International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.3, 2015

RESEARCH ARTICLE

ISSN: 2321-7758

EFFECT OF BACTERIA ON 28DAYS SPLIT TENSILE STRENGTH OF CONCRETE AND ITS STRESS-STRAIN CURVES

SHAIK NASREEN[1]* ,Dr.T.SURESH BABU[2]
[1]Student,M.tech,Department of Civil Engineering,Visvodaya college of engineering, Kavali
[2]Professor,M.tech,Ph.D,Head of Department of Civil Engineering,Visvodaya college of engineering,Kavali

Article Received:01/06/2015 | Article Revised on:17/06/2015 | Article Accepted on:20/06/2015

SHAIK NASREEN

ABSTRACT
Cracks in concrete are inevitable and are one of the inherent weaknesses of concrete. Water and other salts seep through these cracks, corrosion initiates, and thus reduces the life of concrete. Concrete structures usually show some self-healing capacity, i.e. the ability to heal or seal freshly formed micro-cracks. This property is mainly due to the presence of non-hydrated excess cement particles in the materials matrix, which undergo delayed or secondary hydration upon reaction with water. Scientists have developed a new type of self-healing concrete in which bacteria mediate the production of minerals which rapidly seal freshly formed cracks, a process that concomitantly decreases concrete permeability, and thus better protects embedded steel reinforcement from corrosion. Bacterial concrete is a material, which can successfully remediate cracks in concrete. This technique is highly desirable because the mineral precipitation induced as a result of microbial activities is pollution free and natural. As the cell wall of bacteria is negatively charged, metal accumulation (calcite) on the surface of the wall is substantial, thus the entire cell becomes crystalline and they eventually plug the pores and cracks in concrete. It was found that use of bacteria improves the stiffness and compressive strength of concrete.

KEYWORDS: Bacterial concrete, Self-Healing Capacity, Crack Formation, Durability, Split Tensile Strength, Stress-Strain curves

1.INTRODUCTION:

1.1GENERAL

Concrete is one of the most widely used construction materials in the world today. It is made by mixing small pieces of natural stone (called aggregate) together with a mortar of sand, water, Portland cement and possibly other cementations materials. Properly designed and constructed, concrete structures compare favorably with regard to economy, durability and functionality with structures made from other structural materials, such as steel and timber. It is the second most widely consumed substance on earth, after water. Microcracks are the main cause to structural failure.One way to circumvent costly manual maintenance and repair is to incorporate an autonomous self healing mechanism in concrete. One such an alternative repair mechanism is currently being studied, i.e. a novel technique based on the application of biomineralization of bacteria in concrete. The applicability of specifically calcite mineral precipitating bacteria for concrete repair and plugging of pores and cracks in concrete has been recently investigated and studies on the possibility of using specific bacteria as a sustainable and concrete embedded self healing agent was studied and results from ongoing studies are discussed. bacteria like PSEUDONOMAS AEROGINOSA is currently being used for repair of concrete, hence the use of a biological repair technique in concrete is focused. Recently, it is found that microbial mineral precipitation resulting from metabolic activities of favourable micro organisms in concrete improved the overall behaviour of concrete.

The Bacterial spores start germinating only when they make contact with concrete – triggered by the very specific pH of the material – and they have a built-in self-destruct gene that prevents them from proliferating away from the concrete target.Once the cells have germinated, they swarm down the fine cracks in the concrete and are able to sense when they reach the bottom because of the clumping of the bacteria, or so-called quorum sensing.

This clumping activates the concrete repair process and the cells differentiate into three types: cells which produce calcium carbonate crystals, cells which become filamentous – acting as reinforcing fibers – and thirdly cells that produce a glue that acts as a binding agent and fills the gap.

