ENGINEERING PROPERTIES OF AMURO-OKIGWE FIRED CLAY BRICKS FOR BUILDING WORK

ENGR. DR. O. O. ONYEMAOBI MNSE
Department of Materials and Metallurgical Engineering
Federal University of Technology
P. M. B. 1526, Owerri, Nigeria

ABSTRACT

Engineering properties of Amuro-Okigwe fired clay bricks were studied. Chemical composition of the clay revealed a high SiO_2 content. Firing of the bricks took place from 750°C to 1050°C. The bricks exhibited high percentage of plasticity and the shrinkage limit was between 1.790 to 4.270 percent. The bulk density was between 1.77 and 1.94 g/cm^3. The water absorption was between 11.57 and 18.92 percent. The Modulus of Rupture was in the range of 1287 and 3819 Pa. The properties of high SiO_2 content, bulk density and water absorption are appropriate for building.

INTRODUCTION

The traditional building brick is made of clay, formed to a standard shape and fired in a kiln. The colour, strength and texture of the finished brick will depend upon the composition of the clay or shale used, and the method of manufacture. Brick earths are composed of silica and alumina, with small amounts of other materials combine with water to form pure clay, chemically denoted as Al_2O_3, $2S_1O_2$, $2H_2O$. This formula is idealistic in nature as different clays contain some impurities which affects their behaviour. A unique and valuable quality of clay is its plasticity. Unless a clay will hold its shape while being formed it is useless. This factor depends on fineness of particle size.

There are various types of clay; china clay, ball clay, fire clay, marl clay and red clay (laterite clay). Singer et al (1984). Clay used either fired or sundried has been used in the provision of shelter for mankind right from time immemorial. Clay brick for housing are popular because of the availability of clay and laterite clay deposit almost everywhere. They are good for building especially when the moisture content is adequate. The clay mixture is usually cut into blocks which are sun-dried or fired. Clay bricks are good in extremely dry climates as they are strong and durable.

Red clay is one of the most common burrow material in Nigeria. For a very long time this has featured in building constitution works in Nigeria. The mineralogical properties of some residual soils have been studies by Ola (1976) as they relate to building applications. He found out that stabilization with cement, lime and bitumen is the effective means of improving on the engineering properties of the lateritic soils. Oguora (1985) in a study on lateritic soil showed that it is desirable to mix and compact the cement blocks at optimum moisture content in order to achieve maximum compaction.

Lasisi and Ogunjide (1980) working on Ifewara laterites concluded that the finer the grains the greater the compressive strength of the specimen. Other workers, David et al 1985, Lindsey 1969 Singer et al 1984 and ASTM 1982, have studied the various properties of clays.

They showed that when clays are fired, different types of reactions take place involving loss of hygroscopic, hydrated water etc. They also reported on the strengths, shrinkage and firing characteristics of the different clays

There are many brickmaking factories in Nigeria. Presently there more than twenty functioning factories and they are scattered all over the country. The capacity production of the different factories range from 7.5 million to 20 million of normal sized bricks per annum. As a result of the economic situation in Nigeria these factories operate at less than fifty percent capacity. It is possible to reactivate them by focussing more interest on them and making the public aware of the benefits accruing from using burnt bricks. The Federal Government's new housing programme has to be supported by looking for alternative material instead of sandcrete blocks. The present work is thus geared towards finding out the engineering properties of bricks made from Amuro-Okigwe located in Imo State and to make the public aware of the need for a change to burnt bricks.

EXPERIMENTAL METHOD

MATERIAL

The material used for the work was clay brought from Topaz Clay Bricks, Amuro-Okigwe.

EQUIPMENT

It is not possible to list all the equipment used but some of the important ones used include Briquette Moulder, Modulus of Rupture Machine, Extruder, Plastometer, Electric Weighing Balance and Furnace for firing the Briquettes.

METHODOLOGY

The initial processing of the clay started with crushing ten kilogrammes of the clay, soaking in water for two days in order to slake. A -120 mesh sieve was used to sieve it. The filtrate was left for sedimentation to occur. It was poured into a rectangular bath made of plaster of paris to absorb the water content of the clay.

