An Experimental Study On The Strength And Durability Of Bacterial Concrete

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Abstract— **This paper examines the possibility of obtaining the strength of the concrete by the microbiologically induced special growth or filler. Here an attempt was made by using the bacteria “Bacillus subtilis”. Concrete cylinders and prisms were cast with and without addition of bacteria were cast and its split tensile strength and flexural strength were examined. There was an increase in split tensile strength and flexural strength with addition of bacteria. From Scanning Electron Micrography analysis, it is noted that pores were partially filled up by material growth with the addition of the bacteria.**

Keywords—***Strength, Bacteria, filler***

I. Introduction

Concrete is an important versatile construction material, used in widevariety ofsituations. The steel bars providedin concrete take over the load when the concrete cracks in tension. The concrete on the other hand protects the steel bars for attack from the environment and prevent corrosion to take place. However, the cracks in the concrete form a problem. Here the ingress of water and ions take place and deterioration of the structure starts with the corrosion of steel. To increase the durability of the structure either the cracks that are formed are repaired later or in the design phase extra reinforcement is placed in the structure to ensure that the crack width stays within certain limit. The main objective of this research is to (1) To determine the right conditions to be created for the survival of bacteria to repair cracks. (2) To determine the tensile strength of bacterial concrete. (3) To determine the flexural strength of bacterial concrete. (4) To determine the optimum percentage of addition of bacillus megaterium.The “Bacterial Concrete” can be made by embedding bacteria in the concrete that are able to constantly precipitate calcite. This phenomenon is called micro biologically induced calcite precipitation. A common soil bacterium, Bacillus Megaterium, was used to induce $CaCO_3$ precipitation. The basic principle for this application are that the microbial hydrolyzes urea to produce ammonia and carbon dioxide and the ammonia released in surroundings subsequently increases pH, leading to accumulation of insoluble $CaCO_3$.

II. Literature Review

BC Delft, The Netherlands (2008), reported on application of bacteria as self-healing agent for the development of sustainable concrete. A specific group of alkali-resistant spore forming bacteria related to the genus Bacillus was selected for this purpose,a continuous decrease in pore size diameter during cement stone setting probably limited life span of spores as pore widths decreased below 1 micro metre, the typical size of Bacillus pores.

Willem De Munyck et.al (2006), reported on deposition of a layer of calcite on the surface of the specimens resulted in a decrease of capillary suction and a decrease in gas permeability. Department of Biotechnology and environmental sciences, Thapar University (2011), reported on influence of bacteria on the compressive strength, water absorption and rapid chloride permeability. Influence of sporoscarcina pasteurii bacteria on the compressive strength and rapid chloride permeability of concrete. Concrete cubes were prepared with different concentration of S.pasteurii. The cell concentration was determined from the bacterial growth curve made by observing optical density at 600mm.

Kim Van Tittelboom (2003), reported on use of bacteria to repair cracks in concrete. The use of this biological repair technique is highly desirable because the mineral precipitation induced as a result of microbial activities is pollution free and natural. Cracked concrete samples were prepared in two different ways. Crack sealing by means of this biological treatment resulted in a decrease in water permeability.

III. Material Collection

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A. Material

OPC M53 Grade cement, fine aggregate (sand), Aggregate (size 16 to 20mm), Bacteria

B. Cement

Ordinary Portland cement of Birla gold conforming to IS269-1976 and IS 4031-1968 was adopted in this work . The cement used is 53 grade. Cement is a generic term that can apply to all blinders. The chemical composition of these cements can be quite diverse, but by far the greatest amount of concrete used today is made with Portland cements.

C. Coarse Aggregate

Aggregates generally occupy 70 to 80 percent of the volume of concrete and can therefore be expected to have an important influence on its properties. Aggregate classifications are made principally for the purpose of easier identification of particular aggregate lots or to become familiar with the different types of aggregates .There are numerous ways of classifying aggregates. These classifications are made according to source of aggregate, specific gravity or unit weight of aggregate, size of aggregate particles, shape of aggregates, surface texture of aggregates, mode of preparation of aggregates, geological origin of aggregates, and mineral composition of aggregates and reactivity of aggregates . Aggregates are not generally classified by mineralogy ; the simplest and most useful classifications are on the basis of source and specific gravity .

