TERRA COTTA BRICKS IN MATTER INSULATING AND LIGHT BY COAL ADDITION IN AN ARGILLACEOUS MASS

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The idea of the passage of a light concrete product to that of a terra cotta product is fixed on the launching of a manufacturing range of brick products satisfying some properties which will be adapted to contemporary construction and the modern architectural tendencies. This is carried out by using a mixture of two types of clays, grey clay and yellow, plus an additing of porogene agent "coal" which, under the effect of the heat of the furnaces of cooking, sublimates, thus creating pores. This adaptation enabled us to develop a "recipe" of manufacture and a judicious design, by considering a method of production more economic and obtaining a material of better quality. The nature of coal depends on its characteristics in volatile matters, calorific value, density etc. The use of coal in the field of ceramics is to be explored. The work concerns four mixtures (M_1; M_2; M_3; M_4) corresponding to the proportions: (50 – 55 – 60 % and 65 %) for the first type of clay. As for the second the values are 30 % and remain constant. The contents of coal corresponding to each mixture are respectively: (20 – 15 – 10 % and 5 %) with granulometry of (0,25 – 0,50 – 1,00 and 1,60 mm). The technical values of the variant M_2, with, a granulometry of 1,60 mm confers mechanical qualities more or less interesting, for example, a mechanical resistance (compression) of the order of 361.6 kgf/cm^2 corresponding to a bulk density of 1.88 g/cm^3. These structural components out of terra cotta light cumulate structural properties and insulating qualities. In addition, this type of materials, by their porosity, contributes to a good quality of the interior air, in particular by an effective hygrometrical regulation. Thus according to a study of the CSTB, a mono alveolar terra cotta wall absorbs a volume of steam 5 times more important than a wall in concrete blocks, without its initial qualities.

Key words: clays coal porous material, resistant insulating

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Introduction

The insulation of the envelope of the building is determining for the management of energy saving and the quality of life of the inhabitants. However certain carcinogenic allergens, pollutant gas emanations, support the development of the micro-organisms. Nowadays certificate ACERM makes it possible to guarantee the isolating capacity and the characteristics from certain traditional insulators (example: wool of sheep, glass, fibres of wood etc…) The answer to a good practice of insulation is to place the good product at the right place such is the research orientation which takes into account a powerful insulation, a sealing of the air controlled and a well dimensioned ventilation [1]. A mixture of clay to the sawdust or other organic matter is necessary. These substances are consumed during cooking what accentuates the formation of pores. These pores contain confined and mobile air favourable to the insulation [2]. The manufacturers of bricks seek more and more to decrease the thermal conductibility of their products to obtain high thermal resistances and to increase the porosity of the shard [3]. To this list of product, another component could be added. This component with a high capacity of accumulation and restitution could be like heat insulator and acoustic of walls floors or roofs having good air tightness. As porosant element one is interested in an organic component which is coal. This last belongs to the type of sedimentary rock organo-detrital coming from very varied plants (vegetable various, ferns, mushrooms, algae) composed of various fabrics (sheets, stems, barks, resins, pollens, etc). It constitutes a heterogeneous rock containing sufficient carbon to be usable like fuel and others. These principal current uses are: production of electricity in the industrial sectors like the iron and steel industry and the production of vapor without to forget the residential sector what confers to this later to be in use in new light products [4]. The percentage of carbon increases with its age. The denser it is more it burns slowly and more it is more profitable [5]. This work is the complement object study aiming at the sector of ceramic industry or the addition was of vegetable type to knowing: sawdust resulting from the pine of Alep and the Eucalyptus, which provided definitely better characteristics. This reveals that for the same size of particle and a content twice less low, the value of bulk density is lower (produced lighter) and having a value of definitely high mechanical resistance.

Experimental methods

The analyses were carried out on raw materials local (grey clay and yellow clay) and like addition of coal. Initially we determined the natural moisture of each raw material starting from a drying oven of laboratory at the temperature 105 °C of the type: Memmert UL50 (maximum temperature 220 °C with ventilation).

The granulometric analysis was determined by wet process by using a series of sieve of various diameters (& # 1060; = 5; 2; 1; 0.63 and 0.20 mm) and per "pipette of Robinson" by considering the following fractions (1 to 0.063 mm), (0.063 to 0.01 mm), (0.01 to 0.005 mm), (0.005 with 0.001 mm) and those < 0.001 mm.

