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Experimental Study On Enhancing Properties Of Plaster Using Natural Material

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ABSTRACT

This study focuses on improving the properties of lime plaster by adding molasses and sticky rice paste. Lime plaster is known for being durable and flexible, with durability being its most remarkable property, making it highly useful for wall surface preservation. The addtion of molasses and sticky rice paste has been shown to enhance its performance, particularly in terms of compressive strength and workability. Workability tests were conducted on fresh lime plaster, while compressive strength tests were carried out on 7-day cured cubes prepared with these organic additives. Lime, sticky rice, and molasses together play a vital role in improving the quality of plastering material, while also reducing construction costs and carbon emissions. Since these are eco-friendly and non-toxic materials, they pose no harm to humans or the environment. Overall, the inclusion of organic binders makes lime plaster more sustainable and efficient for construction use.

Keywords — Lime Plaster, Stick rice paste, Molasses, Workability, Compressive Strength, environment friendly.

1. INTRODUCTION

Plaster has been one of the oldest construction materials, traditionally made from lime, sand, and water, and applied as a protective and decorative coating for walls and ceilings. Its properties of durability, breathability, flexibility, and autogenous healing made it widely used in historic structures across the world [7]. Lime plaster, unlike cement plaster, can resist cracking and repair micro-cracks naturally, thereby enhancing service life [8]. However, plaster is prone to defects such as cracks, debonding, blistering, and lack of hardness if not properly formulated or applied.

Recent research emphasizes the role of organic additives in enhancing plaster properties. Historical evidence from China demonstrates that sticky rice mortar, an organic–inorganic composite of lime and rice, provided exceptional durability, adhesive strength, toughness, and waterproofing. This technology contributed

significantly to the longevity of structures such as the Great Wall and ancient temples [5][13]. Sticky rice enhances water retention, setting control, and bonding capacity, making lime mortar more resilient [4].

Similarly, molasses, a by-product of sugar manufacturing, has been explored as an economical and eco-friendly admixture. Studies confirm that molasses can act as a retarder, mild plasticizer, and binding agent, improving fluidity, extending setting time, and enhancing compressive strength of mortar and concrete [1][2][3]. Further research also demonstrated that molasses increases workability and strength in structural concrete without adverse durability effects [11].

The integration of molasses and sticky rice paste into lime plaster thus presents a sustainable approach to improve its workability, compressive strength, and durability while reducing reliance on cement-based plaster. This eco-friendly modification aligns with modern needs for cost-effective and environmentally responsible construction materials.

Table 1.1 Literature Review

Material	Research Findings	Research Gap
Molasses	Natural molasses acts as a retarder, mild plasticizer, and viscosity enhancer. It increases workability and improves compressive strength at later ages, offering a cost-effective substitute for chemical admixtures [1][2][3][10][11].	Limited studies on its long-term durability in plaster applications; effect on microstructure at varying dosages requires further research.
Sticky Rice	Sticky rice addition improves adhesive strength, toughness, and water resistance in lime mortar. It contributes to bio-mineralization by integrating with calcite crystals, creating durable mortars used in ancient Chinese structures [4][5][6][12][13][14].	Research mainly focused on historical conservation; fewer studies on modern construction applications and optimized mix proportions.
Lime Mortar with Organic Additives	Combining lime with organic materials like sticky rice, jaggery, and natural fibers enhances mechanical properties, water retention, and sustainability. Eco-friendly alternative to cement mortar [7][8][9][12].	Lack of standardized guidelines for mix design; performance under varied climatic conditions still needs validation.
Historical Mortars	Traditional mortars such as lime, gypsum, and lime-pozzolana showed long-term durability in	Need for more experimental reproduction to adapt historical knowledge to

	heritage structures, maintaining aesthetic and mechanical integrity [8][9].	modern-day plastering materials.
Composite Organic-Inorganic Mortars	Sticky rice–lime mortars act as organic–inorganic composites with high bonding and durability. SEM studies show nano-calcite integration improving strength and compactness [4][13][14].	Applications mostly restricted to small-scale or conservation work; scalability for modern construction remains underexplored.

2. METHODOLOGY

2.1 Material used

Lime – Lime containing small quantities of silica, alumina, and iron oxide in chemical combination with calcium oxide was used. This type of lime has the property of setting and hardening under water as per *IS 1661:1972*. The lime used had a specific gravity of 2.4 and a fineness of 3000 cm²/g.

