IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 6, Issue 5, April 2026

Impact Factor: 8.2

Development of Cementitious Plaster with Enhanced Crack Control Properties

Sarthak Pravin Gaikwad[1], Om Suresh Demse[2], Aman Aziz Sayyed[3], Dattaraj Dilip Jagtap[4], Prof. Chetan Pagar[5], Prof. Ashwini Kadam[6], Prof. Prashant Chavan[7]

Students, Department of Civil Engineering[1-4]

Lecturer (Guide), Department of Civil Engineering[5]

Lecturer (Co-Guide), Department of Civil Engineering[6]

Head of Department (HOD), Department of Civil Engineering[7]

Guru Gobind Singh Polytechnic, Nashik, Maharashtra, India

Abstract: *This project aims to develop an economical, sustainable, and efficient self-healing cement plaster capable of autonomously repairing minor cracks and enhancing the overall lifespan and durability of structures. Cracking is an inevitable issue in cementitious materials due to factors such as shrinkage, temperature variations, and external loading, which ultimately leads to reduced structural integrity, increased permeability, and higher maintenance costs.*

To address this problem, the proposed study focuses on the development of a low-cost self-healing mechanism based on Microbial Induced Calcite Precipitation (MICP). This technique utilizes Bacillus subtilis bacteria, which have the ability to precipitate calcium carbonate ($CaCO_3$) when activated in the presence of moisture and nutrients. The precipitated calcite fills the cracks, thereby restoring the material's continuity and improving its strength and durability.

In addition to the microbial component, the project incorporates locally available and sustainable materials such as fly ash and limestone powder as partial replacements for cement, reducing the environmental impact and cost of the plaster. Natural polymer additives are also introduced to enhance binding properties, flexibility, and crack resistance. The combination of these materials aims to create a composite plaster that is not only self-healing but also eco-friendly and economically viable.

The experimental methodology involves preparing different plaster mixes with varying proportions of bacteria, fly ash, limestone powder, and polymer additives. These samples are subjected to laboratory tests such as compressive strength testing, crack induction, and healing observation over specific curing periods. The healing efficiency is evaluated by measuring crack closure, strength regain, and water permeability reduction. The performance of self-healing plaster is then compared with conventional cement plaster to assess improvements in mechanical and durability properties.

The expected outcomes of this study include enhanced crack-healing capability, improved compressive strength, reduced permeability, and increased service life of plastered surfaces. Moreover, the use of industrial by-products like fly ash contributes to waste utilization and sustainability. The developed material is particularly suitable for rural and low-cost housing applications, where maintenance resources are limited.

Overall, this project promotes innovative, cost-effective, and sustainable construction practices by integrating biotechnology with traditional building materials. It has the potential to significantly reduce repair and maintenance costs while improving the resilience and longevity of infrastructure..

Keywords: Self-healing cement plaster, Microbial Induced Calcite Precipitation (MICP), *Bacillus subtilis*, crack healing, calcium carbonate precipitation, fly ash, limestone powder, natural polymers, sustainable construction, durability enhancement, low-cost housing

I. INTRODUCTION

Plastering is an important finishing process in building construction. It involves applying a layer of mortar (usually cement, sand, and water) on walls and ceilings to create a smooth and protective surface. Plaster not only improves the appearance of buildings but also protects the structural components from environmental effects such as moisture, weathering, and mechanical damage.

However, cracks frequently develop in plastered surfaces due to shrinkage, thermal changes, poor materials, or improper curing. These cracks reduce the durability and aesthetic quality of buildings. Traditional cement plaster has low tensile strength and tends to shrink during drying, which leads to the formation of cracks.

Therefore, the development of cementitious plaster with enhanced crack control properties has become an important area of research in modern construction.

II. PROBLEM STATEMENT

Cracking in cement plaster is a major issue in construction projects. Traditional cement plaster often develops cracks due to shrinkage, improper curing, temperature variation, and poor quality materials. In addition, factors such as differential settlement, excessive water-cement ratio, and environmental exposure further contribute to crack formation. These cracks not only reduce the durability and performance of plastered surfaces but also allow the entry of water, chemicals, and harmful agents, leading to corrosion, dampness, and structural deterioration over time.

As a result, maintenance and repair costs increase significantly, especially in long-term applications. Therefore, it is necessary to develop improved cementitious plaster that can control crack formation and enhance the service life of buildings. The use of advanced materials and innovative techniques, such as self-healing mechanisms, can help in automatically repairing minor cracks and maintaining structural integrity. This not only improves the strength and durability of plaster but also reduces the need for frequent repairs, making construction more economical and sustainable.

