

Bacteria Based Self-Healing of Concrete Using Curd & Chicken Manure

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ABSTRACT: Concrete is the most critical element applied in infrastructure/building. In recent researches it is found that some special types of bacteria can be used as a tool for repair of cracks in already existing concrete structure. This new concrete is essential to repair its crack itself. It reduces the cost of maintenance. It is one such approach on which studies were carried out to investigate crack healing mechanism in enhancing strength and durability of concrete. Microbial activities of bacteria seal the cracks in concrete structure and have excellent resistance to corrosion.

KEYWORDS: Self-Healing Concrete, Bacterial Concrete, Bacillus Subtilis, Calcium Carbonate, Calcium Phosphate, Lactic Acid.

I. INTRODUCTION

The word concrete is derived from a Latin word "Concretus" which means condensed and hardened. Concrete is used as building material. It is a homogeneous mixture of cement, sand, aggregate, water, air, admixtures etc.

Modern concrete has a shorter life span. Formation of cracks shortens the longevity of particular construction. Many researches had been attempted to improve concrete in order to get a better longevity among many other things. That's how the concept of self-healing finds its way to concrete.

The purpose of this research is to investigate the nature of microorganism Bacillus Subtilis for enhancement of self-healing property and strength in concrete. Cracks in concrete are integral and are one of the implicit weaknesses of concrete. Water and other salts percolate through these cracks, corrosion introduce, and thus reduces the life of concrete. So there was a need to develop an inherent self-healing material which can remediate the cracks and fissures in concrete. The concrete structures have various durability issues due to the different conditions and it results to irretrievable damage to the structure and eventually reduction in the strength of concrete structure. Therefore, for enhance the mechanical properties of concrete structures cement is replaced by Bacillus Subtilis. For this purpose Bacillus Subtilis is replaced by 0% (Normal), 0.5%, 1% & 1.5% by the weight of cement.

II. DEFINITION OF SELF-HEALING

Self healing means which repair itself. When the concrete cracks, and water enters the gap, it comes into contact with the bacteria and the food source, setting the healing process off. The bacteria then feed on calcium lactate, joining the calcium with carbonate to form limestone, fixing the crack.

III. CRACKS IN CONCRETE

Crack means to break or to make something break so that a line appears on the surface, but without breaking into pieces.

A . Types of Cracks

1. Sulphate attack cracks.
2. Loading cracks.
3. Plastic shrinkage cracks.
4. Drying shrinkage cracks.
5. D-cracking.
6. Thermal cracks.
7. Settlement cracks.
8. Corrosion cracks.

B . Causes of Cracks

Cracks in a building are of common occurrence. Building components develop cracks whenever stress in the components exceeds its strength. There are numerous causes of cracking in concrete, but most instances are related more to concrete specification and construction practices than by stresses due to induced forces.

Formation of cracks in concrete is mainly due to following reasons:

1. Thermal Changes
2. Elastic Deformation
3. Movement Due To Creep
4. Chemical Reactions
5. Foundation Movement & Settlement of Soil
6. Cracking Due To Vegetation

IV. PROCESS OF SELF-HEALING IN CONCRETE

Self-Healing in concrete is carried out by two processes.

1. Bacteria- Based Process
2. Shape Memory Polymers

A . Bacteria-Based Process

The concept of bacteria-based self healing concrete was developed in the Netherlands, has received considerable interest from the press and is the subject of numerous UK research programmers.

Concrete often cracks due to a variety of processes and in certain circumstances can self-heal those cracks up to width of 0.3mm. Chemical additives can also be added to fresh concrete to improve the self-healing process.

The principle mechanism of bacterial crack healing is that the bacteria themselves act largely as a catalyst, and transform a precursor compound to a suitable filler material which effectively seals newly formed cracks. When bacteria spores are directly added to the concrete their lifetime was found to be limited.

