A study on performance of Bacillus SubtiliS on concrete crack

[1]K Sravani Lakshmi, [2]Dr.Ch.Bhavannarayana, [3]Dr.V.Ganapathi Rao
[1]Pg scholar, [2]PhD Professor, [3]Associate Professor
Kakinada institute of engineering and technology II

Abstract - **Cracks in concrete are inevitable and are one of the inherent weakness of concrete. Water and other salts seep through these cracks, corrosion initiates, and thus reduce the life of concrete. So there was needed to be inherent bio material, self repairing material which can re mediate cracks and fissures in concrete. Bacterial concrete is a material, which can successfully remediate cracks in a concrete. This technique is highly desirable because the mineral precipitation induced as a result of microbial activity is pollution free and natural. As the cell wall of the bacterial is anionic, metal accumulation (calcite) on the surface of the wall is substantial, thus entire cell becomes crystalline and they eventually plug the pores and cracks in a concrete. In this paper an overview of new development obtained in experimental study on self healing concrete. Strength and durability of concrete is mainly affected due to the formation of cracks. Micro cracks are the main cause for structural failure. While larger cracks affect structural integrity. Micro cracks result in durability problems. Ingress of water and chemicals can cause premature matrix degradation and corrosion of embedded steel reinforcement. Also concrete fails due to insufficient tensile strength. In order to overcome this, an attempt is made in Bacterial concrete with non pathogenic, spore forming ,calcite mineral precipitating bacterium "Bacillus Subtilis". The present experimental investigations are taken up to study the strength in ordinary grade (M20) concrete with and without addition of bacteria Bacillus Subtilis .**

keywords - **Bacillus Subtilis, Calcium carbonate precipitating ,Crack strength and durability properties**

I. INTRODUCTION

Concrete is the most widely used construction material. Despite its versatility in construction, it is known to have several limitations. It is weak in tension, has limited ductility and little resistance to cracking. Based on the continuous research carried out around the globe, various modifications have been made from time to time to overcome the deficiencies of cement concrete. The ongoing research in the field of concrete technology has lead to the development of special concrete considering the speed of construction, the strength of concrete, the durability of concrete and the environmental friendliness with industrial material like fly ash, blast furnace slag, silica fume, metakeolin etc. Recently, it is found that microbial mineral precipitation resulting from metabolic activities of favorable microorganisms in concrete improved the overall behavior of concrete. The process can occur inside or outside the microbial cell or even some distance away within the concrete. Use of these Bio mineralogy concepts in concrete leads to potential invention of new material called Bacterial Concrete.

History of Microbiology Bacteria

Microbiology Bacteria are microscopic organisms, single-celled prokaryotic creatures. Bacteria come in different shapes and the sizes. Bacteria are ubiquitous in every habitat on Earth, growing in soil, acidic hot springs, radioactive waste, water, and deep in the Earth's crust, as well as in organic matter and the live bodies of plants and animals. There are typically 40 million bacterial cells in a gram of soil and a million bacterial cells in a milliliter of fresh water; in all, there are approximately five million (5×1030) bacteria on Earth (Whitman et al. 1998, Vol.95) forming much of the world's biomass.

Bacteria were first observed by Antoine van Leeuwenhoek in 1676, using a single-lens microscope of his own design. He called them "animalcules" and published his observations in a series of letters to the Royal Society. The name bacterium was introduced much later, by Christian Gottfried Ehrenberg in 1838. Louis Pasteur demonstrated in 1859 that the fermentation process is caused by the growth of microorganisms. Along with his contemporary, Robert Koch, Pasteur was an early advocate of the germ theory of disease.

There are broadly speaking two different types of cell wall in bacteria, called Gram-positive and Gram-negative. The names originate from the reaction of cells to the Gram stain, a test long-employed for the classification of bacterial species. In the laboratory, bacteria are usually grown using solid or liquid media. Solid growth media such as agar plates are used to isolate pure cultures of a bacterial strain. However, liquid growth media are used when measurement of growth or large volumes of cells are required. Growth in stirred liquid media occurs as an even cell suspension, making the cultures easy to divide and transfer, although isolating single bacteria from liquid media is difficult. The use of selective media (media with specific nutrients added or deficient or with antibiotics added) can help identify specific organisms.

