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Properties of Cement Pastes Replaced Partially by Sugarcane Bagasse Ash

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Abstract

In the present study,experimental program is carried out to study the effect of sugarcane bagasse ash (SCBA) on the various properties of Ordinary Portland Cement (OPC). To do so, various paste specimens were cast with OPC replaced by 10%, and 20% SCBA by weight of cement. The studied factors include compressive strength, apparent porosity, ultrasonic pulse velocity, and sorptivity. To quantify the SCBA potential, the results of OPC replaced SCBA specimens were compared than that of the OPC specimen. From the results, at the higher percentage replacement of SCBA, compressive strength was found to reduce significantly. Moreover, results of an ultrasonic pulse velocity tests revealed that the quality of paste specimen reduces with the increase in percentage replacement of SCBA.

Keywords:OPC, sugarcane bagasse ash, compressive strength, quality test.

1. Introduction

Throughout the world, concrete is widely used in construction activities. Hence, it has been properly labeled as backbone to the infrastructure development of a nation [1]. Currently, our country is taking major initiative to improve and develop its infrastructure by constructing power projects and industrial structures to emerge as a major economic power. To meet this development, huge quantity of concrete is required [2]. Vast utilization of ordinary portland cement (OPC) for formation of concrete leads to various unwanted impact to the environment. Therefore, various materials like fly ash, brick waste, rice husk ash, sugarcane bagasse ash etc. have been introduced as a partial or complete replacements for the cement. Sugarcane is one of the main food crop in tropical and subtropical countries. It is the major resource for sugar production. India is the second largest producer of sugarcane in the world with 361,037,000 metric tonnes of production in a year [3-5]. Sugarcane consists of about 30% bagasse whereas the sugar recovered is about 10%, and the bagasse leaves about 8% bagasse ash as waste. As the sugar production is increased, the quantity of sugar cane bagasse ash (SCBA) produced will also be large and the disposal becomes great problem. SCBA has recently been tested in some parts of the world for its use as a cement replacement material.

2. Materials and Methods

2.1. Materials

The ordinary portland cement used in this study is of 43 grade and complying to IS codalprovision[10]. It was obtained from a he local distributor. Sugarcane bagasse ash was procured through India mart. Tap water (pH less than 7) was used in making the paste specimens.

2.2 Methods

OPC paste specimens and others with predetermined replacement quantities by SCBA (10% and 20%) was prepared and cured for 28 days. various tests such as bulk density, water absorption, apparent porosity, sorptivity and compressive strength were determined. In addition, comparison of the properties were performed with those of OPC paste specimens.

It contains amorphous silica and alumina which indicates cementing properties [6-9].

In the present study, paste specimens are casted with different percentages of SCBA as replacementby weight of cement (10% and 20%) and their properties are investigated. In addition, comparison of properties is performed with the control OPC specimen to assess its suitability for use in cement concrete.

3. Results and Discussion

3.1. Bulk Density

Variation of bulk density of paste specimens is shown in Fig. 1. It is obviously noticed that the bulk density of specimens decreases with increase in replacement of cement by SCBA. OPC paste recorded highest bulk density of 20.89 kN/m^3 among the three specimens. When cement is replaced by 10% SCBA in the paste specimen, bulk density was found to decrease to 17.09 kN/m^3 which amounts to about 18% lesser than that of OPC specimen. As the replacement of cement by sugarcane bagasse ash was further increased to 20%, the bulk density decreases

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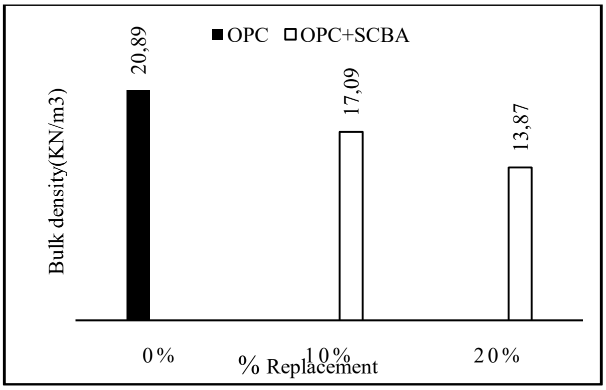

Fig. 1. Bulk density Vs % Replacement by SCBA

considerably to 13.87 kN/m^3. The decrease in bulk density in the paste specimens partially replaced with SCBA may be attributed to its lower unit weight when compared to that of portland cement. This could affect the porosity and in turn might cause reduction in compressive strength of the specimens.

3.2. Water Absorption

Water absorption is an important physical property which has a good bearing on other properties. Fig. 2 shows the water absorption response of the OPC paste and OPC replaced specimens Water absorption for the control OPC paste specimen is remarkably low at 8.04%. Water absorption shows an increase in the value with 12.41% when incorporated with 10% sugar cane bagasse ash. However, significant rise in water absorption of 22.35% was obtained when replacement percentage was further increased to 20 %. It is observed that specimens with lower bulk density exhibit higher water absorption. Increasing values of water absorption corresponding to percentage replacement by SCBA could be due to more interconnected pores in the specimen matrix.

