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Evaluation of Mechanical Properties of Cement Concrete Pavement Using Granite Dust and Baggage Ash

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Abstract

Due to the tremendous increase in construction industry there by increase a pressure for the utilization of naturally available resources. Therefore, the demand of natural resources is increases, in order to overcome the use of such materials. Many researches are focusing on many ways of utilizing either industrial or agricultural wastes as a source of raw materials for the pavement construction industry. The utilization of these wastes would not only economical; it also helps in reduction of greenhouse gases and makes the environment pollution free. Sugar-cane bagasse is one such fibrous waste-product of the sugar refining industry, with ethanol vapour along with this, Granite industry which produces large number of waste. These waste dumped in open land which will create a lot of environmental problems. In this paper, sugarcane bagasse ash can be used as a partially replaced which varying from 0%, 5%, 10%, 15% and 20% by the volume of cement and granite dust as a completely replacement of fine aggregate in cement concrete pavement were used. Fresh concrete test like slump test, compaction factor and vee-bee consistometer were investigated. Hardened concrete test like compression test, split tensile test, young's modulus test, flexural test, cantabro abrasion test, sorptivity were conducted. The result shows that sugarcane bagasse ash can be partially replaced with cement up to 10%.

Keywords: OPC, SCBA, chemical properties, physical tests and durability test.

Introduction

Concrete is very strong and versatile mouldable construction material. Concrete consists of cement, fine aggregate, coarse aggregate and water. When the cement chemically reacts with water (hydration), it will form binding property. OPC is one of the major construction materials. Today's researchers are more focusing on utilization of Agricultural waste and Industrial waste. Agriculture waste like rice husk ash, wheat straw ash, sugarcane bagasse ash are pozzolanic material can be partially replaced with cement. Industrial wastes like fly ash, blast furnace slag and silica fume can be partially replaced with cement [8].Cement production emits CO_2 and forms greenhouse gases; cement alone is responsible for about 5% of global warming. The utilization of SCBA is not only reducing the cost of construction but also keep the environment pollution free [6]. Sugarcane is one of the major crops grown in all over the world, it can be grown over 121 countries of the globe and its total production is over 1300 million tons. Sugarcane can be produced in India over 300 million tons per year that cause about 10 million tons of sugarcane ash as a waste material and not utilized for any purpose. The bagasse is used as a fuel at the sugar mill and also used to produce steam and electricity in a co-generation plant at the ethanol plant. The sugarcane bagasse is burned under control condition below 700℃ and it is brought from NSL sugar factory, Maddur Mandya district. In this experimental investigation SCBA is replaced in the ratio of 0%, 5%, 10%, 15% and 20% by weight of cement and test were conducted at 7 and 28 days of curing[1,2,4]. The On the other hand fine aggregate (M-sand) is completely replaced with granite dust. The utilization of granite dust is not only economical but also reduces the environmental pollution. Granite dust is not utilizing for any purpose they are exposing to the near lakes and creating the environmental pollution [10] In this study there are three cases; case 1 only cement is partially replaced with SCBA in the ratio of 0%, 5%, 10%, 15% and 20% by weight. In case 2 fine aggregate (M-sand) is completely replaced with granite dust and in case 3 combining the maximum strength of above two cases.

Materials

The materials used in this investigation are:

Cement: the cement used in this study is ACC 43 grade ordinary Portland cement conforming to I.S:8112-1989.

Table 1. Physical properties of ordinary Portland cement

SL. NO	Characteristics	Test results	Recommended values (as per IS code)	IS codes
1	Normal consistency	32%	Not less than 30%	IS:4031-Part 4-1988
2	1. Initial setting time 2. Final setting time	65 min 270 min	Not less than 30 min Not more than 600 min	IS:4031-Part 5-1988
3	Specific gravity	3.10	3.0 – 3.15	IS:4031-Part 11-1988
4	Fineness of cement by sieving through No. 9	2%	Not more than 10%	IS:4031-Part 1-1996
5	Soundness test (Le-chateliers Exp.)	2 mm	Not more than 10mm	IS:4031-Part 3-1988
6	Compressive strength 3 days 7days 28days	 24 Mpa 33.8 Mpa 45 Mpa	 Not less than 23 Mpa Not less than 33 Mpa Not less than 43 Mpa	IS:4031-Part 6-1988

