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TEMPERATURE FLUCTUATIONS WITHIN AND OUTSIDE A SILO WITH TREATED TERMITE MOUND CLAY AS CONSTRUCTION MATERIAL

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ABSTRACT: Elevated temperatures and excessive fluctuations within a grain silo result in condensation of moisture on the inner wall surfaces and its migration within the grain bulk, leading to moulding and caking. There is the need to identify appropriate materials for silo construction that will minimize temperature fluctuations and reduce grain spoilage in storage. A 5.6m³ grain silo constructed from 15mm-thick treated termite mound clay bricks was tested for temperature fluctuations. Morning, afternoon and evening temperatures, and the maximum and minimum temperatures recorded over a 24hr period within and outside the silo were monitored for 60 days. The walls were physically examined for possible moisture condensation. The maximum and minimum temperatures recorded within the silo were 20°C and 30°C, respectively, as against 21°C and 36°C for the ambient. The average temperature fluctuation within the silo was 9.5°C as against 10.3°C for the ambient. The temperatures within and outside the silo were quite distinct without any overlap. There was no sign of moisture condensation on the wall surfaces. Grain silos constructed from termite mound clay have the potentials to reduce the temperature fluctuations within the silo, eliminate moisture condensation and reduce grain spoilage.

1. INTRODUCTION

The silo is one of the most popular structures used for grain storage and, because of the ease of handling, steel and aluminium are commonly used as the materials of construction. In warm humid climate, such as that prevalent in Nigeria and where the daily temperature fluctuations are high, metal silos suffer moisture condensation resulting in the development of hot spots and caking of the stored grains *[1]*.

Three sources of heat contribute to the temperature within a silo. These are the external heat from solar radiation which penetrates the wall into the grain bulk, the internal heat from the metabolic activities of the grain itself, and respiration of the organisms within the silo. If the stored produce is dried to a safe moisture content and uninfested, the internal heat sources are negligible. When the internal heat sources in a silo are negligible, the temperature within the silo becomes a function of the ambient conditions and the thermal conductivity of the material with which the silo is constructed.

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Temperature control is a key factor in the storage of grains as it influences the quality of the grain and regulates pest populations in the stored grain *[2]*. The ability of a silo to limit the penetration of solar radiation into the enclosure and hence the regulation of the internal temperatures can be used as indices of silo performance.

Besides the prohibitive cost which has to be reduced, research efforts on silos in Nigeria have been more concerned with reducing the temperature within the storage enclosure, attempting to find materials that could severely limit the flow of heat from the surroundings into the silo enclosure. A number of studies have been undertaken to examine the temperatures and temperature fluctuations experienced within and outside silos of different materials of construction. Lucas and Mijinyawa *[3]* reported that in an environment where the ambient temperatures varied between 21.8°C and 38°C, those within a steel silo varied from 20.2°C to 38°C while for a wooden silo in the same location, the values were between 22°C and 37.2°C. They reported temperature fluctuations of 10°C, 9°C and 7°C for the ambient, steel and wooden silos, respectively. The silos were unloaded. Alabadan and Oyewo *[4]* using silos loaded with grains observed that while the ambient temperatures were between 23.8°C and 32.3°C, those within the wooden silo were 24.7°C to 33.8°C while for the metal silo, the values were 24.5°C to 35.4°C. Average temperature fluctuations were 10.9°C, 9.1°C and 8.5°C for ambient, steel and wooden silos, respectively.

Agboola *[5]* reported the attempts by the Nigerian Stored Products Research Institute, Ibadan, Nigeria to reduce temperature fluctuations within metal silos. The metal silos were subjected to four treatments; these were full insulation with 5cm rock-wool and galvanized steel sheets; insulation of only the roof; painting with white paint; and painting with white paint complemented with top shading with palm leaf thatch. Osunade and Lasisi *[6]* reported that changes in temperature within laterized concrete silos were slower than those within metal silos. The higher temperatures and temperature fluctuations generally experienced with metal silos are attributed to the rapid flow of heat occasioned by the high thermal conductivity of the materials: 62W/m°K for steel and 250W/m°K for aluminium.

