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Use of Bagasse Ash as Partial Replacement of Cement in Concrete

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Abstract:
An agro-industrial waste product of sugar mills - Bagasse Ash was used to replace cement in concrete, up to a certain extent. Laboratory test results show that only up to 2% of cement can be replaced by the Bagasse ash without adverse effect on the concrete.
It is concluded that Bagasse ash does not provide improvement of concrete strength. As a result, the use of Bagasse ash as concrete additive or cement replacement may need to be combined with other bonding materials, such as fly ash or slag.

1. Introduction

The beneficial reuse of waste products from industries seems to be the new trend now. lnges and Metcalf (1972) reported the use of fly ash, while Osinubi (1998, 2000, 2006) showed that phosphatic waste, a by-product from the production of superphosphate fertilizer, pulverized coal bottom ash and blast furnace slag can be effectively used.
Bagasse (the fiber of sugar cane) is the by-product or residue of milling the cane, which can also be produced by chewing the cane by local individuals. About 33% of the bagasse produced, supplies the fuel for the generation of steam (Bilba et al 2003). With present alternative sources of fuel, sugar factories have an excess of bagasse, which together with locally generated bagasse, pose serious environmental production problem, which when inhaled in excess, causes respiratory disease known as bagassiosis (Laurianne 2004).
In Nigeria, the estimated land under sugar cane cultivation is 23 - 30, 0000ha, while large scale cultivation is done at Bacita and Numan with an estimated annual output of 96,000t (Misari et al 1998). According to Ahmad and shaikh (1992), the physical and chemical properties of sugar cane bagasse ash are found to be satisfactory and conform to the requirements for class N pozzolana (ASTM C618-78). The major Oxides in bagasse ash being $Al_2 O_3$, $Fe_2 O_3$, CaO, MgO, Na_2O, K_2O, P_2O_5 and MnO and having loss on ignition less than the specified value of 10%. Although reports by Ola 1983, Osinubi 1998a, 2000a, b, 2006 has shown use of phosphate waste and pulverized coal bottom ash, the use of bagasse ash as pozzolana has received little attention.
In Nigeria, there is little or no control over cement costs, especially as both bulk and bagged cements are mostly imported at very high foreign exchange rates. Economic use of cement in concrete can therefore mainly be achieved in Nigeria by consideration of partial replacement of the cement requirements in concrete by cheaper local pozzolana such as bagasse ash.

2. Pozzolanas

As defined in ASTM specification C618-78, pozzolanas are siliceous or siliceous and aluminous material which in itself possesses little or no cementitious value but will in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitous properties. It has been suggested that, in addition to reacting with $Ca (OH)_2$, pozzolana react also with C_3A or its products of hydration (Collepardi et al 1978). A good review of the subject of pozzolanicity has been written by Massazza and Costa (1979).
Pozzolanas are usually cheaper than the Portland cement that they replace but their chief advantage lies in slow hydration and therefore, low rate of heat development (Bamforth, 1980); which is of great importance in tropical construction works (Otoko and Chinwah 1991). Also, significant pozzolanic reaction reduces the porosity of the paste (Kovacs, 1975); and reduces the permeability (Higginson, 1966).
Fly ash, known also as pulverized – fuel ash, is the most common artificial pozzolana; an extensive review has been written by Berry and Malhotra (1980). The fly ash particles are spherical and are of at least the same fineness as cement (Central Electricity Generating Board, 1972). Modern boiler plant produce fly ash with a carbon content of about 3 percent but much higher values up to 12 present is acceptable (Prices, 1975).

Although Nigeria has about 1296 million metric tonnes reserve of coal at Enugu and substantial deposits at Kaba in Kwara State, only Oji River Power Station is using it for the generation of electricity and therefore the only source of fly ash in the country (Ngwu, 1984). Since the annual production rate of fly ash from only one station in Nigeria may not meet local demands, there is therefore the need to explore the potential of the abundant bagasse ash as pozzolana .

