An Innovative Analysis of Regain strength of self healing concrete

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Abstract

Concrete is most used material in construction, and cracks are formed in concrete structures due to uneven settlements and climatic conditions of atmosphere due to variation of co-efficient of linear expansion valve of concrete. Hear has introduced in the bacteria in concrete itself healing and reduce the cracks in structures and improve the strength and durability for long time using the *Bacillus Flexus* in concrete to heal the cracks. The healing of concrete is process with in duration after that Analyse the regain strength for motor cubes, cubes and cylinder after 28 days, 45 days and 60 days of cracking of concrete specimens. Behaviour of concrete analysis done and ultrasonic pulse velocity test are carried.SEM Analysis is to find the calcite crystals formation in the concrete. It shows that above 80 percent strength gained from initial valve was observed. The first intensive report and novel methodology of crack healing ability of native isolate of *Bacillus flexus* and compressive strength is 10^5cells/ml.

Key Words: bacilli flexus, bacterial concrete, regain compressive strength, regain split tensile strength, Self healing concrete, SEM analysis, Ultrasonic pulse velocity.

I. INTRODUCTION

Concrete is the foremost building material broadly used in building construction, but cracks in concrete are inevitable and are one of the inherent weakness of concrete. The major downside of concrete is its low tensile strength due to which micro crack occurs when the load applied is more than its limit and this paves way for the seepage of water and other salts. This initiates corrosion and makes the whole structure vulnerable and leads to the failure of structure. To remediate this type of failure due to cracks and fissures, an approach of using bio mineralisation in concrete has evolved in recent years. In this method, of enhancing the performance of concrete, the calcite precipitating spore forming bacteria is introduced into concrete. When water enters through the cracks, it reacts with bacteria and forms precipitates of calcium carbonate, as a byproduct, which fills the cracks and makes crack free concrete. This type of concrete prepared with bacteria is called as bacterial concrete [1].

The objective of the experimental work is to know the efficiency of native alkalifilic bacteria *Bacillus flexus* and its use in concrete to improve its strength. Considerable research was done on different *Bacillus spices*. But limited intensive study has not been done on healing ability of native isolate *Bacillus flexus.*

II. EXPERIMENTAL PROCEDURE

2.1 Generation and incubation condition of cracks

According to the slight modification of after curing of the concrete specimens for the specified duration each, the specimens have undergone for compressive strength and tensile strength analysis. The cubes of dimensions 70.7mm × 70.7mm × 70.7mm were taken out of the curing tank after 3 days and left dried for an hour before its test. Gradual increase of the load was applied to the cube by compression strength machine until a realistic crack was visible. The maximum strength obtained at the moment of crack formation was observed and load is released. Similar tests were performed on mortar cubes and cylinders also. The crack formation was carried out for the cubes, mortar cubes and cylinders after curing for 7 days and 28 days following the similar procedure.

2.2 Evaluation of crack self healing and regain strength

The healing of cracked specimens was observed after a couple of days. These specimens were again tested for the regain of strength after curing 28 days, 45days and 60days in water.

2.3 Analysis of strength parameters

The following tests were conducted on certain specimens:

- Compressive strength test
- Split tensile test

2.4 Ultrasonic pulse velocity test

The specimens were subjected to Ultrasonic Pulse Velocity test to assess the quality as per IS: 13311 (part 1) – 1992. It is to measure the time of travel of ultrasonic pulse passing through the specimen under test. The instrument zero was set by reference bar provided. Small amount of grease was applied to the transducer faces before placing on the opposite ends of the bar.

After determining the suitable test points, the transducers held onto the surface of the material until a consistent reading was appeared on the display. This experiment was done for the specimens before and after the formation of the crack.

2.5 SEM analysis

The morphology of the calcium carbonate precipitation by *Bacillus flexus* was studied in a FEI QUANTA 200F SEM. Sample were completly dried in the oven at 50°C for 48 hours and were gold coated by a Baltec SCD30 sputter coater before examination.

III. RESULTS AND DISCUSSIONS:

Crack formation and healing

Cracks were formed in the specimens during the compressive strength test and split tensile strength in the specimens as shown in Fig.1 (a) To (f). Fig. From (g) to (l) shows that the cracks are healed for different levels of concentration. The healing of cracks was observed after curing the specimens 60days.

