EXPERIMENTAL AND COMPARATIVE STUDY OF SELF HEALING OF BACTERIAL CONCRETE

M.Velumani[1], M.Navaneetha[2], S.Sathish[3]

[1]Assistant Professor, [2,3] UG Scholar,
[1,2]Department of Civil Engineering, K.S Rangasamy College of Technology, Tiruchengode

ABSTRACT

Concrete is the foremost building material broadly used in building construction, but cracks in concrete are inevitable and are one of the inherent weakness of concrete. The major downside of concrete is its low tensile strength due to which micro crack occurs when the load applied is more than its limit and this paves way for the seepage of water and other salts. This initiates corrosion and makes the whole structure vulnerable and leads to the failure of structure. To remediate this type of failure due to cracks and fissures, an approach of using bio mineralisation in concrete has evolved in recent years. In this method, of enhancing the performance of concrete, the calcite precipitating spore forming bacteria is introduced into concrete. When water enters through the cracks, it reacts with bacteria and forms precipitates of calcium carbonate, as a by product, which fills the cracks and makes crack free concrete. This type of concrete prepared with bacteria is called as bacterial concrete. Thus, this paper is an attempt to define bacterial concrete, types and classification of micro organisms, working of bio concrete as a repair material, advantages and disadvantages of bacterial concrete and applications by literature review are discussed.

Key words: *Bacterial Concrete, Micro Organisms, E.Coli, Bacillus Subtilis, Self Healing.*

1. INTRODUCTION

Cracking of concrete is a common phenomenon. Without immediate and proper treatment, cracks in concrete structures tend to expand further and eventually require costly repairs. Even though it is possible to reduce the extent of cracking by available modern technology, remediation of cracks in concrete has been the subject of research for many years. There are a large number of products available commercially for repairing cracks in concrete: structures epoxy, resins, epoxy mortar and other synthetic mixtures. Cracks and fissures are a common problem in building structures, pavements, and historic monuments. We have introduced a novel technique in fixing cracks with environmentally friendly biological processes that is a continuous self-remediating process. In the study, E.Coli has been used to induce $CaCO_3$ precipitation. It is therefore vital to understand the fundamentals of microbial participation in crack remediation.

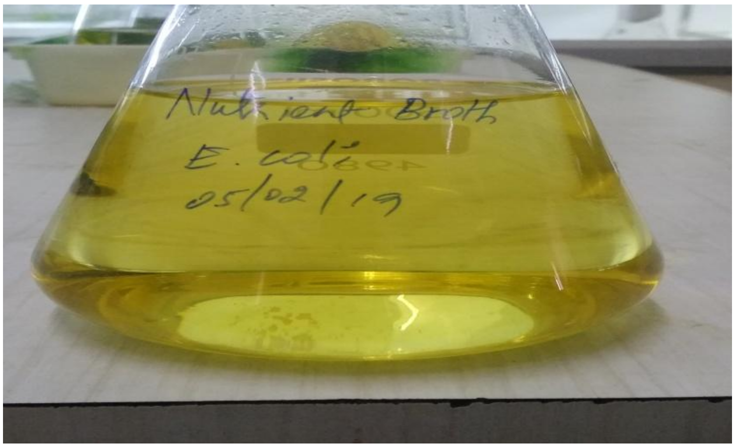

Fig 1.1. E.Coli E. Coli in Nutrient broth

Studies on microbial concrete have reported that the enhancement of the compressive strength is maximum at a particular bacterial concentration, which is not necessarily the highest amongst the considered levels of bacterial concentrations. In this paper, an attempt has been made to establish the cause of the presence of this optimal bacterial concentration. Three different bacterial concentrations of Bacillus subtilis have been used in this study, namely 103 cells/ml, 105 cells/ml and 107 cells/ml of water. Results indicate that though the higher bacterial concentration of 107 cells/ml is more efficient for crack healing, the best performance in compressive strength enhancement is achieved with the bacterial concentration of 105 cells/ml. It is seen that for a given bacterial type and mortar mix, the different calcite precipitation patterns inside the mortar matrix at varying levels of bacterial concentrations constitute the reason for the existence of the optimal bacterial concentration for compressive strength enhancement. Sandip Mondal et al (2018) This research investigated the potential of adding two different mineral producing bacteria into two types of cementitious mortar matrix to enhance self healing ability for autonomous crack repair. zeolite was used as a carrier material to protect bacteria in high pH environment normally exists in concrete. The spore forming ability and ureolytic activity of zeolite-immobilized bacteria were investigated in order to examine potential for producing healing compounds. The self-healing ability of bacteria incorporated normal and fiber reinforced mortars was judged based on the development of compressive strength and permeation properties of cracked specimens with age as well as micro-structural characterization of crack healing compounds using scanning electron microscopy (SEM), energy dispersive spectrometer (EDS) and X-ray diffraction. Sini Bhasker, et al (2017) The "Bacterial Concrete" is a concrete which can be made by embedding bacteria in the concrete that are able to constantly precipitate calcite. This phenomenon is called microbiologically induced calcite precipitation. It has been shown that under favorable conditions for instance Bacillus Pasteruii, a common soil bacterium, can continuously precipitate a new highly impermeable calcite layer over the surface of an already existing concrete layer. The favourable conditions do not directly exist in a concrete but have to be created.