The primary objective of the work herein reported was to examine the range of temperatures and temperature fluctuations experienced within and outside a treated termite mound clay silo.

2. MATERIALS AND METHODS: The silo used for this study was of cylindrical shape, with 2.0m internal diameter, 1.8m height and a capacity of 5.56m³. It was constructed of 150mm-thick termite mound clay burnt bricks *[8]* (Plate 1). Bakshi and Bhartnagar *[9]* and Sinha *[10]* reported that comparative tests on silos in respect of temperature fluctuations may be carried out on unloaded silos. Since the primary interest in this work was to investigate the efficiency of the silo material in reducing the flow of solar heat into the silo, the experiment was carried out on an empty silo. Morning, afternoon and evening temperatures, and the maximum and minimum temperatures experienced over a 24hr period were monitored within and outside the silo. Readings were taken thrice daily at 0600hr, 1200hr and 1800hr for a period of sixty days using combined maximum and minimum thermometers installed within and outside the silo. The obtained data were subjected to a t-test in order to establish any significant difference between the inside and outside temperatures. The walls were regularly inspected for moisture condensation through rubbing with absorbent paper and the palm.

3.0 RESULTS AND DISCUSSION

3.1 Daily Temperature Pattern: The temperatures recorded within and outside the silo during the experimentation period are presented in Fig. 1 to 4. The morning temperatures within the silo were almost constant at 20°C. The ambient morning temperatures varied between 21°C and 27°C with a mode of 24°C. The afternoon temperatures for the silo were also almost constant at 30°C with only a few days recording either 29°C or 29.5°C. The ambient noon temperatures ranged between 32°C and 36°C with a mode of 35°C. The evening silo temperatures were quite similar to those at noon. Evening ambient temperatures varied between 27°C and 36°C but still maintained a mode of 35°C. The morning and noon temperatures within and outside the silo were quite distinct without any overlap. The evening temperatures however had a little overlap. A typical daily temperature pattern for the 45th day of the experiment is shown in Fig. 4. Elevated temperatures promote insect development, increase metabolic activities and, in some cases, grains in contanct with the silo wall may be roasted. Attainment of lower temperatures as found in the silo would eliminate these effects and maintain grain quality in storage.

3.2 Temperature Fluctuations: The temperature fluctuations within and outside the silo are shown in Fig 5. The temperature fluctuation within the silo varied between 9°C and 10°Cwith an average value of 9.5°C. The fluctuation outside varied between 8°C and 13°C with an averge value of 10.5°C. These values are significant because a lower average temperature fluctuation within the silo compared with a higher ambient temperature fluctuation is an indication of the potency of the wall material to limit solar heat flow into the silo enclosure. High temperature fluctuations promote moisture condensation which is eliminated at lower values. The water absorbent papers used to rub the wall surface ramained unmoistened, indicating the absence of moisture on the wall surface. The wall surface was warm when felt with the palm. The temperature fluctuation values were subjected to a t-test, the extracts of which are shown in Tables I and II. The analyses reveal that there was a significant difference at both 1% and 5% levels.

