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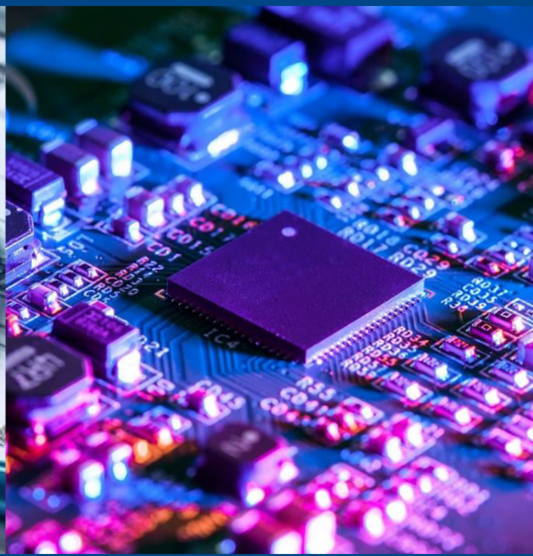

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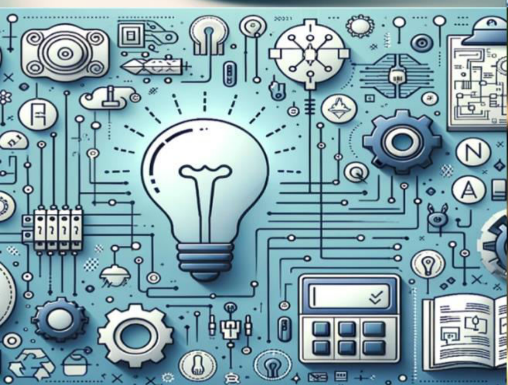

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Use of Bio-Concrete in Repairs of Building Structure

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ABSTRACT: Concrete will continue to be the vital component for infrastructures due to its first-rate properties such as easy availability, low cost, durability, strength and convenience to cast. It can withstand the compressive forces but it is prone to cracking due to tensile forces which in turn results in the reduction of the overall life as well as increase in the vulnerability of the concrete structure. Curing of the concrete increases the possibility of cracking due to the fluctuations in the humidity and temperature. With the aging of the structure, brittleness increases as the moisture content decreases. Retrogression of the reinforcement steel bars due to introduction of corrosive chemicals through cracks, frost damage and water leakage are some of the problems encountered thus pinching the pockets and making the maintenance and repairs costlier. An expeditious self-healing crack mechanism is required which causes the decline in the chemical intrusion, thus dwindling the corrosion and thereby increasing the service life of the concrete structure. In this paper, an attempt has been made to re-mediate the cracks and fissure in the concrete by employing Microbiologically Induced Calcite Precipitation (MICP). The method results in enhancing the strength and durability of the structures by healing the cracks through microbial activities which happens to be eco-friendly. A review of this technique for future commenced use has been discussed.

KEYWORDS: Self-healing concrete, Microbiologically Induced Calcite Precipitation (MICP), chemical intrusion, eco-friendly.

I. INTRODUCTION

Crack formation in concrete is a phenomenon that can hardly be complete avoided due to for example shrinkage reactions of setting concrete and tensile stresses occurring in set structures. While larger cracks can potentially hamper a structures' integrity and therefore 2 require repair actions, smaller cracks typically with a crack width smaller than 0.2 mm are generally considered unproblematic [1-2]. Although such micro cracks do not affect strength properties of structures they do on the other hand contribute to material porosity and permeability. Ingress of aggressive chemicals such as chlorides, sulfates and acids may result on the longer term in concrete matrix degradation and premature corrosion of the embedded steel reinforcement and thus hamper the structures' durability on the long term. In several studies indications have been found that concrete structures have a certain capacity for autonomous healing of such micro cracks [2-5]. The actual capacity of micro crack healing appears primarily related to the composition of the concrete mixtures. Particularly mixtures based on a high binder content show remarkable crack-healing properties [5] what is due to delayed (secondary) hydration of matrix embedded nonhydrated cement and binder particles upon reaction with crack ingress water. Autogenous self-healing of cracks in traditional but also high-binder content mixtures appear limited to cracks with a width smaller than 0.2 mm [2-5]. This somewhat limited effectiveness appears largely due to the restricted expansive potential of the small non-hydrated cement particles lying exposed at the crack surface. Another limitation to application of highbinder content mixtures solely for the purpose of increasing self-healing capacities are current policies which advocate sparse use of cement in concrete for sustainability reasons as current cement production contributes about 7% to global anthropogenic CO2 emissions [6]. For latter reasons, alternative and more sustainable self-healing mechanisms are therefore wanted. One possible mechanism is currently being investigated and developed in several laboratories, i.e. a technique based on the application of mineral-producing bacteria. E.g. efficient sealing of surface cracks by mineral precipitation was observed when bacteria-based mixtures were sprayed or applied onto damaged surfaces or manually inserted into cracks [7-13]. As in those studies bacteria were manually and externally applied to existing structures, this mode of repair can not be categorized as truly self healing. In several follow up studies therefore, the possibility to use viable bacteria as a sustainable and concrete-embedded self healing agent was explored [14-16]. In one study spores of specific alkali-resistant bacteria related to the genus Bacillus were added to the concrete mixture as self-healing agent [16]. These spores germinated after activation

