Journal of
Engineering and
Applied Sciences

MEDWELL PUBLICATIONS SINCE 2000

Study of the Characteristics of Mud Bricks Reinforced with Plastic Polymer

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Key words: Bricks, clay, dune sand, plastic, polymer, mechanical properties, thermal properties

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Page No.: 3429-3436
Volume: 15, Issue 19, 2020
ISSN: 1816-949x
Journal of Engineering and Applied Sciences

Abstract: With the enormous development of human life and increase in energy consumption, new challenges are facing this high consumption, particularly with the climate changes affecting our desert regions in particular Ouargla city at Algeria, according to climatic statics it is one of the hottest regions in Algeria and world. This challenging context, make us continues in this research axes where we aimed at developing better building materials having better thermal and mechanical properties of bricks using plastic materials. In this sense, we study the thermal and mechanical behavior of bricks based on local materials and ecology (Case: Ouargla) such as clay and sand dunes, this composition is where each composition is subjected to a set of thermal (conductivity) and mechanical (compression strength, tensile strength). The results show an overall negative effect in the sense of physico mechanical.

INTRODUCTION

The climate in Southern Algeria is warm in the summer season and in this such climatic condition, the building needs to be comforted by increasing consumption of emarginate materials.

The context of this work in a continuation in a research axis of the creation of building materials with better thermal and mechanical properties from which we seek in the characterization of new earth bricks and given the importance of polymer in the world and the great success of valorization of this type of materials in the road filed (polymer modified bitumen, geo-synthetics and geo-grid, ..., etc.). We are looking for the possibility to develop in the construction field.

In this sense, we will study a brick made of two local materials: clay and dune sand mixed with aplastics particle as an addition. The composition reinforced with plastic materials in different proportions from which each position is subjected a physical and mechanical test (density, compressive strength, tensile strength)[1].

MATERIALS AND METHODS

Clay: For the research needs, we used Touggourt clay from Ouargla city where the clay performed to the following tests:

- Water content
- Bulk density
- Blue methylene value
- Atterberg limits
- Summary chemical analysis

Table 1: Clay test results

Features and characteristics	Results
Water content (NF P 94-050)	2.83%
Bulk density (NF P 94-064)	1.71 g/cc
Bleu methylene value (NF P 94-068)	3.77%
Atterberg's limits (NF P94-051)	WL= 63.9%
	WP = 32.69%
	IP = 31.21%
Chemical analysis	
Insoluble	72.7%
Sulphate SO_3^{-2}	1.61%
Carbonate $CaCO_3$	20%

Table 2: Physical characteristics of dune sand

Features and characteristics	Results
Density	2.63 g cm^{-3}
Sand equivalent	83%
Blue methylene value	0.025%
Chemical analysis	
Insoluble	94%
Sulphate SO_3^{-2}	02%
Carbonate $CaCO_3$	00%

The results are presented in Table 1[2]. In this type of materials, the granular distribution determined by two methods, dry after washing in the sieve 0.08 mm to separate the fine particles, then continues the identification of the diameters of particles using the sedimentation method, the operation method used the follow instruction of NFP 97-057 standards based on the measurement of the density variation by densitometer. Also, an XRD test are applied at the clay of Touggourt, to study the crystalline structure, this technic is based at the interaction of the crystalline structure with the radiation short waves length, this information helps us at identification the crystalline phase and the parameters of mailed of solids elements. The treatment of results is applied using Xpwoder data base and the results show in Fig. 1 and results shows that our clay compose of quartz and montmorillonite.

The sand dunes: For our study, we used the sand dunes of Ouargla. We performed the following test:

- Reel density
- Sand equivalent
- Blue methylene value
- Summary chemical analysis

The results are presented in Table 2[3]. More tests, we also tested the distribution granulometric analysis, the results expressed by a curve expresses the granular distribution by the percentage of passing of each particle diameter.