D. Fine Aggregate

The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.60. Locally available river sand conforming to grading zone I of IS:383-1970. Clean and dry river sand available locally will be used . Sand passing through IS 4.75mm sieve will be used for casting all the specimens . Fine aggregates is defined as material that will pass a No.4 sieve and will, for the most part, be retained on a No. 200 sieve. For increased workability and for economy as reflected by use of less cement, the fine aggregates should have a rounded shape . The purpose of the fine aggregate is to fill the voids in the coarse aggregates and to act as a workability agent.

E. Water

Water is a key ingredient in the manufacture of concrete . It is also material on its own right . Understanding its properties is helpful in gaining and understanding of its effects on concrete and other building materials. Although water is an important ingredient of concrete little needs to be written about water quality , since it has little to do with the quality of the concrete . However mixing water can cause problems by introducing impurities that have detrimental effects on concrete quality . Although satisfactory strength development is of primary concern, impurities contained in the mix water may also affect setting times, drying shrinkage , or durability , or they may cause efflorescence . The water used for experiments was potable water. It should be free from organic matter and the pH value should be between 6 to 7

F. Bacteria

Normally cement and water has pH value upto 12 when mixed together. Most organism die in an environment with a pH value of 10 or above. Bacillus megaterium can withstand pH value above 12, it frequently lives in water, soil, air and decomposing plant residue. It is also present at the root-soil interface and also grows without oxygen in the presence of nitrate.

IV. MIX PROPORTIONS

.The mix proportions for M25 grade of concrete calculated by IS method per m3 is given as

TABLE I
MIX PROPORTION

Cement (kg)	**Fine Aggregate (kg)**	**Coarse Aggregate (kg)**	**Water (Litres)**
515	755	964	196
1	1.45	1.87	0.38

Quantity of Bacteria - As per the past research by Delft University, 5 ml of bacteria solution is adequate for per litre of water for their efficient growth.

G. Experimental investigations

This chapter presents the details of experimental investigations carried out on the test specimens to study the strength-related properties of the concrete containing Bacillus Subtilis. The water cement ratio is reduced to 0.31 which will greatly improve the qualities of interfacial transition zone to give inherent qualities expected to be satisfied by HPC. Metakaolin partially replaced for cement in this study as mineral admixture contributes more towards the strength development and performs well in aggressive conditions. Here, an attempt was made to study the strength development at different replacement levels at different ages with Eco-Sand and the results were compared. The strengthrelated properties such as compressive strength, splitting tensile strength, flexural strength were studied. Minimum three specimens were tested for each mix for each test. The entire tests were conducted as per specifications required.

V. RESULTS AND CONCLUSION

Compressive Strength

For compressive strength test six cubes of size 100mm X 100mm X 100mm for each mix were cast. For each mix proportion 6 numbers of cubes were cast in which 3 numbers were cured for 7 days and the remaining was cured for 28 days. All the cubes are tested in saturation condition, after drying the surface of the specimen containing nomoisture in it. For each mix proportions, three cubes are tested at 7 days, 28 days. Using compression testing machine of 2000kN capacity as per IS: 516 - 1959 code. From that the compressive strength of particular mix cube calculated by dividing the cross sectional area of cube specimen from ultimate load will give a compressive strength at failure load.