The chemical analysis was determined by the sequential spectrometer of X-ray of the type SRS 303 Siemens. Water supply: 3V min. Supply air: 2V min.; pressure water: 4 to 8 bars, Pressure air: 4.5 to 10 bars. The principal minerals combined with clays and natures of phases are determined by diffractometer X-ray of the Siemens type "500D" 20 my – 40 kV with X-ray Cu tube. The preparation of the mixtures is carried out starting from 04 types of compositions of masses made up of clays grey, yellow and of coal which are: (M_1 – M_2 – M_3 – M_4) with the respectively following proportions: (50 – 30 – 20 %), (55 – 30 – 15 %), (60 – 30 – 10 %), (65 – 30 – 5 %). The contents of coal are: (5 – 10 – 15 – 20 %) with a diameter of particles which varies: (0.25 – 0.50 – 1.00 and 1.60 mm). The shaping was carried out in a traditional draw bench. The drying of briquettes proceeded in two stages: with the free air during 24 hours then in a drier with room during 24 hours cooking was carried out in a tunnel kiln with the temperature 950 °C. The characterization of the mechanical and physical properties was related to the drying and firing shrinkage, absorption, porosity, the bulk density, the specific mass. The mechanical resistance is given in an apparatus of inflection Type 401 NEZSCH EN100.

Results and discussions

The results of moistures of careers of the matters considered are carried in Table 1.

According to these results, one notes that grey clay contains less moisture than yellow clay this is at the season of its extraction which is probably the summer. As for the second type of clay a drying is necessary before any use to especially avoid the problems of filling of the equipment during its treatment.

Table 1

Values of natural moistures of the raw materials

Types of matters	Grey clay	Yellow clay	Charcoal
Value moisture of career (%)	5.65	15.1	10.85

The results of chemical analysis are carried in Tables 2-3.

Table 2

Chemical analysis of two clays

Principal elements	Contents (%)	
	Grey clay	Yellow clay
SiO_2	48.02	51.28
Al_2O_3	10.63	12.34
Fe_2O_3	4.68	4.76
CaO	13.49	11.39
MgO	1.67	1.48
SO_3	1.23	0.95
K_2O	1.51	1.67
Na_2O	0.61	0.57
Loss in ignition PF	17.34	14.72

According to Table 2, one notes that the two types of clays are joint on the one hand: the rate of Al_2O_3 which in both cases is < 14 % what makes it possible to classify

them in the group of acid clays [6] and in addition the limestone rate lies between 6-20 making it possible to classify them in the group of marly clays and where the products cooks yellow [7].
Table 3 shows well that the chemical element which constitutes coal comes from the carbon which in its turn draws its origin of CO_2 which is released after decomposition from limestone or dolomite. The value in high loss on the ignition confirms the presence of the other volatile elements which are SO_3 and Cl.

Table 3

Chemical analysis of coal

Content of the principal elements combined with coal (%)													
SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	MnO	NaO_2	K_2O	P_2O_5	SO_3	CuO	CI	PF	Total
1.44	0.32	0.17	3.70	0.34	0.014	< 0.05	0.29	0.035	0.05	0.0059	0.06	93.50	100

The elements playing the part of energy fluxes (K_2O, Na_2O) have a rate slightly more raised concerning yellow clay, which confers better properties of cooking to him. The principal elements which make distinguish these two clays are first of all the rate of SiO_2 which is higher in yellow clay this makes it possible to say than this type of clay is sandier and plays consequently the part of grease-remover. It is also noticed that the rate of CaO, SO_3 is higher in the case of grey clay what is in exact correlation with the rate raised in loss on the ignition.
According to the results of the mineralogical analysis (Table 4) the nimble yellow is of type illite/ montmorillonite and grey clay is of type Illite/Kaolinite /chlorite.
The grain size analysis of the two types of clays is illustrated in Tables 5 and 6. According to Table 5 one notes that grey clay contains much more argillaceous particles than yellow clay this is in correlation with the data of Table 1.
According to Table 6 one observes that the rate of refusal of yellow clay is weaker than that of grey clay. In addition yellow clay is made up much more small particles probably with the mineral montmorillonite which is associated clay and which is in correlation with the results of Table 4.

