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(Research Article)

Effect of partial cement replacement with sugarcane bagasse ash

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Abstract

Research into mixing and replacing the component ingredients of concrete has become necessary since there is a widespread need in most parts of the globe for more affordable housing and the discovery of an alternative to standard Portland cement. Despite the fact that a great number of investigations have been carried out to evaluate the viability of combining cement with sugarcane bagasse ash and sand with laterite soil, no research has been conducted on the influence that combining the two materials has on the characteristics of concrete. This study presents the findings on the strengths, permeability, and structural behaviour of concrete beams containing sugarcane bagasse ash and laterite soil. The goal of the research was to combine traditional concrete with sugarcane bagasse ash to produce sugarcane bagasse ash laterised concrete, which could be used for the construction of low-cost housing.

Ash from sugarcane bagasse and lateritic soil were used as blenders and blended with regular concrete materials. Cement was largely replaced with sugarcane bagasse ash in the following proportions by mass: 0%, 5%, 10%, and 15%. The impact of different degrees of material substitution on the workability and compressive strength of concrete was investigated using a concrete mixture with the proportions 1:2:4 and a water-to-cement ratio of 0.55. The same mixture was utilised, but this time with a continuous slump of 30mm+3mm. This was done in order to assess the influence of different degrees of combination material replacement on the characteristics of concrete and the behaviour of structural beams.

Keywords: Sugarcane bagasse ash; Concrete mix; Lateritic soil; Compressive Strength

1. Introduction

If you want to construct anything, chances are it will be made of concrete. Common Portland cement and aggregates are used as the typical binding ingredient. The cement business is the second greatest CO_2 emitter in the world, behind the power generating sector, with ordinary Portland cement manufacture accounting for between 5 and 8 percent of worldwide emissions. It was also found that the production of one tonne of cement results in the release of around one tonne of carbon dioxide. The need to conduct significant projects and create infrastructure to increase economic growth and productive capacity has resulted in high demand for concrete as a construction material in most regions of the globe. However, agro-waste has been suggested as a partial substitute for normal Portland cement to cut down on CO_2 emissions by lowering cement usage. However, sand has long been the major material utilised as a fine aggregate in civil engineering construction, leading to high demand and a constant rise in sand prices, both of which have led to an increase in building costs.

The growing price of housing and other forms of development means that scientists must constantly explore new, more cost-effective, environmentally friendly materials for construction. Sugarcane bagasse ash, fly ash, great granulated bottom ash, and rice husk ash are all examples of waste materials from industry and agriculture that have been shown

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to be viable alternatives to traditional Portland cement in various parts of the globe. The in-line sugar business produces bagasse, a residue that might be used in the electric generating sector as a bagasse-biomass fuel.

An amorphous silica ash with pozzolanic properties is created when this trash is burnt. Research has been done on the pozzolanic activity of industrial ashes and their potential as binders, especially as a partial substitute for cement. Using agricultural by-products as a cement replacement material may affect the cost of producing concrete and other construction materials like mortar, concrete pavers, concrete roof tiles, and soil cement interlocking block because most of this waste, especially in Africa, is not sold but dumped on lands and into water bodies.

Burning this trash creates a pozzolanic ash composed of amorphous silica. It has been discovered that industrial ashes may be used as binders, especially as a partial substitute for cement, and that they also have a pozzolanic activity. Using agricultural by-products as a cement replacement material could affect the price of producing concrete and other construction materials like mortar, concrete pavers, concrete roof tiles, and soil cement interlocking block due to the fact that most of this waste, especially in Africa, is not sold but dumped on lands and into water bodies.

1.1. Research gaps and objectives

Based on these analyses, researchers have studied the impact of sugarcane bagasse ash and laterite on the construction industry separately. Only one component was evaluated at a time (cement or aggregate), and no research was done on the combined impact of sugarcane bagasse ash and laterite soil in concrete. The purpose of this research is to determine the effect of substituting sugarcane bagasse ash and laterite for cement and fine aggregate, respectively, on the properties of the resulting concrete. Experiments were conducted to evaluate the qualities of fresh and hardened concrete, as well as the performance of structural beams made using bagasse ash and laterite, and these data were used to compile the assessment of performance.

Most developing nations have seen many attempts to build homes for the populous fail owing to a lack of funding. Normal Portland cement production is associated with the release of carbon dioxide (CO_2), a greenhouse gas that contributes to global warming. Concrete's manufacturing costs have been on the increase due to the industry's monopolisation of the sand market as a fine aggregate source. The use of sugarcane bagasse ash as a partial substitute for cement may lower the use of ordinary Portland cement in concrete since low-income earners prefer mixing their cement with bagasse ash in concrete manufacturing. By substituting sugarcane bagasse ash for some of the Portland cement in concrete production, we can prevent the dangerous practise of dumping this waste into open areas, where it may pollute the air and water supplies and constitute a serious threat to human civilization. Demand for the many materials that go into making concrete has remained high, despite the fact that it is the most commonly used building material worldwide. The availability of laterite is an advantage since it can be used almost everywhere. One way to get this is by excavation of the building's substructure, such as the foundation. Therefore, using laterite may take advantage of its availability in concrete production while minimising the cost of on-site disposal of excavated laterite.

