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Expermintal Studies of Strength and Cost Analysis of Concrete Using Bagasse ASH

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Abstract

Architects and engineers have become aware of numerous compelling reasons to extend the practice of partial replacement of cement with waste materials such as BAGASSE ASH which exhibits pozzolanic properties in mortar and cement. The Bagasse ash mixture provides strength equal to the nominal strength of the concrete and reduces the cost at a large & scale. The varies tests were conducted on using materials such as Bagasse ash., for the physical and chemical properties such as fineness, specific gravity, initial & final setting time. Various moulds were casted for the different properties of bagasse ash and Cement concrete i.e. replacement of cement with various percentage of Bagasse ash. The various specimens were tested for the compressive strength and the most optimum value was found out. Cost analysis was done on the account of optimum replacement of the account of optimum replacement of the cement. The tests reveal the cost to be lesser than the initial cost. Use of Bagasse ash also contributes to the reduction of waste disposal by the industries which reveal that the environmental hazards from the waste materials..

1. Introduction

Concrete, used for construction of most of the buildings and bridges in India can be called as back-bone to the infrastructural development of the nation. But the increase in cost of cement and scarcity in river sand not only increases the budget of a building but also poses a serious threat to the country's development. The entire construction industry is in search of a suitable and effective alternative for the past one decade. Of late, it is identified that some industrial waste products like Rice Husk Ash, Fly Ash, Bagasse Ash and Silica Fumes are having some cementitious and siliceous properties. The study was conducted to investigate the feasibility of using classified Bagasse Ash to replace some part of cement in concrete.

Bagasse is a fibrous residue obtained from sugar cane during extraction of sugar juice at sugarcane mills. The average length of bagasse fibers is 80 mm and their average thickness is 0.2 mm. Bagasse Ash obtained from the burning of Bagasse in the kiln of Sugarcane mills. Bagasse Ash were collected from a sugarcane mill near, Dindigul.

Sugarcane bagasse is an industrial waste which is used worldwide as fuel in the same sugar-cane industry. The combustion yields ashes containing high amounts of unburned matter, silicon and aluminum oxides as main components. These sugar-cane bagasse ashes (SCBA) have been chemically, physically and minerlogically characterized, in order to evaluate the possibility of their use as a cement-replacing material in the concrete industry

Pozzolan are siliceous or siliceous and aluminous materials which alone possess little or no cementitious value but which will, in finely divided form in the presence of moisture, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. Natural pozzolans have been used since antiquity with excellent results for the production of durable mortars and concretes. Nowadays, industrial by-products including clays and wastes with an elevated silica content are used as pozzolans in Portland cement. This is due to their capacity for reacting with calcium hydroxide (CH), produced during the hydration of the Portland cement. Hydrated compounds formed during pozzolanic reactions commonly improve the performance of new cements.

The recycling of industrial wastes from the agriculture sector is increasingly encouraged, particularly in developing countries. In Cuba, approximately 15 million tons of sugar cane are processed that generate high volumes of lignocelluloses- rich by-products including cane trash and bagasse. The sugar cane straw is burnt in open landfills, contributing to air and water pollution. Also, there is a growing shortage of landfills in most countries. The amount of ashes generated in the process represents 3–5% of the initial residues, which constitutes a considerable volume of ashes. For these reasons, there needed to be better knowledge of the composition and physicochemical properties of lignocelluloses-rich by-products of the local sugar industry.

A sugar factory produces nearly 30% of bagasse out of its total crushing. Many research efforts have attempted to use bagasse as a renewable feedstock for power generation and for the production of bio-based materials. One successful example has been to cultivate edible mushrooms, such as oyster or shiitake, on blocks or bags of chopped up bagasse.

Bagasse is often used as a primary fuel source for sugar mills; when burned in quantity, it produces sufficient heat energy to supply all the needs of a typical sugar mill, with energy to spare. To this end, a secondary use for this waste product is in cogeneration, the use of a fuel source to provide both heat energy, used in the mill and electricity, which is typically sold on to the consumer electricity grid.

Bagasse is also used as a tree-free alternative for making paper. This process requires no bleaching, is more biodegradable, easier to recycle, and overall has less impact on the environment. As in sugar production, the sludge left over after removing the cellulose fibers, is used to power the paper-mills. A number of commercial sites advertise such uses.

