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REGRESSION ANALYSIS FOR ASSESSING THE IMPACT OF MEGATERIUM BACTERIAL SOLUTION ON BAGASSE ASH CONCRETE

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Abstract

The purpose of this study was to investigate the impact of part substitution of conventional binder (i.e. cement) with bagasse ash and addition of bacillus megaterium bacterial solution at optimal bagasse ash dosage. M25 grade concrete was developed using four proportions of bagasse ash (i.e. 5%, 10%, 15% and 20%) as a replacement of cement. Three concentrations of bacteria (i.e. 103, 105, and 107cells/ml) were used for preparing bacterial solution. 10% of the mixing water was replaced with this bacterial solution. Mechanical strengths of the concrete developed using BA alone and using bacterial solution along with BA were investigated. Additionally, water absorption of the samples in both the conditions was also determined. Test result shows that 10% bagasse ash at 105cells/ml bacterial concentration tends to produce highest mechanical strength. At a higher percentage of bagasse ash (>10%) in concrete the strength started reducing. The value of R2 obtained from the regression analysis for split tensile strength of BA concrete reduced by 0.159 when bacteria were introduced in the concrete. The water absorption capacity of the concrete started declining due to the inclusion of bacteria and therefore regression analysis gave a better value of R2 for bacterial BA concrete as compared to the BA concrete.

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1. Introduction

Concrete will remain to be the most consumed building material in the world because of its numerous benefits. Concrete has several disadvantages but still a huge scope is available for the improvement in the properties of the concrete [1]. Cement causes generation of greenhouse gases such as carbon dioxide in the atmosphere which leads to the condition of global warming [2]. Due to the exponential growth in OPC consumption, this environmental concern is anticipated to worsen further. Use of cement is anticipated to double by 2050, reaching a total of 6,000 million tonnes per year [3]. Numerous research initiatives have been implemented with the goal of partially or completely replacing conventional binder in concrete with its substitutes such as agricultural, industrial, and agro-industrial by-products without compromising the necessary characteristics of the concrete [4]-[8]. BA is one such agricultural waste that causes significant pollution to the environment [9].

A tonne of sugar canes produces around 26% bagasse and 0.62% residual ash [10]. Many researchers have used bacterial to impart better properties in the concrete both in terms of durability and strength by incorporating bagasse ash as a partial substitute of cement [11]-[14]. The current study investigates the effect of introducing bacillus megaterium bacteria in BA concrete at optimum dosage. BA has been used at the rate of 5%, 10%, 15% and 20% in place of cement and 10% of the mixing water is replaced with bacterial solution at concentration of 103, 105, and 107cells/ml. The developed concrete has been investigated for its mechanical strengths as well as for water absorption. A relation of the experimentally obtained strengths has been established with the calculated ones.

2. Materials and Method

OPC43 cement of JAYPEE taken from same batch was utilized in this investigation. The physical properties of cement are given in Table 1 and the range of values is conforming to IS:8112-2013. Sand of Zone-III and fine aggregates with fineness modulus (FM), sp. gravity and moisture content of 2.45, 2.68 and 1.4% respectively have been used. Natural stones of size 20mm and 10mm were used as coarse aggregates. FM, water absorption and sp.

gravity of 20mm and 10mm aggregate were obtained as 77.05, 2.72, 0.85% and 6.26, 2.70, 1.0% respectively. BA was obtained by burning bagasse at 500oC to 800oC. Sp. gravity of BA was 1.85. Bacillus megaterium bacteria were obtained from IMTECH (MTCC) Chandigarh in dried and frozen form.

Total 120 cubes (10cm x10cm x10cm) and 90 cylinders (10cm x20cm) were cast. In the first stage, casting of samples with BA alone was done and after getting the optimum dosage of BA in concrete after 28 days the casting of the concrete with the bacterial solution along with optimum BA dosage was done. The prepared samples were tested after 7, 28, 56 and 90 days for strength in compression. Same samples were used to measure the water absorption after 28 and 90 days. Split tensile tests were performed after 28, 56 and 90 days of curing. Table 1 shows the proportioning of the various samples cast for the study.

Table 1. Proportioning of Samples.

