Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2016, 3(4):111-117**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Assessment of Calcinations Temperature Effect on SCPA as Alternative Binder and Its Pozzolanic Characteristics in Concrete

TO Odewumi

Department of Civil Engineering, The Polytechnic Ibadan, Ibadan, Nigeria

Abstract Calcinated sugarcane peel ash (SPCA) as a binder plays significant role in civil engineering works. This research examined the basic engineering and geotechnical properties of concrete using calcinated SPCA as a partial replacement to improve its strength. Concrete and its properties like workability, setting and strength are essential to the design of concrete structures. In this research, experiments were carried out to investigate the application of calcined sugar cane peel ash at a suitable temperature under varying proportions with cement for the production of concrete. This was carried out to determine most suitable calcinating temperature for workability, consistency, setting time and compressive strength of the concrete. The samples used were obtained from Odo-oba, enroute Ogbomosho, Oyo state. Compressive strength test was also undertaken at varying proportions of ash with cement to determine the strength of the concrete. The ash obtained from these varying temperatures were labeled A-E respectively, calcinations temperature at 800^{0}C (sample E) met the standards ASTM C618 (2005) which specifies that any pozzolans to be used as cement binder in concrete requires a minimum of 70% for SiO_2, Al_2O_3 and Fe_2O_3 and can be adjudged a suitable pozzolanic material, after which the concrete was mixed by varying the percentage (10%, 20% and 30% respectively) of SCPA at calcinations temperature of 800^{0}C as partial replacement for cement. The obtained result showed a considerably increased in the compressive strength of the concrete when SCPA was introduced as partial replacement which gives a more suitable result at 10% after curing from 7 to 28 days (15.56,17.20,19.11 & 22.11N/mm^2) respectively to attain its full strength. It was concluded that calcinations temperature has shown significant effect on SPCA characteristics. Hence, sugar cane peel ash at a calcinating temperature of 800^{0}C should be employed as a modernized form of improving on the strength of concrete.

Keywords SPCA, binder, Calcinations, Pozzolans, Compressive strength

Introduction

In any process carried out by commercial industries, principles on conservation and the use of natural resources must be taken into account. Therefore, it is necessary to consider a new approach to materials and production processes that is based on the reduction of natural resource extraction and the waste generated. "The cement industry is a key industry for sustainable development of any country, can be considered the backbone for development" [1]. With increasing industrial activities around the world, it is imperative to search for materials that can replace some of the current components in commercial cement, with others that have a similar chemical composition and that can reduce production costs without affecting the quality of the concrete [2].

The use of pozzolanic materials is found in many ancient civilizations. Pozzolans were used to improve the properties of lime, and many structures are still extant as a testament to the durability of lime – pozzolan mortars and concrete [3] and [4]. Pozzolans are siliceous or siliceous and aluminous materials which alone possess little or no cementious property but which will, in finely divided form in the presence of moisture, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementious properties (ASTM-C618).Many of these pozzolans are industrially by-products, and considered as waste, so that the resulting benefits in terms of energy savings, economy, environmental protection and conservation of resources are substantial. The most outstanding benefit of incorporating pozzolans in concrete is to improve durability of the concrete [5]. Nowadays, industrial by-products including clays and agricultural wastes with an elevated silica content are used as pozzolans in Portland cement but are not properly optimized to the most suitable percentages of these chemical constituent due to the fact that open burning is mostly adopted. The recycling of agricultural waste is increasingly encouraged. Hydrated compounds formed during pozzolanic reactions commonly improve the performance of new concrete. This research tends to study the calcinating temperature as a factor which influences the pozzolanic activity of sugar cane peel ash (SCPA).

