ISSN:0975-3583,0976-2833 VOL12,ISSUE07,2021

A REVIEW PAPER ON SELF-HEALING CONCRETE

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ABSTRACT
This study is stimulated by the need to reduce the cost of maintenance and repair of the ageing infrastructure. Cracks in concrete are the main reason for the decreased strength of concrete structures also some additional problems like direct loading, external loading, temperature and humidity leads to reduce the concrete strength. It is vulnerable to cracking because of its inherent heterogeneity and the non-ideal service environmental. For reducing of cracks in concrete the proposed approach is self-healing. It is therefore economical to restrict the development of "early age small cracks" at the moment they appear, than to repair them after they have developed to large cracks. For self-healing concrete, we use extensive material to regain the cracks by using the material like bacteria, chemical agents are used. The main cause of selfheal in was attributed to the precipitation of calcium carbonate, the result of reaction between calcium ions from the concrete and carbon-di-oxide dissolved in water. Self-healing remains potentially active for long periods of time and be concrete compactable to not negatively affect material characteristics.

Key words*: bacteria, chemical agents, calcium carbonate, carbon-di-oxide.*

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1. INTRODUCTION

Concrete is one of the most popular construction materials. It is vulnerable to cracking because of its inherent heterogeneity and the non-ideal service environment. Cracks in concrete are the main reason for reduce in serviceability of concrete structures. A statistics says 50% Of construction cost in spend on repair works Concrete in service cracks due to direct stress and sub stress Caused by many kinds of reasons, such as changes of temperature And humidity, inhomogeneous sinking and external loading (Dynamic or static loading). Cracks not only influence the Strength of concrete structure, but also are harmful for the structure safety. Self -healing concrete is one of the emerging methods to arrest cracks in concrete, Tubular capsules bacteria and silica gel immobilized bacteria and polyurethane bacteria can be used in varying percentages in concrete which heals cracks by themselves. From this silica gel immobilized bacteria exhibits the higher activity.

The main cause of self-healing was attributed to the precipitation of calcium carbonate, a result of reaction between calcium ions from the concrete and carbon dioxide dissolved in water. This type of self-healing mainly reduces the water permeability.Other innovative methods, including encapsulation, expansive agents, and bacteria were also attempted by various researchers. As suggested by many previous studies the crackwidth of the concrete material was found to be critical for self-healing to take place, especially for self-healing based on ongoing hydration of cement.Finally, overall conclusions will be drawn based on the experimental findings.

2. MATERIALS AND METHODS

Bacterial strain

The bacterial strain used in the experiments was *B.substilus* . This strain has a highurease activity (40 mM urea hydrolyzed. OD_1 h_1), long

ISSN:0975-3583,0976-2833 VOL12,ISSUE07,2021

survival timeandcan produce CaCO3 in a simple and controllable way. The medium used to grow *B.substilus* consisted of yeast extract and urea. The yeast extract medium was first autoclaved for 20 min at 120^{o}C and the urea solution was added which was sterilized by means of filtration through a sterile 0.22 lm Milipore filter. The final concentration of yeast extract and urea were 20 g/L. Cultures were incubated at 37^{o}C on a shaker at 100 rpm for 24 h. The concentration of bacterial cells was 109 cells/mL.

Survival test of bacteria

In this experiment it was tested how long the bacteria can remain viable and sustain high urease activity. Batches of 2 mL bacterial solution (109 cells/mL, same as in the Section 2.1) were added into a sterile vial (12.5 mm (diameter) 46 mm (height), VWR). The vials were then closed tightly and put in the incubator at 37^{o}C. At certain time intervals, three vials were taken out from the incubator. Bacteria of each vial were inoculated into 100 mL sterile deposition medium (yeast extract 20 g/L, urea 20 g/L and $Ca(NO_3)2.4H_2O$ 79 g/L). The media were then put on the shaker (37^{o}C, 100 rpm) for three days. The amount of urea decomposed by bacteria after three days was calculated based on the total ammonium nitrogen measured in the deposition medium. Since one mole of urea ($CO(NH_2)_2$) produces 2 mol of NH^+_4, the amount of NH^+_4 can thus indicate the amount of urea decomposed, and hence the amount of $CaCO_3$ precipitation.

Activity of bacteria after being immobilized into silica gel

For the self-healing of concrete the silica immobilized bacteria was used as aself-healing agent. Levasil 200/300% sol, with a specific surface area of 200m^2/g and a solid content of 30% was used to embed bacterial cells. Two concentrations of saline water is used. The saline solution with 8.5 g/L NaCl was to resuspend centrifuged bacteria. Another saline water with 60 g/L was used to make silica sol to silica gel. Silica sol, bacterial suspension and saline sol were mixed together with the volume ratio of 5:1:4. About 2h later, the silica sol became silica gel and bacterial cell were incorporated inside the gel.