1.2 ABOUT BACTERIA(PSEUDONOMAS AEROGINOSA)

Pseudomonas aeruginosa is a common bacterium that can cause disease in animals, including humans. It is citrate, catalase, and oxidase positive. It is found in soil, water, skin flora, and most man-made environments throughout the world. It thrives not only in normal atmospheres, but also in hypoxic atmospheres, and has, thus, colonized many natural and artificial environments. It uses a wide range of organic material for food; in animals, its versatility enables the organism to infect damaged tissues or those with reduced immunity. The symptoms of such infections are generalized inflammation and sepsis. If such colonizations occur in critical body organs, such as the lungs, the urinary tract, and kidneys, the results can be fatal. Because it thrives on moist surfaces, this bacterium is also found on and in medical equipment, including catheters, causing cross-infections in hospitals and clinics. It is implicated in hot-tub rash. It is also able to decompose hydrocarbons and has been used to break down tarballs and oil from oil spills

1.3 ADVANTAGES OF USING BACTERIA IN CONCRETE:

Around five per cent of all man-made carbon dioxide emissions are from the production of concrete, making it a significant contributor to global warming. Finding a way of prolonging the lifespan of existing structures means we could reduce this environmental impact and work towards a more sustainable solution.

- This could be particularly useful in earthquake zones where hundreds of buildings have to be flattened because there is currently no easy way of repairing the cracks and making them structurally sound."
- fills the crack in an efficient period of time so that the life period of a concrete structure can be expected over 200years.
- prevents the use of cement in future used as a maintenance for repairing the existing structure by drilling and grouting process.so in this way,less use of cement can be seen.
- as we know, more of cement content is manufacture,the more carbondioxide gases will be released causing global warming ,soon effecting the ozone layer.by using this bacteria,the structure doesnot need to be

repaired except for the less cases and so results in less use of cement.

1.4 CONVENTIONAL CONCRETE

the concrete used in the whole project is an ordinary portland cement of 53 grade, coarse sand ,20mm sized aggregates mixed one under the M20 mix design

1.5 OBJECTIVE OF STUDY

The objective of the project is to determine and compared the mechanical properties of Bacterial concrete and normal concrete such as compressive strength, tensile strength, flexural strength, split tensile strength.

1.6SCOPE OF STUDY

Bacteria used in concrete can also be used while the construction of buildings ,so the entire scope of study is based on using bacteria under cool condition,added to concrete ,properly cured in water ,tests concucted for fresh concrete and hardened concrete.

The compatibility of Bacterial concrete in taking up load coming to the frame of the building is being found out by testing the laboratory specimen of beams and columns.

2.LITERATURE REVIEW

Chiara Barabesi et al, (2007)(17) The calcium carbonate precipitation, a widespread phenomenon among bacteria has been investigated for its scientific and technological importance. Nevertheless, little is known of the molecular mechanisms by which bacteria foster calcium carbonate mineralization. In his laboratory, he has studied calcite formation by Bacillus subtilis, in order to identify genes involved in the biomineralization process. A previous screening of UV mutants and of more than one thousand mutants obtained from the European Bacillus subtilis Functional Analysis project allowed him to isolate strains altered in the precipitation phenotype. Starting from these results, he focused his attention on a cluster of eve genes (lcfA, ysiA, ysiB, etfB, and etfA) called the lcfA operon. By insertional mutagenesis, mutant strains carrying each of the five genes were produced. All of them, with the exception of the strain carrying the mutated lcfA operon, were unable to form calcite crystals. By placing transcription under IPTG (isopropyl--D-thiogalactopyranoside) control, the last gene, etfA, was identified as essential for the precipitation process. To verify cotranscription in the lcfA operon, reverse transcription-PCR experiments were performed and overlapping retrocotranscripts were found comprising three adjacent genes. The genes have putative functions linked to fatty acid metabolism. A link between calcium precipitation and fatty acid metabolism is suggested.

