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Utilization of Local Materials (Pozzolana, Sugarcane bagasse ash or local sand) in reducing Clinker Cost

Mashair Khalil Idris[1], Kamal Eldin Eltayeb Yassin[2]

[1]Sundance Standard and Metrology Organization Khartoum, Sudan (E-mail eng_mesha123@hotmail.com)

[2]Department of Chemical Engineering, Faculty of Engineering, University of Khartoum
Khartoum, Sudan (kamaltyb@gmail.com)

Abstract

Ordinary Portland cement is the most common type of cement used in construction applications in Sudan, but it is an expensive binder due to the high cost of production associated with the high energy requirements of the manufacturing process.

Using cheap local materials (Pozzolana, Sugarcane bagasse ash or local sand) as an alternative to partially replace the expensive clinker (limestone) which eventually will lead to the reduction of total production cost of Portland cement

This paper investigates the use of local materials as an alternative for the production of high-strength and low cost cement. For that purpose, physical properties and chemical composition of local materials were determined as well as the compressive strength properties of the mortar. These investigations were carried by replacing 5%, 10% and 15% by weight of Portland clinker with those local materials.

The mortar cubes were tested at the age of 2, 7 and 28 days. The results showed that besides, improving the strength and other properties of cement, these local materials specially bagasse ash can increase income in addition to its environmental benefits of reducing the costs of waste disposal. It could be concluded that incorporation of about 10% Bagasse Ash as a substitution to clinker is greatly beneficial to the strength and cost gain.

Key words: Sugar Cane bagasse, Pozzolana, Portland Clinker

1- INTRODUCTION

Due to the high rate of population growth and the increase demand for habituate in Sudan, the construction of buildings and infrastructures have increased rapidly and tremendously.

It is well known that, the most common type of cement in general use around the world is ordinary Portland cement (OPC) (1), but it is an expensive binder due to the high cost of production associated with the high energy requirements of manufacturing process itself since the raw materials such as limestone and clay are

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heated in a kiln at 1400-1450°C to form predominantly clinker, which is then finely ground together with additives such as gypsum to obtain Portland cement (2). For the reasons mentioned, the cost of cement is continuously rising and natural resources (such as limestone) are decreasing. To contoabute in solving these problems, this current research objective is using other cheap inorganic materials with cementitious properties such as natural pozzolans e.g. volcanic tuff ,sand and waste products from industrial plants e.g. bagasse ash can be used as a partial replacement for Portland clinker i.e. blended cements . In addition to reducing the cost of binder, there are potential technological benefits from the use of pozzolanic materials as those blended with Portland clinker in mortar and concrete applications. These include increased workability, decreased permeability , increased resistance to sulphate attack , improved resistance to thermal cracking and increased ultimate strength and durability of concrete(3).

As well as improving strength and properties of cement containing these local materials is increasing income and is helping in recycling of these wastes (4).

The local available environmental material to be used in this study in combination with clinker is natural Pozzolana , Bagasse Ash and Local Sand.

In the sugar cane industry, bagasse is the main waste from the milling process. It is often used as fuel for the boilers to generate steam during sugar processing. Burning of bagasse in the boiler produces bagasse ash (BA) as a combustion product (5). This material usually poses a disposal problem in sugar factories particularly in Sudan (6).

Pozzolanas are materials containing reactive silica and / or alumina which on their own have little or no binding property but, when mixed with lime in the presence of water, will set and harden like a cement. They are an important ingredient in the production of an alternative cementing material to ordinary Portland cement (OPC) (7).

In fact, many local materials can be used in cement production as replacement percentage of clinker, depending on their chemical and physical characteristics.

Recently, the use of local materials from other sources has become significant for technical, environmental and economic reasons.

Moreover, when local materials appropriately used in clinker, some important properties of clinker can be improved like compressive strength and it also reduces the cost of cement production due to less clinker use.

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The main objective of this study is to explore the potentiality for using local materials produced from White Nile State(lime stone, bagasse ash and sand) and Al Gazeira State(pozzolana) such as a pozzolanic material so as to be partial replacing of Portland clinker in cement industry.

