UTILIZATION OF BAGASSE IN BRICKMAKING

R & D IN SUDAN

techical brief

Introduction

Addition of certain organic materials improves plasticity of clays rendering them more workable. During firing the additives also act as internal fuels thus reducing the overall firing energy. Other important reasons for mixing additives into brick clays relate to improving the physical characteristics of the bricks such as porosity. Some organic materials are also used as fuels in the kiln tunnels themselves.

In Sudan agricultural residues and animal wastes are used as organic additives. The most suitable of these are bagasse in loose form, cow-dung, shells of groundnuts and sunflower, and saw dust.

Although compressed stalks of different plants can be good fuels in the kiln tunnels, only bagasse (in form of blocks) is used by a few producers.

Figure 1: Moulded bricks pre-drying in the sun before being fired near Kassala. Photo: Theo Schilderman / Practical Action.

Bagasse Characteristics

Bagasse is a by-product of the sugar industry. It is the solid part of sugar cane that is rejected after extracting the molasses. Bagasse waste initially is whitish in colour but turns darker with time till it becomes very dark brown. Initially it is rough and coarse in texture but breaks up under ambient pressure and heat into very fine particles.

In Sudan there are four operational sugar factories located in New Halfa in Kassala State, Geneid in Gezira State, Assalaya in Sinnar State and Kenana in White Nile State. The sugar factories are surrounded by tall heaps of loose bagasse. These heaps are self-igniting and a fire hazard. With the high cost of guarding against fires and absence of any other use, it is surprising that a small factory in Halfa, which produces bagasse blocks, buys the material from the factory at LS 10000* per lorry load!

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Current Work on Bagasse

Many institutions have conducted research on bagasse waste utilization. Among these are the Institute of Energy Research, Department of Forestry, Agriculture Development Eastern Sudan (ADES) - a subsidiary of UNHCR, the International Labour Organisation (ILO), and universities. Research is centred on fuel block production and marketing.

ADES provides training for refugees in and around Girba on jobs they will need when they are repatriated. A small bagasse block production factory owning 15 Terstaram compression machines (made in Belgium), is situated near the sugar factory in New Halfa, although some of the machines are not being used due to lack of demand for the blocks.

Mature and fresh loose bagasse and pit molasses, are mixed in the ratio of 7:2:1 by volume respectively, and moulded and dried in the sun for seven days. Molasses - the binder, is bought from the sugar factory at LS 20000 per ton and bagasse at LS 10000 per lorry load. One ton of molasses produces 700-800 blocks and a ton of bagasse 2000 blocks. Cost of production of a block is LS 75.

ADES has not gone beyond Halfa in marketing the blocks. Within the area households, restaurants and brick producers are using the blocks but supply far exceeds demand. Brick producers elsewhere, including Kassala and Girba, welcome the use of bagasse but fear the cost of transport which is LS 180000 per lorry load to Kassala, for example.

One producer in Kassala is mixing brick clays with loose bagasse instead of cow dung, but is not firing with blocks.

Objective of the Study

The objective of this study was to explore the potential for using bagasse as fuel in brickmaking. The ultimate aim being reduction of energy cost in brick making and minimizing the negative environmental effects of firing bricks with fuel-wood.

Four specific aspects of bagasse utilization were considered:

- use of loose bagasse in brick clays
- use of bagasse blocks in kiln tunnels
- comparison of loose bagasse with cowdung as internal fuel in brick clays
- comparison of blocks with fuel-wood as tunnel fuels.

Preparation for Firing

A team of 15 labourers (three tables) was employed in the production of 118000 bricks at Kurmuta, west of Kassala town. 11 lorry loads (16393.50 kg) of fuelwood (miskit) from Kassala, 8 lorry loads of loose bagasse and 6000 blocks (7980 kg) from Halfa were provided for the production of bricks. Essential production tools, including Buller's bars for gauging firing temperature, were also acquired.

Figure 2: A brick clamp kiln is shown near Kassala. Photo: Theo Schilderman / Practical Action.

Clay was dug in the evenings, using hoes, from a depth of 0.5 to 1.5m. To the pile of clay, 20 buckets (each bucket weighing 20 kg) of loose mature bagasse, which needed no further processing, were added followed by a suitable amount of water. Mixing was carried out and the mix was sprinkled with more water and left to mature overnight. Early the following day the contents were remixed, using bare feet, adding more water if needed, till a workable plasticity was reached. Slop-moulding of bricks was then started using double metal moulds (each compartment measuring 25 x 12 x 7 cm).