3.3. Apparent Porosity

The porosity of a specimen is an indirect measurement of its durability property. Apparent porosity of the specimens in the present work was found as a simple assessment of their durability. Results of apparent porosity has been plotted in Fig.3. The figure indicates a general trend of increasing apparent porosity with percentage replacement of cement by sugarcane bagasse ash. Control OPC paste specimen shows lowest apparent porosity of 19.544%. No significantincrease in apparent porosity

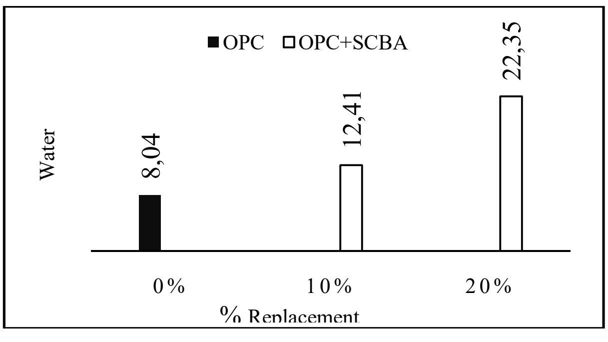

Fig. 2. Water absorption Vs % Replacement by SCBA

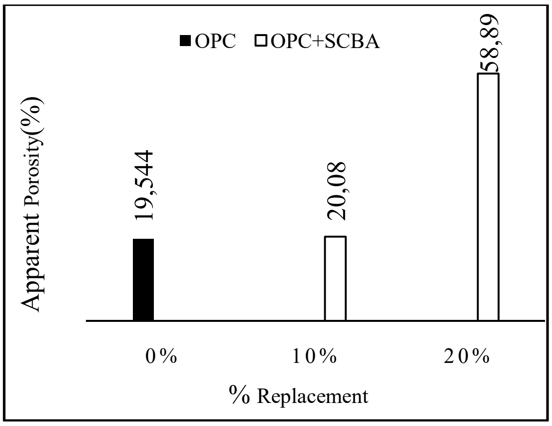

Fig. 3. Apparent Porosity Vs % Replacement by SCBA

occurred when OPC was replaced partially by SCBA up to 10%. For such paste specimen, the porosity was determined as 20.08%, which is slightly higher than that of OPC paste specimen. However, the apparent porosity increased noticeably at 58.89% for the paste specimen with 20% replacement by sugar cane bagasse ash. This amounts to nearly three times higher when compared with control ordinary portland cement paste specimen. It has been already observed that replacement by SCBA decreases bulk density and also increases water absorption. There is a direct relationship of porosity with water absorption. Specimens with higher porosity are likely to result in lower compressive strength due to lower bulk density.

3.4. Compressive Strength

The compressive strength is considered the most important of all the properties for a construction material. After 28 days curing, the specimens were tested for their strength and the results are shown in Fig. 4. As expected, OPC specimen recorded highest compressive strength of 67 MPa among the specimens. As the quantity of replacement of OPC increases, the 28-day compressive strength was seen decreasing considerably. Specimen with 20% replacement by SCBA yields the lowest compressive strength of 14 MPa which is remarkably lower than that of control OPC specimen. N/mm^2.As discussed earlier, replacement of cement by sugar cane bagasse ash makes the specimen lower in bulk density and higher in terms of absorption and porosity. With respect to the compressive strength, sufficiently high value of 38 MPa could be obtained with 10% replacement by SCBA.

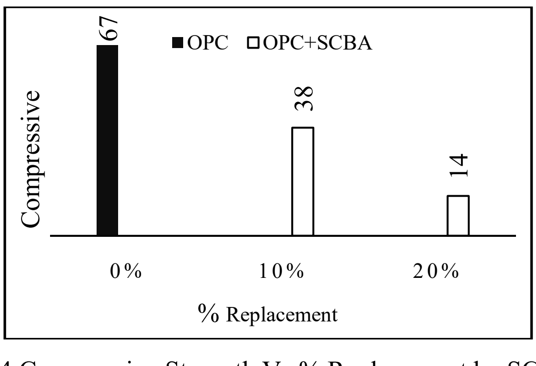

Fig.4.Compressive Strength Vs % Replacement by SCBA

3.5. Water Sorptivity

Water sorptivity is considered as a simple direct test in lieu of durability. Sorptivity was determined for all the specimens. Fig. 5 presents the plot between cumulative determined for all the specimens and are presented in Fig. 5 and Fig. 6. Fig. 5 shows the plot between cumulative water absorbed over the exposed surface area in g/mm2 and square root of time elapsed over a period of 300 minutes. Obviously, the cumulative water absorption increases with percentage replacement of cement by SCBA. In order to find the sorptivity of the specimens, the slope of initial straight portions of the plot are determined which are shown in Fig. 6.

