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STUDY ON THE PROPERTIES OF CONCRETE WITH DEMOLISHED WASTES AND SUGARCANE BAGASSE ASH

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Abstract

The increasing demand and scarcity of construction materials like cement and aggregates make the researches all over the world nowadays to focus on finding ways of utilizing industrial wastes and demolished wastes as source of raw materials and eco-friendly alternatives for concrete ingredients. Using recycled aggregates in concrete leads to preservation of the environment and promotes sustainable development. Recycled aggregate is obtained after crushing and screening of the construction rubble from tested laboratory specimens like cubes and cylinders. Sugarcane bagasse ash, the by-product of Sugarcane is the most fibrous material and contains alumina and silica. Bagasse ash used not only to reduce consumption of cement, cost of making concrete and pollution of the environment but also consumes the excess calcium present in the cement improving the durability related properties of concrete. In this work, mix design for conventional M20 grade concrete is made. Based on the literature survey, conventional coarse aggregate is partially replaced by 30% with recycled coarse aggregate. In this 30% recycled aggregate contained concrete, cement is partially replaced by 0, 5, 10, 15 and 20% with Sugarcane bagasse ash. Experimental study was carried out to investigate the mechanical properties. Based on the test results, the optimum replacement level of cement with Sugarcane bagasse ash is observed as 15% for overall efficiency.

Keywords: Alternatives To Concrete Ingredients; Sugarcane Bagasse Ash (SBA); Recycled Coarse Aggregate (RCA); Mix Design; Hardened Properties.

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1. Introduction

The growing worldwide generation of waste is very much worrying and requires management strategies that focus on environmental sustainability. Investments in research to enable the application of waste can promote the development of new materials for the construction industries. Consequently, the use of waste can minimize both the cost associated with disposal in landfill sites and the final cost of the product. The improper disposal of construction waste in the environment causes several problems, such as, floods, the proliferation of vectors harmful to human health and the degradation of urban landscapes. In order to minimize these problems, recycling is a good alternative. India is one of the largest sugarcane producers in the world. During ethanol and sugar production, sugarcane bagasse is generated. This product is burned in sugarcane mill boilers to generate energy. For each ton of burned bagasse, 24 kg of ash is produced. In the 2013/14 harvest, 658 million tons of sugarcane was produced which generated 4 million tons of ash. The final disposal of this waste is a problem for sugar mills. In this research, two kinds of waste generated on large scale in India are used: demolished wastes (DW) and sugarcane bagasse ash (SBA).

Anthony Torres et al (2016) used RCA to partially replace the coarse aggregate in the mixtures at 10%, 20% and 30% replacement by mass. Multiple variables such as the aggregate type and size, concrete age (7, 14 and 28 days), curing regimen and water cement ratio were investigated to optimize at high strength concrete mixes using local materials. RCA based high strength concrete had a low end strength of 72.9 MPa at 7 days from 30% RCA replacement and a high end strength of 93MPa at 28 days from the 10% RCA replacement. Pandurangan et al (2016) reported the residual adhered mortar present in aggregates treated by acid, mechanical and thermal treatment methods as 2%, 5% and 11% respectively. Juliana Moretti et al (2016) tried construction waste and sugarcane bagasse ash to partially replace basalt stone and quartz sand. Mechanical properties of concrete made with 30% of SBA and 30% of construction waste were similar to the reference concrete. Joint application of SBA and construction waste achieved 93% of compressive strength.

Dilbas et al (2014) investigated the replacement of coarse aggregate with recycled aggregate proportion as 30% and cement with silica fume proportion as 5% in concrete mixtures. The proportion increases the ratio of tensile splitting strength to the compressive strength. Sallehan Ismail et al (2014) determined the strength and drying shrinkage of concrete containing RCA as treated with two different methods as soaked in hydrochloric acid at 0.5mol (M) concentration and impregnated with calcium metasilicate solution. After 60% treatment, the particle density, water absorption and mechanical strength of RCA are significantly improved and also treated RCA improved surface contact and bond strength between cement matrix and the aggregate.

Sadiqul Hasan et al (2014) investigated the concrete properties by using recycled aggregate as replacement of coarse aggregate (0%, 25%, 50%, 75%, 100%) and bagasse ash as the partial replacement of cement observed that there is significant decrease of concrete strength with the addition of recycled aggregate but, effective increment of concrete strength by using up to 10% of bagasse ash. Zoran Jure Grdic et al (2010) justified with partial replacement of coarse aggregate with recycled coarse aggregate by 0%, 50% and 100%. Replacement of 50% of CA decreased the density and compressive strength as 2.12% and 3.88% respectively. Replacement of 100% of decreased the density and the compressive strength as 3.40% and 8.55% respectively.

