PROPERTIES OF CONCRETE MODIFIED WITH SUGARCANE BAGASSE ASH AND STONE DUST

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ABSTRACT

This study evaluates the suitability of sugarcane bagasse ash (SCBA) and stone dust (SD) as a partial replacement of Ordinary Portland Cement (OPC) in concrete. The sugarcane bagasse (SCB) is used as fuel in the boilers of many sugar factories in Bangladesh. The SCB burns at about 500°C to produce heat in such cases. According to the previous studies the chemical composition of SCBA and SD revealed that such by products are likely to be pozzolanic. Sugarcane bagasse ash and stone dust both were passed through 0.074mm sieve and used equal in amount to prepare a mix as a replacement OPC in concrete, then OPC was replaced by weight in ratio of 10%, 20% and 30%.The speciemen were tested for uniaxial compressive strength test, flexural strength and static elastic modulus test. The results shows that at 28 days specimen the compressive strength increased by 6% at 10% replacement of OPC. The flexural strength and modulus of elasticity were increased by 4% and 73% respectively for 10% replacement of OPC. The test results indicated that up to 10% replacement of OPC by SCBA and SD results in better for particular concrete properties and further environmental and economic advantages can also be exploited by using bagasse ash as a partial replacement of OPC material.

Keywords: *Sugarcane bagasse ash (SCBA), stone dust (SD), ordinary portland cement (OPC), compressive strength, flexural strength*

1. INTRODUCTION

Concrete is by far one of the most important building material and widely used construction material in the world. Over 10 billion tons of concrete are produced each year (Meyer, C., 2009). The consumption of concrete is increasing all over the world due to the availability of the component material, simplicity of the production, application covers a large variety of construction works, it is mouldable, durable, relatively fire resistant. The most important characteristic is that it can be engineered to satisfy almost any reasonable set of performance specification. Portland cement is the most important constituent of concrete. But cement manufacturing consumes large amount of energy about 7.36*106 KJ per ton of cement (Tarun, R. N., 1996). On the other hand approximately 1 ton of CO2 is released into the atmosphere during the production of 1 ton of cement. On the other hand the production of concrete requires large amount of natural resources. The coarse aggregates such as granite and limestone are mined from the earth, the fine aggregate mainly comes from the rivers and the raw material for cement, limestone, is also mined from the earth. This occurs a considerable strain on the non-replenish able resources. The way through which the concrete production is to achieve sustainability is the reduction of cement in concrete. Over the last few decades, research has uncovered several wastes and by product material from various industries as potential partial cements replacement material in concrete. The commonly used waste or by product materials are fly ash, slag, silica fume, coconut shell ash, coconut bagasse ash, sugarcane bagasse ash, stone dust etc. Sugarcane bagasse ash and stone dust are used in concrete to achieve energy conservation and economic, ecological and technical benefits. They can be used in concrete as pozzolanic mineral admixture. According to ASTM C125, pozzolan is a siliceous or siliceous and aluminous material which itself possesses little or no cementitious value but will in finely divided form and in presence of moisture, chemically reacts with calcium hydroxide at ordinary temperature to form compounds possessing cementitious property (Nadia, S. I., 2013). The use of SCBA and SD in combination in concrete has significant environmental and economic benefits compared with OPC. One of the primary advantages these materials over traditional cements from an environmental standpoint is the much lower CO2 emission rate from their manufacture in comparison with the production of OPC (Roy, D.M., 1999). In addition, their use in concrete provides a use of such materials otherwise these would be waste products of industry to be disposed of at great cost.

The main objective of this thesis is to investigate the suitability of sugarcane bagasse ash and stone dust as a replacement of cement in the production of concrete. It is necessary to reduce the production of cement worldwide, because the main constituent material of cement is lime stone. With the increasing demand of concrete all over the world the production of cement has been increased rapidly. For the production of cement a huge amount of lime stone is mined from the earth. This places a considerable strain on the non-replenish able natural resources (Onera, A., 2005). On the other hand the production of each ton of Portland cement releases an equal amount of CO_2 into the atmosphere. At the same time the production of OPC is very energy consuming. So it has become a great concern of the researchers on this field to find a suitable replacement of OPC.

2. METHODOLOGY

At first the materials were collected for the tests. Then the properties of the materials were determined. After that the dimension of the specimen were selected. Then the concrete specimens were casted. Then the specimens were cured in water. After instrumental setup the specimen were tested for different tests. Then the specimens were tested and data were collected from the tests. From the collected data the tables were prepared and the graphs were plotted. By analysing the tables and graphs the results were prepared.

3. ILLUSTRATIONS

3.1 Materials

3.1.1 Fine Aggregate

Coarse sand used as fine aggregates having specific gravity 2.5 and fineness modulus (FM) value 2.94.