Fig. 2.1 Lime

Sand – Natural River sand passing through a 2.36 mm sieve was used, tested as per *IS 2386*. The specific gravity of the sand was found to be 2.453.

Sticky Rice Paste – Indrayani, a medium-grain native variety of rice grown mainly in the western region of Maharashtra, was used. The rice was boiled and then ground in a mixer to form a sticky paste, which served as an organic additive in the plaster mix.

Fig. 2.2 Sticky Rice Paste

Molasses – Blackstrap molasses, a dark and viscous by-product obtained from the sugar manufacturing process, was used. It contains residual sugars along with minerals such as calcium, magnesium, iron, and manganese. Sugarcane molasses for this study was procured from *Ashok Sahakari Sakhar Karkhana, Ashoknagar, Tal–Shrirampur, Dist.–Ahmednagar*.

Fig. 2.3 Molasses

2.2 Proportions

Proportion 1: -

Table no. 2.1 Mix proportion 1:3 (Lime:sand)

Combination	Proportion	No. of Cubes	Lime (kg)	Sand (kg)	Molasses (ml)	Sticky Rice Paste (ml)
1	1:3	3	0.60	5.31	15	50
2	1:3	3	0.60	5.31	25	60
3	1:3	3	0.60	5.31	35	70

Proportion 2: -

Table no. 2.2 Mix Proportion 1:1.5 (Lime:sand)

Combination	Proportion	No. of Cubes	Lime (kg)	Sand (kg)	Molasses (ml)	Sticky Rice Paste (ml)
1	1:1.5	3	1.92	1.42	50	100
2	1:1.5	3	1.92	1.42	75	200
3	1:1.5	3	1.92	1.42	100	300

2.3 Casting of Cubes

2.3.1 Casting of cubes with Proportion 1:3

1. Allocation of raw material like Lime, sand, sticky rice paste & molasses.
2. I have casted cubes in 3 combinations, 3 cubes for each combination means total 9 cubes casted.
3. For every combination quantity of lime and sand is constant but quantity Molasses and
4. lime is varying in every combination. (quantities are mentioned in the table no 1 & 2).
5. Mix proportion is 1:3 with water cement ratio 0.40.
6. After combining all of the dry ingredients, add the water, molasses and sticky rice paste.

7. Casted the cubes of 7.02cm X 7.02cm X 7.02cm.
8. After 24 hours of setting, remove cubes from moulds.
9. Curing is not required.

Fig. 2.4 Cubes made with proportion 1:3

2.3.2 Casting of cubes with Proportion 1:1.5

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7. Casted the cubes of 7.02cm X 7.02cm X 7.02cm.
8. After 24 hours of setting, remove cubes from moulds.
9. Curing is not required.
10. After 7 days of setting compressive strength is conducted on cubes.

Fig. 2.5 Cubes made with proportion 1:1.5

2.4 Testing on Fresh Plaster Mix

2.4.1 Workability – Flow Table Test

Objective: - To determine the fluidity of plaster. This also indicates the workability or consistency of the plaster mix.

Apparatus: - Flow Table 1. Balance, 2. Container, 3. Flow table 4. Mould 5.Tamping rod

Test Procedure: -

i. Before starting the test, wet and clean the tabletop and the mould from gritty materials.
ii. Keep the mould firmly at the centre of the table.
iii. Now fill plaster mix in two-layer, each layer should be one half of the volume of the mould.
iv. Tamp each layer 25 times using a tamping rod uniformly.
v. After tamping the top layer, struck off the excess plaster mix using the trowel.
vi. Also, clean the area of the table outside the mould.
vii. Then remove the mould immediately by steady upward pull.
viii. Raise the table and drop at 12.5 mm, 25 times in 15 seconds.
ix. Measure the diameter of the concrete spread about its 6 direction and compute its mean value.