Test X-Ray Diffraction (XRD): The curve shows the results obtained for the sand dune (Fig. 2). Next steps undertaken from diffractrogramme, we can see that:

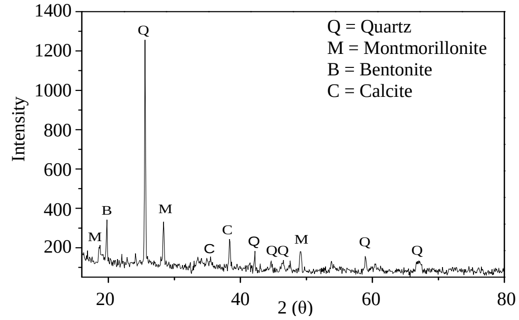

Fig. 1: Diffractometry analyses of clay

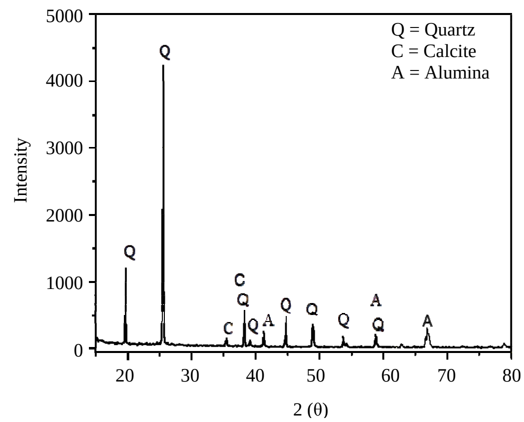

Fig. 2: Diffractometry analyses of dune sand

- Quartz forms a large proportion of minerals with a percentage of 80%
- The gypsum is in the form of whitish fine grains with a percentage of about 3%
- Feldspar and calcite are present with low percentages in round 10%

Plastic material: For our study, we used the High-Density Polyethylene (HDPE), this polymer has a round shape without the presence of light color (transparent), the experimental plan for this point contains two tests (Fig. 3):

- Thermogravimetry analysis (ATG)
- Differential Thermal Analysis (DTA)
- Dynamic Scanning Colometry (DSC)

The thermogravimetric (ATG) and thermogravimetric derivative (DTG) analysis test, first consist of measuring the mass change over time with the temperature change, the ATG curve is presented in Fig. 4-5. The second test is really effective in detecting the first derivative of ATG curve, from which it can detect small records.

Fig. 3: High-density polyethylene used

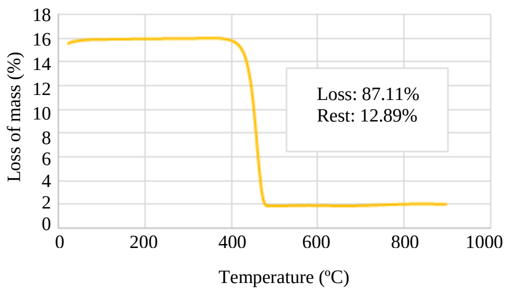

Fig. 4: ATG curve of high-density polyethylene used

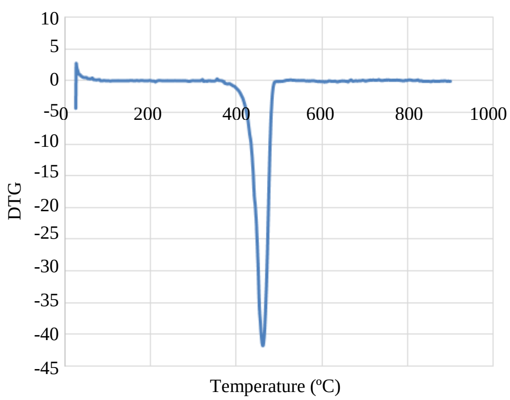

Fig. 5: DTG curve of high-density polyethylene used

RESULTS AND DISCUSSION

This research shows the thermal and mechanical properties of the bricks based on clay Touggourt Ouargla region (raw and cooked), these bricks also comprises an additive which a plastic material which the High Density Polyethylene (HDPE) (Fig. 6).

Samples with different concentrations compounds HDPE and each sample is subjected to various tests on the bricks crafted namely:

- Mechanical tests
- Flexural
- Compression
- Heat test
- Thermal conductivity

Table 3: Brick composition

Values (%)	C1	C2	C3	C4
Clay	70	69	68	67
Dune sand	30	30	30	30
Plastic	0	1	2	3

For the purpose of the study, the evaluation of HDPE on the bricks, we prepared two types of bricks:

- Raw bricks
- Cooked bricks

For this study, we chose four compositions for each type of brick, the compositions shown in Table 3 following (Fig. 7).

Raw bricks: Figure 8 shows the variation of the density of raw bricks based on the percentages of HDPE. From Fig. 8, we find that More are added the rate of HDPE in the adobe, the density of adobe decreases, the influence due to the difference between the bulk density bricks and sand relative density of HDPE, the mineral component has a mass >1 g cm^{-3} density, unlike plastics which does not exceed 0.5 g cm^{-3}.