3.1.2 Coarse Aggregate

Stone chips used as coarse aggregates having specific gravity 2.76 and FM value 3.29.

3.1.3 Cement

Various physical properties of ordinary Portland cement given below:

Table 1: Physical properties of cement

Property	Test Result
Specific Gravity	3.17
Normal Consistency	27%
Initial Setting Time	107 min
Final Setting Time	225 min

3.1.4 Sugarcane Bagasse Ash (SCBA)

Various physical properties of sugarcane bagasse ash given below:

Table 2: Physical properties of sugarcane bagasse ash

Property	Values
Specific Gravity	2.17
Color	Black
Density(gm/cm^3)	1.13
Moisture Content	5.64%

3.1.5 Stone Dust (SD)

Various physical properties of sugarcane bagasse ash given below :

Table 3: Physical properties of stone dust

Property	Values
Specific Gravity	2.83
Color	Pinkish Gray
Density(gm/cm^3)	2.03
Moisture Content	6.58%

3.1.6 Concrete Mix Proportions

Cement = 0.5 Kg
Fine aggregate = 1.45 Kg
Coarse aggregate = 1.75 Kg
Water = 0.25 Kg

3.2 Test works

3.2.1 Uniaxial Compressive Strength Test (UCS)

Three duplicate 4×8 inch cylinders were tested at 3, 7, 28, and 90 days after casting. The cylinders were demolded at 24 hrs and moist cured for the duration of their lifetime. Using a UTM machine, uniaxial compressive load was applied. The failure load was measured and used to calculate the compressive strength. Figure 3.7 shows the experimental setup of uniaxial compressive strength test and figure 3.8 shows the failure pattern of the specimen. It was observed that the failure pattern is mortar failure and shear failure.

3.2.2 Flexural Strength Test (FS)

Three duplicate2×2×8inch beams were tested at 3, 7, and 28 days after casting. Flexural tests of moist-cured specimens shall be made as soon as practical after removal from moist storage. Surface drying of the specimen results in a reduction in the measured flexural strength. When using moulded specimens, turn the test specimen its side with respect to its position as moulded and centre it on the support blocks .When using sawed specimens, position the specimen so that the tension face corresponds to the top or bottom of the specimen as cut from the parent material. Centre the loading system in relation to the applied force. Bring the load-applying blocks in contact with the surface of the specimen at the third points and apply a load of between 3 and 6 % of the estimated ultimate load. Using 0.004 in. (0.10 mm) and 0.015 in. (0.38 mm) leaf-type feeler gages, determine whether any gap between the specimen and the load-applying or support blocks is greater or less than each of the gages over a length of 1 in. (25 mm) or more. Grind, cap, or use leather shims on the specimen contact surface to eliminate any gap in excess of 0.004 in. (0.10 mm) in width. Leather shims shall be of uniform1⁄4 in. (6.4 mm) thickness, 1 to 2 in. (25 to 50 mm) width, and shall extend across the full width of the specimen. Gaps in excess of 0.015 in. (0.38 mm) shall be eliminated only by capping or grinding. Grinding of lateral surfaces should be minimized inasmuch as grinding may change the physical characteristics of the specimens. Capping shall be in accordance with the applicable sections of Practice C 617. Load the specimen continuously and without shock. The load shall be applied at a constant rate to the breaking point. Apply the load at a rate that constantly increases the extreme fiber stress between 125 and 175 psi/min (0.86 and 1.21MPa/min), when calculated in accordance with 8.1, until rupture occurs.

3.2.3 Static Elastic Modulus Test (SEM)

The elastic modulus was measured at 3, 7 and 28 days. The test was performed using three duplicate 4×8 inch cylinders. Similar to those used for the compressive strength test, the cylinders were demolded at 24 h and moist cured until moments before testing at 3, 7 and 28 days. This measurement takes into effect the elastic region from the 50 micro strain point to 40% of the ultimate (failure) load for the age tested, otherwise known as the chord modulus. The readings were analysed and converted to strains and compared against the applied stress to quantify the elastic modulus for the concrete.

3.2.4 Results and Graphs

3.2.5 Uniaxial Compressive Strength Test (UCS)

The strength results obtained from the experimental investigations are showed in table. All the values are the average of the three trails in each case in the testing program of this study. The results are discussed as follows. Fig.1 provides a comparison of the compressive strength development over time between the concrete specimen of 0% (SCBA+SD), 10% (SCBA+SD), 20% (SCBA+SD) and 30% (SCBA+SD) mixtures that were designed for a 28-day compressive strength of 3,000 psi. The data points represent the average of three duplicate specimens. Fig4.1and Table4.1 depict that the compressive strength increases with time, which is a natural characteristic of concrete. From the figure and table given earlier also shows that the compressive strength increases with the increase of the percentage of sugarcane bagasse ash and stone dust, but the compressive strength decrease when the percentage of SCBA and SD exceeds 10% of replacements of OPC.