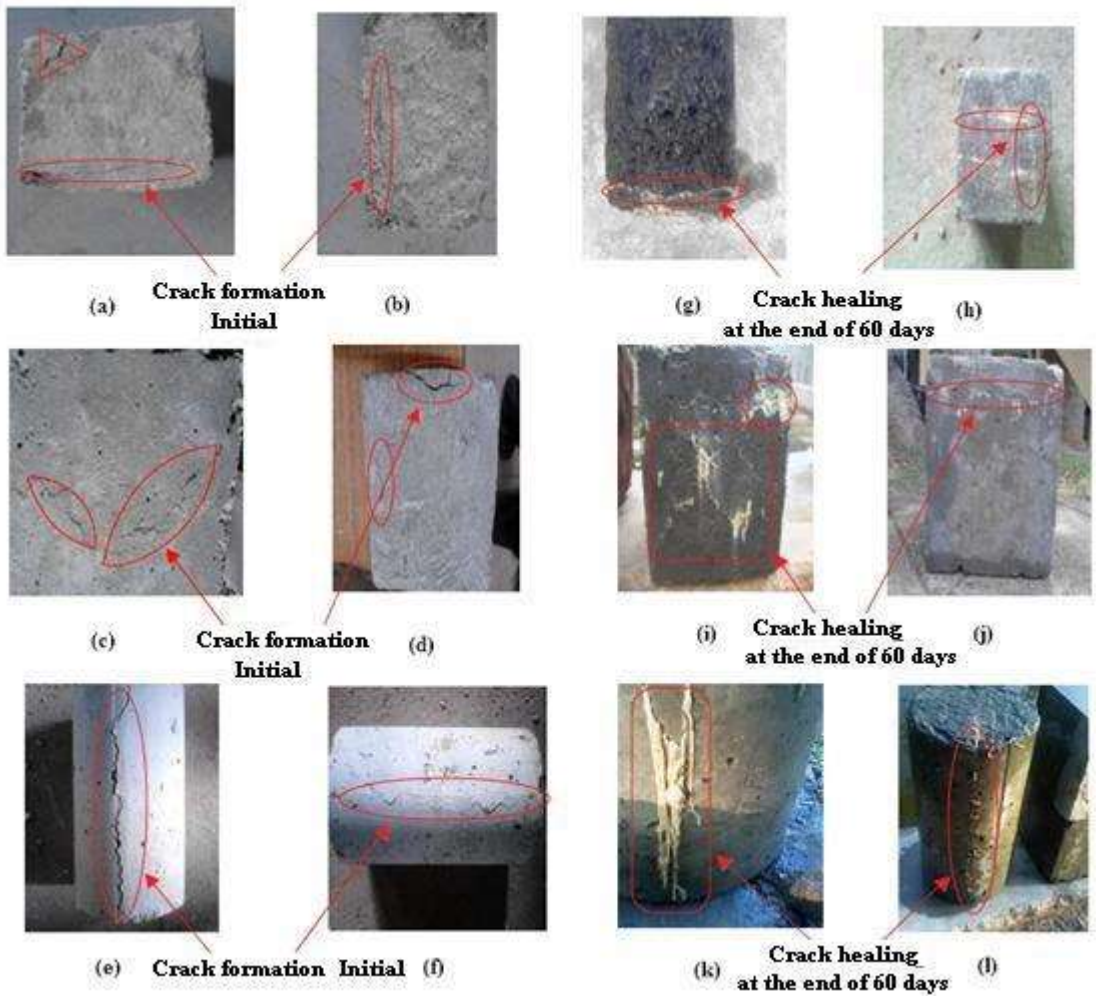


Fig.1 crack formation specimens (a) to (f) and crack healing of samples (g) to (l)

Strength regains

The regain strength of the specimens (Cube, mortar cube, cylinders) was noted by testing specimens using UTM after the healing of cracks for 28, 45 and 60 days curing and the results were observed as shown in the figs. 2, 3&4 for different levels of concentration of bacterial cells along with the control specimens and where 0 is equal to control system.