Table I: t-test analysis at 1% level of significance of temperature fluctuation

Location	Mean	SD	t	df	t_{ab}
Ambient	10.28	1.56			
Within Silo	9.54	0.48	3.54	118	2.36

Table II: t-test analysis at 5% level of significance of temperature fluctuation

Location	Mean	SD	t	df	t_{ab}
Ambient	33.95	1.53			
Within Silo	29.54	0.48	21	118	1.98

Plate 1. Termite Mound Clay Brick Silo used for the study

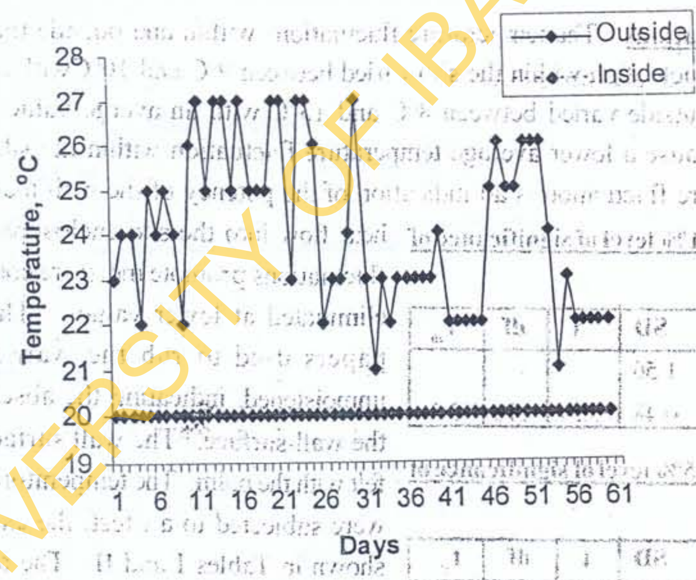

Fig.1 Morning Temperatures Within and Outside the Unloaded Silo

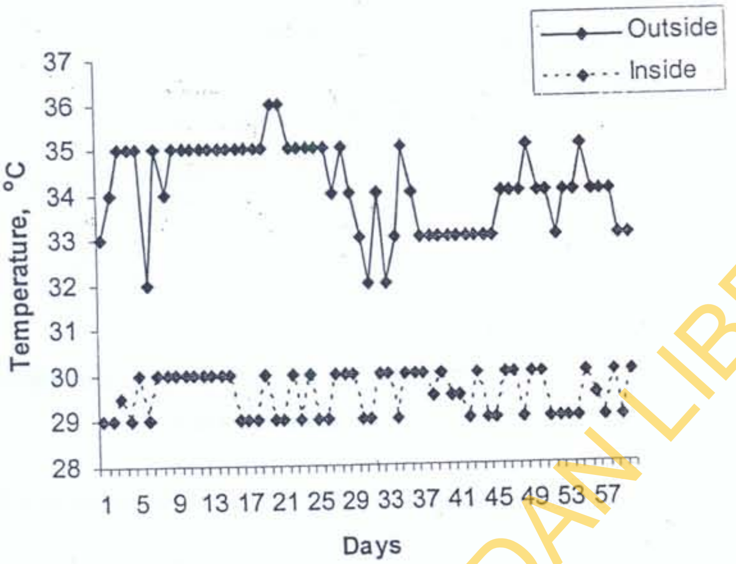

Fig.2 Afternoon Temperatures Within and Outside the Unloaded Silo

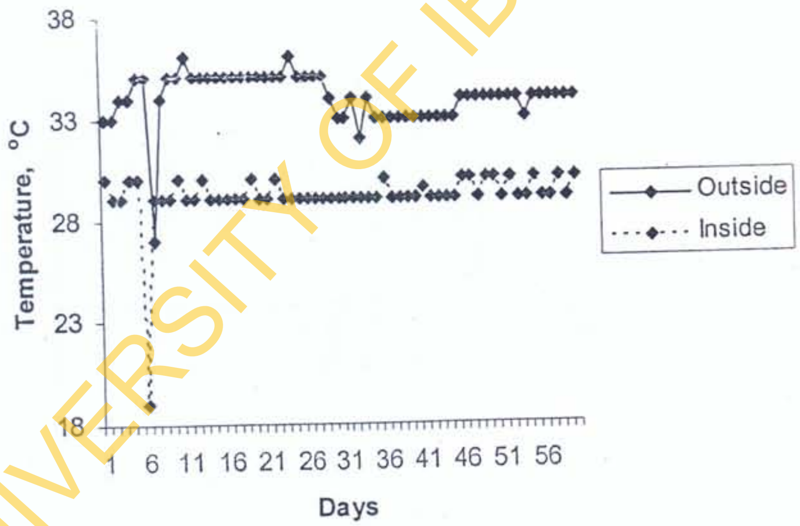

Fig.3 Evening Temperatures Within and Outside the Unloaded Silo