Therefore, more HDPE occupied a volume on the bricks, the equivalent weight of that volume decreases relative if occupied by mineral composition (brick or sand).

Flexural strength: Figure 9 shows the variation of the flexural strength of the raw bricks based on percentages of HDPE.

From Fig. 9, we find that y ‘a decrease in flexural strength compared to the control blocks (without HDPE) and this decrease creates a negative relationship between the content of HDPE and the bending strength (more than HDPE, less resistance).

To test found that HDPE particles on the mineral matrix, has not arrived at a change of form, ie it is not helped in the resistance of the charges applied by the machine ‘trial.

Compressive strength: Figure 10 shows the variation of the compressive strength of raw bricks based on percentages of HDPE.

From Fig. 10, we find that there's a decrease in resistance to compression and the same remarks noted in this case also (decrease compressive strength depending HDPE; HDPE can not resist compressive loads).

Cooked bricks: After the preparation of the mixtures and las brick firing in an electric furnace T = 800°C for 8 h, we noticed a few things such as (Fig. 11):

- The melt >87% HDPE
- Mass Parte 7-8%

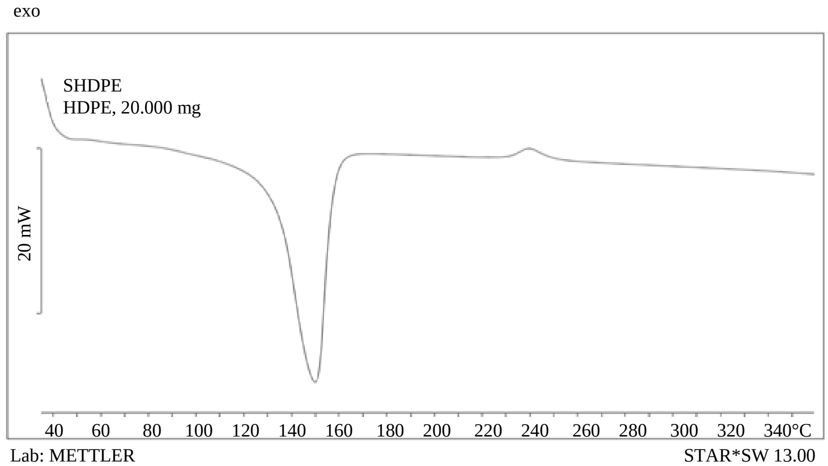

Fig. 6: Dynamic analyse differential

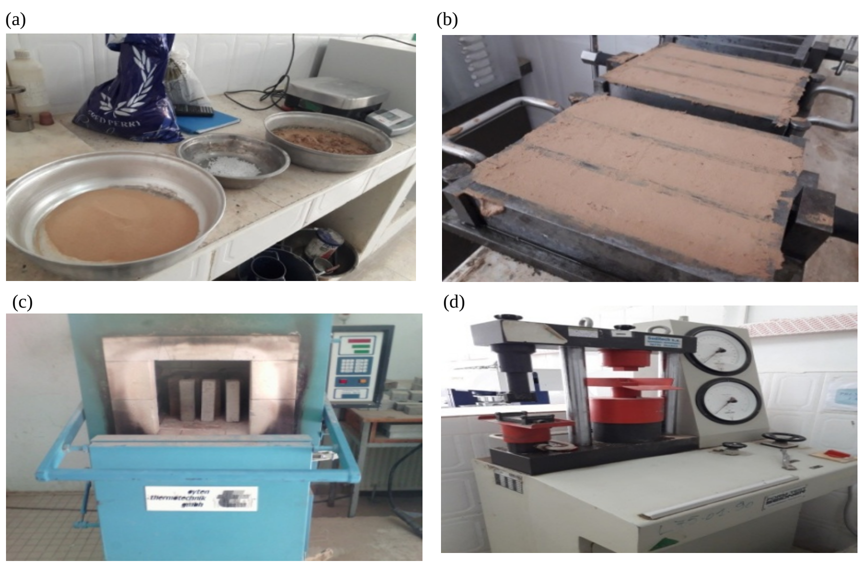

Fig. 7(a-c): (a) Preparation of mold, (b) Weigh the quantities before mixed and (c) Mixture and loaded molds

