Experimental Study on Self-Healing Bacterial Concrete by Using E-Coli Bacteria

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Abstract— Concrete is an adaptable material having lowered tensile & shear strength. Basically concrete is brittle material and contains lots of micro-cracks present in the body. The elasticity of concrete is fairly constant at low stress levels but starts decreasing at higher stress levels as matrix starts cracking. Concrete has a very low coefficient of thermal expansion and concrete shrinks. All concrete structures will crack to some point, due to shrinkage and tension. Concrete which is under load of forces for long duration of time, creep of concrete may happen. Carbonate-producing bacteria have provide lots of benefits as a promising, natural, environmental friendly novel technique to improvement of concrete characteristics, considerable research has been conducted on utilizing microbial-induced carbonate precipitation to overcome several concrete problems such as crack repair, reduction and modification of porosity, and permeability. Furthermore, bacterial carbonate precipitation (bio deposition) has shown positive influences on compressive strength improvement of concrete, it also reduces water absorption and carbonation of concrete as an alternative surface treatment. As part of metabolism, some bacteria produces enzyme urease which catalyzes the hydrolysis of urea to generate carbonate ions without an associated production of protons which leads to CaCO3 precipitation in presence of calcium ions. Therefore, bacteria cells not only provide a nucleation site for CaCO3 precipitation in presence of calcium ions.

Keywords: E-coli, Bio-concrete, Compressive Strength, Bacterial Solution, Self- healing

I. INTRODUCTION

Self–healing concrete is a product that will biologically produce limestone to fill cracks that appear on the surface of concrete structures. These self -healing concrete lies dormant with in the concrete for up to 200 years. However, when a concrete structure is get damaged and water starts to seep through the cracks that appear in the concrete. By using a special type of bacteria, the concrete can be start healing when the bacteria can be mixed with the concrete while mix proportioning.

Here we used E.coli bacteria to heal the concrete and also get sufficient strength than the conventional concrete. The spores of the bacteria were contact with the water and nutrients. When bacteria gets activated they starts to eat CaCO3 precipitation.

As the bacteria feeds oxygen is consumed and the solublCaCo3 is converted into the limestone. The limestone solidifies on the cracked surface and sealing it up. Current study has to overview that biotechnology can really be a supportive Device to reduce micro cracks in concrete structures by using E.coli in concrete. This latest category of concrete, that is set to fix itself, shows a powerful enormous improvement in community infrastructure's service-life, there by considerably reducing the maintenance costs and lowering Co2 emissions. Several made of bacterial concrete in last few years. This paper cover the investigation based on bacterial solution are discussed.

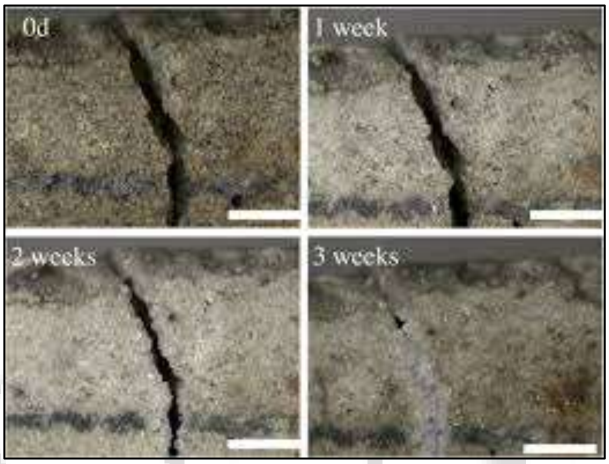

Fig. 1: Self-Healing Concrete

II. ESCHERICHIA COLI

Theodore Escherich who was the first to describe the colon bacillus under the name bacterium coli commune (1885). And named it Escherichia coli. Based on minor differences in bio chemical characteristics, colon bacilli were described under various names but in view of the mutability of the bio chemical properties in this group.

They have all been included in one species e coli which is further sub divided into biotypes and serotypes. A few other species have been described in the genus but they are of little medical importance. These include E fergusonii, E Herminie and E vulneris which have been isolated in frequently from clinical specimen.