The ultimate aims are reduction of clinker cost in cement, improving of compressive strength and minimizing the negative environmental effects of some of agricultural waste like bagasse ash. To achieve this, experimental investigations were carried out to examine the impact of local materials in Portland cement by partial replacement of Portland clinker at the ratio of 0%, 5%, 10% and 15% by weight on the properties of pastes and mortar containing local materials, such as normal compressive strength tests and chemical composition tests. The main ingredients consist of Portland clinker, local materials (Sugar cane bagasse ash (SCBA), Sand, Pozzolana), local sand and water. After mixing, mortar specimens were casted and subsequently all test specimens were cured in water at 2, 7and 28 Days. The results are useful for designers and civil engineers to employ local materials such as a Pozzolanic material in concrete.

2- Materials and methods

2.1 Materials

Three samples of local materials were chosen (Pozzolana, Bagasse ash and Sand) for their chemical compositions were then added to clinker (limestone). A fresh clinker from White Nile Cement factory was used. The chemical compositions of clinker and local materials were provided in **Table (1)**

Table (1): Chemical Composition of Clinker and Local Materials

Component	Clinker	Local Materials		
		Local Sand	Bagasse Ash	Pozzolana
SiO2	21.22	92.02	65	75.50
Al2O3	4.59	1.91	3.95	7.65
Fe2O3	3.79	1.19	9.17	5.18
CaO	63.56	3.08	12.6	1.12
MgO	3.83	0.4	0.6	0.80
SO3	0.90	0.03	0.1	0.89
L.O.I	1.85	0.53	9.02	8.73

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2.2 Preparation of Materials

There are no specifications or test methods to determine the grind ability of raw materials. Many types of grinding machines were developed to grind the clinker such as; ball mill, tube mill, rod mill. In this study, the ball type grinder was used. Bagasse ash was taken from Assalaya Sugar Factory , Sand and limestone from White Nile State ,and Pozzolana from Al Gazeira State. Clinker and gypsum from White Nile factory were mixed with local material in the different amounts; 5%, 10% and 15% by weight replacement then ground and screened through a sieve of 212µ mesh size. The gypsum was used at %4 by weight in the production of local materials. Finally, these tests were used to investigate the pozzolanic properties of Local materials, and its effects on the performance of the mortar such as strength and chemical properties.

2.3 Test Methods

The composition of the mortar specimen mixes was 1:2:6 (water/cement/local sand). After mixing, the mixtures were cast into 40*40*160 mm steel mold prism and were put into the chamber which were set at 100% humidity and 20±2°C temperature. Steel molds were removed after 24 hr and specimens were cured in the water with 20±2°C temperature. Flexural and compressive strength tests were applied at the test span of 2, 7, and 28 days. First, the flexural test with one-point loading was applied to the center of the specimen (The tests were carried out in accordance with the requirements of BS EN 196-1: 2005 - Part 1: Determination of strength). The broken parts were used for compressive strength test. The experimental results of two identical specimens were averaged for each span of time (8).

3. RESULTS AND DISCUSSIONs

Table (2) shows content of different percentage clinker to complete the tests and the chemical(9) & physical test(10) and compressive strength values of mortar were given in **Table (3)** The replacement amount has an important role for the strength development of blending cement at specified times.

Table (2): Sample of The Local Material Mixed with Different Percentage Clinker:

Sample No	Gypsum %	limestone %	Local Materials		
			Local Sand	Bagasse Ash	Pozzolana
1	4%	96%	Zero%	Zero%	Zero%
2	4%	91%	5%	5%	5%

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3	4%	86%	10%	10%	10%
4	4%	81%	15%	15%	15%

Therefore, the relationship between local materials and strength development were taken into consideration and represented in **Figure (1).**

