An Experimental Study on Bagasse ash as Replacement for Cement in Lightweight Concrete

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Abstract- The present study is to investigate experimentally the fresh and hardened properties of lightweight concrete using sugarcane bagasse ash(SCBA) as replacement for cement by weight at 0%, 5%, 10%, 15% and 20% and expanded polystyrene (EPS) beads as 100% replacement for coarse aggregate respectively. From the result it was found that there is marginal increase in workability with bagasse ash content up to 10% beyond that there is possibility of reduction in slump value. The compressive strength of lightweight concrete increases with bagasse content up to 15% and beyond this there is possibility of drastic reduction in strength and this 15% bagasse ash replacement strength is slightly less than opc based lightweight concrete at 28 days but this value is comparable.

Keywords- Sugarcane bagasse ash (SCBA), expanded polystyrene (EPS) beads, workability, compressive strength.

I. INTRODUCTION

Ordinary Portland cement is recognized as a major construction material throughout the world and in terms of its per capita consumption, it is second most consumed material in the country, next only to water. However, the production of Portland cement, an essential constituent of concrete, leads to the release of significant amount of CO_2, a greenhouse gas (GHG); production of one ton of Portland cement produces about one ton of CO_2 and other GHGs. The environmental issues associated with GHG, in addition to natural resources issues, will play a leading role in the sustainable development of the cement and concrete industry during this century. Researchers all over the world today are focusing on ways of utilizing either industrial or Agricultural waste, as a source of raw materials for industry. This waste, utilization would not only be economical, but may also result in foreign exchange earnings and environmental pollution control. Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials. Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry. When this bagasse is burned under controlled conditions, it gives ash having amorphous silica, which has pozzolanic properties Therefore it is possible to use sugarcane bagasse ash (SCBA)) as cement replacement material to improve quality and reduce the cost of construction materials in concrete. Expanded polystyrene (EPS) is a lightweight cellular plastics material consisting of fine spherical shaped particles which are comprised of about 98% air and 2% polystyrene. It has a closed cell structure and cannot absorb water. It is a waste material from packaging industry and may create disposal problem. Utilizing crushed polystyrene granules in concrete is a valuable waste disposal method. Therefore; lightweight concrete with polystyrene beads is safe for the environment and is not contribute to the destruction of earth's ozone layer. Moreover, because polystyrene polymer has no nutritive value, it is not trigger fungus or any other bacteria growth and has no dangerous effect on plants or animals. Therefore this material can be used as replacement for coarse aggregates in the constituents of concrete in order to produce lightweight concrete.

The objectives of this research were to make utilization of Sugar cane bagasse ash (SCBA) as replacement for cement is incorporated in concrete in order to achieve increase in strength and a better bonding between aggregate and cement paste. The mix design used for making the concrete specimens was based on trial batches as there was

no proper mix design code for lightweight concrete. This bagasse ash has been chemically and physically characterized replaced in different proportion with cement and incorporated in concrete. EPS beads are used as a replacement for coarse aggregate in lightweight concrete by studying its physical properties. Fresh concrete test such as slump cone test were carried out as well as hardened concrete test like compressive strength at the age of 3, 7 and 28 days will be carried out and the optimum limit of replacement of bagasse ash as replacement for cement in concrete is conducted.

II. EXPERIMENTAL INVESTIGATION

A. Materials

Cement and Bagasse Ash

Sl. No	Particular	53 grade OPC	Bagasse Ash	Specifications
1	Normal consistency	30%	OPC+5% - 33% OPC+10% - 36% OPC+15% - 38% OPC+20% - 40%	IS:269-1958
2	Specific gravity	2.90	2.04	IS:269-1976
3	Setting time (in min)			IS:269-1976
	(a) Initial setting time	90min	OPC+5% - 110 OPC+10% - 120 OPC+15% - 135 OPC+20% - 135	Should not be less than 30 min
	(b) Final setting time	07 hrs		Should not be less than 600 min
4	Fineness	2.5%	60%	IS:269-1976

Chemical properties of OPC and Bagasse ash

CHEMICAL	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	LOI
OPC	18.4%	5.6%	3%	66.8%	1.4%	2%
Bagasse Ash	71.48%	0.20%	5.89%	1.06%	2.20%	4.55%