III. METHODOLOGY

Research Methodology

Research methodology refers to the systematic procedure adopted to carry out the experimental work and achieve the objectives of the study. In this project, the methodology was designed to develop a cementitious plaster with improved crack resistance and enhanced performance compared to conventional plaster.

The study involved several stages, including the selection and collection of materials, preparation of plaster mix, casting of specimens, application of plaster on panels, curing of specimens, and laboratory testing. Each step was carefully planned and executed to ensure reliable and accurate results.

Initially, a conventional plaster mix was studied as a reference mix. After that, modified plaster mixes were prepared by adjusting the proportions of materials and incorporating additives to improve crack control properties. The behavior of both conventional and modified plaster was evaluated through different laboratory tests.

The experimental work was carried out in a controlled environment to maintain consistency in results. Proper measuring equipment, moulds, and testing apparatus were used during the preparation and testing of specimens.

The overall research methodology adopted in this study includes the following steps:

- Identification of research problem and objectives
- Literature review related to plaster materials and crack control techniques
- Collection and selection of suitable construction materials
- Preparation of plaster mix based on selected proportions
- Casting of test specimens and preparation of plaster panels
- Proper curing of specimens to achieve required strength
- Conducting laboratory tests to evaluate the performance of plaster

ISSN: 2581-9429
Volume 6, Issue 5, April 2026
Impact Factor: 8.2

Observation, analysis, and comparison of results

This systematic methodology helped in evaluating the performance of the developed cementitious plaster and determining its effectiveness in controlling cracks.

Start
↓
Literature Review
↓
Collection of Materials
↓
Mix Design of Cementitious Plaster
↓
Preparation of Plaster Mix
↓
Preparation of Test Specimens
↓
Application of Plaster on Panels
↓
Curing of Specimens
↓
Testing of Specimens
↓
Analysis of Results
↓
Conclusion

Collection of Materials

The quality of materials used in plaster preparation plays a crucial role in determining the strength, durability, and crack resistance of the plaster. Therefore, all the materials required for the experimental work were collected from reliable sources and tested for quality before use.

The main materials used in the preparation of cementitious plaster include cement, sand, water, and additional materials used to improve crack control properties.

DOI: 10.48175/568

Cement

Ordinary Portland Cement (OPC) was used as the primary binding material in the plaster mix. Cement acts as the main ingredient responsible for the strength and binding of plaster. It reacts with water through a process known as hydration, which results in the formation of a hard and durable material.

The cement used in this study was fresh, free from lumps, and stored in a dry environment to prevent moisture absorption.

Fine Aggregate (Sand)

Sand is used as a fine aggregate in plaster to provide volume, improve workability, and reduce shrinkage. The sand used in this project was clean, well-graded, and free from organic impurities, clay, and dust particles.

Proper grading of sand helps in achieving a smooth plaster finish and reduces the chances of cracks.

Water

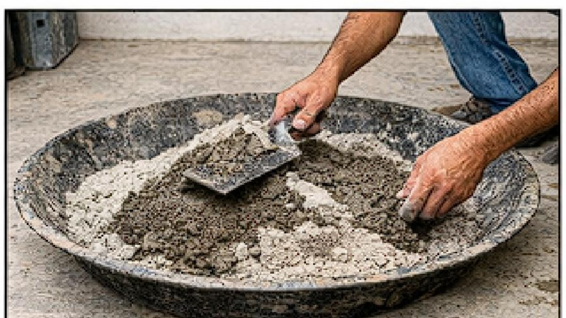
Clean potable water was used for mixing and curing of plaster specimens. Water plays an important role in the hydration process of cement and affects the workability of the plaster mix.

The quality of water used was free from harmful chemicals, oils, and impurities that could affect the strength and durability of plaster.

Additives

Certain additives were included in the plaster mix to improve crack resistance and enhance the overall performance of the plaster. These additives help in controlling shrinkage, improving bonding, and reducing the chances of crack formation.

All the materials were stored properly in the laboratory to maintain their quality before use.