E blattae sound in the gut of cockroaches is bio chemically different in being indole and beta-Galactosidase negative. It has not been isolated from clinical specimens. Unlike other coliforms, E coli is a parasite living only in the human or animal intestine.

Voided in feces l, it remains viable in the environment only for some days. Detection of E coli in drinking water, therefore, is taken as presence evidence of recent pollution with human or animal feces.

Morphology:

E coli is gram negative, straight rod measuring 1-3*0.4-0.7 microns, arranged singly or in pairs. It is motile by peritrichate flagella, through some strains may be nontitle. Capsule and fimbriae are found in some strains. Spores are not formed.

A. Culture characteristics:

It is anaerobe and a facultative anaerobe. The temperature range is 10-40 °C (optimum 37°C). Good growth occurs on ordinary media. Colonies are large and thick and also are moist, greyish white in colour. Colonies are partially translucent dices. This description applies to the smooth from seen on fresh isolated, which is easily emulsifiable in saline. On the rough form give rise to colonies with an irregular dull surface and are often autosugglutinable in saline. The S- R variation occurs as a result of repeated subculture and is associated with the loss of surface antigens and usually of virulence. Many pathogenic isolated have polysaccharide capsule. Some strains may occur in the mucoid forms.

Many strains, especially this isolated from pathologic conditions, are hemolytic on blood agar. On macConkey's medium, colonies are get bright pink due to lactose fermentation. Growth is largely inhibited on selective media such as DCA is SS agar used for the isolation of salmonella and shigellae. Growth occurs in broth which disperse completely on shaking as general turbidity and heavy deposit.

B. Biochemical reactions:

Glucose, lactose, mannitol, maltose and many other sugars are fermented with the production of acid and gas. Typical strains do not ferment sucrose.

The four biochemical test widely employed in the classification of enterobacteria are the indole, methyl red (MR), votes - proskauer (VP) AND curate utilization test, generally referred to by the mnemonic 'IMViC'. E coli is indole and MR positive, and VP and curate negative (IMViC + + - -). Geletin is not liquified, H2S is not formed, urea is not split and growth does not occur in KCN medium.

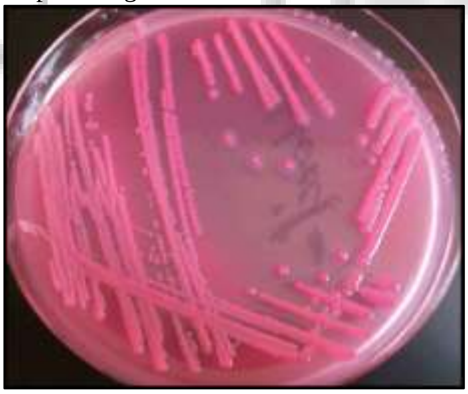

Fig. 2: Escherichia Coli

III. LITERATURE SURVEY

"G. Adhithya Vijay, R. Tamilarasan, C. Yashwanth, A. Arun and E. Arunachalam" Has published a paper on self-healing concrete. It's a concrete of future construction technology which say a some commonly found bacterial species can be used to strengthen the concrete and change it bulk property. Mainly the bacteria they used can produce CaCo3 by using lactose as food. The effectiveness of this technique can be evaluate by using comparison of Normal OPC cement vs bacterial cement. So basically the bacteria added in concrete feels the cracks up to some extent and increase the volume of concrete. Here they conduct a experiment to determine the strength of concrete by adding different percentage of bacteria which show the positive results. The experiment show higher the bacteria content greater the strength.

"Senthilvel M. Balamurugana S. & Navaneetha B." Has published paper on self-healing concrete and their paper tells us that bacteria used coccrete is more effective than conventional concrete.it has more advantageous and it transforms the concrete from eco harming to eco-friendly. SHC reduce the emission of CO2. It also say it require minimum 40ml of bacteria for healing cracks.