II. OBJECTIVE

The main objective of the present experimental investigation is to study the strength of before and after cracking of concrete on ordinary grade concrete. The present work is divided into three phases, they are

- PHASE – I : Culture of Bacteria
- PHASE – II : To study the strength behavior of concrete

- PHASE–III : Observing crack filling of concrete

III. MATERIALS USED

- Cement
- Fine aggregate
- Coarse aggregate
- Water
- Calcium lactates
- Bacillus Subtilis

Cement

Ordinary Portland cement of 53 grade, available in local market is used in the investigation. The cement used for all tests is from the same batch. The cement used has been tested for various properties as per IS : 4031-1988 and found to be conforming to various specifications of IS : 12269-1987.

Coarse Aggregate

Crushed angular granite from local quarry is used as coarse aggregate. The cleaned coarse aggregate is chosen and tested for various properties such as specific gravity, fineness modulus, bulk modulus etc. The physical characteristics are tested in accordance with IS : 2386 – 1963.

Fine aggregate

The locally available river sand is used as fine aggregate in the present investigation. The cleaned fine aggregate is chosen and tested for various properties such as specific gravity, fineness modulus, bulk modulus etc. in accordance with IS : 2386-1963.

Water

Water used for mixing and curing is fresh potable water, conforming to IS:3025-1964 part 22,part 23 and IS: 456-2000.

Calcium lactates

The calcium lactate was needed for bacteria to severing purpose to add the 10 gms per kg of cement.

Bacillus Subtilis

Bacillus is a genus of Gram-positive, rod-shaped bacteria and a member of the division Firmicutes. Bacillus species can be obligate aerobes or facultative anaerobes and test positive for the enzyme catalase (Turnbull PCB, 1996). Bacillus species continue to be dominant bacterial workhorses in microbial fermentation. The bacteria used in the present study were isolated from soils contaminated with sewage water of Kakinada city.1M MgSO4 0.35ml ,50% glucose 1ml, 10% yeast extract 1ml 10% casea amino acids 0.1,amino water to 100 ml, wash buffer , 10 x T- base 10 ml ,1M MgSO4 100 ml water to 100 ml .

Preparation

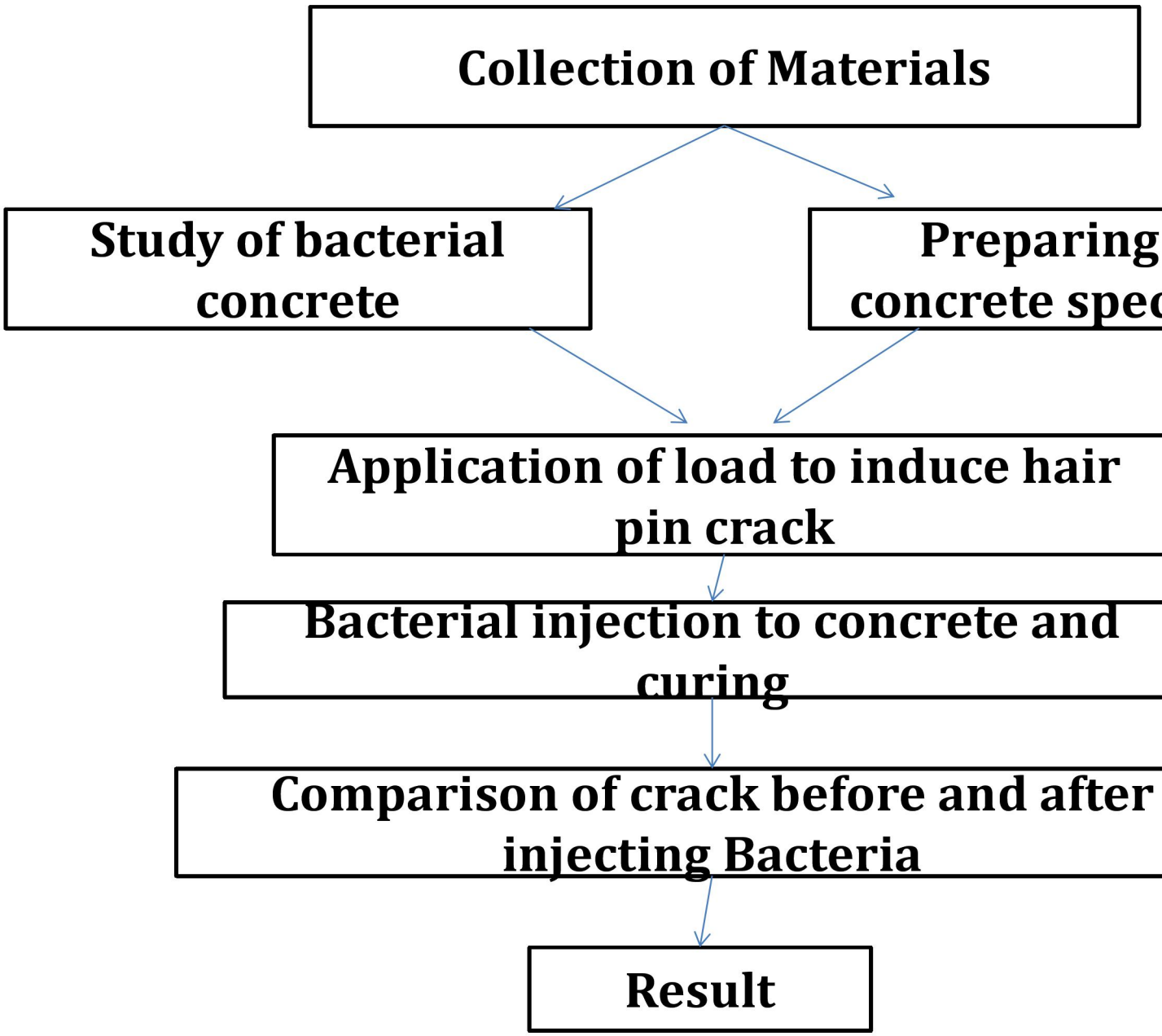
- Streak out overnight at 37o C on LB agar strain required
- Put 2ml of spc medium plus amino acids into large glass tube .Inoculate with single colony of strain required
- Allow to grow for 5 hours with shaking at 37 Oc
- After 5 hrs put 0.5 ml of the culture into 5 ml of spll plus amino acids .Grow at 37 oC for 90 minutes .
- Harvest culture in large centrifuge at 6000 rpm for 10 minutes
- Retain 0.5 ml of the culture supernatant and discard the remaining amount .Resupend the cells in the retained medium they are now ready to use or add glycerol to a final of 10% and freeze at 80 oC until required The colonies developed were purified by streak plate method and sub cultured.Biochemical characterization was done by performing tests such as Grams staining , catalase test, motility, methyl red, indole, endospore , starch, citrate, casein hydrolysis, gelatin , nitrate reduction and sugar utilization (Collins and Cumins, (1986) and Gordon et.al (1973). The organism was identified as per Bergey's manual of systemic Bacteriology . Most of the isolates were Baciullus sp. One of the isolate was identified as Bacillus subtilis.

