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[ijerst.editor@gmail.com](mailto:ijerst.editor@gmail.com)  
[editor@ijerst.com](mailto:editor@ijerst.com)

**Research Paper****EFFECT OF ADDITION OF NATURAL ADMIXTURE ON HYDRATION AND COMPRESSIVE STRENGTH OF CEMENT****K. DASHARATHAM<sup>1</sup>, Dr. B. SIVA KONDA REDDY**<sup>1</sup>*M. Tech Student, Department of Civil Engineering, JNTUH University College of Engineering Sultanpur, Sultanpur, Choutkur, Telangana 502273*<sup>2</sup>*Professor, Department of Civil Engineering, JNTUH University College of Engineering, Hyderabad, 500085*

**Abstract** This research explores how the addition of a natural admixture influences the hydration process and compressive strength of cement mortar. Typically sourced from plants or minerals, natural admixtures are examined for their potential to modify and enhance the properties of cementitious materials, have gained attention as sustainable alternatives to chemical additives in construction materials. In this research, a selected natural admixture was blended with ordinary Portland cement mortar in varying proportions. The hydration process was monitored using standard techniques, while compressive strength was evaluated at different curing ages.

Results indicate that the inclusion of the natural admixture influenced the rate of hydration and significantly affected the mechanical performance of the mortar. Optimal dosage levels were identified where improvements in compressive strength were observed without compromising workability. The findings highlight the potential of natural admixtures in enhancing the sustainability and performance of cement-based materials.

In this study, the impact of incorporating a natural admixture at varying dosages on the compressive strength of cement mortar cubes was investigated. Results showed a consistent improvement in compressive strength with increasing admixture content, ranging from 1 ml to 5 ml. Compared to the control sample with no admixture, the strength enhancement varied from 1.46% to 18.07% at 28 days of curing and values range approximately from 24.64 (7days at 0 ML) to 55.62 (150 days at 5 ML) here is almost 5 MPa higher at 7 days and about 8.5 MPa higher at 28 days. Almost all ages, the 5 ml condition consistently yields higher strength than 0 ml.

Results showed that increasing the admixture dosage led to a rise in both chemical shrinkage and hydration degree. Notably, the degree of hydration improved by 35.42% at a 4 mL dosage compared to the control sample without admixture. Correspondingly, cement mortar cubes (70.7 × 70.7 mm) exhibited a 10.84% increase in compressive strength at the same dosage. These findings suggest that the natural admixture positively contributes to hydration kinetics and mechanical performance.

**Keywords:** Long-term performance, Natural admixtures, Cement mortar, Compressive strength, Hydration behavior, Optimal dosage and Micro structural analysis

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**1. INTRODUCTION**

This paper briefly introduces various admixtures and their functions, explains the fundamentals of cement hydration, and outlines the techniques used to analyze this process. The use of naturally sourced admixtures in cement-based mortar a method with roots in ancient construction is now being reconsidered as an eco-conscious alternative in modern building. These additives, commonly obtained from agricultural or industrial waste, play a crucial role in shaping two fundamental performance

characteristics of mortar are hydration dynamics and compressive strength.

The mechanism of concrete involves a series of **chemical and physical transformations** that begin as soon as the materials are combined. From mixing to hardening, the primary process is **hydration**, where water reacts with cement to form binding compounds. This is supported by **compaction** to eliminate air gaps and **curing** to maintain moisture, all of which contribute to the concrete's eventual strength and durability. Concrete is a synthetic building material formed by blending cement, water,

fine aggregates such as sand, and coarse aggregates like gravel or crushed stone. When water is mixed with cement, a chemical process known as **hydration** occurs. This reaction causes the mixture to harden, turning it into a durable, stone-like solid that binds all components together.

### 1.1 Objectives of the study

The main focus of such studies is to assess whether a particular natural admixture can serve as an environmentally sustainable and cost-effective element in cement mortar without diminishing its vital characteristics.

