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EVALUATION OF RAW CLAY FROM TRIPOLI FOR ITS UTILIZATION AS A BUILDING MATERIAL

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The physico-chemical properties of Swani brick clay have been investigated by chemical analysis, grain size determination, dilatometric examination, drying and firing, linear shrinkages, loss of burning weight and water absorption studies. The results obtained by all above methods confirm that the clay is quite suitable for making solid bricks, hollow blocks, ceiling drain and roofing tiles. It has to be blended with fine grained fire clay for making vitrified pipes.

INTRODUCTION

In this paper it is intended to provide sufficient information about the characteristics of the raw clay found in Swani, 23 kilometres south of Tripoli. This clay is being used at present for the manufacture of perforated blocks of various sizes for building industry. With rapid increase in the population of Jamahiria, this need has assumed the character of an acute problem. The Libyan government recognising the seriousness of the problems sanctioned a brick plant at Swani with a capacity of 800 tons/day. The plant started production in 1978. The making of cement requires high temperature firing (1450–1550°) which brings about huge consumption of oil. In the case of manufacture of perforated blocks the temperature is only between 1100 and 1150° thereby reducing the final cost of the product and also relieving the pressure on the supply of cement at the same time.

EXPERIMENTAL

1. Chemical analysis. Full chemical analysis has been executed following the Bennet method [1]. The alkaline salts were determined flame-photometerically. The results are given in Table 1.

2. Analysis of grain size. Determination [2] analyses were carried out on the raw materials sample. The grain distribution graph is given in Fig. 1. This diagram shows the results very clearly and in a way easy to compare. Deviation in the parallel examinations lay within admissible limits.

3. Dilatometric graph. Thermal expansion shrinkage of the dried clay piece having 6 cm. length and 2 cm. diameter, recorded by the dilatometer [3] is given in Fig. 2. This graph shows the expansion and shrinkage of a sample body when heated to about 1100° and then cooling it later on. As each mineral has its own expansion/contraction characteristics when heated, certain conclusions can be drawn from the graph regarding the composition of the raw material sample.

4. Drying firing and absorption studies. The quantity of water content required for necessary shaping of the clay in wet extruding process has been determined according to the Atterburg method [4].

The determination of linear drying shrinkage, linear firing shrinkage [5] loss of burning weight, water absorption and burning colour was made with wet shaped sample bodies which had been dried at 110° upto constant weight. The sample bodies were burnt in an electric furnace in an oxidising atmosphere. In order to be able to determine the tendency of the raw material to form reducing grains or to puff up, considerably high heating speed of 120° hr. has been chosen.

Table 1. Chemical analysis of Swani brick clay

L/I	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O
8.3	67.8	13.9	4.16	0.13	2.77	0.17	1.54	0.23

The water absorption of the sample bodies burnt at three different temperatures had been determined by boiling them for two hours in water [6]. The values obtained are given in Table 2.

RESULTS AND DISCUSSION

In chemical analysis, the SiO_2 is contained in the clay mineral, micas and free quartz, while Al_2O_3 is present in the clay mineral and micas; and the micas also contain the alkalis Na_2O and K_2O. Fe_2O_3 is present not only in the iron mineral but may also form a small part of the structure of the clay mineral and mica. Small proportions of CaO and MgO arise from the clay mineral and mica and when greater than 1.0% calcite, dolomite and gypsum are probably present. Ignition loss includes the combined water present in the clay mineral and mica, the water of crystalization from gypsum, the loss due to oxidation of carbonaceous matter and carbon dioxide from the breakdown of carbonates. In the råw clay tested (Table 1) the alkaline content effective as a flex is not very high. A characteristic of this material is the appreciable content of silica about 69% compared with a very small content of alumina about 14%. The share of Fe_2O_3 and CaO is comparatively high.

The characteristic property of a clay is its plasticity. The very fine particles impart this property. It is in fact the large surface of fine clay particles and their ability to hold water flims that lead to the phenomenon of plasticity. The size fraction less than two microns is referred to as clay. In most cases fine particles of silica flour and mica are also found. The clay under study is very fine sand. Stones and other large inclusions were not found in the sample. As shown in the grain distribution graph (Fig. 1), the distinct maximum between 20–40 μ is characteristic for this clay. The prevailing grain refraction group 2 μ for the clay content is small (36.6%) for a stoneware product. The plasticity of the mass diluted with water is fair enough to be sufficient for the extrusion of drain pipes and similar products, at least with vacuum.