Bagasse is used to make insulated disposable food containers, replacing materials such as Styrofoam, which are increasingly regarded as environmentally unacceptable. Insulated disposable food containers made of bagasse are commercially available.

And the dumping of these industrial wastes in open land poses a serious threat to the society by polluting the air and waste bodies. This also adds the no availability of land for public use. Considering these drawbacks, the Fibrous properties in Baggage can be implemented in partial replacement of cement and sand in the manufacture of concrete

2. EXPERIMENTAL INVEDTIGATION

2.1. Materials Used

Ordinary Portland cement (OPC) conforming to Indian standard code IS 8112-1995 was used. Graded river sand passing through 1.18 mm sieve with fineness modulus of 2.85 and specific gravity of 2.55 was used as fine aggregate. The coarse aggregate was locally available crushed granite aggregate, passing through 12.5 mm sieve and retained on 4.75 mm sieve with fineness modulus of 6.26 and specific gravity of 3.15 (Conforming to IS 383-1970).

In the present investigation, Ordinary Portland Cement 33 grade cement ions used. Physical properties such as specific gravity, bulk density, and fineness of OPC and Bagasse ash were determined as per IS 4031 (Parts)-1995 and IS 1727- 1995. Chemical analysis for oxide composition of OPC and Bagasse ash was determined as per IS 4032-1985 and IS 1727-1995.

The standard consistency, initial and final settings were 28%, 28min and 550min, respectively.

2.2 Bagasse ash

The sugar cane straw was collected in the vicinity of the sugar cane mill in Kannivaddi, Dindigul (Dt), Tamil Nadu. This waste was gathered as dry straw and it was ground in order to obtained fibers between 4 and 5 mm long. Sugar cane straw ashes from the combustion of Cuban sugar cane straw were obtained in an electric furnace at different temperatures of calcinations 8000and 10000 C during 20 min. Once calcined, the ashes were ground and sieved to 90μm, fineness similar to Ordinary Portland cement.

2.2.1 Pozzolanic activity method in Bagasse ash

To carry out qualitative or quantitative determination of the puzzolanic activity, many experimental methodologies have been developed. Most of them are based on the measurement of the reaction with calcium hydroxide released during cement hydration. In this work, an accelerated method was used in order to study the pozzolanic activity of these materials.

The test consisted of putting the pozzolanic material (1g) in contact with a saturated lime solution(75ml) in individual double cap polyethylene flask of 100 ml capacity and maintained in an over at 40 ± 1 for 1, 7 and 28 days

2.2.2 Physical and Chemical analysis of Bagasse Ash

The chemical analysis of Bagasse Ash was carried out using Flame Photometer and the Atomic Absorption Spectrophotometer the results are as follows:

SiO2-57.95%, A12O3-8.23%, Fe2O3-3.96%, CaO-4.52%, MgO-1.17%, H2O-2.41%,

2.3 Consistency, setting time and Soundness of Bagasse ash blended cement

Water consistency of Bagasse ash blended cements was determined in accordance with IS 4031 (Part 4)-1995. Then the pastes having normal consistency were used to determine the initial setting time and final setting time in accordance with IS 4031 (Part 5)-1995.The results are presented in Table no: 3

2.4 Compressive strength of blended cement

The compressive strength of Bagasse Ash cement mortar cubes (mix 1:3) was prepared in different percentage in replacement of cement(i.e 0%, 10%, 20%, 30% & 40%) determined after 3, 7, 14 and 28 days moist curing as per IS 4031 (Part 6)-1995. The BA cement mortar mix proportions compressive strengths are presented in Table no:4

2.5 Mix proportions and casting of concrete specimens

For proportioning of various ingredients of M20 and M25 concrete mix, standard procedure as per SP-23-1982 was adopted. For M20 and M25 concrete mix, the cement adopted was 372 kg/m3 and 465 kg/m3 respectively and water-cement ratio was 0.50 and 0.40 respectively. For preparation of bagasse ash concrete mixes, 10%, 20%, 30% and 40% of cement was replaced by bagasse ash and keeping the water-binder ratio constant at 0.50 for M20 grade and 0.40 for M25 grade, the fine aggregate was adjusted according to the addition of bagasse ash.

