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Dressing of Structural Cracks Using Bio Concrete

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Abstract: Microbiology induced cracks remediation technique is a methods that has been proved beyond doubt of its efficiency. The review of literature carried out in this area indicates that the work related to quantification of repair technique in comparison with conversional methods of repair is scarce. The investigation includes two different types of specimens namely cubes and damaged RC beams subjected to high temperature, that are already available. For the cube specimens two different water cement ratios (0.56) with normal, porous (no compaction) and cracked cubes are included. The cracking of cues is done in a pre determined way by inserting a 0.5mm thick aluminum plate to a depth of 75mm top on a 100mm size of concrete cube of m20 grade mix B.sphaericus is used for investigations. The investigation of damaged beams includes three different digress of damages namely, low medium, and high, determined by rebound hammer and Ultrasonic pulse velocity test. The comparison of results of cubes and rehabilitated beams lead to the conclusion, that the bio concrete application is the most effective one the cement mortar is the least effective method.

I. INTRODUCTION

A. General

Natural processes, such as weathering faults, land subsidence, earthquakes and human activities create fractures and fissures in concrete structures and historical stone monuments. These fractures and fissures are detrimental since they can reduce the service life of the structure. In the case of monuments and buildings of historical importance, these cracks tend to disfigure and destroy the structure. Therefore it is necessary to remove the cracks of the buildings. Normally artificial materials are used to plug the cracks. Therefore a novel technique for remodelling damaged structural formations has been developed by employing a selective microbial plugging process, in which microbial metabolic activities promote calcium carbonate precipitation.

B. Bacterial Concrete

Bacterial concrete refers to a new generation of concrete in which selective cementation by microbiologically-induced $CaCo_3$ precipitation has been introduced for remediation of micro-cracks. Considerable research on carbonate precipitation is done by selecting ureolytic bacteria but very limited work has been reported on the application part of it. Bacterial urease enzymes degrade urea into ammonia and carbon dioxide, which lead to increase in pH of the media and carbonate precipitation. Various researchers have confirmed the presence of organic $CaCo_3$, precipitate in the environment for an extended period of time using *Bacillus pasteurri.*

Considerable research on carbonate precipitation by bacteria has been performed using ureolytic bacteria. These bacteria are able to influence the precipitation of calcium carbonate by the production of a Urease enzyme. This enzyme catalyzes the hydrolysis of Urea to CO_2 and ammonia, resulting in an increase of the pH and carbonate concentration in the bacterial environment. Once super saturation is achieved precipitation of calcium carbonate crystals occurs by heterogeneous nucleation on bacterial cell walls. Research has indicated that a concrete which is low in permeation properties lasts longer without exhibiting signs of distress and deterioration. *Bacillus sphaericus* yet other ureolytic bacteria which showed strong potential in precipitating the insoluble calcium carbonate were selected as a test organism

C. Bio-Cement

Bio-cement is the carbonate precipitate obtained from ureolytic bacteria such as *Bacillus pasteurii* and *Bacillus sphaericus.* Ureolytic bacteria along with carbon-di-oxide and calcium chloride to form calcium carbonate.

II. EXPERIMENTAL INVESTIGATIONS

A. Production of concrete samples

Following are the details of the used for producing concrete used throughout the investigations

Volume 4 Issue XII, December 2016
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Cement*:* (as per IS 12269-1987)
TYPE : ORDINARY PORTLAND CEMENT
(53 GRADE)
SPECIFIC GRAVITY : 3.1
FINENESS : 10%

FINE AGGREGATE : (IS 383-1970)
SPECIFIC GRAVITY : 2.6
FINENESS MODULUS : 2.5
ZONE : III
COARSE AGGREGATE: SIZE USED : 10mm
SPECIFIC GRAVITY : 2.6
FINENESS MODULUS : 7.2

Water: Clean water as available in AMACE campus, which is free from all impurities is used for the entire work of concrete preparation and curing.

Mix design has been carried out as per IS 102621982 for M20 grade of concrete. The final results are:

Quantity of materials per m^3 of concrete
Cement : 486.91 kg
Sand : 565.84 kg
Coarse aggregate : 1028.68 kg
Water : 214.24 kg/m^3

The trial mix has been cast and tested for arriving at 28 days strengths. The average compressive strength on 28 days of the standard 100mm side cube is 31.25 N/mm^2 as against the target mean strength of 27.59 N/mm^2. This mix is used for casting the specimens. From the initial test on this permeability of concrete using cubes of 100mm side, it is felt that there can be more porosity introduced in the mix. This is achieved by keeping the water cement ratio to 0.56.

