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Experimental study on characteristics of bacterial concrete

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ABSTRACT

Concrete is a building material and is widely used in all types of construction works. As we know the concrete is good in compression and week in tension due to micro crack occurs when the load applied on it. Due to these micro cracks the concrete loses its strength and water enters through these cracks which causes corrosion to steel. This initiates corrosion makes the whole structure vulnerable and leads to the failure of structure. Thus, to overcome from this problem a technique of adding bacteria into the concrete in order to enhance it properties like compressive strength. The Bacteria may be of liquid or powder form. Together it is called as bacterial concrete, in this concrete the bacteria (Bacillus subtillis) and calcite reacts with water forms a by-product called calcium carbonate (lime stone), which fills the crack and makes the structure sound as it was earlier. This process is called microbiologically induced calcite precipitation. The tests on materials were conducted for the best results and the tests are specific gravity, consistency, Impact Value Test, Shape Test, Sieve Analysis, PH Value (Bacteria), Bacteria Count etc. The different percentages of bacteria we used in order to know which percentage gives maximum strength. The percentages were made with reference to the amount of cement added into the concrete, the percentages by weight of cement we tried are 1.68%, 2.52%,3.17%,10%,15% and 20%. And we found 15% bacterial concrete gave highest compressive strength in 3- and 7-days test, the result of all tests is given in compressive strength table 2.

Keywords— *Bacterial concrete materials, material tests, mix design, compressive strength test*

1. INTRODUCTION

Bacterial concrete is a product which biologically produces limestone by which cracks on the surface of concrete surface heal. Selected types of the bacteria (Bacillus Subtilis) is added to the concrete when it is being mixed. The self-healing agents can lie in concrete for hundreds of years. When a concrete structure damages and water starts to penetrate in the cracks present in it the bacteria start to feed on the calcium lactate consuming oxygen and converts the soluble calcium lactate into insoluble limestone. The limestone formed thus seals the cracks present. This process is similar to how a fractured bone gets naturally healed into human body and to reform bone. Oxygen which becomes an essential element for the corrosion of steel to take place is being used in the bacterial conversion. Hence the durability of steel in construction becomes higher. Utilization of concepts of bio mineralogy in concrete lead to invention of a new material termed as Bacterial Concrete. Bacterial concrete refers to a new generation concrete in which selective cementation by microbiologically induced CaCO3 precipitation has been introduced for remediation of micro- cracks.

2. MATERIAL USED IN BACTERIAL CONCRETE

2.1 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Water should be free from acids, oils, alkalis, vegetables or other organic impurities.

2.2 Cement

Cement is a fine, grey powder. It is mixed with water and materials such as sand, gravel, and crushed stone to make concrete. The cement and water form a paste that binds the other materials together as the concrete hardens. In the present work 53 grade cement was used for casting cubes. The cement was of uniform color i.e. grey with a light greenish shade and was free from any hard lumps.

2.3 Fine Aggregate

The sand used for the experimental works was locally procured and conformed to grading zone II. Sieve Analysis of the Fine Aggregate was carried out in the laboratory as per IS383-1970.

2.4 Coarse Aggregate

Crushed basalt stones obtained from local quarries were used as

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coarse aggregate. The maximum size of coarse aggregate used was 20 mm. The properties of coarse aggregate were determined by conducting tests as per IS: 2386 (Part – III).

2.5 Bacillus Subtilis Bacteria

Bacillus subtilis will be brought up in its log phase in concreting site in liquid or aqueous state. This stage is having bacterial concentration 2 x 10^8 cells/ml. This full-grown stage is aimed to lasts for 2 to 3 hours at room temperature. These bacteria should be impregnated in concrete in its full-grown stage.

Bacillus Subtilis is a Gram – Positive bacterium rod - shaped and catalase positive. Bacillus subtilis are typically rod shaped and are about 4 to 10 micrometer long and 0.25 to 1 micrometer in diameter. As with other members of the genus bacillus, it can form an endospore to survive extreme environmental condition of temperature and desiccation.

Fig. 1: Bacillus Subtilis Liquid

3. HOW DOES BACTERIAL CONCRETE WORKS?

- Self-healing concrete is a product that will biologically produce lime stone to heal cracks that appear on the surface of concrete structure.
- Specially selected types of bacteria genus Bacillus, along with calcium-based nutrients known as calcium lactate & nitrogen phosphorus are added to the ingredients of the concrete when it is being mixed these self-healing agents can lie dormant within the concrete for up to 200 hundred years.
- when a concrete structure is damaged water starts to seep through the cracks that appear in the concrete, the spores of the bacteria germinate on contact with the water and nutrients.
- Having been activated, the bacteria start to feeds oxygen is consumed and the soluble calcium lactate is converted to insoluble limestone. The lime stone solidifies on the crack surface, thereby sealing it up.
- The consumption of oxygen during the bacteria conversion of calcium lactate to limestone has an additional advantage. Oxygen is an essential element in the process of corrosion of steel and when bacterial activity has consumed it all and increase the durability of steel reinforced concrete construction.

