

[doiglobal.org/doi/10.2025/6847dc9c48ee4](https://doi.global.org/doi/10.2025/6847dc9c48ee4)

AN EXPERIMENTAL INVESTIGATION ON HEMP FIBER CONCRETE WITH DOLOMITE NAD METAKAOLIN

¹DR.K.CHANDRAMOULI, ²J.SREE NAGA CHAITANYA, ³K.DIVYA, ⁴CHALLA GOPI KRISHNA

¹Professor & HOD, ^{2,3} Assistant Professor, ⁴ B. Tech Student

^{1,2,3,4} Department of Civil Engineering, NRI Institute of Technology, Visadala (V), Medikonduru (M), Guntur, Andhra Pradesh, INDIA.

Email: koduru_mouli@yahoo.com jarugumillichaitanya1989@gmail.com

ABSTRACT

In addition to partially replacing cement with dolomite and metakaolin, this study examines the performance of concrete that contains hemp fibers as an additive. The purpose of the study is to assess these modified concrete mixtures' mechanical qualities. According to preliminary research, adding hemp fiber to concrete may improve its tensile strength and ductility. As cement alternatives, dolomite and metakaolin exhibit promise in enhancing durability and mitigating environmental effects. The possibility for creating high-performance and sustainable concrete materials is highlighted in this abstract. The best replacement ratios and their combined impacts will be examined in further detail. The goal of the inquiry is to support more environmentally friendly building techniques. Test for compressive strength and split tensile strength for 28, 56 and 90 days.

KEYWORDS: Met kaolin, Dolomite, Hemp Fibber, High-performance, Compressive strength, Split tensile strength

1. INTRODUCTION

Concrete, a synthetic material that resembles rock, is the most widely used building material in the world in terms of volume. Its composition is primarily composed of cement, water, and fine and coarse aggregates; admixtures are commonly used to alter its properties. Concrete's allure stems from the hydration process, in which cement and water react chemically to form a solid, binding paste that envelops the particles. This paste hardens and strengthens with time, producing a composite that is durable and versatile. Its widespread use can be attributed to its exceptional compressive strength, fresh moldability, and affordable price. The foundation of modern infrastructure is concrete, which has an impact on the built environment all over the world through everything from enormous bridges and tall skyscrapers to ordinary pavements and house foundations.

The chemical formula for dolomite, an anhydrous carbonate mineral, is $\text{CaMg}(\text{CO}_3)_2$. Additionally, it is the name of a sedimentary rock called dolostone that is primarily made of this mineral. Often referred to as dolomitic limestone, it is created when calcium carbonate, or limestone, partially or completely changes through a process known as dolomitization, which usually involves fluids high in magnesium. Dolomite is distinguished for its variety of hues, hardness, and durability. It is widely used as a filler in a variety of building products, as well as an aggregate and in the manufacturing of cement. It is a useful resource in numerous industries due to its special qualities.

Kaolin clay is calcined to produce metakaolin, a highly reactive pozzolanic substance. Purified kaolinite is heated to precise temperatures, usually 600–800°C, throughout this production process. This dehydroxylates the clay and turns it into an amorphous aluminosilicate. Metakaolin, in contrast to industrial by-products, is designed to function well in cementitious systems. It can absorb calcium hydroxide generated during cement hydration and form more compounds that contribute to strength because of its smaller particle size and strong reactivity. Because it increases strength, longevity, and resistance to chemical attack, metakaolin is highly prized in concrete. Additionally, it makes finished concrete lighter in color and less permeable.

As a "green" substitute for traditional synthetic fibers, hemp fibers are being investigated more and more as a sustainable reinforcement in concrete. Natural lignocellulosic fibers with a low density and good tensile strength are derived from the *Cannabis sativa* plant. Hemp fibers can improve the flexural strength and ductility of concrete, reducing the brittleness of conventional concrete. By more efficiently spreading stress and bridging microcracks, they also help to increase crack resistance. Additionally, by absorbing and gradually releasing water, hemp fibers can facilitate internal curing, which is advantageous for concrete hydration. This makes the concrete composite more environmentally friendly and possibly more effective.

2. OBJECTIVES

1. To examine how well dolomite works as a partial substitute for cement in concrete mixtures, with an emphasis on how it affects tensile and compressive strength.
2. To use metakaolin's pozzolanic activity to assess how it affects concrete's early and long-term compressive strength when used as a partial cement substitute.
3. To look at how hemp fibers can improve concrete's resistance to cracking and post-cracking behaviour.