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Miren Etxeberria et al (2007) Considered coarse aggregate replacement 0%, 25%, 50% and 100% with recycled coarse aggregate and Medium compressive strength concrete made with 50% or 100% of RCA. The compressive and tensile strength of recycled aggregate concrete were higher than that of conventional concrete.

The DW and SCBA have the potential to be recycled because of the high volume that is produced and also because of the fact that they have similar characteristics to the natural aggregates used in concrete. This study aims to evaluate the potential for the joint application of these wastes to replace cement and coarse aggregates that are consumed on a large scale in all over the world.

2. Materials and Methods

Conventional concrete of grade M20 is designed with 30% conventional coarse aggregate replaced with recycled aggregate. In this concrete, cement is partially replaced with SBA up to 20%. Concrete prepared and workability tests by slump cone test and compaction factor test are conducted. For determination compressive and tensile strength respectively, 150mm cubes and 150×300mm cylinders are cast conventionally with machine mixed concrete.

2.1. Materials

Ordinary Portland cement 53 grade (Ramco brand) conforming to IS: 269-1976 is used in concrete. The physical properties of the cement are listed in Table 1. SBA black in colour is collected during the cleaning operation of a boiler operating in the Madras Sugar Mill, located in the city of Tirukovilur, Tamil Nadu. The ash collected is sieved through IS standard sieve size 90µm. It is then measured by volume to replace the cement at 5%, 10%, 15% and 20%. Specific gravity of SBA is 2.1. The chemical properties of cement and SBA are presented in Table 2 for comparison.

Table 1: Physical Properties of OPC 53 Grade Cement

S.No	Properties	Cement	SBA
1	Specific gravity	3.0	2.10
2	Fineness	9.8%	8.8%
3	Normal consistency	30%	33%
4	Initial setting time	37 min	32 min
5	Final setting time	412 min	410 min

Table 2: Chemical composition of Cement and SBA

S.No	Property	Cement	Bagasse Ash
1	SiO_2+Al_2O_3+Fe_2O_3(%)	32.41	88.4
2	Cao (%)	62.21	1.8
3	MgO (%)	0.66	1.6
4	Na_2O+K_2O (%)	0.88	4.2
5	SO_3 (%)	1.85	0.1
6	LOI (%)	3.4	0.8

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Locally available river sand of specific gravity 2.6, fineness modulus 2.30 and water absorption 0.74 and conforming to Grading zone II of IS: 383 –1970 is used. In the present experimental work, tap water suitable for concreting and curing which has pH value of 7 as per IS: 456-2000 was used.

Crushed granite aggregate with a maximum size of 20mm is used as coarse aggregate. RCA is obtained from the laboratory tested concrete specimens with nominal size 20 mm. The properties of conventional coarse aggregate and RCA are presented in Table 3. The individual aggregates are blended to get the desired combined grading. Recycled coarse aggregate is surface treated by low concentration acid to minimize the weak or loose mortars attached on the surface. RCA is soaked in 1M Hydrochloric acid (HCl) for 24 hours and then washed in normal water to remove the adhered mortar and then heated in muffle furnace at a temperature of 500°C for 2 hours, resulting in a thermal crash by which the remaining adhered mortar is removed by hitting the sample with rubber mallet.

Table 3: Properties of coarse aggregates

S.No	Properties	Conventional CA	RCA
1	Specific gravity	2.7	2.46
2	Fineness modulus	7.89	5.85
3	Water absorption (%)	1.10	4.16
5	Crushing strength (MPa)	27	21
6	Impact strength (MPa)	25.6	-
7	Residual mortar content (%)	-	36.6

2.2. Preparation of Concrete

Bagasse ash and recycled aggregates used for this study are shown in figure 1. Proportions for concrete mix design of M20 are carried out according to IS: 10262-2009 recommendations. For making the mixes, partially 30% of the conventional coarse aggregates are replaced with RCA. Containing cement partially replaced with SBA (0, 5, 10, 15 and 20%) by volume and 30% coarse aggregates replaced with RCA by weight, totally five different proportions of concrete are considered.

Figure 1: Recycled constituents

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2.3. Testing for Properties

The concrete prepared is first subjected to workability tests and then the strength tests with relevant specimens as explained below:

Workability Test: With the prepared concrete, slump cone test and compaction factor test are conducted in the standard manner as recommended by the Indian specifications. The variation of workability properties is shown in figure 2.