"Manas Sarkar, Nurul Alam, Biswadeep Choudhuri, Brajadulal Chattopadhyay and Saroj Mandal" Has published paper on development of e coli bacterial strain for green and sustainable concrete technology it says the most common E coli bacteria strain have same characteristics like hot spring microbial consortium for industrially viable and also it is commercially applicable for the development of HPC (High Performance Concrete) In that they experimented on concrete mix by partial removal of cement and adding e coli to improve strength and durability of concrete and also it is easy and low cost technology will give high performance concrete that will be useful in construction of buildings, bridges etc.

IV. EXPERIMENTAL WORK

1) Mixing of concrete.

Mixing of concrete by a small hand mixer. Inside of the haul spread out the measured quantity of coarse aggregate and fine aggregate in alternate layers. Pour the cement on the top of it. This uniform mixture is spread out then dry mix it, this operation is continued till such a good time a good uniform, homogenous concrete is obtained. It is a particular importance to see that the water should not poured but it is only sprinkled. For required consistency water should be added end of the mixing. After that the bacteria medium is sprinkled over the concrete mixture.

2) Placing.

Placing of also plays an important role in strength of concrete as it is also as important as designing, batching and mixing of concrete. Neatly placed concrete gives better finishing and gives optimum results at the end. The precautions to be taken and methods adopted while placing concrete in the moulds.

3) Hand compaction

For small concrete works hand compaction is adopted. Hand compactions is also applied in structures where large quantities of reinforcement is there and in which mechanical compaction is not well suited as hand compaction. Hand compaction consists of rodding, ramming or tamping. When hand compaction is adopted, the consistency of concrete is maintained at a high level. In case of roof or floors slab or road pavements, tamping method is usually adopted as thickness of concrete is less and smooth and level surface is required.

4) Curing.

Curing is one of the important process in making of concrete. Concretes gain its strength by heat of hydration of cement. The heat of hydration is a process that continues for long time and curing fulfills that job by keeping concrete moist, warm till the very end until the desired properties that is workability and strength and sufficient degree of temperature is meet as such requirement of structure. The casted cubes and cylinders are immersed in water tanks for 3 days, 7days, 14 days and 28 days.

A. *Mix Design.*

1) Concrete grade: M25
2) Exposure: Severe (for reinforcement work)
3) Quality control: Fair
4) Workability: 75 mm
5) Cement used: OPC 43 grade
6) Sand grading: Zone 1
7) Specific gravity of cement: 3.15
8) Water cement ratio: 0.45
9) Cement = 15.04 kg
10) Sand = 26.07 kg
11) Coarse aggregate = 36.36 kg
12) Water =7.5 lit.

Fig. 3: Concrete Material

Sr. No.	Water	Cement (kg/m^3)	FA (kg/m^3)	CA (kg/m^3)
1	186	372	654.54	1198.8
2	0.5	1.0	1.73	3.22

Table 1: Content for $1m^3$ of Concrete

S.No	Materials	Quantity
1	Cement	11.28 kg
2	Fine aggregate	19.57 kg
3	Coarse aggregate	36.36 kg
4	Water	5.64 lit
5	Bacterial solution	30 %, 40 %, 50 %
6	Total Cubes	09

Table 2: Quantity of Materials

B. *Culture*

The bacteria used in this study were an Escherichia Coli which was cultivated. (Ingenious Cell Culture Development Lab) and Agar plates are used for isolating of pure culture of bacteria strain.

Fig. 4: cultivated bacteria.

Bacterial food - Calcium lactate, Total added 200gm.
Per batch of 3 blocks 66.7gm used i.e. 1.33% of cement.

Fig. 5: bacterial food

pH	NaOH Content	Days of culture from
8	2.5	2
9	2.8	5
10	2.7	13
11	2.9	22
12	3.1	36

Table 3: bacterial pH increase

V. TEST RESULTS

A. *Comprehensive Strength:*

This test is carried out by preparing test cubes. The cube moulds are made for specimen size 15*15*15 cm. The metal moulds can be assembled and taken apart by bolting or unbolting. The concrete is hand compacted or Machine vibrated. The specimens are covered with wet gunny bags for 24 hrs. and then immersed in curing tank containing fresh clean water. These are kept in water for 3, 7, and 28 days and then taken out and tested under compression testing machine. The failure load divided by c/s area i.e.225 cm2 gives the ultimate compressive strength of cubes.