Researchers investigate how the admixture affects critical performance metrics of the mortar, starting with its impact on cement hydration. This includes examining whether the admixture alters the initial and final setting times, and analyzing its effect on the heat released during the hydration reaction information that is particularly important in contexts like mass concrete where thermal control is essential.

A second critical goal of this research is to examine how natural admixtures affect the mortar's ability to bear compressive loads. The study investigates how varying amounts of a natural admixture influence compressive strength at different curing times. Specifically, it measures strength performance across dosage levels and through distinct curing periods.

This study aims to evaluate the compressive strength of cement mortar cubes without any admixtures and compare them with cubes containing varying dosages of a natural admixture, assessing the strength at different curing durations.

## 2. Literature Reviews

**Hersh F. Mahmood et al:**In their 2021 study, explored the impact of using natural plant-based extracts, specifically from grapes and mulberries, as eco-friendly admixtures in concrete. The study observed that the incorporation of grape and mulberry extracts led to notable improvements in workability, indicating that the concrete mix became easier to handle and place.

**Goyal et al. (2019):**In a study conducted by Goyal et al. (2019), the researchers investigated the effects of using rice water and jaggery water as natural admixtures in cement mortar. The results demonstrated a notable improvement in

compressive strength, with gains reaching up to 15% compared to control specimens. This enhancement was particularly evident in samples that underwent extended curing beyond 21 days, suggesting that the beneficial effects of these natural admixtures become more pronounced over time.

**Anneaquilina and Ruben Paul burg,-2018 :**In their 2018 research, Anne Aquilina and Ruben Paul Burg examined the effects of using Opuntia Ficus extract, derived from a type of cactus, as a natural admixture in cement-based materials. The study concluded that while Opuntia Ficus extract is not suitable for applications requiring high early strength, its retarding properties make it potentially valuable in scenarios where delayed setting is desirable, such as in hot climates or during long transport times for ready-mix concrete.

## 3. Methodology

The methodology section delineates the systematic approach employed to address the research objectives. It encompasses a detailed description of the materials, procedures, and analytical techniques utilized throughout the study. This section serves to elucidate the rationale behind the chosen methods, thereby enabling the research process to be replicated in future investigations. By providing a transparent account of the research design, the methodology ensures the reliability and validity of the study's findings.

### Compressive strength

Compressive strength refers to the ability of cement-based materials like concrete and mortar to withstand forces that press or squeeze them. It represents the highest pressure a material can handle per unit area before breaking or becoming excessively deformed.

In construction and civil engineering, this property is vital for assessing the reliability and performance of structural components. It is especially important in elements like

foundations, columns, and beams that are regularly subjected to heavy loads.

Several factors influence the compressive strength of cement and concrete. These include the type of cement used, the water-to-cement ratio, and the curing process. Aggregate properties and the compaction of concrete also the reason. Additionally, strength typically increases over time, which is why standard tests are often done at intervals like 3, 7, and 28 days.



Testing of cube specimen

#### **Methodology to determine the rate of hydration by chemical shrinkage method:**

The Study of Cement Hydration kinetics can be done in one of the following ways

- Chemical Shrinkage
- Isothermal Calorimetry
- Chemical Shrinkage procedures conforming to ASTM C 1608 Standards were followed in conducting tests for the Thesis
- Chemical Shrinkage is defined as “the absolute (internal) volume change accompanying the hydration of cement, due to the fact that the cement hydration products occupy less physical volume than the reactants.”

#### **Methods for Measuring Degree of Hydration:**

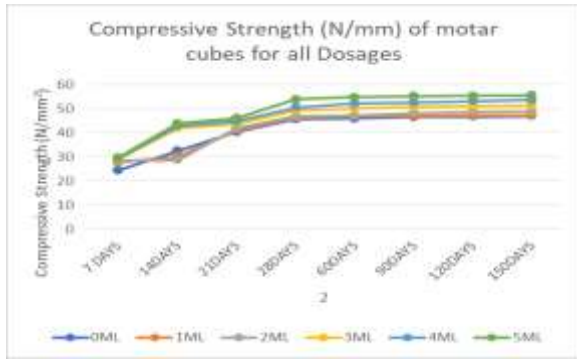
- The degree of hydration refers to the extent to which cement has reacted with water over time. It is typically expressed as the fraction of cement that has

undergone hydration compared to the total amount available.