Fig. 2.6 Flow Table test setup

Fig. 2.7 Flow of Lime Plaster

Fig. 2.8 Flow Table Apparatus

2.5 Testing on Cubes

2.5.1 Compressive Strength Test

Objective: – To determine compressive strength of cube

Apparatus: – Compression Testing Machine

Test Procedure: -

i. Prepare the Cubes with determined Proportion of Plaster mix of size 7.02cm X 7.02cm X 7.02cm

ii. Remove the specimen from the mould after 24 hours of setting time.

iii. Take the dimension of the specimen to the nearest 0.2m

iv. Clean the bearing surface of the testing machine

v. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.

vi. Align the specimen centrally on the base plate of the machine.

vii. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.

viii. Apply the load gradually without shock and continuously at the rate of 140 kg/cm2/minute till the specimen fails

Fig. 2.9 Compression Testing Machine

Fig. 2.10 Cube placed in CTM

Fig. 2.11 Cubes failed under compression

3. RESULT AND DISCUSSION

3.1 Result of Workability test

Test on fresh Plaster Mix
Proportion – 1:1.5 (Lime: Sand)

Table no. 3.1 Flow table test results

Combination	Proportion	W/C ratio	Flow Value (%)
1	1:1.5	0.40	76%
2	1:1.5	0.40	88%
3	1:1.5	0.40	98%

3.2 Result of Compressive Strength Test

7 Days Compressive Strength Test result of Sustainable Plaster
Proportion – 1:1.5 (Lime: Sand)

Table no. 3.2 Compressive Strength test Results

Combination	Proportion	Size of Cube	Avg. Comp. Strength (N/mm²)
1	1:1.5	7.02 × 7.02 × 7.02 cm	3.3
2	1:1.5	7.02 × 7.02 × 7.02 cm	3.6
3	1:1.5	7.02 × 7.02 × 7.02 cm	4.1

3.3 Cost Analysis

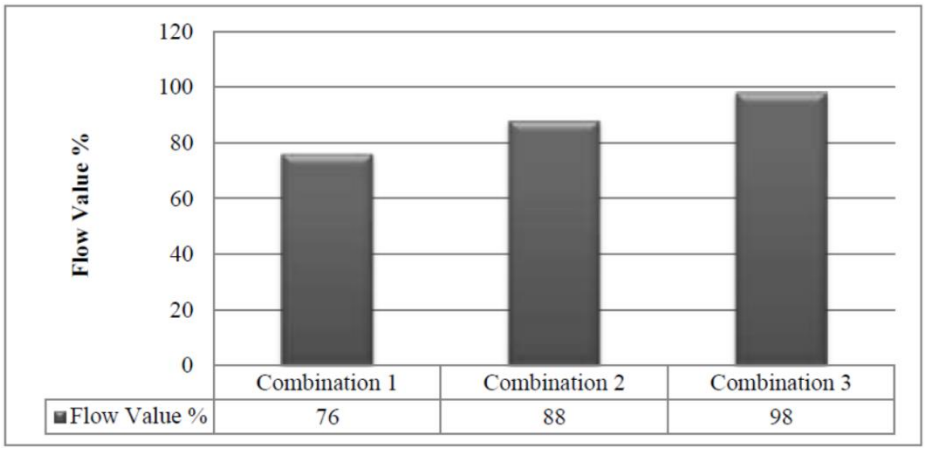
Wall Plastering Rate Analysis (Lime Plaster)

- Area = 1 sq.m
- Thickness = 12 mm
- Mix Proportion = 1:1.5 (Lime : Sand)

Table no. 3.3 Rate Analysis

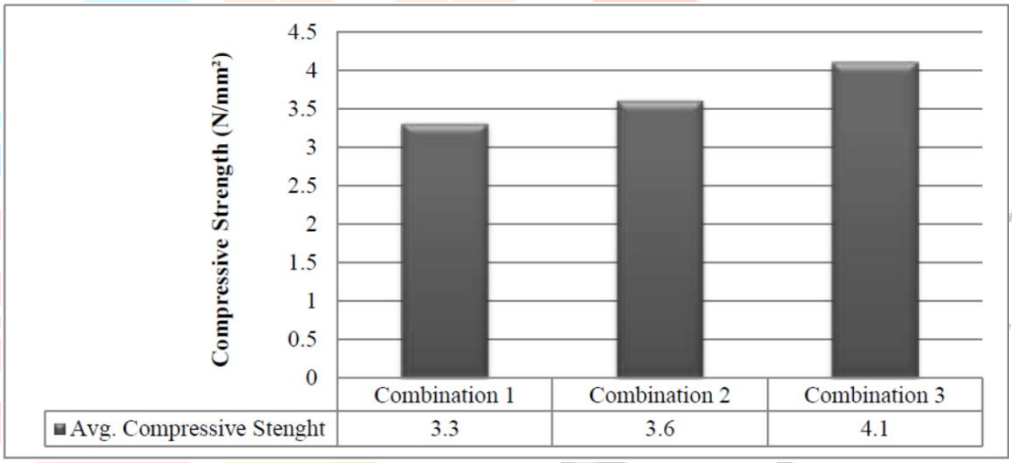
Sr. No	Description/Material	Qty	Unit	Rate	per	Amount (Rs.)
1	Lime	22.44	Bag	20	Bag	448.8
2	Sand	0.01008	Cu.m	2133	Cu.m	21.50064
3	Rice	0.38	Kg	60	Kg	22.8
4	Molasses	0.867	Lit	10	Lit	8.67
					Total	**Rs. 501**
Add 10% miscellaneous charges					Total	**Rs. 551**