Table 4: Compressive Strength

Sugarcane bagasse ash +Stone dust	**Compressive Strength (MPa)**			
	Curing Days			
	3 Days	**7 Days**	**28 Days**	**90 Days**
0% + 0%	15.94	17.37	19.08	20.34
5% +5%	17.12	18.23	20.23	21.77
10% +10%	16.11	17.98	19.38	20.67
15% +15%	12.98	14.57	14.95	15.43

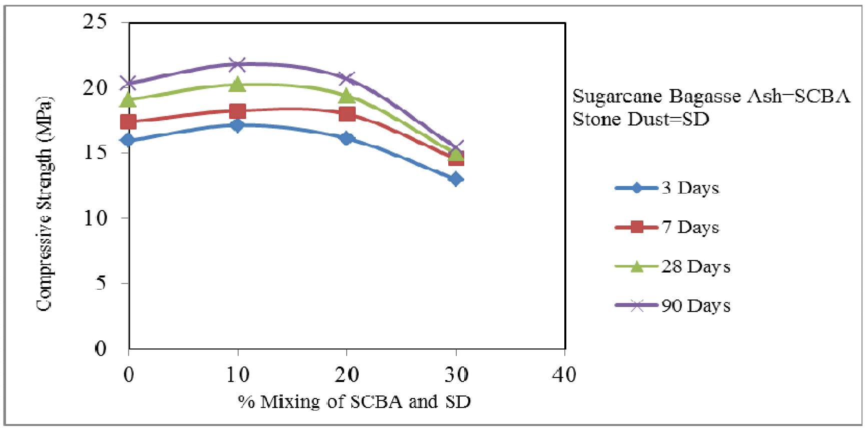

Figure 1: Compressive Strength Vs % Mixing of Sugarcane bagasse ash and Stone Dust

It could be because of the strengths of the interface zone and hardened cement paste are increased in stone powder which causes the particles of these materials to wrap up tightly on the surface of the aggregate and fill the gaps between the cement particles. On the other hand sugarcane bagasse ash is a pozzlanic material and it could be the reason of the increasing of strength when the replacement is 10%. The decrease of strength can be interpreted as that, sugarcane bagasse ash and stone dust both are pozzolanic material and they have no binding property but they can act as a binder in the presence of a binding material like OPC.

3.2.6 Flexural Strength Test (FS)

Table 5 shows the flexural strength of OPC concrete and the concrete produced by replacing OPC by sugarcane bagasse ash and stone dust by 10%, 20% and 30%. It is observed that the flexural strength increases with the 10% replacement of OPC, but when OPC is replaced by 20% the strength is less than the OPC concrete. It may be because of the pozzolanic property of sugarcane baggage ash and stone dust.

Table 5: Flexural Strength

Curing Days	**Flexural Strength (KN)**			
	Sugarcane bagasse ash + Stone dust			
	0% + 0%	**5% + 5%**	**10% + 10%**	**15% + 15%**
0	0	0	0	0
3	2.9	3.83	2.76	2.6
7	4.23	4.39	3.87	3.6
28	4.63	4.83	4.19	4.07

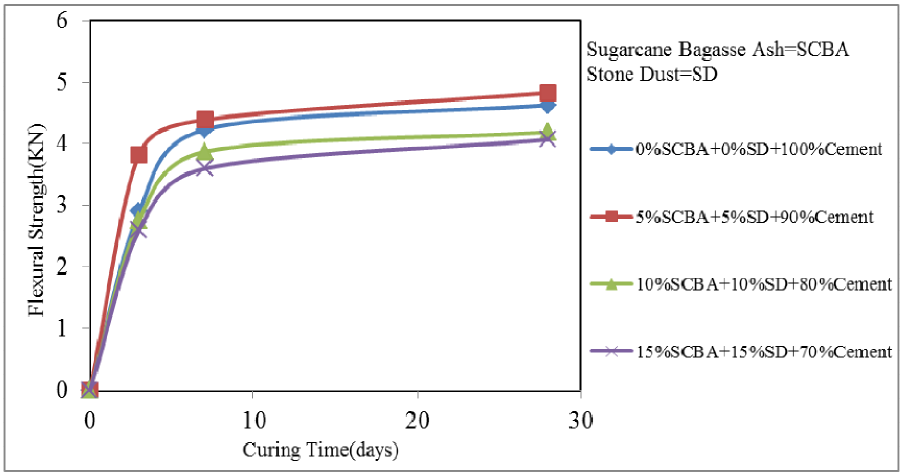

Figure 2: Flexural strength vs Curing time

3.2.7 Static Elastic Modulus Test (SEM)

Defining modulus of elasticity of concrete is difficult. Because concrete is not a linearly elastic material. Since the slope of σ-ε curve of concrete is not constant. We must first describe modulus of elasticity (Ec). This is not influenced by the time effect. Instantaneous Ec can be defined in 3 ways:

