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Incorporation of Bagasse Ash and Stone Dust in Cement Concrete

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Abstract

Nowadays, one of the main concerns of the researchers, is to control the increasing rate of pollution. Several studies are conducted to overcome the burden of environmental pollutants. The Sugarcane bagasse ash (SBA) being pollution needs proper disposal. In addition to SBA, the stone dust (SD) being remaining of the stone processing plants, also requires proper disposal. SBA due to cementitious nature and SD being inert nature can be used as a partial substitute to the cement and sand, respectively. Hence, the suitability of the partial replacement of the cement with SBA and sand with SD, needs to be explored. In this pilot study, the slump, compressive strength (CS) and splitting tensile strength (TS) of the normal strength concrete for partial replacement of cement with SBA and of sand with SD are examined. 9% of cement weight is replaced with the same amount of SBA. And 40% and 50% of sand weight is replaced with equal weight of the SD. The specimens are tested according to the ASTM standards. The highest slump is noticed for the normal concrete having zero percent of SBA and SD. The samples comprising of replacement of 9% SBA and 40% SD showed the highest CS as compared to other samples. The incorporation of 9% SBA and 50% SD gave maximum TS. Hence, the partial replacement of cement with SBA and sand with SD, can be employed for strength improvement of normal strength.

Keywords: Normal strength concrete, Sugarcane bagasse ash, stone dust, strength improvement.

1. INTRODUCTION:

In the modern era, the researchers are trying to utilize the industrial wastes in some beneficial products to overcome the burden of pollution. The industries have significant role for the financial stability of the world but on other hand the by-products and wastes generated in the industries during the manufacturing process also grounds a huge burden of pollution on the society. One of the wastes produced by Sugarcane industry is bagasse ash. Bagasse ash being waste of the sugar mills is damped out in valuable lands because of which various ecological issues have been

accounted for (Cokca et al. 2009). Janjaturaphan and Wansom 2010 reported that the Sugarcane bagasse ash (SBA) is a cementitious material which carries good binding properties and could be utilized for improving the engineering properties of the soil. Sugarcane bagasse could be used as a substitute for the manufacture of particleboards and it could also be utilized for various applications of civil engineering like construction of floors etc. (Battistelle et al. 2016; dos et al. 2014). Castaldelli et al. (2013) stated that the SBA could be employed for preparing concrete and other building material, such as blocks and bricks.

Like the SBA the stone dust (SD) being waste material is also available in large quantity. SD can reduce the cost of concrete by replacing the sand partially. The dust produced during the processing of stone in the stone processing plant, normally surpasses the limit specified by the ASTM C778-17 and the sand needs to be washed. This process shows a significant economic loss in the available natural resources, and an increase of waste that makes dust disposal problem at quarries (Malhotra & Carette 1985; Kalcheff 1977), since, only slight amounts are used as a filler material in asphalt concrete. Balamurugan et al. (2013) reported that significant improvement was reported in mechanical strengths of M20 and M25 grade concrete when sand was replaced by SD. Safiuddin et al. (2007) investigated the effectiveness of the sand replacement with quarry dust for cement concrete. It was stated that the sand replacement with quarry dust, resulted minute rise in the dynamic modulus of elasticity with reduced compressive strength as compared to that of the plane concrete.

In the current research program, the behaviour of the normal strength concrete for the partial replacement of cement with Sugarcane bagasse ash and sand with stone dust are evaluated. The general aim is to examine the effectiveness of the usage of Sugarcane bagasse ash and stone dust in the same mix of the concrete. In this study, the compressive and splitting tensile strengths along with the slump of the concrete are evaluated for replacement of the 9% cement weight with same amount of Sugarcane bagasse ash and 40% and 50% of sand weight with same quantity of the stone dust.

