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Self-Healing Technology for Microbial Concrete: A Review

Rashmi S. Majgaonkar
P.G. Student, Department of Civil Engineering
Pankaj Laddad College of Engineering and Management, Buldhana, Maharashtra, India

Abstract: *Concrete is the most common material, crack is the main problem that arises in a concrete structure. This causes corrosion in the steel reinforcement. The structure deteriorates with cracks, so due attention is needed to this problem. This work consists of various self-medication methods used by researchers to inhibit cracks and prevent further deterioration of the structure. This article discusses the different types of bacteria used to heal cracks. The maximum strength increased, and the width of the crack healed using these methods, also mentioned in the article.*

Keywords: Self-healing, microbial concrete, micro structure and CaCO3 precipitation

I. INTRODUCTION

Concrete has been used in almost all construction activities because it provides good compressive strength and performance. Concrete also has advantages such as good strength and lower cost compared to other building materials [1]. The concrete industry is considered the largest industry worldwide and produces almost 6.5 million cubic meters. See annually [2]. A particular industry is also responsible for Co_2 emissions, this gas is creating the effects of global warming and climate change. Cement plants produced a huge amount of CO_2 when the raw material received a combustion process pf[3].

Concrete is a brittle material, when the load, including the tension as well as the compressive load, is set on a concrete structure, then the actual problem begins. Cracks can develop in a concrete structure, although the tensile force is taken by steel reinforcement [4]. Because the crack causes the liquid particles to seep into the concrete, this can lead to corrosion of the steel reinforcement. Cracks are also responsible for leaks in the concrete structure and thus reduce the strength of the structure [5]. Therefore, the main problem of concrete cracks should be solved, and CO_2 emissions should also be taken care of [6].

When cracks develop in a concrete structure, then repair technology plays a crucial role. The cost of repairs and other repair factors must also be checked, the durability of repairs depends on the type of repair and quality. This solution many times does not strongly affect the spread of cracks day in and day out, and the strength of the concrete structure also decreases with age [7]. Therefore, another solution should be tested to solve the problem of cracks in the concrete structure. Self-healing concrete is now popular with the researcher and engineer when cracks light up and other problems such as leakage and impregnation, preventing corrosion of steel reinforcement. Self-healing concrete seems to be a promising solution and an alternative to other repair technologies [8].

Researchers are developing various technologies for self-medication of concrete, and this applies to different types of bacteria, mineral impurities and adhesive agents. Bacterial agents in the self-healing of concrete receive poplars among these different solutions. If proper bacterial spores with a nutrient are induced in concrete, the concrete mixture will have good self-healing effects [9]. Bacterial spores become more active after contact with water, the metabolic process begins, then calcium carbonate is also precipitated. If this amount of precipitation has developed, then this healing material also begins to intensify, the process of bacterial synthesis begins, and the by-product of calcium carbonate ($CaCo_3$) begins to fill cracks, developed in a concrete structure [10]. Cracks can be sealed in full or to a limited extent depending on the bacterial nutrients, which makes the concrete part what it is. The production of durable concrete using self-medication technology is becoming popular with researchers. Nanomaterial technology, which can be used to self-medicate a concrete structure, can have advantages, and therefore researchers are beginning to experiment with this [11]. The use of ureolithic bacteria, including Bacillus Pasteurii and Bacillus Subtilis, is implemented in concrete cracks for sealing, as it induces urea, and CaCO3 sediment helps accordingly. The longevity of the concrete sample that was detected increases with bacterial spores in the sample [12].

II. BACTERIAL SELF-HEALING MECHANISMS

2.1 Use of Natural Fibers

Self-healing of concrete with natural fibers such as jute, flax and coir fibers was used in bacterial spores. The bacterial calcite includes Bacillus sphaericus NCCP-313, Bacillus cohnii NCCP-666 and Bacillus subtilis KCTC-3135T in concrete. It is observed that the rate of self-medication in concrete is 75% in the case of bacteria that have been immobilized by fibers for up to 7 days and 28 days [13]. The water permeability ratio was found to decrease to 42%, while the self-healing factor was increased when testing the sample in the initial days, cellulose fibers were added in appropriate proportions. Bending strength was also increased to 7.8% [14].

