A REVIEW ON DIFFERENT TECHNIQUES OF SELF HEALING CONCRETE

Pandey Shivam , Nishad Rahul, Gosar Vimal, Pachori Sunita

Department of Humanities &Sciences,
Thakur College of Engineering & Technology, Mumbai, Maharashtra, India
sp9619357472@gmail.com
rahulnishadcb72@gmail.com
rahulnishadcb72@gmail.com
sunita.pachori@thakureducation.org

Abstract: ***In this paper, a review of new development research on Self Healing of cracks in concrete based on the materials and asphalt concrete are given. Formation of cracks in the concrete leds to water and moisture transportation through the concrete and due to this corrosion occur, which can permanently damage the structure. For prevention of this impacts a self healing properties were developed. Reason the damage of concrete structure is due to changing in the climate and expansion & contraction of concrete. Bacterial, Capsule, Induction Heating, Internal Curing, Chemical method arec the types of Self Healing Concrete discussed this review paper. It was found from the many researches groups that the formation of cracks are healed in the initial stage and then later on it increases the strength and durability of of structures.Bacterial Concrete reduces the maintenance cost. Along with this if the self healing agents were mixed in the greater quantity it reduces the strength of cement. Bacterial Concrete method has proved to be better than the other methods because it is eco-friendly and durability& strength increases for various building materials. More works are required for optimize them.***

Keywords: Cracks in concrete, Self Healing, Bacteria, Capsule, Induction Heating, Internal Curing

1. Introduction:

In the Civil Engineering the main issue is the strength and durability of structures which comes parallel with the materials, that is concrete. In the past many researches on the self healing concrete were developed. Self Healing Concrete materials were developed to increases the strength and the life time of concrete. Different mechanisms were already tested with the results by diff research groups, but still requirements are needed for optimize them. Self Healing efficiency was evaluated based on the amount of regain in strength, durability, stiffness, etc. Regaining in mechanical properties os determine by reloading the previous load and thus damage sample and comparing a mechanical properties gained by reloading with original properties. Self healing agents such as epoxy, resin, bacteria, fiber, chemical, etc are used to heal the cracks in concrete. Among this, Bacterial Concrete is used commonly and it is also found that bacterial concrete is more effective than the other method. When bacteria are mixed with the concrete it forms calcium carbonate in the form of precipitate and these precipitate heals the cracks and increases the strength and durability. Sir H.M. Jonkers *et al*(2010) studied the self healing properties of concrete using different methods. He selected the Bacterial Concrete method to improve strength and durability of concrete. In Bacterial Concrete, the bacteria used are found naturally anywhere on the earth surface and in the depth of rock as well, that is more than 1km inside the earth.

The varioustypes of bacteria are used in concrete are:-

- Bacillus pasteurized
- Bacillus sphaerieus
- Escherichia coli
- Bacillus subtitles
- Bacillus cohnii
- Bacillus balodurans
- Bacillus pseudofirmus

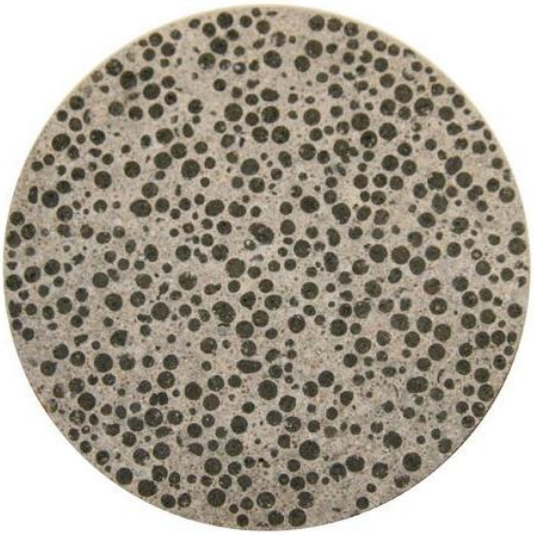


Figure 1: Cracks in concrete

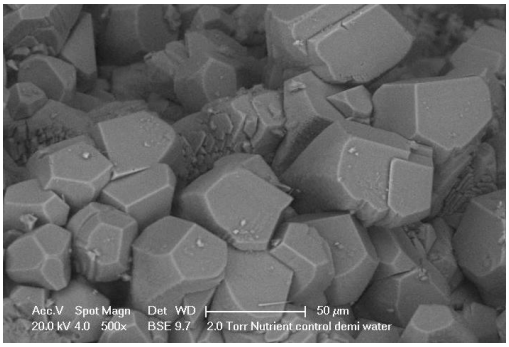


Figure.2: Biominerals observed by ESEM [1]

