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Strength and Durability Aspects of Developed Microbial Concrete

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***Abstract*—A sturdy cement is one that performs agreeably under expected presentation conditions for determined existence of the structure. Strength and administration life are significant contemplations in solid structures subject to forceful condition. Run of the mill business ventures require durable toughness which is a steady objective of designers, contractual workers, planners and solid maker around the world. Concrete has an extreme burden bearing limit under pressure however the material is feeble in strain. Thus, it splits under stacking. Break in concrete happens because of physical and substance ecological assault that invigorates the weakening of inserted steel bars, which influences the sturdiness of cement and diminishes the life of structure. The fundamental focal point of this paper is to inspect the Probability of getting quality of cement by microbiologically actuated exceptional filler with the blend of counterfeit elements of cement. In this examination, a Bacillus bacterium (Bacillus subtilis) has been utilized to actuate CaCO3 precipitation. This marvel is called Microbiologically Induced Calcite Precipitation (MICP). This project presents to evaluate the influence of Bacillus Subtilis along with granite as coarse aggregate and Artificial fine aggregate and also its self-healing properties is evaluated by health monitoring technique to check the quality of concrete.**

Keywords*— *Bacillus Subtilis, Compressive and Split tensile Strength, UPV Test

I. INTRODUCTION

Concrete is one of the most important construction material. Concrete compresses of various raw materials (cement, fine aggregate, coarse aggregate, granite chips, water) in different proportions to attain its required strength as a homogeneous mixture. Here granite chips are used as partial replacement of coarse aggregate to increase the toughness of concrete. Concrete have certain boundaries in its character such as, it is week in tension, it have limited ductility, crack formation is one of the major problem in concrete. The main aim is to make high durable concrete by reducing the crack caused by self weight as well as crack formed after loading. The concept of bacterial concrete is introduced to seal the cracks in the concrete by incorporating the mineral producing bacteria with metabolize crystal. This bacteria is used with water at different concentration in concrete to seal the cracks. This process is called as microbiological induced
calcite precipitation. This is one of the best alternative and environmental friendly method to increase the durability of concrete.

II. MATERIALS

A. Cement

Normal PPC of grade53 is used in this project. Different kind of tests on property of cement is done as per IS 4031-1998. The specific gravity of the cement used in this project is 3.2.

B. Coarse aggregate

Coarse aggregate of size 20mm is used here. As per IS 383-1970 all the basic test required to determine the character(ie. Water obsorption,crushing value, impact test) of the coarse aggregate is done.

C. Granite chips

Granite chips is a waste product that obtained during the manufacturing process of granite. They are obtained in abnormal shape and sizes, it should be grained and passed through 20mm sieve and retain on 4.75mm. The retaining granite chips are used as alternate to coarse aggregate upto 30%.

D. M – Sand

Manufactured sand (M-Sand) is used as a substitute for river sand. They are produced by crushing hard granite rocks into fine powder and used as fine aggregate. In this project well processed M-sand is used as fine aggregate.

E. Potable water

Water is the key ingredient, which when mixed with cement,it forms heat of hydration reaction that helps to bind all the materials in concrete. Portable water confirming to the requirements of IS: 456-2000 was used for casting and curing.

F. Bacillus subtilis

Bacillus subtilis, Bacillus subtilis, it is a Gram-positive bacteria and non pathogenic bacteria. They are basically live in vegetative soil at a temperature between 25-35 degree celcius. It is a spore forming bacteria which secretes antibiotic during the process of spore formation for their healthy living and survival. Bacillus subtilis is brought up in its log phase in concreting site in liquid or aqueous state. This stage is having bacterial concentration 106 cells/ml. They are mixed along with the water used in concrete.

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III. CULTIVATION OF BACTERIA

Bacillus subtilis was prepared from soil sample. It is maintained in a nutrient agar solution. Serial dilution and plate count test is done for determining the identification and concentration of bacteria present. This technique is utilized to isolate the organisms,in the event that it is available in huge number in the blend. At whatever point required a single colony of the culture is inoculated into nutrient broth of 100 ml in 250ml conical flask and the growth conditions are maintained at 370C temperature and placed in 140 rpm orbital shaker.

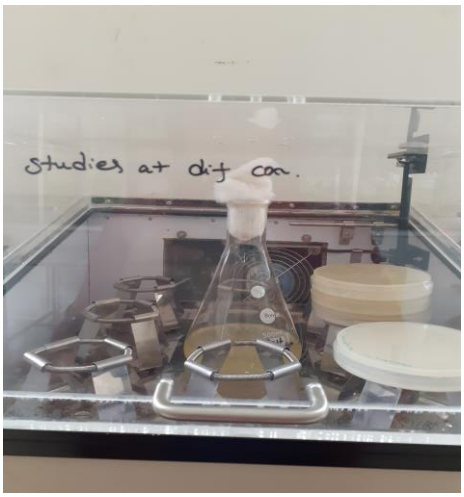

Fig- 1: Cultivation of bacteria

IV. MIX DESIGN

Mix design is done to achieve the target mean strength and using of materials with required proportion as per the Indian standard codel provisions. The compressive strength of concrete is determined by cubes of size 150mmx150mmx150mm. Split tensile strength of the concrete was obtained by the cylinder of size 150mm diameter and 300mm height. In our investigation we've made M30 concrete.