i) Initial Modulus of Elasticity, E
ii) Secant modulus
iii) Tangent modulus

In this work, 1st method was use to found slope of the curve i.e. modulus of elasticity of concrete.
Table 6 presents the results for the 28-days static elastic modulus. The results show that the 10% replacement of OPC by sugarcane bagasse ash and stone dust gives the optimum elastic modulus. The stress-strain curve for 28-days is given in figure 3.

Table 6: Static elastic modulus of 28-days specimen

Static Elastic Modulus E (GPa)	**Sugarcane bagasse ash + Stone dust**			
	0% + 0%	5% + 5%	10% +10%	15% + 15%
	0.944	1.63	1.42	0.628

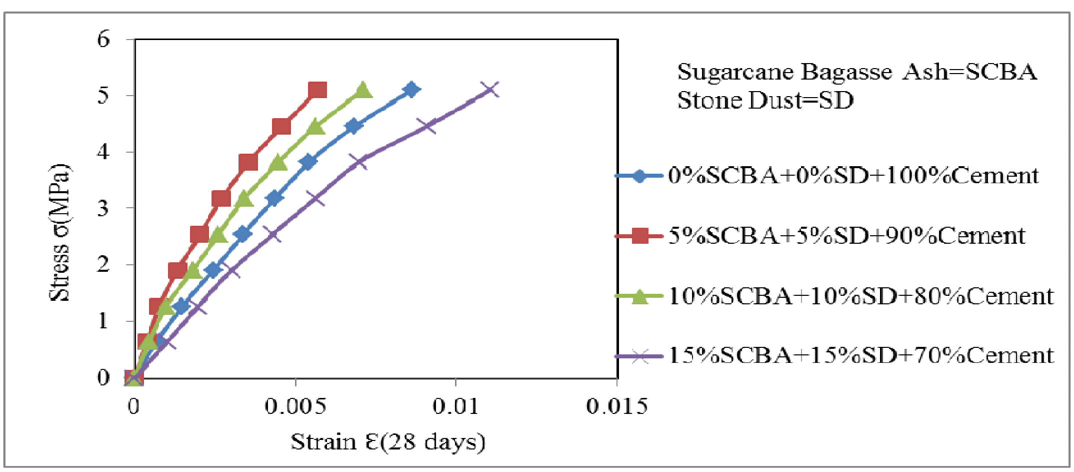

Figure 3: Stress-Strain Curve of concrete (28 days)

4. CONCLUSIONS

The aim of this study was to investigate the mechanical properties of concrete with the partial replacement of ordinary Portland cement by sugarcane bagasse ash and stone dust. In pursuit of this objective, various forms of literature was reviewed regarding these additives (sugarcane bagasse ash and stone dust), experimental work was performed and the test results were discussed. This chapter was set out to draw conclusions on the property test of concrete produced by OPC 10%, 20% and 30% replacement of OPC. The properties are compressive strength, elastic modulus and flexural strength. Concrete compressive strength with 10% replacement of OPC by sugarcane bagasse ash and stone dust increased by 7%. Concrete with 10% replacement of OPC by sugarcane bagasse ash and stone dust shows more elastic property. Flexural strength increases with 10% replacement of OPC by sugarcane bagasse ash and stone dust..

REFERENCES

Meyer, C.(2009): “The greening of the concrete industry.” Cement and Concrete Composites, Articles in Press.

Nadia S. I. and Mohammed A. K. (2013): Properties of High Strength Concrete Containing Stone Powder as Natural Pozzolanic Materials, J. of university of Anbar for pure science : Vol.7,NO.2.

Onera, A., Akyuzb, S. and Yildiz, R. (2005): “An experimental study on strength development of concrete containing fly ash and optimum usage of fly ash in concrete.” Cement and Concrete Research, 35(6), 1165-1171.

Roy, D.M. (1999): “Alkali-activated cements: Opportunities and challenges.” Cement and Concrete Research, 29(2), 249-254

Tarun, R. N., Shiw, S. S., and Mohammad, M. H. (1996): Permeability of High Strength Concrete Containing Low Cement Factor, Journal of Energy Engineering,122 (1), pp.21-39