The primary purpose of this research is to assess the structural effectiveness of concrete made using sugarcane bagasse ash (SB-LA-XX-YYC). The precise goals are as follows:

- One goal is to determine how much different degrees of material substitution affect the ductility and compressive strength of concrete.
- Test the effects of combined material substitution on the compressive, tensile, and flexural strengths of 30mm slump concrete.
- Objective: 3. to compare the permeability of hardened concrete with and without varying quantities of mixed material replacement.
- The purpose of this study was fourfold: (a) to evaluate the shear and bending characteristics of sugarcane bagasse ash laterised concrete with and without shear reinforcement; and (b) to contrast these results with those of conventional concrete.
- Examine the effects of crack load, ultimate load, and the physical failure pattern of reinforced beams when constructed on sugarcane bagasse ash and laterite soil.

2. Material and methods

2.1. Materials used

2.1.1. Cement

All 53 grades of ordinary Portland cement used in the project were from the same batch, and special attention was paid to ensuring that the cement was kept dry and protected from the humidity and wetness of the monsoon season. Cement purchased was subjected to physical and chemical testing in line with IS: 12269-1987 and IS: 4032-1977, respectively. The properties of cement have been shown in Table 1.

Table 1 Properties of OPC 53

Properties	**Values**
Standard Consistency	31.5%
Fineness	8%
Setting Time	
Initial	80 min
Final	240 min
Compressive Strength	
3 days	28.75 MPa
7 days	41.65 MPa
28 days	55.70 MPa

2.1.2. Sugarcane Bagasse Ash (SCBA)

Table 2 Physical Properties of SCBA

Properties	**Values**
Density	575 kg/m3
Specific Gravity	2.3
Particle Size	0.10-0.20μm
Specific Surface Area	2500.00 m2/kg
Shape of Particle	Almost spherical

Table 3 Chemical Properties of SCBA

Properties	**Values**
Silica (SiO2)	63.00
Alumina (Al_2O_3)	31.50
Ferric Oxide (Fe_2O_3)	1.80
Manganese Oxide (MnO)	4×10^{-3}
Calcium Oxide (CaO)	0.49
Magnesium Oxide (MgO)	0.35
Loss on Ignition	0.70

About 52% of sugarcane bagasse is cellulose, 26% is hemicelluloses, and 4% is ligin. About 28 percent bagasse (at 52% moisture content) and 0.64 percent residual ash are produced from one tonne of sugarcane. The chemical makeup of the ash is dominated by silicon dioxide (SiO_2). Ash is utilised as a fertiliser in sugarcane crops despite being a substance with a high degradation barrier and a low nutritional content. This boiler ash was collected from a sugar refinery in Motihari, Bihar, during the process of cleaning the boiler. The sugarcane bagasse was used in the process. The physical and chemical properties have been discussed in Table 2 and Table 3 respectively.

2.1.3. Fine Aggregate

In the current investigation, the fine aggregate consisted of river sand that had been sieved through a 4.75 mm screen but had been kept on a 600 m screen. This river sand had been classified as belonging to Zone II according to IS 383-1970. Clay, silt, and other organic and inorganic contaminants are not present in the sand. In line with the International Standard (IS) 2386-1963, the aggregate was evaluated based on its physical specifications, including its gradation, fineness modulus, specific gravity, and bulk modulus. The properties have been mentioned in Table 4.

Table 4 Properties of Fine Aggregates

Properties	Values
Specific Gravity	2.62
Bulk Density	1.55 g/cc
Fineness Modulus	2.75
Zone	2

2.1.4. Coarse Aggregate

Throughout the whole of the experiments, crushed coarse aggregates with a size of 20 millimetres were sourced from the nearby crusher facilities. In line with Indian Standards 2386-1963 and 383-1970, the aggregate was evaluated according on its physical specifications, which included gradation, fineness modulus, specific gravity, and bulk density, amongst other things. The properties have been shown in Table 5.

Table 5 Properties of Coarse Aggregates

Properties	Values
Specific Gravity	2.75
Bulk Density	1.621 g/cc
Fineness Modulus	7.26
Impact Value	25.30
Crushing Value	25.32

2.1.5. Water

When mixing the concrete, fresh, easily accessible water that is devoid of any organic matter or oil is utilised. A graduated jar was used to accurately measure the needed amounts of water before it was put to the concrete. Weigh batching was used to collect the remaining components of the material needed to prepare the concrete mix. The pH number shouldn't be lower than 7, at the very least.

2.2. Mix design

Mix Design procedure has been adopted as per IS 10262:2009. M35 grade concrete was designed having aggregate size of 20mm, minimum cement content of 320 kg/m3, water-cement ratio of 0.4, 75mm of slump value and for a severe exposure condition. The design steps have been shown below.

$$f'_{ck} = f_{ck} + 1.65s = 35 + (5 \times 1.65) = 43.25 \frac{N}{mm^2}$$

So, corresponding to 43.25 N/mm2 target mean strength; water cement ratio required will be 0.40.

