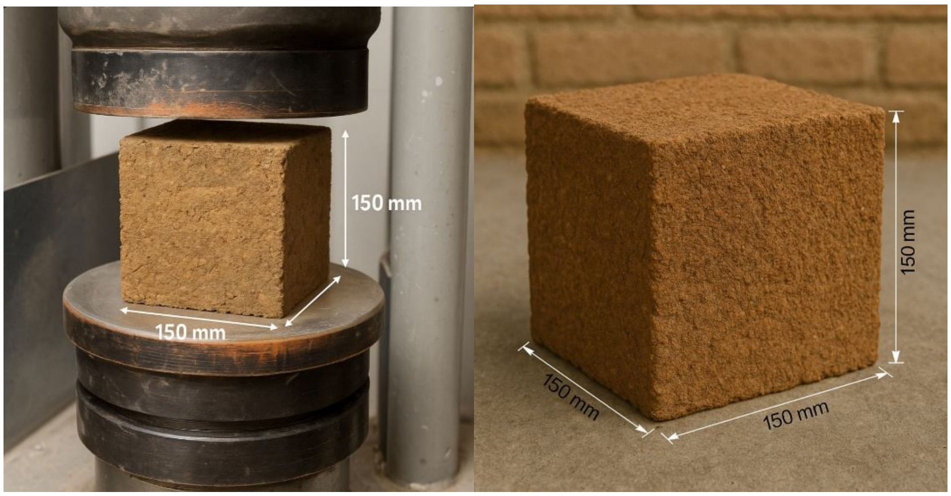
B. Experimental Testing of Strength and Durability

The experimental testing includes Compressive Strength Test, Water Absorption Test, Erosion Resistance Test, and Linear Shrinkage Test.

1) Compressive Strength Test (ASTM C109)

The mud mortar samples were tested according to IS 2250 -1981. Three samples each were used for testing compressive strength at the end of 7th day and 28th day of curing. Cement mortar cubes were demoulded after 24 hours of casting and immersed in curing tank for 28 days. Lime mortar cubes were demoulded after 72 hours of casting and left in air for four days. At the end of 7 days lime mortar cubes were immersed in curing tank. Hence 28-day strength alone is taken for lime mortar cubes. Mud mortar samples were given gunny bag curing for 28 days.

Fig.2: Compressive Strength Test



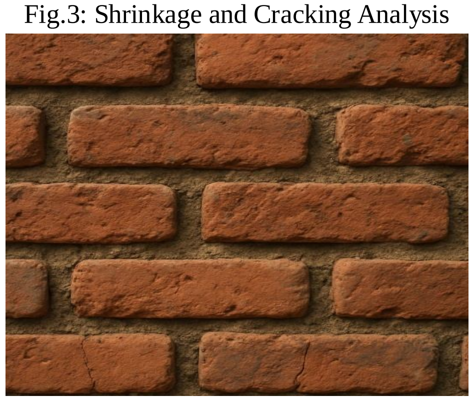
2) Water Absorption Test (ASTM C1403)

This test was carried out according to the IS: 1725 – 1997. In these three specimens of each combination were dried in a ventilated oven at a temperature of 105 to 115 C till attain constant mass and noted it's mass. Completely dried blocks were then immersed in clean water for 24 hours and noted the new mass. The average difference of masses was expressed in percentage.

3) Shrinkage & Cracking Analysis

The linear shrinkage of mortar samples were determined using linear shrinkage apparatus. It is a rectangular box of inner dimensions 25 cm x (L1) 2.5cm x. 1.5cm. The inside surface of the box was greased to prevent the soil from sticking to the walls. Mortar sample was prepared using the required water content. It was then filled into the apparatus by proper compaction and neatly smoothened off with the spatula so that the sample exactly fills the mould (Fig. 1a). This was then left as such in the shade for 14 days. The length of the sample after 14 days was measured (L2) (Fig. 1b). The difference in length is expressed in percentage of the initial length to get the percentage linear shrinkage.

Fig.3: Shrinkage and Cracking Analysis



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Environmental and Economic Assessment

- *Life Cycle Assessment (LCA)*: Comparison of environmental impact with traditional mortar.
- *Cost Analysis*: Evaluation of economic feasibility compared to cement mortar.