2. MATERIALS AND CASTING, PROPORTIONING, AND DESIGNATION:

2.1 Materials

Ordinary Portland cement (OPC) complying with the ASTM C150 Type I, is utilized in this experimental study. The maximum size of coarse aggregates is taken as 3/4 inch (19 mm). Sand graded between No.4 (4.75mm) sieve and No.100 (150 μm) is used in making of all samples. The stone dust used complies with the requirements of ASTM C33/33M-18. Locally available Sugarcane bagasse ash of Mardan Sugar Mill is used in the current investigation. Sugarcane bagasse ash obtained is sieved through No. 200 sieve.

2.2 Samples preparation and properties

The samples for each test are cast and cured according to the ASTM standard specified for corresponding test. The mix design of the 1:2:4 is used for the concrete with water to cement ratio of 0.68. The samples used in the study are designated as NC, 9B:40S, and 9B:50S. The NC designates the sample, which have zero percent of

Sugarcane bagasse ash (SBA) and stone dust (SD). In each of the 9B:40S, and 9B:50S, the 9B presents the percentage of cement weight replaced by same quantity of SBA while 40S presents the percentage of the sand replaced by same amount of SD. Hence 9B:40S is the sample having 9% cement weight replacement with SBA and 40% of sand with SD. Designations and mixing properties of the samples are demonstrated in the Table 1. Three samples are tested for each property and mean of the three results is considered as a final value for the corresponding property.

Table 1. Sample designation and mixing properties

Sample	Mix design	W/C	Binder		Fine Aggregate		Coarse Aggregate
			OPC	SBA	River Sand	Stone Dust	
NC	1:2:4	0.68	100%	0%	100%	0%	100%
9B:40S			91%	9%	60%	40%	100%
9B:50S			91%	9%	50%	50%	100%

OPC = Ordinary Portland cement, NC = Normal concrete (0% SBA and 0% SD)
SBA = Sugarcane bagasse ash

3. EXPERIMENTAL PROCEDURES

The standard procedure of the ASTM C143 / C143M-15a is used for the slump test. ASTM standard C39 / C39M-17 is used to perform the compressive strength test of the standard size cylindrical specimens in 2000 kN compression testing machine. The cylindrical standard size specimens are tested according to the ASTM standard C496 / C496M-17 for determining the splitting tensile strength.

4 RESULTS AND DISCUSSIONS

4.1 Slump

Slump test results of the normal concrete (NC) specimens and Sugarcane bagasse ash (SBA) and stone dust (SD) incorporating specimens (i.e. 9B:40S and 9B:50S) are displayed in the Table 2. The slumps of 3.62 inch, 2.87 inch, and 2.56 inch are noticed for NC, 9B:40S, and 9B:50S, respectively. The NC having zero percent of SBA and zero percent of SD gave the highest slump for the same W/C ratio. The slumps of the 9B:40S and 9B:50S are 0.75 inch and 1.06 inch, repectively, less than that of the NC.

Table 2. Results of slump tests

Samples	W/C ratio	Slump (Inch)	Slump (%)	Slump difference (%)
(1)	(2)	(3)	(4)	(5)

NC	0.68	3.62	100	0
9B:40S	0.68	2.87	79	21
9B:50S	0.68	2.56	71	29

The percentage comparsion of the slumps and their percent differences with respect to NC, are given in the fourth column and fifth column, respectively, of the Table 2. The slump of the 9B:40S and 9B:50S, reduced by 21% and 29%, respectively as compared to that of the NC. Hence, it can be deduced that the addition of SBA and SD into concrete may reduce its workability. The possible reason for the decrease in the slumps may be the high tendency of the SD for water absorption due to its clayey nature.

4.2 Compressive Strength:

28 days compressive strength (CS) test results of the normal concrete (NC) specimens and Sugarcane bagasse ash (SBA) and stone dust (SD) incorporating specimens (i.e. 9B:40S and 9B:50S) are revealed in the second column of Table 3. The CS of 3009.9 psi, 3221.1 psi, and 3194.7 psi, are observed for NC, 9B:40S, and 9B:50S, respectively. The CS of the 9B:40S and 9B:50S are 211.2 psi and 184.8 psi, respectively, greater than that of the NC. The maximum CS of 3221.1 psi is noted for 9B:40S.