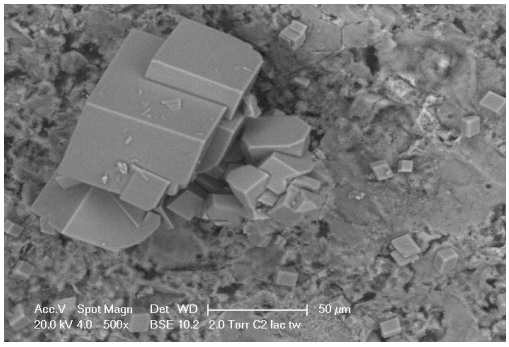
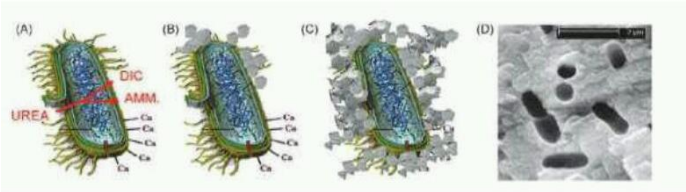


Fig.3 : Biominerals observed by ESEM [1]

The bacteria are found in highly dedicated environments such as desert, rock and even in ultra-basic environments which is homologous to internal concrete environment. In Bacterial Concrete, selectedtype of bacteria with calcium based nutrients known calcium lactate are added to the concrete when it is being mixed. The self healing agent can lie within the concrete matrix for two hundred years. When crack occurs and water passes through the cracks, the bacteria present in the concrete matrix starts to feed on the calcium lactate by consuming oxygen and converts the calcium lactate into the insoluble calcium carbonate(limestone). And this limestone heal the cracks. It is similar process of how the fracture of human bones gets naturally healed by osteoblast cell. The conversion of bacterial concrete takes place either in the interior or exterior of the microbial cell or even some distance away in the concrete.

Advantages:-
1) Heals the cracks quickly.
2) It increases the the strength, durability and stiffness.
3) It is pollution free and eco-friendly.
4) Lower repair and maintenance cost.
Disadvantages:-
1) Cost of bacterial concrete is higher.
2) Growth of bacteria is not good in any atmosphere and media.



Calcium Hydroxide is present in concrete matrix and it reacts with atmospheric carbon dioxide and form Calcium Carbonate:

$$CO2 + Ca(OH)2 \rightarrow CaCO3 + H2O$$

The self healing process in Bacterial concrete is more efficient due to active metabolic of calcium lactate from the bacteria:

$$Ca(C3H5O2)2 + 7O2 \rightarrow CaCO3 + 5CO2 + 5H2O$$

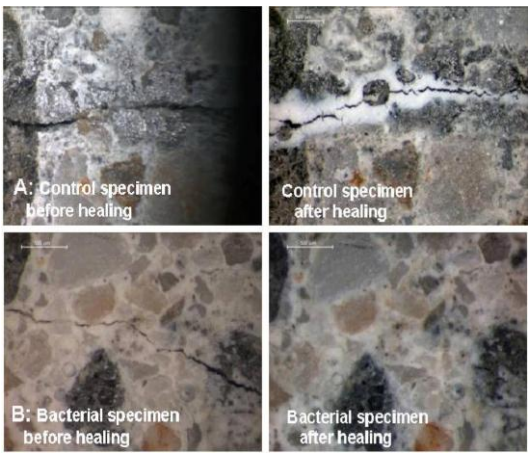


Fig. 5: Experimented cracked concrete [1]

This process was used to not only produce calcium carbonate but also carbon dioxide with Portland ore present on the crack surface. The fact that Portlandite does not dissolve away from the crack surface reacting directly on spot with Bacterial produced CO2 to addition of calcium carbonate results in efficient crack healing (Fig 5). It was concluded that bacteria improvises calcite in cracks thereby increasing the strength of concrete.