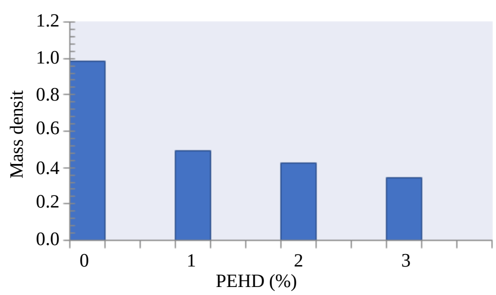

Fig. 8: Mass density

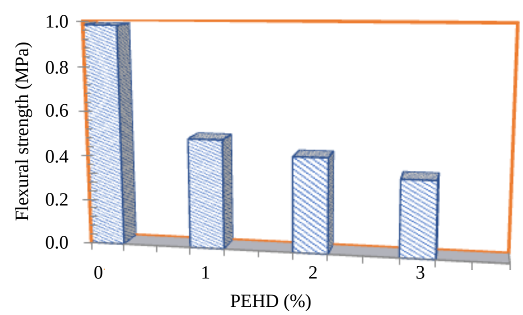

Fig. 9: Flexural strength

Mass density: Figure 12 shows the variation of the density of the fired bricks based on the percentages of HDPE. In this case, there is also a drop density but it is only with great intensity. This time due to the temperature influence on the four cases specially witnessed where the density is decreased from 2.00-1.86 g cm^{-3}. For bricks treated with HDPE has a temperature of 800°C,

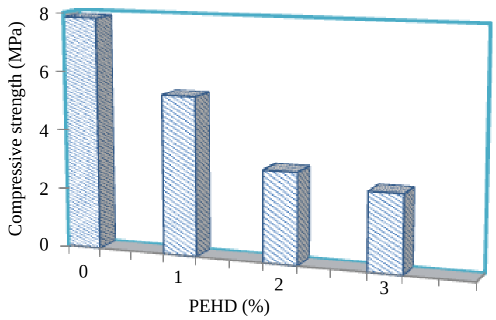

Fig. 10: Compressive strength

Fig. 11: Bricks after cooking

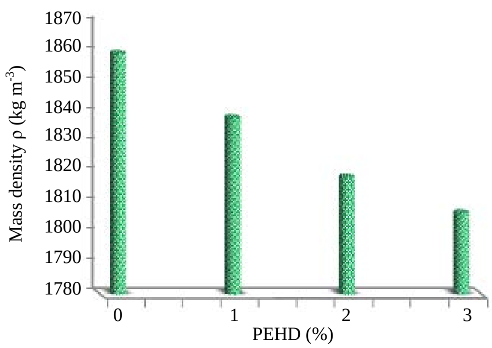

Fig. 12: Mass density

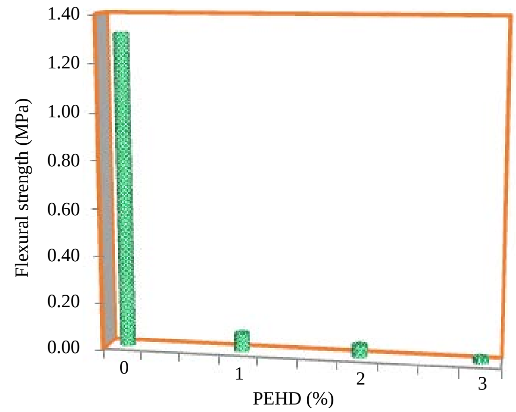

Fig. 13: Flexural strength

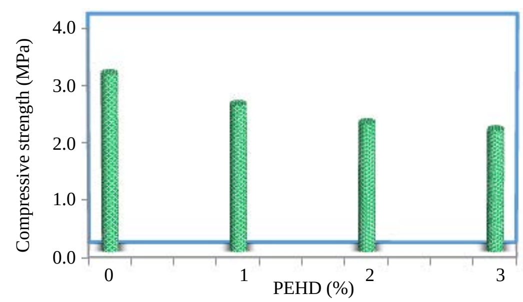

Fig. 14: Compressive strength

polyethylene loss over 87% of these compositions according to the thermogravimetric analysis at the temperature of 414°C (these weight losses creates voids in the brick matrix.

The flexural strength: Unlike the densities, the intensity of the influence HDPE on the flexural strength is very large protruding 92%. This is expected in a situation where the bricks losses between 0.82 and 2.46% of the components of HDPE in the box operation creates weak points in the brick matrix but the rate of influence is remarkable compared rates a loss of mass (Fig. 13).