EPS Beads

Sl.no	**Beads Size in mm**	**Thermal Conductivity (w/mk)**
1	0.5-0.7	0.036
2	0.7-1.0	0.031
3	1.0-3.0	0.022

Natural River Sand

Test	Results
Specific gravity	2.60
Water absorption (%)	1.09
Bulk Density (kg/lt) Loose compacted	 2.49 2.52

B. Methodology

The main objective of this experiment is to evaluate the pozzolanic recactivity of bagasse ash with cement, binding property of EPS with other constituents of concrete, workability by slump cone test and 28 days compressive strength of 150mm X 150mm X 150mm concrete cube specimens at different replacement levels of bagasse ash with cement and 100% replacement of EPS beads in lightweight concrete.
As per **ASTM-C618** specifications the combined chemical composition of **Sio_2+Al_2o_3+Fe_2o_3=77.57%** satisfies the pozzolanic nature of bagasse ash according to test specification the bagasse ash qualifies to be a class N pozzolana and the loss on Ignition value for the bagasse ash was found to be (LOI) 4.55 **%** which is slightly less than than specified by the same standard satisfying the above requirements the bagasse ash has got pozzolanic properties and hence it can used as replacement material for cement to produce concrete. In the present investigation, as there is no IS codal provisions for lightweight concrete for mix proportioning trial mixes are done to prepare concrete specimens. The batching was done by weight rather than the volume. REO MIX-141 chemical is used to bind the EPS beads with other constituents of concrete in order to avoid segregation and bleeding and it is added during mixing process in terms of percentage by weight of cement and REO BUILD-919 super plasticizer is added to reduce the water content and to increase the slump value. Compressive strength test is carried out by placing the 28 days cured specimen after drying for 24hrs have been compressed using UTM.

C. Mix Design

Trial Mixes for Replacement 0%, 5%, 10% 15%, 20% of SCBA

Trail 1 [BAGASSE ASH=0%]

Materials	**Dry weight (kg/m^3)**	**Dry weight (kg/m^3/.035cu.m)**
OPC	300	10.5
Bagasse Ash	-	-
Eps Beads	11	0.385
River Sand	923	32.035
Water	166	6.62
Reo Mix -141	600gm	21gm
Reo Build -919	900gm	31.5gm
Total Density	1400	49.81

Trial 2 [BAGASSE ASH=5%]

Materials	**Dry weight (kg/m^3)**	**Dry weight (kg/m^3/.035cu.m)**
OPC	285	9.98
Bagasse Ash	15	0.53
Eps Beads	11	0.385
River Sand	294	32.24
Water	166	6.62
Reo Mix -141	600gm	21gm
Reo Build -919	900gm	31.5gm
Total Density	1401	49.75

Trial 3 [BAGASSE ASH =10%]

Materials	**Dry weight (kg/m^3)**	**Dry weight(kg/m^3/.035cu.m)**
OPC	270	9.45
Bagasse Ash	30	1.05
Eps Beads	11	0.385
River Sand	924	32.24
Water	166	6.62
Reo Mix -141	600gm	21gm
Reo Build -919	900gm	31.5gm
Total Density	1401	49.75gm

Trial 4 [BAGASSE ASH= 15%]

Materials	**Dry weight (kg/m^3)**	**Dry weight(kg/m^3/.035cu.m)**
OPC	255	8.925
Bagasse Ash	45	1.575
Eps Beads	11	0.385
River Sand	900	31.5
Water	166	6.62
Reo Mix -141	600gm	21gm
Reo Build -919	900gm	31.5gm
Total Density	1377	49.005