The following properties of the bricks, plasticity, shrinkage, dry shrinkage, total porosity, bulk density, moisture content, Tolerances on distortion and on dimensions (mm), water absorption, chemical analysis breaking load after firing at different temperatures were measured.

A brass rectangular mould (6.5cm x 4.25cm x 2.5cm) was used to mould the briquettes. Compaction was achieved by hand and the moulds were number OK_1.. Okn for easy identification. Two of the measured properties; Shrinkage and Apparent porosity would be described.

SHRINKAGE MEASUREMENT

The bricks were pressed in the rectangular mould (6.5cm x 4.25cm x 2.5cm) and the dimensions were measured using a vernier calliper. The moulds were put in a drier for ten days, then the dimensions measured. The shrinkage was calculated as a percentage of the initial green dimensions i.e. $\frac{\Delta L}{L}$ where ΔL is the change in length of the dried brick and L is the original length of the green brick.

APPARENT POROSITY

The bricks were fired and tested. The specimens were dried at 110°C. The dry weight (W_1) of each brick was measured after which the brick was transferred into and suspended in boiling water for about fifteen minutes. The hot water was gradually displaced with cold water.

After 30 minutes in cold water the weight (W_2) was measured. The soaked specimen was then weighed in air (W_3). The apparent porosity of the bricks was calculated using the following relations.

$$\frac{W_3 - W_1}{W_3 - W_2} \times 100\% \quad \ldots\ldots(1)$$

where the terms have been defined.

For modulus of Rupture the following was used according to ASTM (1982).

$$\text{Modulus of rupture } S = \frac{3WL}{2bd^2} \quad \ldots\ldots(2)$$

where:

S = Stress in specimen at midspan (Kg/cm^2) or ($Pa\ 10^4$),

W = Maximum load indicated by the testing machine (Kgf) or (N)

L = Distance between the supports in mm

b = Average overall, width, face to face of specimen in mm and

d = Average overall depth, bed surface to bed surface, of the specimen in mm.

The theory and complete methods of tests given by Thring (1962), Singer et al (1984) and ASTM part 16 (1982) were used for other tests. The briquettes were also fired in an electric furnace at four temperatures of 750°C, 850°C, 950°C and 1050°C. After firing the bricks were tested for breaking load and other parameters mentioned earlier.

RESULTS

The chemical composition was measured using standard methods and the results are given in Table 1. The plasticity test result is shown in Table 2. Table 3 lists that of modulus of Rupture of unfired bricks, while Table 4 shows the various engineering properties of Amuro red clay bricks. Figure 1 illustrates the results of fired shrinkage against temperature, while total shrinkage with temperature is shown in Figure 2. The correlation of apparent porosity and water absorption with temperature are given to Figure 3. A comparison of some of the results with ASTM standards is given in Table 5.

DISCUSSION OF RESULTS

It is seen from Table 1 that the main constituents of Amuro-Okigwe clay are SiO_2 and Al_2O_3 These two constituents combine with water to produce clay. The

other elements help in the formation of fluxes. Amuro-clay has a high iron content of 10.977 percent and a high Na_2O content of 10.169 percent.

From Table 2, the average plasticity of the clay was 31.4 percent while the average modulus of plasticity (original height/deformation height) was 3.483. The moisture content of the clay before sieving was 20.1 percent. Amuro clay has a very high plasticity. At room temperature the clay bricks cracked and firing at 750°C showed that the bricks experienced large cracks. This is probably attributed to high alkalis concentration ($Na_2O + K_2O$ of 11.129%). The high alkali concentration renders it unsuitable as a refractory material. Nwosu (1991) considered that the acceptable $Na_2O + K_2O$ content for refractory clays should be less than 3 percent.