Five labourers moulded one pile of clay weighing 11 000 -13500 kg per day. Two labourers brought clay from the pit to the moulder on the moulding table and the other two carried away the green bricks for drying. Each pile of clay produced 3500 to 4000 green bricks. As soon as moulding was completed, the following day's clay pile was prepared.

Drying was done on flattened ground, bricks being turned for even drying. After two days bricks were dry enough to be piled in a honeycomb manner for airing.
This continued for seven days and then the bricks were loaded into kilns. At the time of loading average weight of a brick was 2.31 kg. All production stages were manual.

Fuels and Brick Firing

The 118000 green bricks were loaded into two clamp kilns (see table 1 below for number of bricks loaded into each kiln). The two kilns were plastered with mud and their tunnels were filled with miskit wood for fire ignition. Each kiln required 4 labourers.

The first kiln (Kiln 1) was fired using miskit wood only. Firing continued for 26 hours using a total of 5827 kg of wood.

The second kiln (Kiln 2), after igniting with wood, was fired with bagasse blocks for 23 hours. It consumed 1439 kg of wood and 3524.5 kg of bagasse blocks. Bagasse blocks can be fed into tunnels every 3 to 4 hours compared to every 0.5 to 1.5 hours with wood.

Sets of Buller's bars were put into each kiln at different heights. Each set was viewed through spy-holes. Each set contained bars numbered 11, 13, 15 and 17 as indicators of temperatures 845, 890, 940 and 990°C respectively. Firing was stopped in each kiln after melting of every number 17 bar. By then physical indicators of complete firing were visible. These were a drop in height of the kiln, appearance of whitish colour on the uppermost layer, ending of the emission ol white smoke and blackening mud cracking of the mud plaster layer.

The kilns were cooled for seven days and then off-loaded.

Firing Results

These are summarised in Table (1).

Grade 1 refers to well burnt bricks while grade 2 means a lower firing bond. Grade 3 bricks are those from the outer-most layers in the kiln and therefore underfired.

Kiln 2 (bagasse blocks) yielded proportionally more grade 1 and less other grade bricks than kiln 1. Kiln 2 also produced a higher percentage of saleable bricks i.e. the sum of grades 1 and 2.

Additionally, compared with using cow dung as a clay additive, bagasse was found to be easier to work with. Bagasse is fine and its smell, when wet, is more tolerable. Dung is found in hard lump form, which does not break up easily and leaves voids in bricks when fired. In contrast clays mixed with bagasse result in bricks with a smooth surface finish, as the green mix quite homogenous.

Table 1: Type and quantities of bricks produced at Kurmuta.

Product	Wood fired		Bagasse fired	
	Number	%	Number	%
Grade 1 bricks	35700	64.91	42040	66.73
Grade 2 bricks	9000	16.36	9520	15.11
Over burnt	2850	5.18	3470	5.51
Losses	1450	2.64	970	1.54
Outer layer (grade 3)	6000	10.91	7000	11.11
Total bricks in kiln	55000	100.00	63000	100.00

Table 2: Results of laboratory tests

Sample	Moisture %	Volatile %	Fixed Carbon	Ash Content %	Cal. Mj/kg	Value
Bag. blocks	6.73	62.41	27.99	9.60		18.66
Loose bag.	9.41	66.23	29.34	4.42		19.17
Miskit stem	14.94	76.25	21.93	1.82		19.71
Miskit root	6.80	72.22	25.81	1.97		19.54
Cow-dung	4.02	47.93	7.3	44.77		12.81
Green brick	3.34					
Loose clay	2.84					

Table 3: Comparison of costs of dung and loose Bagasse with total production costs

Particulars	Dung	Kiln 1	Kiln 2
Internal fuel cost (LS)	43000	277388	317735
Tunnel fuel cost (LS)	913920	337341	551317
Tot. Production cost (LS)	3771339	2441768	2772749
Internal fuel %	1.14	11.36	11.46
Tunnel fuel %	24.23	13.82	19.88
Int. + Tunnel fuels %	25.37	25.18	31.34

Laboratory tests

Table (2) shows results of tests carried out by the Institute of Energy Research in Soba, Khal10um on fuel and clay samples.

Fuel Costs

Table (3) compares cost of energy between using bagasse and cow-dung as internal fuel in the bricks. The column headed "Dung" refers to data collected from an earlier firing of a kiln of capacity 140000 bricks, containing cow-dung, fired with wood. Kiln 1 and Kiln 2 refer to firings with wood and bagasse blocks as tunnel fuels respectively and containing loose bagasse as the clay additive,

In and around Kassala most brickmakers fire their kilns only with wood and do not add any fuel to the day. The cost of fuel is then 50-60 % of total production cost. Reduction of this percentage is an important objective.