Mix Type	Cement	Sand	Water Cement Ratio
Conventional Mix	1	4	0.50
Modified Mix	1	4	0.45 – 0.50

Preparation of Plaster Mix

The plaster mix was prepared using cement, sand, water, and selected additives in predetermined proportions. A conventional cement mortar mix proportion of **1:4 (cement : sand)** was used as the base mix.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 5, April 2026
Impact Factor: 8.2

The dry materials were first mixed thoroughly to achieve uniform distribution. After dry mixing, the required quantity of water was added gradually while mixing continuously until a homogeneous and workable plaster mix was obtained. In mixes containing additives, the additive materials were measured accurately and mixed uniformly with the dry ingredients before adding water. Proper mixing ensured consistency and uniformity in the plaster composition.

The following procedure was adopted during the preparation of plaster mix:

The required quantities of cement and sand were measured using weighing equipment.

Cement and sand were dry mixed thoroughly on a clean mixing platform until a uniform color was obtained.

The selected additives were added to the dry mixture and mixed evenly.

Water was gradually added to the mixture while continuously mixing.

The mixing process was continued until a homogeneous and workable plaster mix was obtained.

Proper mixing ensured uniform distribution of materials and prevented segregation in the plaster mix.

The prepared mix was used immediately after mixing to avoid loss of workability and premature setting.

Preparation of Test Specimens

Test specimens were prepared to evaluate the strength and performance characteristics of the plaster. Proper preparation of specimens is necessary to obtain accurate and reliable test results.

The specimens were prepared using moulds of standard size. Before casting, the moulds were cleaned properly and coated with a thin layer of oil to prevent the plaster from sticking to the mould surface.

Sr. No	Specimen Type	Size	Number of Specimens
1	Cubes	70.6 mm × 70.6 mm × 70.6 mm	3
2	Plaster Panels	300 mm × 300 mm	2

Casting Procedure

The prepared plaster mix was placed into the moulds in layers.

Each layer was compacted properly to remove air voids and ensure proper bonding.

The moulds were filled completely with the plaster mix.

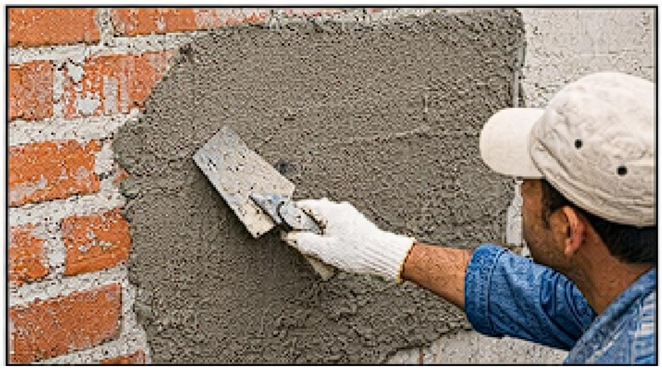
The top surface was leveled using a trowel to obtain a smooth finish.

The specimens were kept undisturbed for 24 hours to allow initial setting of the plaster.

After casting, the specimens were kept undisturbed for approximately **24 hours** to allow initial setting. Once hardened, the specimens were carefully removed from the moulds and prepared for curing.

Application of Plaster on Panels

In addition to specimen casting, the plaster mix was also applied on prepared masonry or concrete panels to simulate actual plastering conditions.The panel surfaces were first cleaned and moistened to ensure proper bonding between the plaster and the base surface. The plaster was then applied uniformly using a trowel to the desired thickness.



Procedure for Plaster Application

The panel surface was cleaned to remove dust, dirt, and loose particles.
The surface was slightly wetted with water to improve adhesion.
The prepared plaster mix was applied uniformly on the surface using a trowel.
The thickness of the plaster layer was maintained uniformly across the panel.
The plaster surface was finished smoothly using finishing tool.
Proper finishing was done to achieve a smooth surface. The panels were then kept under controlled conditions for observation of crack formation and performance of the plaster.

Curing of Specimens

Curing is a very important process in cement-based materials, as it ensures proper hydration of cement and helps in achieving the desired strength and durability.
After removing the specimens from the moulds, they were placed in a curing tank filled with clean water.

Specimen	Curing Method	Duration
Cube Specimens	Water Curing	7 Days
Cube Specimens	Water Curing	28 Days
Plaster Panels	Moist Curing	7 Days

ISSN: 2581-9429
Volume 6, Issue 5, April 2026
Impact Factor: 8.2

Curing Procedure

The specimens were demoulded after 24 hours of casting.

The specimens were immersed completely in a water curing tank.

The curing process was maintained for different time periods such as 7 days and 28 days.

The temperature and cleanliness of the curing water were maintained properly.

Proper curing prevented rapid drying of plaster and reduced the chances of shrinkage cracks.