3. Materials and Methods

The bagasse obtained from Nwaja area of Port Harcourt city, Nigeria was air dried, burnt to ashes and passed through BS No 200 sieve. The specific gravity of the bagasse ash was 1.91. The detectable oxide composition of the bagasse ash obtained is summarized in table 1.

S/No	Property	Concentration (% by weight)
1.	CaO	3.20
2.	$S_1 O_2$	41.15
3.	Al_2O_3	7.00
4.	Fe_2O_3	2.70
5.	MgO	O.12
6.	K_2O	8.75
7.	SO_4	0.03
8.	T_1O_2	1.10
9.	Loss on ignition	17.55

Table 1: Detectable oxide composition of bagasse ash

Pozzolana cements are obtained by blending or intergrading a mixture of ordinary Portland cement and a Portland pozzolana conforming to BS EN 196-5:2011. In the preparation of all specimens, the required amounts of bagasse ash by dry weight of cement were measured and mixed in the dry state before addition of water. For determination of unconfined compressive strength, the bagasse concrete was compacted into a detachable mould (150m x 150m x 150m), specimens removed and wrapped with polyethylene sheets to prevent moisture loss.

After studying the physical and chemical analysis of bagasse ash, different percentages of its presence in cement and cement concrete were studied with respect to standard consistency, initial and final setting time and with respect to compressive strength of the hardened concrete.

4. Effect of Bagasse Ash on Consistency and Setting Time

The variations in standard consistency, initial and final setting time with bagasse ash in cement is shown in Table 2 and Fig. 1

Serial No.	Percentage Replacement	Standard Consistency	Initial Setting Time	Final Setting Time (min)
1	0%	30.00	104	218
2	2%	31.75	103	210
3	4%	32.00	107	220
4	6%	33.25	110	233
5	8%	34.00	113	245
6	10%	35.00	115	248
7	12%	35.75	120	275

Table 2: Variation in standard consistency, initial and final setting time with bagasse ash in cement

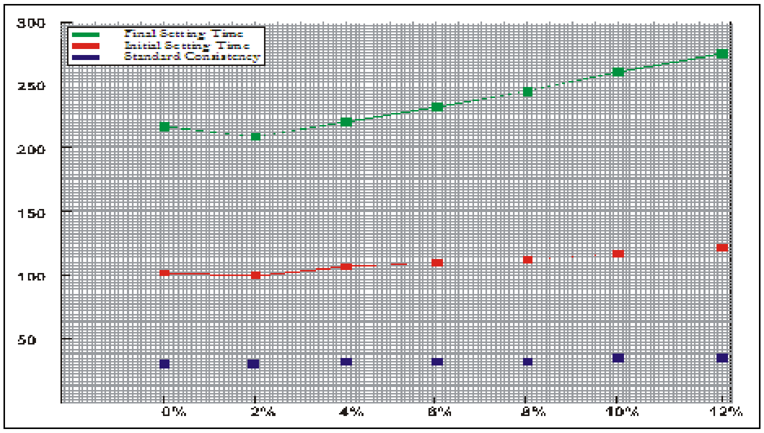

Figure 1: Variation in Standard Consistency and in Setting Time

Fig.1 shows the variation of standard consistency with different percentages of bagasse ash in cement. The standard consistency of ordinary Portland cement is 30.00. From table 2, the standard consistency increased with increase in bagasse ash content. The affinity for water increased with increase in bagasse ash content by 1.50%, 3.00%, 4.50%, 5.00% and 7.15% for 2%, 4%, 6%, 8%, 10% and 12% bagasse ash content respectively, compared with that of water requirement for standard consistency of ordinary Portland cement.
In general, there is a linear relationship between water required for standard consistency and the bagasse ash content. The increase in water required for standard consistency may be due to the fact that the bagasse ash being lighter in weight (specific gravity of 1.92 compared to that of cement of 3.15) has more finer particles and occupies more volume which needs more water for the same consistency.
The variation of the initial setting time with different percentage replacement of cement by bagasse ash is shown in Fig. 1. The initial setting time for ordinary Portland cement is 30 minutes according to BS 12 - 1996. The initial setting time for the cement used in the present studies is 104 minutes. The initial setting time for 2 % bagasse ash content is nearly the same as that of ordinary Portland cement, thereafter, the initial setting time increased with increase in bagasse content.

