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EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF FIBRE REINFORCED BACTERIAL CONCRETE

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ABSTRACT

Concrete is a common building material used in construction projects. It is common knowledge that one of concrete's flaws is its susceptibility to cracking. When concrete is in a flexible stage or after it has fully set, cracks may appear. By enabling corrosive substances to enter the concrete matrix, which causes steel to corrode and lose tensile strength, microcracks in concrete also reduce durability. Such an occurrence could result in more serious issues like spalling and possibly early structural failure. Concrete structure maintenance and repair require a lot of labour and money. Once the building is done, it is difficult to determine the extent of the damage. Self-healing could be the answer. There are numerous methods of self-healing, including such as Autogenous and Autonomous self-healing ability of concrete cracks. The objective of this paper was to report the effects of bacteria-based additives on the properties of concrete such as Flexural strength, Normal Stress ,Ultimate Stress Tangent modulus of concrete of conventional concrete and Bacterial concrete and also using Polypropylene Fibers o.5% and 1% specimens using bacteria

Key words: Bacterial Concrete, Polypropylene Fibers, repair, Self Healing

1. INTRODUCTION

The manufacturing of cement, a key component of concrete that is widely used in building, contributes significantly to both the depletion of natural resources and environmental damage. It is strong enough to withstand a compressive load, but it is vulnerable to breaking since its tension is weak, which eventually shortens the structure's lifespan. Therefore, any attempt to extend the life of a construction will tangentially increase environmental sustainability. Concrete cracks allow pollutants to enter the building, reducing its strength and durability. It is either necessary to patch the cracks, which is expensive, or add additional strength to make sure the crack width stays within a predetermined range.. Only for durability reason, this extra steel is not desirable. One way to increase the durability of structure and reduce such extra cost is to use self – healing concrete. Self – healing of concrete is any process by the material itself involving the recovery and hence improvement of performance of material

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1.1. LITERATURE REVIEW

1) Daisi L et. al, (2003) One such article outlines this same outcomes of either a novel method for bacteriologically exacerbate existing environmental cleanup of concrete cracks. Calcareous formation was induced using Bacterium utilising, a typical soil bacterial infection. The above user's fundamental tenets are it microorganisms cellulase approximate solution nitrates to generate produced carbon pollutants, while the hydrogen emitted into the environment rises pH as well as causes a concentration of irresolvable calcium carbonate. The microbes have been immobilised in polymeric polyethylene, gypsum, slag cement, as well as coal ash, after which decided to apply in cracked concrete rehabilitation to shield this same bacteria out from higher ph values.

Through contrasting the compression strength of both the parented concrete samples with that of the influence, bacteriologically improved fracture rehabilitation has been assessed. The active participation of microbes in the formation of calcium carbonate was demonstrated by electron microscopy (SEM) assessment, and indeed the proportion of caco3 inside the vicinity of the characterised crack formation was measured by X-ray diffractometer. Depending mostly on findings of this research, it really is indicated that MCR does have great potential for preserving systemic fractures in both concrete and a variety of these other materials.

2) Ramakrishnan. V et.al, (2002) He suggested a brand-new method for repairing concrete fissures and cracks by bacterially causing calcareous formatio. A method called as polymerization method mineral carbonation falls under a more general subfield of system knows as remineralization. A natural soil pathogen called Bacterium pasteuri has the ability to cause calcium carbonate to recrystallize. Calcite demonstrated its potential benefits like a microorganism’s sealer by combining aggregates and differentially integrating simulation model cracks and exterior fractures in igneous rocks. Since calcareous form ratio is caused by bacterial metabolism, MIC is an extremely coveted combustion reaction. This same method may be employed to increase the samples of ruptured concrete specimens rigidity and strength. He looked at the reliability of bacteria-treated beams that were also subjected to mildly acidic, sulphate, and cold surroundings. He further looked into how diverse microbial doses affected how long concrete would last. This was discovered that a few of the bacteria-filled concrete members outperformed the regulate elements (no bacteria). Even as number of microorganisms risen, so did the implementation state. Through the use of XRD and SEM tests, microorganism calcareous formation was measured. The existence of mineral carbonation from within crack formation, filament microbial perceptions, as well as a fresh overlay of crystals just on concrete surfaces were all confirmed either by SEM's distinctive image processing and microscopy functionality. This calcareous surface strengthens the specimen's barrier properties, boosting its defense against acid, sulphate, as well as dehydration attack.