Table 2: Sieve analysis of fine aggregate

Total mass, gm		1000						
IS Seive size mm'	Wt Retained (gm)	Cumulative wt. Retained (gm)	Cumulative %Wt. Retained	% Passing	Gradation Limits			
					Zone I	Zone II	Zone III	Zone IV
10	0	0	0	100	100	100	100	100
4.75	11	1.1	1.1	98.9	90 – 100	90 - 100	90 - 100	95-100
2.36	61	6.1	7.2	92.8	60 - 95	75 - 100	85 - 100	95-100
1.183	405	40.5	47.7	52.3	30 - 70	55 - 90	75 - 100	90-100
0.6	214	21.4	69.1	30.9	15 - 34	35 - 59	60 79	80-100
0.3	137	13.7	82.8	17.2	5 - 20	8-30	12-40	15-50
0.15	172	17.2	100	0	0 - 20	0-10	0 – 10	0-15
				Zone	I	II	III	IV

FM :	3.079

Remarks: Satisfy to zone-I Gradation.

Table 3: Sieve analysis of Granite Dust

TOTAL MASS		1000 grams						
SIEVE SIZE	WEIGHT	CUMULATIVE	CUMULATIVE %	% PASSING	Gradation Limits			
(mm)	RETAINED	Wt. RETAINED	Wt. RETAINED					
	(Gms)	Gms	(Gms)		Zone I	Zone II	Zone III	ZONE IV
10	0	0	0	100	100	100	100	100
4.75	0	0	0	100	90-100	90 - 100	90 - 100	95-100
2.36	6.5	0.65	0.65	99.35	60 - 95	75 - 100	85 - 100	95-100
1.18	7	0.7	1.35	98.65	30 - 70	55 - 90	75 - 100	90-100
0.6	260	26	27.35	72.65	15 - 34	35 - 59	60 79	80-100
0.3	352.5	35.25	62.6	37.4	5 - 20	8-30	12-40	15-50
0.15	195.5	19.55	82.15	17.85	0 - 20	0-10	0 - 10	0-15
0.075	178.5	17.85	100	0				
			274.1		I	II	III	IV

Aggregates:

Fine aggregate

Aggregate which is passing from 4.75 mm sieve is known as fine aggregate. In this investigation fine aggregate is used as M sand (manufactured sand) from locally available aggregate crusher

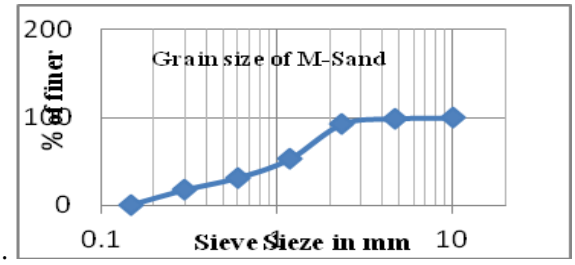


Figure 1: Gradation of fine aggregate (M- Sand)

Coarse aggregate

The aggregate which is greater than 4.75 mm is known as coarse aggregate. In this investigation coarse aggregate is used as 20 and 12 mm from locally available aggregate crusher.

Table 4: Physical properties of coarse aggregate

SL. No.	Characteristics	Test results	Recommended values	IS Code
1	Specific gravity	2.5	2.5-3	IS 383-1970
2	Aggregate impact test	22 %	30%	IS 2386-4-1963
3	Aggregate crushing test	25.25 %	30%	IS 2386-4-1963
4	Los Angeles abrasion test	32.2 %	35%	IS 2386-4-1963

Granite dust

Fine aggregate is completely replaced with granite dust. It is completely waste material of granite and they are not using for any purpose. They are disposing to the nearby lake, creating environmental problem. The granite dust which are using in this study is brought from Jigani, Anekal Tq Bengaluru Dist. Karnataka.

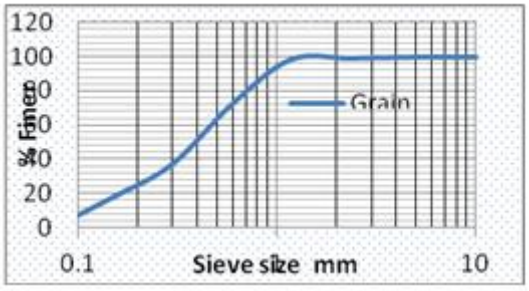


Figure 2: Gradation of Granite dust

Water

Water available in the college campus conforming to the requirements of water for concreting and curing as per BIS: 456-2000. The pH value should not be less than 6.