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by crack ingress water and produced copious amounts of crack-filling calcium carbonatebased minerals through conversion of precursor organic compounds which were also purposely added to the concrete mixture. However, in that study it was found that the bacteria-based self-healing potential was limited to relatively young M (7-days cured) concrete only, as viability and related activity of bacterial spores directly (unprotected) 3 embedded in the concrete matrix was restricted to about two months.

II. LITERATURE REVIEW

1) EIRINI TZIVILOGLOU , VIRGINIE WIKTOR , HENK M. JONKERS AND ERIK SCHLANGEN

This paper presented the results of a study on bacteria-based self-healing mortar prisms. However, the focus was not on proving their enhanced healing behavior over mortar specimens without the healing agent. Particular emphasis was given to the three performance requirements that need to be met in order to ensure the efficiency of the bacteria-based self-healing system. It was concluded that the combination of the results that show: i) mineral formations on the surface of the crack, ii) crack sealing along with reduced permeability after cracking and iii) proof of bacterial activity can verify the efficient performance of the bacteria-based self-healing mortar.

2) Poonam Ghodke, Swarda Mote

Bacterial concrete is a smart concrete exhibiting human-like self-healing characteristics enhancing the strength of the structures, especially under tension. The overall service life of the structure is found to be increasing. Appropriate utilization of corrosion causing moisture as a catalyst in the process results in maintaining the quality of the concrete. Self-healing concrete is better than the traditional concrete because of its eco-friendly nature. Effective crack remediation with maximum moisture impermeability is one of the striking assets of the self-healing concrete.

3) H. M. Jonkers

The overall conclusion of this work is that the proposed two component bio-chemical healing agent, composed of bacterial spores and a suitable organic bio-cement precursor compound, using porous expanded clay particles as a reservoir is a promising bio-based and thus sustainable alternative to strictly chemical or cement-based healing agents, particularly in situations where concrete parts of a construction are not accessible for manual inspection or repair. However, before practical application becomes feasible, further optimization of the proposed system is needed. E.g., the amount of healing agent needed should be minimized in order to become economically competitive with currently existing repair techniques and furthermore to reduce consequences such as loss in compressive strength.

4) Esampelly Balakrishna , Thangarala Pranay Kumar,Teegala Vijay Kumar

The techniques for creating self-healing concrete are provided in this paper. The addition of bacteria to concrete is very beneficial as it raises the concrete's attribute level above that of regular concrete. The study examined various bacterial species that can be employed to treat concrete cracks. Concrete cracks are filled in and repaired by bacteria through the production of calcium carbonate crystals that block the cracks. Numerous researchers investigating the self-healing properties of concrete have discovered that bacteria enhance the properties of traditional concrete, increasing its strength by 13.75% in 3 days, 14.28% in 7 days, and 18.35% in 28 days. As everyone knows, self-healing concrete is less expensive to maintain and repair using traditional methods. Therefore, in order to improve concrete structures, we must refine and apply these techniques. The concepts and techniques for creating self-healing concrete are presented in this paper.

