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Bacterial Concrete or Self-Healing Concrete

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Abstract

Crack formation is very common phenomenon in concrete structure which allows the water and different type of chemical into the concrete through the cracks and decreases their durability, strength and which also affect the reinforcement when it comes in contact with water, CO_2 and other chemicals. For repairing the cracks developed in the concrete, it requires regular maintenance and special type of treatment which will be very expansive. So, to overcome from this problem autonomous self-healing mechanism is introduced in the concrete which helps to repair the cracks by producing calcium carbonate crystals which block the micro cracks and pores in the concrete. The condition of growth is different for different types of bacteria. The selection of the bacteria was according to their survival in the alkaline environment such as B. pasteurii, Bacillus subtilis and B. spharicus which are mainly used for the experiments by different researchers for their study. Bactria improves the structural properties such as tensile strength, water permeability, durability and compressive strength of the normal concrete which was found by the performing different type of experiment on too many specimens had varying sizes used by different researchers for their study of bacterial concrete in comparison with the conventional concrete and from the experiment it was also found that use of light weight aggregate along with bacteria helps in self healing property of concrete. For gaining the best result a mathematical model was also introduced to study the stress-strain behavior of bacteria which was used to improve the strength of concrete.

Key words,
Bacterial Concrete, Flexural test, Compressive Strength

1. INTRODUCTION

Concrete is very good material to resist the compressive load to a limit but if the load applied on the concrete is more than their limit of resisting load, it causes the strength reduction of concrete by producing the cracks in the concrete and the treatment of the cracks in very expensive. Some of the property like durability, permeability ad strength of the concrete structure is also decreases. Due to increase in the permeability of the concrete the water easily pass through the concrete and come in the contact with the reinforcement of the concrete structure and after some time corrosion start due to this strength of the concrete structure will decreases so it will be necessary to repair the cracks. By introduce the bacteria in concrete it producing calcium carbonate crystals which block the micro cracks and pores in the concrete. In concrete micro cracks are always avoided but to some extent they are responsible to their failure in strength. Ravindranatha, N. Kannan, Likhit M. L (**2014**) described that Bacillus pasteurii exhibits a phenomenon known as bio-calcification as a part of its metabolic activity. Bio-calcification is a process through which the micro-organsim externally secretes calcium precipitate, which in the presence of a carbonate ion forms CaCO3 which fills up the voids in the concrete texture thus making it more compact. This inturn improves the strength in concrete due to growth of the filler material within the pores of the concrete mixerThe common problem found in buildings is Crack. Crack may be due to many reasons. Some reasons are listed below,

- Concrete expands and shrinks due to temperature differences
- Settlement of structure
- Due to heavy load applied
- Due to loss of water from concrete surface shrinkage occurs

- Insufficient vibration at the time of laying the concrete
- Improper cover provided during concreting
- High water cement ratio to make the concrete workable
- Due to corrosion of reinforcement steel
- Many mixtures with rapid setting and strength gain performance have an increased shrinkage potential.

1.1 Bacteria Used in Bio Concrete

In suspension state, concrete mix is added with bacteria. Concrete being extremely alkaline in nature, the bacteria added should fit in some special norms. The added bacteria should be able to withstand the harsh environmental conditions of concrete. Concrete is a dry material and the pH value of cement and water when mixed is up to 13 which makes it confrontational as most of the organisms cannot survive in an environment having pH value higher than 10.shown in fig.1

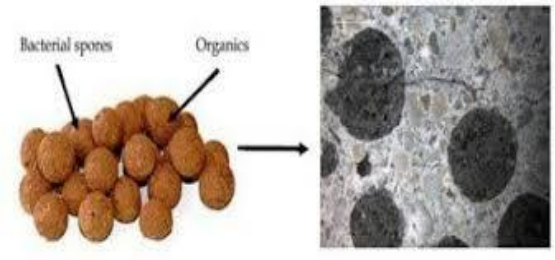


Fig: 1 Self healing admixture composed of expanded clay particles loaded with bacterial spores and organic bio mineral precursor compound (calcium lactate).when embedded in concrete matrix

1.2 Types of Bacteria

Bacteria naturally occur in nature in various forms. They are present not only on the surface but also beneath the surface of the earth. The various bacteria that can be used in concrete are:

1.3 Anaerobic Bacteria If anaerobic bacteria like closely related specie of shewanella are added to concrete, the compressive strength increases from 25-30%.