Sr. No	Days of curing	Comp. Stress (N/mm²)	Average (N/mm²)
1	7	11.77	11.24
2		1085	
3		11.11	
1	14	16.22	16.88
2		15.89	
3		16.16	
1	28	18.45	19.18
2		19.77	
3		19.33	

Table 4: Conventional Concrete

Sr. No	Days of curing	Comp. Stress (N/mm²)	Average (N/mm²)
1	7	14.12	14.72
2		14.37	
3		15.69	
1	14	19.46	19.85
2		19.98	
3		20.12	
1	28	22.14	23.12
2		23.11	
3		24.12	

Table 5: Bacterial Concrete

B. Slump Cone Test:

This is the most commonly used test for determination of workability. This method can be used on the site as well as in the laboratory. The apparatus essentially consists of metallic mould in the form of the frustum of a cone and a metallic tray. The mould is known as slump cone. To conduct test first thoroughly clean the mould from inside to remove any moisture. Place the mould on a smooth surface horizontal rigid and non-absorbent. Fill the mould with the concrete to be tested in four layers, tamping each layer 25 times with tamping rod. And then remove the mould in single vertical motion.The concrete subsides and his subsidence is called slump. Measure the slump. The slump value = 74mm

Fig. 6: Workability Test

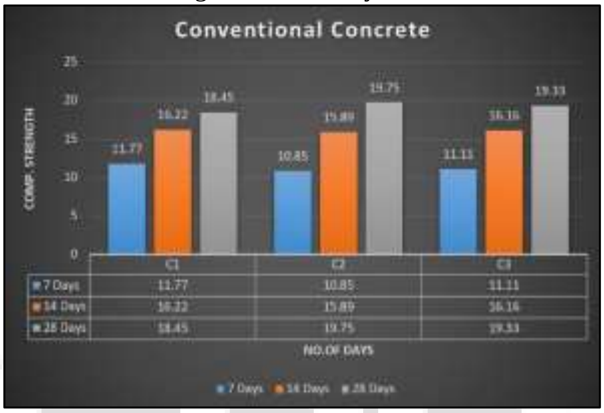

Fig. 7: Compression strength of conventional concrete

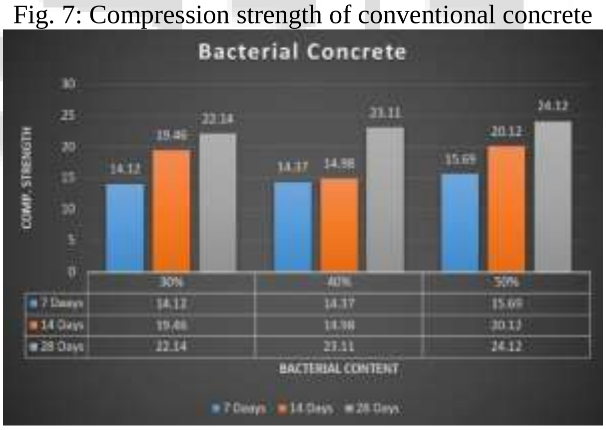

Fig. 8: Compression strength of bacterial concrete.

Fig. 9: chart showing comparison between conventional and bacterial concrete

VI. CONCLUSION

Introducing the bacteria E.coli in the concrete makes improvement in the properties and characteristics of concrete. For that Experimental investigation were conducted to determine the compressive strength and workability test. From this experiment the test results, the addition of bacteria gave better results of concrete performance than the conventional concrete. According to the comparative studies, it is clear that the bacteria needs its pH Improvement by adding NaOH content and thus 30%,40%,50% addition of bacteria gives the maximum compressive strength of 14.72, 19.85 and 25.12 N/mm2 for 7,14 and 28 days which is more than the conventional concrete. From the results, we can concluded that carefully cultured E.coli bacteria can be safely used in improving the performance and characteristics of concrete. Hence we can use the bacterial concrete in the structures.

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