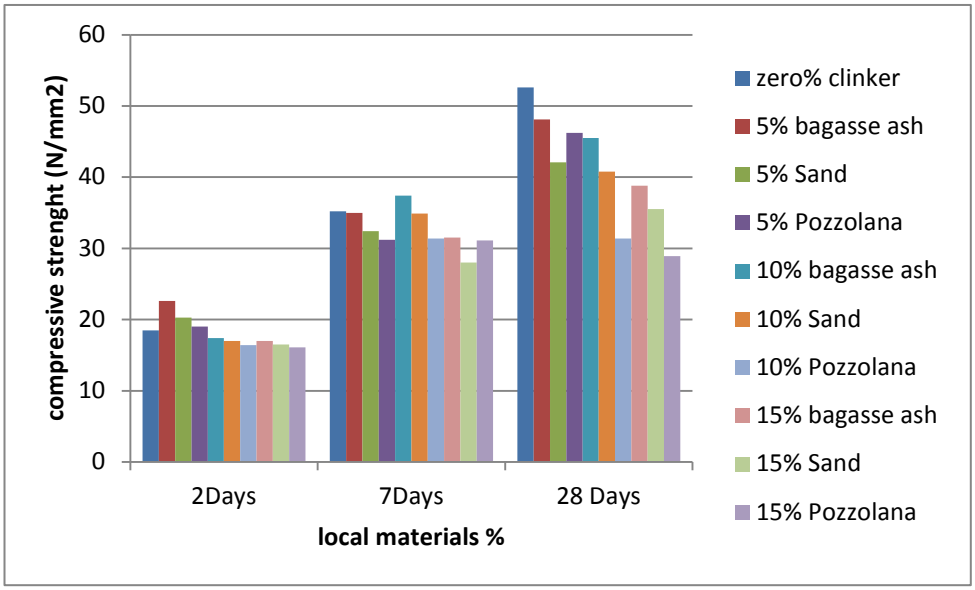

Figure (1)
Relationship Between Portland Clinker partial Replacement and incorporation of Local Materials(Bagasse Ash, Sand, Pozzolana) in Compressive Strength of Mortar

Figure (1) illustrates the typical development of compressive strength for clinker and local materials (Pozzolana, Bagasse Ash, Sand) by adding 0%, 5%, 10% and 15% for 2 days, 7days and 28 days. It is evident that, the compressive strength of Mortar increases by adding local material 5% up to10% then decreases up to 15% at different times for Portland cement.

Economical advantages:

The production of cement is energy intensive and it is an inbound industry which depends on the availability of raw materials near to the cement manufacturing area. The process is divided into three steps, raw material preparation process, the clinker burning process and the finish grinding process. Out of these processes, clinker burning is the most energy intensive process, accounting for about more than 90% of consumed fuel , about 30% of the electric power consumption , it also known that

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about 40% of the electric power is consumed by the finish grinding process and about 30% by the raw material preparation(8).

The production cost of incorporating local materials is much lower than that of ordinary Portland cement. for that local materials cost is not more than its transportation (load –distance factor) which employ that the total cost is minimized by the addition of adding not more than 5% as percentage SSMO (Sundance Standard and Metrology Organization) for Portland cement. In the studied plant, milling of 32 tons (96% lime stone + 4% of gypsum & clay) can reduce the raw material from 32tons to 30.4 tons by adding 1.6 tons of local material(Bagasse Ash, Pozzolana and Sand) which will make a substantial decrease in the experience lime stone.

Table (4) shows the cost of transporting different materials to the factory and **table (5)** illustrates the cost of production clinker by adding local materials.

Table (4)

Cost of transporting Raw Material from Production to the Factory

Local material	Cost for one ton
Lime stone	107
Pozzolana	500
Bagasse Ash from Assalaya Sugar Factory	65
Bagasse Ash From Kenana Sugar Factory	104
Sand	120

Table (5)

Cost of Production Clinker from Local Material

Raw material	Clinker Ton/hr	cost of Clinker /hr. (Sudanese pound)	cost of Clinker /month
96% lime stone	30.74	3289.18	2368209.6
5% bagasse ash Kenana* +91% lime stone	29.14+ 1.6	3284.38	2364753.6
5% bagasse ash Assalaya* +91% lime stone	29.14+ 1.6	3221.98	2319825.6
5% pozzolana + 91% lime stone	29.14+ 1.6	3917.98	2820945.6
5% sand+ 91% lime stone	29.14+ 1.6	3309.98	2383185.6
10% bagasse ash kenana +86% lime stone	27.54 + 3.2	3279.58	2361297.6
10% bagasse ash Assalaya	27.54 + 3.2	3154.78	2271441.6

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+86% lime stone			
10% pozzolana +86% lime stone	27.54 + 3.2	4546.78	3273681.6
10% Sand +86% lime stone	27.54 + 3.2	3330.78	2398161.6
15% bagasse ash Kenana + 81% lime stone	25.94 + 4.8	3274.78	2357841.6
15% bagasse ash Assalaya + 81% lime stone	25.94 + 4.8	3087.58	2223057.6
15% pozzolana + 81% lime stone	25.94 + 4.8	5175.58	3726417.6
15% Sand + 81% lime stone	25.94 + 4.8	3351.58	2413137.6

- Kenana and Assalaya are sugar production plants in the White Nile State in Sudan.