A maximum green strength of 8570 paschals was obtained at a diameter of 0.90cm. On firing it was observed that the transverse strength of the bricks increased with temperature. The fired strength is higher than that of the green strength. This is to be expected as the air spaces and pores in the unfired bricks make the bricks porous while the fired bricks have the hygroscopic moisture removed. The particle sizes have been compacted so as to yield very strong bonding forces which result in the high strength of the bricks. Work on Guru clays show dry strength of 323 to 4900 paschals and 43.63% to 44.39% SiO_2 (Nwosu 1991). The Amuro clay has high SiO_2 content of 47.44 percent (see Table 1) and this is one reason for this.

From Table 4 it is seen that the fired shrinkage obtained was between 1.790 percent and 4.270 percent. At low temperature the shrinkage is low but when the temperature is increased to 950°C there is a rapid increase in shrinkage. As clay is fired many reaction take place. These include removal of free hygroscopic and combined water, reduction or oxidation of the body constituents at maturing temperature. These cause the shrinkage given in Table 4 and Figure 1.

The rate of volume change of clay bodies varies with the stage of firing process. Unlike the drying shrinkage which occurs during the initial stages of drying the weight loss during firing occurs during the final end of firing. The length of volume changes during firing are observed on test pieces by periodic removal of samples from a furnace or by continuous measurement throughout firing.

Results obtained in the firing of laterite clays confirm that small expansion up to about 750°C and rapid shrinkage above 875°C. Stevens and Birch (1963) found three critical stages of rapid shrinkage in refractory bricks namely 480 - 600°C, 850 - 938°C and 927 - 1296°C. Figures 1 and 2 follow the above trends. It is during rapid expansion that strains are set up that may rupture them.

Figure 3 gives the correlation of apparent porosity and water absorption with temperature. It is seen that the apparent porosity decreased as the firing temperature increased. The water absorption also follows this trend. It is suggested that a binder be used to improve this. If the binder is added to the laterite clay it should now be fired to a high temperature to reduce the rate of water absorption of bricks and thus increase the strength. If the rate of absorption is high the bricks would be porous thereby reducing the durability as well as the beauty of the bricks.

Having investigated the various engineering properties of Amuro-Okigwe clay bricks it is necessary to discuss the advantages of clay bricks over sandcrete blocks. While cement is basically a physical gel bond affected by a few variables such as the percentage of tricalcium aluminate and mixing ratios of cement/water, cement/sand/gravel etc, the matrix of a brick is a glossy silicate formed as a result of pure chemical reaction under intense heat of the furnace. The strength of clay bricks is far greater than that of cement blocks which is of greater importance to the builder. It is a well known fact that sandcrete blocks break easily. The respective Nigerian Standards give 2400 paschals for burnt bricks and 140 - 520 paschals for sandcrete blocks.

The comparison of the results with ASTM standards (1982) is given in Table 5, from Table 5, the engineering properties compare favourable with ASTM standards. It is common practice to carry out frequent tests of bricks, mortar and brickwork, to ensure that the work complies with required standards for crushing strength and drying shrinkage. For example the minimum modulus of rupture given by ASTM (1982) is 1380 paschals while the result for Amuro-Okigwe brick had a minimum of 1287 paschals and a maximum of 3819 paschals. The tolerances on distortion and dimensions were within acceptable ranges.

Also the clay bricks exhibit excellent beauty due to red colouration. Bricks are more economical as there is no need for plastering and painting of the walls. The bricks can be fired up to a temperature above 900°C which makes the wall fire resistant. Clay bricks also have good insulation properties which contribute to greater thermal comfort. In Europe clay brick walls are normal. A few houses exist in Owerri, Ekulu housing Estate Enugu and other places decorated with burnt bricks. These walls were popular some years ago but the craze of Nigerians for moulding sandcrete blocks

and casting in structure has decreased the use of bricks. However, with the skyrocketing cost of cement which went up to over five hundred naira (₦500.00) per bag last year, it is hoped that the popularity of burnt bricks would be revitalized.

CONCLUSION

There is need to improve the quality of clay bricks to serve as good building bricks. The firing of Amuro bricks should be in the range of 750 - 1050°C. The Amuro clay chemical composition has a high silica content of 47.50%, Al_2O_3 of 17.092% and Fe_2O_3 of 10.977%. The Na_2O content of 10.169% is a probable cause of the high shrinkage. The modulus of rupture is appropriate for building, is comparable to ASTM standards.

