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Evaluation Properties of High Strength Concrete for Sustainable Structure

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ABSTRACT—

A recent development in concrete technology is high-strength concrete. It classifies compressive strengths of at least 40 MPa. Since HSC is a different kind of solid, designers haven't used it frequently. Due to a lack of research, it has only been used in a few large, precise constructions and some reinforced concrete members. The goal of our study is to determine the appropriate proportion of mineral additive to cement in order to achieve the highest packing density. Based on the findings, a mix design will be created. Five mineral admixtures will be used in cement as pozzolanic materials. The mineral admixtures used were Rice-husk ash, Fly ash, Metakaolin, Quartz powder, and Fly ash. In order to reduce the amount of water required for cement hydration, a third-generation superplasticizer will also be added to the mix design. This investigation revealed that, in concrete microbial cells can be utilized for purpose of crack healing of both Macro and Micro sizes. From the isolation stage, 11 bacterial cultures having potential are isolated, and when the further screening proceeded, the number reduced to just 2. It is because of the concrete's high alkaline harsh environment. The survival of major group of bacterial genus becomes difficult in such a high pH environment. In this way it can be said that only those isolates which can survive in high pH environment needs to be isolate, separated for use in concrete. It is better to use soil which is rich in lime and magnesia in order to obtain calcite precipitating bacteria. As the chances of getting one in such soil is quite higher For developing bacterial cells, it was observed that rather than using direct plate technique we should use enrichment culture technique. With the help of this technique we can limit the growth of other bacteria which are not required

Keywords— concrete microbial, bacterial cultures, high alkaline, Concrete Masonry,

I. Introduction

Concrete has just overtaken water as the second most used substance worldwide. In the past, our needs might be satisfied with low grade or strength concrete mixtures. However, subsequent advancements and large structures made it clear that previous techniques were insufficient. Researchers made the decision to look for novel materials and technologies that may satisfy our needs. High Strength Concrete is a novel phrase coined during this series of studies. The term "High performance concrete" now has a new measurement thanks to the emerging invention of High Strength cement.[1–4] In the field of building and development, it has a lot of promise. When compared to conventional cement, it offers excellent mechanical and durability features. Additionally, it can replace plain steel in

Standards like packing density, micro structural improvement can be used to accomplish HSC. The advantage like water resistance and strength are likewise given by HSC. Different examination of the HSC has been performed for assurance of mechanical and durability properties. The outcomes demonstrate that HSC have more prominent compressive and flexural strength and a decreased water penetrability. The most extreme compressive strength is between 120-150 MPa. [5-7]Occasionally strength may likewise reach up to 200MPa.[8] At such a high compressive strength the coarse aggregates are the weakest part in concrete. The concrete is liable to fail from coarse aggregates.

To accomplish a compressive quality, we can remove the coarse totals and accomplish consistency and homogeneity in the blend. The pozzolanic properties of materials like silica fume, fly ash and so forth are utilized to accomplish high density and strength. HSC incorporates bond of higher grade (for the most part OPC 53), quartz powder, quartz sand, steel fibres and silica fume, steel aggregates and a superplasticizer (III generation). We likewise utilize superplasticizers so as to decline water-cement ratio with extra advantage of getting great workability. [9],

Here comes up the two new challenge. One is the extensive production of cement and concrete give rise to some hazardous environmental effects to concrete leads to negative environmental effects. The second one is durability of concrete. In concrete the cracks are the major shortcoming in concrete structures, Cracks are responsible for deterioration of concrete ne it Micro or Macro cracks. We need to overcome these two challenges. We know that key constituent of concrete is cement and aggregates. Some facts related to concrete is that the key constituents of concrete are cement and aggregates.[10], [11] The making of cement only leads to 7% CO_2 emission by human's activities, which is a huge number. By knowing these facts, it is difficult to say concrete is a sustainable material[12]–[14]. To avoid these phenomenon and make a eco-friendly concrete, concrete was replaced partially with come greener materials we replace concrete partially with greener choices like fly ash, blast furnace slag, or rice husk ash which are by results of iron, coal and agrarian materials or businesses and so on.