5. Effect of Bagasse Ash Content on Compressive Strength

Variation in 7 days and 28 days compressive strength is shown in Table 3, fig 2 and fig 3.

Serial No.	Percentage Replacement	7 days Compressive Strength in N/mm^2	28 days Compressive Strength in N/mm^2
1	0	39.58	50.10
2	2	39.15	59.75
3	4	37.30	57.60
4	6	37.30	57.15
5	8	36.60	56.75
6	10	36.10	56.20
7	12	35.70	55.80

Table 3: Compressive strength of different amount of replacement of cement by bagasse ash

6. Discussion and Conclusion

The initial setting time at 2% bagasse content is almost the same as for 0% but increase thereafter, may be due to reduction in the density of the mixture. The water cement ratio of 0.4 is kept constant for the different percentage replacement of cement by bagasse ash.

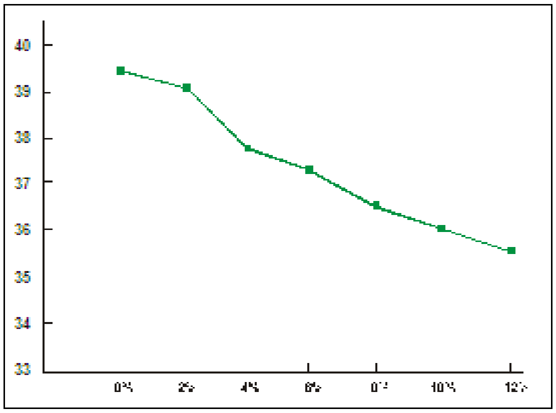

Figure 2: Variation in 7days compressive strength

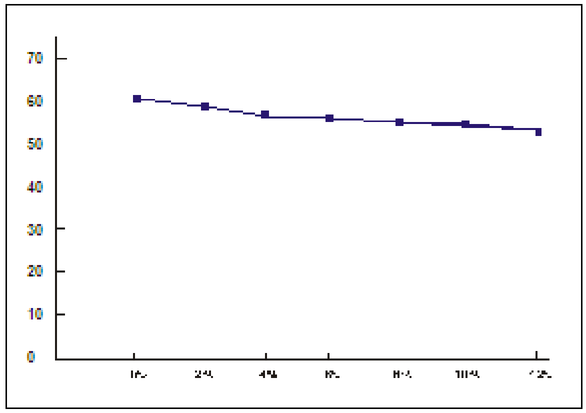

Figure 3: Variation in 28days compressive strength

From table 3, fig 2 and fig 3, it is observed that compressive strength decreased with increase in bagasse ash content at 7 days curing period compared to 7 days strength of pure cement concrete (i.e. 0% replacement).
However, it can be observed from table 3, that the compressive strength at 2% bagasse ash replacement for 28 days curing period is almost the same values as for the 0% bagasse ash content, with a norminal decrease in the compressive strength of 0.6%, while at all other bagasse content there is drastic decrease in the compressive strength. 2% replacement is therefore taken as the optimum bagasse ash replacement for the concrete mix.
As 2% replacement is rather small, it may not be of much economic value, replacing only 2% of the cement. It could therefore be concluded that no concrete strength increase was found by adding bagasse ash to concrete. As a result, the use of bagasse ash as concrete additive or cement replacement may need to be combined with other bonding materials such as, fly ash or slag. Only the pozzolanic reaction between SiO_2 in the fly ash or slag and CaO in the bagasse ash, along with the addition of water reducer or super plasticizer can improve the strength of bagasse ash concrete.