V. RESULTS

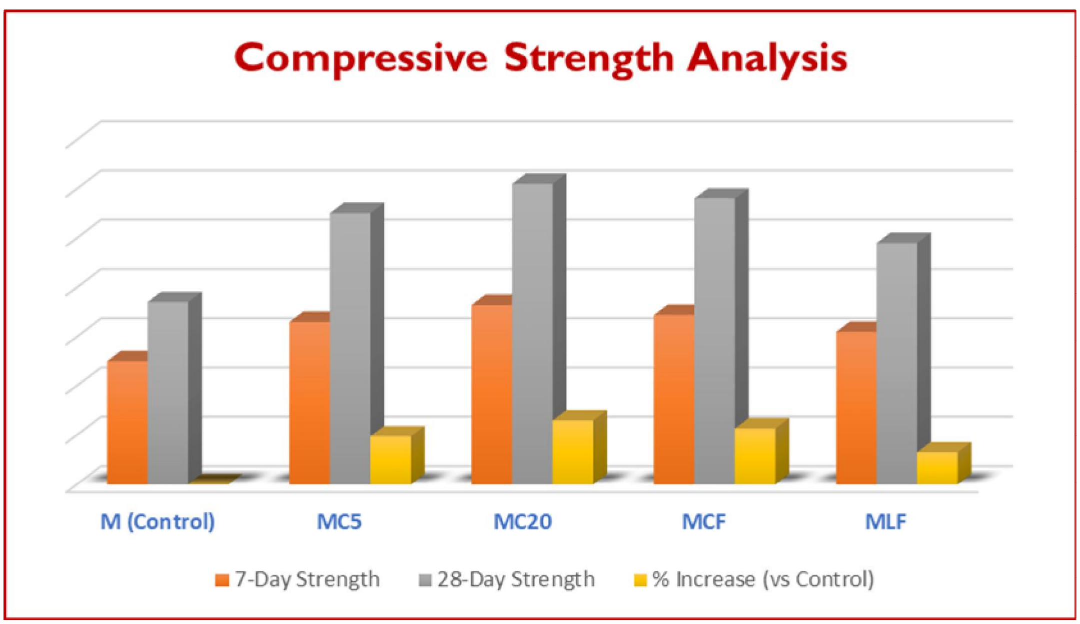
To check the physical properties, mortar samples were tested for compressive strength, water absorption and linear shrinkage. The results of compressive strength, water absorption and linear shrinkage of the different mixes are presented in this section. The linear shrinkage test was conducted on M, MC5, MC20, MCF and MLF samples.

A. *Compressive Strength Test*

The compressive strength of various mud mortar samples was tested on 7th and 28th day of curing using cube samples of standard size (70.6 mm × 70.6 mm × 70.6 mm). The test was conducted in accordance with ASTM C109 and IS 2250 (1981).

Table 5.1: Compressive Strength Results

Soil + Sand + Water	1.25	1.85	–
M + 5% Bio-Enzyme	1.65	2.75	48.6%
M + 20% Bio-Enzyme	1.82	3.05	64.8%
MC20 + Coconut Coir	1.72	2.90	56.7%
M + Lime + Coir	1.55	2.45	32.4%