Sugarcane bagasse ash:

The bagasse ash used in the investigation is brought from NSL Sugar Factory in the nearby vicinity. The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicellulose and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO2). Bagasse Ash was burnt for approximately 72 hours in air in an uncontrolled burning process. The temperature was in the range of 700- 6000 0C.The ash collected was sieved through BS standard sieve size 425 µm and its colour was black.

Table 2.5: Physical properties of Bagasse ash

SL.NO.	Characteristics	Test results
1	Specific gravity	1.708
2	Colour	Black

Table 2.5.1: Chemical composition of SBA (Source: Metal and mineralogical Testing Laboratories at jalahalli cross)

SL.No.	Description of properties	Percentage (%)	**IS Code**
1	Si	67.2	
2	Al_2O_3	5.98	
3	Fe_2O_3	2.08	
4	Cao	2.72	**IS:11477-1985**
5	MgO	2.36	
6	O	0.91	
7	K_2O	3.65	
8	L.O.I	13.9	
9	S	1.01	

Experimental Work

Mix No.	Cement Kg/	SCBA Kg/	FA Kg/m3	CA Kg/m3	W/C ratio	Water Kg/m3
0%	413.33	0	690.53	1088.37	0.45	186
5%	392.66	20.67	690.53	1088.37	0.45	186
10%	372	41.333	690.53	1088.37	0.45	186
15%	351.331	61.999	690.53	1088.37	0.45	186
20%	330.664	82.666	690.53	1088.37	0.45	186

In this investigation M20 grade of concrete is considered. The mix design is followed based on IS 10262-2009 and the mix proportion is 1: 1.67: 2.63. Water cement ratio for this mix design is 0.45. The SCBA is replaced in the percentage of 0%,5%,10%,15% and 20% by weight of cement. The tests are considered in this investigation are Compressive strength, sorptivity, cantabro abrasion, Split tensile and flexure test were conducted at the age of 7 and 28 days of curing.

Results and Discussions

% of SCBA	Compressive strength(MPa)		Split tensile strength(MPa)		Flexural strength strength(MPa)		Cantabro loss in (%)	
	7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
0%	25.556	30	3.065	4.291156	8.08	8.403	13.7761	15.96205
5%	22.074	26.815	1.580	3.254	7.52	7.989	19.37605	12.77459
10%	22.220	27.185	1.886	3.772	7.57	8.183	14.30189	9.20903
15%	17.926	23.704	1.698	2.806	7.10	7.953	18.50105	18.09356
20%	14.963	23.185	1.627	3.065	6.95	7.520	14.41166	16.01563
Granite dust%	18.000	27.2	2.240	3.112	7.39	7.767	12.97784	12.07888

Compression Test Results

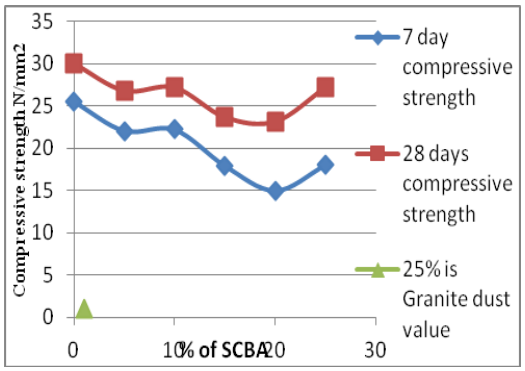


Figure 3: 7 and 28 day compressive strength of all mixes

The result obtained from the different proportion is plotted in the graph. It can be clearly observed that the 10% replacement of SCBA having higher strength compared to other percentages of SCBA. Further increase in SCBA reduction in the strength.

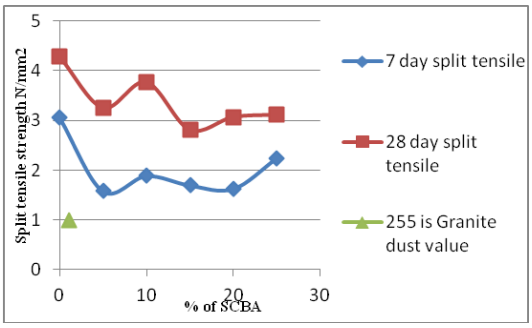


Figure 4: 7 and 28 day Split tensile strength of all mixes

The split tensile tests were casted and tested at 7 and 28 days. The result were plotted in graph, from the graph it is clearly observed that the 10% replacement of SCBA got the higher strength compared with other percentage. Further increase in SCBA lower the strength.