The compressive strength: Figure 14 shows the variation of the compressive strength of the fired bricks based on percentages of HDPE. The compressive strength was taken as the impact of the loss of mass of HDPE and bricks of the component also decreased in this case is not with the same intensity, with the briquestraités HDPE loss between 18 and 28% their compressive strength compared to the control brick Based on analyzes of mud bricks and cooked according to their physico mechanical, there was a significant reduction characteristics according to different causes: the negative impact of HDPEon the green bricks, although, good mechanically but is unable to integrate into the brick matrix, making HDPE operates independently of him (poor adhesion). On the other hand, the negative impact of HDPE on the bricks baked in other reason because HDPEhas lost >80% of its compounds during the cooking process at a temperature of 414°C, they let behind empty which further deteriorate the baked bricks physically and mechanically. It prose in the phase following an intermediate phase between the raw and cooked, based on an assumption that at a temperature above the glass transition temperature between the rubbery and glassy behavior (tg = 139°C) determined by the DSC, the HDPEin a start a mergeoperation in the matrix makes contact with the solid particles and plays a role of connection between these particles. And ensuring that temperature than HDPE loss does not a significant rate of these components (lower tan a 139). Have named

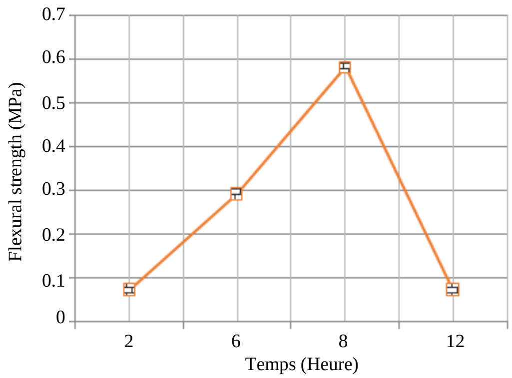

Fig. 15: Flexural strength

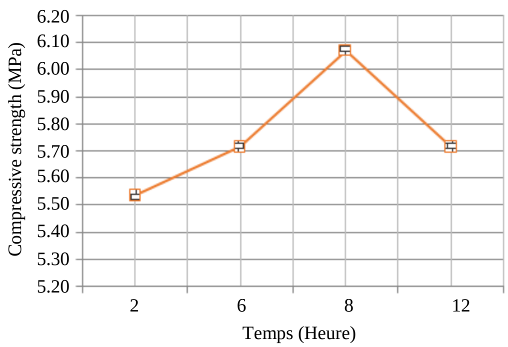

Fig. 16: Compressive strength

this case brick as brick semi-cured. In this point, we present the measured characteristics of brick that is proposed what we call “semi cooked,” hence, after preparation with the same method of adobe specimens mentioned in point 1% of HDPEand after preparation of the 4 test specimens these test specimens are stored at a temperature of 160ºC×4 for 2, 6, 8 and 12 h. The samples are subjected to the same tests mentioned previously, it was Fig. 15 expressed the evolution of these characteristics depending on storage time at 160ºC, these testing flexural strength and compressive.

The flexural strength: Figure 15 shows the variation of the flexural strength of the bricks according to time. From Fig. 15, we find that The bending strength increases with time up to 8 hours of a linearly validate our proposal “half baked” but after eight o’clock a sudden drop bending resistance is seen at 12 h of storage has 160ºC. We believe in a starting weight loss at this temperature (time effect replacing the influence of temperature).

The compressive strength: Figure 16 shows the variation of the compressive strength of the brick as a function of time.

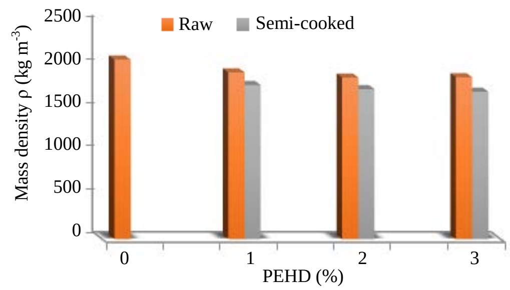

Fig. 17: Mass density

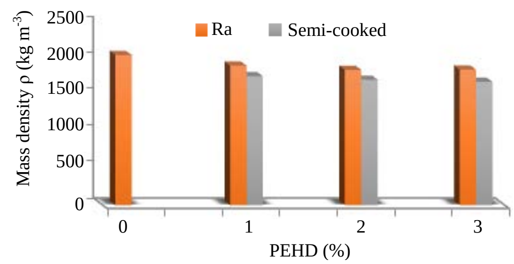

Fig. 18: Flexural strength

From Fig. 16, we find that the compressive strength increases are a function of time up to 8 h in a linear fashion validate our proposal “half baked” but after eight o'clock a sudden drop in compressive strength is observed at 12 h storage has 160ºC. We believe in a starting weight loss at this temperature (time effect replacing the influence of temperature).