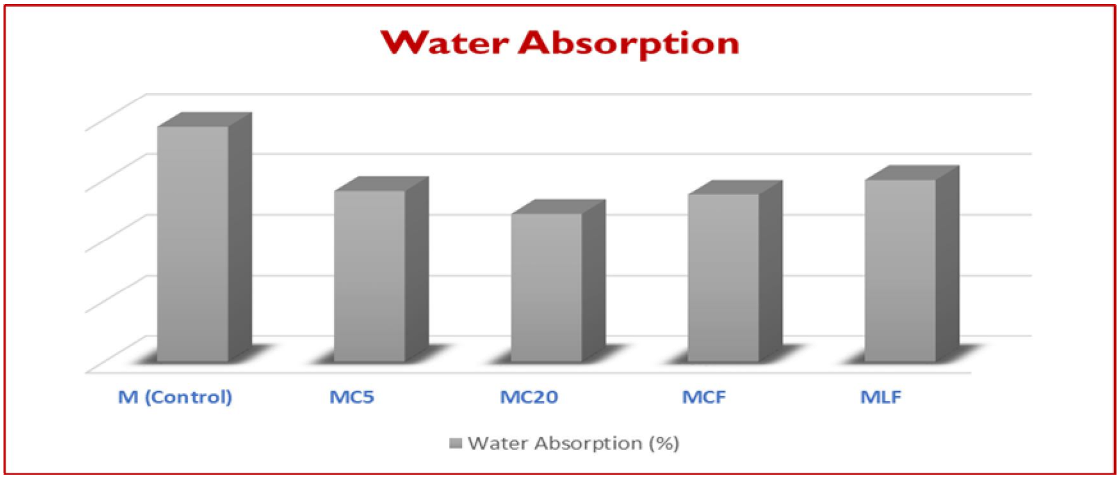


B. Water Absorption Test

Water absorption was tested to evaluate resistance to moisture ingress, following IS:1725 – 1997. Dried samples were weighed, immersed in water for 24 hours, and reweighed to calculate the percentage of absorbed water.

Table 5.2: Water Absorption Percentage

2,010	2,400	19.4
2,050	2,340	14.1
2,080	2,335	12.2
2,100	2,390	13.8
2,060	2,370	15.0

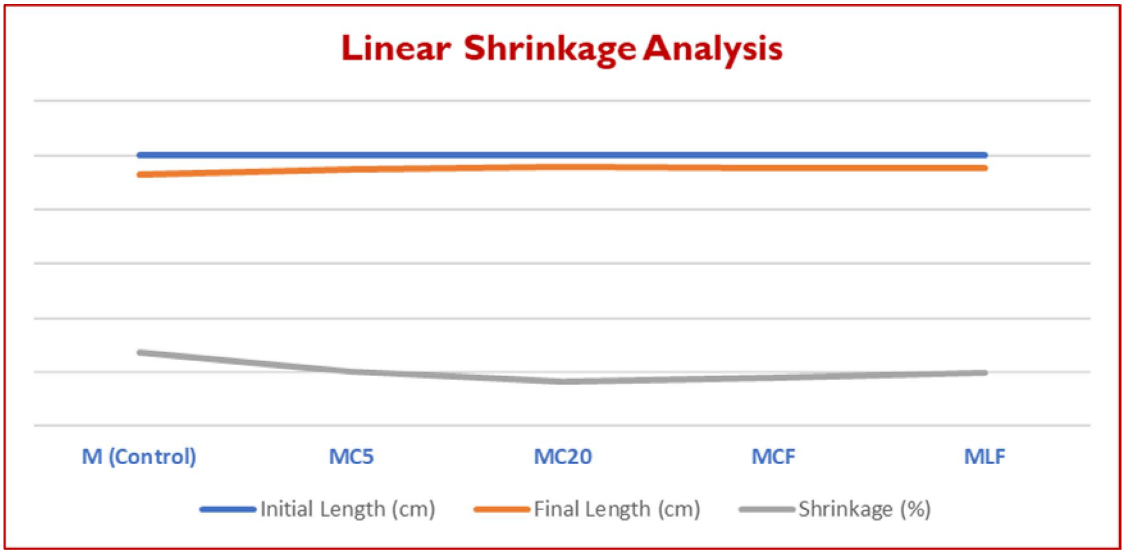


C. Shrinkage & Cracking Analysis

The shrinkage test was performed using a rectangular mould and shade curing for 14 days. The shrinkage was calculated based on the reduction in length over time.