Sugar cane peel is an agricultural by-product and these by-products in many context cannot be considered as waste for they could be used as fuel source, feed for animals or as raw materials for various manufacturing processes while large amount of it is also burnt in open field, thereby causing pollution. The peel itself cannot be used as cement replacement but the ash obtained from pyro-processing the residue that is of interest, two factors require consideration in the pyro-processing; the ash content and the chemical constituents of the ash. The ash content is important because it indicates the amount of peel which needs to be burnt i.e. the yield. It was already known that sugar cane bagasse and sugar cane straw (sugar cane leaves) can be recycled in the manufacture of commercial cements and other composites, either as raw material or as pozzolanic material. For use as pozzolans, the agricultural wastes need prior calcinations but pozzolanic activation can vary substantially as a result of the calcining conditions and the nature of the source materials. However, there are contradictory reports about the pozzolanic effectiveness of sugar cane bagasse ash, possibly due to the use of different calcining temperatures [6].

Materials and Methods

Materials and equipment to be used for the calcinations and production of concrete by varying the partial replacement of Sugar Cane Peel Ash (SCPA) to cement include: Ordinary Portland Cement (OPC), Lithium bromide, Lithium tetra borate, Lithium meta borate, Integrated X-ray Analyzer, Oven, Electric furnace, Stop clock, Desiccator, Box –resistance heating electric furnace, Sugar cane peel Ash (SCPA), Fine aggregate (Sand) and Coarse Aggregate (Granite).

The fine aggregate used was obtained in Ibadan; it is silty in nature with little soil sand in it. Also, granite which was obtained from quarry along Ibadan- Lagos expressway was used for this research. They are of various sizes found such as 3/8, 3/16, 4/16 inches etc. The 3/8 inch size was used in this research. The water for mixing the concrete was obtained from a borehole source around the Sango area in Ibadan.

The sugar cane peel used for this study was collected from odo-oba, via Ogbomoso, Oyo state, Southwestern Nigeria. It was sundried (7 days), pulverized and calcined by controlled burning at a temperature range of 400-800^{0}C for 45 minutes. After cooling, the resultant ash was grinded into finer particles using mortar and pestle and was sieved using a 212µm sieve. The obtained ashes, base on heating conditions, were labeled A-E respectively, weighed using a weighing balance and placed in desiccator for cooling. Fusion method was adopted in analyzing the samples, and the chemicals used in fusing the samples were Lithium Tetra borate and Lithium Meta borate at a ratio of 66% to 34%, respectively. The chemicals were weighed and place in the crucible furnace with the aid of a glass rod for 1hour at 110^{0}C and then mixed with 2 grams of each of samples A-E. 1ml of Lithium Bromide was added to the mixture and placed inside an automatic fusion machine for 20 minutes. The samples were then placed under an Integrated X-ray analyzer to obtain the general oxides. Dangote brand of Ordinary Portland cement was used for the study. River sand used for the study was also obtained at the bank of Eleyele River in Ibadan. The sand is free from deleterious materials and falls within zone 2 of BS 882(1979) classification chart with a bulk density of 1528kg/m3 and a specific gravity 2.62.water fit for drinking was used for the study and as such no test was conducted on the water. The tests carried out include: Sieve analysis test, Bulk Density, Compressive cube test, Workability test, setting time test and Consistency limit test.

Result and Discussion

The results obtained from the experimental test were presented in tables and figures.

