PRACTICAL ACTION
Technology challenging poverty

UTILIZATION OF COW-DUNG IN BRICKMAKING

Introduction

Sudan is the largest country in Africa. Half of its 30 million inhabitants live on about 15% of the land [1]. Vegetation ranges from equatorial forest in the south to desert in the north, and semi-arid plain in the rest of the country. This plain is bounded by mountains and high plateaus on the countries western, southern and northeast boundaries. Tropical continental climate extends over most of the Sudan. Average rainfall is less than 25 mm in the north and increases to 1500 mm in the southern mountains. Temperatures range from 17°C in January to 47°C in April and May.

Figure 1: Preparation and mixing of cow-dung bricks.
Photo: Practical Action.

The River Nile and its many tributaries yearly deposit fine sand, silt and clay along their banks. The raw material clay was the first to be utilized for the production of ordinary red brick and roofing tiles[2] where the rivers and streams were close to consumption centres.

The quality of products, depending on prevailing socio-economic factors in the country, fluctuated from time to time. Going back into history it is interesting to note that World War II in the 1940's and Sudan's independence from British rule in 1956 and the human migrational movements which accompanied these two times periods have quite obviously influenced the manufacture of production tools, methods, and local skills and know-how in the country.

The main constraint faced by traditional brickmakers nowadays is energy cost which is at present 50 - 60% of total production cost. Energy inefficient clamps are used for firing the bricks with fuelwood which is transported to the production sites from very far distances at very high cost.

95% of the national stock of bricks in Sudan is produced in clamps and the rest in the less widespread Scotch and Bull's trench kilns. Other forms of kilns are being tried using furnace oil and/or other types of fuels [3].

Soil Map of Sudan

Several soils have developed in Sudan because of differences in climate, nature of parent rock, relief, drainage and vegetation. Desert sands occur in the north and west of Sudan. The low mountain range along the Red Sea has immature semi-desert soils. Soils in the east are alkaline.

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technical brief

The far south and southwest have leached lateritic soils. Central Sudan, known as "clay plain", consists of alkaline soils containing the clay mineral montrnorillonite. The northern clay plain soils are generally weathered sediments derived from the volcanic Ethiopian highlands. These soils are commonly alkaline, containing calcium carbonate and gypsum, with the clay fraction composed largely of montmorillonite.

The southern plain soils are thought to be residual soils and are similar to the northern plain soils but without gypsum. In addition, as already noted, alluvial soil occur along the Nile and portions of other rivers.

Aspect of comparison	Before 1949	1949 -1956	After 1956
Length, cm	22.2 - 23.5	21.3 - 21.6	18.6 - 19.7
Width, cm	10.6 - 11.2	10.4 – 10.5	9.0 - 9.8
Depth, cm	5.5 - 5.8	6.5 - 6.6	4.3 - 5.5
Water absorption, %	23.7 - 31.1	19.0 - 22.0	28.3 - 38.1
Strength, kg/cm^2	29.1 -116.8	60.0 - 120.0	21.5 - 58.0

Table (1): Fluctuation of dimensions in bricks and properties with time

The distribution of soils as outlined above is not clear cut. Soils vary over very short distances as shown in Table (2). Balabata, Zafota and Gurera are local names of soils. The same soils may have other names in different parts of Sudan. Depending on the sand content some of the soils are brittle when formed into bricks unless reasonable portions of organic components are added. Different layers are mixed by cutting vertically when winning clay for making bricks. Cow-dung reduces brittleness and improves workability.

Agricultural and Other Residues

High cost of energy for brickmaking and in other sectors, including households, motivated many institutions to conduct research aimed at exploring the use of waste and residues as alternative fuel to wood. Sudan has huge agricultural wastes and other residues estimated by NEA[5] to be 10 million metric tonnes per year (1993). The most important and promising of these are stalks of various crops such as sorghum, cotton, sunflower, and shells or husks of maize, groundnuts and coffee. Some seeds like "garad"[6] can also be incorporated into clays. Agricultural wastes can be used as solid fuels for firing kiln tunnels. However, because of their low unit weight, they have to be processed by way of compaction to reduce transport costs. Some attempts to gasify some plants e.g. hyacinth and agglomerate charcoal fines were technically quite successful, yet more efforts are needed to make the end-products commercially viable.

	Composition by		
Component	**Balabata**	**Zafota**	**Gurera**[4]
SiO_2	44.21	49.09	75.04
Ai_2O_3	17.03	15.68	8.23
Fe_2O_3	11.11	10.07	4.35
TiO_2	2.53	1.85	0.90
CaO	5.57	6.32	4.67
MgO	3.01	2.52	1.07
K_2O	1.75	2.53	1.26
Na_2O	0.95	2.10	0.73
L.O.I	12.82	8.08	5.58

Table (2): Chemical composition of Balabaty. Zafota and Gurera Clays at Geriefshark, Khartoum.