B . Types of Bacteria Used In Concrete

1. Bacillus pasteurii
2. Bacillnes phaericus
3. Escherichia colli
4. Bacillus Subtilis
5. Bacillus cochnii
6. Bacillus pseodofirrius
7. Bacillus baloduaris

C . Classification of Bacteria

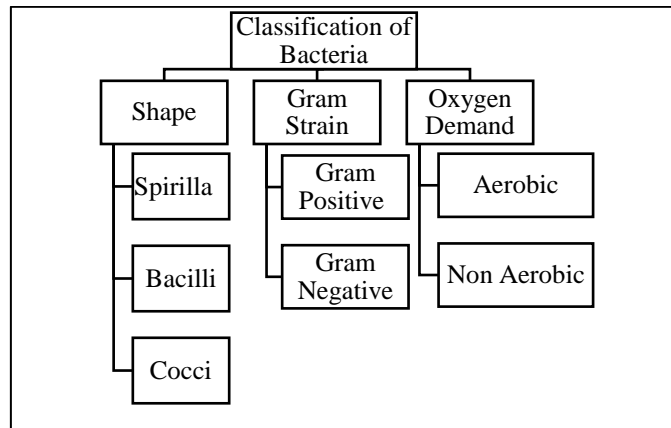


Figure 1 : Classification of bacteria

V. OUR METHODOLOGY

We used curd and chicken manure, as an economical alternative for a economical bacteria-based self-healing process in a concrete .We extracted water which floats up on curd. As this water is the best source of lactic acid. Also chicken manure contains huge amount of calcium carbonate and calcium phosphate.

We added chicken manure and curd to the concrete.Both the material we used was added to the concrete mix in proportion to total weight of Cement. (0.0%, 0.5% ,1.0% & 1.5%).

When these materials were used in concrete mix then, the lactic acid present in the curd will react with the calcium phosphate present in chicken manure, and forms calcium lactate.

Both the materials (Curd and Manure) are the very much effective alternatives of costly admixtures and chemicals that are already available in markets.

Advantages

- ✓ Improve compressive strength of concrete.
- ✓ This concrete is economical.
- ✓ Less maintenance required.
- ✓ One time expenditure.
- ✓ Reduce permeability of concrete.

Mix Design

By Doing all necessary test we have find the properties of the cement, fine aggregate , Coarse aggregate. We also make concrete mix design of M25 concrete as per IS 10262:2009.Our mix design by mass in proportion Cement : Fine Aggregate : Coarse Aggregate =1 : 1.36 : 2.86. we casted cube by adding four different proportions of Bacillus Subtillis (0.0 % , 0.5%, 1%, 1.5%) and the fixed amount of feed (Curd and Chicken manure) 40 ml each per 0.5% bacteria.

Water	Cement	Fine Aggregate	Coarse Aggregate
191.6 lit	425.78 Kg	578.08 Kg	1220.09 Kg
0.45	1	1.36	2.86

Table 1 : Mix Proportion By Mass

Water	Cement	Fine aggregate	Coarse aggregate
22.5 lit	50 kg	68 kg	143 kg

Table 2 : Quantities for 1 bag of cement



Compressive Strength Test

Compressive strength of concrete is the strength of hardened concrete measured by the compression test. The compression strength of concrete is a measure of the concrete's ability to resist loads which tend to compress it.

We have test the cube for knowing the compressive strength of the cubes by the CTM machine at the 14 days and 28 days after the cube casted.

The following result has been found out by us

Days	Percentage	Cube no.	Area(mm ²)	Peak Load (kN)	Strength (N/mm ²)	Average
14	0.0%	1	21952	468.26	21.33	21.74
		2	22362	501.2	22.41	
		3	22333	479.32	21.46	
	0.5%	1	22160	509.5	22.99	23.81
		2	21352	541	25.34	
		3	21366	493.3	23.09	
	1.0%	1	23431	708.5	30.24	31.34
		2	23354	763.4	32.69	
		3	22571	702	31.10	
	1.5%	1	22046	614.6	27.88	28.40
		2	22635	608.2	26.87	
		3	22571	687.2	30.45	
28	0.0%	1	23206	608.12	26.21	27.10
		2	22190	639.26	28.81	
		3	22465	590.35	26.28	
	0.5%	1	23788	671.8	28.24	30.30
		2	22443	660.8	29.44	
		3	22936	762.1	33.23	
	1.0%	1	22620	823.1	36.39	37.33
		2	22722	825.9	36.35	
		3	22560	885.7	39.26	
	1.5%	1	22835	870.9	38.14	35.79
		2	22609	737.7	32.63	
		3	22490	823.3	36.61	