5) Fadi Althoey , Osama Zaid , Mohamed M. Arbili , Rebeca Martínez-García , Ali Alhamami , Hammad Ahmed Shah , Ahmed.M. Yosri

The present work has also suggested that bacterial agents positively impact Portland cement's concrete and mortar compression strength. The healing of cracks in bio-based concrete relies on the accessibility of nutrients and the persistence of bacterial living cells. Past research also used this method; it needs a particular method to reserve the live cells, which stances a big challenge for its application in large-scale bio-based self-healing concrete. The advantage of utilizing a bacterial agent is that it reduces water infiltration and chloride ions' permeability. The inclusion of bio-based material is observed to enhance bio-concrete's strength and durability characteristics.

6) Kevin Paine

Within this paper previous research on the use of bacteria-based self-healing of concrete has been reviewed in relation to the problems associated with the setting, hardening and carbonation of concrete and the problems associated with

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healing large cracks. The paper commenced with a discussion of the effects of setting and hardening of concrete and how this affects the way in which self-healing agents must be added to the concrete. In particular, the necessity for encapsulation of the spores and of the medium, in order to counter effects of concrete hardening on the spores and eliminate any effects of the precursor and additional nutrients on the fresh and early-age properties of concrete. The germination and growth of bacteria and the precipitation of calcite are known to be affected by temperature and humidity, and consequently the role of these parameters was discussed. Furthermore, as concrete ages it tends to carbonate and this leads to a loss of pH – from around 14 in the first few hours to potentially as low as 6.5 in the long-term. The Page 13 significance of the carbonation on the ability of bacteria-healing to take place and the consequences for selection of bacteria was described. One potential advantage of bacteria-healing over other self-healing systems is that it is renewable as the bacteria may sporulate after healing and be available for future healing. This is useful in dynamic systems. The requirements for ensuring sporulation takes place were discussed; in addition to methodologies for re-supplying the bacteria with essential nutrients and medium should these be consumed. Finally, the paper ended with a discussion of the ability of bacteria to heal large cracks, and describes techniques being considered in UK research to utilize bacteria-healing as part of a multi-scale healing system.

7) Vidhya Lakshmi1 , Arul Gideon.R , Karthikeyan.K , Uthayakumar

From the discussion it is concluded that, the use of bacteria Sporosarcina Pasteurii in concrete can serve as the best option in Microbially Induced Calcite Precipitation due to its various special features. The method of self healing by the incorporation of bacteria into the concrete has greater advantage that it will save manual inspection, repair, time, money and moreover increase structure durability. The minor cracks in the structures can be remediated and the compressive strength of the concrete was found to be same as the conventional concrete. Since there is a lesser water absorption in the bacterial concrete, greater will be the durability of the concrete. Further study has to be carried out inorder to determine the limitation of percentage replacement of bacterial solution as only 20%, 30% and 40% of bacterial solutions were used in this study. The study exhibited that there are both advantage and even limitations about different healing agent and thus more research have to work as a further study.

8) Shital Wani, Shubham Ghuge, Sayali Kadam, Snehal Gulve

Cracks were sufficiently healed during the Observation period after adding the Bacterial paste of Bacillus subtilis and water . Self-healing efficiency on concrete of M-25 grade was observed to be increased by 25% compared to conventional concrete. Self-healing concrete is the best solution for the demand of sustainable concrete due to its ability of self repair and durability. In future, self-healing concrete is going to play the most important role in concrete technology.

9) Mr. Sk. Alisha, Mr. P. Rohit, Mr. K.S.N. Sachin, Mr. V.Rajesh Babu

Self-healing concrete is that the best answer for the demand of property concrete because of its ability of self-repair and sturdiness. In future, self-healing concrete goes to play the foremost necessary role in concrete technology. The study of this paper is a review on self-healing concrete. We will notice that the self-healing concrete has excellent properties compared to traditional concrete. Because of several helpful properties the self-healing concrete square measure usually employed in many sorts of infrastructure. It is conjointly associated in nursing eco-friendly in nature. So, it cannot damage the surroundings then no problems square measure found associated with surroundings. The Optimum content of B Megaterium are often taken is 106 cells/ml. The Optimum amount of salt is zero.5% of cement taken. Due to value effective we will simply use in construction work. Heat of association is high on microorganism cubes; thence it takes a lot of water to cure. The compressive strength is raised up to twenty over traditional Concrete. In typical concrete the upkeep value of structure is extremely high. However once the self-healing concrete is made-up then the value of maintenance work is reduced. This can be because of adding microorganism in concrete. Self-healing concrete is barely applicable to cracks whose breadth is a smaller amount than one.5mm

10) Rosy , Chandan Kumar , Priti Kumari , Dr. Krishna Murari

Introducing the bacteria e coli into the concrete, improves the properties and characteristics of concrete. Experimental investigations were conducted to determine compressive strength, split tensile strength of conventional and bio concrete. Based on the test results, it was observed that addition of bacteria gives better result. It was observed that both tensile and compressive strength of concrete increases due to addition of bacteria.