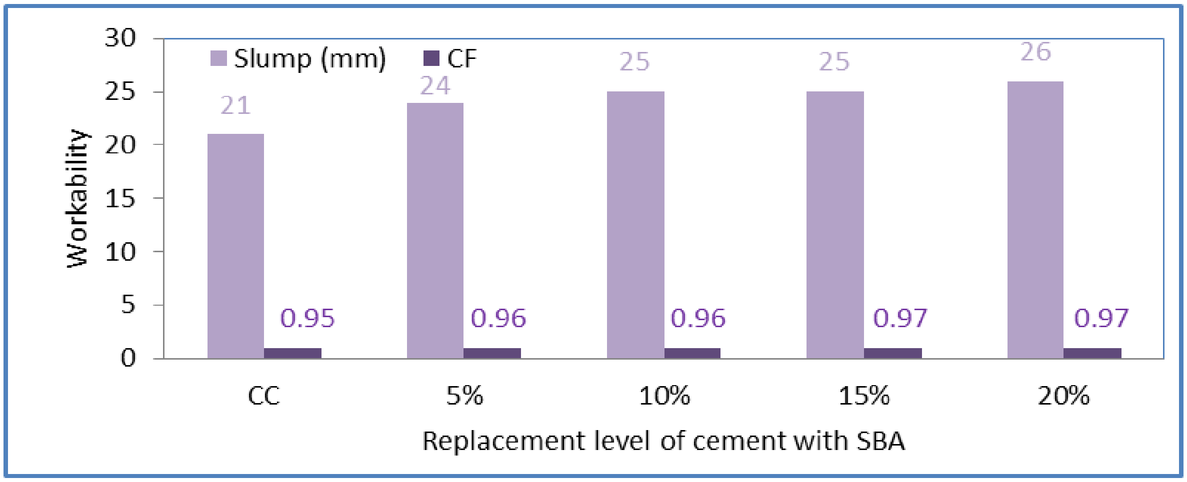

Figure 2: Variation of workability properties

Strength test: Using standard steel moulds, concrete cubes and cylinders are cast and concrete is compacted by placing on the vibrating table. After 24 hours of casting, the specimens are demoulded and put for pond curing in a curing tank. The appropriately cured specimens are tested on 7 and 28 days of curing and the compressive strength and split tensile strength are obtained. The views of testing are shown in figure 3. The variation of compressive strength is shown in figure 4 and that of splitting tensile strength is shown in figure 5.

a. Compression b. Split tension

Figure 3: Testing of concrete specimens

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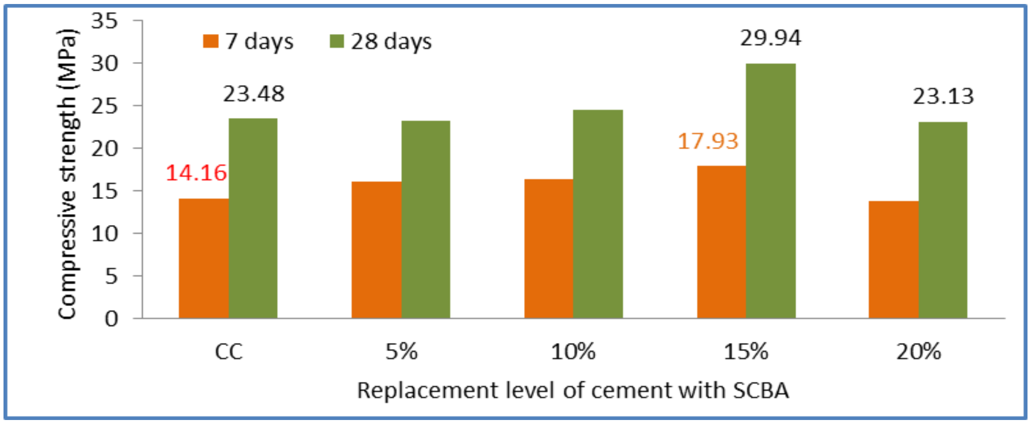