2. Literature Survey

Sir H.M. Jonkers *et al* (2011) selected Healing Porous Asphalt Concrete in which two methods were implemented:

1. Capsule Method
2. Induction Heating Method

In Capsule Method, Bitumen is considered in two phases, viz. Maltenes (Liquid Phase) & Asphaltenes (Solid Phase). As soon as the liquid dries up, making the asphalt dry and brittle, only the first few centimeters of the surface are affected. To solve this Capsules filled with Maltenes were mixed with the concrete and when the crack would occur, the capsule would break and heal it (Fig 6).

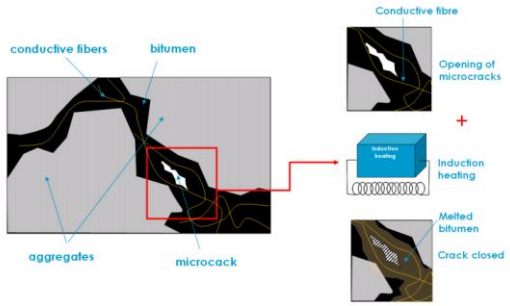


Fig. 6: Capsule Method [3]

In Induction Method, the basic approach was to heat the asphalt with induction energy to increase its healing rate and making the concrete conductive by adding electrically conductive filler & fibers connected in closed loop circuits. With the fact that eddy current is induced in closed loop circuits when magnetically susceptible and electrically conductive materials are placed in vicinity of the coil, with the same frequency of magnetic field, heat is generated through the energy lost in resistance of the material for the eddy current, which melts Bitumen closing the crack. It was concluded that the self healing capacity of the concrete is increased with the use of encapsulated oil and micro-stell fibers(Fig 7).

In this research their are three steps:-

1) Optimum combination of conductive fillers and fibres.

2) Temperature reached depending on the electrical conductivity.

3) Proof of the healing, the samples will be repeatedly broken in 3 point bending, heating and healing again.

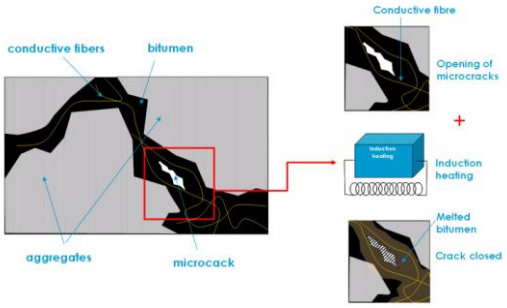


Fig. 7: Induction Heating Method [3]

N. Ganamanikarnika (2015) used a super absorbent polymer to study the behavior of the self healing concrete. Internal Curing (Self Healing) is a process of crystallization using ingredients present in the substrates itself. The concrete was mixed with many substances as in the Table 1. Initially the dry components were mixed which comprised of Cement, Fine & Coarse Aggregates for a minute followed by addition of water and super plasticizer for 4 minutes.The effect of Internal Curing studies on different types of concrete peoperty.

A) Fresh Properties [slump and density].

B) Mechanical Properties [compressive strength, flexural strength and split tensile strength].

It was concluded that density of fresh concrete composition decreased with increase in amount of curing water. For harder concrete, the decrease in density with increase in amount of SAP (Super Absorbent Polymer) was found.

Table 1: Mixing Proportion of Components (in kg)

Cement	Fine Aggregates	Coarse Aggregates	Silica Fume	Super Plasticizer	Water
620	520	902	25	5	215

Rishabh Lala et al explains the experiment on self healing which was introduced by **Chan-Moon Chung**. When two substances

methacryloxypropyle-terminated poly dimethylsiloxane and benzoyl isobutyl-ether are mixed in the presence of sunlight, they forms a water proof polymer, which sticks to concrete. Now, this balm is filled in a tiny capsule which is made up of urea and formaldehyde, which protects the chemical mixture to reacts with sunlight. When cracks occur due to external condition, the capsule break and the balm come out. Then due to exposure of sunlight, the balm reacts and forms a water proof polymer. A fact proved by an immersing a block on water. After 24 hours of immersion, weigh the blocks to see how much of water get absorbed. On average, untreated concrete block absorb 11.3 grams of water. Concrete coated with capsule - free polymer placed in a 3.9 grams but only 0.4 grams of water were absorbed.