3.4 Graph & Discussion



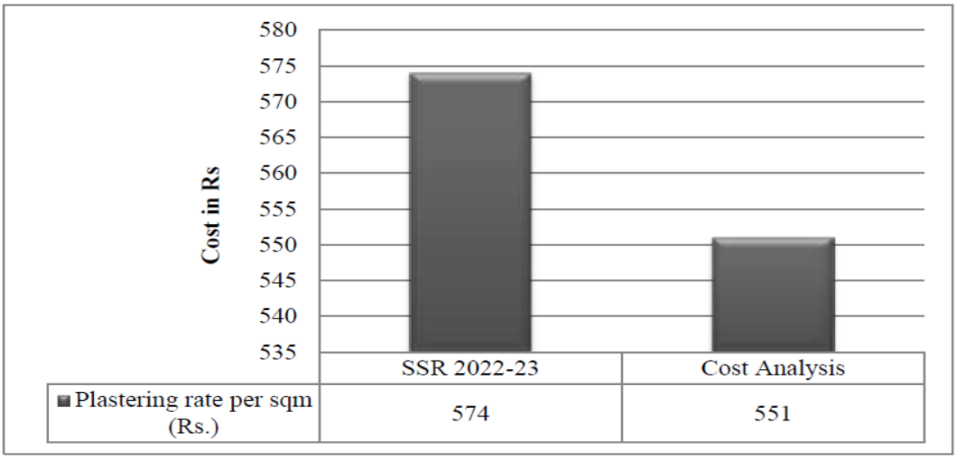
Graph no.1 - Flow Value of Plaster Mix

- Graph no. 1 Shows that Flow value i.e. workability for Combination 1, 2, 3 are **76%,88%** and **98%** respectively. Combination 3 has highest flow value
- If workability lies in between 0 to 150% that means lime plaster mix with molasses and sticky rice paste possess good workability.
- The combination's flow value increases as the amount of molasses and sticky rice paste increases.



Graph no. 2 Compressive Strength Test (N/mm²)

- Graph no. 2 shows that, 7 days Compressive strength of combination 1, 2, 3 are **3.3 N/mm², 3.6 N/mm²** & **4.1 N/mm²** respectively.
- In which Combination 3 has highest compressive strength which is **4.1 N/mm².**
- The compressive strength also increases with the amount of molasses and sticky rice paste.



Graph no.3 Cost Comparison of Cement Plaster rate with Sustainable Lime plaster

- From graph no.3 we can see that, cost of 12 mm thick 1sqm cement plaster from SSR 2022-23 is Rs.574 which is quite expensive than cost of sustainable plaster.
- The Plaster mix I prepared with addition of molasses and sticky rice paste is cost effective.

4. CONCLUSIONS

- Since cement is a dangerous building material that causes pollution, lime is the most environmentally friendly substitute for cement.
- Every ingredient used to make sustainable lime plaster is natural, organic, and fully safe for the environment and occupants.
- According to the current experimentation, lime plaster with molasses and sticky rice paste has good workability.
- This combination of sticky lime plaster, rice paste and molasses provides good compressive strength and Toughness.
- The inclusion of organic materials like molasses and sticky rice paste improves the workability and strength of lime plaster.
- Comparing the cost per square meter of plastering with a thickness of 12 mm reveals that lime plaster is less expensive than typical cement plaster.

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