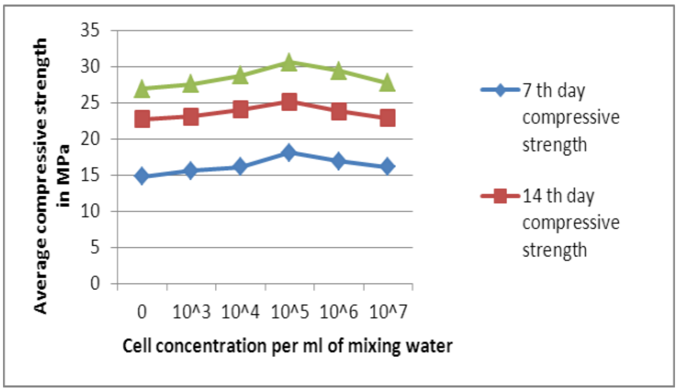

Chart -1: Cell Concentration Vs Compressive Strength

The cube compresssive strength were carried out at various ages such as 7days, 14days and 28 days. The water binder ratio of all mixes was fixed as constant value of 0.38. The compressive strength for various concentrations are given in chart 1. The experimental set up for cube compressive strength is shown in Figure.1.

Fig -1: Cube Compressive Strength – Experimental set up

Split Tensile Strength

For tensile strength test six cylinder of size 100mm X 150mm for each mix were cast. Cast iron steel mould was used for casting of these cylinders. For each mix proportion 3 numbers of cylinders were cast and cured for 28 days. Split tensile strength test are carried out at the age of 28 days using compression testing machine of 2000kN capacity as per IS 516 - 1959. To avoid direct loading on the cylinder specimen, the wooden strip are kept in between loading portion and cylinder surface. The loading is continued till the specimen splitting an dial readings are noted as shown in figure 2.

$$F_t = \frac{2P}{\pi DL}$$

Where,

Ft- Split tensile strength of concrete in MPa
P - Failure load in kN
D- Diameter of cylinder (100mm)
L - Length of cylinder (150mm)

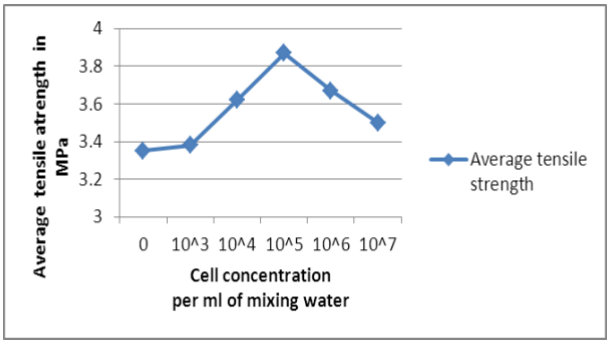

Chart -2: Cell Concentration Vs Tensile Strength

The split tensile strength results at 28 days were carried out. For each mix propotion an average of three cylinders were cast and tested at 28 days. The water binder ratio of all mixes was fixed as constant value of 0.38. The split tensile strength for various concentrations are given in chart 2.

Fig -2: Split tensile Strength – Experimental set up

In this present study, totally seven mix proportions are made and for each mix proportions three specimens are cast. Totally 21 specimens are cast including control beam specimens. The size of the beam is fixed as 100mm X 150mm X 1000mm. The reinforcement details were adopted according to IS 456 - 2000

Flexural Strength

For a rectangular sample under a load in a two-point bending setup where the loading span is one-third of the support span. Flexural strength is calculated based on following relationship

$$\sigma = \frac{FL}{bd^2}$$

L is the length of the support (outer) span
b is width of the beam
d is thickness of the beam.
F is the load (force) at the fracture point

The flexural strength results at 28 days were carried out. For each mix propotion an average of three cylinders were cast and tested at 28 days. The water binder ratio of all mixes was fixed as constant value of 0.45. The flextural strength for various concentrations are shown in Chart 3.

