

# Review on Carbon Absorption in Concrete

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**Abstract**—The construction industry is one of the largest contributors to global carbon dioxide (CO<sub>2</sub>) emissions, primarily due to the extensive use of Ordinary Portland Cement (OPC). In response to increasing environmental concerns and the demand for sustainable construction materials, carbon-absorbing concrete has emerged as a promising solution.

This review paper presents a comprehensive analysis of carbon absorption concrete developed using Magnesium Oxide (MgO) and Rice Husk Ash (RHA) as partial replacements for OPC. MgO contributes to carbon sequestration through carbonation reactions, while RHA, a silica-rich agricultural by-product, enhances pozzolanic activity and microstructural densification.

Based on published literature and recent experimental investigations, this paper reviews the effects of MgO and RHA on mechanical properties, durability, carbonation depth, and CO<sub>2</sub> uptake capacity of concrete. The review highlights optimal replacement levels, underlying reaction mechanisms, advantages, limitations, and future research directions, establishing MgO–RHA blended concrete as a viable pathway toward low-carbon and sustainable construction.

**Index Terms**—Carbon absorption concrete, Magnesium Oxide, Rice Husk Ash, nesquehonite, Carbonation, Sustainable concrete, CO<sub>2</sub> sequestration.

## I. INTRODUCTION

The rapid growth of infrastructure development has led to a significant increase in cement consumption worldwide, making the construction sector one of the largest sources of anthropogenic CO<sub>2</sub> emissions. Conventional OPC production involves high energy consumption and limestone calcination, resulting in substantial greenhouse gas emissions. Reducing the environmental impact of cement-based materials has therefore become a critical research priority.

Carbon-absorbing concrete represents an innovative approach toward sustainable construction by integrating supplementary cementitious materials and reactive binders capable of sequestering CO<sub>2</sub>. Magnesium Oxide (MgO) has gained attention due to its lower calcination temperature and ability to undergo carbonation reactions, thereby permanently binding CO<sub>2</sub> in the form of magnesium carbonates. Rice Husk Ash (RHA), an agricultural waste product rich in amorphous silica, offers excellent pozzolanic properties and contributes to improved strength and durability of concrete.

The combined use of MgO and RHA provides a dual benefit of reducing cement content and enhancing carbon sequestration potential. This review paper aims to critically examine existing literature on MgO–RHA blended carbon-absorbing concrete, focusing on material characteristics, methodology adopted in experimental investigations, mechanical performance, durability aspects, and environmental significance. Partial replacement for fine aggregates has gained significant research attention. This approach supports sustainable construction practices by reducing environmental pollution and conserving natural sand resources and waste management.

## II. LITERATURE REVIEW

- 1) A.K. Sharma, et.al., (2019) The aim of this study is to evaluate the high performance of concrete containing supplementary cementations material. The design of M30 is as per the IS code 10262:2009 mix ratio obtained as 1:1.42:2.67 is used for this research. The result as per the experimental work shows that the strength of concrete with 5% alccofine increase the compressive strength from 318 Kg/cm<sup>2</sup> to 322 kg/cm<sup>2</sup> after 28 days of curing. The increase in