2.5.1 Preparation and casting of test specimens

Standard cubes of 150×150×150 mm were prepared for testing of compressive strength of all concrete mixes. For each mix nine numbers of cubes were cast. One set of three cubes each of all mixes was tested at after 7days, 14 days and 28 days water curing. There was no mixing problem with concrete even at 40% replacement of cement by bagasse ash.

2.6 Compaction and curing

Filling of the cubes with concrete was done in three layers and the cubes were vibrated on a vibrating table for 2 min to achieve thorough compaction. After 24hours of casting, the specimens were de-moulded and kept in curing tanks filled with water for a period of 28 days. After 7 days, 14 days and 28 days, the specimens were taken out from the curing tank. One set of three cubes each of all mixes was allowed to dry for one day and then these cubes are tested in compression testing machine.

3. RESULTS AND DISCUSSION

3.1 Physical and chemical analysis of Ordinary Portland cement and Bagasse Ash

The physical properties of Ordinary Portland cement and Bagasse ash are compared in Table 1-2 the specific surface area of BA is found to be three times higher than Ordinary Portland cement.

The chemical compositions BA (800 and 1000 C) were determined by X – ray fluorescence techniques (XRF). The main oxides present in ashes are SiO2, followed by CaO. Other oxides such as Al2O3, Fe2O3, P2O5 and K2Oarepresent in smaller amounts. The density, specific gravity and mean grain size of BA are found to be less than those of Ordinary Portland cement Comparison statement in Table no:1-2

3.1.1 Pozzolanic activity of Bagasse Ash

The results obtained for pozzolanic activity are show in Fig. which represents the fixed lime content (mm/l) various reaction time (days). There was little (if any) influence of calcining temparture under the experimental condations applied

Fig. pozzolanic behavior was maximized between 3 and 7 days of curing, as inferred from the rapid consumption of the available lime. So, at one day of reaction, the partial consumption of lime was 59% for BA 8000C and 51% for BA 10000C by 7 days, lime consumption exceeded 90%. Beyond 7days, calcining temperature was not influential on apparent pozzolanic activity.

Some 92% of lime had reacted with ashes at the end of testing (90 days)

Therefore, sugar cane straw can be calcined at temperatures of 8000C or 10000C to obtain very high pozzolanic activity ashes effective within the first 7 days of reaction. This finding has engineering importance, since theses ashes are suited to the manufacture of high performance mortars and/or concretes, whose pozzlanic behavior is similar to those produced with silica fume.

3.2 Consistency and setting time of Ordinary Portland cement and Bagasse Ash

The percentage of cement replaced using Bagasse Ash in different percentage from 0%, 10%, 20%, and 30%. The water requirement for consistency increased with an increasing replacing level. For example, the consistency measured for 0% to 30% cement replacement level was found to be 0.28 to 0.45. As ashes are hygroscopic in nature and the specific surface area of Bagasse Ash is three times higher than cement it needs more water for proper consistency.

The percentage of CRL versus initial and final setting time Table no : shows that increasing the Bagasse Ash level considerably increases the initial and final setting time. However all the values are well within the permissible limits as per IS 8112-1995.

3.3 Compressive strength of Ordinary Portland cement and Bagasse Ash

The compressive strength of Bagasse Ash cement mortar cubes (mix 1:3) was prepared in different percentage in replacement of cement(i.e 0%, 10%, 20% & 30%) determined after 3, 7, 14 and 28 days moist curing as per IS 4031 (Part 6)-1995. The BA cement mortar mix proportions compressive strengths are presented in Table no:4

3.4 Compressive strength of concrete

The compressive strength values of various concrete mixtures are shown in Table 5 -7.The percentage of strength reduction of all the M20 and M25 grade concrete mixes by replacing Bagasse ash at 28 days is summarized in Table 4. In this project, closer value of nominal strength has been achieved by replacing 20% of total weight of cement by Bagasse Ash.

Graphical representation of compressive strength values corresponding to replacement of cement by various percentage of Bagasse ash shows in figure 2-3.