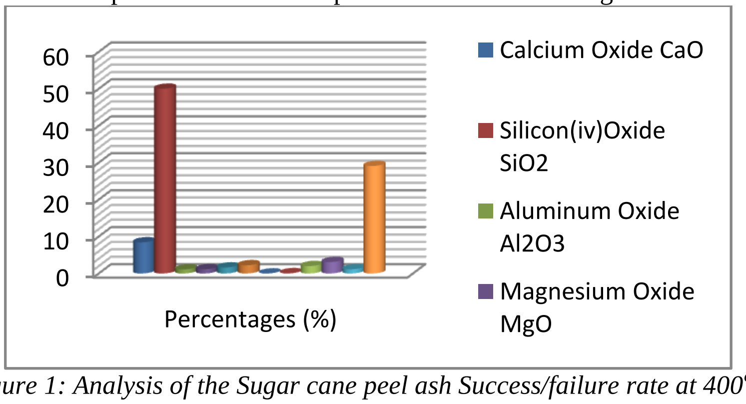

Figure 1: Analysis of the Sugar cane peel ash Success/failure rate at 400^{o}C

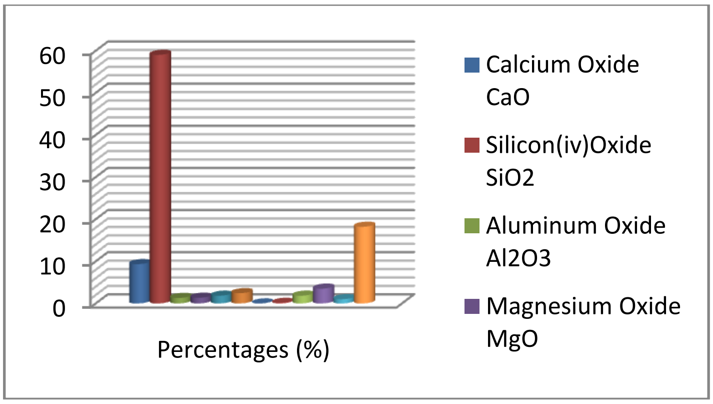

Figure 2: Analysis of the Sugar cane peel ash Success/failure rate at 500°C

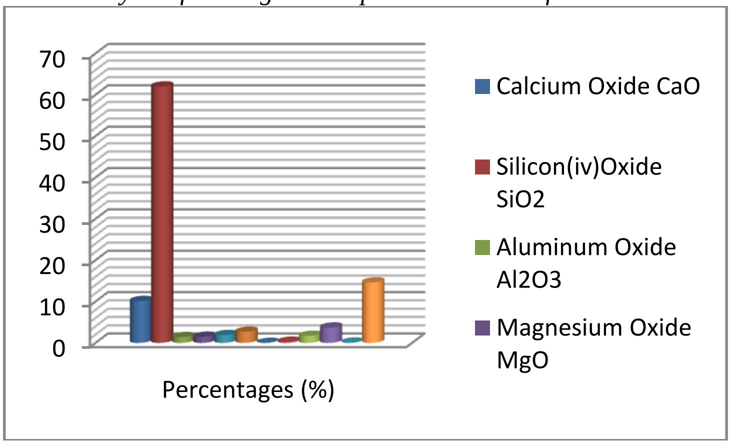

Figure 3: Analysis of the Sugar cane peel ash Success/failure rate at 600°C

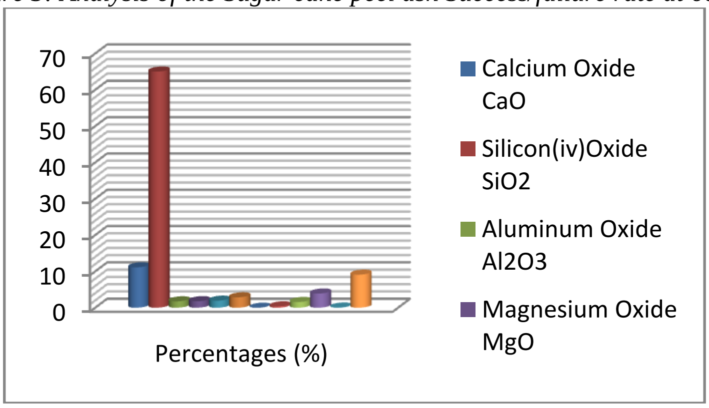

Figure 4: Analysis of the Sugar cane peel ash Success/failure rate at 700°C

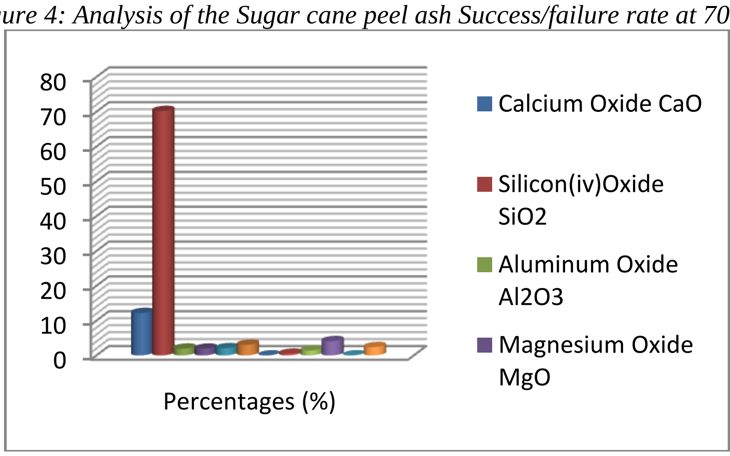

Figure 5: Analysis of the Sugar cane peel ash Success/failure rate at 800°C

Table 1: Percentage composition of the pozzolanic constituent of SCPA

Temperature (^0C) Total content (%)	400	500	600	700	800
$SiO_2+Al_2O_3+Fe_2O_3$	52.75%	62.15%	65.31%	68.72%	74.27%

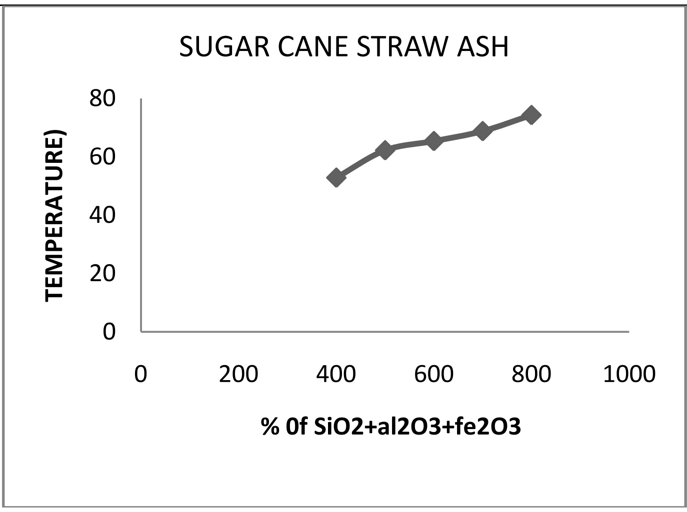

Figure 6: Graph showing the total content of silica, alumina and ferric oxide at varying temperatures

Results of the chemical compositions of sugar peel ash shows that pozzolanic activity at any temperature is a function of the material used. From fig. 1-5 and fig. 6 above, the silica content was 50.02% at 400^0C, 59.02% at 500^0C, 62.02% at 600^0C, 65.02% at 700^0C and 70.22% at 800^0C. Of the active oxides, silica