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III. CONCLUSION AND FUTURE WORK

After studying all the literature we have understood and concluded that the Bio-concrete represents a ground breaking advancement in sustainable construction materials, leveraging microbial-induced calcium carbonate precipitation (MICP) to address critical challenges such as crack healing, durability, and environmental impact. Key findings from this study demonstrate that bio-concrete not only autonomously repairs micro-cracks, extending structural lifespan, but also reduces maintenance costs and resource consumption compared to traditional concrete.

The effectiveness of bio-concrete hinges on factors like bacterial selection (e.g., Bacillus subtilis or Sporosarcina , nutrient carriers, and environmental conditions, which must be optimized for practical applications. While challenges such as scalability, cost, and long-term performance in harsh conditions remain, ongoing research into genetically modified bacteria and eco-friendly nutrient systems shows promise for overcoming these limitations.

From an environmental perspective, bio-concrete aligns with global sustainability goals by lowering CO_2 emissions associated with cement production and minimizing material waste. Future work should focus on large-scale implementation, lifecycle analysis, and integration with smart construction technologies.

In summary, bio-concrete stands at the forefront of innovative construction materials, offering a synergistic blend of biology and engineering to build resilient, eco-friendly infrastructure for the future.

REFERENCES

[1] W. Zhong, W. Yao, (2008) Influence of damage degree on Self-healing of Concrete. Construction and BuildingMaterials, 22: 1137-1142.
[2] K. van Breugel (2007) Is There a market for self-healing cement-based materials. In: Proceedings of the first international conference on self-healing materials, Noordwijkaan zee, the Netherlands.Pecker Alain, "Earth Quake Foundation Design, Soil Mechanics Laboratory, Palaoseau, France.
[3] Jonkers, H., 'Bacteria-based self-healing concrete', HERON 56 (1) (2011) 1-12.
[4] Potential application of Bacteria to improve the strength of cement concrete. C. C. Gavimath*, B. M. Mali1, V. R. Hooli2, J. D. Mallpur3, A. B. Patil4, D. P. Gaddi5, C.R.Ternikar6 and B.E.ravishankera7.
[5] H.M. Jonkers, A. Thijssen, O. Copuroglu, E. Schlangen, Application of bacteria as selfhealing agent for thedevelopment of sustainable concrete, Proceedings of the 1st International Conference on BioGeoCivil Engineering, 23–25 June 2008, Delft, The Netherlands.
[6] Abo-El-Enein, Ali, FatmaTalkhan, Abdel-Gawwad, "Application of microbial biocementation to improve thephysico-mechanica properties of cement mortar", Housing and Building National Research Center (2013).
[7] J. Dick, W. Windt, B. Graef, H. Saveyn, P. Meeren, N. De Belie, W. Verstraete, Biodeposition of a calciumcarbonate layer on degraded limestone by Bacillus species, Biodegradation 17 (4) (2006) 357–367.
[8] V. C. Li, & E. Yang, Self-healing in concrete materials. In S. van der Zwaag (ed.) (2007) Selfhealing materials – An alternative approach to 20 centuries of materials science. Springer, the Netherlands, 161– 194.
[9] Kusuma K., Amit Kumar Rai, Prashant Kumar, Harini K. and Harshita M.N, (2018) 'SELFHEALING COCRETE'. International Research Journal of Engineering and Technology Volume: 05 Issue: 05
[10] Amirreza Talaiekhozan, Ali Keyvanfar, Ramin Andalib and Rosli Mohamad Zin, 'A Review of Self-healing Concrete Research Development', Journal of Environmental Treatment Techniques 2014, Volume 2, Issue 1, Pages: 1-11

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