3. MATERIALS

3.1 Cement: Cement is a finely powdered binding substance that solidifies to bond aggregates such as gravel and sand when combined with water. Strong, long-lasting materials like concrete and mortar are produced by this technique. Cement, which is mostly composed of clay, limestone, and other minerals, is essential to the durability and stability of infrastructure and buildings.

3.2 Fine aggregate: Small particles that fit through a 4.75 mm filter make up fine aggregate, which is usually sand or broken stone. It is essential for filling in the spaces between bigger coarse aggregate particles in mortar and concrete, which increases the density and workability of the mixture.

3.3 Coarse aggregate: Larger particles, such as crushed stone or gravel, are retained on a 4.75 mm sieve to form coarse aggregate. This substance gives concrete mixtures bulk, strength, and longevity by serving as their structural core. It greatly improves a structure's overall stability and load-bearing capacity.

3.4 Water: In many construction operations, such as mixing cement, making mortar, and curing concrete, water is

an essential ingredient. The strength and durability of cement concrete and mortar are directly impacted by water quality, which also affects the overall performance of the completed structure.

3.5 Dolomite Powder: Dolomite powder is a finely crushed substance made from dolomite rock that occurs naturally. It has the chemical formula $\text{CaMg}(\text{CO}_3)_2$, which is a double carbonate of calcium and magnesium. Because of its special chemical and physical characteristics, it is widely employed in a variety of industries, such as glassmaking, construction, and agriculture.

3.6 Metakaolin: By calcining kaolin clay at particular temperatures (600–800°C), a highly reactive pozzolanic substance known as metakaolin is produced. The clay becomes an amorphous aluminosilicate as a result of this process, which makes it a useful additional cementitious material. It greatly improves the strength, resilience to chemical assault, and durability of concrete.

3.7 Hemp fiber: Hemp fiber is a naturally occurring lignocellulosic fiber that is extracted from the stalk of the *Cannabis sativa* plant, particularly from cultivars that have very low THC levels. Textiles, paper, ropes, composites, and sustainable building materials like hempcrete are just a few of the many uses for them. They are processed by retting and decortication to remove them from the woody core.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength

The minimum compressive strength of a cube is represented as the cube of compressive strength (15 cm x 15 cm x 15 cm). The cubes are usually assessed after 28, 56 and 90 days.

Table 1: Compressive strength results of concrete with Dolomite Powder used as a partial replacement for cement.

| Sl.no | % of Dolomite Powder | Compressive Strength Results, N/mm ² | | |
|-------|----------------------|---|---------|---------|
| | | 28 days | 56 days | 90 days |
| 1 | 0% | 49.72 | 53.81 | 57.76 |
| 2 | 5% | 52.11 | 56.39 | 60.46 |
| 3 | 10% | 54.64 | 57.48 | 63.61 |
| 4 | 15% | 56.71 | 61.55 | 66.22 |
| 5 | 20% | 53.23 | 57.73 | 62.09 |
| 6 | 25% | 51.78 | 56.36 | 60.52 |

Table 2: Compressive strength results of concrete with Metkaolin used as a partial replacement for cement.

| Sl.no | % of Metakaolin | Compressive Strength Results, N/mm ² | | |
|-------|-----------------|---|---------|---------|
| | | 28 days | 56 days | 90 days |
| 1 | 0% | 49.72 | 53.81 | 57.76 |
| 2 | 5% | 52.81 | 57.23 | 61.38 |
| 3 | 10% | 55.23 | 59.84 | 64.42 |
| 4 | 15% | 57.35 | 62.29 | 67.03 |
| 5 | 20% | 54.68 | 59.44 | 63.53 |

Table3: Compressive strength of Hemp fiber concrete.

| Sl.no | % of Hemp fibers | Compressive Strength Results, N/mm ² | | |
|-------|------------------|---|---------|---------|
| | | 28 days | 56 days | 90 days |
| 1 | 0% | 49.72 | 53.81 | 57.76 |
| 2 | 0.25% | 53.28 | 57.78 | 62.04 |
| 3 | 0.5% | 55.93 | 60.71 | 65.23 |
| 4 | 0.75% | 58.97 | 64.07 | 68.92 |
| 5 | 1% | 58.33 | 63.55 | 68.18 |

Table4: Ccombined Compressive strength of concrete with 15%MK+15%Dol+0.75% HF.