Cracks in concrete make a major impact over durability and serviceable life of concrete. Cracks makes it easy for moisture, Carbon dioxide (CO2), Sulphate, gases and other liquids for trans-pass concrete effectively up to its centre and fortification which brings about rot of support and decrease the quality and sturdiness of cement. Therefore, it makes cracks themselves undesirable in concrete structures. The micro cracks can rehabilitate by concrete itself. This healing process is known as "Autogenic healing" which is also known as "Self-healing". [15]–[18]Therefore, cracks can be healed by mixing specific healing material in the concrete matrix. In this we will try to make HSC which will be capable to heal its cracks by itself if occurs to increase the life of concrete and give a concrete structure serviceable for more time. Bacteria plays a major role in making self-healing concrete. A type of bacteria that can must precipitate with calcite (CaCO3) to form crystalline layer over cracked surface. The bacteria also should be alkali-resistant (alkaliphilic) in nature because concrete is extremely alkaline. [19]–[23]

Bacteria

Bacteria are the single cell microbes. There is no nucleus and any other membrane in them therefore, they have simple cell structure. DNA contains generic information of bacteria in a single loop., all this present in the control centre of the bacteria. Plasmid is also one of many circles of different genetic materials. It contains genes, which give advantages to bacterium over bacteria.[17], [21], [24]

Classifications of Bacteria

Classification based on shapes: According to their basic shapes, bacteria can be classified into 5 groups.

i) Spherical (Cocci)

ii) Comma (vibrios)

iii) Spiral (spirilla)

iv) Rod (Bacilli) &

v) Corkscrew (spirochaetes).

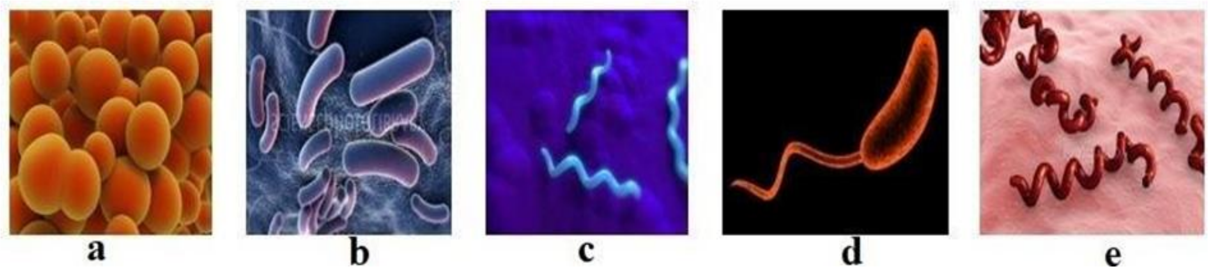


Figure 1 Classification of bacteria based on shapes. (a. Spherical (Cocci); b Rod (Bacilli); c. Spiral (Spirilla); d Comma (Vibrios); e Corkscrew (Spirochaetes). "Source: www.microbiologyonline.org

II. LITERATURE REVIEW

The authors Wang et al .(2013) conducted a study. The primary objective of this investigation was to get self-healing concrete using microencapsulated bacterial spores. Microcapsules used to encapsulate the bacteria spores for SHC. This encapsulation technique used to increase the bacterial life in concrete. The viability of encapsulated bacteria was investigated. This was a great research by author, which helped to attain more life for incorporated bacteria. Bacteria spores were encapsulated in a size of 5 μm. The capsule contains inert substances to protect the spores of bacteria. The concentration of spores of bacteria in the microcapsule was about 109 cells/g microcapsule (dry weight). These microcapsules are broken down under high tensile force (crack generates). These broken capsules liberate bacteria in the matrix of concrete and precipitation takes place. Series of tests were performed for different concentration.

Viability of the spores can be calculated by using the amount of decomposed urea. The spores in the capsules only germinate when the capsules were broken. Then they reached the nutrients. They need time to transform from dormant state to active state. It was found that spores remained viable after immobilization into the microcapsules. The micro capsulation does not affect the volume of the sample, but this process show decrease in tensile and compressive strength. In addition to higher than 3% microcapsules dosage there was a significant loss in tensile strength while in case of 1% to 5% microcapsules dosage there was a huge loss of about 15% to 34% in compressive strength was recorded by testing specimens.

In case of water absorption there was a lower water absorption in case of nutrients and microencapsulated bacteria. The distribution of pore size and porosity is obtained with the Mercury intrusion porosimetry (MIP) test. they observed that microencapsulated technique increased the viability of the bacterial spores, but it certainly decreases the mechanical properties of the concrete

like decrease in tensile and compressive strength. This type of technique could be useful in further scopes of bacterial concrete.[34]

The authors Mian et al. (2015) conducted a study with main objective of this study was to get proficiency of crack healing in concrete is dependent on bacterial carbonation precipitation. In this study, the author observed different aspects of crack healing by bacteria. The microstructural analysis was done by using SEM images and SEM observation of carbonation precipitation and by X-Ray diffraction (XRD). The compressive strength and water permeability along with visual inspection were also observed. The tests specimens and testing methods were used according to the Chinese standards. They observed slight rise in the compressive strength of concrete. Water permeability of bacterial concrete was relatively decreased by 84% and 96% for 7- and 28-days immersion in water, which was greater than that of control concrete.