From table (3) it can be seen that even though cow-dung is a very cheap fuel, using it as a brick additive does not result in any reduction in the proportional total cost of fuel compared with using the more expensive bagasse. However, with using bagasse blocks in the firing tunnels instead of wood there is some increase in the proportional total fuel cost. Significantly, in each case total energy cost compared to total production cost is below the disturbingly high percentage of 50 – 60.

For bagasse blocks to be acceptable as wood alternative fuel in firing bricks. their cost compared to total production costs must be lower or at least equal to that of wood. Table (4) compares the two firings on an actual cost and energy use basis. To calculate the tabulated values the following conversions were used:

Table (4) Cost of Energy: bagasse vs. miskit wood.

Particulars		Kiln 1 Loose	Wood	Kiln 2 Loose	Wood	Bag. Blocks
A. Cost including Transport						
Calorific value	MJ/Kg	19.17	19.35	19.17	19.35	18.66
Quantity fired	Kg	6285.71	6827.4	7199.99	] 039.00	3325.00
Energy / fuel MJ		120497.06	132110.19	138623.81	20104.65	62044.50
Total energy / Kilns	MJ		252607.25			220172.96
Cost/ Kg	LS	44.13	49.41	44.13	49.4]	150.37
Cost fuel LS		277388.38	337341.83	317735.55	51336.99	499980.25
Total Cost/ Kiln	LS		614730.21			869052.79
Cost/ Brick	LS		11.17			13.79
Tot. cost / Tot. energy	LS/MJ		2.43			3.94
Energy / Kiln			4.59			3.49
B. Cost without transport						
Cost / Kg		3.75	49.4]	3.75	49.41	56.39
Cost / fuel		23571.41	337341.83	26999.96	51336.99	187496.75
Tot. cost / Kiln	LSS		360913.24			265833.70
Cost/ brick LS / brick			6.56			4.2]
Cost/ Energy	LS/MJ		1.42			1.20
Energy / MT of clay	MJ		1987.01			1510.82

Table (5): Comparison of the different cost components of the two firings

Item	Kiln 1 (55000)	Kiln 2 (63000)
A. Cost other than energy		
Moulding	495000	567000
Drying	96250	110250
Loading kiln	110000	126000
Firing	110000	166000
Off-loading kiln	110000	126000
Land rent (15% of produce)	301125	344925
Leveling, cleaning & water	244091	279595
Other costs	160572	183927
Total	1627038	1903 697
B. Energy cost (table 4)	614730	869052
C. Cost in B of table 4	360913	265834
Cost in B / Cost in A (%)	37.78	45.65
Cost in C / Cost in A (%)	22.18	13.96

- calorific values: See table 2 above
- 1MT of clay = 432.9 bricks
- Weight of 1 green brick = 2.31 kg
- Weight of 1 bagasse block = 1.33 kg
- Size of 1 block of Bagasse = 30 x 14 x 8cm
- Weight of 1 bagasse block = 1.33 kg

In section A of the table, titled "Costs including Transport", cost per brick is higher in kiln 2 (LS 13.79) than in kiln 1 (LS 11.17), as is the cost per unit energy. This is due in part to the high cost of transporting the bagasse blocks from Halfa.

In section B, costs are computed disregarding cost of transport of Bagasse (loose and blocks) from Halfa. The Miskit wood is available locally in Kassala. Under this section it can be clearly seen that costs per brick, energy and MT of clay are all less for kiln 2 than kiln I. In Halfa and the nearby places like Girba, or elsewhere where bagasse blocks would be produced locally they would have a great advantage over wood.

Table (5) also gives a detailed breakdown of other cost components of the two firings.

Figure 3: Pile of clay fired bricks with scotch kiln behind.
Photo: Mohammed Majzoub / Practical Action.

Recommendations

The use of well-matured loose bagasse in brick clays, where available, as an alternative to cow-dung, is recommended. It produces bricks of good surface finish i.e. smooth and brilliant in colour. Dung, in contrast, leaves voids when it burns out. It also produces greyish ashes on the brick, rendering colour dull.

Bagasse blocks in the vicinity of production sites are a good alternative to wood.
They would have wider application if current production costs of LS 75 and transport costs were reduced. Wood, though, is needed to start the firing of kilns which burn bagasse blocks, but it might be possible to identify other waste materials for this purpose with further study.

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