3) AnnieaJ*et.al*,(2005) Structural concrete (RC) beam of dimensions 150 x 400x 3000 mm was casted, checked, as well as particularly in comparison for concrete members, including load conditions, brittle fracture, widths of crack formation, amount of crack formation, failure mechanism, overall load-carrying strength, moments-curve relationship, and translational stresses across both steel and concrete.

Up until the maximum demand level, the load vs displacement behaviour of self compacting concrete and conventional concrete beams was comparable. After hit peak stress, self compacting concrete beams demonstrated a reduction in load along increasing displacement, but CVC conventional concrete beams showed no such decrease. Whereas the maximum and breakdown forces for conventional concrete beams was approximately equal, the maximum and failing load for self compacting concrete beams were over 20% less, respectively.

Throughout all stress phases, fracture width stayed inside the bounds established by IS456-2000. All kinds of beam average crack width remained comparable. Conventional or self-compacting concrete crack spacing was nearly identical.

4)Ganesh .N*et. al*,(2007) The researchers took the time to investigate how steel fibres affected the flexure-sensitive durability &behaviour of fiber-reinforced self-compacting concrete structural parts. With this investigation, 20 beams was casted, from which 2 was basic self-compacting concrete beams with no fibres. Aspect ratio (15.15 and 30) with fibre content (0%, 0.25%, 0.5%, and 0.75%) as a fraction have been the report's parameters. Following the findings of an exploratory studies, it was determined also that fibres had enhanced both crack initiation loading and thus the post-cracking behaviour. The maximum stress showed a slight increase. The elasticity was greatly improved by the fibre additions. It became discovered that fibres made about 0.5percent of the mass.

5) Partheeban Pachaivannanet (2020) Presented the experimental study on the effect of steel fibers and polypropylene fibers on the mechanical properties of concrete, experimental program consisted of compressive strength test, split tensile strength test and flexural strength test on steel fiber reinforced concrete polypropylene fiber reinforced concrete three types of fibers used of length 30mm crimped steel fibers of length 25mm and endure 600 polypropylene of length 50mm with aspect ratio 50. The main aim of this experiment is to study the strength properties of steel fibers and polypropylene. Fibers reinforced concrete of M30 grade with 0%, 0.25%, 0.5% and 0.75% by volume of concrete.

6) Magudeaswaran Palanisamy (2017) the paper describes that due to its self healing abilities, eco-friendly nature, increase in durability etc, it is better than the conventional technology. It is very effective in increasing the strength and durability of concrete. It also shows better resistance to drying shrinkage, resistance to acid attack, better sulphate resistance. Bacterial concrete prepared with admixtures like silica fume, fly ash etc, also gives better strength and

durability. This paper improved our understanding on bacterial concrete. Due to the introduction of bacteria into concrete there has been increase in the compressive and flexural strength with decrease in permeability, water absorption and corrosion of reinforcement when compared to conventional concrete

2. MATERIALS USED

2.1 CEMENT & AGGREGATES

Used was ordinary Portland cement that complied with IS 12269. As the fine aggregate, clean, well-graded, naturally occurring river sand from the local area that complied with IS 383-1970 and had a fineness modulus of 3% was employed. To minimise other effects on the outcome, distilled water was utilised to mix the mortar.

