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Performance Evaluation of M20 Grade Bacterial Concrete an Experimental Approach

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Abstract: The measurement and analysis of patterns in images are crucial tasks in various fields including computer vision, image processing, medical imaging, and machine learning. The ability to identify and measure the patterns of objects within images provides significant insight into the structure, content, and characteristics of the images. This paper explores different methods for detecting and measuring patterns of objects in images, with a focus on the most prominent approaches, including edge detection, texture analysis, feature extraction, and machine learning-based methods. We also discuss the challenges faced when measuring patterns in images and propose future directions for research.

Keywords: Pattern recognition, image processing, edge detection, texture analysis, feature extraction, machine learning, computer vision.

I. INTRODUCTION:

Concrete is a very important and essential material that is always used in building infrastructure. In recent years, there have been efforts to improve the properties of concrete, such as its strength and ability to last in different environments. In the future, it seems that concrete will continue to be a key construction material with no real alternatives. Over the past century, there have been major advances in concrete technology. In the last two decades, durability and resistance to corrosion have become important factors in evaluating how concrete behaves. To increase the lifespan of concrete from about 40 to 50 years to as long as 150 years, research is being done to find materials that can provide reliable performance under various conditions. The main problem with regular cement concrete is that it tends to crack under tension. Small cracks on the surface of concrete can lead to a loss of strength because water can enter the structure. This causes the steel reinforcement to corrode and reduces the lifespan of the structure. Even though cracks may not be visible, they can grow into larger cracks over time, which can damage the reinforcement. The breakdown of reinforced concrete leads to high maintenance and repair costs. Micro-cracks are often the first signs of structural failure.

II.OBJECTIVE

The goals of this study are outlined below:

1. To create bacterial concrete by incorporating bacteria into st andard M20 grade concrete.
2. To determine the best amount of bacterial cells from differen t types, such as Bacillus Megaterium (BM), Bacillus Subtilis (BS), and Pseudomonas Aeruginosa (PA), to be mixed into concrete in order to improve its strength and d urability.
3. To enhance the mechanical properties of concrete through the use of bacteria..

III.EXPERIMENTAL WORK

Materials:

Cement: In this experimental study, ordinary Portland cement (OPC) of 53 grade was used, which meets the requirements outlined in IS: 12269-2013.

The specific gravity of the cement was determined to be 3.15.

Bacteria: Bacillus Megaterium (BM), Bacillus Subtilis (BS), and Pseudomonas Aeruginosa (PA) were identified as bacteria that can survive in high-alkaline environments.

These bacteria were observed to thrive under conditions of high pH levels, up to a value of 13, which was achieved in the cement-water mixer.

Fine Aggregates: River sand, which is locally available, was used as the fine aggregate.

The sand used was confirmed to fall within grading zone II according to IS: 383-1970 specifications. Standard tests were conducted on the fine aggregate to determine its physical properties.

Natural Coarse Aggregates: Coarse aggregates are essential components of concrete.

They provide volume to the mix, help reduce shrinkage, and contribute to the overall cost-effectiveness of the concrete.

Water: Standard drinking water was used for all the concrete mixes.

Mix Designation: The mix proportion for M20 grade concrete was determined in accordance with IS: 10262 – 2009, and it was set at 1: 1.59 : 2.96 with a water-cement ratio of 0.45.

In this proportion, three types of bacteria—BM, BS, and PA—were incorporated at three different concentrations: 10^4, 10^5, and 10^6 cells/ml respectively. The specimens were designated as BM1, BM2, BM3, BS1, BS2, BS3, PA1, PA2, and PA3. The water-cement ratio remained consistent across all mix proportions. A total of ten different mixes were prepared, including one control mix and nine bacterial concrete mixes.