Therefore, the relationship between pure clinker and partial addition of local materials (5%, 10% and 15%) and the cost are also shown in **Figure (2).**

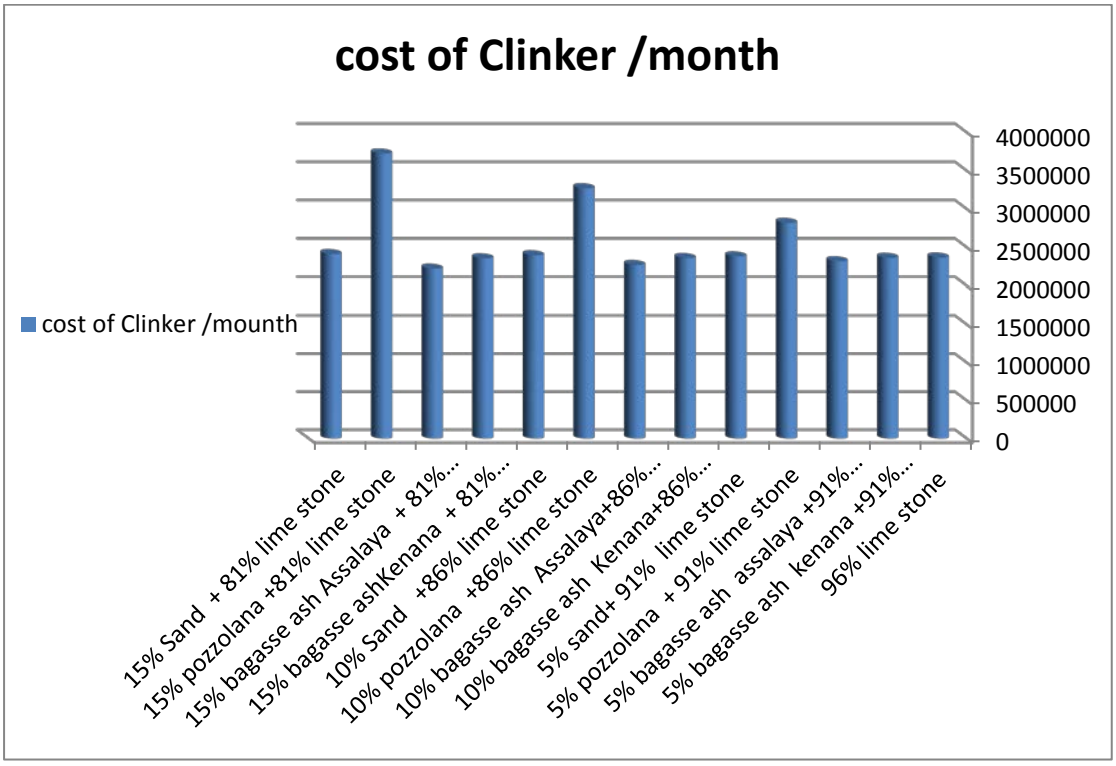

Figure (2)

Relationship Between Portland Clinker pure and the partial replacement with Percentage of Local Materials(Bagasse Ash, Sand, Pozzolana):

According to table(5) and figure(2, the suitable local material added to the raw material to produce 32 ton/hr with the best strength and cheapest cost is bagasse ash from Assalaya Sugar factory.

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4. CONCLUSIONS AND RECOMMENDATIONS

With reference to the presented results, it could be concluded that:

The availability of sugar cane bagasse ash with pozzolanic materials can become an important raw material and technological advantage in the manufacturing of cement.

Decreasing cost and increasing Compressive strength were confirmed on adding 5% &10% bagasse ash. The biggest advantage is to minimize the negative environmental impacts of bagasse ash disposal in the White Nile State of Sudan known for its high production of sugar cane.

Bagasse ash is abundantly available in White Nile state. Its use for replacing 5% of clinker to produced Portland clinker is highly recommended to produce a low cost cement. Another alternative is to use 10% Portland pozzolana to have a very high compressive strength cement.

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