Table 1 Ordinary Portland cement's physical characteristics

Sl. No.	Properties	Test Results	Requirements as perIS :12269-1987
1	consistency	32%	--
2	Specific gravity	3.15	--
3	Initial setting time	50 min.	Not less than 30 min.
	Final setting time	245 min.	Not more than 600 min.
4	Soundness by Le Chatelier	1.5 mm	Not more than 10 mm
5	Fineness of Cement	3%	Less than 10%

Table 2 Characteristics of both fine and large aggregate

Sl. No.	Property	Fine Aggregate	Coarse Aggregate
1	Specific gravity	2.65	2.70
2	Loose Density	1440 kg/m^3	1460 kg/m^3
3	Rodded Density	1630 kg/m^3	1620 kg/m^3

2.2 BACTERIA

One substance that has the potential to successfully fix concrete cracks is bacterial concrete. This technology is especially desired because the natural and pollution-free mineral precipitation produced by microbial activity.

Several bacterial concretes were suggested by researchers working with various microorganisms. The concrete contained Bacillus pasteurii, Bacillus sphaericus, E. coli, and other microorganisms. This study made use of the Bacillus subtilis strain JC3. Calcite can continuously precipitate, which is the main advantage of embedding bacteria in concrete. This phenomenon is known as microbiologically produced calcite precipitation (MICP). Because of the wide range of scientific and technological ramifications of calcium carbonate precipitation, a frequent bacterial occurrence, researchers have studied it.

Table 3 Biochemical characteristics of the pure culture Bacillus subtilis JC3

Characteristics	***Bacillussubtilis*JC3**
Shape,size,gramstain	Longrods,0.6-0.8μm in width and 2.0 to 3.0μm in length, grampositive
Colonymorphology (on nutrient agar plate)	Irregular,dry, white, opaque colonies
Fermentation:Lactose Dextrose Sucrose	No acid, no gas No acid, no gas Acid and gas
H2Sproduction	-
Nitratereduction	-
Indoleproduction	-
MethylRedtest	-
Vogesproskauer test	-
Citrateutilization	-
Catalaseactivity	+
Gelatinliquefaction	+
Starchhydrolysis	+
Lipidhydrolysis	+
Note:—+|:-Present —–—:-Absent	

2.3 POLYPROPYLENE FIBERS

Polypropylene fibres are important because of their superior alkaline resistance and affordable raw polymer material. They are made in two different forms—monofilament and fibrillated—by the continuous extrusion of a polypropylene homopolymer resin. Ground-supported slabs frequently use micro synthetic fibres made entirely of polypropylene to reduce plastic shrinkage cracking and plastic settlement cracking. These fibres typically have a diameter of 18m and a length of 12mm. The cohesiveness of the mixture, its resistance to freeze-thaw cycles, its resistance to explosive spalling in the event of a serious fire, and its resistance to plastic shrinkage during curing can all be improved by the addition of polypropylene fibres.

Fig 1. Polypropylene Fibers

Table1 . 4 The characteristics of polypropylene fibres

PARAMETER	SPECIFICATIONS
Cut length	6 mm or 12 mm
Tensile strength	4000 to 6000 kg/m3
Density	0.91 g/cm3
Colour	colourless

The highest amount of fibre is produced by polypropylene for a given weight due to its low specific gravity. Because of its high yield, polypropylene fibre is lightweight and offers outstanding bulk and cover. The lightest fibre, polypropylene is even lightweight than water. It is 20% and 34% lighter than nylon and polyester, respectively. For less weight, it offers more warmth and mass.