Figure 4: Variation of compressive strength for different trial mixes

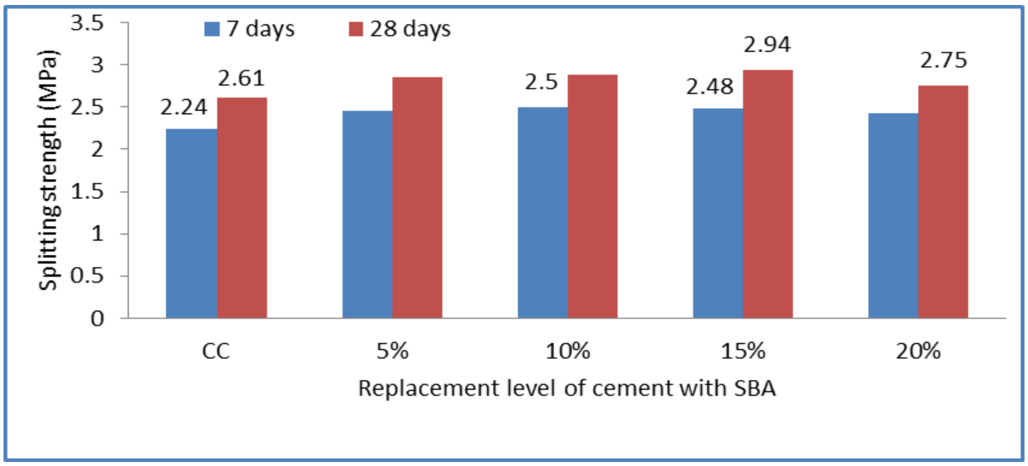

Figure 5: Variation of tensile strength for different trail mixes

Weight observation: As the replacement is by volume of cement with SBA, the weight of net concrete will obviously be slightly less and hence there will be decrease in the density of concrete. Weight of concrete is observed using concrete cylinder specimens and the weight less than the conventional concrete is obtained for different replacement levels and illustrated in figure 6.

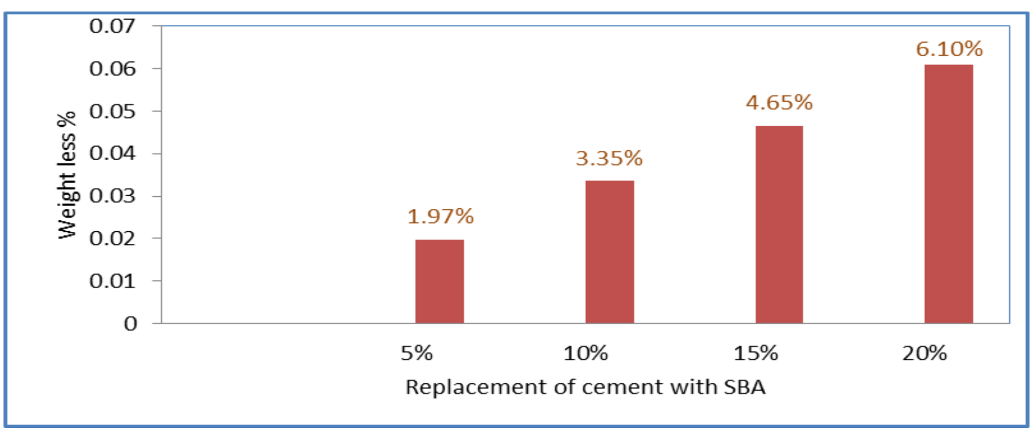

Figure 6: Weight less compared to conventional concrete

3. Results and Discussions

Workability of concrete increased for the increase in the replacement level of cement with SBA for same water/cement ratio compared to conventional concrete as shown in figure 3. Both the slump values and the compaction factor values agree with each other for the assessment of the workability characteristics of concrete.

The compressive strength increases up to 15% replacement level and decreased thereafter for both 7th day and 28th day testing compared to conventional concrete as shown in figure 5. SBA addition leads to enhance the compactness and fills the pores in the concrete thus increases the strength of concrete. The optimum dosage of replacement 15% yielded strength 29% greater than the conventional concrete.

The splitting tensile strength of 7 days increased up to 10% replacement level and the 28 days strength increased up to 15% replacement level as shown in figure 6. The maximum tensile strength at 28 days reached at 15% replacement level is 12.6% greater than the conventional concrete. Moreover, the 20% replacement level also yields 5.4% greater than the conventional concrete.

Obviously, for the replacement level increase, there is decrease in weight of concrete. The % decrease in weight for increase in the replacement level is illustratively shown in figure 7 which is almost gradually linear.

4. Conclusions and Recommendations

- The combination of SBA and RCA increases workability of fresh concrete and therefore plasticizer is not needed.
- The results show that the combination of Sugarcane bagasse ash and recycled coarse aggregate in blended concrete has significantly higher compressive strength, tensile strength and slightly light weight compared to that of the conventional cement concrete.
- It is found that coarse aggregate replaced with 30% recycled coarse aggregate; cement could be advantageously replaced with Sugarcane bagasse ash up to maximum limit of 15% feasibly.

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