4. CHEMICAL PROCESS OF BACTERIAL CONCRETE

When the water comes in contact with the un-hydrated calcium in the concrete, calcium hydroxide is produced by the help of bacteria, which acts as a catalyst, this calcium hydroxide reacts with atmospheric carbon dioxide and forms limestone and water. This extra water molecule keeps the reaction going.

$$CaO + H2O \rightarrow Ca(OH)2$$

$$Ca(OH)2 + CO2 \rightarrow CaCO3 + H2O$$

The limestone then hardens itself and seals the cracks in the concrete.

5. MATERIAL TESTS

5.1 Cement

5.1.1 Setting time of cement

(a) Initial setting time = **43 minutes**
(b) Final setting time = **599 minutes**

5.1.2 Specific Gravity

Specific gravity of cement = **3.16**

5.1.3 Normal Consistency

Normal consistency of cement = **28%**

Fig. 2: Consistency test

5.1.4 Physical Examination

(a) Color was uniform grey
(b) No lumps
(c) No adulteration
(d) No over dated

5.2 COARSE AGGREGATES

5.2.1 Crushing value test

The crushing value of given sample = **28.14%**

5.2.2 Los Angeles Abrasion Test

The los Angeles Abrasion Value =**16.2%**

5.2.3 Impact Value Test

Aggregate Impact Value = **18.58%**

5.2.4 Shape Test

(a) The flakiness index = **18.24%**
(b) Elongation index = **14.51%**

Fig. 3: Shape test

5.2.5 Specific Gravity

The specific gravity of coarse aggregates = **2.67**

5.3 TESTS ON FINE AGGREGATE

5.3.1 Specific Gravity

The specific gravity of sand = **2.7**

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5.3.2 Sieve Analysis

Table 1: Sieve Analysis

Observations and Results:

IS SIEVE SIZE	WEIGHT RETAINED (Kg)	CUMMULATIVE WEIGHT RETAINED (Kg)	% WEIGHT RETAINED	% CUMULATIVE WEIGHT	% FINER
4.75mm	0.0265	0.0265	2.65	2.65	97.35
2.36mm	0.0305	0.057	3.05	5.7	94.30
1.18mm	0.121	0.178	12.1	17.8	82.20
600 microns	0.238	0.416	23.8	41.6	58.40
300 microns	0.367	0.783	36.7	78.35	21.65
150 microns	0.153	0.936	15.3	93.65	6.35
Pan	0.0165	0.950	1.65	95.3	4.7

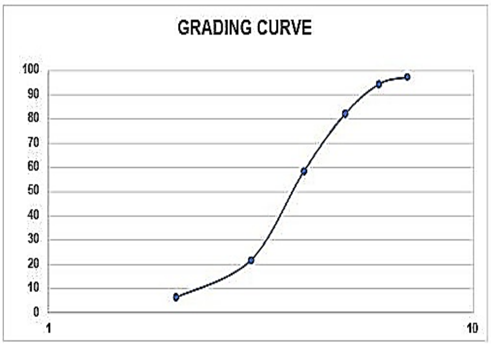

Fig. 4: Sieve Analysis grading curve

Fineness modulus = **2.39**

5.4 Bacteria (Bacilius Subtilis) Test

5.4.1 PH Value

The PH value of Bacillus Subtilis is = **6.8 - 7.2**

5.4.2 Bacteria Count:

The Bacteria count/ ml is = **$2x10^8$ /ml**

5.4.3 Specific Gravity

The Specific gravity of Bacillus Subtilis = **1.09**

Fig. 5: Bacteria Specific gravity test

6. DESIGN MIX

The concrete of Grade M30 Was designed as per IS 10262:2009

The Steps of design are as follows

Step 1: Target Strength for Mix Proportion

fck = fck+1.65*S =30+(1.65*4) =**36.6 N/mm^2**

Step 2: Selection of Water Content **=0.45**

Step 3: Water Required for $1m^3$ =197 lit

Step 4: Calculation of Cement Content (197/.45) =438 kg/m^3

Step 5: Proportioning of Volume of Course Aggregate (CA) and Fine Aggregate (FA)

For .45=.61

Volume of CA=.61

Volume of FA=1-.61=.39

Step 6: Mix Calculations

(a) Volume of Concrete= $1m^3$

(b) Volume of Cement = (Mass of Cement/Specific gravity of Cement)*(1/1000) (438/3.16)*(1000^{-1}) =.138m^3