IV. TESTS CONDUCTED

The following tests were conducted during this experiment

- Sieve Analysis
- Specific Gravity for cement
- Specific Gravity for Fine Aggregate
- Specific Gravity for Coarse Aggregate
- Slump Cone Test
- Compressive Strength Test
- Split Tensile Strength Test
- Flexural Strength Test

V. METHODOLOGY



VI. TESTS CONDUCTED

The following tests were conducted during this experiment

- Sieve Analysis
- Specific Gravity for cement
- Specific Gravity for Fine Aggregate
- Specific Gravity for Coarse Aggregate
- Slump Cone Test
- Compaction Factor Test
- Aggregate Impact Test
- Aggregate Crushing Test
- Consistency Test
- Flexural Strength Test
- SEM Analysis

VII.TEST RESULTS

Physical properties of Cement

The Physical properties of Cement has tabulated below

S.NO	PROPERTY	VALUES
1	Fineness of Cement	6%
2	Specific Gravity	2.60
3	Normal Consistency	32 %
4	Setting Time Initial Setting time Final setting time	 30 mins 7 hours

Physical properties of Coarse Aggregate

The Physical properties of Coarse Aggregate has tabulated below

S.NO	PROPERTY	VALUES
1	Specific Gravity	2.89
2	Bulk Density i)Loose State ii)Compacted State	 10.95 kN/m3 11.89 kN/m3
3	Water Absorption	0.5%
4	Flakiness Index	17.6%
5	Elongation Index	19.7%
6	Crushing Value	23.23%
7	Impact Value	26.36%
8	Fineness Modulus	3.42

Physical properties of Fine Aggregate

The Physical properties of Fine Aggregate has tabulated below

S.No	Property	Values
1	Specific Gravity	2.84
2	Fineness Modulus	2.30
3	Bulk Density i)Loose State Ii)Compacted State	 10.44 kN/m3 17.54 kN/m3
4	Grading of Sand	Zone – III

Average Compressive Strength Test

The Average compressive strength at various proportions has tabulated below

Type of Concrete	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
Normal Concrete	15.23	19.04	21.83

10^4 Cells/ml	16.72	22.56	23.46
10^5 Cells/ml	18.69	23.52	25.74
10^6 Cells/ml	16.93	22.89	23.81