The microstructural analysis by (SEM) Scanning Electron Microscope shown a complete precipitation and mineral formation, visually the healing capacity of bacteria was observed clearly. The crack with width of 0.48 mm was completely healed within 80 days. This study concludes, using biological healing agent helps in proper crack repairing and give eco-friendly concrete, which helps in green construction.[35]

The authors Krishnapriya et al. (2015) conducted a study. The main objective of this study was identify and isolate of bacteria which can improves the concrete strength. It was India based research. The Bacteria culture (Bacillus megaterium) collected from MTCC located in Chandigarhm An alternate substrate for growth of bacteria wheat bran was used in this study for maintaining economical sporulation. OPC 53 grade was used according to India standards. Concrete grade of M25 was prepared according to the Indian standards.

The compressive strength was obtained over the specimen prepared. Its seen strength of bacteria incorporated concrete was greater than strength of control concrete specimen. The microstructural analysis was done using SEM micrographs using Jeol JSM – 6390 apparatus. The SEM analysis shown positive results towards precipitation of calcium carbonate (CaCO3) by bacteria and visual inspection also shown crack healing capacity of bacteria. It was observed that the use of Bacillus genus spore forming bacteria as self-healing agent is possible and it could help in increasing life of structural concrete.[36]

The authors Jonkers et al. (2016) attempted a study, recovery of water tightness (RWT) was analysed along with different tests performed against water ingression. The healing agent was used of Bacillus genus having alkaliphilic properties including other organic mineral compounds. Healing agent introduced in OPC (CEM I 42.5 N, ENCI, The Netherlands) along with normal weight aggregates and lightweight aggregates (LWA) were mixed to get desirable mortar mix. The efficiency of crack healing of bacterial-based healing agent was analyzed by using stereomicroscopic images. The test was performed, and it was observed that lightweight mortar having bacteria-based healing agent can show improved crack sealing than other samples. The better liquid tightness was also observed in this sample. It was observed that oxygen was only consumed by the bacteria-based healing agent samples. This study concludes that the lightweight mortar shows better liquid sealing along with better crack sealing. The lightweight aggregates could perform better role in self-healing bacterial concrete.[37]

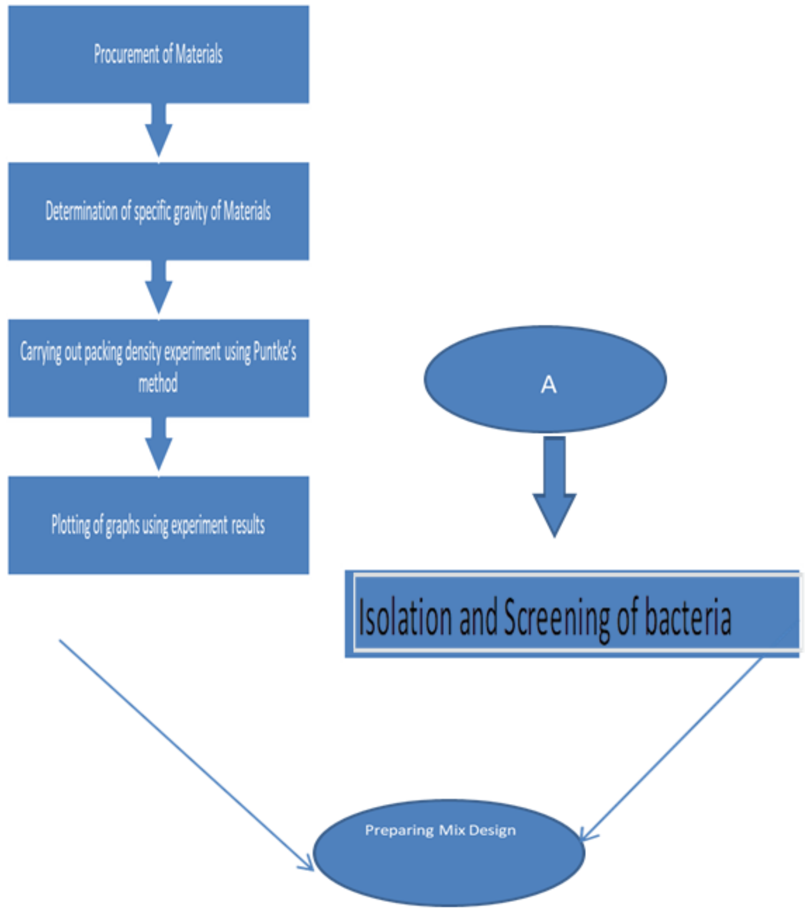
The authors Kim et al. (2018) isolated three strains for Bacillus genes (JH7, JH3 and HYO08), from two different samples of concrete. This study suggests that CaCO3 crystals having differentt properties which can be produced by different calcium carbonate precipitation (CCP)-capable strains.