(c) Volume of Water = (Mass of Water/Sg of water)*(1/1000) =197/1000 =.197m^3

(d) Volume of all aggregates =(a-(b+c) =(1-(.138+.197)) =.665m^3

(e) Mass of CA =e*Vol of CA*Sg of CA*1000 = (0.665*0.61*2.67*1000) =1083.086 kg

(f) Mass of FA= e*Vol of FA*Sg of FA*1000 = (0.665*0.39*2.7*1000)

(g) Ratio = Cement**:** Fine Aggregate**:** Coarse Aggregate = 438: 700.245: 1083.086 **=1:1.6:2.47**

7. COMPRESSIVE STRENGTH

Bacterial Mortar cube moulds of size 75mm x 75mm x 75mm were cleaned and checked against the joint movement. A coat of oil was applied on the inner surface of the moulds and unbroken prepared for the concreting operation. Meantime the specified quantities of 1:3 ratio cement, fine mixture was weighed accurately for concreting. Fine mixture and cement were mixed completely by hand until the specified colour of the mixture came uniform. Then, weighed amount of mixture were further mixed until uniform dry mixture is obtained. Then, calculated amount of Bacteria liquid and water were further added and compounding were continuing for two to three minutes to obtain a regular combine. The wet mixture was poured into the moulds in a pair of three layers and compacted manually. Once compacting is completed, the upper surface was levelled and finished with a mason's trowel. The corresponding identification marks were labelled over the finished surface and that they will be tested for 3,7 days strengths in an exceedingly compressive strength testing machine

Fig. 6: Mixing of materials

Fig. 7: Casting of cubes

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Fig. 8: Curing of cubes

Fig. 9: Testing of Cubes

Fig. 10: After test broken piece of mortar cube

Table 2: Compressive Strength test

PEAK STRESS(MPA)	3 DAYS		N/mm²	7 DAYS		N/mm²
	S1	S2	AVG	S1	S2	AVG
NORMAL	28.6	27.5	28.05	32.5	33.5	33.0
CONCENTRATION I (40ML/Litre of Water) 1.68% of cement	33.8	34.8	34.3	35.4	39.2	37.3
CONCENTRATION II (60ML/Litre of Water) 2.52% of cement	35.7	34.9	35.3	38.9	39.2	39.05
CONCENTRATION III (80ML/litre of water) 3.17% of cement	36.5	35.8	36.15	41.2	41.8	41.5
CONCENTRATION IV 10% of cement	38.2	38	38.1	44.2	44.1	44.15
CONCENTRATION V 15% of cement	39.01	38.8	38.9	45.6	46.02	45.81
CONCENTRATION VI 20% of cement	37.2	36.8	37.0	45.14	44.9	44.02

8. CONCLUSION

After doing test on bacterial concrete, we analyses the difference between normal and bacteria concrete

- After doing compression test, we found maximum compressive strength at 15% concentration of bacteria by weight of cement added.
- The compressive strength of cement mortar cubes having bacteria count 2 x 10^8 was increased by 40% in 7 days and 35% in 3 days
- Bacterial concrete is found to be capable of enhancing compressive strength. The reduction in permeability, water absorption, corrosion of reinforcement could be studied in future for better understanding.
- Increase in compressive strength is mainly due to the consolidation of the pores inside the cement mortar with microbiologically induced calcite precipitation.
- In this study it is found that bacillus subtilis was suitable bacteria for self-healing concrete when comparing to other bacteria from bacillus family from literature.

9. REFERENCES

[1] Mayur Vekariya, Prof. Jayeshkumar Pitrode, “Bacterial Concrete: New Era for Construction Industry” Sep 2013, Volume- 4,Issue- 9.

[2] Mostafa Seifan, Ali Khajesh Samani, Aydin Berenjain, “Bio Concrete : Next generation of self-healing concrete”.29 Jan 2016.

[3] Koustubh A. Joshi,,Madhav B. Kumthekar, Vishal P Ghodake,” Study of Self healing Mechanism and its Impact on Bacillus Bacteria Impregnated Concrete”,

[4] June 2016,Volume -3,Issue -6.

[5] Kusuma K,Amit Kumar Rai,Prashant Kumar,Harini K,Harshita M.N,”Self – healing concrete”,May 2018,Volume -05,Issue -05,IRJET.

[6] Abhishek Thakur, Akshay Phogat,Khushpreet Singh,” Bacterial Concrete and effect of different bacteria on the Strength and water absorption characteristics of concrete: A Review “,Sep-oct 2016,Volume-07,Issue-05.

[7] S Soundharya, Dr. K Nirmalkumar, “Study on effect of Calcite-Precipitating Bacteria on Self-healing Mechanism of Concrete,” July-2014,Vol -01,Issue -04.

[8] Pawar Bhagyashri, Magdum Archana, Bhosale Megh, Pol Sayali,”Bacterial Concrete’, Oct-2007,volume-04, Issue -02.