- Several methods can be used to assess this, including:
- X-ray Diffraction (XRD): This technique identifies and quantifies the unreacted cement minerals remaining in the paste, helping to estimate how much hydration has occurred.
- Loss on Ignition (LOI): This method measures the amount of chemically bound water in the hydrated cement paste. A higher bound water content generally indicates a higher degree of hydration.
- Isothermal Calorimetry: This involves measuring the heat released during hydration. The total heat produced up to a certain time is compared with the theoretical heat for full hydration, providing a direct estimate of hydration progress.
- Chemical Shrinkage Measurement: As hydration progresses, volume changes (shrinkage) occur. Monitoring this shrinkage over time allows calculation of the hydration degree as a ratio of the shrinkage at a given time to the total expected shrinkage.
- Le Chatelier’s Shrinkage: This method assesses early-age volume changes in the paste, which correlate with hydration progress.
- Compressive Strength Development: Although not a direct or fully accurate measure, the increase in compressive strength over time can indicate hydration progress. However, strength is also influenced by other factors such as mix design, curing conditions, and material quality.

## **4. Results and Analysis**

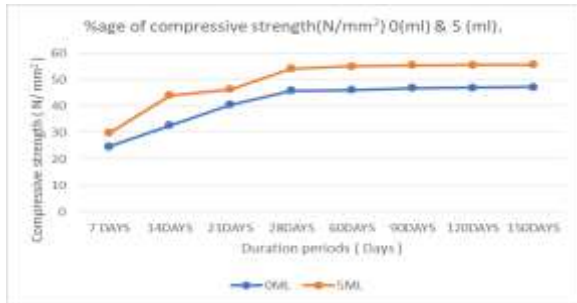
### **COMPRESSIVE STRENGTH (N/mm<sup>2</sup>) OF MOTAR CUBES OF ALL DOSAGES:**



Comparison of compressive strength of motar cubes

- **Increasing Trend with Days:** For each volume (0ML to 5ML), the values generally increase as the number of days increases.
- **Increasing Trend with Volume:** For each day interval, the values tend to increase as the volume increases from 0ML to 5ML.
- **Values Range:** Values range approximately from 24.64 (7 days at 0ML) to 55.62 (150 days at 5ML).

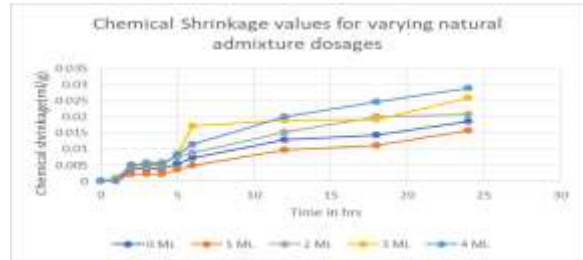
**COMPRESSIVE STRENGTH (N/mm<sup>2</sup>) DIFFERENCE BETWEEN 0ML & 5ML**



**Strength Development Over Time:**

- At 0 mL, strength grows steadily from ~24.6 MPa at 7 days to ~47.2 MPa by 150 days.
- At 5 mL, the progression is from ~29.8 MPa to ~55.6 MPa over the same period.
- Across all ages, the 5 mL condition consistently yields higher strength than 0 mL  
Eg: Almost **5 MPa higher at 7 days** and about **8.5 MPa higher at 28 days**.
- At 7 days increasing percentage in strength over 0 ml to 5 ml is 20.98%.
- At 28 days increasing percentage in strength over 0 ml to 5 ml is 18.14%.
- At 150 days increasing percentage in strength over 0 ml to 5 ml is 17.96%.

