Global Journal of Engineering and Technology Advances

eISSN: 2582-5003

Cross Ref DOI: 10.30574/gjeta

Journal homepage: https://gjeta.com/

GJETA

(RESEARCH ARTICLE)

Check for updates

Formulation and cost analysis of biocompatible plaster for sustainable construction

Sanika Jaygade, Sandesh Ashok Kamble, Devraj Mallesh Chalavaji, Yash Haribhau Bhalerao and Vijay Surendra Gupta

Department of Civil Engineering, Datta Meghe College of Engineering, Navi Mumbai, 400 708, India.

Global Journal of Engineering and Technology Advances, 2025, 22(02), 113-119

Publication history: Received on 23 December 2024, revised on 08 February 2025; accepted on 11 February 2025

Article DOI: https://doi.org/10.30574/gjeta.2025.22.2.0018

Abstract

The objective of this research is to explore the utilization of natural materials as a sustainable and eco-friendly alternative to conventional cement-based construction components. By focusing on the development of biocompatible plaster, crafted from gypsum, cow dung, guar gum powder, citric acid, and water, this project aims to achieve a significant milestone in environmentally conscious construction. A critical aspect of our research involved determining the proportion of materials essential for an optimal plaster mix through rigorous experimentation and testing. These foundational elements were instrumental in our estimation and costing analysis, providing a robust framework for budgetary projections and financial planning. Through a comprehensive approach, we provided accurate financial projections for implementing biocompatible plaster on a 100 square meter area, considering both material and labor factors. This holistic analysis underscores our commitment to sustainable construction practices and informed decision-making in construction material selection and application. This research showcases the potential of harnessing nature's elements to create robust and biocompatible building materials, setting a noteworthy precedent for greener and more responsible construction in the future.

Keywords: Biocompatible plaster; Sustainable construction; Natural materials; Cost analysis

1. Introduction

Traditional plastering materials, such as cement, have significant environmental impacts due to their high carbon emissions and resource consumption during production. These materials also require extensive curing processes and water usage, contributing to environmental degradation. In contrast, biocompatible plaster offers a sustainable alternative by utilizing natural, readily available ingredients that minimize environmental harm.

The primary objective of this project is to develop a biocompatible plaster that is cost-effective, environmentally friendly, and suitable for sustainable construction. Biocompatible plaster, formulated from natural materials such as gypsum, cow dung, guar gum powder, and citric acid, offers several advantages over traditional plaster. Gypsum, a key ingredient, is known for its natural abundance and minimal environmental impact during processing. It also provides a smooth finish and acts as a natural fire retardant. Cow dung, traditionally used in rural construction, has been included in this formulation for its beneficial properties, including enhancing thermal insulation, maintaining indoor temperatures, and contributing to the overall breathability of walls. Guar gum powder, a natural thickening agent, improves the smoothness and workability of the plaster, while citric acid serves as a pH balancer and antifungal agent, ensuring the longevity and durability of the plaster.

Sustainable building materials are crucial in modern construction to address the growing concerns of climate change and resource depletion. Biocompatible plaster aligns with green building practices by reducing carbon footprint,

* Corresponding author: Yash Bhalerao Vijay Gupta

improving indoor air quality, and enhancing energy efficiency. This project seeks to demonstrate the viability of biocompatible plaster as a practical and scalable solution for sustainable construction.

2. Aim and objectives

- To formulate Biocompatible plaster with optimum proportion of natural ingredient.
- To carry out standard consistency, initial and final setting time and water absorption test on biocompatible plaster.
- To evaluate detail cost analysis of biocompatible plaster.

3. Problem statement

- **Environmental Impact:** Cement production is a major source of carbon emissions, contributing significantly to global greenhouse gas emissions. This environmental impact contradicts the imperative to reduce carbon footprints in construction.
- **Resource Depletion:** Cement production requires significant amounts of non-renewable resources, particularly limestone and clay. The extraction and processing of these resources lead to habitat destruction and ecosystem disruption.
- **High Water Demand:** Cement plaster requires substantial water for mixing and curing. In regions with water scarcity, this poses challenges.
- **Lack of Insulation:** Cement plaster does not provide effective thermal insulation, leading to higher energy consumption for heating and cooling.
- **Material Cost:** Material cost varies from place to place.

4. Methodology

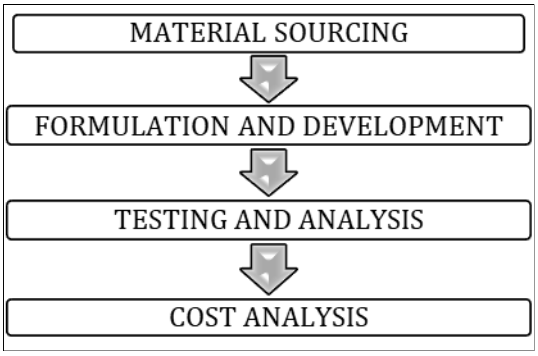

Figure 1 Methodology chart

4.1. Material Sourcing

In the process of formulating our biocompatible plaster, procuring the necessary materials played a pivotal role. We were fortunate to find all the required materials readily available in the local market, ensuring convenience and accessibility for our project. Here is a breakdown of the materials we sourced and their respective prices:

- **Gypsum:** We acquired Gypsum, the primary component of our plaster, at the rate of ₹160 for every 20 kilograms. This cost-effective pricing allowed us to maintain the affordability of our final product.
- **Cow Dung**: Cow dung, known for its organic properties and contributions to biocompatibility, was sourced at a reasonable rate of ₹100.
- **Guar Gum Powder:** Guar gum powder, utilized to enhance the adhesive properties of our plaster, was obtained at ₹400 for every 500 grams. This additive adds value to our formulation by improving its performance.
- **Citric Acid:** Citric acid, a critical component for controlling the setting time of the plaster, was procured at ₹35 for every 100 grams. Its cost-effectiveness makes it a viable option for our formulation.

4.2. Formulation and Development

Our journey in formulating the biocompatible plaster involved several experimental trials. Each trial aimed to strike the ideal balance between structural integrity and biocompatibility. These trials were pivotal in refining the composition to achieve the desired proportion of materials.

In our first experimental trial, we embarked on formulating the biocompatible plaster by utilizing a composition of 60% gypsum, 30% cow dung, 8% guar gum powder, and 2% citric acid, resulting in a 200-gram sample. A critical issue arose during this trial: the plaster exhibited substantial adhesion to the pan’s surface, making it difficult to remove.

This observation raised concerns that the proportions of cow dung and guar gum powder may have been excessive, contributing to the undesirable stickiness of the plaster.

Figure 2 Plaster mix

In our second experimental trial, we continued the journey to refine our biocompatible plaster formulation. In this trial, we adjusted the proportions, employing a composition consisting of 70% gypsum, 20% cow dung, 8% guar gum powder, and the remaining fraction allotted to citric acid. There was a subtle improvement in terms of consistency and workability. This observation indicated that we were moving in the right direction, albeit incremental.

In our third and pivotal experimental trial, we made significant adjustments to the composition to bring us closer to our goal of an optimal biocompatible plaster. This time, the formulation consisted of 90% gypsum, 5% cow dung, with the remaining proportions allocated to guar gum powder and citric acid. The plaster’s consistency transformed into a workable state, free from the excessive stickiness observed in previous trials. This achievement was a testament to the importance of striking the right balance between materials in achieving the desired plaster properties.

To determine the optimal ratio of materials for our biocompatible plaster, we undertook a methodical approach starting with the measurement of material weights. Specifically, we weighed gypsum, cow dung, guar gum, and citric acid, obtaining values of 182 grams, 14 grams, 2 grams, and 1 gram, respectively. Subsequently, we converted these weights into volume measurements by leveraging the densities of each material. Through this conversion process, we standardized the measurements to facilitate accurate ratio calculations. Notably, the proportion of guar gum powder and citric acid, although essential for certain properties, was relatively minimal in quantity compared to gypsum and cow dung. As such, we focused primarily on establishing the ratio between gypsum and cow dung, reflecting their significant contributions to the plaster's overall composition.

After rigorous calculations and adjustments, we arrived at the optimized ratio of 5:1 for biocompatible plaster, where 5 represents gypsum and 1 represents cow dung. By meticulously determining the ratio and proportion of materials, we lay the foundation for producing biocompatible plaster with tailored characteristics that align with sustainability goals and construction standards.

4.3. Testing And Analysis

The comprehensive evaluation of biocompatible plaster is fundamental to understanding its suitability for a wide range of construction applications and its alignment with sustainability and environmental goals. Our methodology adhered to established standards, such as IS code 2542-1978, ensuring the reliability and accuracy of our results. These tests encompassed critical aspects of plaster quality, including standard consistency, initial and final setting times, and water absorption.

4.3.1. Standard Consistency

The consistency test for plaster is performed to determine the quantity of water required to achieve the desired workability. This test is essential as it helps in controlling the quality of plaster and ensures that it is suitable for its intended application. The consistency is typically expressed as a percentage of water required by weight concerning the weight of the plaster.

This result indicates that the biocompatible plaster tested attains its ideal workability when combined with 60% of its weight in water of mix. It signifies that the plaster can be easily mixed and applied for various construction or design tasks when prepared with this water-to-plaster ratio.

Figure 3 Standard consistency test

4.3.2. Initial and Final Setting Time Test

It helps determine when the plaster is workable and when it has set to a point where it can no longer be used. This is crucial for applications that require the material to be applied, shaped, or finished within a specific timeframe.

- Initial Setting Time: The plaster had an initial setting time of 10 minutes. This indicates the point at which the plaster starts to lose its plasticity and can no longer be shaped or worked with.
- Final Setting Time: The final setting time was observed to be 25 minutes. This marks the time when the plaster has completely set and achieved its maximum strength.