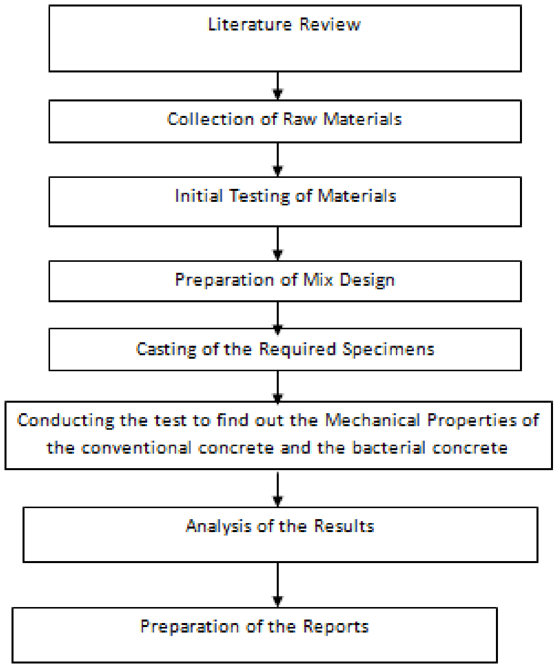
Leuschner et al, (200)(37) Research was conducted to examine the effects of dehydration and rehydration on radioactive phosphorous and carbon molecular mobility in dormant Bacillus subtilis spores. Data show that phosphorous mobility is dependent on hydration and is confined to core-specific components whereas carbon is immobilized to the water insoluble core area.

Massimiliano Marvasi et al, (2009)(42) Copyright © 2009 Federation of European Microbiological Societies. Published by Blackwell Publishing Ltd. All rights reserved Although the implications of calcium carbonate precipitation by microbes in natural environments are quite relevant, the physiology and genetics of this phenomenon are poorly understood. They have chosen Bacillus subtilis 168 as their model to study which physiological aspects are associated with calcium carbonate (calcite) formation during biofilm development when grown on precipitation medium. A B. subtilis eftA mutant named FBC5 impaired in calcite precipitation was used for comparative studies. Their results demonstrate that inactivation of etfA causes a decrease in the pH of the precipitation medium during biofilm development. Further analysis demonstrated that eftA extrudes an excess of 0.7 moles H+/L with respect to B. subtilis 168 strain.

Day J L et al, (2003)(18) This paper describes the results of an innovative approach in concrete crack remediation utilizing microbiologically induced calcite. A common soil bacterium, Bacillus pasteurii, was used to induce calcite precipitation. The basic principles for this application are that the microbial urease hydrolyzes urea to produce ammonia and carbon dioxide, and the ammonia released in surroundings subsequently increases pH, leading to accumulation of insoluble calcite. To protect the cells from the high pH of concrete, the microorganisms were immobilized in polyurethane polymer, lime, silica fume, and fly ash, and then applied in concrete crack remediation. Microbiologically enhanced crack remediation was evaluated by comparing the compressive strengths of the treated concrete specimens and those of the control. Scanning electron micrographic (SEM) analysis evidenced the direct involvement of microorganisms in calcite precipitation and X-ray diffraction analysis quantified calcite distribution in the region of the treated cracks. Based on observations made in this study, it is concluded that MECR has excellent potential in cementing concrete as well as several other types of structural cracks.

V. Ramakrishnan et al, (2001)(73) He proposed a novel technique in remediating cracks and fissures in concrete by microbiologically inducing calcite precipitation. Microbiologically induced calcite precipitation is a technique that comes under a broader category of science called biomineralization. Bacillus pasteurii, a common soil bacterium can induce the precipitates of calcite. As a microbial sealant, Calcite exhibited its positive potential in selectively consolidating simulated fractures and surface fissures in granites and in the consolidation of sand. MICP is highly desirable chemical reaction because the calcite precipitation induced is a result of microbial activities. The technique can be used to improve the compressive strength and stiffness of cracked concrete specimens. A durability study on concrete beams treated with bacteria, exposed to alkaline, sulfate and freeze-thaw environments was studied by him. The effect of different concentrations of bacteria on the durability of concrete was also studied by him. It was found that all the beams with bacteria performed better than the control beams (without bacteria). The durability performance increased with increase in the concentration of bacteria. Microbial calcite precipitation was quantified by X-ray diffraction (XRD) analysis and visualized by SEM. The unique imaging and microanalysis capabilities of SEM established the presence of calcite precipitation inside cracks, rod shaped bacterial impressions and a new calcite layer on the surface of concrete. This calcite layer improves the impermeability of the specimen, thus increasing its resistance to alkaline, sulfate and freeze-thaw attack.