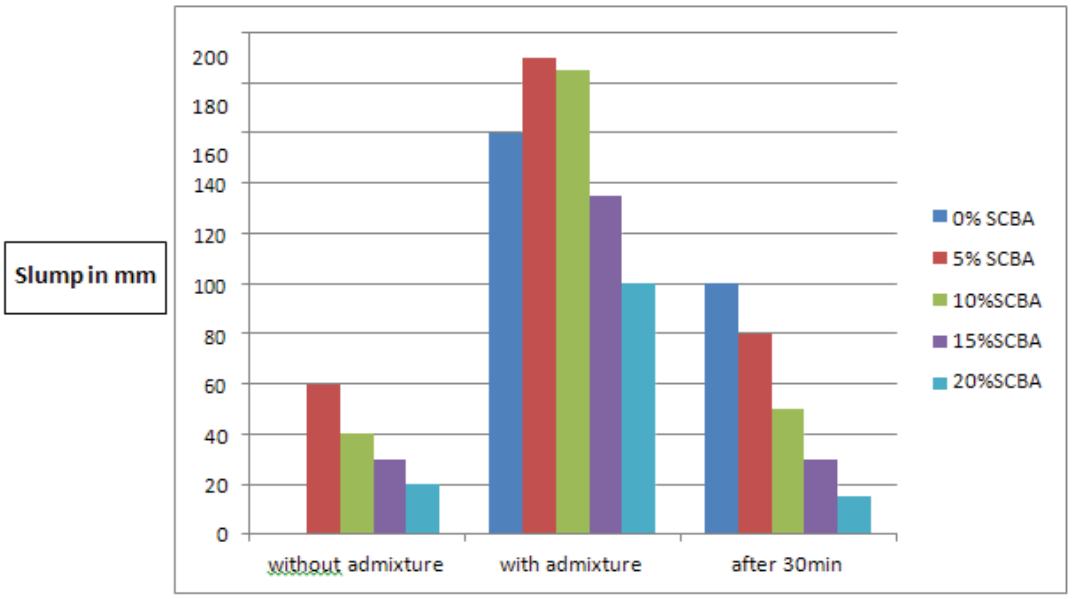
Trial 5 [BAGASSE ASH =20%]

Materials	**Dry weight (kg/m^3)**	**Dry weight(kg/m^3/.035cu.m)**
OPC	240	8.40
Bagasse Ash	60	2.10
Eps Beads	11	0.385
River Sand	900	31.50
Water	166	6.62
Reo Mix -141	600gm	31gm
Reo Build -919	900gm	31.5gm
Total Density	1377	49.005

III. RESULTS AND DISCUSSIONS

The following are the results of fresh concrete by conducting slump test

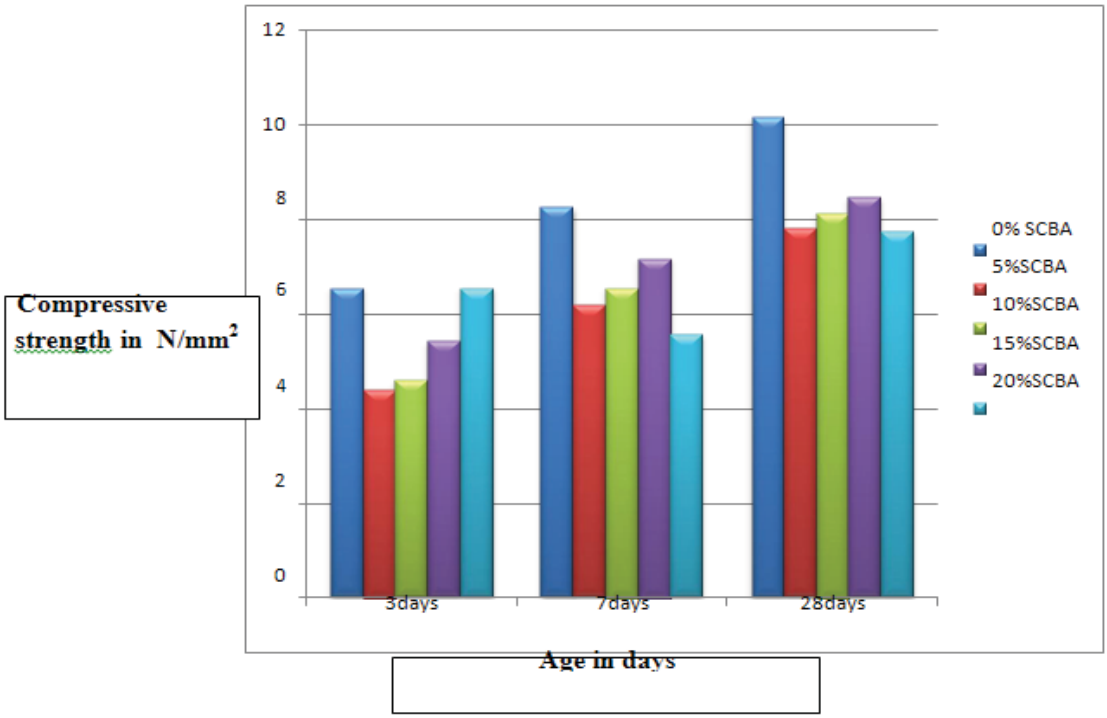
SL.NO.	SLUMP	0%	5%SCBA	10%SCBA	15%SCBA	20% SCBA
01	Without Admixture	00	60	40	30	20
02	With admixture	160	190	185	135	100
03	After 30min	100	80	50	30	15