Table 5.3: Linear Shrinkage Results

25.0	23.3	6.8
25.0	23.75	5.0
25.0	23.95	4.1
25.0	23.9	4.4
25.0	23.8	4.9

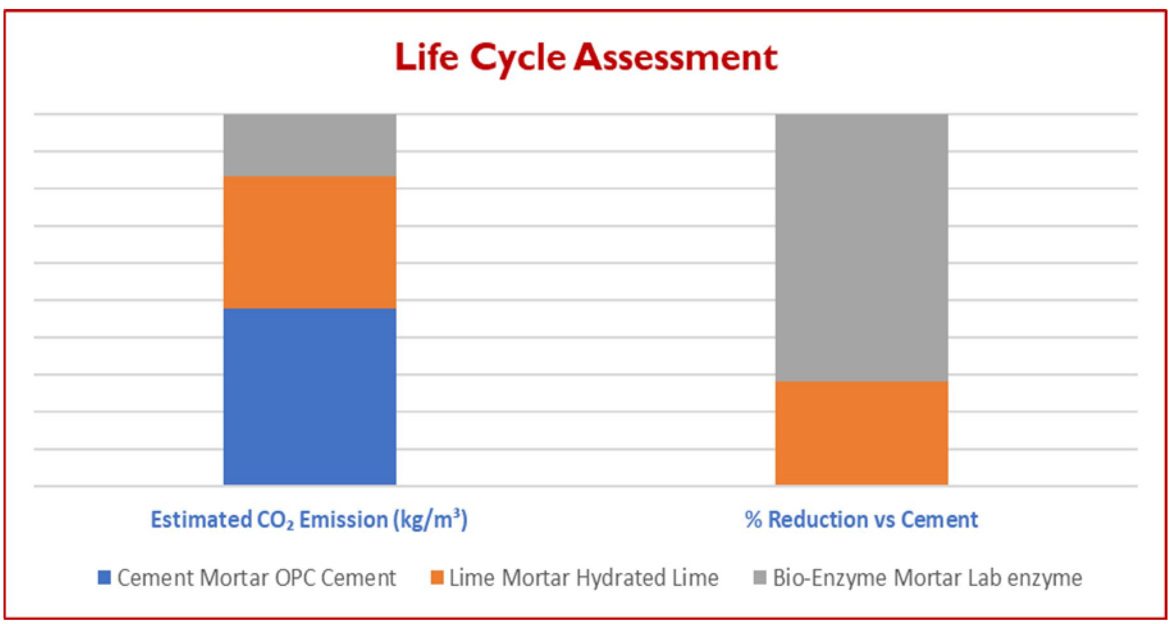


D. Life Cycle Assessment (LCA)

A comparative LCA was conducted using embodied carbon data from cement production (0.93 kg CO_2/kg) and estimated carbon output from enzyme production (0.05 kg CO_2/kg).

Table 5.4: Life Cycle Assessment

OPC Cement	195	–
Hydrated Lime	145	25.6%
Lab enzyme	68	65.1%

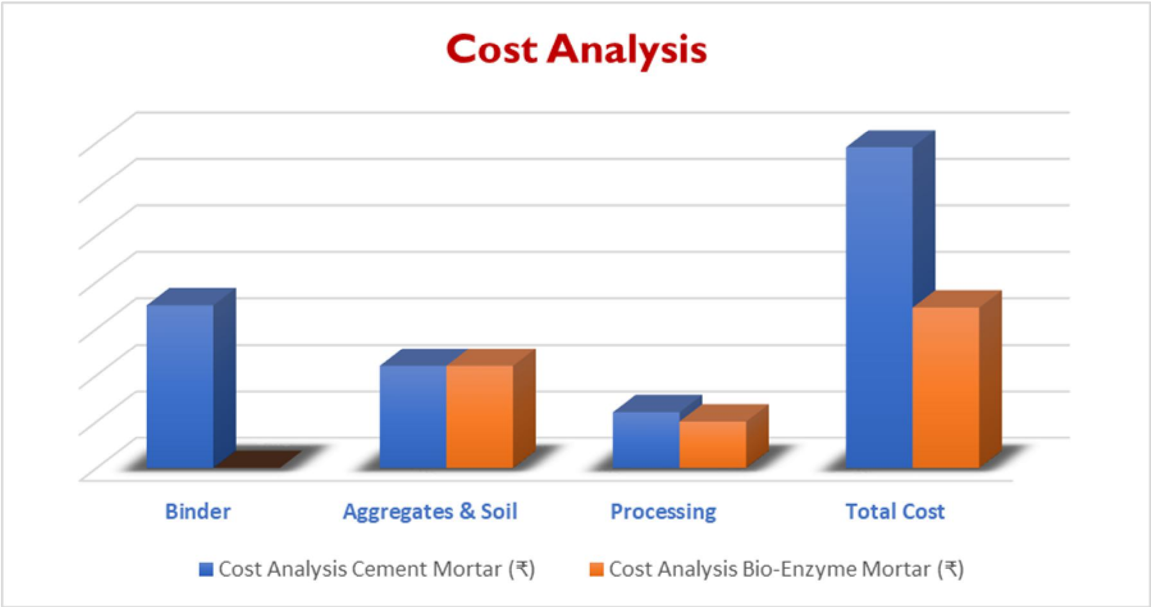


E. Cost Analysis

A cost evaluation was performed considering raw material, preparation, and labor for 1 m³ mortar production.

