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GREEN CEMENT FROM SUGARCANE LEAVES COMBUSTION ASH

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ABSTRACT

The production of bottom ashes as a pozzolan material from combustion of sugarcane leaves (SCL) for partial replacement of ordinary Portland cement (OPC) was investigated. SCL samples were water washing and densified to improve their physicochemical characteristics and thermal behavior. The resulting briquettes were burned under a controlled temperature below 800°C in a fixed bed reactor. The combustion ashes obtained qualify as a pozzolan material and are suitable to be used as a partial replacement of OPC up to a value of 20%.

Keywords: biocement, pozzolan, alkali reduction.

INTRODUCTION

Cement industry is responsible for around 5% of global CO_2 emissions. The production of one ton of cement results in the release of one ton of CO_2 into the atmosphere. (Madani Hosseini, Shao, and Whalen 2011; Fabiyi 2013) Bio-silica (amorphous silica) produced from combustion of organic residues blended with OPC can mitigate this emission. Agro-waste can produce bio-silica, a pozzolan material for partial replacement of OPC. Good properties are obtained when SiO_2+Al_2O_3+Fe_2O_3 ash oxides exceeds 70% by weight. The reactivity of bio-silica can be optimized by controlling the temperature and incineration time (Madani Hosseini et al. 2011). However, agro-wastes combustion usually cause problems of slagging and fouling in boilers and furnaces due to the presence of alkalis, Cl, and S in the fuel (Vamvuka and Zografos 2004). Washing pretreatments are used for removal of these harmful elements (Deng, Zhang, and Che 2013).

Sugarcane industry in Peru generates 2 million tons per year of SCL which do not have any use being burned in the fields. (Assureira, & Assureira, 2013). In this work the integral use of SCL as solid biofuel and combustion ash as pozzolan for cement industry was investigated. Results of test applied to SCL samples showed high alkali, Cl and S contents that were reduced by water washing SCL for 30 minutes at 80°C decreasing the slagging and fouling risk. The percentage of reduction achieved is reported. To increase the energy density of the fuel a mixture of dried and ground washed SCL, corn starch and clay (75%, 15% and 10%) was densified. The briquettes (diameter 36 mm, 396 kg/m^3, HHV 16.4 MJ/Kg) were burned in a fixed bed reactor under controlled temperature (below 800°C) and resident time (16 min.) to obtain reactive ash. The production of SCL combustion ashes as a pozzolan for partial replacement of OPC was investigated

RESULTS AND CONCLUSIONS

SCL were characterized by ultimate, proximate analysis, HHV and ash chemical composition. The contents of ash, S and Cl were high (11.4%, 0.26% and 0.53%, measured on wt.%, db). Also, ash composition showed high contents of Na_2O (2.1%) and K_2O (8.7%) alkali oxides. These suggest

ash deposition and corrosion in boilers. Water washing removed substantial fractions of ash, S and Cl from SCL (60.4, 60.2% and 77.9% respectively). The alkalis oxides (Na_2O and K_2O) decreased greatly (56.9% and 41.0% respectively). All these contributed to an improvement in fuel quality. The SCL briquettes combustion ashes showed that SiO_2+Al_2O_3 +Fe_2O_3 ash oxides was 88.2% satisfying the requirements for pozzolan materials according to ASTM C618-15 standard. Also SO_3 and LOI were within the established limits. Amorphous content was 45%, showing ash reactivity. Strength activity index at 28 days was 101 MPa > 75 MPa minimum value specified for Class F fly ash confirming that the ash qualify as a pozzolan material. Cementitious mixtures (PUCP IP) with 20% of ash replacement were produced and tested. The chemical and physical properties (Table 1) satisfied the requirements of the standard ASTM C595-15 for Portlad-pozzolan cements IP type. This study shows that SCL combustion ashes are a good pozzolan and suitable for partial replacement of OPC up to a value of 20%.

Table 1 - Chemical and physical characteristics of PUCP cementitious mixtures with 20% of ash replacement

Property	Unit	PUCP IP(20)	ASTM C595-15
Magnesium oxide, MgO	%	2.2	6.0 máx.
Sulfur trioxide, SO_3	%	2.45	4.0 máx.
Loss on ignition, LOI	%	1.8	5.0 máx.
Fineness (Amount retained - wet sieved on N°325)	%	7	
Autoclave expansion	%	0.01	0.80 máx.
Time of setting, Vicat test			
Initial setting time	minutes	146	45 mín.
Final setting time	minutes	315	420 máx.
Air content of mortar	%	3	12 máx.
Compressive strength			
3 days	MPa	21.5	13.0 mín.
7 days	MPa	28.9	20.0 mín.
28 days	MPa	42.6	25.0 mín.

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