Flexure Strength Test

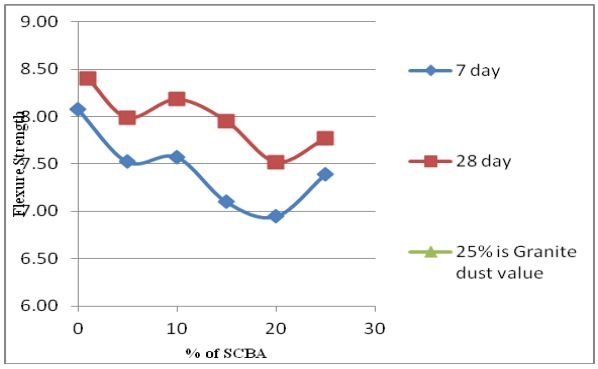


Figure 5: 7 and 28 day flexure strength of all mixes

The results of flexure strength (modulus of rupture) tests at 7 and 28 days are depicted. The test results are plotted in graph. From graph it is clearly observed that 10% of SCBA has higher strength compared with other percentage of SCBA. Further increase in SCBA reduction in strength.

Cantabro loss

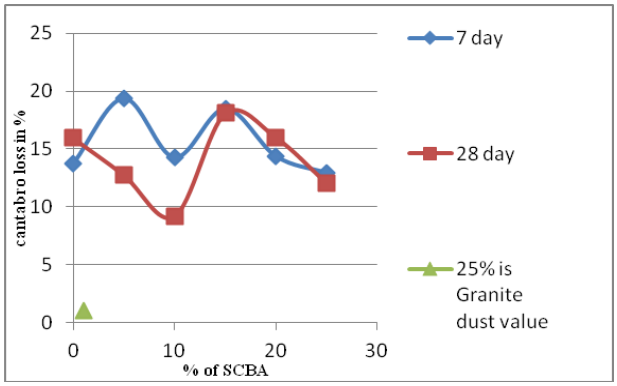


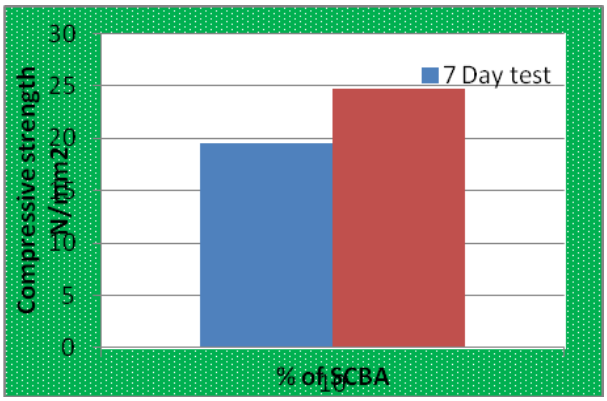
Figure 6: 7 and 28 day Cantabro loss

The result of cantabro abrasion results are plotted in above fig. it is clearly observed that the loss in 10% is less compaired to normal concrete. As the percentage of SCBA increases increase in losses**.**

Partially Replacement of Cement with SCBA and Complete Replacement of M-Sand with Granite Dust

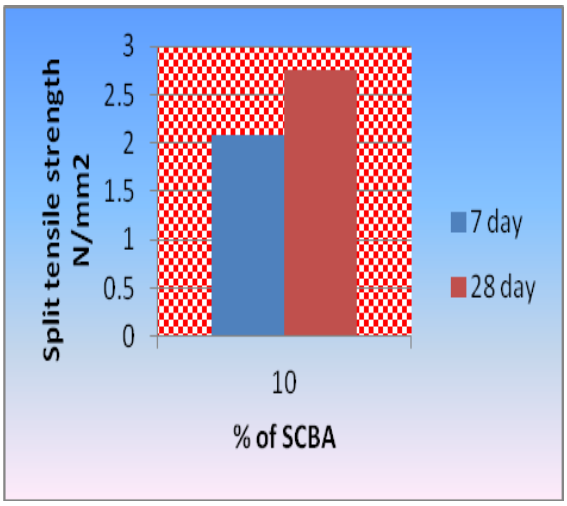
Nomenclature	Compressive strength (MPa)		Split tensile strength(MPa)		Flexural strength strength(MPa)		Cantabro loss in (%)	
	7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
Results	19.4	24.6	2.07	2.7	7.1	7.8	19.6	15