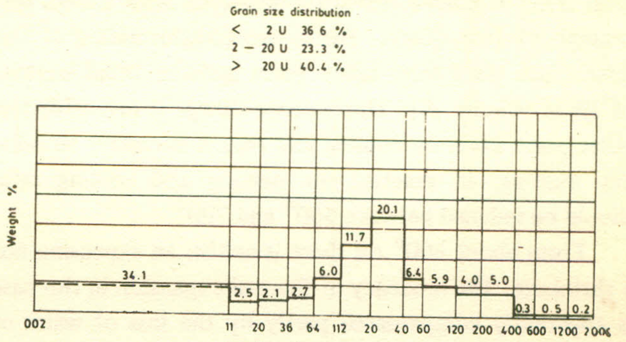

Fig. 1. Grain size distribution graph.

The chemical and mineralogical changes that take place on heating this clay are those of dehydration, oxidation, recrystallization and vitrification.

The water required to develop maximum plasticity for silicious clays is 15–24% [7]. The water of plasticity of the clay under investigation as given in Table 2 is 70%. This confirms the above finding that the clay is rather sandy but due to very fine particles of sand it is fairly plastic.

The thermal expansion (Fig. 2) of the dried sample body takes place almost immediately after the heating has started and it rises with increasing temperature. The anoma-

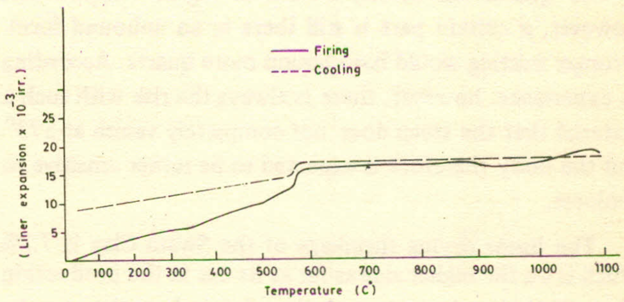

Fig. 2. Dilatometric graph.

Table 2. Physical characteristics of Swani bricks clay

Water of plasticity (%)	Linear drying shrinkage (%)	Firing °C temperature	Heating °C/h	Linear firing shrinkage (%)	Loss of firing weight (%)	Water absorption percent weight	Colour after firing
24.78%	7.2%	1160	120	2.8	4.25	11.85	Red
		1200	120	6.7	4.25	10.12	Dark red
		1250	120	11.1	2.26	7.60	Red-brown

ly at 573° is characteristic for materials with a high percentage of free quartz. Hence the transformation of the quartz into the β form takes place under a rapid increase of 2% in volume [8]. This volume change is reversible and takes place again on cooling and care is necessary to prevent dunting. In practice the heating and cooling rates should be reduced between 500° and 700°.

From about 600° on there is neither an expansion nor a shrinkage. The tendency of thermal expansion in this case is apparently compensated partly by the loss of water of hydration and partly by the effect of refraction in dry condition. This compensating tendency of thermal expansion lasts till about 850°.

After a temporary slight decrease of expansion a new expansion at about 1000° may be noticed in the curve. This in fact is the beginning of a transformation of quartz into trydimite and later on cristobolite which is accompanied by an increase in volume. When reaching the admissible heating limit of 1100° in the dilatometer, the transition to the firing shrinkage will only be slightly indicated. Therefore, the cooling graph (Fig. 2) still runs within the range of shrinkage and even somewhat above the heating graph.

The cooling graph shows a steep at 573°. It is this range of temperature in which the quartz changes rather rapidly to the α form from the β form under a contraction in volume. The size of the steep shows that the shared mass of free quartz has mostly bound in higher temperature. However, a certain part is still there in an unbound form. Stronger heating would have bound more quartz. According to experience, however, there is always the risk with such a material that the steep does not completely vanish at 573° and the body therefore is expected to be rather sensitive to coolness.

The linear drying shrinkage of the Swani Clay is 7.2% which is on the higher side as far as its use in the production of vitrified pipes is concerned; therefore, a lean clay may be added to reduce this shrinkage. If a building clay can tolerate a temperature of 1100° or more without melting out of shape, then a high strength product with low water absorption is likely to be produced. The stability of the clay in firing is comparatively high and samples heated upto 1250° showed no signs of overheating. The firing colour which is brick red to lower temperatures changes to red brown with increase in firing temperatures. The water absorption of the body is comparatively high for stoneware and reaches 10.12% at 1200° and 7.6% at 1250°

CONCLUSIONS

The first conclusion from the data obtained is that the examined clay is very suitable for the production of perforated bricks and blocks, ceiling, drain and roofing tiles and solid building bricks of all types.

The second conclusion is that the tested clay is not naturally meant for the production of vitrified pipes because water absorption is too high, which will definitely result in too low a density. This is obviously caused by an insufficient content of grain size of less than 2 μ. Al_2O_3 content amounting to about 14% present in the clay deviates from the standard values of 18 to 30% usually found in stone-ware clays. The only way out is to blend this clay with a sufficient amount of fireclay of very fine grains having good plasticity. Fortunately we have in Sebah such types of fire clays. Detailed studies on these clays have been made and published [9].

All the data and results are based on the raw material samples obtained from the brick factory at Swani in March, 1979.

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