3.Methodology :



4.MIX DESIGN OF CONCRETE

The strength is mainly influenced by water cement ratio, and is almost independent of the other parameters the properties of concrete with a compressive strength of 20MPa,are influenced by the properties of aggregate in addition to that of water cement ratio. To obtain good strength, it is necessary to use the lowest possible w/c ratio which affects the workability of the mix. In the present state of art, concrete which has a desired 28days compressive strength of minimum 20 MPa, can be made by suitable proportion of the ingredients using normal methods for compacting the mixes.

4.1 MIX DESIGN PROCEDURE

1. The strength of the cement as available in the country today has greatly improved since 1982. The 28-day strength of A, B, C, D, E, F. Category of cement is to be reviewed.
2. The graph connecting, different strength of cements and W/C is to be reestablished.
3. The graph connecting 28-day compressive strength of concrete and W/C ratio is to be extended up to 80Mpa, if this graph is to be cater for high strength concrete.
4. As per the revision of 456-2000, the degree of workability is expressed in terms of slump instead of compacting factor. This results in change of values in estimating approximate

sand and water contents for normal concrete up to 35Mpa and high strength concrete above 35Mpa. The table giving adjustment of values in water content and sand % for other than standard conditions, requires appropriate changes and modifications.

5. 5.In the view of the above and other changes made in the revision of IS456-2000, the mix design procedure as recommended in IS 10262-82 is required to be modified to the extent considered necessary and examples of mix design is worked out.

4.2 MIX DESIGN FOR GRADE M_{20}(WITHOUT BACTERIA)

Step 1: ***Test data for materials***

The material properties of all the constituents of concrete have been found out. The results of those tests are tabulated in the table 5.1.

Step 2: ***Target Mean strength***

$f'_{ck} = f_{ck} + 1.65 \times S$ (standard deviation from table 1 of IS10262:2009)

$= 20 + 1.65 \times 4 = 26.6$ N/mm^2

Step 3: ***Selection of W/C ratio***

Maximum w/c ratio for M20 as per IS 456 is 0.50.

Step 4: ***Selection of water content***

Maximum water content for 12.5mm aggregate – 191.5litre

Table 1. Experimental Investigation

S. No.	Materials	Result
1	Cement used	OPC 53 grade confirming IS 12269
2	Specific gravity of cement	3.12
3	Specific gravity of Coarse aggregate Fine aggregate	 2.2 2.08
4	Water absorption of Coarse aggregate	1%
5	Sieve analysis Coarse aggregate Fine aggregate	 2.94 3.09

Step 5: ***Calculation of cement content***

W/C ratio = 0.50

Cement content = 191.5/0.50 = 383 kg/m^3

From table 5 of IS 456, minimum cement content for 'severe' exposure condition=320 kg/m^3

383 kg/m^3 > 320 kg/m^3, hence ok.

Step 6: ***Proportion of volume of CA and FA content***

From table 3 of IS 10262,Volume of aggregate corresponding to 12.5mm size as per IS 383 and fine aggregate(zone 2) for w/c ratio of 0.50 = 0.56

Volume of Coarse aggregate content=0.56*0.9=0.50

Volume of Fine aggregate content= 1- 0.50 = 0.50.

Step 7: ***Mix calculations***

Volume of concrete = 1 m^3

Volume of Cement = (Mass of Cement/S.G of cement)×(1/1000)

= (382/3.12)×(1/1000)

= 0.122 m^3

Volume of Water= (Mass of Water/S.G of Water)×(1/1000)

= (191.5/1)×(1/1000)

= 0.191 m^3

Volume of all in aggregates = 1 – (0.122 +0.191)

= 0.687 m^3

Mass of Coarse aggregate = 0.687 × 0.50 × 2.2 × 1000

= 755.7 kg

Mass of Fine aggregate = 0.687 × 0.50 × 2.08 × 1000

= 716.19 kg

Mix ratio= 383: 716.19: 755.7

= 1: 1.8: 1.9

Thus the nominal mix for M20 grade concrete requires 383kgs of cement, 716.19kgs of fine aggregate and 755.7kgs of coarse aggregate.

4.3 5ML BACTERIAL MIX:

5ml of bacteria(pseudonomas aeroginosa) was added to every 500 ml of water while mixing concrete, so a total of 65ml of bacteria was added to 6.5 liters of water used for mixing cement of 14kgs.