S.N	Sample	Bagasse ash	Cement	Bacteria
1	BA0	0	100	0
2	BA5	5	95	0
3	BA10	10	90	0
4	BA15	15	85	0
5	BA20	20	80	0
6	B3BA10	10	90	103 cells/ml
7	B5BA10	10	90	105 cells/ml
8	B7BA10	10	90	107 cells/ml

3. Results and Discussion

A. Effect on Compressive Strength

The effect of the inclusion of the BA alone and BA at optimum dosage with bacterial solution (10% of mixing water) on compression strength has been obtained from the testing and the same has been plotted in the Figure 1 (a) and (b).

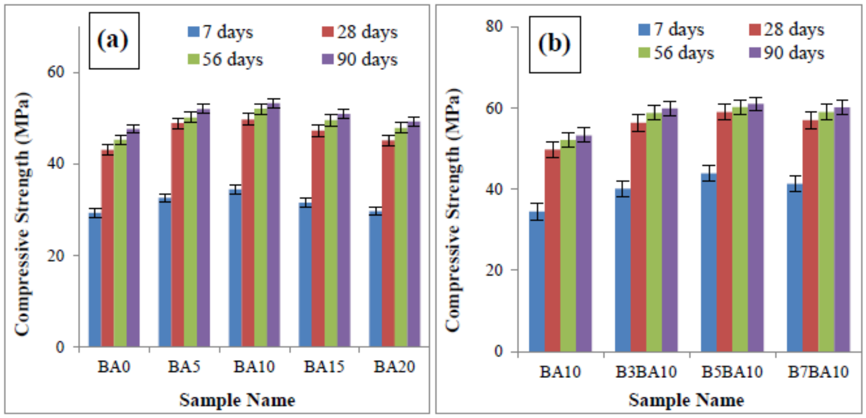

Figure 1. Compressive strength of (a) BA concrete (b) Bacterial BA concrete

Figure 1 (a) delineates that at 7, 28, 56 and 90 days, the compression strength has increased up to BA dosage of 10% and beyond that it started reducing. The strength of BA10 samples at 7, 28, 56 and 90 days increased by 17.39%, 15.38%, 15.11% and 11.77% respectively as compared to BA0samples. The interaction between bagasse and calcium hydroxide, which results in the production of CSH gel, may have enhanced the strength. However, the strength only improved up until BA10, after which it began to decline. This might be because of the reason that the interaction between bagasse ash and calcium hydroxide came to a halt owing to a lack of excess hydroxide [15].

Figure 1 (b) represents the effect of the three bacillus megaterium concentrations on the compressive strength of BA10 concrete. The compressive strength enhanced up to 105 cell/ml of bacillus megaterium bacterial concentration and started decreasing at 107cells/ml. B5BA10 samples have maximum improvement in compressive strength of around 27.51% and 18.58%, as compared to BA10 samples at 28 day of testing. This increase in the strength might be because of the reason that the bacteria colonies, developed in concrete, caused calcite precipitation which leads to the filling of the voids and increase in the density of the mix and thereby increase in the strength [16].

B. Effect on Split tensile strength

The effect of the inclusion of the BA alone in concrete and replacement of 10% mixing water with bacterial solution along with the BA replacement at optimum dosage on the splitting tensile strength has been tested and the same has been plotted in the Figure 2 (a) and (b). All the testing has been conducted after 28, 56 and 90 days of curing.

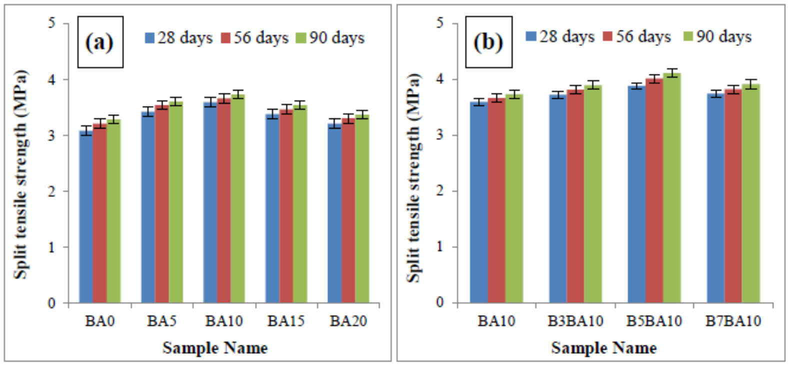

Figure 2. Split tensile strength of (a) BA concrete (b) Bacterial BA concrete.