Table 3 : Compressive Strength of Cubes

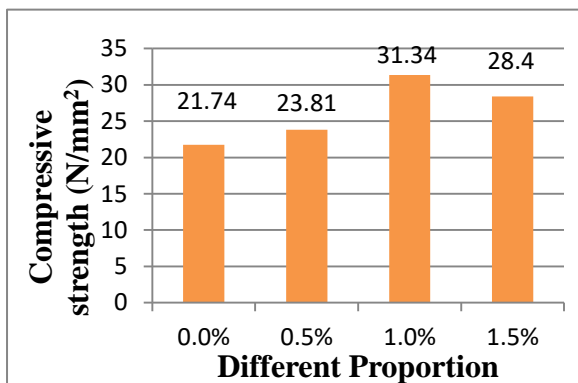


Figure 2 : Compressive strength of concrete at 14 days

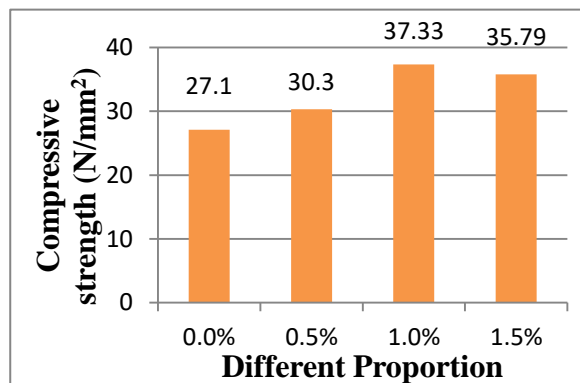


Figure 3 : Compressive strength of concrete at 28 days

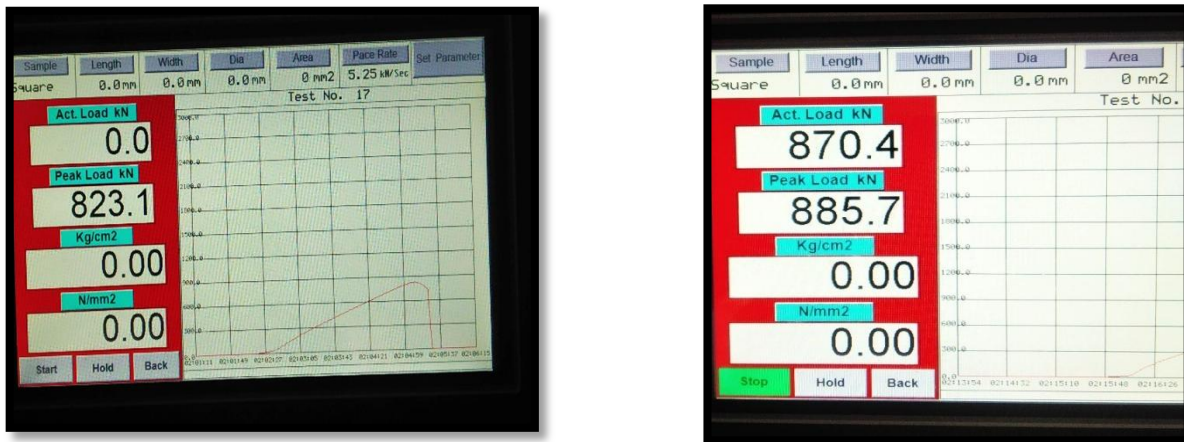


Figure 4 : Peak Load on the Cubes

VI. ULTRASONIC PULSE VELOCITY TEST

The ultrasonic pulse is generated by an electro acoustical transducer. ,When the pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. It's generally used to find the presence of voids and cracks.

Following result we have found out by us

Cured Period (Days)	Percentage (%)	Cube No.	Pulse velocity by Cross Probing before breaking Cube (km /s)	Pulse velocity by Cross Probing After breaking the cube following days (km/s)			Average			
				0	14	28	Before Breaking (km/s)	After Breaking the Cube (km/s)		
								0	14	28
28	0	1	4.26	2.57	2.57	2.57	4.24	2.61	2.61	2.61
		2	4.23	2.73	2.73	2.73				
		3	4.23	2.53	2.53	2.53				
	0.5	1	4.23	2.72	2.93	3.35	4.26	2.63	2.85	3.19
		2	4.24	2.59	2.92	3.17				
		3	4.31	2.59	2.71	3.04				
	1.0	1	4.27	2.82	3.34	3.86	4.23	2.74	3.16	3.78
		2	4.26	2.68	3.11	3.64				
		3	4.15	2.73	3.03	3.85				
	1.5	1	4.20	2.75	2.92	3.39	4.28	2.71	2.91	3.27
		2	4.31	2.63	2.82	3.13				
		3	4.32	2.75	2.97	3.28				

