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Original Research Paper

Experimental Study on Strength Properties of Concrete by Partial Replacement of Cement With Sugarcane Bagasse Ash

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ABSTRACT

Concrete is the most widely used material for the construction. One of the important ingredients of concrete is cement. During the production of cement, large amount of CO_2 is emitted, which affects the global environment. With increasing demand and consumption of cement, scientists and researchers are in search of developing alternate binders that are eco-friendly. Initiatives are emerging worldwide to strike a balance between the developments in infrastructure and prevention of the environment from contamination, by using the industrial and agricultural wastes. In this study, the feasibility of using Sugarcane Bagasse Ash (SBA), a finely ground waste product from the sugarcane industry, as partial replacement for cement in conventional concrete is examined. The disposal of this material is causing environmental problems around the sugar factories. On the other hand, the boost in construction activities in the country created shortage in most of concrete making materials especially cement, resulting in an increase in price. The percentages selected for this study are 0%, 5%, 10% and 15% by the weight of cement in concrete. Based on the experimental tests, it can be concluded that SBA, an agrowaste product, can be utilized effectively in partial replacement of cement, thus reducing CO_2 emissions and disposal problems to some extent.

INTRODUCTION

Cement is the most important ingredient for the preparation of concrete and is produced in large quantities. Due to its enormous production, large amount of CO_2 is emitted which in turn affects the environment. Sugarcane Bagasse Ash (SBA) is a byproduct of sugar factories found after burning sugarcane bagasse, which itself is found after the extraction of all economical sugar from sugarcane. This agrowaste produced after juicy extract is taken and burnt at uncontrolled condition and at very high temperature. This ash is allowed to cool and taken for disposal, which causes serious environmental pollution. A good solution for the problem of recycling agro-industrial residues would be to burn them in a controlled environment, and use the ashes for more noble means (Ghavami et al. 1999). Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials (Ganesh et al. 2007). Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry (Committee Board 2004). It is possible to use SBA as cement replacement material to improve quality and reduce the cost of construction materials, thereby reducing disposal problems. This study analyses the effect of SBA in concrete by partial replacement of cement in the ratio of 0%, 5%, 10% and 15% by weight. The experimental study examined the compressive strength, split tensile strength and flexural strength of concrete.

MATERIALS AND METHODS

The materials used for the present study are:

Cement: Ordinary Portland cement was used. The specific gravity of cement is 3.15.

Fine aggregates: Locally available riverbed sand, free of debris is used as fine aggregate. Aggregates of size less than 4.75 mm size are termed as fine aggregates. In the present study, the sand conforms to zone II as per the Indian standards. The specific gravity of sand is 2.65.

Coarse aggregates: Aggregates of size greater than 4.75mm size are termed as coarse aggregates. Aggregate of 20mm size were used for the study. The specific gravity of coarse aggregates is 2.82.

Water: Water used for the study conforms to the specifications of IS: 456-2000.

Sugarcane bagasse ash: The sugarcane bagasse ash consists of silica (66.45%), alumina and ferric oxide (29.13%), calcium oxide (1.83%), magnesium oxide (0.83%), sulphur

trioxide (0.56%). Loss of ignition is 0.72%. Sugarcane bagasse ash is collected from nearby sugarcane industry located at Thiruvalam, Vellore. The collected bagasse ash was collected in wet condition and dried. The bagasse ash is sieved through 75μ size. The specific gravity is 2.28.

The specimens used were cubes of size 150mm × 50mm × 150 mm, cylinders of size 150mm × 300mm and prisms of size 500mm × 100mm × 100mm. The mix design is adopted as per IS:10262:2009 standards. The grade of concrete used was M30 grade and water cement ratio was 0.45. Based on the mix design, required quantity of cement, fine aggregate, coarse aggregate, bagasse ash and water were taken. The quantities of sugarcane bagasse ash required for 5%, 10%, and 15% replacement by weight of cement were calculated. The Bagasse ash was replaced with cement in calculated proportions. The ingredients of concrete were mixed thoroughly in a suitable mixer until required consistency is achieved. Before casting, moulds were prepared and machine oil was spread uniformly on the inner surfaces of the mould. The prepared concrete was uniformly poured into the moulds and thoroughly compacted using vibrator. The top surface of the moulds was levelled using trowel. The specimens were allowed to set for 24 hours and cured for 7 days and 28 days. The specimens were taken just prior to testing. The compressive strength, flexural strength and split tensile strength were measured using compression testing machine and flexural testing machine. These tests were conducted as per Indian standards.

