

Experimental Study on Structural Behaviour of Bacterial Concrete

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ABSTRACT: Concrete are the most important materials used in construction industries where the external forces more than the design loads mainly the lateral forces which leads to the deformation and produce cracks in the joints of the structural member. The usage of cement has been increased more over the world results in the air pollution which leads to the ozone depletion. To overcome these type of problem like crack formation and usage of cement content used for repair works can be reduced by using the self healing bacterial concrete. These are materials which heals crack automatically when the cracks are formed. These self healing is achieved by means of using the biological healing aspect by using bacterial concrete. Bacteria are used during the mixing of concrete will cure the cracks automatically by means of it screeds known as calcium carbonate precipitate. To avoid that formation of corrosion of cracks bacterial concrete along with 25% of fly ash are used which results in self healing process. These self healing which cure and arrest the cracks in the structure which gives the environment free pollution and sustainable structure.

I .INTRODUCTION

Concrete is most widely used construction material because of its high compressive strength, relatively low cost, etc. One adverse property of concrete is its sensitivity to crack formation as a consequence of its limited tensile strength. For that reason concrete is mostly combine with steel reinforcement to carry the tensile loads although these rebars restrict the cracks width they are mostly not design to completely prevent cracks formation. Cracks endanger durability of concrete structure as aggressive liquid and gases may penetrate into these cracks may cause damage. When cracks appear in concrete structure and water starts to seep in through, the spores of the bacteria starts microbial activities on contact with water and oxygen. In the process of precipitating calcite crystals through nitrogen cycle the soluble nutrients are converted into insoluble CaCO_3 . Calcium carbonate solidifies on the crack surface thereby sealing it up. The consumption of oxygen during metabolic biochemical reaction to form CaCO_3 help in arresting corrosion of steel because the oxygen responsible to initiate the process of corrosion thereby increasing the durability of steel reinforced concrete structures.

II. SELECTION OF MATERIAL REQUIREMENTS

2.1 Cement



Fig 2.1 Cement

Ordinary Portland cement (OPC) is by far the most important type of cement. The OPC was classified into three grades, namely 33grade, 43grade, 53grade depending upon the strength of the cement at 28 days tested as per IS4031-1998. If the 28days Strength is not less than 33N/mm², 43N/mm² and 53N/mm² it is called 33grade, 43grade, 53grade cement respectively. OPC of 33grade from JSW brand conforming to IS 269 is used in this experimental work.

2.2 Fine aggregate



Fig 2.2 Fine aggregate

The aggregate size is lesser than 4.75mm is considered as fine aggregate. The sand particle should be free from any clay or inorganic materials and found to be hard and durable. Silt test is carried out to specify the limits of presence of organic matter and silt in fine aggregates. It was stored in open space free from dust and water. In our experiment fine aggregate are found from bed of river. It conforms to IS 383-1970 Comes under zone II. River sand passing through 4.5mm sieve and retained on 60 micron sieve is used and will be tested as per IS 2386(part I)-1963. The fineness modulus of sand is 5.57% with specific gravity of 2.65.

2.3 Coarse aggregate



Fig 2.3 Coarse aggregate

The aggregate size bigger than 4.75mm, is considered as coarse aggregate, it can be found from original bed rocks. Coarse aggregate are available in different shapes like rounded, irregular are partly rounded, angular, flaky etc. It should be free from any organic impurities and the dirt content was negligible. There has been a lot of controversy on subject whether the angular aggregate or rounded aggregate will make better concretes. They suggest that if at all the rounded aggregates is required to be used for economical reason but if should be broken and then used. But the angular aggregate are superior to round aggregate. The size of 20mm coarse aggregate has been selected for the study. The physical properties will be tested as per IS 2386(part I)-1963. The fineness modulus of coarse aggregate is 2.7 with specific gravity of 2.68.

2.4 Water

Portable tap water available in the laboratory with pH value 7.0 and confirming to the requirements of IS 456-2000 is used for making concrete and curing the specimen.

2.5 Flyash



Fig 2.5 Flyash

Ordinary class F flyash of cementitious property collected from the nearer thermal power plant of specific gravity 2.2 is taken. The quality parameters of flyash for use in concrete confirming to IS 3812 (part I) has been used.

2.6 Microorganisms(Bacteria-BacillusSubtilis)

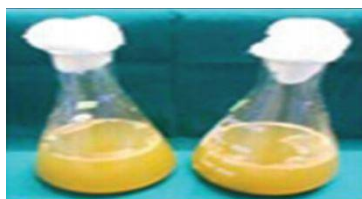


Fig 2.6 Bacillus subtilis

Bacillus subtilis a model laboratory soil bacterium is cultured. The pure culture is maintained constantly on nutrient agar slants. It forms irregular dry white colonies on nutrient agar. Whenever required a single colony of the culture is inoculated into nutrient both of 200ml in 500ml conical flask and the growth conditions are maintained at 37degree temperature and placed in 125rpm orbital shaker. The medium composition required for growth of culture is peptone, nacl, yeast extract.

2.6.1 Properties Of Bacillus Subtilis

- It is discovery of transformation in strain of Bacillus subtilis in 1958 focused attention on the genetics of the Bacterium.
- Bacillus subtilis cells are in rod-shaped.
- It is 4-10 micrometers long and 0.25-1.0 microns in diameters.
- If the cell volume of about 4.6 FL at stationary phase.