Table 4 : Pulse Velocity by Cross Probing

Before testing the strength of concrete we conducted UPV test on cubes and after the breaking the cubes or the checking the strength of cubes we again conducted UPV test. After breaking the cubes by CTM we also test UPV on this cubes after 14 days and 28 days

As the UPV test gives the result of quality of concrete we can see after the 14 & 28 days the pulse velocity increases as it shows that the quality of concrete is also increase that describe somehow the void and crack in the concrete self healed.

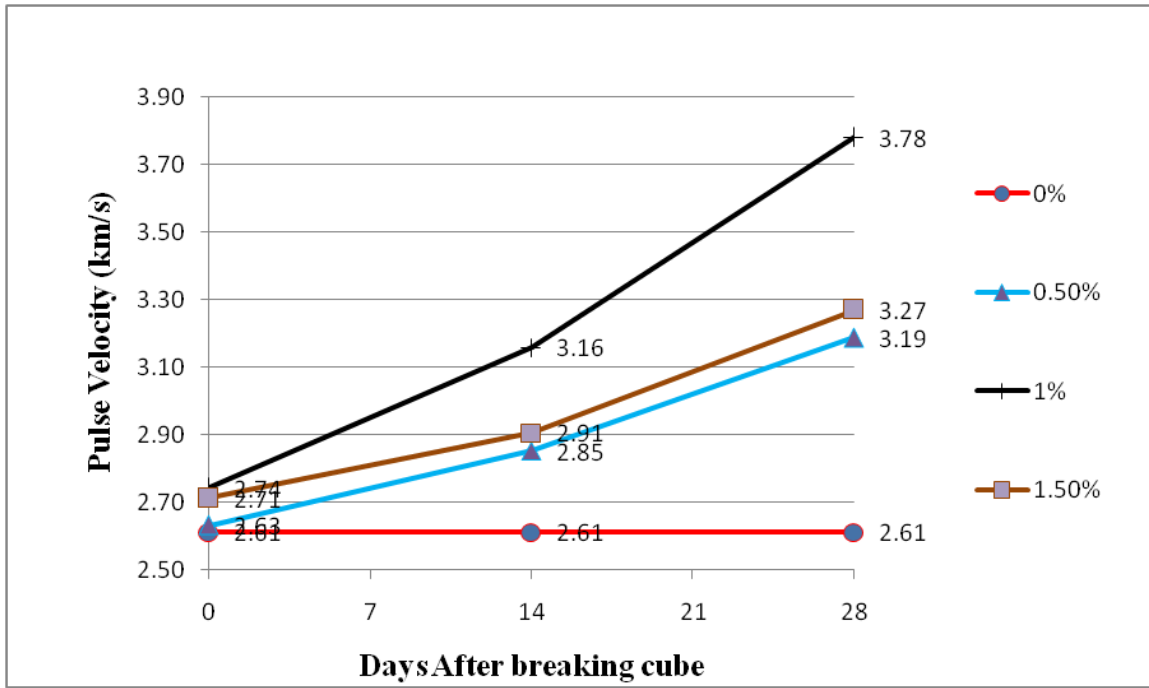


Figure 5 : Pulse Velocity by cross Probing after breaking cubes



Figure 6 : Ultrasonic Pulse Velocity on Cubes

VII. CONCLUSION

- We conclude that the concrete cubes, which we casted by adding three different proportions of Bacillus Subtillis (0.5%, 1%, 1.5%) and the fixed amount of feed (Curd and Chicken manure) 40 ml each per 0.5% bacteria heals itself.
- We've performed several tests on the cubes like determining strength of the cubes on compression testing machine (also with the use of this test we've generated cracks on cubes) and Ultrasonic pulse velocity test (to determine the quality of concrete).

- The graph of Pulse velocity to the days shows that the graph for 1.0 % is more faster healing cubes than other proportions.
- With the help of the above listed test, we conclude that the concrete cube with the 1% proportion of the bacterial mix is more effective (both in terms of strength and healing).

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