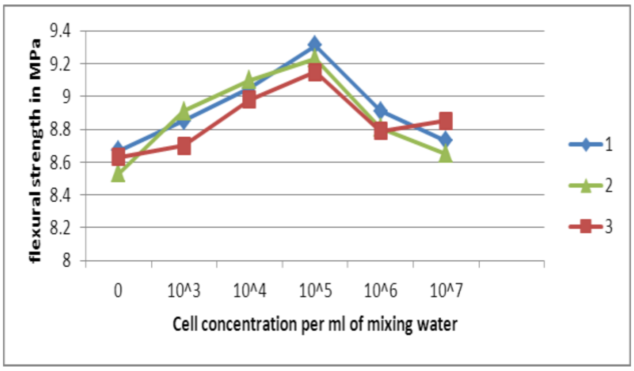

Chart -3: Cell Concentration Vs Flexural Strength

Conclusion

Bacillus subtilis can be produced from lab which is proved to be a safe and cost effective. The compressive strength of concrete cube is maximum with the addition of bacillus subtilis bacteria for a cell concentration of 105 cells per ml of mixing water. The addition of bacillus subtilis bacteria increases the compressive strength of concrete. In standard grade concrete the compressive strength is increased up to 10.68% 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 split tensile strength and flextural strength than the conventional concrete. From the above it can concluded that bacillus subtilis can be easily cultured and safely used in improving the strength charecteristics of concrete.

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REFERENCES

[1] Ramakrishnan V, Ramesh KP, and Bang SS. South Dokata School of mines and technology USA, Bacterial Concrete, Proceedings of SPIE,vol.4234, pp:168-176.

[2] Ramchandran SK, Ramakrishnan V, Bang SS. South Dokata School of mines and technology USA Remediation of concrete using Microorganisms ACI materials Journal 28(2001),pp:3-9.

[3] Chiara Barabesi, Alessandro Galizzi, Giorgo Mastromei, Mila Rossi, Elena, Tamburni and brunella perito pavia, Italy Bacillus subtilis Gene Cluster involved in Gopala Krishana S, Annie Peter J, Rajamane NP. Strength and durability characteristics of concretes containing HVFA with and without processing.

[4] Proceedings of the International Conference on Recent Trends in Concrete Technology and Strucutures, INCONTEST (2003), pp: 203-216 Calcium carbonate Biomieralization, Journal of Bacteriology, (2007), pp: 228235.

[5] Ramikrishnan V, Panchalan RK, Bang, SS. Improvement of concrete durability by bacterial mineral precipitation ICF 11, Torino , Italy, (2005).

[6] Santhosh KR, Ramakrishnan V,Duke EF,and Bang SS, SEM Investigation of Microbial Calcite Precipitation in Cement Proceedings of the 22nd International Conference on Cement Microscopy ,pp,293- 305,Montreal,Canada, (2000).

[7] Day JL, Panchalan RK,Ramakrishnan V, Microbiologically induced sealant for concrete crack remediation Proceedings of the 16th Engineering Mechanics conference, Seattle, WA, (2003).

[8] Bang SS, Galiant JK, and Ramakrishnan V.Calcite precipitation Induced by polyurethane immobilized Baciilus pasteurii" Enzyme and Microbial Technology,28(2001)404-409.

[9] Ramakrishnan V, Panchalan RK, Bangs SS,Improvement of concerete durability by bacterial mineral precipitation" Proceedings ICF 11,Torino,Italy,(2005).

[10] Mehata PK, Factors influencing durability of concrete structures, International Conference on Maintanance and Durability of Concrete Structures, JINTU, Hyderabad, pp, 7-12, March 4-6, (1997).

[11] Zhong L, Islam MR. A New Microbial Process and its Impact on Fracture PERFORMANCE OF STANDARD GRADE BACTERIAL,Remediation,70th Annual Technical Conference and Exhibition of the Society of Petroleum Engineers, Dallas, Texas, Oct 22-25,(1995).

[12] Jagadesh P, Ramachandramurthy A, Murugesan R and Sarayu K, "Micro Analytical Studies on Sugar Cane Bagasse Ash", Sadhana Academy of Science, Vol.40, No.5, pp.1629-1638, 2015

[13] KarthikPrabhu T, SubramanianK, "Experimental Studies on RCP by using Cost Effective and Recycled Materials for Improving the Strength and Reducing the Cost of Pavement", Asian Journal of Research in Social Sciences and Humanities, 6 (12), pp. 1 -14.