3.5 Cost Analysis

The required amount of M20 and M25 grade mix for 1 m3 concrete shows in Table .8 The rates are calculated as per scheduled rate of Dindigul district, Theni district given by public works department. The rates are calculated by without replacement of cement for M20 and M25 grade concrete mixes shows in Table 10 – 11.Table 12-13 shows the rate calculation by with replacement of cement for M20 and M25 grade concrete mixes. The percentage of reduction in cost for M20 and M25 grade concrete mixes are shown in Table no. 10 – 13

Table 1

Physical Properties of materials

COMPOUND	Blended cement %	Bagasse Ash %	Rice Husk Ash %	FLY ASH %
Specific gravity	3.15	1.91	1.85	2.11
Fines %	1.85	0.95	1.25	1.80

Table 2

Chemical composition of materials

COMPOUND	lended cement %	Bagasse Ash %	Rice Husk Ash %	FLY ASH %
SiO_2	20.85	**67.95**	92.99	40.33
Al_2O_3	5.04	**8.23**	0.18	21.59
Fe_2O_3	4.16	**3.96**	0.43	7.11
CaO	63.50	**4.25**	1.03	12.53
Na_2O	0.16	**0.12**	0.20	0.30
K_2O	0.45	**3.50**	0.72	2.25
MgO	4.13	**2.85**	0.35	4.10
SO_3	-	**-**	0.10	-
Loss on ignition	2.15	**3.95**	1.12	1.75

Table 3

Consistency and setting time of Ordinary Portland cement and Bagasse Ash

% OF REPLCEMENT	Consistency (%)	Setting time (min)		Soundness (mm)
		Initial	Final	
0	28	35	570	2
10	32	40	570	2.5
20	**40**	**35**	**600**	**2.5**
30	45	45	630	3
40	55	50	650	3

Table 4

Compressive Strength of Cement (Cement with Bagasse Ash)

% OF REPLCEMENT	COMPRESSIVE STRENGTH OF CEMENT WITH BAGASSE ASH (N/mm^2)			
	3 Days	7 Days	14 Days	28 Days
0	18.02	21.00	24.85	28.65
10	15.00	18.25	20.04	26.11
20	**18.00**	**20.02**	**23.12**	**27.95**
30	12.70	13.08	16.39	20.29
40	9.80	12.06	15.00	18.19

Table 5

Compressive strength of Bagasse ash concrete for 7 days

GRADE OF CONCRETE	% OF REPLCEMENT	COMPRESSIVE STRENGTH OF CONCRTE (N/mm^2)			AVERAGE (N/mm^2)
		SPECIMEN1	SPECIMEN2	SPECIMEN3	
M_{20}	0	15.06	15.03	15.696	15.16
M_{20}	10	12.45	13.23	14.21	13.18
M_{20}	**20**	**14.54**	**14.21**	**14.38**	**14.36**
M_{20}	30	10.11	10.28	9.32	9.86
M_{20}	40	12.25	6.20	9.00	9.15
M_{25}	0	17.16	17.30	16.95	17.29
M_{25}	10	15.32	15.11	16.74	15.76
M_{25}	**20**	**18.76**	**18.56**	**18.22**	**18.57**
M_{25}	30	14.19	14.71	14.89	14.86
M_{25}	40	14.00	14.51	15.17	14.56

Table 6

Compressive strength of Bagasse ash concrete for 14 days

GRADE OF CONCRETE	% OF REPLCEMENT	COMPRESSIVE STRENGTH OF CONCRTE (N/mm^2)			AVERAGE (N/mm^2)
		SPECIMEN1	SPECIMEN2	SPECIMEN3	
M_{20}	0	17.67	17.34	16.54	17.10
M_{20}	10	14.45	15.87	16.08	15.16
M_{20}	**20**	**16.57**	**16.98**	**15.45**	**16.08**
M_{20}	30	13.49	11.47	12.65	12.24
M_{20}	40	13.14	11.47	11.69	12.10
M_{25}	0	21.67	21.32	21.05	21.30
M_{25}	10	17.23	17.45	17.11	17.18
M_{25}	**20**	**19.98**	**19.11**	**19.56**	**19.76**
M_{25}	30	14.19	14.71	14.89	14.86
M_{25}	40	13.19	14.20	14.61	14.00