Table- 1: Mix proportion

Materials	Cement	Sand	Coarse aggregate
Quantity(kg/m^3)	438.2	608	1160
Ratio	1	1.38	2.65

Table- 2: Percentage Of Replacement Of Granite Chips

Percentage of granite chips replacement	Nominal coarse aggregate	Granite chips
30%	816	343

V. EXEPERIMENTAL TESTS

A. Compressive strength test

After casting of cubes as per the mix design. The cubes are cured for 28 days to reach their maximum strength. After the curing process the cubes are dried for 24 hours in room temperature for compression test. After the drying process the cube is tested in compression testing machine. Before placing the cube the surface of the machine should be cleaned there should not be any obstruction. Then the cube is placed and the load gradually applied without shock and continuously at the rate of 5.2 KN/sec till the specimen fails. The maximum load recorded and any unusual features in the type of failure noted down. It is carried out for both 7days and 28days specimen.

Fig- 2: Compressive strength test on cube

B. Split tensile strength test

Splitting tensile strength is done to evaluate tensile strength of the respective grade of concrete. For split tensile test cylinder specimen of size having height of 100mm and diameter of 150mm is casted as per the mix design and cured for 28days. After the curing process it is dried for 24hrs and tested. Before placing the cylinder specimen in the machine surface two steel plate is placed at top and bottom surface of the cylinder specimen as shown in fig3 for uniform distribution of load on the surface of the cylinder. the Split tensile strength tests are carried out at 7 and 28 days for the cylindrical specimen using compressive testing machine of 2000 kN according to IS:516-1959. The load is applied slowly till the specimens split and readings are noted.

Fig- 3: Split tensile strength on cylinder

C. Ultrasonic pulse velocity test

This method consists of producing an ultrasonic longitudinal pulse by an electro acoustical transducer which is in contact with one surface of freshly placed concrete member under investigation. After the traversing is done at known distance in the concrete, pulse to be measured from which the pulse

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pulse velocity is calculated by calculating the transist time of the pulse from the time circuit. This procedure is called the "Ultrasonic method." Ultrasonic pulse velocity test is generally done to determine the presence of voids in the internal structure of concrete by means of passing the ultrasonic rays through the body on concrete and also to know the denseness of the concrete structure. All the respective bacterial concrete samples viz. conventional,10ml 15ml,20ml, 25ml, 30ml were tested.

Fig- 4: UPV Test on cube

VI. RESULTS

A. *Compressive strength test*

Table-3: Compressive Strengtth of Bacterial Concrete

Bacterial solution added(ml)	7 days(MPa)	28 days(MPa)
10	31.11	33.33
15	31.07	33.71
20	31.38	35.24
25	31.5	35.55
30	32.1	36.02

Table-4: Compressive Strengtth of Conventional Concrete

Conventional concrete	Compressive strength(MPa)
7 days	23.8
28 days	28.6

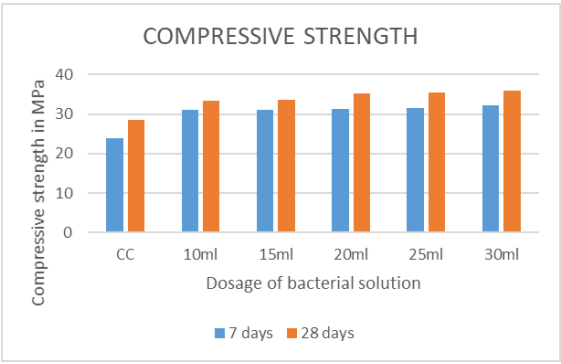

Fig-5: Compressive Strength Result

B. *Split tensile strength test*

Table-5: Split Tensile Strength of Conventional Concrete

Bacterial solution added(ml)	7 days(MPa)	28 days(MPa)
10	1.06	1.69
15	1.27	1.72
20	1.48	1.84
25	1.63	1.86
30	1.92	2.2

Table-6: Split Tensile Strengtth of Conventional Concrete

Conventional concrete	Compressive strength(MPa)
7 days	1.27
28 days	1.41

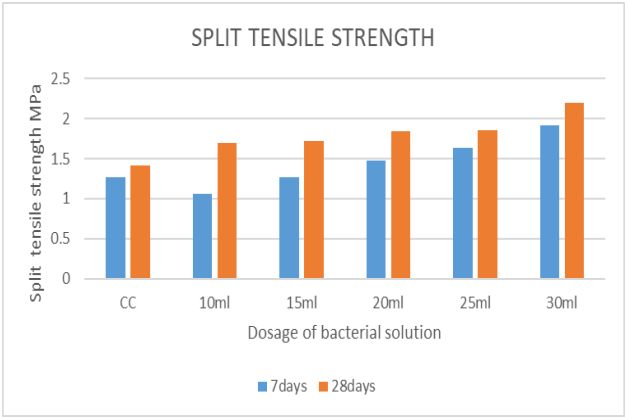

Fig-6: Split Tensile Strength Result

C. *Ultrasonic pulse velocity test*

Table VII Ultrasonic Pulse Velocity Test

Property of concrete	RCC member	Prob distance	Time (micro sec)	Velocity (km/sec)	Probing method
Conv. concrete	Cube	150	28.8	5.2	Direct
Bacteria concrete					
10 ml	Cube	150	28.2	5.3	Direct
15 ml	Cube	150	27	5.5	Direct
20 ml	Cube	150	25.6	5.85	Direct
25 ml	Cube	150	26.2	5.75	Direct
30 ml	cube	150	25.2	5.88	Direct

VII. CONCLUSION

Based on the investigation and results presented in this paper, the following conclusions are reached:

- The compressive and split tensile of M30 microbial concrete is found to be higher than M3O conventional concrete.
- The compressive strength of concrete after 28 days using Bacillus Subtilis has been increased upto 26% compared to conventional concrete.
- The split tensile strength of concrete using Bacillus Subtilis has been increased upto 56% compared to conventional concrete.
- Ultrasonic Pulse Velocity test that is conducted on the bacterial concrete specimen shows that the value of ultrasonic pulse velocity is increased due to enriched pore and micro structure. The values obtained are above 4.5 km/sec which shows excellence of strength of the concrete.

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