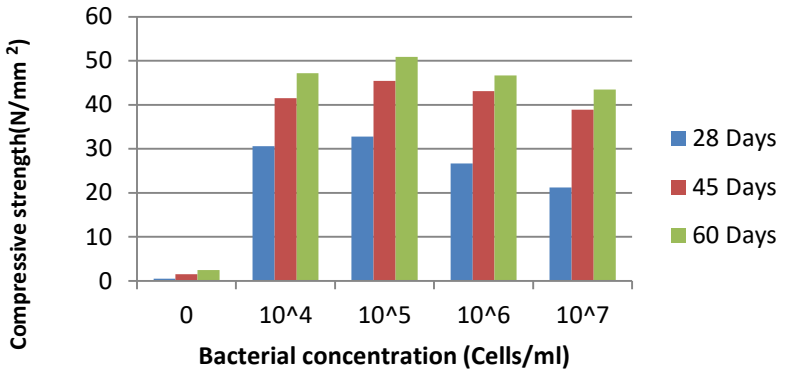


Fig.2 Mortar cube regains strength

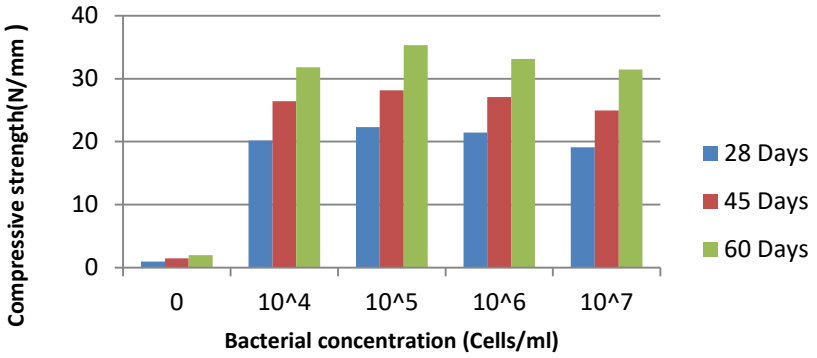


Fig.3 Cube regains strength

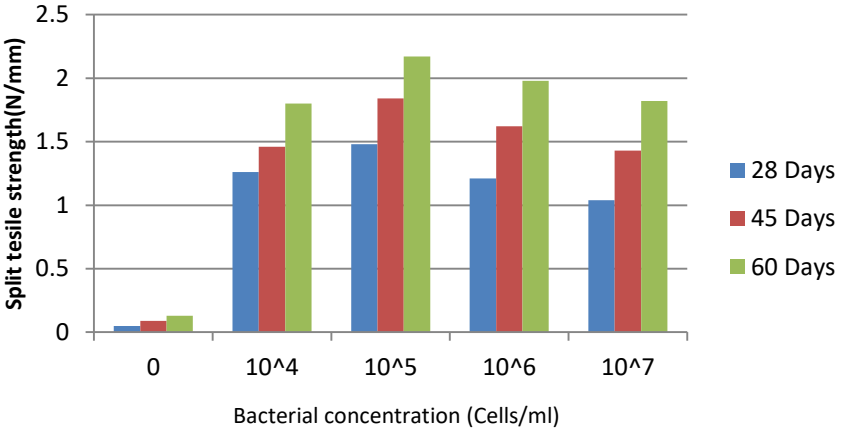
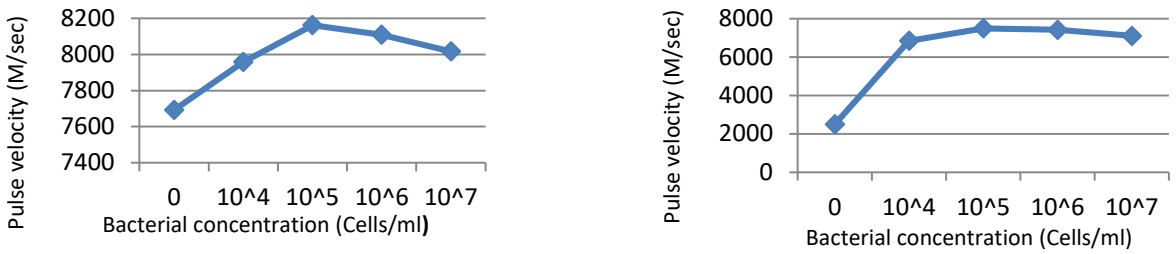


Fig.4 Split tensile regains strength

Ultrasonic Pulse Velocity test

Ultrasonic plus velocity test for each sample of specimen was conducted before and after formation of cracks. From the comparisons of each specimen under test as shown fig. 5 (a), (b), 6 (a), (b) & 7 (a), (b). It can be clearly observed that the pulse velocities reduced considerably after crack filling due to bacterial concentration.