2.4. MECHANISM OF BACTERIAL CONCRETE

Self-Healing concrete is produced by a biological reaction between non-reacted limestone and a calcium-based nutrient, which involves the use of bacteria to repair building cracks. Bacillus bacteria of a particular type and calcium lactate, a nutrient, are both used. When mixing is complete during the preparation of concrete, these products are added to the wet concrete. These bacteria are capable of going dormant for up to 200 years. Water seeps into the cracks as they form in the concrete. The bacteria's spore starts to grow and begins to feed on the calcium lactate that is consuming oxygen. lime stone that dissolves. The insoluble limestone starts to become more solid. Consequently, the crack is automatically filled without outside assistance. The other benefit of this process is, as the oxygen is consumed by the bacteria to convert calcium into limestone, it helps in the prevention of corrosion of steel due to cracks. This improves the durability of steel reinforced concrete construction.

2.5. CHEMICAL PROCESS OF SELF-HEALING OR BACTERIAL CONCRETE

Calcium hydroxide is produced when water interacts with the unhydrated calcium in concrete with the aid of bacteria, which serves as a catalyst. Limestone and water are created when this calcium hydroxide reacts with the carbon dioxide in the air. The reaction continues as a result of the extra water molecule. The lime stone self-hardens and fills in the concrete cracks.

2.6. ADVANTAGES AND DISADVANTAGES OF BACTERIAL CONCRETE

Advantages of Bacterial Concrete:

- Self-repairing of cracks without any external aide.
- Significant increase in compressive strength and flexural strength when compared to normal concrete.
- Resistance towards freeze-thaw attacks.
- Reduction in permeability of concrete.

- Reduces the corrosion of steel due to the cracks formation and improves the durability of steel reinforced concrete.
- Bacillius bacteria are harmless to human life and hence it can be used effectively.

3. EXPERIMENTAL PROGRAM

3.1 FLEXURAL BEHAVIOUR OF CONCRETE

The investigation is being carried out to find out more about the flexural behaviour of concrete. There are 12 evenly balanced, simply supported beams that have been cast and tested. The cross section of the beam sample is 200 mm by 250 mm by 3000 mm. Concrete of the ordinary and standard grades, both of which contain bacteria, is used to cast the beams.

3.2 PREPARATION OF SPECIMEN MOULDS

Two wooden planks are stacked on top of one another to create the moulds, with the space between them being the same width as the beam that will be cast. Wooden pieces of the right width are kept between the boards to maintain spacing. On a flat platform, the entire casting process takes place. A base plate is not included with the moulds. At the ends of the moulds, bolts and nuts are provided to secure the frame.

3.3 FABRICATION PROCESS

The limit state approach is used to build the beams. Steel is ready and available for the balanced portion, which has been determined. Stirrup bars are cut and bent in position and spaced according to the design, while longitudinal steel bars are cut and straightened to the desired length.

3.4 CASTING AND CURING

On a level concrete surface, the beam moulds are assembled with a piece of paper positioned between the mould and the ground. The interior of the mould has been properly greased. In order to maintain the required effective depth, cover blocks of sufficient thickness are placed beneath the case's bottom. The ingredients are thoroughly mixed in an electrically powered mixer to achieve homogeneity. A 25mm needle vibrator is used to compress the two layers of concrete after they have been poured into the moulds. The moulds are destroyed 24 hours after casting. When the required amount of curing time has passed, the specimens are taken out of the curing tank, the moisture is removed, and the surface is dried.

4. METHODOLOGY

4.1 PREPARATION OF BEAM MODEL

The beams are 200 mm wide, 250 mm deep, and 3000 mm long. They have two 12 mm diameter bars for tensile reinforcement, two 10 mm diameter bars for compression steel, and a 20 Mpa compressive strength for concrete. At either third end of the beams, at a distance of 125 mm, there are stirrups made of bars with an 8 mm diameter. The Beam is made up of sections that have been double- and over-reinforced. Fig. 3.8 provides the beam's cross-section. Conventional and JC3 bacteria 105 cfu with 0.5%PPF (M20) beam have maximum moments of resistance that are, respectively, 34.6 KN-m and 36.20 KN-m.