RESULTS AND DISCUSSION

The strength results obtained from this study were represented in graphical form. The average of all the three trials was taken in each case and the results were discussed.

Effect of SBA on compressive strength: The compressive strength results are presented in Fig. 1. From the test results, the compressive strength for control mix at 7 and 28 days was found to be 26.7 Mpa and 31.6 Mpa respectively. The optimum value of compressive strength was observed at 5% of SBA and the values of compressive strength at 7 and 28 were found to be 27 Mpa and 33.5 Mpa respectively. Beyond 5% there is marginal decrease in strength. This may be due to the reason that, the quantity of SBA (pozzolana) present in the mix is higher than the amount required to combine with the liberated lime during the process of hydration, thus leading to excess silica leaching out and causing a deficiency in strength, as it replaces part of the cementitious material but does not contribute to strength.

Effect of SBA on split tensile strength: The split tensile strength results are presented in Fig. 2. From the test results, it is observed that maximum tensile strength values are

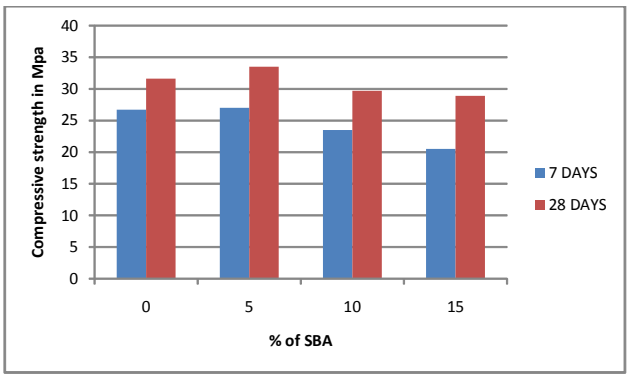

Fig. 1: Variation of compressive strength with per cent SBA.

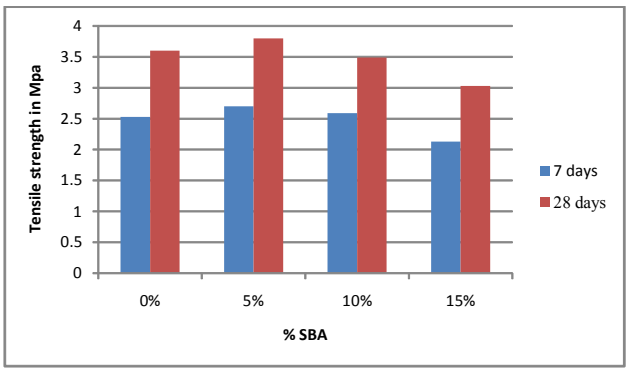

Fig. 2: Variation of split tensile strength with per cent SBA.

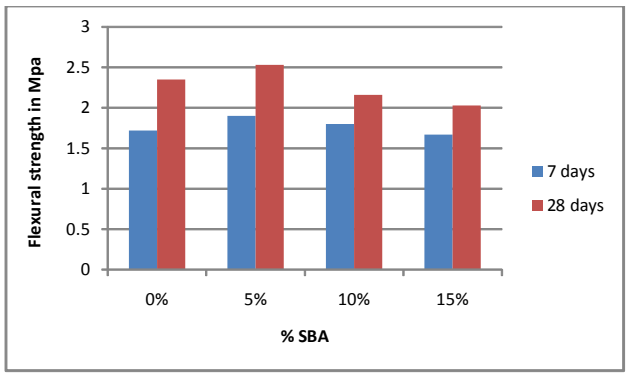

Fig. 3: Variation of flexural strength with per cent SBA.

observed at 5% of SBA and are 2.7 Mpa and 3.8 Mpa at 7 and 28 days. The value of split tensile strength for control mix was 2.53Mpa and 3.6 Mpa at 7 and 28 days respectively.

Effect of SBA on flexural strength: From Fig. 3, it is observed that maximum flexural strength value is 1.9 Mpa and 2.53 Mpa at 7 and 28 days at 5% SBA. The flexural strength value of control mix is 1.72 Mpa at 7^{th} day, and 2.35 Mpa at 28 days.

CONCLUSIONS

Based on the conducted experiments and according to the results obtained, it can be concluded that sugarcane bagasse ash can increase the overall strength of the concrete when used up to a 5-10% cement replacement level. Sugarcane bagasse ash is a valuable pozzolanic material, and it can potentially be used as a partial replacement for cement. This could reduce the environmental problems and minimize the requirement of land fill area to dispose SBA.

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