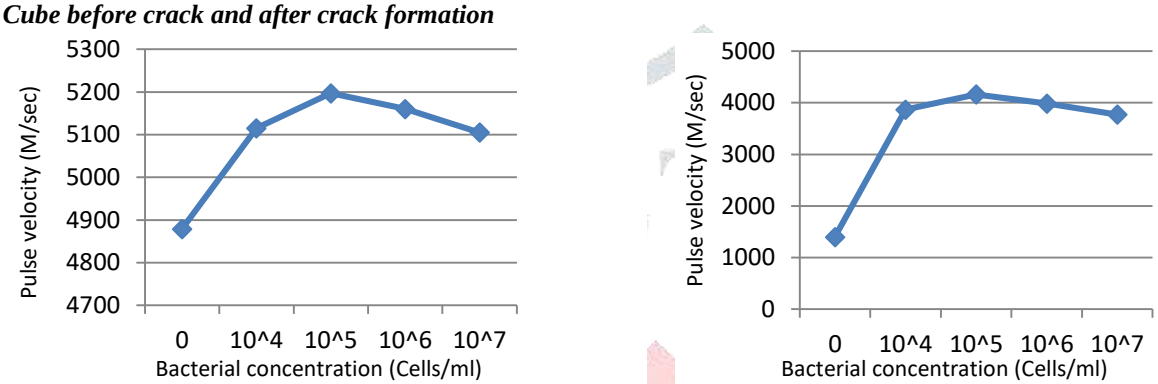
Mortar cube before crack and after crack formation



(a) (b)

Fig. 5 (a) Mortar cube 28 days before the crack (b) Mortar cube after crack filling 90 days

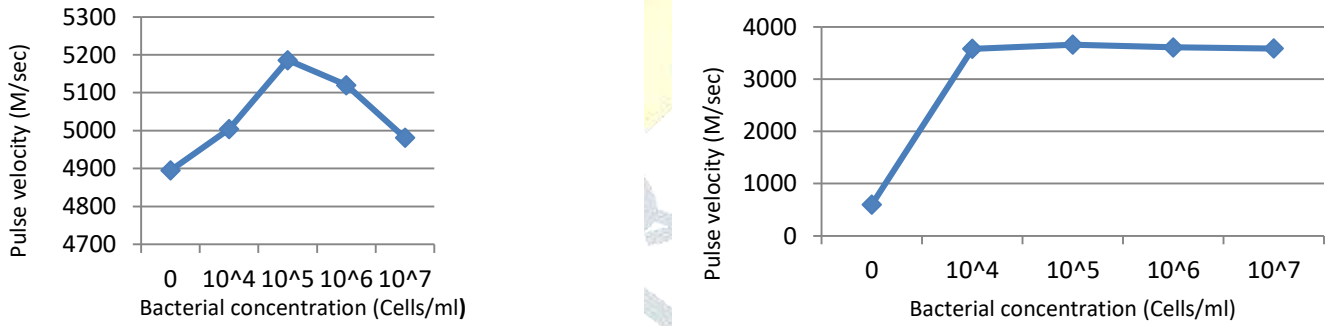
Cube before crack and after crack formation



(a) (b)

Fig.6 (a) pulse velocity of Cube 28 days before crack (b) pulse velocity of *Cube After crack filling 90 days*

Cylinder before crack and after crack formation



(a) (b)

Fig. 7 (a) pulse velocity of Cylinder at 28 days before crack (b) pulse velocity of Cylinder After crack filling 90 days