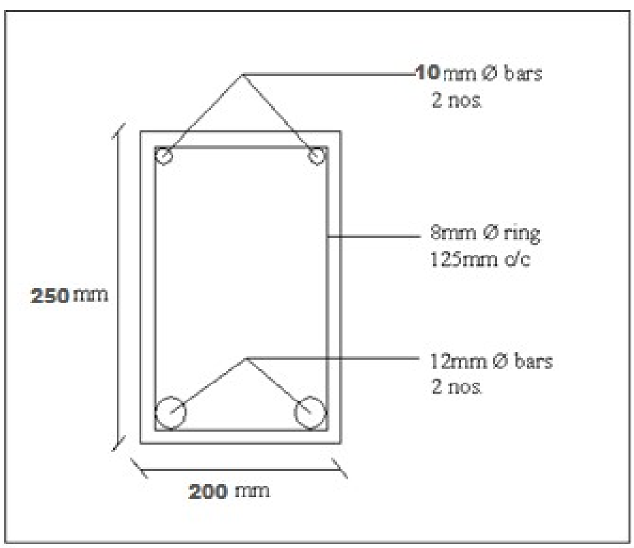

Figure: 2 Cross-section of beam

4.2 ARRANGE MENT OF EAM BYTWO POINT LOADING

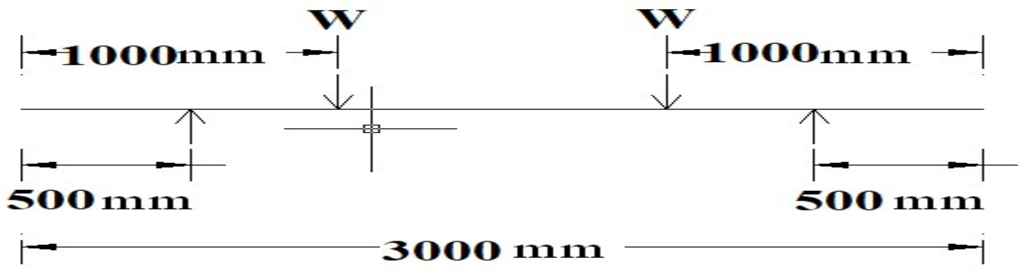

Figure:3 Experimental setup of Two point load system beam

4.3 TESTING PROCEDURE FOR FLEXURAL BEAM

The beams are assessed under symmetrical two point loads on a 3000 mm simply supported span. Two roller supports that rest on cast iron blocks on the wing table of the Universal testing machine hold up the beam. Two point loading is used to apply the load to the two rollers, which are spaced 1 m apart, using a loading beam of sufficient rigidity from the machine's fixed cross head. A third point load and controlled deflection are used during testing. The crack growth is precisely indicated with a pencil. Until the load reaches 0.85 times the maximum load recorded, the test is repeated. The testing is now stopped by gradually opening the outlet valve. According to IS: 516-1999, the test is conducted.

Figure 4: Experimental Setup for the Flexure Beam

Figure 5: Experimental Setup for the Flexure Beam

5. EXPERIMENTAL INVESTIGATIONS' RESULTS

Table.5 Test results of Conventional and JC3 bacteria 10^5 cfu with 0.5%PPFM20grade concrete beams

Beam Label	Max.Load,KN	Central Deflection at Max Load (mm)	Max.Moment (kN-m)	Strain in concrete	Strain in steel	Load at first crack(kN)	Deflection at service Loads(mm)
Conventional concrete (M20)							
CB1	32.1	43.6	5.0	0.002	0.003	21.96	4.6
CB2	34.6	43.2	5.3	0.00216	0.002	23.21	4.6
CB3	33.6	43.5	5.4	0.00218	0.002	23.33	4.7
Fiber reinforced Bacterial concrete (JC3 bacteria 10^5 cfu with 0.5%PPF (M20)							
PFBB1	34.8	41.8	5.7	0.0021	0.002	25.69	4.2
PFBB2	36.2	40.3	6.0	0.00214	0.003	28.44	4.1
PFBB3	35.2	41.6	5.6	0.00205	0.002	25.49	4.2
Fiber reinforced Bacterial concrete (JC3 bacteria 10^5 cfu with 1%PPF (M20)							
PFBB1	34.8	40.6	4.9	0.002	0.001	24.86	3.9
PFBB2	35.1	39.1	5.6	0.00211	0.002	26.34	3.9
PFBB3	34.4	40.4	5.1	0.00202	0.001	24.21	3.6