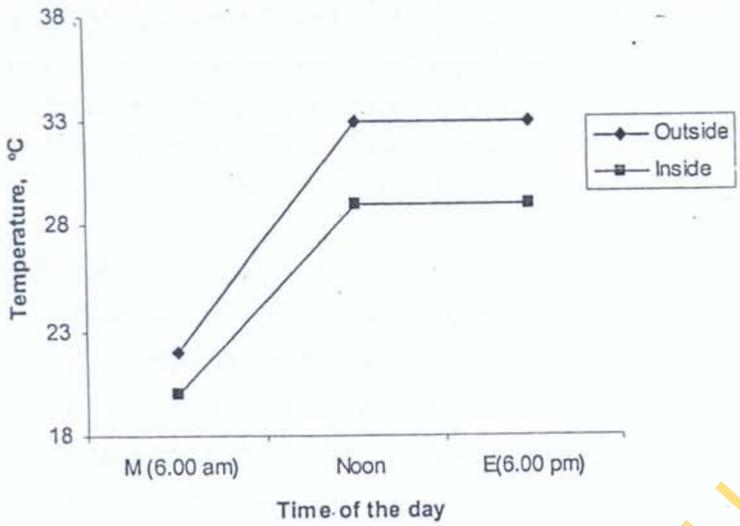

Fig.4 Temperatures Within and Outside the Unloaded Silo

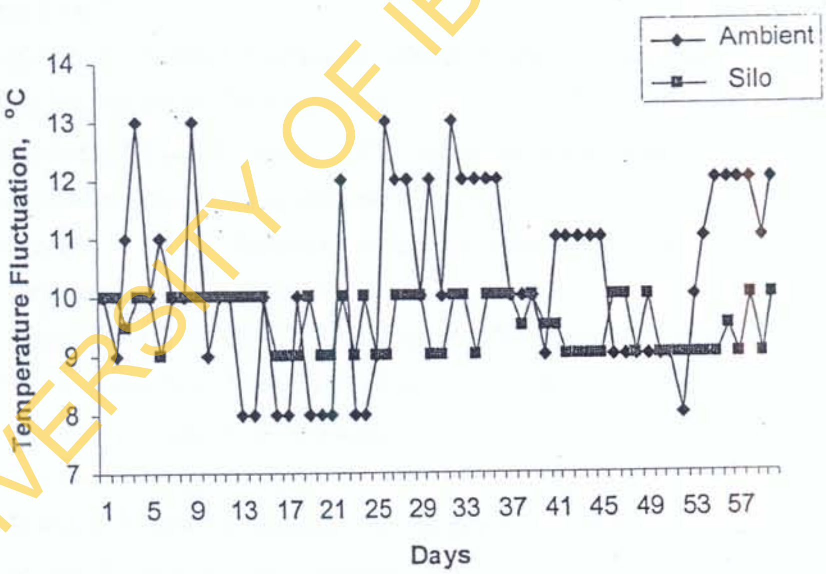

Fig. 5 Temperature Fluctuations Within and Outside the Silo

4. CONCLUSIONS AND RECOMMENDATIONS: Grain silos constructed from treated termite mound clay bricks are capable of maintaining lower temperatures that are conducive for grain storage. Fluctuations in temperature can be reduced, thus eliminating the possibility of moisture condensation and maintaining grain quality. It is recommended that temperature measurements be carried out on the silo under full load in order to establish the possible temperature gradients that may develop.

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