is normally considered as the most important and should not fall below 40% of the total ASTM C618 (2005).The five samples met this standards which are the calcining temperature from 400^0C-800^0C, the silica content at 800^0C was the highest and lowest at 400^0C. The alumina content was 1.10% at 400^0C, 1.30% at 500^0C, 1.40% at 600^0C, 1.76% at 700^0C and 1.96% at 800^0C. Alumina content at 800^0C was the highest and lowest at 400^0C. Ferric oxide content was 1.63% at 400^0C, 1.83% at 500^0C, 1.89% at 600^0C, 1.94% at 700^0C and 2.09% at 800^0C. Ferric oxide content at 800^0C was the highest and lowest at 400^0C. The total content of silica, alumina and ferric oxide was 52.75% at 400^0C, 62.15% at 500^0C, 65.31% at 600^0C, 68.72% at 700^0C and 74.27% at 800^0C. ASTM C618 (2005) specifies that any pozzolans to be used as cement binder in concrete requires a minimum of 70% for SiO_2, Al_2O_3 and Fe_2O_3. From the table and figure above calcination temperature at 800^0C met these standards and can be adjudged a suitable pozzolanic material. Thus, the SCPA ascertained at this temperature (800^0C) was used as a case study in the partial replacement of SCPA with cement at varying percentages to ascertain its suitability.