Compressive Strength



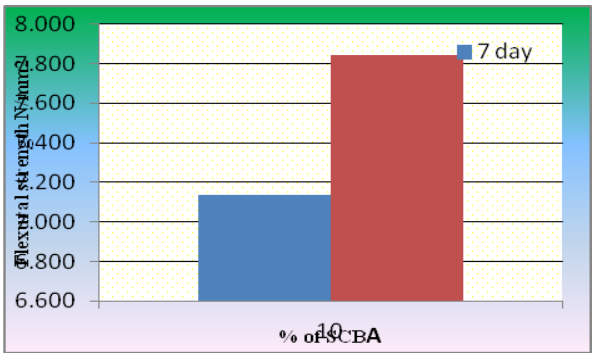
From the above fig we can clearly observed that the compressive strength of concrete, is achieve the target strength. So both the materials by combining we can use.

Split tensile strength



From the above fig. we can conclude the average split tensile strength is achieved as compared to the other percentage of SCBA.

Flexural strength



Conclusion

From this investigation it is clear that the cement is partially replaced with SCBA and fine aggregate with granite dust. Following parameters are

- The cement is replaced with SCBA up to 10% without any considerable loss in workability and strength of concrete.
- The compressive strength, split tensile and flexure strength of concrete for 10% replacement of SCBA is increased at 28 day as compared with 7 day; it is due to pozzolanic properties of bagasse ash.
- The use of SCBA and granite dust in the concrete, it not only reduce the cost consideration and also reduce the environmental pollution.
- Partial replacement of OPC and complete replacement of granite dust enhance the physical and durability property of concrete.
- Both bagasse ash and granite dust can be used in concrete without any change in strength and workability

References

[1]. Ganesan, K., Rajagopal, K., & Thangavel K., 2007. Evaluation of Bagasse Ash as Supplementary Cementitious Material, Journal of Cement and Concrete Composites 29, p. 515.

[2]. R. Srinivasan, K Sathiya, 2010. Experimental Study on Bagasse Ash in Concrete, International Journal of Service Learning in Engineering 5(2), p.60.

[3]. Payá,J.,et. al.,2002. Sugarcane bagasse ash (SCBA): studies on its properties for reusing in concrete production, Journal of Chemical technology and Biotechnology 77, p.. 321.

[4]. N. B. Singh, V. D.Singh and Sarita Rai, 2000. Hydration of Bagasse Ash-Blended Portland cement, Journal of Cement and Concrete Research 30, p.1485.

[5]. Bhuvaneshwari M, Jessy Rooby and Rony Jacob, Shear-Behaviour of Plasti-Fibre Reinforced Concrete Beams, international journal of earth sciences and engineering, Volume 08, No. 02, P.P.532-539

[6]. Eduardo M. R. Fairbairn, Branca B. Americano, Guilherme C. Cordeiro, Thiago P. Paula, Romildo D. Toledo Filho, Marcos M. Silvoso, Cement replacement by sugarcane bagasse ash: CO2 emissions reduction and potential for carbon credits, Journal of Environmental Management 91(2010),pp 1864-1871

[7]. Tao Ji , Cai-Yi Chen, Yi-Zhou Zhuang, Jian-Feng Chen, A mix proportion design method of manufactured sand concrete based on minimum paste theory, Construction and Building Materials ,44 (2013), pp 422–426

[8]. Aigbodion.V.S, Hassan.S.B, Olajide.S,O, Agunsoye.O.J, AbdulRahaman.A.S. Okafor.G.E, The use of rice husk ash as an aggregate for foundry sand production in Nigeria, Proceedings of The Nigerian Metallurgical Society (NMS), (2008) Annual Conference & Annual General Meeting, pp 16-22.

[9]. Aukkadet Rerkpiboon, Weerachart Tangchirapat , Chai Jaturapitakkul, Strength, chloride resistance, and expansion of concretes containing ground bagasse ash, Construction and Building Materials, 101 (2015),pp 983–989

[10]. Baboo Rai, Khan Naushad,Abhishek Kr,Tabin Rushad S and Duggal S.k "influence marble powder/granules in concrete mix", International journal of Civil and Structural Engineering, Vol, No 4, 2011, PP 827-834.