3. Conclusion

In this paper, different self healing techniques are discussed. The first is using bacteria to precipitate calcite in cracks. With this method, large cracks in reinforced cement can be filled. The Bacterial self healing concrete technology is better than the other technologies because it is eco-friendly. According to many research groups, the cost of bacterial concrete is increases by 30% to conventional concrete. This method is easy and convenient. This process provides long life to structure. But more work is required on the following factors such as economical factors and quality of bacteria.The paper also describe by the application of bacteria in concrete. It is found that strength of the concrete increases with decrease in water transportation or watet absorption, etc. Bacterial Concrete will be come soon in construction of durable, cost effective and eco-friendly high quality building.
The second is for asphalt concrete in which the self healing capacity is increased by using encapsulated oil and micro-stell fibres. The approach of this concrete has proven in laboratory. The third is Internal Curing in which adding of Super Absorbing Polymer (SAP) into the concrete as a internal curing agent by adding additional curing water to concrete which increases the strength of concrete.

REFERENCES

[1] H.M.Jonkers (2010), "Recent advances on self healing", Proceeding of FraMCoS - 7, May 23-28, 2010, pg no. 291 - 298
[2] N. Ganamanikarnika (2015), "An Experimental Investigation on Self Healing of High Performance Concrete", International Journal sath (2015), ISSN: 2348-8352, pg no.59-63.
[3] H.M.Jonkers (2011), "Bacteria-based Self-healing concrete", "HERON volume-56 (2011) no.1/2", pg no. 1-12.
[4] Abhishek Thakur (2016), "Bacterial concrete and effects of Different Bacteria on the Strength and water absorption characteristics of concrete: A Review", International Journal of Civil Engineering and Technology (IJCIET), Volume-7, 5 - September - October - 2016, pg no.43-56, ISSN: 0976-6308.
[5] Mayur Shantilal Vekariya (2013), "Bacterial Concrete: New Era For Construction Industry", International Journal of Engineering Trends and Technology (IJETT), Volume-4, 9 - September - 2013, pg no. 4128 - 4137, ISSN : 2231 - 5381.
[6] M. Hanumanth Rao, (2015), “Experimental study on Bacterial cement composites”, International Journal of Computer Engineering in Research Trends, Volume 2, 12 December 2015, pg no. 953-958, ISSN No. 2349-7084.
[7] S. Soundharya (2014), “Study on the effect of calcite- precipitating Bacteria on self-healing Mechanism of concrete (Review Paper)”, International Journal of Engineering Research and Management Technology, Volume 1, 4 July 2014, pg no. 202-208, ISSN No. 2348-4039.
[8] M.V.Seshagiri Rao (2013)," Bioengineered Concrete - A Sustainable Self - Healing Construction Material", Research Journal of Engineering Sciences, vol 2(6), pg no. 45-51, June (2013), ISSN : 2278-9472.
[9] Saheena Brevity Abdul Vabah, " Self Healing Bacterial Concrete", Rajadhani Institute of Engineering and Technology, Attingal, Thiruvananthapuram, July 2014.
[10] S. Dinesh et al (2017), " A Review on Bacteria - Based self - healing agent", Imperial Journal of Interdisciplinary Research(IJIR), vol - 3, issue - 1, 2017, ISSNNo. :- 2454 - 1362.
[11] E.Ezhilarasi (2016)," Experimental Study on Flexural Behaviour of Self Healing Concrete using Bacillus Subtitles Bacteria", International Journal of Engineering Research and Technology (IJERT), Volume 5, 12-December-2016, pg no. 147-152, ISSN: 2278-0181.