4.4 .10ML BACTERIAL MIX:

10ML of bacteria (pseudonomas aeroginosa) was added to every 500 ml of water while mixing concrete,so a total of 126ml of bacteria was added to 6.5 liters of water used for mixing cement of 14kgs.

5.5 15ML BACTERIAL MIX:

15ML of bacteria (pseudonomas aeroginosa) was added to every 500 ml of water while mixing concrete,so a total of 195ml of bacteria was added to 6.5 liters of water used for mixing cement of

14kgs.

5.EXPERIMENTAL RESULTS:

5. 1 WORKABILITY TEST RESULTS:

- **CONVENTIONAL CONCRETE:**

compaction factor =0.88

vee-bee value= 8 sec

slump loss=5mm

- **5ML BACTERIAL COCNCRETE:**

compaction factor =0.89

vee-bee value= 4 sec

slump loss=13mm

- **10ML BACTERIAL COCNCRETE:**

compaction factor =0.94

vee-bee value= 4 sec

slump loss=15mm

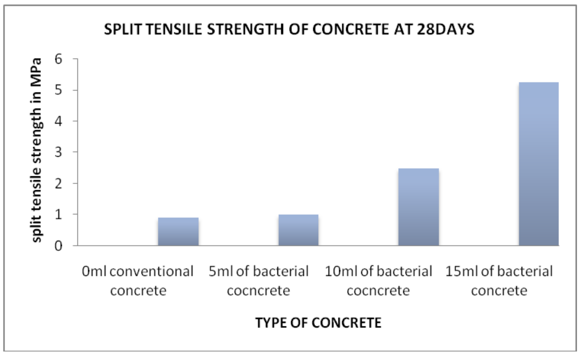
- **15ML BACTERIAL COCNCRETE:**

compaction factor =0.95

vee-bee value= 3 sec

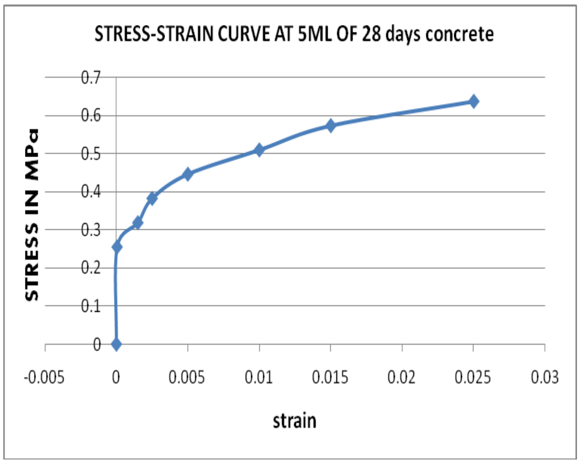
slump loss=17mm

5.2 FINAL TEST RESULTS:



Fig(a) .Showing Comparison of Split Tensile strengths of conventional concrete & Bacterial concrete at 28 days

5.3 STRESS-STRAIN CURVES:



Fig(b) M20 5ml BACTERIAL CONCRETE (28 DAY STRESS-STRAIN CURVE)

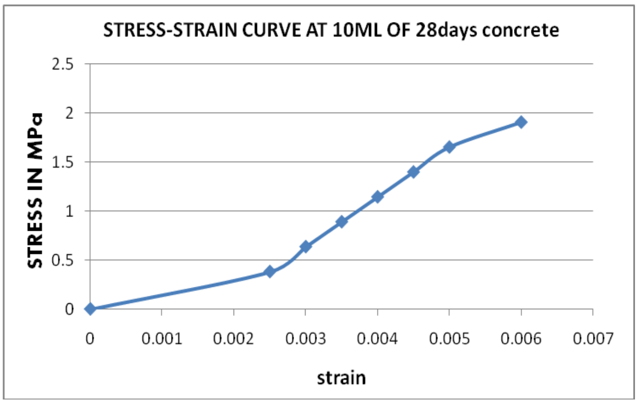
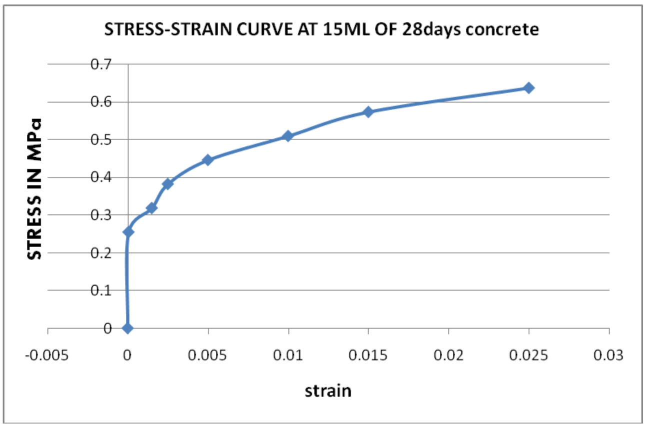