Table 7

Compressive strength of Bagasse ash concrete for 28 days

GRADE OF CONCRETE	% OF REPLCEMENT	COMPRESSIVE STRENGTH OF CONCRTE (N/mm^2)			AVERAGE (N/mm^2)
		SPECIMEN1	SPECIMEN2	SPECIMEN3	
M_{20}	0	20.45	20.78	19.40	20.21
M_{20}	10	16.80	17.87	17.68	17.45
M_{20}	**20**	**18.35**	**18.78**	**19.67**	**18.76**
M_{20}	30	14.56	16.45	16.78	15.98
M_{20}	40	16.26	14.40	15.84	15.50
M_{25}	0	24.31	25.78	24.97	24.80
M_{25}	10	22.33	22.56	22.15	22.13
M_{25}	**20**	**24.20**	**24.48**	**22.86**	**23.45**
M_{25}	30	16.15	17.89	18.95	17.14
M_{25}	40	15.90	18.91	16.19	17.00

Table 8
Percentage of Strength reduction by replacing Bagasse Ash at 28 Days

GRADE OF CONCRETE	% OF REPLCEMENT	LOSS IN COMPRESSIVE STRENGTH, %
M_{20}	10	13.66
M_{20}	**20**	**7.17**
M_{20}	30	20.93
M_{20}	40	23.31
M_{25}	10	10.77
M_{25}	**20**	**5.55**
M_{25}	30	30.89
M_{25}	40	31.45

Table 9
Required amount of M_{20} and M_{25} mix for 1 m^3concrete

MATERIALS	QUANTITY FOR M_{20} GRADE MIX	QUANTITY FOR M_{25} GRADE MIX
Cement	372 Kg	465 Kg
Fine aggregate	558 Kg	500 Kg
Coarse aggregate	1204 Kg	1185 Kg
Water	186 lit	186 lit

Table 10
Without replacement of cement for M_{20} mix

Material	Quantity (in bag)	Quantity in m^3	Per m^3 / per bag	Rate (R.s)
Cement	7.44	0.11	350	2604
Fine aggregate	-	0.22	1100	242
Coarse aggregate	-	0.452	778	351
			Total Rs.	**3197**

Table 11
Without replacement of cement for M_{25} mix

Material	Quantity(in bag)	Quantity in m^3	Per m^3 or per bag	Rate
Cement	5.28	0.083	350	1848
Fine aggregate	-	0.22	1100	242
Coarse aggregate	-	0.447	778	348
Bagasse ash		0.033	0	0
Super plasticizer	4.02		**70**	**281**
Total				**2719**

Table 12
With Replacement of Cement for M_{20} mix (20%)

Material	Quantity(in bag)	Quantity in m^3	Per m^3 or per bag	Rate
Cement	5.28	0.083	350	1848
Fine aggregate	-	0.22	1100	242
Coarse aggregate	-	0.447	778	348
Bagasse ash		0.033	0	0
Super plasticizer	4.02		**70**	**281**
Total				**2719**

Table 13
With Replacement of Cement for M_{25} mix (20%)

Material	Quantity (in bag)	Quantity in m^3	Per m^3 or per bag	Rate
Cement	9.3	0.147	350	3255
Fine aggregate	-	0.258	1100	284
Coarse aggregate	-	0.385	778	352
Total				**3891**

Material	Quantity (in bag)	Quantity in m^3	Per m^3 or per bag or kg	Rate (Rs.)
Cement	6.51	0.103	350	2280
Fine aggregate	-	0.258	1100	284
Coarse aggregate	-	0.385	778	300
Bagasse ash		0.044	0	0
Super plasticizer	4.87		70	341
			Total	**3205**

Table 14
Percentage of reduction in cost (Replacement of cement 20%)

GRADE OF CONCRETE	QUANTITY OF CONCRETE	REDUCTION IN COST, %
M_{20}	$1m^3$	15
M_{25}	$1m^3$	17.6

CONCLUSIONS

Based on the experimental results, following conclusion can be drawn:

- 20% replacement of cement by the Bagasse ash results (i.e.) the strength is almost equal to the nominal strength of the concrete.
- It is cost effective too as it mitigates the cost by 12% for 1 m3 of concrete.
- Thus a cheaper concrete can be made with industrial waste products for an equivalent strength.
- The utilization of bagasse ash in concrete solves the problem of its disposal thus keeping the environment free from pollution.

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