| Sl.no | Combined Replacement(s) | Compressive Strength Results, N/mm ² | | |
|-------|-------------------------|---|---------|---------|
| | | 28 days | 56 days | 90 days |
| 1 | 0% | 49.72 | 53.81 | 57.76 |
| 2 | 15%MK+15%Dol+ 0.75% HF | 66.19 | 71.82 | 76.81 |

4.2 Split tensile strength

A load is applied along a horizontal cylindrical specimen until failure occurs to estimate the material's split tensile strength, which is a measurement of its resistance to tension. Better durability and resistance to cracking in concrete constructions for 28,56 and 90 days

Table 5: Split tensile strength results of concrete with Dolomite Powder used as a partial replacement for cement.

| Sl.no | % of Dolomite Powder | Split tensileStrength Results, N/mm ² | | |
|-------|----------------------|--|---------|---------|
| | | 28 days | 56 days | 90 days |
| 1 | 0% | 4.94 | 5.34 | 5.73 |
| 2 | 5% | 5.22 | 5.64 | 6.19 |
| 3 | 10% | 5.41 | 5.87 | 6.28 |
| 4 | 15% | 5.68 | 6.16 | 6.61 |
| 5 | 20% | 5.37 | 5.84 | 6.25 |
| 6 | 25% | 5.22 | 5.68 | 6.09 |

Table 6: Split tensile strength results of concrete with Metakaolin used as a partial replacement for cement.

| Sl.no | % of Metakaolin | Split tensileStrength Results, N/mm ² | | |
|-------|-----------------|--|---------|---------|
| | | 28 days | 56 days | 90 days |
| 1 | 0% | 4.94 | 5.34 | 5.73 |
| 2 | 5% | 5.27 | 5.71 | 6.11 |
| 3 | 10% | 5.49 | 5.96 | 6.38 |
| 4 | 15% | 5.83 | 6.23 | 6.86 |
| 5 | 20% | 5.38 | 5.75 | 6.25 |

Table 7: Split tensile strength of Hemp fiber concrete.

| Sl.no | % of Hemp fibers | Split tensile Strength Results, N/mm ² | | |
|-------|------------------|---|---------|---------|
| | | 28 days | 56 days | 90 days |
| 1 | 0% | 4.94 | 5.34 | 5.73 |
| 2 | 0.25% | 5.32 | 5.76 | 6.18 |
| 3 | 0.5% | 5.56 | 6.04 | 6.47 |
| 4 | 0.75% | 5.93 | 6.43 | 6.92 |
| 5 | 1% | 5.79 | 6.26 | 6.76 |

Table 8: Ccombined Split tensile strength of concrete with 15%MK+15%Dol+0.75% HF.

| Sl.no | Combined Replacement(s) | Split tensile Strength Results, N/mm ² | | |
|-------|-------------------------|---|---------|---------|
| | | 28 days | 56 days | 90 days |
| 1 | 0% | 4.94 | 5.34 | 5.73 |
| 2 | 15%MK+15%Dol+ 0.75% HF | 6.74 | 7.29 | 7.88 |

5. CONCLUSION

1. The normal concrete compressive strength results for 28, 56 and 90 days is 49.72, 53.81 and 57.76 N/mm².
2. At 15% partial replacement of cement with dolomite powder which gives compressive strength result for 28, 56 and 90 days is 56.71, 61.55 and 66.22 N/mm².
3. At 15% partial replacement of cement with metakaolin which gives compressive strength result for 28, 56 and 90 days is 57.35, 62.29 and 67.03 N/mm².
4. At 0.75% addition of Hemp Fibre to concrete then the compressive strength result for 28, 56 and 90 days is 58.97, 64.07 and 68.92 N/mm².
5. Compressive strength result for combined replacement of 15% dolomite and metakaolin for cement and 0.75% hemp fiber is addition to concrete for 28, 56 and 90 days is 66.19, 71.82 and 76.81 N/mm².
6. The normal concrete split tensile strength results for 28, 56 and 90 days is 4.94, 5.34 and 5.73 N/mm².
7. At 15% partial replacement of cement with dolomite powder which gives split tensile strength result for 28, 56 and 90 days is 5.68, 6.16 and 6.61 N/mm².
8. At 15% partial replacement of cement with metakaolin which gives split tensile strength result for 28, 56 and 90 days is 5.83, 6.23 and 6.86 N/mm².
9. At 0.75% addition of Hemp Fibre to concrete then the split tensile strength result for 28, 56 and 90 days is 5.93, 6.43 and 6.92 N/mm².
10. Split tensile strength result for combined replacement of 15% dolomite and metakaolin for cement and 0.75% hemp fiber is addition to concrete for 28, 56 and 90 days is 6.74, 7.29 and 7.88 N/mm².