- the percentage of Alccofine from 5% in the concrete shows the decrease in the compressive strength of concrete.
- 2) Ayoade, et al., (2024) This research highlights that integrating materials like fly ash and blast furnace slag into concrete not only boosts carbon sequestration but also enhances compressive strength and durability. MC usually contains more than 85% active MgO, and the CO<sub>2</sub> sequestration capacity can reach up to 92.8 wt%. This research highlights the potential for carbon-absorbing concrete to advance sustainable construction practices and reduce the carbon footprint of the built environment. By replacing portions of cement with SCMs, the industry can achieve CO<sub>2</sub> reductions of 20% to 60% and lower lifecycle emissions by 30-50%. Additionally, the study notes that carbonation curing offers a dual benefit by sequestering CO<sub>2</sub> and shortening construction timelines. Carbonation curing not only enhances CO<sub>2</sub> sequestration but also reduces construction time, providing both environmental and economic benefits.
  - 3) Wang et al., (2020) This study investigates how reactive MgO cement (MC) can capture CO<sub>2</sub> from industrial exhaust. It establishes that 98% relative humidity is the primary governor for CO<sub>2</sub> diffusion in MC systems. The reaction between CO<sub>2</sub> and solid alkaline phases produces hydrated magnesium carbonates (HMCs), such as nesquehonite, which fill matrix voids and improve structural stability. Furthermore, a 7-day curing period at low (10%) CO<sub>2</sub> concentrations can yield strength results comparable to 100% CO<sub>2</sub> curing for one day.
  - 4) Haque et al., (2024) The authors position magnesium cements as "CO<sub>2</sub>-negative" materials due to their inherent ability to absorb atmospheric carbon. In RMC mixtures 4% to 46% CO<sub>2</sub> sequestration was observed at 28 days, depending on the mix composition and curing age. The formation of stable carbonate minerals like hydromagnesite densifies the matrix, contributing to an interlocked network structure.
  - 5) Joseph Mwiti Marangu et.al., (2024) This paper shows that the experimental results from this study show that ternary blends using RHA and calcined clay can lead to a 33% increase in compressive strength. The addition of these materials refines the microstructure, resulting in a 32% decrease in porosity compared to traditional mixes. However, due to the delayed pozzolanic reactivity, the full-strength potential is often reached at later stages, such as 56 to 90 days.
  - 6) Rashwan et al., (2020) : RHA is defined here as a "super-pozzolan" due to its 85–90% amorphous silica content. The research identifies 10% as the optimum replacement ratio for RHA by weight of cement, which produced a 32% increase in compressive strength at a water-cement ratio of 0.51. This improvement is largely attributed to the "filler effect," where fine RHA particles refine the pore structure.
  - 7) Iqra et al., (2025): This review explores the synergy between RHA and MgO binders, where silica in RHA reacts with MgO to form magnesium silicate hydrate (M-S-H) gels. RHA's porous structure functions as an internal curing reservoir, releasing moisture to facilitate the hydration and carbonation of MgO in dense environments. Low to moderate RHA replacement levels can reduce total water absorption and permeability by up to 42%.
  - 8) Wang et al., (2024): The hydration of reactive magnesium cement (RMC) primarily produces Mg(OH)<sub>2</sub>, which initially results in lower compressive strength (under 5 MPa at 14 days) without specific promoters. Certain additives like Glu can promote the initial dissolution of MgO, thereby increasing the production of Mg(OH)<sub>2</sub> and subsequent mechanical strength.
  - 9) Feifei Jiang et al., (2025): In this ternary system, MgO acts as an expansive agent to mitigate early-age shrinkage cracks, while RHA maintains high internal humidity to support continued MgO hydration. In field applications, a composite of 8% MgO and 2% RHA achieved a 10.5% higher 28-day compressive strength than conventional concrete, with MgO hydration degrees exceeding 80% due to the internal curing effect.

10) Yixiao Wang et al., (2022): This study provides a critical benchmark for carbon capture reactive MgO has a theoretical CO<sub>2</sub> uptake capacity of up to 92.8 wt.%, which is nearly double that of ordinary Portland cement (50.4 wt.%). The chemical transformation of CO<sub>2</sub> into stable mineral crystals like nesquehonite physically fills capillary pores and enhances the structural integrity of the concrete.

### III. LITERATURE SUMMARY

Through this study of all literature, it shows that the strength of concrete with 5% alccofine increase the compressive strength from 318 Kg/cm<sup>2</sup> to 322 kg/cm<sup>2</sup> after 28 days of curing. MC usually contains more than 85% active MgO, and the CO<sub>2</sub> sequestration capacity can reach up to 92.8 wt%. Carbonation curing not only enhances CO<sub>2</sub> sequestration but also reduces construction time, providing both environmental and economic benefits. The carbonation of MC can take place via the formation of magnesium carbonate (MgCO<sub>3</sub>) from hydrated Mg (OH)<sub>2</sub> by the uptake of CO<sub>2</sub>:  $Mg(OH)_2 + CO_2 \rightarrow MgCO_3 + H_2O$ . Evaluate the interference of acid gases with the accelerated carbonation of MgO systems. Based on an extensive literature review, most researchers reported that 10%-20% RHA as a replacement and 3%-8% Magnesium Oxide [MgO] as an additive can be used for cement that provides an optimal balance between CO<sub>2</sub> absorption.

### IV. CONCLUSION

As that through the literature study the designed to examine the behaviour of M30 grade concrete when partially replaced with Rice Husk Ash [RHA] derived by from Rice Husk waste and Industrial grade of Magnesium Oxide [MgO] is used as an additive for the carbon absorption in concrete.