Data Analysis

Cubes Casted on 5th of May 2016

Head pan weight: 1.9kg Ratio / mix design used: 1:2:4 (cement to sand to concrete). The concrete was mixed by varying the percentage of SCPA at calcination temperature of 800^0C as partial replacement for cement.

Casting of 0% of Sugar Cane Peel Ash (SCPA) (A1 – A4)

Cement = 5 kg
Fine Aggregate = 10 kg
Coarse Aggregate = 20 kg
Water = 3 litres
Numbers of cubes = 4

Casting of 10% of Sugar Cane Peel Ash (SCPA) (B1 – B4)

Cement = 4.5 kg
Sugar Cane Peel Ash (SCPA) = 500 g
Fine Aggregate = 10 kg
Coarse Aggregate = 20 kg
Water = 3.3 litres
Numbers of cubes = 4

Casting of 20% of Sugar Cane Peel Ash (SCPA) (C1 – C4)

Cement = 4 kg
Sugar Cane Peel Ash (SCPA) = 1 kg
Fine Aggregate = 10 kg

Coarse Aggregate = 20 kg
Water = 3.7 litres
Numbers of cubes = 4

Casting of 30% Sugar Cane Peel Ash (SCPA) (D1 – D4)

Cement = 3.5 kg
Sugar Cane Peel Ash (SCPA) = 1.5 kg
Fine Aggregate = 10 kg
Coarse Aggregate = 20 kg
Water = 4.2 litres
Number of cubes = 4

Observations During / After Mixing

i. The concrete mixed with Sugar Cane Peel Ash (SCPA) absorbed water quickly and faster as the percentage increases compare to the concrete mix with zero percent (0%).
ii. The Sugar Cane Peel Ash (SCPA) concrete mix absorb more water as the percentage increases than the other mix with zero percent (0%) of cow dung.
iii. The setting time to hardening of the concrete is more delay as the percentage of Sugar Cane Peel Ash (SCPA) is added which is higher compare to the zero percentage (0%) of Sugar Cane Peel Ash (SCPA) concrete mixture.

Crushing Result

Below tables express the results as obtained before and after crushing the cubes. The curing days for the cubes are 7, 14, 21 and 28 days respectively

Table 2: Compressive strength at 7 days (10 – 05 – 2016)

Specimen	Weight of Cube (kg)	Crushing load (kN)	Crushing strength (kN/mm^2)	Density of cube (kg/m^3)
0%	8.380	325	15.44	2,488.9
10%	8.300	305	14.56	2,459.3
20%	8.150	150	7.67	2,414.8
30%	8.010	115	6.11	2,373.3

The compressive strength is low due to the number of curing days

Table 3: Compressive strength at 14 days (17 – 05 – 2016)

Specimen	Weight of Cube (kg)	Crushing load (kN)	Crushing strength (kN/mm^2)	Density of cube (kg/m^3)
0%	8.700	350	17.56	5, 577.80
10%	8.550	342	16.20	2, 533.30
20%	8.000	208	9.24	2, 370.40
30%	7.800	122	6.42	2, 311.11

The compressive strength increases compare to the 7 days curing.