Sl. No	Type of test	Properties studied	Specimen size	No. of Specimens tested
1	Cube compressive strength	Cube compressive strength at 7, 14, 28 days	150 x 150 x 150 mm cube	150
2	Splitting tensile strength	Splitting tensile strength at 7 days and 28 days	150 mm x 300 mm cylinder	60
3	Flexural strength	Flexural tensile strength (Modulus of rupture) at 28 days	150 x150 x 750 mm Prism	30

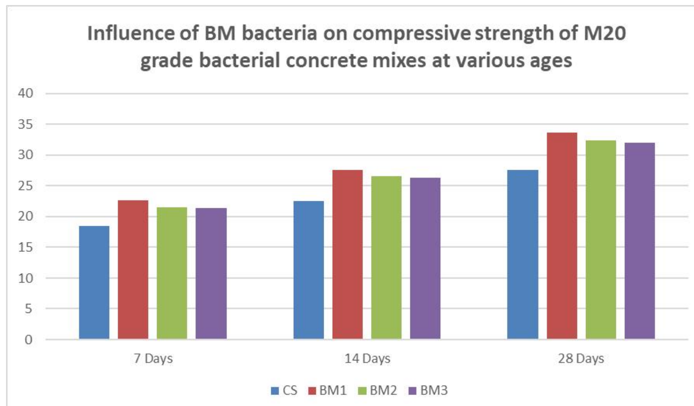
IV.RESULT AND DISCUSSION

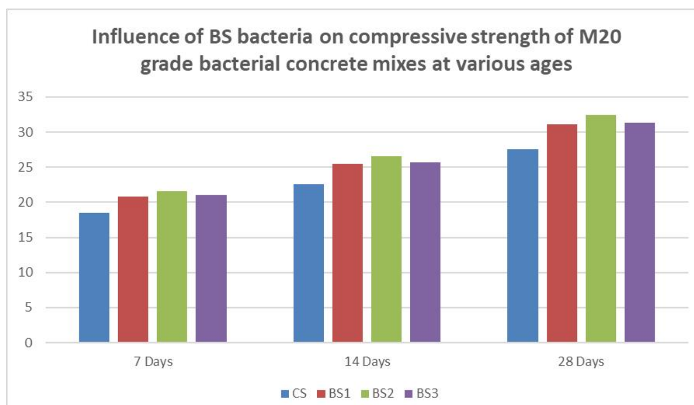
Workability:

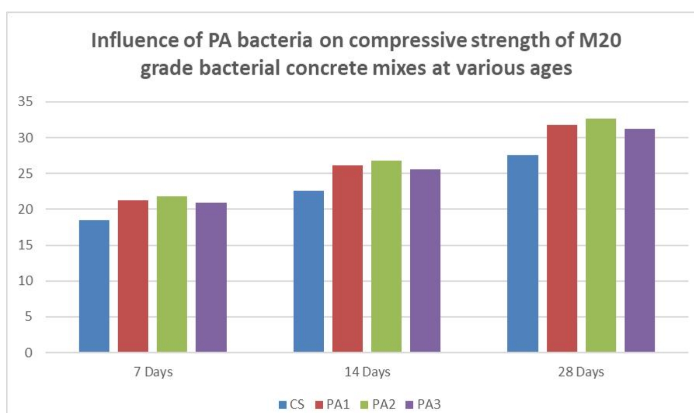
Mix designation	Type of bacteria	Cell concentration (cells / ml)	Slump in 'mm'
CS	Control Specimen	-	95
BM1	Bacillus Megaterium	10^4	98
BM2		10^5	102
BM3		10^6	105
BS1	Bacillus Subtilis	10^4	95
BS2		10^5	102
BS3		10^6	106
PA1	Pseudomonas Aeruginosa	10^4	97
PA2		10^5	104
PA3		10^6	108

Compressive Strength:

Mix designation	Type of bacteria	Cell concentration(cells / ml)	Average cube compressive strength in MPa		
			7 days	14 days	28 days
CS	Control Specimen	-	18.48	22.56	27.54
BM1	Bacillus Megaterium	10^4	22.63	27.56	33.62
BM2		10^5	21.47	26.58	32.45
BM3		10^6	21.42	26.33	31.98
BS1	Bacillus Subtilis	10^4	20.87	25.52	31.12
BS2		10^5	21.63	26.56	32.48
BS3		10^6	21.02	25.65	31.28
PA1	Pseudomonas Aeruginosa	10^4	21.28	26.10	31.80
PA2		10^5	21.77	26.78	32.64
PA3		10^6	20.96	25.60	31.20