B. Nano-Carbon Fibres

Nano-carbon fibres are very thin long filaments comprising of sheets of carbon atom arranged in hexagonal pattern aligned along the axis of the filament length. Due to its high strength and light weight they are used in aircraft engineering and in this case they are used along with Bio-cement in the repair and rehabilitation of concrete.

Carbon nanotubes (CNTs) and graphene are the strongest materials yet discovered, with tensile strengths up to about 15.5 million psi, or about 150 times high-strength steel. It has been known since the mid-1950's that molecular level strength can be very large compared with macro material strength. Macro-materials are comparatively weak because of molecular defects, weak intermolecular bonds, or voids or foreign matter in the material matrix. The challenge is to design and synthesize macro materials that preserve a greater portion of the desired molecular properties (Engineer Research and development Centre, US).

C. Scope of the Project

To use concrete with water-cement ratio of 0.56 and include specimens with 100mm side cubes to compare strengths of uncracked cubes, cracked cubes, cracked cubes with bio-cement and cracked cubes with Bio-cement and Nano-carbon fibres. The crack is made using aluminium plate. The thickness and depth of the crack is 0.9mm and 75mm respectively. The same rehabilitation method adopted in cracked beam.

III. RESULTS AND DISCUSSION

A. Preparation And Testing Of Concrete Cubes With Addition Of Nano-Carbon Fibre

Concrete cubes were cast as per the above mix, along with which various fixed quantities of Nano-carbon fibres were added (0g, 2g, 4g and 8g).These cubes were tested after 14 days curing and a comparative study was done with the obtained results based on the compressive strength of these cubes. Fig 1.Curing of concrete cubes given below.

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Figure. 1 Curing of Concrete Cubes (Mix+Nano-carbon Fibre)

The obtained results have been tabulated in table 1 given below

Table 1. Test Results of Concrete with Nano-carbon Fibre

S. No	Quantity of Nano-Carbon added in the concrete mix (in grams)	Compressive Strength (N/mm^2)	Percentage increase in strength (%)
1	0	13.96	0
2	2	14.76	5.73
3	4	15.85	13.53
4	8	16.12	15.47

1) The effect of the presence of the 0.9mm width slit for a depth of 75 mm in a 100 mm side concrete cube is to reduce its compressive strength by 21.05% after 28 days.
2) The cement mortar paste treatment of this intentional crack has increased to about 13.33% of strength compared to the cracked cubes.
3) The bacterial (B.pasteurii)* treatment of this intentional crack has increased to about 6.66% of strength compared to the cracked cubes.
4) The bacterial (B.pasteurii)* +5% nano-carbon fibre treatment of this intentional crack has increased to about 10% of strength compared to the cracked cubes.
5) The bacterial (B.pasteurii)* +10% nano-cabon fibre treatment of this intentional crack has increased to about 13.33% of strength compared to the cracked cubes.
6) The bacterial (B.pasteurii)* +15% nano-carbon fibre treatment of this intentional crack has increased to about 33.33% of strength compared to the cracked cubes.
7) The bacterial (B.pasteurii)* +20% nano-carbon fibre treatment of this intentional crack has increased to about 46.66% of strength compared to the cracked cubes.
8) The bacterial (B.pasteurii)** treatment of this intentional crack has increased to about 60% of strength compared to the cracked cubes.
9) The bacterial (B.pasteurii)** +5% treatment of this intentional crack has increased to about 50% of strength compared to the cracked cubes.
10) The bacterial (B.pasteurii)** +10% treatment of this intentional crack has increased to about 40% of strength compared to the cracked cubes.
11) The bacterial (B.pasteurii)** +15% treatment of this intentional crack has increased to about 46.66% of strength compared to the cracked cubes.
12) The bacterial (B.pasteurii)** +20% treatment of this intentional crack has increased to about 43.33% of strength compared to the cracked cubes.
13) The cement mortar +20% nano-carbon fibre paste treatment of this intentional crack has increased to about 30% of strength

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

compared to the cracked cubes

14) The epoxy resin treatment of this intentional crack has increased to about 53.55%.

15) *B.pastuerii Cultured in nutrient media

16) **B.pastuerii cultured in brain-heart infusion

IV. CONCLUSION

The testing of materials for ordinary portaland cement and BIO CONCRETE has been conducted and results are tabulated. The comparison of results of cubes and rehabilitated beams lead to the conclusion, that the bio concrete application is the most effective one the cement mortar is the least effective method.

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