2.7 Material Tests

S.No	Test for materials	Result
1	Specific gravity of cement	3.17
2	Specific gravity of fine aggregate	2.65
3	Specific gravity of coarse aggregate	2.68
4	Water absorption of coarse aggregate	0.15%
5	Water absorption of fine aggregate	0.10%
6	ShapeTest(ElongationIndex)	23.35
7	ShapeTest(Flakiness Index)	10.9
8	Fineness modulus of fine aggregate	5.57%
9	Specific gravity of flyash	2.2

Table 2.1 Material Tests

III.MIX DESIGN

3.1 GENERAL

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The main objective is to stipulate the minimum strength and durability. The mix design adopted in our project for the grade of M30.

3.2 MIX PROPORTIONS

Cement = 437.77 kg/m³

Flyash	= 109.44 kg/m ³
Fine aggregate	= 688.78kg/m ³
Coarse aggregate	= 1044 kg/m ³
Water cement ratio	= 0.45
Final mix design	= (1:1.56:2.36)

IV.EXPERIMENTAL PROGRAM

4.1 COMPRESSIVE STRENGTH TEST

The test was conducted as per IS 516-1959. The specimens were kept in water for 7 days, 14 days and 28 days and surface dry conditions were obtained by wiping water on the surface. The cubes of size 150×150×150mm are placed in the machine such that the load is applied on the opposite side of the cubes are casted. Align carefully and load is applied, till the specimen breaks..The formula used for calculation is given, **Compressive Strength =**

Total failure load / Area of the cube



Fig 4.1Compressive strength test

4.2 FLEXURAL STRENGTH TEST

A beam specimen should be cast for determining the flexural strength of concrete. The Standard specimen size is 150mm× 150mm × 700mm. The testing machine may be set to any reliable type of sufficient capacity for the test. Permissible errors should not gretaer than 0.5%To centre distance of 60 cm for the 15cm specimens and at 40cm for the 10cm the test specimen should be cast for 28 days and tested for maximum load. The flexural strength or modulus of rupture should be calculated using the formula given below $f_b = \frac{3PL}{BD^2}$ where B is the measured width (cm) of the specimen, a is the distance between supports (cm), D is the measured depth (cm), L is the length (cm) of the span on which the specimen is supported, and P is the maximum total load (kg) applied to the specimen. Modulus of rupture is about 60% to 100% higher than the direct tensile strength.



Fig 4.2 Flexural strength test

4.3 SPLITTING TENSILE TEST

The splitting strength of the conventional concrete specimens are to be compared with that of the specimens made with added of above said percentage of flyash and bacterial solution. The test was conducted as per IS 5816:1999. The specimens were kept in water for curing for 28 days and on removal were tested in wet condition by wiping water. Central line was drawn on the two opposite faces so as to ensure that lines are in the same axial plane. Care was taken so that the upper platen with the lower platen. The load is applied without shock and increased continuously at a nominal rate within the $1.2\text{N/mm}^2/\text{min}$ until failure. The failure load of tensile strength of cylinder is calculated by using the formula, **Tensile strength = $\frac{2P}{3.14 d^2}$** Where, P = Failure load of the specimen, D = Diameter of the specimen, L = Length of the specimen



Fig 4.3 Split tensile strength test

V. DISCUSSION AND RESULTS

5.1 TABULATION FOR COMPRESSIVE STRENGTH OF 7 DAYS AND 28 DAYS

Table 5.1 Compressive strength for 7days and 28 days

S.No	Description of Sample	7days	28 days
1.	Conventional concrete	20.88 N/mm ²	37.03 N/mm ²
2.	BC (25% of Flyash, 100ml of bacterial solution)	24.89 N/mm ²	42.22 N/mm ²
3.	BC (25% of fly ash, 300ml of bacterial solution)	27.78 N/mm ²	45.18 N/mm ²

5.1.2 TABULATION FOR FLEXURAL STRENGTH OF 28 DAYS

Table 5.2 Flexural strength for 28 days

S. No	Description of Sample	28 Days	
		Ultimate Load in Kn	Flexural Strength in N/mm ²
1	Conventional concrete	41.85kN	8.68N/mm ²
2	BC (25% of Flyash, 100ml of bacterial solution)	43.87kN	9.1N/mm ²
3	BC (25% of fly ash, 300ml of bacterial solution)	45.13kN	9.36N/mm ²

5.1.3 TABULATION FOR SPILITTING STRENGTH OF 28 DAYS

Table 5.3 splitting tensile strength for 28 days

S. No	Description of Sample	28 Days	
		Ultimate Load in kN	Tensile Strength in N/sq mm
1	Conventional concrete	120kN	3.2N/mm ²
2	BC (25% of Flyash, 100ml of bacterial solution)	130kN	3.55N/mm ²

3	BC (25% of fly ash, 300ml of bacterial solution)	150kN	4.1N/mm ²
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VI. CONCLUSION

Bacterial concrete technology has proved to be better than many conventional technologies because of its eco-friendly nature, self healing abilities and increase in durability of various building materials. We have shown that the bacteria incorporated in 400ml has considerably filled the cracks present in the concrete and it also found that there is an increase of 15% in compressive strength when compared to controlled cubes. The use of this biological repair technique is highly desirable because of the mineral precipitation induced has a result of microbial activities is pollution free and natural. There is an increase of 8% in flexural strength when compared to the conventional concrete. There is an increase of 22% in split tensile strength when compared to conventional concrete. The study on the use of bacteria and flyash replacement in concrete shows to be more significant

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