International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

SELF HEALING CONCRETE

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ABSTRACT :

Self-healing concrete, an innovative material, holds the promise of addressing crack repair challenges in traditional concrete structures by using natural or engineered mechanisms. This review consolidates findings from six prominent research papers on the topic, focusing on bacterial self-healing methods, mechanisms of calcium carbonate precipitation, and encapsulation techniques. It evaluates the efficacy of these methods in enhancing durability, compressive strength, and resistance to harmful chemicals. Insights into practical applications and limitations are discussed to pave the way for future advancements in sustainable construction materials.

Keywords: Self-healing concrete, bacteria-based concrete, calcium carbonate precipitation, bio-mineralization, durability, crack repair, autogenous healing, autonomous healing.

Introduction :

Self-healing concrete is mostly defined as the ability of concrete to repair its cracks autogenously or autonomously. It is also called self-repairing concrete. Cracks in concrete are a common phenomenon due to its relatively low tensile strength.

Literature Review :

Paper 1: "A Review on Self-Healing Concrete Using Bacteria" (Iheanyichukwu et al., 2018)
Summary: The study highlights bacterial precipitation of calcium carbonate ($CaCO_3$) as an effective self-healing mechanism. Key mechanisms include autogenous and autonomous healing, with bacteria such as Bacillus sphaericus encapsulated in hydrogels or aggregates for crack repair. The work emphasizes the importance of bio-mineralization pathways and the factors influencing calcium carbonate formation, such as pH and calcium ion concentration.
Findings: Encapsulation in hydrogels showed healing efficiencies up to 90%, with reduced permeability and enhanced durability. Limitations include cost and the need for optimal encapsulation techniques.

Paper 2: "A Review Paper on Self-Healing Concrete" (Magaji et al., 2019)
Summary: This paper explores natural, chemical, and biological processes for self-healing. It focuses on the role of ureolytic bacteria in precipitating calcium carbonate to seal cracks. Autonomous healing through encapsulated glue and microcapsules was also reviewed.
Findings: Biological self-healing using bacteria is more sustainable compared to chemical methods. However, issues with long-term durability and environmental adaptability of bacteria remain challenges.

Paper 3: "A Review on Self-Healing Concrete Using Microbial Agents" (Das et al., 2024)
Summary: This paper investigates the use of Bacillus subtilis in M25 grade concrete with varying bacterial concentrations. The study emphasizes microbial activities under alkaline conditions and calcium carbonate precipitation as a crack-sealing mechanism.
Findings: Specimens with bacteria showed improved compressive strength and reduced permeability. Healing efficiency was influenced by bacterial concentration and curing conditions.

Paper 4: "Microbial Healing of Cracks in Concrete: A Review" (Joshi et al., 2017)
Summary: The study discusses microbially induced calcium carbonate precipitation (MICCP) and its applications in self-healing concrete. Various encapsulation methods, including lightweight aggregates and polymeric capsules, were analyzed.
Findings: Lightweight aggregates allowed sustained bacterial activity for up to six months but resulted in reduced structural strength. Encapsulation in polymeric capsules offered better control over bacterial activity.

Paper 5: "Bacteria-Based Self-Healing Cementitious Materials" (Wang et al., 2016)

Summary: The research focuses on encapsulating Bacillus sphaericus in diatomaceous earth for crack healing. Healing mechanisms under different environmental conditions were analyzed.

Findings: Healing efficiency varied with encapsulation materials, achieving crack sealing up to 0.5 mm. Encapsulation materials influenced the workability and mechanical properties of concrete.

Paper 6: "Sustainable Self-Healing Concrete: A New Frontier" (Ling et al., 2017)

Summary: The paper evaluates self-healing concrete's environmental benefits, emphasizing reduced carbon emissions and increased durability. It explores the use of vascular systems for delivering healing agents to cracks.

Findings: The vascular method enhanced healing efficiency in marine environments but posed challenges in implementation due to design complexities.

Conclusion :

Self-healing concrete demonstrates significant potential in enhancing the durability and sustainability of concrete structures. The reviewed studies underscore the importance of bacterial-based healing agents, particularly in precipitating calcium carbonate to seal cracks. Encapsulation methods, such as hydrogels and polymeric capsules, have shown promising results but require further optimization for cost-effectiveness and long-term durability. Challenges such as environmental adaptability, reduced mechanical strength due to encapsulation, and scalability must be addressed. Future research should focus on refining these technologies for broader applications in the construction industry.

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