It was found that the clay has a high plasticity. The bulk density of 1.77 - 1.94 g/cm^3 is good as a building brick. The water absorption is appropriate as a building material for example the ASTM standard is 19 while that obtained was 16.52. The saturation coefficient maximum obtained was 0.75 compared to ASTM standard of 0.80.

It is concluded that a revitilisation of burnt bricks for housing should be encouraged. Burnt brick bungalows have a beauty that cannot be compared to painted sandcrete block houses. The different Governments should put in place programmes that would promote the effective use of burnt bricks for houses. These are cheaper, easier to lay and more durable. They have a lower coefficient of expansion. They are used for both internal, external buildings and for decorative purposes.

ACKNOWLEDGEMENT

The author is grateful to PRODA Enugu for providing the facilities for this work and Topaz Clay Products Ltd., Amuro-Okigwe for providing the clay. The help of Mr. Ibe is also acknowledged.

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Table 1. Chemical Composition of Amuro-Okigwe laterite clay

Constituent	% Composition
SiO_2	47.436
Al_2O_3	17.092
Fe_2O_3	10.977
T_1O_2	Undetermined
CaO	absent
MgO	absent
Na_2O	10.169
K_2O	0.960
Lol	13.136

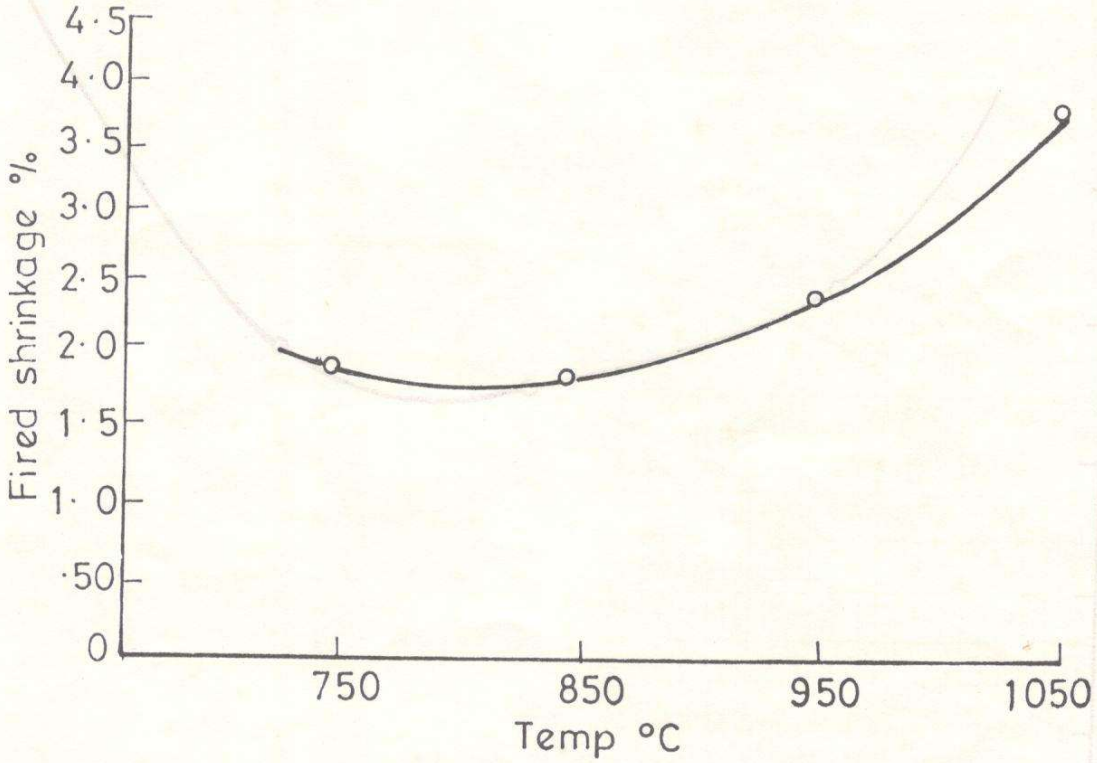


Fig. 1 Fired shrinkage vs Temperature

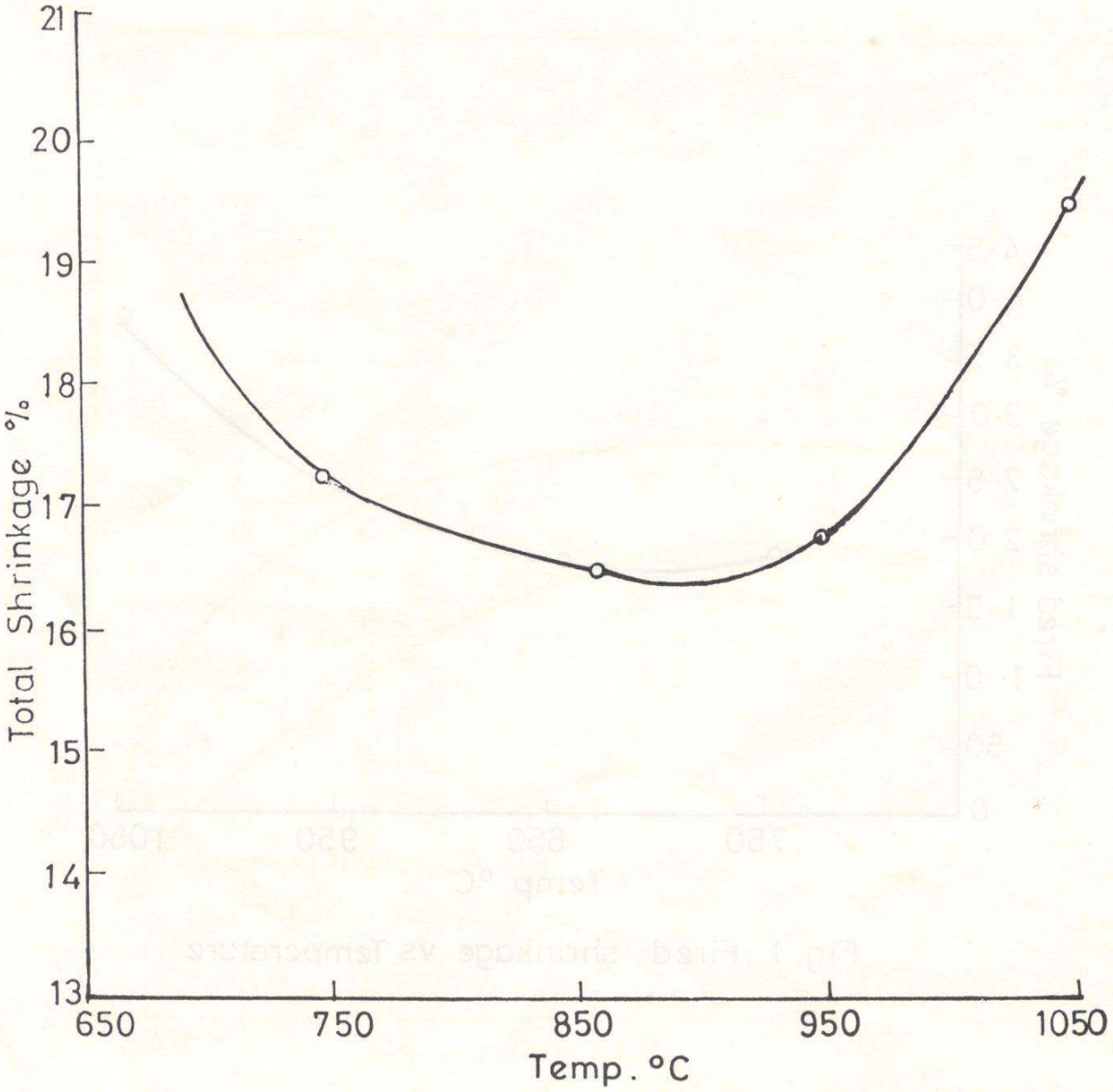


Fig. 2 Total Shrinkage vs Temp.