Testing Procedures

After curing, the plaster specimens were subjected to various laboratory tests to evaluate their mechanical properties and crack resistance performance.

These tests were conducted using standard testing procedures and equipment available in the laboratory.

Sr. No	Test Name	Purpose
1	Compressive Strength Test	Determine strength of plaster
2	Workability Test	Check ease of application
3	Water Absorption Test	Evaluate durability
4	Crack Observation Test	Study crack formation

Compressive Strength Test

The compressive strength test was conducted to determine the load-carrying capacity of the plaster specimens. The specimens were placed in a compression testing machine and load was applied gradually until failure occurred.

Workability Test

The workability of the plaster mix was evaluated to determine the ease of mixing, placing, and finishing of the plaster.

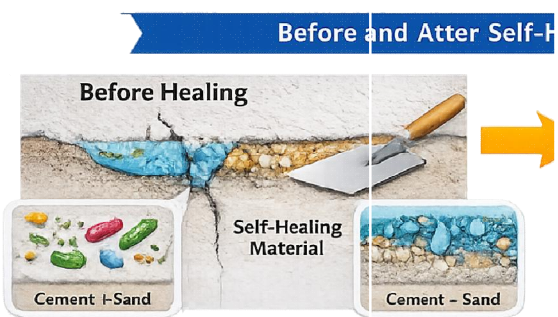
Crack Observation Test

The plaster panels prepared during the experiment were observed carefully to identify the formation of cracks. The size, pattern, and number of cracks were recorded and compared with conventional plaster.

Water Absorption Test

This test was conducted to evaluate the durability and permeability of the plaster. The specimens were immersed in water and the amount of water absorbed was measured.

The results obtained from these tests were recorded and analyzed to assess the effectiveness of the cementitious plaster with enhanced crack control properties.



Analysis

The results indicate that plaster containing *Bacillus subtilis* exhibits superior crack-healing ability due to the formation of calcium carbonate, which helps in sealing micro-cracks effectively. This self-healing mechanism enhances the overall performance of the plaster.

DOI: 10.48175/568

Additionally, the modified plaster shows improved compressive strength, reduced water absorption, and enhanced durability compared to conventional plaster. It is also observed that achieving proper mix proportions is essential to obtain optimum performance and maximum efficiency of the self-healing properties.

IV. CONCLUSION

Self-healing cement plaster using MICP is effective in repairing cracks and improving durability. It is cost-effective, eco-friendly, and suitable for low-cost and rural construction. This method reduces maintenance and increases the lifespan of structures. Additionally, it helps in reducing water penetration and prevents further deterioration of the structure. The use of materials like fly ash also supports waste utilization and sustainable construction practices. Overall, this technique provides a reliable and innovative solution for long-lasting and resilient buildings.

V. ACKNOWLEDGMENT

The authors sincerely express gratitude to the Research and Development (R&D) Cell of Guru Gobind Singh Polytechnic, Nashik for their continuous encouragement, guidance, and for providing the necessary infrastructural facilities and resources to successfully complete this project. The materials used in this project were selected and handled using the facilities provided by the institute.

The experimental work, including specimen preparation and testing, was carried out using laboratory equipment such as Compression Testing Machine (CTM), weighing balance, measuring cylinder, mixing tray, cube moulds, trowel, Vernier caliper, water curing tank, and oven available at Guru Gobind Singh Polytechnic, Nashik. The results and discussion are based on the observations and data obtained from experiments conducted using these facilities.

REFERENCES

[1]. 1 Achal, V., Mukherjee, A., & Reddy, M. S. (2011). Microbial concrete: Way to enhance durability of building structures. *Journal of Materials in Civil Engineering*.

[2]. De Muynck, W., De Belie, N., & Verstraete, W. (2010). Microbial carbonate precipitation in construction materials: A review. *Ecological Engineering*.

[3]. Jonkers, H. M. (2011). Bacteria-based self-healing concrete. *Heron Journal*.

[4]. IS 1661:1972 – Code of Practice for Application of Cement Plaster.

[5]. IS 4031 – Methods of Physical Tests for Hydraulic Cement.

[6]. Neville, A. M. (2011). *Properties of Concrete* (5th Edition). Pearson Education.

[7]. Mehta, P. K., & Monteiro, P. J. M. (2014). *Concrete: Microstructure, Properties, and Materials*. McGraw-Hill Education.

[8]. Relevant research articles and journals on self-healing concrete and MICP technology.