The investigation is carried out to study the maximum load , central deflection at maximum load ,maximum moment, strain first crack and deflection For observation of the above Test results of Conventional concrete , JC3 bacteria 10^5 cfu, 0.5%PPFM20grade concrete and JC3 bacteria 10^5 cfu with 1%PPF (M20) concrete beams results was observed in that results JC3 bacteria 10^5 cfu, 0.5%PPFM20grade concrete Will give more strength.

Table.6 Ultimate Stress and Strain of bacterial and conventional concrete at 28 days at ultimate stress values:

	Ultimate Stress (N/mm^2)	**Strain at Ultimate Stress**
Ordinary Grade Concrete		
Conventional Concrete	24.35	0.002
JC3 bacteria 10^5 cru with 0.5%PPF		
Bacterial Concrete	**32.58**	**0.0021**
JC3 bacteria 10^5 cfu with 1%PPF		
Bacterial Concrete	31.48	0.002

The investigation is carried out to study the Ultimate Stress and Strain of bacterial and conventional concrete at 28 days, For observation of the above Test results of Conventional concrete , JC3 bacteria 10^5 cfu, 0.5%PPFM20grade concrete and JC3 bacteria 10^5 cfu with 1%PPF (M20) concrete results was observed in that results JC3 bacteria 10^5 cfu, 0.5%PPFM20grade concrete Will give Ultimate Stress of 32.58(N/mm^2) and Strain at Ultimate Stress 0.0021 (N/mm^2) for better results

Table.7 Values of the Tangent modulus of elasticity for conventional and bacterial concrete

Age(No.ofdays)	**InitialTangent Modulus(N/mm^2)x10^5**
Ordinary Grade Conventional Concrete	
7	0.18
14	0.17
28	0.19
JC3 bacteria 10^5 cfu with 0.5%PPF	

7	0.26
14	0.26
28	0.37
JC3 bacteria 10^5 cfu with 1%PPF	
7	0.44
14	0.47
28	0.56

The investigation is carried out to study the Values of the Tangent modulus of elasticity for conventional and bacterial concrete For Observation of the above Values of the Tangent modulus of elasticity for Ordinary Grade Conventional Concrete, JC3 bacteria 10^5 cfu with 0.5%PPF and JC3 bacteria 10^5 cfu with 1%PPF was observed in 7 days, 14 days and 28 days in that results bacterial concrete JC3 bacteria 10^5 cfu with 0.5%PPF will give increase of Initial Tangent Modulus at 7 days, 14 days and 28 days

6. CONCLUSION

- While observing the results between conventional concrete and Bacterial concrete is as follows
- From the results it can be concluded that easily cultured Bacillus Subtilis can be safely used in improving the performance and characteristics of concrete.
- When bacteria concrete added Polypropylene Fibers 0.5% and 1% its performance is increased in bacteria concrete with added 0.5% Polypropylene fibers.
- From the results it can be concluded that easily cultured Bacillus Subtilis can be safely used and decreasing the performance and characteristics of concrete from bacteria concrete added with 1% Polypropylene Fibers.
- As the compressive strength of cement mortar is maximum with the addition of *Bacillus subtilis* JC3 bacteria for a cell concentration of 105 cells per ml of mixing water.
- The Bacterial concrete with JC3 bacteria 10^5 cfu with 0.5%PPF mixes have shown improved stress values for the same strain levels compared to that of Conventional concrete mixes. .

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