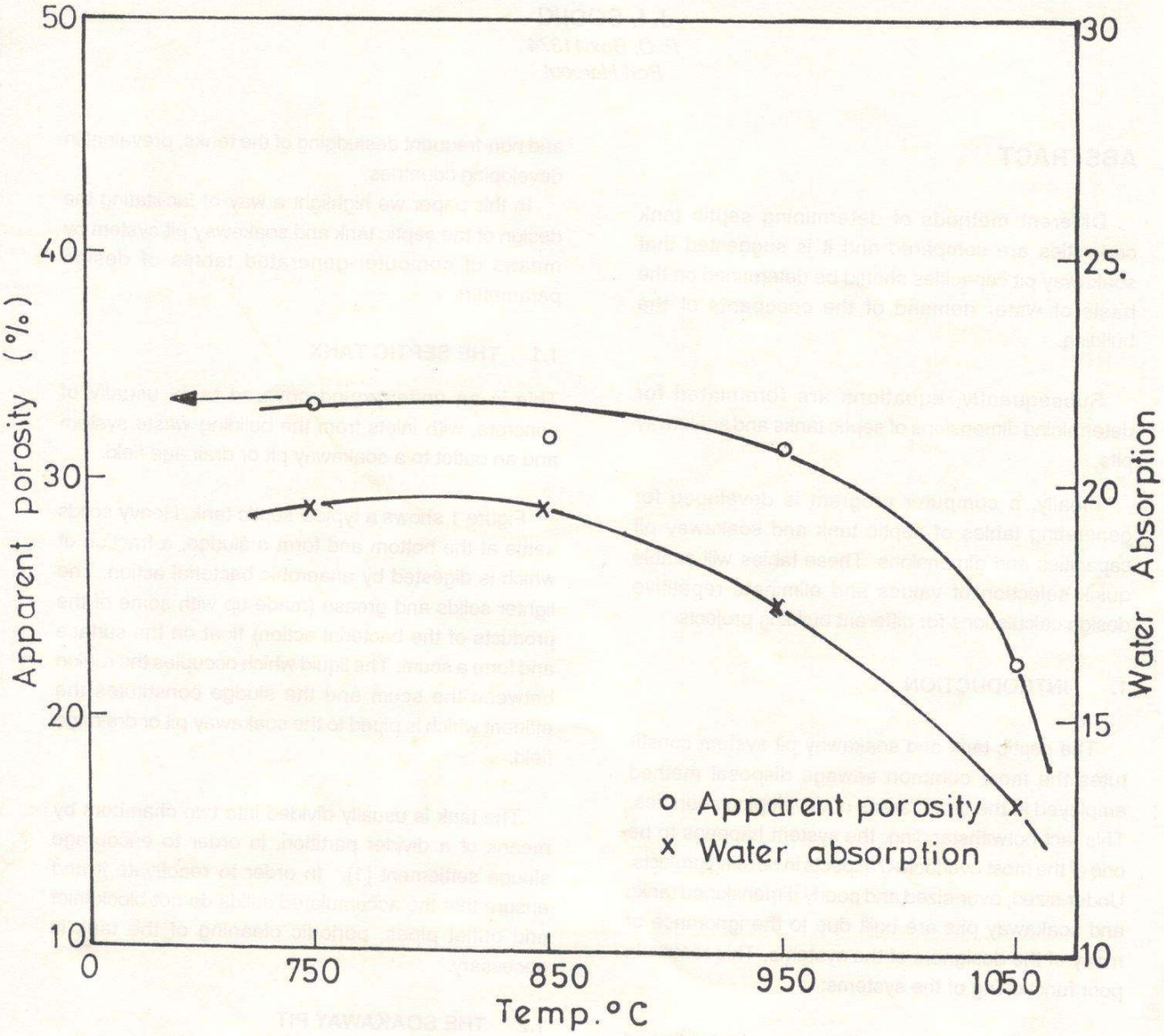


Fig. 3 Correlation of Apparent porosity and Water absorption with Temperature.