7. Acknowledgement
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8. References

1. AHMED, S.F and SHAIKH, Z. (1992). Portland - Pozzolana cement from sugar cane bagasse ash. In: Hill, N., Holmes, S. and Mather, D. (Eds), Lime and other alternative cements. Intermediate technology publications, London, pp. 172-179.
2. ASTM specification 618 – 78.Specification for fly ash and raw or calcined natural pozzolan for use as a mineral admixture in Portland Cement Concrete.
3. BAMFORTH, P.B. 1980.In the measurement of the effect of partial Portland cement replacement using either fly ash or granulated blast-furnace slag on the performance of mass concrete, Proc. Inst. C.E., London, part 2, 69,pp.777 – 800.
4. BERRY, E.E. and MALHOTRA, V.M. 1980.Fly ash for use in concrete.A critical review, J. Amer. Concr. Inst., 77, No. 8, pp. 59-73
5. BILBA, K., ARSENE, M.A. and OUENSANGA, O. (2003). Sugar cane bagasse fibre reinforced cement composites part I, Influence of the botanical components of bagasse on the setting of bagasse/cement composite. Cement and Concrete Composites, Vol. 25, No. 1, pp. 91-96.
6. CENTRAL ELECTRICITY GENERATING BOARD. 1972. Pfa utilization, 104 pp. (Wolverhampton)
7. COLLLEPARDI, M, BALDINI, G.; and PAURI, M 1978. The effect of pozzolanas on the tricalcium aluminate hydration. Cement and Concrete Research, 8, no6.pp 741 - 51.
8. HIGGINSON E.C. 1966. Mineral admixtures, ASTM Sp. Tech. Publication, No. 160 – A,pp 543-55
9. INGLES, O.G. and METCALF, J.B. (1972). Soil stabilization principles and practice. Butterworth, Sydney.
10. KOVACS, R. 1975.Effect of hydration products on the properties of fly-ash cements. Cement and concrete Research, 5, No. 1,pp. 73-82
11. KUMAR, S.S. and SUNDER, K.S. 1981.Role of lignin shury thinner in cement production. World Cement Technology, pp.208-506.
12. LAURIANNE, S.A. (2004). Farmer's lungs. www.emedicine.com/med/topic 771.htm/15.11.2005.
13. MASSAZZA, E. and COSTA, U. 1979.Aspects of the pozzolanic activity and properties of pozzolanic cements. II cement, 76, Noi.1,pp.3-18
14. MISARI, S.M., BUSARI, L.D. and AGBOIRE, S. (1988). Current status of sugar cane research and development in Nigeria. Proceedings of national co-ordinated research programme on sugar cane, NCRI, badeggi, pp. 2-12.
15. NGWU, E.N. 1984Nigeria Coal Corporation, Production of Ore Coals.Weekly Star. Nigeria.

16. OLA, S.A. (1983). Geotechnical properties and behaviour of some Nigerian lateritic soils, in: Ola, S.A. and BALKEMA, A.A. (Eds.), Tropical soils of Nigeria in Engineering practice. BALKEMA, ROTTERDAM.
17. OSINUBI, K.J. (1998a). Laboratory investigation of engineering use of phosphate waste. Journal of Engineering Research, vol. 6, No. 2, pp. 47-60.
18. OSINUBI, K.J. (2000a). Laboratory trial of soil stabilization using pulverized coal bottom ash. NSE Technical Transactions, vol. 35, No. 4, pp. 1-13.
19. OSINUBI, K.J. (2000b). Treatment of laterite with anionic bitumen emulsion and cement: A comparative study. Ife Journal of Technology,, vol. 9, No. 1, pp. 139-145.
20. OSINUBI, K.J. (2006). Influence of compactive efforts on lime - slag treated tropical black clay. Journal of Materials in Civil Engineering, ASCE, vol. 18, No. 2, pp. 145-175.
21. OTOKO, G.R. and CHINWAH, J.G. 1991.The use of 'Garri' as admixture in hot weather concreting. The journal of the Nigerian Institute of Structural Engineers, vol. 1, No. 4, pp. 13-18
22. PRICE, W.H. 1975Pozzolans – a review. J. Amer. Concr. Inst., 72, No. 5, pp. 225-32