**CHEMICAL SHRINKAGE VALUES AT DIFFERENT DOSAGE OF ADMIXTURE**



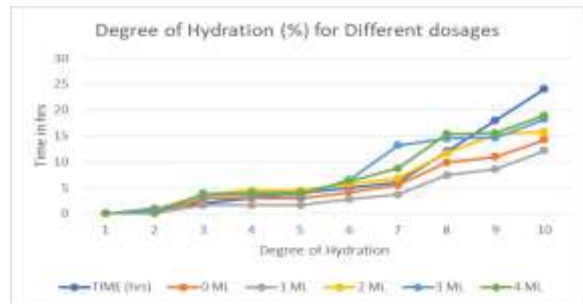
**Early hours (up to 6h):** Chemical shrinkage begins modestly by hour 2 it's already noticeable (e.g., 0.00385 mg/g in the 0 mL sample), rising steadily through the first few hours.

**Mid to late phase (12–24h):** Shrinkage values nearly double or triple (e.g., 0.01847 mg/g at 24h for 0 mL), matching known behavior where chemical shrinkage continues to develop well into the first day

Across time intervals, higher water additions tend to yield greater shrinkage. For instance, at 24 hours:

- **0 mL:** 0.01847 mg/g
- **4 mL:** 0.02886 mg/g.

**DEGREE OF HYDRATION (%) VALUES AT DIFFERENT DOSAGES OF ADMIXTURE**



- Hydration starts swiftly within **1 hour**, even minimal differences appear.
- (Eg: 0.74 for 2 mL and 0.59 for 3 mL).
- By the **2–6 hour** window, hydration ramps up especially notable at the 3 mL level (13.17 by hour 6).
- Hydration continues growing rapidly. By **12 hours**, values range from about **7.4 to 15.4**, depending on admixture.
- After **18 hours**, the values generally rise further, though growth starts to slow.

- The hydration degree reaches its peak in this dataset: **14.2** at 0 mL versus **18.94** at 4 mL.

## 5. Conclusions

The cement's consistency was measured, and the fine aggregates were sorted through sieving. Subsequently, compressive strength tests were performed on mortar cubes containing different amounts of natural admixture to evaluate their strength.

1. The standard consistency value of cement is 33%.
2. The compressive strength of cement mortar cubes at 7days, 28days and 150 days for 0ml and 5ml are 24.64 – 29.81, 45.75 - 54 and 47015 – 55.62 MPa respectively.
3. There is increase in compressive strength from 1.46% to 18.07% for 1ml to 5ml of admixture dosages respectively about 28 days.
4. At 7 days percentage increase in strength over 0 ml to 5 ml is 20.98%.At 28 days percentage increase in strength over 0 ml to 5 ml is 18.14%.At 150 days percentage increase in strength over 0 ml to 5 ml is 17.96%.
5. Tests conducted with varying dosages from (1ml to 5ml) showed a clear trend that strength increased as the amount of admixture increased.
6. The most notable improvement was observed at a dosage of 5ml, where the compressive strength reached 54 N/mm<sup>2</sup> with 18.07% increase in strength compared to the mix without any admixture.
7. For w/c=0.4, the chemical shrinkage values for ml addition of Natural admixture in the cement paste are 0.06907, 0.07696, 0.09697 and 0.10005 mL/g respectively.
8. For w/c=0.4, the degree of hydration 1,2,3and 4ml for addition of Natural admixture in 53.1% and 59.18 % cement paste are ,74.57% and 76.93% respectively
9. At a water-to-cement ratio of 0.4, the degree of hydration increased by 35.42% when using 4 ml of admixture compared to the mix without any admixture.
10. Also, the Degree of hydration follows the same trends as Chemical Shrinkage

The results indicate that the inclusion of a natural admixture in the cement paste leads to an increase in both chemical shrinkage (at the micro level) and the

degree of hydration. Similarly, the compressive strength (at the macro level) of mortar cubes and concrete shows a corresponding improvement. Specifically, the compressive strength of mortar cubes with 4 mL of admixture increased by 10.84% compared to those without admixture.

This experimental study clearly demonstrates that natural admixtures can effectively boost the compressive strength of cement mortar.

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