Jaguang Zhang, et al (2017) Expanded Perlite (EP) particles were found to exert a positive effect on the healing capacity of concrete cracks. In this research they use non-ureolytic and alkaliphilic bacteria and EP particle .After cultured these bacteria according to the OD_{600} value of obtained bacterial suspension reached upto 0.4.The concentration of bacterial spores was microscopically measured as 3.6 x 10^9 cell/ml. These bacteria gives high healing capacity to concrete .The values of completely healed crack width after 28 days of healing were up to 0.79mm.

Sagar M . Gawande , et al (2017) Microbiologically enhanced crack remediation (MECR) utilizes a biological by-product, CaCO3 which has shown a wide range of application potential as a sealant. Its prospective applications include remediation of surface cracks and fissures in various structural formations, in-base and sub-base stabilization, and surface soil consolidation. In principle, MECR continues as microbial metabolic activities go on. This inorganic sealant not only is environmentally innocuous but also persists in environments for a prolonged period.

Nasiru Zakari, et al (2016) Microbiologically induced calcium carbonate precipitation (MICCP) is comprised of a series of complex biochemical reactions, including concomitant participations of Bacillus pasteurii, urease (urea amidohydrolase), and high pH. In this process, an alkalophilic soil microorganism, Bacillus pasteurii, plays a key role by producing urease that hydrolyzes urea to ammonia and carbon dioxide. The ammonia increases the pH in surroundings, which in turn induces precipitation of $CaCo_3$, mainly as a form of calcite.

Nele De Belie, et al (2016) The objective of the research work is to isolate and identifying Calcium Precipitating bacteria and to check the suitability of bacteria for use in concrete to improve strength. Bacterial strains were isolated from the alkaline soil samples from cement industry and tested for urease activity and wheat bran is used .Substantial increase in strength and complete healing of cracks was observed in specimen cast with B. megaterium and B.licheniformis.The enhancement of strength and healing of cracks can be attributed to the filling of cracks in concrete by calcite visualized by SEM.

2. METHODOLOGY

2.1 Literature Review

It gives the ideas and investigations of standard journals for the project

2.2 Material Collection

Materials like Ordinary Portland cement of Grade M_{25}, Fine Aggregate (M Sand) , coarse aggregate and Bacterial medium are used.

2.3 Testing of Material

The test such as Fineness, Specific Gravity, Density and OD_{600} for standard of materials

2.4 Mix Design

The Mix Design will be as per Indian standards

2.5 Casting and curing of Specimen

The Specimens such as cubes , cylinder and prism are casted and are subjected to water curing

2.6 Testing the specimen

The Specimen is tested for compressive strength, Tensile strength in laboratory and self healing nature by SEM Analysis

2.7 Results and Conclusion

The results will be based on comparing conventional and bacterial concrete. The Table.1 shows the specimens casting for both conventional and bacterial concrete.

TABLE. 1. CASTING SPECIMENS

S.NO.	SPECIMEN FOR CASTING
01	Cube (150 mm X 150 mm X 150 mm)
02	Cylinder (300 mm X 150 mm)
03	Prism (300 mm X 100 mm X 100 mm)

3. RESULTS AND DISCUSSION

The various results obtained from tests on bacteria to check its activity are as shown in Table.2.