Table 4

Mineralogical analysis of clays

Principal minerals	Contents (%)	
	Grey clay	**Yellow clay**
Quartz	32	27.5
Calcite	21	18
Dolomite	3	2
Feldspar: potassic	1	1
Feldspar: sodic, calcic	2.5	2.5
Semi gypsum hydrate	2	2
Ferriguneux minerals	4.5	4.5
Illite	13.5	15
Kaolinite / chlorite	12	13.5
Montmorillonite	8.5	14

Table 5

Granulometric analysis of clays "Pipette of Robinson"

Type of clay contents (%)	Dimensions of the particles (mm)				
	1 to 0.063	0.063 to 0.01	0.01 to 0.005	0.005 to 0.001	< 0.001
Grey clay	14.65	30.99	13.20	11.00	30.16
Yellow clay	12.40	25.28	13.28	22.72	26.32

Table 6

Granulometric analysis of clays "Wet process"

Type of clay contents (%)	Mesh sizes of sieve (mm)				
	5.00	2.00	1.00	0.63	0.20
Grey clay	0.00	0.00	0.03	0.03	0.10
Yellow clay	0.00	0.00	0.00	0.1	0.03

While referring to the granulometric classification of the grounds one notes that grey clay known as consists of “fine sand” and yellow clay is of character “silt” [2].
Histogram below Fig. 1 shows the variation of the moisture of shaping of the various mixtures according to the addition of coal and its granulometry.

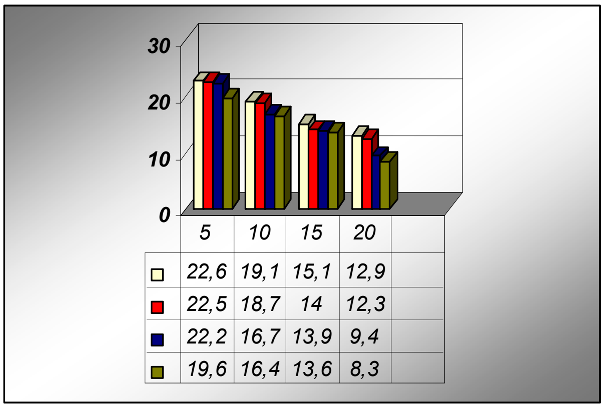

Fig. 1. *Variation of the moisture of shaping according to the addition of coal and its granulometry*

Coal tends to play the part of a grease-remover. For each addition one notes a reduction in the moisture of the argillaceous mixture according to the increase in the content and the size of this last. Starting from a content of 10% and a size of particles of 0.50 mm the capacity binding becomes weak. For this same size of particles and a content of coal of 20 %, the quantity of water for the shaping reaches the value of that used to moisten powders intended for pressing. This type of alternatives (proportions of mixtures) are allotted low mechanical resistances.

The drying shrinkage varies same manner as moisture of shaping. The corresponding values are definitely higher than the normal for the sizes of particles (0.25 – 0.50 – 1.00 mm) and a coal rate of 5 %. The recorded values are respectively: (9.00 – 8.70 and 8.50 %). This last reaches the values wished starting from the size of 1.60 mm for the coal rates higher than 5 % the recorded values enter the fork of the standards. The values higher than 8 % pose problems of production. It is conceived that the gradients of moisture during drying through the product will generate displacements during first phases of drying and thus of the constraints prejudicial to the quality of the products [3]. The variations of firing shrinkage are proportional to the size and the coal content. For a size of particles of 1.60 mm, the values corresponding to (5 – 10 – 15 and 20 %) are respectively 0.67 – 0.91 – 1.50 and 2.00 %. High values are due to the CO_2 outburst and the other volatile substances such as SO_3, Cl as indicates it Table 2 of the chemical analysis. These reactions are accompanied by a rearrangement by the particles and an orientation ordered in the crystal lattice which leads to a texture consolidated compared to the initial state followed by a contraction “shrinkage” [8-9].
The comparative results for the coal of contents 5 and 10 % for sizes of particles of 0.50 and 1.60 mm (Table 7), let us to suppose that the value of moisture 16.40 % will be regarded as the quantity of water necessary to provide a mass witch can be worked by holding account in parallel of the natural water contained in coal. Consequently it should be stressed that the element responsible for the great drying shrinkage (see Table 7) is with the quantity of high water of shaping which one associates the natural water of coal. This fact the threshold of plasticity is exceeded involving a rise of shrinkage.