In their study they finally concluded that self-healing ability of concrete depends upon many factors, type of bacteria, availability of calcium carbonate, pH and others. Therefore, it is very important to cultivate and induce the bacteria as per the nature available and requirement

The capacity to existing in such a basic, high pH environment is significant for CaCO3 precipitating microbes since solid it self speaks to such situations. In this manner, the proposed that three strains, two of Bacillus species JH3 an Jh3 and one Sporosarcina sp. HYO08, could be promising possibility for eco-accommodating mechanical applications. Each of three strains were brooded under similar conditions, the distinctive structure (state) of the subsequent accelerated precious stones could be because of contrasts in their intrinsic systems of use of calcium. Along these lines, strain likely have a ideal micro-environment to initiate CCP, for example, a particular pH level.

III. METHODOLOGY

We need to carry out the Optimum packing density optimization of the materials in Binary, Tertiary, quaternary models in order to achieve Highest packing density. Side by side we will get the samples for Bacteria isolation and to all the necessary steps to isolate and screen Calcium precipitating bacteria for our Study. Once the samples are made, they will further be tested for their mechanical properties as well as water absorbing capacity, The voids within the Concrete Cubes. In order to get the idea of crack healing capacity of concrete we also need to do continuous Microscopic and SEM Analysis. The step by Step Flow methodology adopted for the study is given below.



Split tensile strength test

IS 5816: 1999 was the standard used for conducting this test. Due to brittle nature of concrete it becomes extremely weak in tension compared to compressive strength. Hence, it is basic to decide the concrete tensile strength to at which it my break. CTM is used for performing this test and concrete cylinders (diameter and length is 100mm and 200mm respectively). The load is applied at a consistent rate of 1.2 to 2.4 MPa/min. The split tensile test is conducted on concrete cylinders as shown in at Figure

Figure 2 Split tensile strength test under CTM

For calculating Split tensile strength following equation is used (Eq. 5):

Split Tensile Strength Test (N/mm2) = 2 *P*

$M\ L\ D$ (5)

Here, P = Load at failure (N)

L = Length of cylinder (mm) D = Diameter of cylinder (mm)

Table-1 Flexure Strength in N/mm2

	Flexure Strength in N/mm^2		
Designation	7 Days	14 Days	28 Days
Control concrete	3.7	3.96	4.86
Standard concrete	3.98	4.2	5.86
isolate concrete	4.1	4.51	5.36