From the above chart, it indicates that there will be zero or no slump value in OPC, when Sugarcane bagasse ash (SCBA) is replaced with OPC at various replacement levels there will be increase in slump value as compared to OPC which means workability of lightweight concrete increases as percentage of sugar cane bagasse ash for w/c ratio 0.55 and the value obtained is within the maximum slump value of 100mm for lightweight concrete which is also attained and this workability decreases as percentage of SCBA is increased. When the chemical admixtures are added there will be enormous increase in slump value in OPC and also in sugar cane bagasse ash replacement with cement. After 30 minute, there will be decrease in slump value due to increase in percentage of sugar cane bagasse ash which in turns retards setting time as compared to OPC. Hence up to 15% SCBA replacement with cement can impart good workability without any chemical admixtures and also up to 10% SCBA replacement with cement can impart good workability with chemical admixtures.

The following are the results of hardened concrete by conducting compressive strength test

NO. OF DAYS	PERCENTAGE OF REPLACEMENT of SCBA	AVERAGE COMPRESIVE STRENGTH N/mm^2
3	0	6.54
3	5	4.41
3	10	4.6
3	15	5.43
3	20	6.54
7	0	8.25
7	5	6.20
7	10	6.55
7	15	7.18
7	20	5.56
28	0	10.15
28	5	7.8
28	10	8.14
28	15	8.46
28	20	7.74



From the above chart, it indicates that the increase in percentage of replacement of SCBA with cement in lightweight concrete there will be slight decrease in strength as compared to OPC based lightweight concrete. The results show that 15% of replacement gives maximum compressive strength at 28 days as compared to 0%, 5%, 10% and 20% replacement of SCBA. As the 15% replacement of SCBA with cement based lightweight concrete strength is slightly less than OPC based lightweight concrete which is comparable.

IV. CONCLUSIONS

Based on the limited experimental works carried out, the following conclusion is obtained

1. Normal consistency of OPC+BA will increase for various percentage of bagasse ash as compared to OPC since the fineness of bagasse ash is less it consumes more water.
2. Setting time of OPC+BA replacement increases with increase in percentage of bagasse ash because bagasse ash acts as a good mineral admixture which retards setting time, low heat of hydration and attains maximum strength slowly.
3. Workability of lightweight concrete increases with increase in percentage of bagasse ash with cement as compared to OPC and up to 15% SCBA replacement with cement can impart good workability without any chemical admixtures and the value obtained is within the maximum slump value of 100mm for lightweight concrete is achieved as per provision and this workability decreases as percentage of SCBA is increased and when chemical admixtures are added there will be enormous increase in slump value in OPC and also in sugar cane bagasse ash replacement with cement hence up to 10% SCBA replacement with cement can impart good workability with chemical admixtures.
4. The 15% of replacement of bagasse ash gives maximum compressive strength at 28 days as compared to 5%, 10% and 20% replacement of SCBA and this 15% replacement of SCBA with cement strength is slightly less than OPC based lightweight concrete which is comparable.
5. If the bagasse is burnt again at controlled temp fineness of cement is increased hence it will improve the fresh and hardened properties of concrete.

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