Figure 2(a) indicates that the maximum split tensile strength was also attained at 10% replacement of bagasse ash with cement. The strength of BA5 and BA10 samples increased initially and then dropped for BA15 and BA20 samples. The highest improvement in strength of about 16.55% was observed when bagasse ash was used to replace 10% of the cement at 28 days. The split tensile strength of the samples with 10% bagasse ash substitution improved much more with the addition of bacterial concentration, as shown in Figure 3 (b). An increment in split tensile strength of 3.62%, 8.07% and 4.17% were obtained for B3BA10, B5BA10 and B7BA10 respectively as compared to BA10 mix at 28 days. It is seen that the maximum strength of 3.88 MPa was obtained for B5BA10. The explanation for this increase might be related to the growth of CSH gel up to 10% bagasse ash replacement [17].

C. Water Absorption

Water absorption (WA) values of BA mixed concrete sample and bacterial samples were evaluated using ASTM C642 at 28 and 90 days of water curing. Figure 3 shows the water absorption of BA mixed concrete specimens at 28 and 90 days of curing.

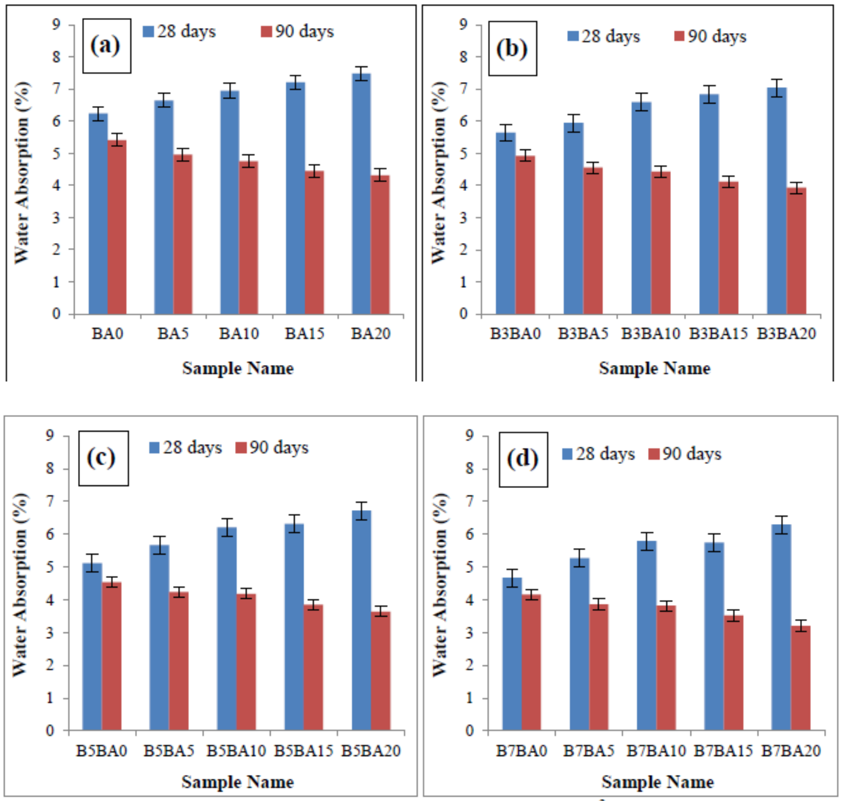

Figure 3. Water absorption of (a) BA concrete (b) Bacterial (103 cells/ml) BA concrete (c) Bacterial (105 cells/ml) BA concrete (d) Bacterial (107 cells/ml) BA concrete.

It can be noticed from Figure 3 that the percentage of WA enhances with BA level after 28 days of curing. This is owing to the fact that BA is finer than OPC. After 90 days of curing, the percentage of WA values decreased significantly. This is due to the pores gradually sealing. Obviously, adding BA reduces permeability pores over a lengthy period of curing [17]. Reduction in water absorption values with Inclusion of bacteria to the mix of bagasse ash concrete. The main reason for reduction of WA is calcite produced by the bacteria and fills the pores which are present on concrete samples [18].

4. Correlations

A. Calculated and Experimental strength

The values of the split tensile strengths have been calculated with the help of the compressive strength values obtained experimentally. Figure 4 (a) and (b) shows correlation of split tensile strength for the BA and bacterial BA concrete respectively.