Table 7

Comparative results of the physical and mechanical characteristics of the products obtained with content of coal 5 and 10% and sizes of particles of 0.50 and 1.60 %

Content of coal 5 %											
H_f, (%)	**Drying shrinkage (%)**	**Firing shrinkage (%)**	**Abs (%)**	**Apparent porosity (%)**	**Sealed porosity (%)**	**Total porosity (%)**	**M_v g/cm^3**	**M_s g/cm^3**	**R_{Flex} kf/cm^2**	**R_{Comp} kf/cm^2**	**Φ (mm)**
22.50	8.70	0.30	2.90	6.20	5.30	10.50	2.14	1.92	154.0	616.00	**0.50**
19.60	8.00	0.67	5.20	10.70	7.01	71.17	2.06	1.75	145.4	581.6	**1.60**
Content of coal 10 %											
H_f (%)	**Drying shrinkage (%)**	**Firing shrinkage (%)**	**Abs (%)**	**Apparent porosity (%)**	**Sealed porosity (%)**	**Total porosity (%)**	**M_v g/cm^3**	**M_s g/cm^3**	**R_{Flex} kf/cm^2**	**R_{Comp} kf/cm^2**	**Φ (mm)**
18.70	7.20	0.80	7.60	15.00	10.30	25.30	1.98	1.52	121.6	486.4	**0.50**
16.40	6.70	0.91	940	17.70	11.90	29.60	1.88	1.45	90.4	361.6	**1.60**

Legend: **H_f** – Moisture, **Abs** – Absorption, **M_s** – Specific mass, **R_{Flex}** – Bending strength, **Φ** – Diameter, **M_v** – Bulk density, **R_{Comp}** – Compressive strength.

Table 8

Variation of the characteristics of the various mixtures according to diameters of particles (1.60 mm) and the content (10 %) of coal optimized

Characteristics (%) Coal	Diameter of the coal particles (1.60 mm)										
	H_f (%)	Drying shrinkage (%)	Firing shrinkage (%)	Abs (%)	Apparent porosity (%)	Sealed porosity (%)	Total porosity (%)	M_v g/cm^3	M_s g/cm^3	R_{Flex} kf/cm^2	R_{Comp} kf/cm^2
5	19.60	8.00	0.67	5.20	10.70	7.01	17.71	2.06	1.75	145.4	581.6
10	**16.40**	**6.70**	**0.91**	**9.40**	**17.70**	**11.90**	**29.60**	**1.88**	**1.45**	**90.4**	**361.6**
15	13.90	5.70	1.50	12.4	22.00	13.80	35.80	1.78	1.31	64.7	258.8
20	8.30	4.20	2.00	19.8	30.50	17.00	48.60	1.59	1.07	39.4	157.6

In addition by always considering the values indicated in Table 7 and that of the histogram we observe that the bulk densities and the specific masses decrease according to the increase in the content of coal and the size of its particles. As for the values of porosities, these last are in correlation with those of absorption. To the values of porosities and high absorptions correspond of low resistances. The properties sought in this study are to have a product equipped with a low bulk density a high porosity and better a mechanical resistance. The optimized physical parameters (Table 8) making it possible to gather these three properties those are taken into account in the mixture M_2 with a size of coal particles of 1.60 mm.

Conclusion

For the moment the ceramic industries have an increasing look on insulating and light products.

A former study to this research was the subject of a project on the development of this type of material by incorporating different sawdust of two woods as porogene and insulating agent.

The products obtained showed desired characteristics.

Thus our objective is fixed on the use of another type of addition which is coal.

This later has always been used in the production of electricity, the residential sectors, iron and steel industrial sector, production of vapour.

Its adding with the sizes of particles which vary of 0.25 – 0.50 – 1.00 and 1.60 mm and of the contents of 5 – 10 – 15 and 20 % in four types of argillaceous mixtures give a range of products having different characteristics.

A low content of addition with low size of particle gives great drying shrinkage thus making drying delicate. Higher contents gave a rather weak capacity binding.

A comparative study and of optimization enters the various mixtures enabled us to deduce that the mixture answering the required criteria provided a bulk density of M_v = 1.88 g/cm^3 and correspondent with a value of bending strength of R_{flex} = 361.6 kf/cm^2.

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