Table 4: Compressive strength at 21 days (24 – 05 – 2016)

Specimen	Weight of Cube (kg)	Crushing load (kN)	Crushing strength (kN/mm^2)	Density of cube (kg/m^3)
0%	8.900	392	18.42	2, 637.00
10%	8.700	385	18.11	2, 577.80
20%	7.800	228	11.13	2, 311.11
30%	7.450	130	6.78	2, 207.40

There is an increase in the strength compare to the 14 days

Table 5: Compressive strength at 28days (31 – 05 – 2016)

Specimen	Weight of Cube (kg)	Crushing load (kN)	Crushing strength (kN/mm^2)	Density of cube (kg/m^3)
0%	9.300	480	22.33	2, 755.6
10%	9.050	475	22.11	2, 681.5
20%	9.500	250	12.11	2, 222.2
30%	7.100	135	7.00	2,103.7

This also increases compare to previous number of curing days

Consistency Limit Results

Consistency limit is a basic aim to find out water content require to produce a cement paste of standard consistency as specified by the 15:4031 (part 4) – 1988. The table below showed the results obtained by varying the percentage of Sugar Cane Peel Ash (SCPA) added in as cement replacement.

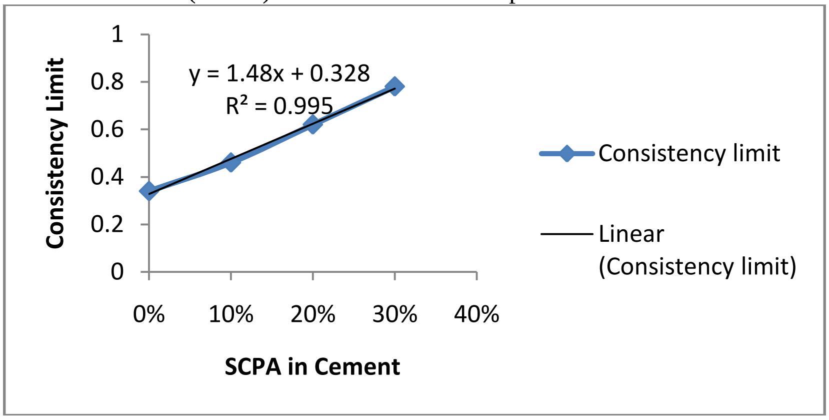

Figure 6: Consistency limits result for different mix varying the Sugar cane peel Ash (SCPA) in cement

Workability

Workability implies the ease with which concrete mix is handling and it can be determine by slump test. Slump test as for 1S: 1199 –1959 is followed, the used of slump core and tamping rod. The table below has shown the workability of each mix of concrete varying the percentage of Sugar Cane Peel Ash (SCPA).

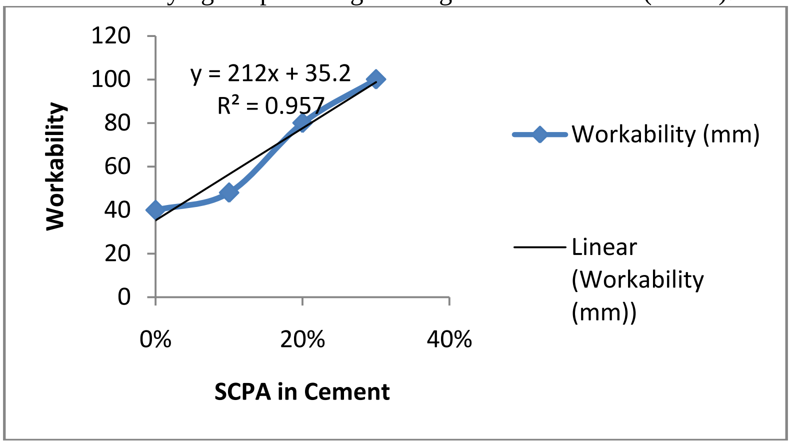

Figure 7: Workability result of Sugar Cane Ash (SCPA) in various mix of concrete

Setting Time

This is determining the initial and final hardness of concrete. It is been carried out on each mix varying the percentage of Sugar Cane Peel Ash (SCPA). It was obtained by observation and by the use of a needle to penetrate to obtain the final setting time. The table below has shown the initial and final setting time of each concrete mix respectively.