It has been found out that dung is another form of waste which can be utilized in building, as well as in agriculture. Cowdung is mixed with brick clays, goat dung used as a fertilizer and donkey dung as a protective coating of mud walls and roofs.

Cow-Dung "Ziballa": The Best Additive to Brick Clays

Ziballa is an Arabic word meaning dung. It also means garbage, and garbage collectors in Egypt are known there as "Zaballeen". Cow-dung imparts useful properties to the raw bricks when mixed with brick clays. Dung has also many other uses (some are described above), especially among cattle herders of southern Sudan(7).

Cow-dung improves the plasticity of clays and acts as reinforcing agent reducing concentrated cracks that can lead to breakage within the raw bricks. Upon firing the dung fibres ignite, thus assisting in even .firing of bricks and minimizing the development of high temperature gradients within the brick - a phenomenon which may lead to firing cracks. When the fibres burn out they leave cavities within the brick which reduce unit weight and improve thermal characteristics. Cavities on top and bottom surfaces of the bricks increase the bond when bricks are laid in a mortar bed.

Figure 2: Slop-moulding and drying of bricks. Photo: Practical Action

The effect of four organic additives on Blue Nile clay was studied at the Building and Roads Research Institute (BRRI) of Khartoum University. Four sets of raw brick samples were machine-moulded. Half of each set was sun-dried and the other half dried in shade. Both halves were fired to the same predetermined temperature. While the mode of drying had no appreciable influence on properties, crushing strength varied greatly with the type of additive. The study found out that mixing Blue Nile clay with Ziballa yielded the highest average strength value (170 - 180 kg/ cm^2). Next to Ziballa came groundnut shells (120 - 135 kg / cm^2) and saw dust (110 - 125 kg/ cm^2). Garad seeds yielded the least value.

Dung %	Slop-moulded			Sand-moulded		
	Strength	Water Absorp-tion	Density	Strength	Water Absorp-tion	Density
4.8	45	25	1.37	61	24	1.45
13.0	20	30	1.22	43	28	1.39
20.0	17	33	1.22	92	29	1.31
25.9	13	34	1.15	18	33	1.21
31.0	23	31	1.19	16	34	1.20
35.5	15	35	1.15	25	25	1.31
39.4	17	35	1.12	23	33	1.07
42.9	30	31	1.27	26	31	1.21
46.0	80	36	1.13	22	32	1.19

Table (3): Effect of varying dung content on selected properties of slop- and sandmoulded bricks

Effects of Cow-Dung on Brick Properties

These findings are based on experiments undertaken by Practical Action in Kassala, eastern Sudan to study the effect of cow-dung on brick clays and properties of fired red bricks. The predominant type of soil in Kassala is "gurera" (see Table 2 for chemical composition).

For the study clay was taken from a depth of 0.5 - 1.5m, cutting vertically to ensure mixing different layers. Dry dung collected from nearby farms was sieved using rabbit wire to eliminate stalks and other coarse impurities like gravel. Ten sets of raw brick samples with dung contents ranging from 5 - 47% by volume were moulded. Contents of each sample were thoroughly mixed and enough water was added to give a workable plasticity. Each sample set consisted of 50 bricks, half of them slop-moulded in a double metal mould, and the other half sand-moulded in a single compartment wooden mould. Both moulds have the same dimensions (23 x 11 x 7 cm). All samples were-sun dried (8) for three weeks, and fired in a clamp kiln for four consecutive days[9]. Capacity of the kiln was completed to 14000[10] bricks by loading 20 - 30% "normal" bricks together with the samples. After firing, 4 individual bricks from each sample set were packed and sent for testing strength, water absorption and density. Green and fired dimensions were also determined. Table (3) shows the experimental results for the slop and sandmoulded samples with the same dung content.

Figure 3: Staking of bricks for clamp-firing. Photo: Practical Action

Graphical Presentation of Data of Table (3)

Figures following below depict a graphical representation of dung content of bricks (by volume percent) vs. strength, water absorption and density respectively. Each figure shows the relation between percentage of dung and one of the three properties for two sets of samples. One set is slop-moulded and the other is sandmoulded.