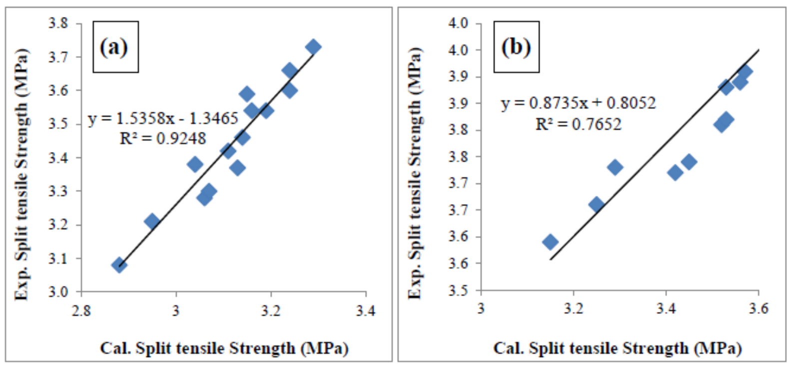

Figure 4. Correlation of experimental and calculated split tensile strength for (a) BA concrete (b) Bacterial BA concrete.

From Figure 4 observed that the inclusion of bacteria is causing a poor correlation value between the calculated and experimental values. The value of R2 for strength of BA concrete reduced by 0.159 when bacteria were introduced in the concrete.

B. Compressive strength and Water absorption

A relationship between the water absorption and compressive strength of the bagasse ash concrete and bacterial bagasse ash concrete has been established and the same has been represented in figure 5.

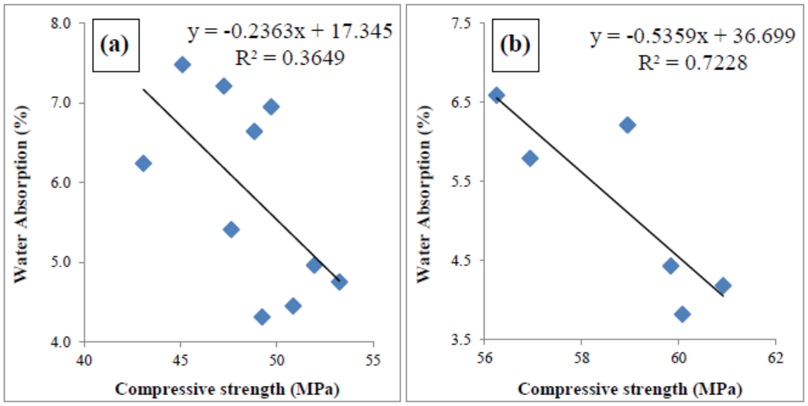

Figure 5. Correlation of compressive strength and water absorption for (a) Bagasse ash concrete (b) Bacterial bagasse ash concrete.

From Figure 5 (a) it is clear that the correlation of compressive strength with water absorption is not good for bagasse ash concrete [19]. Figure 5 (b) shows a better correlation between compressive strength and water absorption for bacterial bagasse ash concrete. It might be because of the reason that bacteria introduction in the mix has reduced the voids and porosity of the mix and therefore the water absorption also has reduced. The R2 of BA mix and bacterial bagasse ash mix are 0.3649 and 0.7728.

5. Conclusion and Future Scope

1. The optimum dosage of BA was obtained at 10% replacement. The strength in compression for BA10 samples at 7, 28, 56 and 90 days increased by almost 17.39%, 15.38%, 15.11% and 11.77% respectively as compared to BA0 samples. Split tensile and flexural strengths also showed similar trend.

2. Maximum enhancement in split tensile, flexural and compressive strengths of B5BA10 at 28 days was obtained as 8.07%, 4.37% and 18.58% respectively.

3. The water absorption of concrete with increasing BA content increased at 28 days of testing but decreased at 90 days of testing. The maximum reduction of water absorption was 25.52% at 90 days of curing. The introduction of bacteria in BA concrete reduced the water absorption in concrete.

4. The correlation of calculated and experimental flexural and split tensile strength reduced due to the inclusion of bacteria in the mix.

5. The compressive strength correlation with water absorption improved in bacterial bagasse ash concrete as compared to bagasse ash concrete.

6. In the future, this work will further be extended for the microstructural analysis.

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