Therefore, this study adopted a uniform 10% replacement level of Rice Husk Ash [RHA] for all modified mixes and percentage of Magnesium Oxide (MgO) is varied with different mix proportion. Four concrete mixes were prepared:

- M0 – Conventional Concrete
- M1 – 10% RHA+ 3% MgO
- M2 – 10% RHA+ 4% MgO
- M3 – 10% RHA+ 5% MgO

All mixes were designed as per IS 10262:2019. Dry mixing was carried out for cement, aggregates, and RHA and MgO for the respective percentage of replacement and additive percentage of materials for mix proportions before the addition of water to ensure uniform mixture of all replacement and additives. The water–cement ratio of 0.45 was kept constant for all batches. Workability was measured using the slump cone test to investigate any reduction caused by the hydrophobic nature of rubber particles. Concrete specimens including 150 x 150 x 150 mm cubes, 150 × 300 mm cylinders, and 100 × 100 × 500 mm flexural beams were cast for each mix. After demoulding, all specimens were cured in water for 7 and 28 days. Mechanical property tests-compressive strength, split tensile strength, and flexural strength were performed according to IS 516:2018 and IS 5816:1999.

### REFERENCES

- [1] A.K. Sharma, S. D. Prasad, et.al (September-2016). To Study High Grade Concrete M30 as Building Material with Ambuja Method using with and without Alccofine. SSRG International Journal of Civil Engineering (SSRG – IJCE), 3(9) ISSN: 2348 – 8352.
- [2] Olaleye R. Kayode & Shakiru A. Ayoade. (2024). Enhancing Sustainability in Construction: A Systematic Review of Carbon-Absorbing Concrete Technologies and Applications. European Journal of Applied Science, Engineering and Technology, 2(6), ISSN:2079-2077.
- [3] Wang et al. (2020 February). Accelerated Carbonation of Reactive MgO and Portland Cement Blends Under Flowing CO<sub>2</sub> Gas. Cement and Concrete Composites (Elsevier), Vol 106. ISSN: 0958-9465
- [4] Haque et al. (2024, February). Magnesium Cements and Their Carbonation Curing: A State-of-the-Art Review. Low-carbon Materials and Green Construction [Springer], 2(2). ISSN: 2731-6319
- [5] Joseph Mwiti Marangu., Meenakshi Sharma, et.al. (April 2024). Durability of Ternary Blended Concrete Incorporating Rice Husk Ash and Calcined Clay. Buildings [MDPI], 14(5). ISSN 2075-5309

- [6] Rashwan et al. (October 2020). Assessment of Using an Optimal Dose of Superplasticizer with the Optimum Replacement of Rice Husk Ash (RHA) on Concrete Compressive Strength. *International Journal of Civil Engineering and Technology* 11(10), ISSN: 0976-6308.
- [7] Iqra et al. (September 2025). A Review of Recent Advances in MgO-Based Cementitious Composites for Green Construction: Mechanical and Durability Aspects. *Buildings [MDPI]*, 15(19), ISSN 2075-5309.
- [8] Huanhuan Wang.,et.al (April 2024). Improving the Hydration and Carbonation of Reactive MgO Cement with Amino Acids and the Influencing Mechanisms. *Journal of Thermal Analysis and Calorimetry [Springer]* Vol 149.ISSN: 1588-2926
- [9] Feifei Jiang., et.al (June 2025). Effect of Combined MgO Expansive Agent and Rice Husk Ash on Deformation and Strength of Post-Cast Concrete. *Materials [MDPI]* 18(12). ISSN 1996-1944.
- [10] Yixiao Wang et al. (December 2022). The Capture and Transformation of Carbon Dioxide in Concrete: A Review. *Symmetry [MDPI]* 14(12). ISSN: 2073-8994.
- [11] IS 10262:2019, “Concrete Mix Proportioning – Guidelines”, Bureau of Indian Standards, New Delhi, 2019.
- [12] IS 516:2018, “Methods of Tests for Strength of Concrete”, Bureau of Indian Standards, New Delhi, 2018.
- [13] IS 5816:1999, “Method of Test for Splitting Tensile Strength of Concrete”, Bureau of Indian Standards, New Delhi, 1999.