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Experimental Study of Flexural and Torsional Behaviour of Beams With bacterial Concrete

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***Abstract:** The main concept of replacing cement with fly ash can accomplish as sustainable development, in construction industry, concrete is a most broadly utilized development material and cement is the only manufactured material and other materials like fine aggregate and coarse aggregate and water are natural resources. As per reports its states that by manufacturing a ton of cement 800 to 900 kg of co_2 is emitted in to the atmosphere which results in to the global warming. In this project we are utilizing the fly ash as a byproduct, presently large amounts of fly ash are generated in thermal industries whichinternational journal of science and research h are dumped as waste and it will be adverse impact on environment and humans. And in this project, it is decided to use bacteria and to enhance its properties of hardened concrete. For this bacillus subtilis has been chosen based on previous work done. The design mix is to made of M40 grade concrete. The ingredients for concrete are tested. It is proposed that incomplete substitution of cement by fly ash enriched by bacteria and to test the flexural and torsional strength of concrete at different ages.*

***Index Terms**: Flexural, Torsional, S1CC, S1CCB, S1CF, S1CFB, Bacillus subtilis.*

I. INTRODUCTION

Concrete is generally utilized material in the world, in excess of ten billion tons of cement are devoured every year, In view of worldwide use it is set second position after water concrete in a structural matter fundamentally made out of water, FA and CA inserted in a solidify lattice of material called bond, which tops off the voids among totals and follow them firmly[4]. The most important material in concrete is cement, The manufacture of cement leads to produce huge amount of carbon dioxide in to atmosphere. The assembling of concrete causes different ecological and social outcomes relying upon contemplations which are both harmful and are invited[5]. Different endeavours have been made to decrease the carbon dioxide discharge identifying with cement from both modern and academicals divisions by substitution of traditional clinkers with mechanical bi items, for example fly ash. The utilization of modern squanders picking up significance as added substances, since they increase quality, decline thickness and above all reduction natural effects. Now a day's concrete is considered as a strong, solidand mostly used constructive material,the cracks in concrete can diminish the toughness of a structure, and finally it will prompts disappointment of structure[3]. These cracks happen in concrete because of stacking, warm effect, plastic shrinkage.

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On the off chance the water droplets go in to the concrete because of absence of porousness then it can harm the steel support present in the concrete. When this problem occurs, the strength carrying capacity of concrete decreases and which leads to failure of structure. To prevent these problems bacteria was introduced in concrete. Bacterial concrete it is type of concrete which heals by itself so it is known self -healing concrete. Bacterial concrete is uncommonly made to expand the toughness of solid structure by oneself mending activity of that solid. Cracks which forms superficially layer of concrete were relieved because of calcite precious stones delivered by bacteria[2]. Compressive strength of the concrete wasincreased by bacteria such as Bacillus Subtilis,Corrosion inreinforcement of reinforced concrete can be reduced by Bacillus Subtilis,hence, these materials are utilized to build the life expectancy of concrete structure without spending high measure of expense for fix and well being reason.

II. EXPERIMENITAL

A. Materials used

B. Cement

Ordinary Portland cement – 53 grade have been utilized in the venture. The cement was tested according to IS 4301:1988. It conformed to IS 12269: 1987. The tests which were conducted are mentioned in Table No.1

Table 1 Tests conducted on Cement

S No	Name of Test	Results
1	Specific Gravity of cement	3.10
2	Normal Consistency	31%
3	Initial setting time	126 minutes
4	Final setting time	260 minutes
5	Fineness	5%

C. Fine Aggregate

Clean and dry river sand were used as fine aggregate. The sand conforming to Zone II. Specific gravity and water absorption is 2.66 and 0.5% respectively.

D. Coarse Aggregate

The crushed stones were used as coarse aggregate. The aggregates passing through 20mm sieve and below as given in IS 383 – 1970 has been used. The test results obtained while testing the coarse aggregate has been tabulated below in Table 2.