TABLE. 2 VARIOUS TEST ON BACTERIA

Test	To determine	Result
Haemocyto meter test	Cell concentration	10^6 cells/ml of Bacterial solution
Gram staining	Morphology	Gram positive
Urease test	Urease test	Color change – yellow to pink
CaCO3 test	Quantity of calcite precipitation	3 mg/l
Spectrophotometer test	Cell concentration	108 cells/ml of Bacterial solution

3.1 COMPRESSIVE STRENGTH

The strength gain was about 50% and in concrete for E.coli compared that of conventional mix. Table.3. shows that the compressive strength is more for bacterial concrete for concentration of 10^6/ml of water. The strength increment is found to be 12.2% respectively for E.coli

TABLE.3 COMPRESSIVE STRENGTH OF CEMENT CONCRETE (MPA)

Age, (Days)	Conventional	E.coli
7 days	25.31	28.33
28 days	30.23	35.56

ISBN : 978-93-87793-75-0

3.2 SPLIT TENSILE STRENGTH

Table.4. indicates the split tensile strength of conventional and bacteria concrete. It is observed that the split tensile strength of bacterial concrete is marginally higher compared to conventional mix.

Table.4. Split tensile strength of concrete (MPa)

Age,(Days)	Conventional	E.coli
7 days	3.42	3.45
28 days	3.75	4.45

4. CONCLUSIONS

The importance of this work is to understand, the use of urease producing bacteria isolates, such as Bacillus subtilis, bacillus pasteuri E.coli species in healing of cracks in concrete. The study has reviewed different types of bacteria that can be used for healing cracks. This study has also identified that bacteria has a positive effect on the compressive strength of Portland cement mortar cubes and concrete. The advantage of using bacteria decreases water penetration and chloride ion permeability. The present study results recommends that using the ‘‘microbial concrete” can be an alternative and high quality concrete sealant which is cost effective, environmental friendly, and eventually leads to improvement in the durability of building materials. The use of microorganisms for the improvement of the strength and durability of building materials has drawn much attention of civil research groups all over the world. A lot of improvements need to be done before the technology can be implemented in day-to-day life. Due to the variation in the temperatures, humidity, type of concrete, mechanism of various parameters such as type of mix, concentration of bacteria vary considerably from place to place, hence a consolidated commendation of any microorganisms under different environmental conditions also needs to be concentrated. Hence, lot of research is necessary before such technology is ready for field of civil applications. Most of the studies focussed on MICP were carried out to evaluate strength, water absorption and crack remediation of mortars and concretes. Further studies should be directed to make overall process green and economic. Though most of research groups are working for alternative approaches to obtain a protective layer of calcium carbonate on the surface of building materials the present work is to provide an in-depth application of the different methodologies based on literature to fill the gap of current research towards enhancement of the durability of various construction materials.

5. REFERENCE

1. Sandip Mondal et al , " Investigation into the optimal bacterial concentration for compressive strength enhancement of Microbial concrete" , Indian Institute of Engineering Science and Technology pp 204 -213 (2018)

2. Sini Bhasker ,et al , " Effect of Self Healing on strength and Durability of Zeolite – immobilizated bacterious cementitious, Mortar", pp 24 -31 (2017)

3. Jaguang Zhang , et al, " Immobilizing Bacteria in expanded perlite for the crack Self Healing in concrete", pp 611-614(2017)

4. Sagar M . Gawande , et al, " Behavioural Study of Bacterias in Formation of M_{35} Grade concrete as Bio concrete" , International Research of Engineerng and Technology , vol 4, Issue 5 , pp2026-2029 (2017)

5. Nasiru Zakari ,et al, " Test and Methods of Evaluating the Self Healing efficiency of concrete", Construction and Building materials , pp 1124-1129 (2016)

6. Nele De Belie , et al "A study on Bacteria Based Concrete" , Eco efficient Repair and Rehabilitation of structures pp532 – 549 (2016)

7. Haoling , et al, "Self Healing cementitious materials based on Bacteria based Self Healing Concrete" , Research Institute of Green Construction Materials pp298-302 (2015)

8. Institute of Green Mian Luo ,et al , "Factors affecting crack repairing capacity of Bacteria based Self Healing concrete", Research Construction Materials pp 2-6 (2015)

9. Rakesh Chidara , et al, " Achievement of Early compressive strength in concrete using Sporosarcina Pasturii Bacteria as an admixture", National Institute of Construction management, volume 4 ,pp2-7(2014)

10. Vijeth N Kashyap, et al , " A Study on effect of Bacteria on Cement Composites" , International Journal of Research n Engneering and Technology vol -5 (2014), pp356 – 360

11. J.Y.Wang ,et al, " Self Healng Concrete by use of Microencapsulated Bacterial Spores", Cement and Central Research,pp 140-151 (2014)

12. Erick Schlangen , et al, " Addressing Infrastructure Durability and Sustainability by Self Healing Mechanisms .Recent Advances in Self Healing concrete and Asphalt", The second International Conference on Rehabilitation and Maintanence in Civil Engineering, pp49-57 (2013)