Table 3. Results of compressive strength (CS) and splitting tensile strength (TS) tests

Samples	**28 days CS (psi)**	**28 days TS (psi)**
(1)	(2)	(3)
NC	3009.9	273.46
9B:40S	3221.1	251.58
9B:50S	3194.7	274.45

The percentage comparison of the CS is demonstrated in the Figure 1. The CS of the 9B:40S and 9B:50S are found 7% and 6%, respectively, more than that of the NC. It can be concluded that the collective role of both SBA and SD may resulted in the improved CS. The Sugarcane bagasse ash may be helpful in improving the CS by virtue of its cementitious nature, which can bond excess quantity of the inert ingredients (aggregates) of the mix. Similarly, the SD may also be helpful in strengthening the bond between the inert materials due to its clayey nature. Hence, the usage of optimized amount of the SBA and SD may be helpful in upgrading the CS of the concrete.

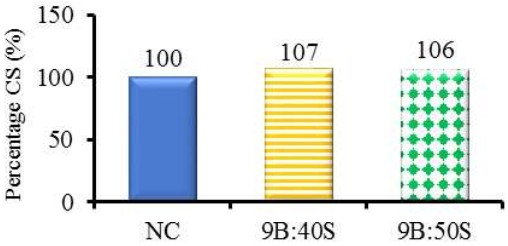

Figure 1. Percentage comparison of the compressive strengths (CS)

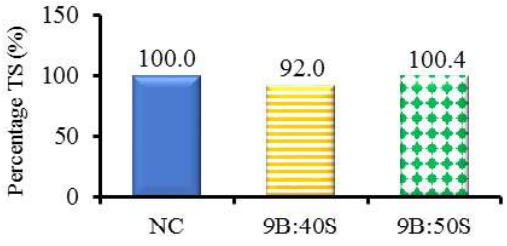

Figure 2. Percentage comparison of the splitting tensile strengths (TS)

4.3 Splitting tensile Strength:

28 days splitting tensile strength (TS) of the normal concrete (NC) specimens and Sugarcane bagasse ash (SBA) and stone dust (SD) incorporating specimens (i.e. 9B:40S and 9B:50S) are demonstrated in the third column of Table 3. The TS of 273.46 psi, 251.58 psi, and 274.45 psi are noticed for NC, 9B:40S, and 9B:50S, respectively. The TS of the 9B:50S is 1 psi greater than that of the NC. While the TS of the 9B:40S is 21.88 psi less than that of the NC. The 9B:50S outperformed the other SD samples in upgrading TS.

The percent comparison of the TS is presented in the Figure 2. The TS of the 9B:40S is 8% less than that of the NC. And the TS of 9B:50S exceeded the TS of the NC by minute amount of 0.4%. A significant variation in the TS of the concrete is noticed by varying the amount of partial replacement of the sand with SD. As compared to sand samples with 0% SD, increase in the TS of the samples having partial replacement of the sand with SD is observed. This can be associated with the improvement in the packing and binding among the SD particles and other surrounding aggregates due to presence small size particles. But this increase in clinging can be limited only to a specific percent for any unique mix design. So, use of the optimized percentages of the partial replacement are very important for attaining the maximum possible TS of any mix design of concrete. The percentage of the SBA and SD need more in-depth optimization for the TS.

5. CONCLUSIONS:

Following conclusions are made from the present investigation:

- The slumps of the 9B:40S and 9B:50S, reduced by 21% and 29%, respectively, as compared to that of the normal concrete (NC).
- The compressive strength of the 9B:40S and 9B:50S, increased by 7% and 6%, respectively, as compared to that of the NC.
- Splitting tensile strength (TS) of the 9B:40S is 8% less than that of the NC. And the TS of 9B:50S increased by 0.4% than that of the NC.

The experimental outcomes showed significant improvement in the considered strength properties of the concrete by the partial replacement of the cement with Sugarcane bagasse ash and sand with stone dust. The optimization of the percentages of the partial replacements with Sugarcane bagasse ash and with stone dust in NC is under consideration in the parallel study.

6. ACKNOWLEDGEMENTS:

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