Table 2 Tests conducted on coarse aggregate

S No	Name of Test	Results
1	Impact Test	16.66%
2	Water Absorption Test	0.5
3	Specific Gravity Test	2.66

E. Fly Ash

Fly ash is a by productfrom consuming pulverized coal in electric power producing plants. In our project Class F fly ash has been used. ASTM C 618 covers specifications for Class F fly ash. They are basically derived from the combustion of anthracite and bituminous coal. The specific gravity and fineness is 2.12 and 31% (45 micron) respectively.

F. Bacteria

Bacteria are microscopic living creature, generally one-celled, that can found all over, some are unsafe and some are useful. Bacterial concrete it is type of concrete which heals by itself so it is known self -healing concrete, the extra ordinary properties of this sort of concrete is it tops off the cracks created in structures by the assistance of bacterial response in the wake of solidifying. In our project special type of bacteria known as Bacillus Subtilis is used. The one of the advantage of this process is, as the oxygen is consumed by the bacteria to convert the calcium in to limestone, it helps prevent the corrosion of steel due to cracks. This improves the life of steel reinforced concrete construction.

III. PROCESS OF METHODOLOGY

G. Mix Proportion

In this project concrete mix design M40 was designed based on IS: 10262-1982, IS 456-2000. This code helps us a general applicable method for selecting mix proportion for high strength concrete and optimizing this mixture proportion on basis of trail batches. Mix design are given below in table 3. In these table the mix ratio is 1:1.23:2.36 and w/c is 0.40 is adopted.

Table 3 Mix proportion for conventional concrete

Material	Quantity
Cement	450 Kg
Fine aggregate	648 Kg
Coarse aggregate	1148 Kg
Water	180 Litres

based on the mix design, specimens are cast as conventional concrete, fly ash concrete and bacterial concrete and tested.

S1CC **-** Conventional concrete as per mix design

S1CF25 – CF indicates fly ash concrete made with partial replacement of cement with equal volume of fly ash and number indicates the percentage of cement replaced in fly ash concrete.

S1CFB25 – CFB indicates bacterial concrete made with partial replacement of cement with equal weight of fly ash enriched with bacteria Bacillus subtilis and the number indicates the percentage of cement replaced in the bacterial concrete.

H. Cube Specimens

Casting of cubes (100mm X 100mm X 100mm) specimens were made to cast as per mix design for conventional concrete and for S1CF and S1CFB with respective percentage of replacement of cement with equal volume of fly ash enriched with bacteria.

I. Flexural Beam Specimens

In this project tests were conducted to find the strength of bacterial concrete in structural members in flexure and torsion. RCC beams of size 1200mm X 150mm X 200mm were used to find the flexural strength. Top reinforcement is 2 numbers of 10mm dia steel rods and bottom 2 numbers of 12mm dia steel rods, 6mm dia stirrups are provided at 150mm center to center. Beams were cast with concrete proportions of S1CC, S1CF25, S1CF40, S1CF50, S1CF60, S1CFB25, S1CFB40, S1CFB50, S1CFB60.

Fig 1 Flexural Beam moulds

Fig 2 Reinforcement for Beam

J. Torsional Seam Specimens

In this project torsion RCC beam of size 1200mm X 150mm X 200mm with projecting arms on both ends with same cross section of 400mm were used to find torsional strength. Top reinforcement is 2 numbers of 10mm dia steel rods and bottom 2 numbers of 12mm dia steel rods, 6mm dia stirrups are provided at 150mm center to center. Beams were cast with concrete proportions of S1CC, S1CCB, S1CF25, S1CFB25.

IV. RESULTS AND DISCUSSION

K. *Compression Test*

Conventional concrete specimens were made as per mix design and S1CF and S1CFB with respective percentage of replacement of cement with equal volume of fly ash and fly ash enriched with bacteria.

Fig 3 Compressive Strength Test

After 7 days, 14 days, 28 days the specimens are tested with the help of compression testing machine. We have tested three cubes and average has been taken as shown in below table 4.