6. REFERENCES

- [1]. Kaushal Prajapati, Prof. Dr. Jayant Supare, Prof. Dr. Valsson Verghese. A Review on Experimental Investigation on Strength of Concrete by Partial Replacement of Cement by Dolomite Powder, International Journal for Research in Applied Science & Engineering Technology (IJRASET), 7(4), Apr 2019.
- [2]. Sharma, R., Khan, R.A. Effect of Dolomite Powder as Partial Replacement of Cement on Strength Properties of Concrete. International Journal of Engineering Research & Technology (IJERT), 9(09), Sep 2020.
- [3]. Patel, H., Modi, J. Evaluation of Compressive Strength of Concrete by Partial Replacement of Cement with Dolomite Powder. International Journal of Scientific Development and Research (IJSDR), 5(11), Nov 2020.
- [4]. Kumar, M., Choudhary, V. Effect of Dolomite Powder on Mechanical Properties of Concrete. International Journal of Engineering Research & Technology (IJERT), 10(04), Apr 2021.
- [5]. Singh, D.K., Singh, R. Influence of Dolomite as Supplementary Cementitious Material on Strength and Durability of Concrete. Journal of Building Materials and Structures, 8(2), Dec 2022.
- [6]. Ansari, S., Jamal, H. Experimental Study on Partial Replacement of Cement by Dolomite Powder in Concrete. International Journal of Advance Research and Innovative Ideas in Education (IJARIIE), 7(3), 2021.
- [7]. Mishra, R., Gupta, S. Performance of Concrete with Dolomite Powder as a Partial Replacement for Cement. International Journal of Civil Engineering and Technology (IJCIET), 11(6), 2020.
- [8]. Ambily, P.S., Ravisankar, K. Effect of Metakaolin on the Mechanical and Durability Properties of High Performance Concrete. Construction and Building Materials, 179, Mar 2019.
- [9]. Kadri, E.H., Kenai, S., Ezziane, K., et al. Performance of Metakaolin Concrete at High Temperatures. Fire Safety Journal, 106, May 2019.
- [10]. Siddique, R., Khan, M.I., Kadri, E.H. Strength and Durability Characteristics of Concrete Incorporating Metakaolin. Advances in Civil Engineering Materials, 8(1), Jan 2019.
- [11]. Ghafari, E., Arezoumandi, M., Sadeghi-Nik, A. Evaluation of Compressive Strength and Water Absorption of Metakaolin Concrete. Materials Today: Proceedings, 21, Part 1, 2020.
- [12]. Al-Jabri, K.S., Hago, A.W., Al-Nuaimi, A.S., et al. Evaluation of Metakaolin in Concrete Mixes. Materials and Structures, 53(2), Feb 2020.
- [13]. Singh, V., Sharma, R. Influence of Metakaolin on Properties of Self-Compacting Concrete. International Journal of Engineering Research & Technology (IJERT), 9(12), Dec 2020.
- [14]. Reddy, T.P., Prasad, A.R., Kumar, P.V. Mechanical Properties of Concrete with Partial Replacement of Cement by Metakaolin. International Journal of Civil Engineering and Technology (IJCIET), 12(3), Mar 2021.
- [15]. Amel, B., Hichem, S. Mechanical Properties of Concrete Reinforced with Hemp Fibers. Construction and Building Materials, 207, May 2019.
- [16]. Al-Kaabi, N., Al-Saidi, M., Al-Ghabri, F. Durability of Concrete Reinforced with Natural Hemp Fibers. Journal of Civil Engineering and Construction Technology, 10(1), 2019.
- [17]. Asim, K., Sajjad, A. Experimental Investigation on Mechanical Properties of Hemp Fiber Reinforced Concrete. International Journal of Scientific Engineering and Technology Research, 9(10), Oct 2020.

- [18]. Li, Y., Wu, H., Zhang, J. The Influence of Hemp Fiber Reinforcement on the Mechanical Properties and Durability of Concrete. *Materials*, 13(18), Sep 2020.
- [19]. Ramesh, P., Kumar, K.S., Mani, P. Experimental Study on Strength Properties of Concrete using Hemp Fibers. *International Journal of Engineering Research & Technology (IJERT)*, 10(02), Feb 2021.
- [20]. Saravanan, G., Muthukrishnan, S. Performance of Hemp Fiber Reinforced Concrete under Various Curing Conditions. *Journal of Materials in Civil Engineering*, 34(3), Mar 2022.