Based on this, we will calculate the water content. As per IS code, for 25-50mm water required is 186 liters with 3% increase in every 25mm increase in slump.

So, for 75mm slump value-

$$Water\ Required = 186 + \left(\frac{3}{100} \times 186\right) = 191.580\ l$$

Hence, the cement content will be

$$\frac{w}{c} = 0.4 => \frac{192}{c} = 0.4 => c = \frac{480kg}{m^3}$$

Volume of coarse aggregate is taken as 0.62 times. However, for every change in 0.05 in w/c ratio; we have to change 0.01 in the volume of coarse aggregates.

$$\therefore Volume\ of\ coarse\ aggregates = 0.640$$

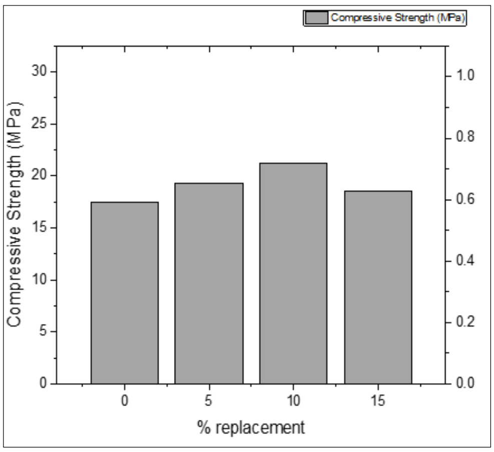
$$and, Volume\ of\ Fine\ aggregates = 1 - 0.64 = 0.36$$

The total quantity per unit volume is shown in Table 6.

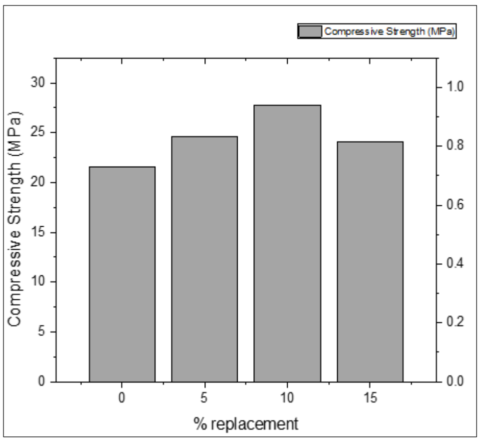
Table 6 Mix Design Values

Ingredient	**Values**
Cement	0.104 m^3
Water	0.192 m^3
Coarse Aggregate	1232.78kg
Fine Aggregate	693.43kg
W:C: FA: CA	*192: 330: 693.43: 1232.78*
SCBA	*0%, 5%, 10%, 15%*

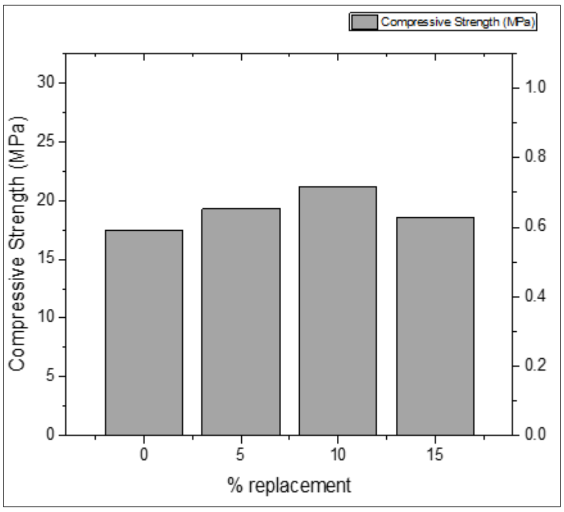
3. Results and discussion



(a) 7 days



(b) 14 days



(c) 28 days

Figure 1 Graph showing the variation of compressive strength

Compressive strength of M35 grade of concrete after partial replacement of cement with SCRB at various percentages and information about the effect of HCL on compressive strength are presented in this section. These findings are the result of experimental practises and analyses that are presented in this chapter.

4. Conclusion

According to the results of the experimental investigation, the compressive strength of concrete rises with the aid of SCBA if it is used to partly replace cement in concrete; however, this effect is reversed after the cement has been completely replaced. Additionally, it has been observed that the use of HCL for the curing of cubes in lieu of regular water is also effective in the improvement of compressive strength.

The following is a summary of the conclusion based on the experimental investigation. The compressive strength of the mix gradually diminishes over the course of seven days when the proportion of SCBA in the mix design is increased. The compressive strength of the cube will grow by a particular amount after 14 days have passed. The experiment found that the maximum compressive strength was achieved 28 days after 10% of the cement was substituted with SCBA.

After curing for 28 days, compressive strength is decreased to extremely low levels due to acid attack.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

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