SCANNING ELECTRON MICROSCOPIC ANALYSIS

(m) *(n)* *(0)*

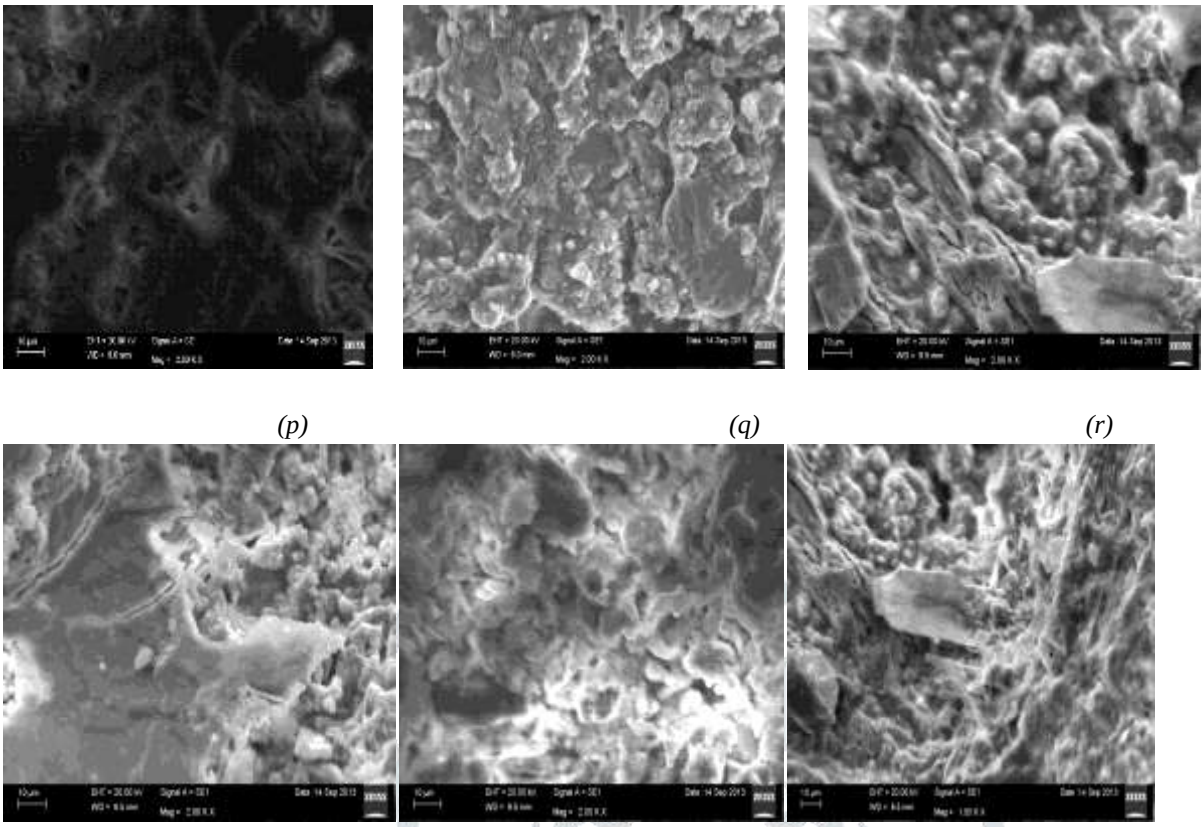


Fig.8 Scanning Electron Microscopic for different cells of bacterial concentration (m) control specimen, (n) 10^4 cells/ml, 200x (o) 10^5 cells/ml 200x, (p) 10^6cells/ml, 200x, (q) 10^7 cells/ml, 200x, (r) 10^5 cells/ml at 150x,

The significant improvement in compressive strength of bacterial concrete is the formation of calcite by *B. flexus* within the pores of cement and matrix, which fill the pores the similar results also represented by other *Bacills species*.

The average compressive strength of three specimens as shown in the fig.1 to fig.3 from the results observed that the compressive strength a of specimen with bacterial concrete was increased.

In the formulation of the concrete Cao is a major component. From the earlier discussion it is evident that calcite is formed by the bacteria when hydrolysis is performed. Moreover, Calcium lactate which was added to the nutrient to feed the bacteria helps in developing $CaCO_3$ So, the increased amount of Calcium adds strength to the concrete after adding the bacteria without affecting any other properties. A maximum utility proportion was observed for the given calcium lactate for the 10^5 no. of cells of bacteria. The healing of the cracks represented from the Fig.7 (g) to (l) after the formation of cracks.

An SEM micro graph for the control specimen without having any bacteria is shown in Fig.8. (m) in which no crystals are observed from which it can be understood that no precipitation is formed. It is the reason for the low compressive strengths of the specimens. Fig.8. (n) To (r) show the SEM micrographs for the specimens after crack healing. Crystals were noticed in the pictures which are formed due to the calcite formation by the bacteria during healing.

IV. CONCLUSION

The crack was more and more difficult to repair with increase of average crack width and repair ability of *Bacillus flexus* was limited for specimen with crack width up to 0.50 mm, after 90 days of curing above 80 percent strength regain was observed. Ultrasonic puls velocity test proved that the increase of pulse velocity in the specimen for concentration of bacteria at 10^5cells/ml indicates good healing activity. However our continuing researches focus on obtaining a sustainable bacterial based concrete. In feature more influence factor and molecular mechanism of concrete crack self-healing under laboratory, construction site condition need to be researched for better practical applications can be consider. Real-time situation parameters, extra supplementary techniques could be applied such as surface coverage by moisture relating material to prolong the wet storage should be studied. Self-healing in concrete will result in high strength, crack free and durable concrete structures in features.

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