Table 4 Average Compressive Strength

Duration	Average compressive strength (N/mm²)							
	S1CC	S1CF25	S1CF40	S1CF50	S1CCB	S1CFB25	S1CFB40	S1CFB50
7 days testing	24	22	19.4	17.8	26.5	28.8	26.7	22.07
14 days testing	37.8	29	26	24	37.9	39.2	34.62	27.4
28 days testing	43.9	37	31	27.6	45.6	47.5	45.39	36.34

From Table 4, we can observe that the compressive strength of fly ash concrete is less than conventional concrete. And the bacterial concrete S1CFB25 is greater than S1CC.

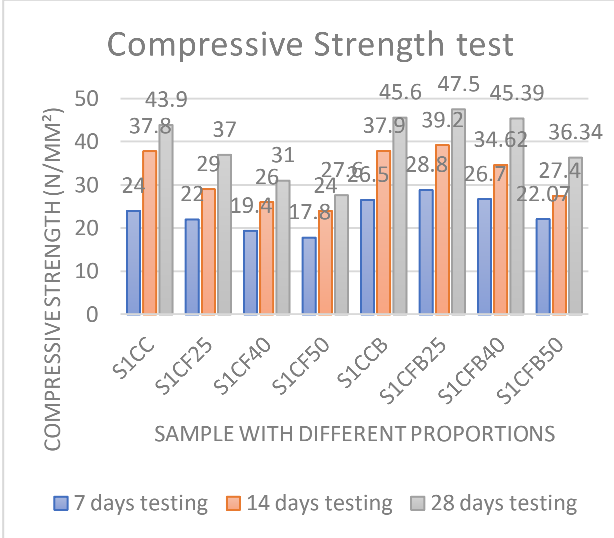

Fig 4 Compressive Strength Test

The compressive strength of S1CFB25 is 47.5 N/mm^2 and this is 8.2 % higher than S1CC. In direct compression by using fly enriched with bacteria cement can be replaced up to 40%.

L. *Flexural Test*

After 28 days the beams were taken for testing. Beams were placed in the loading frame as shown in Fig 5. The clear span is 1000 mm and load is applied at the middle of the beam which distributes equally at two points to the beam at 165 mm from centre of each side.

To measure the loads proving ring with dial gauge was kept and to note down the deflection dial gauges has been provided as shown in Fig 5.

Fig 5 RCC Flexural Beam Testing Arrangements

After 28 days curing beams were tested for flexure and ultimate loads are given in table 5.

Table 5 Flexure test results on RCC Beam

Mix Proportion	Ultimate Load (KN)	Mix Proportion	Ultimate Load (KN)
S1CC	152	S1CCB	164
S1CF25	148	S1CFB25	160
S1CF40	144	S1CFB40	148

S1CF50	136	S1CFB50	140
S1CF60	128	S1CFB60	132

The ultimate load for S1CC beam is 152 KN and ultimate load of fly ash beams is gradually decreasing as the percentage of replacement of cement increases and for S1CF60 the ultimate load is 128 KN. In bacterial concrete the highest ultimate load is 164 KN for the bacterial concrete S1CCB.

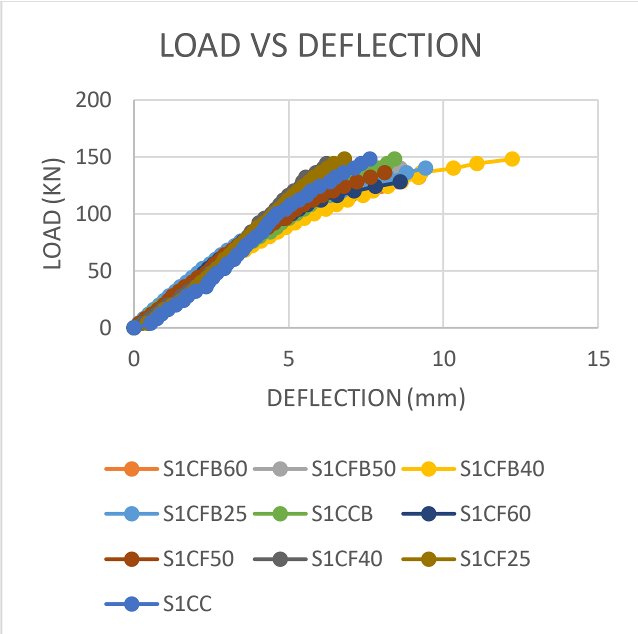

Fig 6 Load vs Deflection on Experimental results

Load vs deflection curve of RCC flexure beam are drawn in Fig 6. S1CCB is better option to S1CC to replace cement with enriched bacteria.