For all samples it was found, that irrespective of the manner of releasing bricks from moulds, an increasing percentage of dung in the raw bricks decreases their strength and density. Water absorption increases in the same way. Cow-dung has less density than clays and leaves voids (pores) in fired bricks. Once a crack is occurring the pores ease the propagation of the crack along the direction of load thus decreasing strength of the brick. The more pores there are in the brick the higher the amount of water is needed to fill them, resulting in a higher water absorption. Sand-moulding produces bricks of better qualities than slop-moulding. For the same cow-dung content strength and density are found to be higher and water absorption lower. Clay for sand-released bricks is more stiff compared to the more wet clay for water-released bricks. The initial water content influences the number of pores in the fired brick. Slopmoulded bricks also tend to have the higher shrinkage.

Energy and Other Costs

The main objective for the Practical Action intervention with bricks manufacturers in Kassala was to lower energy cost below 50% of total production costs and to improve the quality of fired bricks. Quality improvement has been achieved by training the producers to improve their production techniques and use sand-moulding.

Improvements in energy terms can be illustrated in the case of one producer in Khor Shaigiyia, 8 km north of Kassala town. The producer, Abdel Hamid Ahmed Ali, produced bricks of poor quality[11] before the Practical Action intervention.

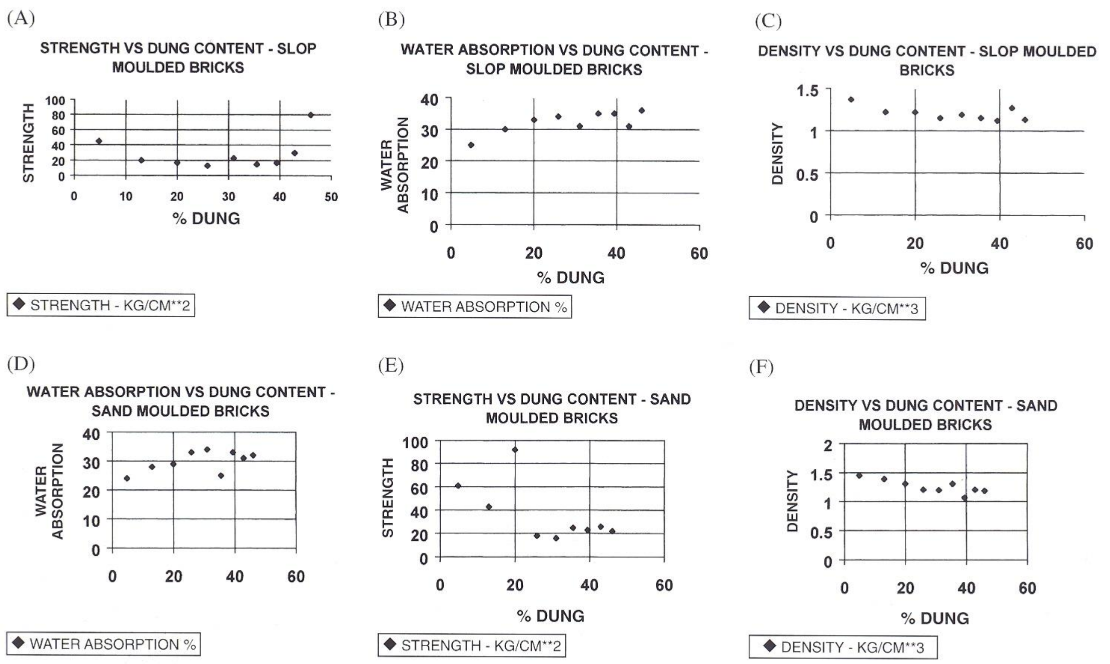

Table (4) shows improvements achieved by Abdel Hamid Ahmed Ali as a result of training and proper use of cow-dung.

Aspect	**Before (Ls)**	**After (Ls)**	**% of total production cost.**	
Cost of production (14000 bricks):			**Before**	**After**
Cow dung	200,000	430,000		
Fuel-wood	1,637,000	913,970		
Total fuel	1,837,000	1,343,970	53.16	35.63
Labour cost	1,438,000	2,223,869	41.62	58.96
Tools	180,000	203,500	5.20	5.39
Total prod. Cost	3,455,000	3771339		
Cost/ 1000 bricks	24,679	26,938		
Sales / 1000 bricks	45,000	50,000		
% Surplus over costs	82.34	85.61		

Table (4): Comparison of production costs and profits before and after Practical Action's intervention.

From the table, it is clear that energy cost is reduced from 53.16 % to 35.63 % of the total production costs. This is due to the use of more cow-dung which resulted in a reduction of fuel-wood. Labour costs increased intervention because more labour was needed in the preparation of clay and careful moulding. Although the percentage of profit does not show an appreciable increase, quick return of capital was experienced instead. The good quality of the bricks generated a higher demand. Besides the appearance of the bricks, the Sudanese Standards Authority was convinced that the use of improved bricks (25 x 12 x 7 cm) in building construction can save up to 25 % of the quantity of bricks required to build a unit volume of wall. There is also an accompanying saving in the consumption of plasters, mortar and other materials.