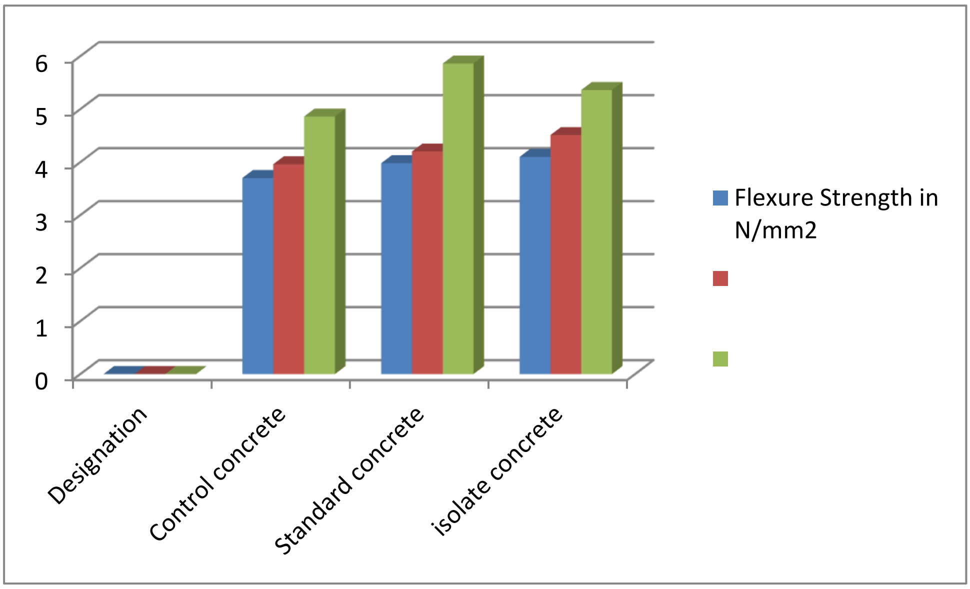


Figure-3 Flexure Strength in N/mm2

VI. Conclusions

- The concrete with Standard culture of bacteria showed highest Flexure Strength 5.86 (MPa) when compared to Flexure Strength of Isolate concrete 5.36 (MPa) and control concrete specimen 4.86 (MPa).Only those bacterial isolates can be used in crack healing of concrete which show positive urease activity and endospore formation. It is a fact that the microscopic organisms which are unable to frame endospore can't survive in an exceptionally highly alkaline environment of new concrete.
- The scope of this examination was to make a concrete which has high strength and if cracks occurred it will be able to heal its crack autonomously. In further research the long term durability, its cost effectiveness and its behavior in normal world needs to be explored. It is also needed to be checked that how this type of concrete will behave in marine conditions.

References

1. Abhilash Shukla ,Vinayak Sharma (151648) Ayush Thakur (151660) to STUDENTS ' DECLARATION," A. P. Report and B. O. F. Technology, "BIO CONCRETE : A BACTERIA BASED SELF-HEALING CONCRETE vol. 2019, no. 151660, 2019.
2. A. Talaiekhozan, A. Keyvanfar, A. Shafaghat, R. Andalib, M. Z. A. Majid, and M. A. Fulazzaky, "A Review of Self-healing Concrete Research Development," J. Environ. Treat. Tech., vol. 2, no. 1, pp. 1–11, 2014.
3. C. T. Liu and J. S. Huang, "Fire performance of highly flowable reactive powder concrete," Constr. Build. Mater., 2009.
4. D. Y. Yoo and N. Banthia, "Mechanical properties of ultra-high-performance fiber- reinforced concrete: A review," Cem. Concr. Compos., 2016.
5. E. Tziviloglou, V. Wiktor, H. M. Jonkers, and E. Schlangen, "Bacteria-based self-healing concrete to increase liquid tightness of cracks," Constr. Build. Mater., 2016.

6. F. Nosouhian, D. Mostofinejad, and H. Hasheminejad, “Influence of biodeposition treatment on concrete durability in a sulphate environment,” Biosyst. Eng., 2015.
7. H. H. C. Wong and A. K. H. Kwan, “Packing density : a key concept for mix design of high performance concrete,” Mater. Sci. Technol. Eng. Conf. Hong Kong, 2005.
8. H. J. Kim et al., “Calcium carbonate precipitation by Bacillus and sporosarcina strains isolated from concrete and analysis of the bacterial community of concrete,” J. Microbiol. Biotechnol., 2015.
9. H. M. Jonkers, A. Thijssen, G. Muyzer, O. Copuroglu, and E. Schlangen, “Application of bacteria as self-healing agent for the development of sustainable concrete,” Ecol. Eng., 2010.
10. J. Stark and K. Bollmann, “Delayed Ettringite Formation in Concrete,” ZKG Int., 2000.
11. J. Wang, Y. C. Ersan, N. Boon, and N. De Belie, “Application of microorganisms in concrete: a promising sustainable strategy to improve concrete durability,” Applied Microbiology and Biotechnology. 2016.
12. J. Y. Wang, D. Snoeck, S. Van Vlierberghe, W. Verstraete, and N. De Belie, “Application of hydrogel encapsulated carbonate precipitating bacteria for approaching a realistic self- healing in concrete,” Constr. Build. Mater., vol. 68, pp. 110–119, 2014.
13. J. Y. Wang, H. Soens, W. Verstraete, and N. De Belie, “Self-healing concrete by use of microencapsulated bacterial spores,” Cem. Concr. Res., 2014.
14. K. H. Kwan and W. W. S. Fung, “Packing density measurement and modelling of fine aggregate and mortar,” Cem. Concr. Compos., 2009.
15. K. Van Tittelboom and N. De Belie, Self-Healing in Cementitious Materials—A Review. 2013.