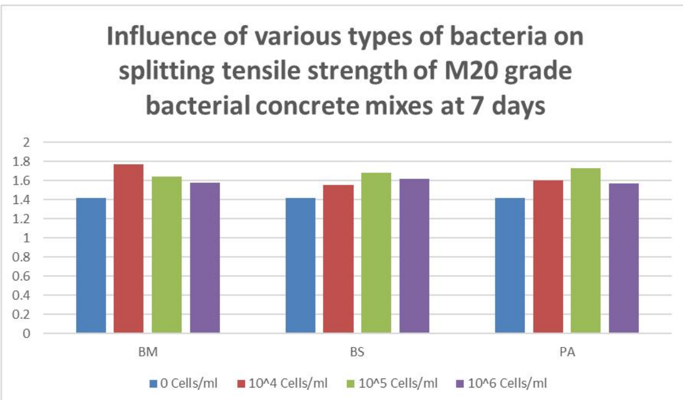


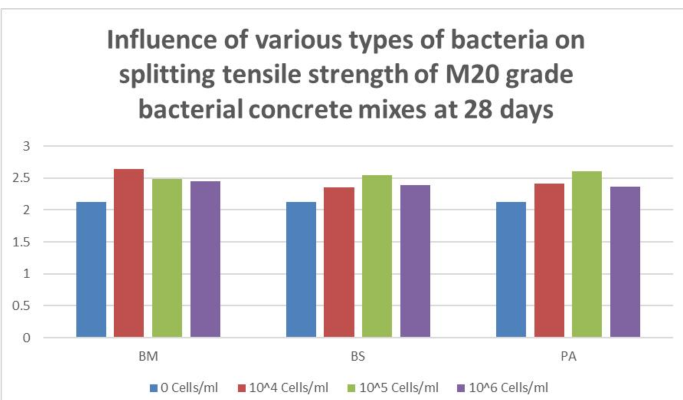




Split Tensile Strength:

Mix designation	Type of bacteria	Cell concentration (cells / ml)	Average splitting tensile strength at 7 days (MPa)	Average splitting tensile strength at 28 days (MPa)
CS	Control Specimen	-	1.42	2.12
BM1	Bacillus Megaterium	10^4	1.77	2.64
BM2		10^5	1.64	2.49
BM3		10^6	1.58	2.45
BS1	Bacillus Subtilis	10^4	1.55	2.35
BS2		10^5	1.68	2.54
BS3		10^6	1.62	2.39
PA1	Pseudomonas Aeruginosa	10^4	1.60	2.41
PA2		10^5	1.73	2.60
PA3		10^6	1.57	2.37

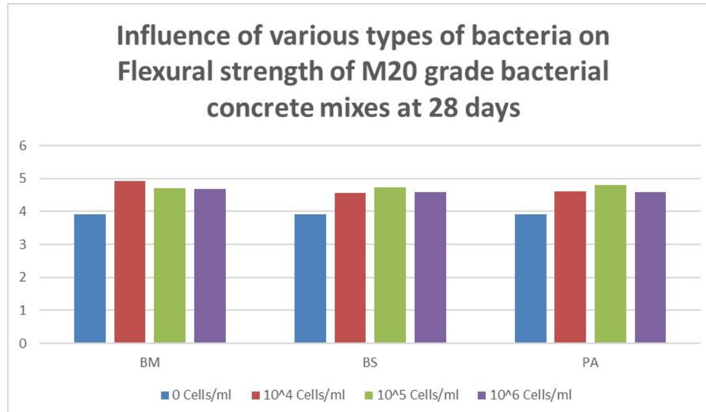




Split Tensile Strength:

Mix designation	Type of bacteria	Cell concentration (cells / ml)	Average flexural strength at 28 days (MPa)
CS	Control Specimen	-	3.92
BM1	Bacillus Megaterium	10^4	4.93
BM2		10^5	4.70
BM3		10^6	4.67
BS1	Bacillus Subtilis	10^4	4.55
BS2		10^5	4.74
BS3		10^6	4.59
PA1	Pseudomonas Aeruginosa	10^4	4.62
PA2		10^5	4.80
PA3		10^6	4.58

Mix designation	Type of bacteria	Cell concentration (cells / ml)	Average flexural strength at 28 days (MPa)
CS	Control Specimen	-	3.92
BM1	Bacillus Megaterium	10^4	4.93
BM2		10^5	4.70
BM3		10^6	4.67
BS1	Bacillus Subtilis	10^4	4.55
BS2		10^5	4.74
BS3		10^6	4.59
PA1	Pseudomonas Aeruginosa	10^4	4.62
PA2		10^5	4.80
PA3		10^6	4.58



V.CONCLUSION

The following conclusions are drawn from the experimental studies conducted on concrete mixes that include bacteria and those that do not.

Workability

• The presence of bacteria in concrete does not impact its workability.

Cube Compressive Strength

- At the ages of 7, 14, and 28 days, the compressive strengths of bacterial concrete mixes were higher than those of the control concrete mix without bacteria.
- This suggests that adding bacteria to concrete enhances its compressive strength.
- Bacterial concrete mixes consistently showed higher cube compressive strength compared to the control mix.
- The increase in strength is primarily due to the filling of pores in the concrete through calcium carbonate (calcite) precipitation.
- The 7-day compressive strength of bacterial concrete was approximately 66 to 67 percent of the 28-day compressive strength.

This indicates that the addition of bacteria does not significantly improve early strength.

- The increase in compressive strength between 28 days was only 7 to 10 MPa for concrete without bacteria, whereas for bacterial concrete, the increase was between 10 to 16 MPa.

This characteristic is beneficial for the design of structures like bridge piers, abutment walls, and other mass concrete elements where early strength is not crucial.

- The optimal cell concentration for achieving maximum cube compressive strength was found to be 104 cells/ml for BM bacteria, and 105 cells/ml for BS and PA bacteria.
- The maximum increase in compressive strength of 22.08 percent was achieved with BM bacterial concrete at a cell concentration of 104 cells/ml.
- The bacteria used in this study performed well.
- Therefore, it is strongly recommended for the production and application of bacterial concrete.

Splitting Tensile Strength

- The splitting tensile strength of all bacterial concrete specimens was greater than that of the control concrete.The highest splitting tensile strengths were observed in BM1, BS2, and PA2 specimens, with values of 2.64 MPa, 2.54 MPa, and 2.60 MPa respectively at 28 days.
- Splitting tensile strength increases as compressive strength increases.

The splitting tensile strength of bacterial concrete is approximately 7 to 8 percent of its cube compressive strength. The maximum increase in splitting tensile strength was observed in BM bacterial concrete, at 24.53 percent.

Flexural Strength

- The flexural strength of all bacterial concrete specimens was higher than that of the control concrete.
- The highest flexural strengths were found in BM1, BS2, and PA2 specimens, with values of 4.93 MPa, 4.74 MPa, and 4.80 MPa respectively at 28 days.
- Flexural strength increases along with compressive strength.
- The flexural strength of bacterial concrete is about 15 percent of its cube compressive strength. The maximum increase in flexural strength was observed in BM bacterial concrete at 25.76 percent.
- The optimal cell concentration for achieving maximum flexural strength was 104 cells/ml for BM bacteria and 105 cells/ml for BS and PA bacteria.
- The flexural strength of bacterial concrete at 28 days was higher than the value predicted by the expression 0.7√fck as specified in IS : 456 - 2000.

This indicates that the code underestimates the flexural strength of bacterial concrete.

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