Flax fibers were used in the mixture so that self-medication of the sample could be experimented with the use of bacterial spores. Coir fibers provide good compressive strength compared to other natural fibers for the self-healing concrete sample [13]. Synthetic microfiber is observed to be a good content when mixed with a nanosilic, it is found that plastic shrinkage is cracked by this solution [35]. Highly effective healing of concrete with impurities, fibers and crystalline impurities was studied. The permeability of concrete and the self-healing ability of concrete construction were studied. The use of fibers and crystalline impurities in HPC was satisfactory for the continuous loading experiment on the sample for 7 days [44].

2.2 To Inhibit the Corrosion Process

Steel is corroded after cracks have developed in concrete, microbial healing of cracks in concrete is not quickly processed. If bacteria are used to reduce nitrates, corrosion can be stopped and cracks will also heal, this can be achieved if NO2 is produced and CaCo3 precipitation develops. The activated compact denitrifying core must be detected in concrete to stop corrosion [4].

The potential for crack healing was studied using the ureolithic type of microbial agents that self-healed in concrete. Cracking was successfully performed in the case of 450 microns, and the required days - up to 120 days. Corrosion of the gain was also stopped by this crack healing behavior[27]. Crystalline impurity can improve the strength of concrete, as well as reduce permeability when the structure is exposed to the environment, which leads to corrosion in the concrete structure. Compressive strength, self-medication, and concrete strength characteristics have been tested for different types of cement [41]. The technique of self-medication of encapsulated polyurethane has been studied so that corrosion of reinforcement can be minimized. Fixed concrete beams were exposed to chloride solution, and n self-medication in the corrosion procedure was investigated experimentally [48].

2.3 To increase Compressive Strength

Concrete properties, including compressive strength, tensile strength, were improved when Sporosarcinapasturii bacteria were used in concrete for crack healing technologies. Maximum results occurred when Zeolite was used up to 10% compared to this material [7]. Bacillus sphaericus(LMG 22257) was used so that microbial precipitates of calcium carbonate are formed to heal cracks. Treatment was performed for up to 20 days, the resulting compressive strength was 43% higher for the sample on which the experiments were performed [8].

Varnishes are resistant bacteria to the genus Bacillus, which formed a dispute used in concrete to heal the compaction of concrete. The cement stone sample was effective in healing the crack, and the crack diameter was constantly decreasing, making it resistant to cracks [17]. Experiments were performed to heal the crack width of 0.6 mm using healing methods using bacterial spores. Improved monitoring methods have been used to progress in tracking crack healing [18].

The compressive strength increased significantly in bacterial spores used in concrete, while porosity and permeability were reduced [19]. Calcite deposition was observed in the cracked area [20]. There is a major influence on the CaCO3 crystal methodology, and this depends on the type of culture of the bacteria used [21]. The use of pure culture is carried out in a sample, then a decrease in water absorption was detected, it was also found that the chromatic aspect has good changes [22]. When bacteria immobilize in graffiti, the pre-cracked sample is effective. If it was immobilized in light units, the compressive strength was successfully increased [23].

Bacterial-based self-medication agents when added to samples then found that porosity increases from 100 to 1000 nm. The compressive force was also increased when these agents added to the samples and experiments were performed [24]. The healing material caused by bacterial spores, adding it to a light solution, then the property of crack compaction is affected to a significant degree, when exposed to wet dry cycles of the healing state [25].

It has been found that the technologies used to reduce CO2 emissions are insufficient to effectively reduce this content. Research work aimed at reducing this release with bacteria (BacillusTequilensis) induction in concrete [26]. The role of different bacteria and their strength is discussed.

III. CONCLUSION

The durability of the concrete structure increases if the correct self-treatment of cracks is built in. The strength of the structure has also increased to some extent. The width of the cracks to the main volumes can be completely healed under the necessary environmental conditions. Microbial concrete is very useful for crack healing and further development. The benefits of different bacteria for concrete healing are discussed in the article.

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