Bacterial activity after immobilization

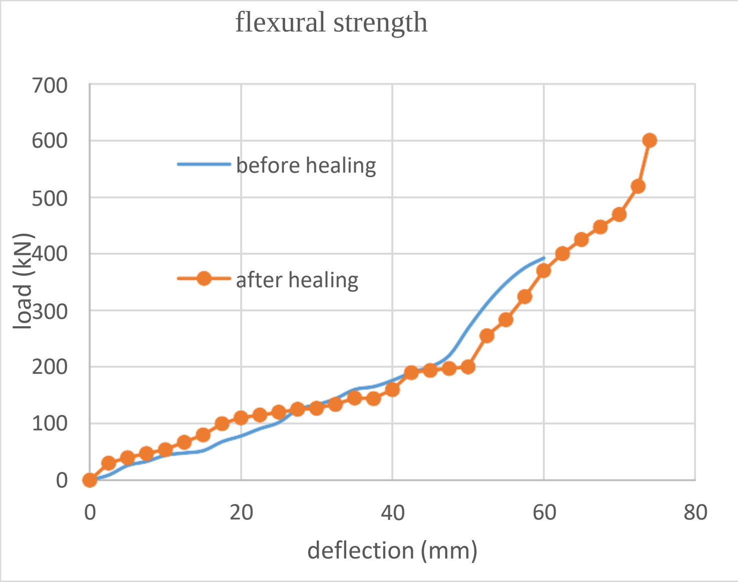
ISSN:0975-3583,0976-2833 VOL12,ISSUE07,2021

The bacterial carbonatogenesis activity was determined by the decomposition of urea in the deposition medium (DM) consisting of 20 g/L urea and 79 g/L$Ca(NO_3)_2 \cdot 4H_2O$. The amount of CaCO3 precipitated by bacteria can be indicated bythe quantity of urea decomposed in the deposition medium. The more urea decomposed,the more $CaCO_3$ formed. Since the deposition medium consisted of urea and$Ca(NO_3)_2$, the increase of CO_2 because of urea decomposition and the decrease ofCa_2+ and CO_2because of the formation of $CaCO_3$ would make it difficult to relateconductivity with the amount of urea decomposed. Therefore, the decomposed ureawas calculated also by measuring the TAN values in the deposition medium. The viability of the bacteria after being immobilized into silica gel were immersed into 50 mL urea solution and 50 mL deposition medium, separately.Besides, as the first control, the same amount of free bacterial cells (un-immobilized)was also added to the same urea solution and deposition medium. As the second control, silica gel without bacteria were also immersed into the samemedia. The experiments were done in triplicate. The conductivity of the urea solutionwas measured every 24 h for 4 days

Glass tubes with healing agent

To incorporate immobilized bacteria into mortar specimens, glass tubes with a length of 40 mm and an inner diameter of 3 mm were used to carry the healing agents. First, glass tubes were glued together and one of their ends was sealed by an adhesive. Then the healing agents were injected into each tube from the other end, which was sealed afterwards. For self-healing by using silica-gel immobilized bacteria, two glass tubes were glued together. One tube was filled with bacterial suspension (BS, same as in Section 2.4 and silica-sol. The other tube was filled with the same deposition medium (DM) as described in Section 2.4.

2.5.Specimen preparation and Testimg techniques



Prism specimens were casted as per the above specifications and curing was done for 28 days. After curing the prism specimens were tested under Flexural load test. During testing, a Load was gradually increased until the crack will appears.

Fig 1.flexural strength

Self healing mechanisms

The rate of self healing will be depending upon the growth of bacillious bacteria. The bacterias are induced in filled capusule placed zig zag manner in concrete. The capusule can be bracking during the intial cracking of concrete. The crack will de filled due to rate of growth of bacteria.

3.RESULTAND DISCUSSION

The graph shows that the deflection of the curve increased in 12 days after healing process achieved.

fig 1. deflection curve for prism

ISSN:0975-3583,0976-2833 VOL12,ISSUE07,2021

fig 2. Crack pattern of specimen

The initial crack witdh have 0.075mm will arrested by bacteria and after 7 days the width of crack is 0.0285mm. The full crack width will be arrested with 12 days. The good bond strength can be achieved between the two crack surfaces of concrete.

After heals attained, the prism member was subjected to two point load. The member withstand the load litle high compare than previous load. The crack forming were delayed, the healed concrete will be resist more than 15% of flexural strength than conventional concrete prism.

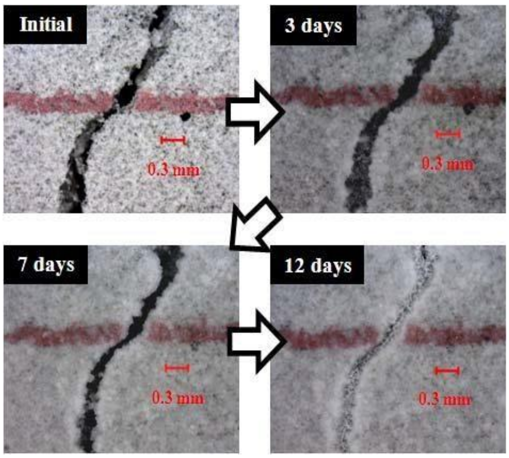


Fig 3. Crack-closing process of a crack at initial, 3, 7 and 12 days(refer to JAROENRATANAPIROM)

4.ACKNOWLEDGEMENTS

The author gratefully acknowledged and express their gratitude to Dr **P.Ponmurugan (department of boitechnology, KSR college of technology, Erode)** for his valuable support, suggestions and comments for the development of this paper**.**

5. CONCLUSION

Based on this experimental study, the following conclusions can be drawn.

Healing agents that are embedded inside the matrix may be useful to obtain self-healing properties in concrete. The application is using Bacteria to precipitate the cracks in concrete; with this method relatively large cracks can be closed by self-healing. By this method strength improvement will not occur, but by filling of cracks will block the path of reinforcement and will stop the leakage. 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. The tests with different crack mouth openings show all a similar amount of strength recovery.Crack healing is only observed when the cracked specimens are stored under water. Therefore it is promising to use bacteria like silica gel, polyurethane, and bacillus calcite is to self-heal early concrete micro cracks. By using self-healing concrete reduce the cost for repair in construction.

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ISSN:0975-3583,0976-2833 VOL12,ISSUE07,2021

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