Conclusions

1. Some agricultural residues and animal wastes are useful in brickmaking. Examples are: saw dust, groundnut shell, "garad" seed, charcoal fines, bagasse and cow-dung.
2. Cow-dung, when added to brick clays modifies properties of those clays and results in better brick qualities compared to other organic waste additives.
3. Addition of cow-dung to clays improves plasticity, reduces green breakage and acts as internal fuel in firing bricks thus reducing firing cracks.
4. The higher the cow-dung content in bricks the lower their strength and density, and the higher the water absorption.
5. 20 -30% cow-dung in clays is the best ratio that gives the desired combination of opposing qualities: strength vs. density, dimensional changes (and losses) and workability of clays.
6. Sand-moulding is superior to slopmoulding since it results in higher strength & density, lower water absorption and losses.

Recommendations

Since the Practical Action Sudan research in Kassala described in this case study concentrated foremost on the improvement of the qualities of bricks as a result of incorporating cow-dung into brick clays the accompanying and therefore possible saving in fuel-wood is the content of additional research at Practical Action. There is a need to do this as the question of reduction of cost of energy is a pressing commercial environmental issue in the Sudan.

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Further Reading

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- *How to Measure the Energy Used to Fire Clay Bricks: A Practical Guide for Brickmakers, Field-workers and Researchers* Practical Action Technical Brief,
- *Ten Rules for energy Efficient cost Effective Brick Firing*, Practical Action Technical Brief,
- *Utilization of Bagasse in Brickmaking* Mohammed Majzoub GTZ Technical Brief, Practical Action Sudan, 1999, *Brick by Brick: Participatory Technology Development in Brickmaking*, by Kelvin Mason, Practical Action Publishing, 2001.
- *Fuel for Free? Waste Materials in Brick Making*, by Kelvin Mason, Practical Action Publishing, 2007.

Exchange rate at January 1999:
2.332 LS = 1 US $

End notes

1. A civil war is raging in the country since 1955 which only temporarily ceased between 1972 - 1983 (rule of General Numeiri). Massive internal migration to urban and production centres, together with other environmental and socio-economic factors have resulted in large uninhabited areas amongst Sudan's total geographical area of 2,6 million square kilo meters.
2. The production and development of roofing tiles or sheets has ceased in the country with the departure of the British rulers and Italian Missionaries. Houses in urban which are roofed with tiles reflect the value which is attached to this material.
3. Practical Action, Sudan experimented with a vaulted kiln in eastern Sudan. A certain potter in Omdurman is firing the same kiln with agricultural wastes and old tyres. Two Hoffmann kilns are operated in Khartoum/Atbara.
4. Kassala soil is mainly of gurera type and results shown in Table (3) refer to this type of soil.
5. NEA: National Energy Administration, Khartoum.
6. gagad: seeds of a local tree used in dyeing hides and for treatment if coughs and diarrhoea.
7. Dung is ignited to warm cattle camps and ward off wild animals and insects. Unlike wood, it turns slowly and camp fires can be left unattended. Its ashes are used for cleaning teeth and body decoration. Mixed with cow urine and clay, dried and fired, dung produces brilliant red hair dyes. Potters fire their products using dung. It is also used as a fertilizer by tobacco growers, and as a table salt by fishermen.
8. In green bricks, water is met in three ways: free water which fills the pores; water which clings to the pore walls after free water is removed; and chemically combined water. The first two "water types" are removed during drying and the third during firing.
   - $T^0 < 150^0C$ drying or smoking stage: last traces of free water are removed:
   - T^0 up to 800 ^0C preheating stage: clay is decomposed and its combined water is liberated and passing out of the chimney;
   - (iii) $T^0 > 800^0C$ to max: full firing stage;
   - (iv) Soaking: maintain max. temperature: principal re-crystalization, recombination and liquid formation (vitrification) reaction take place during this period.
9. Bricks are fired in clamps in batches of 80 - 500 thousands. Clamps of larger capacities are preferable because they are more fuel-efficient than smaller ones (smaller surface areas).
10. Strength = kg/cm^2; Water Absorption = %; Density = kg/cm^2 x 10^3, Note: Values are averages of four individual bricks for each dung composition.
11. Warped bricks with broken corners and large surface voids as a result of excessive water, characteristic of slopmoulding.

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