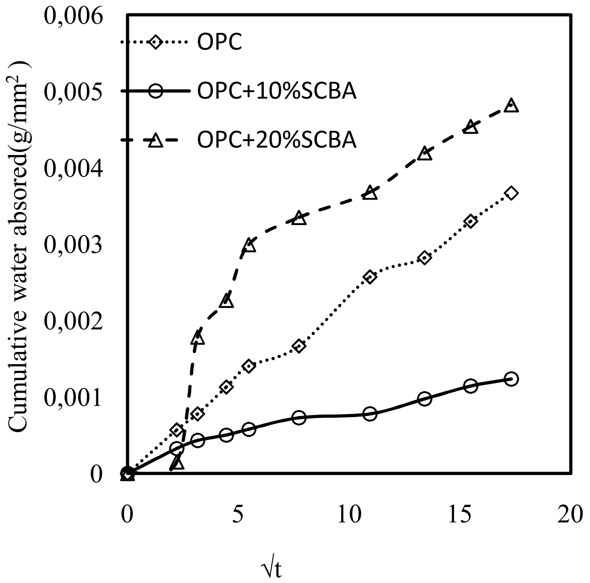

Fig.5. Cumulative water absorbed Vs Square root to time

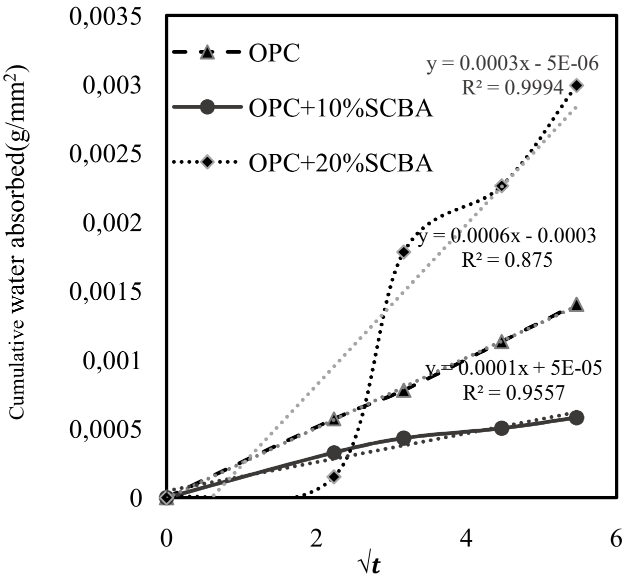

Fig.6. Finding slope of the curve for sorptivity

Table-1. Quality of Paste for Rebound Hammer Number

Specimen ID	Av. Rebound hammer Number	Quality of Paste
OPC	30	Good Layer
OPC+10% SCBA	27	Fair
OPC+20% SCBA	22	Poor

Table-2. Pulse Velocity for Paste Quality Grading

Specimen ID	Pulse Velocity (Km/s)	Paste Quality Grading
OPC	3.8	Good
OPC+10%SCBA	3.6	Good
OPC+20%SCBA	3.2	Medium

3.6. Rebound Hammer and Ultrasonic Pulse Velocity

Non-destructive tests on the specimens were conducted using Ultrasonic pulse velocity (UPV)[11] andRebound hammer tests [12]. The results of rebound hammer test are summarized in Table 1. OPC paste specimen yielded an average rebound hammer number of 30 which indicates good quality of paste. However, increase in the SCBA content resulted in notable decrease in rebound hammer of the specimens. When the OPC is replaced by 10% and 20% SCBA, the values of rebound hammer reduced to 27 and 22 respectively indicating the quality of the specimens as fair and poor.

Table 2 shows the results of UPV test conducted on the paste specimens. Based on the results obtained, it is discovered that the quality of specimens decreases with increase in % replacement by SCBA. This may be due to increase in voids for these specimens.

4. Conclusion

1.Bulk density decreases with increase in percentage replacement by SCBA.
2.Water absorption rises with higher replacement level as compare to OPC specimen.
3.Compressive strength of OPC replaced by SCBA was observed to be though replacement up to 10% still retains satisfactory strength.
4. Apparent porosity increases with increase in replacement level of OPC by SCBA.
5. Water sorptivity increases when OPC is replaced by SCBA.
6. Based on the results of non-destructive tests by UPV and Rebound hammer, it may be suggested that the use of SCBA up to 10% in terms of quality of paste specimens.

SCBA is a by-product of sugarcane which contain amorphous silica and alumSina which is beneficial for cement concrete. By using these material in cement concrete, environmental pollution may be substantially reduced. Moreover, economic gain may be achieved by suitable replacement of SCBA in cement concrete.

Disclosures

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