1.4 Aerobic Bacteria

The various types of aerobic bacteria that can be used in concrete are

1.4.1 Bacillus sphaericus

- Escherichia coli
- Bacillus subtilis
- Bacillus cohnii
- Bacillus pseudofirmus
- Bacillus halodurans
- Bacillus massiliensis

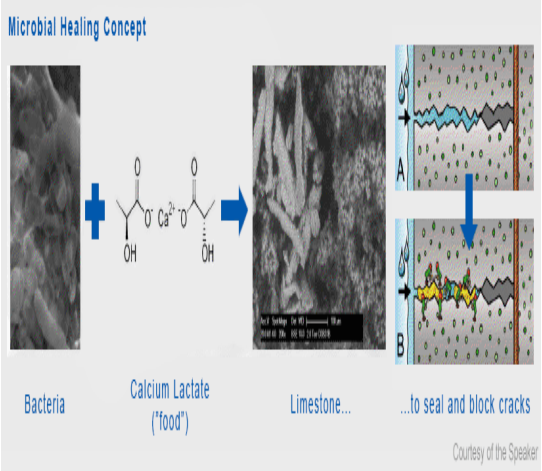


Fig 2. Microbal Healing process in concrete bacteria reacting with calcium lactate

It has been observed after 7 days strength the s.soli and L. fusiformis showed better compressive strength while as B. massiliensis and A. crystallopoietes no strength improvement was observed. A.crystallopoietes showed the maximum strength after 28 days.

2. Experimental Analysis

Test and Result of Self-Healing or Bacterial Concrete and Normal Concrete
Standard test were conducted on normal concrete and self-healing concrete. Test conducted were Compressive strength tests on a concrete cube for 7 and 28 days shown in table 1and Flexural Strength Test result for 7 and 28 days of Bacterial Concrete shown in table.2

Table1 Compressive Strength Test result for 7 and 28 days for Bacterial Concrete

SL No	DAYS	NORMAL CONCRETE (N/mm^2)	BACTERIAL CONCRETE (N/mm^2)
1	7	20.85	27.10
2	28	30.00	38.95

Table: 2 Flexural Strength Test result for 7 and 28 days of Bacterial Concrete

SL No	DAYS	NORMAL CONCRETE (N/mm^2)	BACTERIAL CONCRETE (N/mm^2)
1	7	3.90	4.6
2	28	7.05	7.80

From the results we can see that both the compression strength and the flexural strength of the bacterial concrete is greater than that of normal concrete.

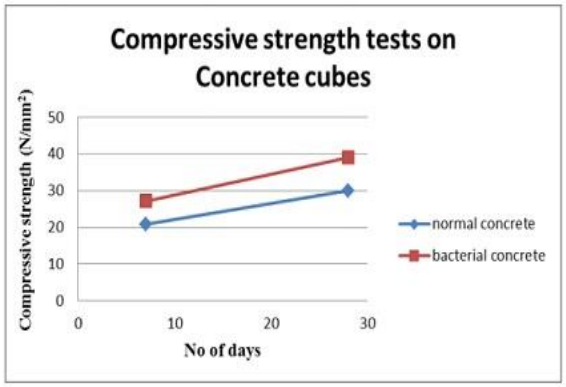
2.1 Advantages of Bacterial Concrete

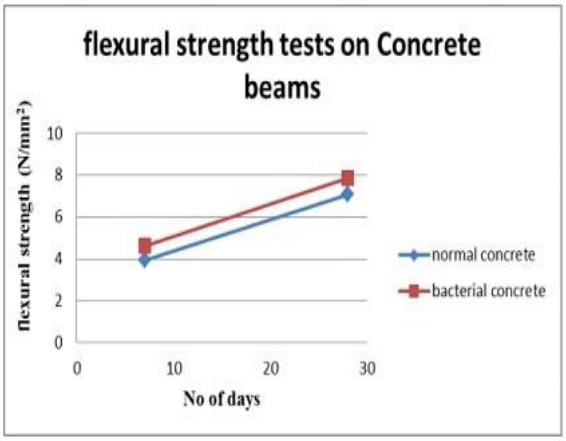
- Self-repairing of cracks without any external aide.
- Significant increase in compressive strength and flexural strength when compared to normal concrete.
- Resistance towards freeze-thaw attacks.
- Reduction in permeability of concrete.
- Reduces the corrosion of steel due to the cracks formation and improves the durability of steel reinforced concret e.
- Bacillus bacteria are harmless to human life and hence it can be used effectively.

2.2 Disadvantages of Bacterial Concrete

- Cost of bacterial concrete is double than conventional concrete.
- Growth of bacteria is not good in any atmosphere and media.
- The clay pellets holding the self-healing agent comprise 20% of the volume of the concrete. This may become a shear zone or fault zone in the concrete.
- Design of mix concrete with bacteria here is not available any IS code or other code.
- Investigation of calcite precipitate is costlyResult and Des

3. Results and Discussions





Conclusion

The conclusion can be summarized as:

• The compressive, split tensile and flexural strength of M20 bio-concrete is found to be higher than M2O conventional concrete.

• The percentage increase in compressive strength of bio concrete using B. Subtilisfor 7 days is 6.42% and for 28 days is 9.16% higher than conventional concrete.

• The percentage increase in compressive strength of bio concrete using B. Sphaericusfor 7 days is 65.93% and for 28 days is 52.42% higher than conventional concrete.

• The percentage increase in compressive strength of bio concrete using B. pasteurii for 7 days is 29.99% and for 28 days is 29.97% higher than conventional concrete.

• The percentage increase in split tensile strength of bio concrete using B. subtilis for 7 days is 38.17% .and for 28 days is 14.41% higher than conventional concrete.

• The percentage increase in split tensile strength of bio concrete using B. sphaericusfor 7 days is 31.14%

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