The ultimate load obtained from theoretical analysis and experimental results of beam made out with S1CC and S1CF25 and S1CFB25 are given in table 6.

Table 6 Theoretical Analysis of RCC Flexure Beam

Mix proportion	Theoretical Ultimate Load (kN)	Ultimate Load through experimental (kN)
S1CC	77.48	152
S1CF25	76.28	148
S1CFB25	78.98	160

The ultimate loads by experimental investigation is higher than the theoretical values in all three considered proportions. Experimental ultimate load of S1CC is 1.96 times of theoretical ultimate load, S1CF25 is 1.94 times and S1CFB25 is 2.05 times. This indicates that bacterial concrete gives higher strength than conventional concrete in flexural concrete.

M. Torsional Test

Torsional beam is a RCC beam of size 1200mm X 150mm X 200mm with projecting arms as seen in Fig 7, on both sides with the projection of same cross section to a length of 400mm. loading arrangement for torsional beams is shown in Fig 7.

Fig7 RCC Torsional Beam Testing Arrangements

After 28 days curing beams were tested for torsional and ultimate loads are given in table 7.

Table 7Torsional test results on RCC Beam

Mix Proportion	Ultimate Load (KN)
S1CC	76
S1CF25	64
S1CCB	88
S1CFB25	80

The ultimate load for S1CC beam is 76 KN and for S1CF25 the ultimate load is 64 KN. In bacterial concrete the highest ultimate load is 88 KN for S1CCB.

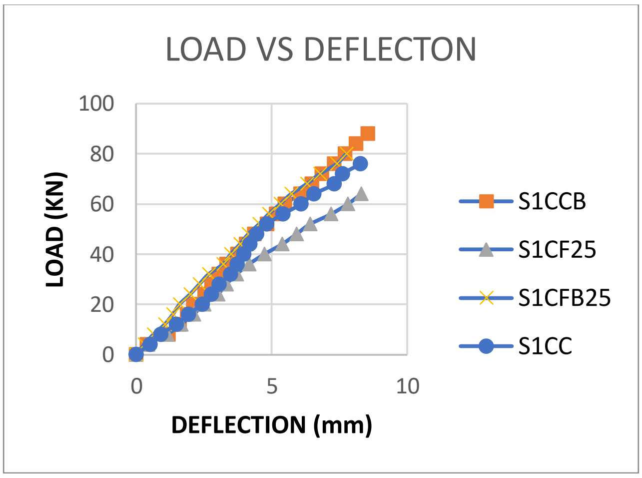

Fig 8 Load vs Deflection on Experimental results

Load vs deflection curve of RCC torsion beam are drawn in Fig 8. S1CCB is better option replace cement with enriched bacteria.

From above table and Fig we came to know that bacterial concrete S1CCB is showing better load carrying capacity.

IV. CONCLUSION

- The compressive strength of S1CFB25 is 8.2 % higher than S1CC.
- In direct compression by using fly enriched with bacteria cement can be replaced up to 40%.
- The bacterial concrete made with Bacillus subtilis has obtained higher strength than normal fly ash concrete of respective percentage of replacement.
- The structural members made with S1CFB25 performed better than other proportions in flexural and torsional beams.
- Hence based on strength, durability and performance as a structural element S1CFB25 is suitable concrete to replace control concrete.
- The ultimate loads by experimental investigation is higher than the theoretical values in all three considered proportions.
- Experimental ultimate load of S1CC is 1.96 times of theoretical ultimate load, S1CF25 is 1.94 times and S1CFB25 is 2.05 times.
- By using fly ash reduction in emission of green house gas to atmosphere can be achieved.
- By using bacterial concrete natural resources like water, lime stone, clay can be minimised in beneficial way.

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