Figure 4 Initial and final setting time test

4.3.3. Water Absorption Test

The water absorption test is a crucial evaluation in understanding the plaster's ability to retain water and its resilience against moisture. This test is designed to assess the plaster's capacity to absorb and hold water, which is particularly important in construction, as it affects its durability and resistance to environmental conditions.

4.4. Cost Analysis

Estimating and costing for plaster on a scale of 100 square meters involves a comprehensive approach that encompasses material quantities, labour costs, and overall project expenses.

4.4.1. Cost Analysis of Biocompatible Plaster

Table 1 Cost analysis of biocompatible plaster

Sr. no	Particular	Quantity	Rate in Rs	Per	Amount in Rs
1.	Materials				
	Gypsum	2.256	2500	Ton	5640
	Cowdung Powder	117.56	5	Kg	587.8
	Gaurgum Powder	25.762	150	Kg	3864.3
	Citric Acid	11.82	60	Kg	709.2
2	Labour				
	Head Mason	1	1000	Day	1000
	Mason	2	500	Day	1000
	Male Mazdoor	2	500	Day	1000
				Total	13801.3

4.4.2. Cost Analysis of Cement Plaster

Table 2 Cost analysis of cement plaster

Sr. No.	Particular	Quantity	Rate in Rs	Per	Amou-nt in Rs
1	Materials				
	Cement	14 bags	500	Ton	5640
	Sand	1.47 m^3	3300	Kg	587.8
	Contingencies, tools, and plants	Lump sum	500	Kg	3864.3
2	Labour				
	Head Mason	1	1000	Day	1000
	Mason	2	500	Day	1000
	Male Mazdoor	2	500	Day	1000
				Total	15351

5. Conclusion

- In conclusion, our project on biocompatible plaster has yielded insightful findings and promising results.
- Our extensive research led to the establishment of an optimal mix ratio of 5 parts gypsum to 1 part cow dung, achieving a balance between performance and cost-effectiveness.
- The plaster's workability was found to be ideal at 60% water content, signifying its workable and adjustable consistency. The plaster exhibited an initial setting time of 10 minutes and a final setting time at 25 minutes, indicating a balanced setting characteristic suitable for various applications.
- Speaking of budgeting, our cost analysis revealed that the cost for 100 square meters of biocompatible plaster amounts to 15,320₹, significantly lower than conventional cement plaster, which costs 17039₹. This substantial cost difference underscores the economic viability and affordability of biocompatible plaster, making it a compelling choice for sustainable construction practices.

Compliance with ethical standards

Acknowledgments

The authors wish to acknowledge the support received from the Department of Civil Engineering, Datta Meghe College of Engineering while conducting the research. The authors are also grateful to the Head of the Department of Civil Engineering, Datta Meghe College of Engineering, Navi Mumbai India for rendering various help in carrying out the experiments.

Disclosure of conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] K.M. Shelote and R. Jajodya, H.R. Gavali," Experimental and Computational Analysis of Energy Efficient Plaster," SSRN, 12 April 2019.

[2] Deepak Meshram, "Experimental Study of Eco–Friendly Vedic Plaster," IRJET, Volume 08, Issue 07, July 2021.

[3] Sanket Rajkumar Bondre, Prof. Dr S.G. Makarande and Asst. Prof. Ms. R. K. Kakpure,"An experimental investigation on suitability of cow waste in construction material," IJCRT, Volume 1, ISSN: 2320-2882, , Issue 4 April 2023.

[4] Leopold Mbereyaho, "Assessment of Cohesive Soil – Cow Dung Mortar Properties as Replacement of cement Mortar for Simple Plastering Works," RJESTE, Volume 3, Issue 2, 2020.

[5] Paulina Faria1, Tania Santos2 and jean-Emmanuel Aubert3, "Experimental Characterization of an Earth Eco-Efficient Plastering Mortar," Journal of Materials in Civil Engineering Published by American Society of Civil Engineers Online ISSN: 1943-5533, DOI:10.1061/(ASCE)MT.1943-5533.0001363, June 2015.

[6] Ajinkya Sanjay Bhalerao1, Dr. S. B. Khaple" "Experimental Study on Ecofriendly Natural Herbal Lime Plaster"," 2023 JETIR July 2023, Volume 10, Issue 7

[7] Abdallah Dadi Mahamat1 and Oumar Idriss Hamid2," Effect of Cow's Dung on Thermo-physical Characteristics of Building Materials Based on Clay," RJESTE, ISSN: 2040-7459; e-ISSN: 2040-7467, June 05, 2015.

[8] Dr. S. K. Sekar ,P. Thirumalini, "Review on Herbs used as Admixture in Lime Mortar used in Ancient Structures", Director, Centre for Disaster and Mitigation, Management. (CDMM), Velloren Institute of technology,Vellore 632014. (2013)

[9] Vasu.K,"Experimental investigation on partial replacement of cement with cow dung ash," IJARIIE-ISSN(O)-2395-4396, Vol-5 Issue-3, 2019.

[10] Gladis Camarini and Maria Clara Cavalini Pinto,"Effect of citric acid on properties of recycled gypsum plaster to building components," Volume 124, Pages 383-390, , 15 October 2016.