Table 5.5: Cost Analysis

3,500	250 (enzyme materials)
2,200	2,200
1,200	1,000
₹ 6,900	₹ 3,450



VI. CONCLUSION

This study will contribute to sustainable construction by developing bio-enzyme stabilized mud mortar as a viable alternative to traditional mortars. It will address both structural performance and environmental sustainability, promoting the use of natural stabilizers in eco-friendly building materials.

By creating bio-enzyme stabilised mud mortar as a competitive substitute for conventional mortars, this research will support environmentally friendly building practices. By encouraging the use of natural stabilisers in environmentally friendly construction materials, it will address both structural performance and environmental sustainability.

Bio-enzyme treated mud mortar presents a promising sustainable alternative to conventional building materials. Its environmental benefits, affordability, and improved mechanical properties make it a viable choice for future construction practices. Adoption of this technology can contribute to greener, more sustainable infrastructure development worldwide.

REFERENCES

[1] Gupta, A., & Kumar, P. (2020). Sustainable soil stabilization techniques for eco-friendly construction: A review. Construction and Building Materials, 230, 117102.
[2] Kaur, R., & Kumar, S. (2022). Experimental study on the effectiveness of bio-enzymes in soil and mortar stabilization. Journal of Sustainable Materials, 8(3), 112-125.
[3] Marto, A., Latifi, N., & Soon, T. Y. (2017). Application of bio-enzymes for soil stabilization: A review. Environmental Geotechnics, 4(2), 143-156.
[4] Mehta, P. K., & Monteiro, P. J. (2021). Concrete: Microstructure, Properties, and Materials (5th ed.). McGraw-Hill Education.
[5] Reddy, B. V. V., Shivakumar, N., & Jagadish, K. S. (2019). Durability and performance of stabilized mud mortars in construction. Journal of Materials in Civil Engineering, 31(8), 04019106.
[6] Sivapullaiah, P. V., Sridharan, A., & Chandrakaran, S. (2018). Bio-enzyme stabilization of clay for improving construction materials. Geotechnical and Geological Engineering, 36(2), 747-758.

[7] Shil T, Pradhan R, Nanda S and Mohapatra BG (2021) Strengthening of soil subgrade using bio-enzyme. In Recent Developments in Sustainable Infrastructure (13–25). https://doi.org/10.1007/978-981-15-4577-1_2

[8] Vedula M, Nath P, Chandrashekar BP (2002). A critical review of innovative rural road construction techniques and their impacts. National rural roads development agency, New Delhi. https://arunachalpwd.org/pdf/renolith001.pdf

[9] Peter Paa-Kofi Yalley and Dorothy Manu (2013), "Strength and durability properties of cow dung stabilized earth bricks", Civil and Environmental Research, Vol. 3, Issue 13, pp.117-125

[10] Panchal, Sandeep & Khan, Mohammad & Sharma, Anurag. (2017). Stabilization of soil using bio-enzyme. International Journal of Civil Engineering and Technology. 8. 234-237.

[11] Rastogi S, Gupta S (2023) A review: Revolutionizing Soil Stabilization through Bio- enzymes. J Bioremediat Biodegrad, 14: 582. DOI: 10.4172/2155-6199.1000582

[12] Renjith, Rintu & Robert, D.J. & Fuller, Andrew & Setunge, Sujeeva & O'Donnell, Brian & Nucifora, Robert. (2017). Enzyme based soil stabilization for unpaved road construction. MATEC Web of Conferences. 138. 01002. 10.1051/matecconf/201713801002.

[13] Sreekumar, M. G., and Nair, D.G., (2013), "Stabilized lateritic blocks reinforced with fibrous coir wastes", Int.J. of Sustainable Construction Engineering & Technology, Vol 4, No. 2, pp. 23-32.

[14] Kalita, A., Singh, N. K., Paksok, D., & Tashi, K. (2024). Effect of enzyme-based soil stabilization: A review. SSRG International Journal of Civil Engineering, 11(12), 94-101.