Fig.(c) M20 10ml BACTERIAL CONCRETE(28 DAY STRESS-STRAIN CURVE)



Fig(d) .M20 15ml BACTERIAL CONCRETE(28 DAY STRESS-STRAIN CURVE)

6.DISCUSSION OF TEST RESULTS:

1. With the addition of 5ml,10ml,15ml bacteria into concrete, the average Split Tensile strength increased by 29%,42%,46% respectively at 28 Days
2. The above mentioned addition in strength may be due to the interaction of bacteria with concrete forming a precipitate which furthers helps in providing a bond between cement molecules.

7.CONCLUSION

From the tests conducted on bacterial and Conventional Concrete Specimens, the following conclusion have been drawn

- The above addition in strength is because of adding bacterial liquid to concrete, which generates calcite precipitate in concrete matrix.
- Therefore, due to addition of small amount(5ml) of bacterial liquid to the conventional concrete, a great addition in Split tensile is observed. This is mainly due to production of calcite precipitate in concrete (hardened) when it is cured properly with water,thus this calcite acts as a cement

agent and recovers the whole cracked area to the inner side of concrete surface.

- However, among the different proportions of bacteria added (5ml,10ml,15ml) to concrete mix, 15ml bacterial concrete gives the best results in Split Tensile test.
- The main advantage of bacterial concrete is that we can improve the life span of a concrete structure upto 200 years if this technology has been further enhanced and bring into special importance.
- These bacterial concrete is a self-healing concrete which heals cracks for effective duration of initial 5 hours upto as long as possible and the bacterial cell life is 200years.
- These bacterial usage can save the cement and the conctruction of a building can be made economical ,as we know cement production gives rise to production of carbondioxide to the higher levels,so further controlling is made very effective.
- These bacterial concrete usage can be made common in next few decades heading towards victory of civil engineering structures as per the scientific view of highly authorized laboratories .

8.REFERENCES

[1]. International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 9- Sep 2013

[2]. IS 10262-2009 Concrete mix proportioning - Guidelines' Bureau of Indian Standards, New Delhi, India.

[3]. IS 12269-1987 Specification for 53 grade Portland Cement' Bureau of Indian Standards, New Delhi, India.

[4]. [4]Neville, A.M. (1996) Properties of concrete (4th edition). Pearson Higher Education, Prentice Hall, New Jersey.

[5]. Ramachandran, S.K., Ramakrishnan, V., and Bang, S.S. (2001) remediation of concrete using micro-organisms. ACI Materials Journal 98(1):3-9.

[6]. Self-healing of concrete (Gruyaert E., Snoeck D., Steuperaert S., Van Tittelboom K, Wang J.)

[7]. Microbial Concrete: A Way to Enhance Durability of Building Structures Varenyam Achal, Abhijit Mukherjee, and M. Sudhakara Reddy

[8]. Achal, V., Mukherjee, A., Basu, P. C., and Reddy, M. S. (2009a). "Lactose mother liquor as an alternative nutrient source for microbial concrete production by Sporosarcina pasteurii." Journal of Industrial Microbiology and Biotechnology, 36, 433-438.

[9]. Achal, V., Mukherjee, A., Basu, P. C., and Reddy, M. S. (2009b). "Strain improvement of Sporosarcina pasteurii for enhanced urease and calcite production." Journal of Industrial Microbiology and Biotechnology, 36, 981-988.