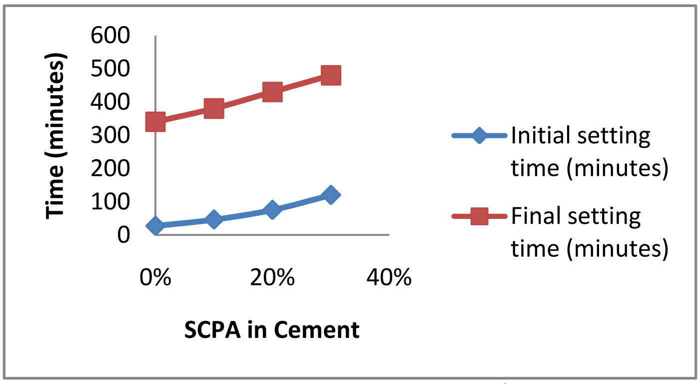

Figure 8: Setting time result varying the percentage of the Sugar Cane peel Ash (SCPA) in cement

Conclusion and Recommendation

The study investigated the effect of calcination temperature on the pozzolanic of sugar cane peel ash (SCPA) on concrete. From the analysis of the result, one can rightly conclude as follow; Sugar Cane peel Ash (SCPA) concrete can be made to perform well in certain floor and wall applications when a ten percentage (10%) only of Sugar cane peel Ash (SCPA) are added. It requires more quantity of water as the percentage increases in the concrete, therefore it has a serious limitation that must be understood before it is put to use, it has an advantage that offers lightness of weight and low thermal conductivity that makes it useful construction material. The initial and final setting time increases as the percentage of Sugar Cane Peel Ash is added. This would result in delay in the construction work. Sugar cane peel Ash (SCPA) concrete is recommended for use only when a ten percentage (10%) of Sugar cane peel Ash is added. While the concrete is suitable for use on certain floor and wall that will not be subjected to heavy load or structures that are of temporary use. Sugar cane peel Ash (SCPA) concrete is not to be use in a water accumulated area or for structures that are related to water. Sugar cane peel Ash (SCPA) concrete of high percentage over 10% is not suitable for concrete production due to the increase in the ash content. In general Sugar cane peel Ash (SCPA) concrete is not suitable for use where high structural strength is required or where it would be subjected to heavy traffic and several abrasive actions.

References

1. Nakhla, D.A and El-Hagal, S (2014) A proposal to Environmental Balanced Sugar cane Industry in Egypt. International Journal of Agricultural Policy and Research, Vol. 2(9), pp.321-328.
2. Chusilp, N, Jaturapikatul, C and Kiattikomol, K (2009) Effects of LOI of Ground Bagasse Ash on the Compressive Strength and Sulfate Resistance of Mortars. Constr. Build. Mater., 23. Pp 3523-3531.
3. Musbau, A.S, Efe, E.I and Kolawole, A.O (2012) Structural Strength Characteristics of Cement-Cassava Peel Ash Blended Concrete. Civil and Environmental Research, Vol 2, No.10, pp. 68-77
4. Raheem, S. B, Arubike, E. D and Awogboro, O. S (2015) Effects of Cassava Peel Ash (CPA) as Alternative Binder in Concrete. International Journal of Constructive Research in Civil Engineering (IJCRCE), Volume 1, Issue 2, pp. 27-32.
5. Sanchez, A.N and Sagues, A.A (2014) Chloride Corrosion Threshold Dependent on Steel Potential in Reinforced Concrete. Paper No. 4118, Presented at the NACE Corrosion 2014, San Antonio, TX.NACE International, Houston, TX.
6. Singh, N.B, Singh, V.D and Rai, S (2000) Hydration of Bagasse ash-blended Portland cement. Cement and Concrete Research, 30(9), pp. 1485-1488