Average Split Tensile Strength Test

The Average Split Tensile strength at various proportions has tabulated below

Type of Concrete	**7 days (N/mm^2)**	**14 days (N/mm^2)**	**28 days (N/mm^2)**
Normal Concrete	1.37	1.79	1.96
10^4 Cells/ml	1.50	2.03	2.11
10^5 Cells/ml	1.68	2.12	2.31
10^6 Cells/ml	1.52	2.06	2.14

Average Flexural Strength Test

The Average Flexural strength at various proportions has tabulated below

Type of Concrete	**7 days (N/mm^2)**	**14 days (N/mm^2)**	**28 days (N/mm^2)**
Normal Concrete	2.73	3.05	3.26
10^4 Cells/ml	2.86	3.32	3.29
10^5 Cells/ml	3.02	3.39	3.55
10^6 Cells/ml	2.88	3.34	3.41

VIII. CONCLUSION

- Based on the present experimental investigation, Bacillus Subtilis be produced from lab which is proved to be a safe and cost effective.
- The addition of bacillus Subtilis bacteria improves the hydrated structure of concrete.
- The addition of bacillus Subtilis bacteria increases the flexural strength of concrete. In standard grade concrete the flexural strength is increased up to 48.40% at 28 days by addition of bacillus Subtilis bacteria when compared to Conventional concrete.
- The addition of bacillus Subtilis bacteria showed significant improvement in the flexural strength than the conventional concrete.
- The cracks are formed after testing of the specimens, that crack are to be filled by bacillus Subtilis bacteria.
- Scanning electron micrograph for specimens, the calcite precipitation is maximum at 105cells per ml of mixing water.

REFERENCES

- Ramakrishna V, Ramesh KP, and Bang SS. South Dakota School of Mines and Technology, USA, Bacterial Concrete, Proceedings of SPIE, Vol. 4234 pp. 168-176,Smart Materials.
- Ramchandran SK, Ramakrishna V, and Bang SS. South Dokata School of Mines and Technology, USA Remediation of concrete using Microorganisms ACI Materials Journal,98(2001) 3-9.
- Bouzoubaa N, Zhang MH, Malhotra VM. Mechanical properties and durability of concrete made with HVFA blended cements using a coarse FA. Cement and Concrete Research. 31(2001) 1393-1402.
- Chiara Barabesi, Alessandro Galizzi, Giorgio Mastromei, Mila Rossi, Elena, Tamburini and Brunella Perito Pavia, Italy Bacillus subtilis Gene Cluster Involved in Calcium Carbonate Biomineralization, Journal of Bacteriology, 2007, pp. 228-235.
- Gopala Krishnan S, Annie Peter J, Rajamane NP. Strength and durability characteristics of Concretes containing HVFA with and without processing.Proceedings of the International Conference on Recent Trends in Concrete Technology and Structures. INCONTEST 2003. Vol. 2, 2003, pp. 203-216.

- Bang SS, Galinat JK, and Ramakrishnan V. Calcite precipitation induced by polyurethaneimmobilized Bacillus pasteurii" Enzyme and Microbial Technology,28(2001) 404-09.
- Ramikrishnan V, Panchalan RK, Bang, SS. Improvement of concrete durability by bacterial mineral precipitation" Proceedings ICF 11, Torino, Italy, 2005.
- Mehata PK. Factors influencing durability of concrete structures. International Conference on Maintenance and Durability of Concrete Structures, March 4-6,1997, JNTU, Hyderabad. pp. 7-12.
- Zhong L, Islam MR. A New Microbial ProcesRemediation, 70th Annual Technical Conference and Exhibition of the Society of Petroleum Engineers, Dallas, Texas, Oct 22-25, 1995.
- Bachmeier K, Williams A E, Warminton J and Bang, S.S. Urease activity in Microbiologically-induced calcite precipitation" Journal of Biotechnology, 93(2002)171-181.
- Day JL, Panchalan RK, Ramakrishnan V. Microbiologically induced sealant for concrete crack remediation Proceedings of the 16th Engineering Mechanics conference, Seattle, WA, 2003.
- Ghosh P, Mandal S, Chattopadhyay BD, and Pal S. Use of Microorganisms to improve the Strength of Cement-Sand Mortar. Proceedings of International Conference on Advances in Concrete and Construction, ICACC-2004, India. pp. 983-988.
- Santhosh KR, Ramakrishnan V, Duke EF, and Bang SS, SEM Investigation of Microbial Calcite Precipitation in Cement Proceedings of the 22nd InternationalConference on Cement Microscopy, pp. 293-305, Montreal, Canada, 2000.s and its Impact on Fracture.