The tests discussed above in seeking the best storage time at 160ºC and after the mechanical result is different, we fate as the ideal time to take a maximum value of compressive strength and bending it’ is 8 h. This time was used in the manufacture of tubes with different content HDPE which are subject to the same tests mentioned above, it was these Fig. 17-22 expressed the evolution of these features depending on HDPE after 8 am conservation 160ºC in the following point.

Volumic mass: Figure 17 shows the variation of density as a function of percentages of HDPE specimens of brick semi-cooked

From Fig. 17, we find that the semi-baked brick has a density less compared to the green bricks. The latter returned to HDPE performed phase change and mass loss rate low in manufacturing conditions.

The flexural strength: Figure 18 shows the variation of the bending resistance as a function of percentages of HDPE specimens semi bricks-cooked.

From Fig. 18, we find that the flexural strength is much less compared to controls (without HDPE; resistance brick mixed with 1% of HDPE was increased

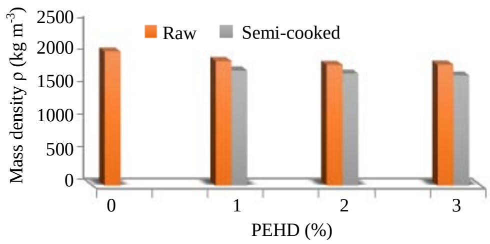

Fig. 19: Compressive strength

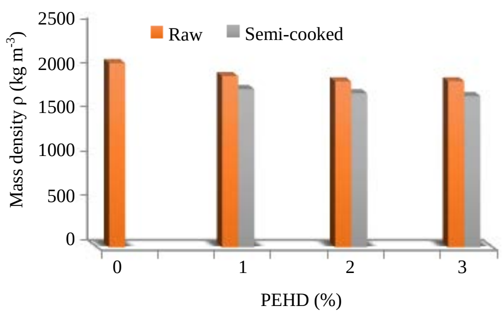

Fig. 20: Ultrasound propagation speed

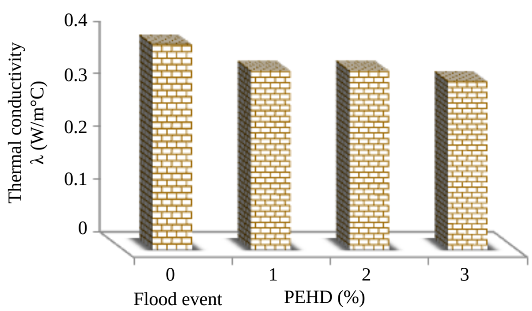

Fig. 21: Thermal conductivity

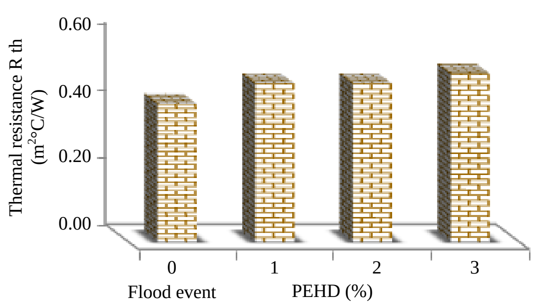

Fig. 22: Thermal resistance

in the case of semi-cooked and exceeds the if crueavec the same content PEHD par 28%, the other two levels has not happened to exceed flood resistance is the bending strength decreases it is important.

The compressive strength: Figure 19 shows the variation of the compressive strength of the brick as a function of percentage of HDPE. Unlike the flexural strength, Fig. 19 shows the compressive strength increased in the three levels of HDPE with rates of 07, 72 and 92% relative to the green bricks change by 1, 2 and 3% of HDPE, respectively. The values of semi cooked, it is still lower as a mud brick without polyethylene (Reference).

Ultrasonic testing: Figure 20 shows the variation of the flexural strength of the bricks according to percentages HDPE.

From Fig. 20 and according to the speed of sonic propagation obtenues par semi-baked case of bricks and flood event of bricks, we notice that the bricks treated by the first method has physical characteristics improved compared audeuxième method. The temperature treatment (firing) has a great effect on the characteristics of new bricks.

Thermal results of semi baked brick: For this work, we choose the "Non-Steady-State Probe" method for measuring the thermal conductivity for. Figure 21 shows the variation of thermal conductivity (bricks based on percentages of HDPE).

From Fig. 21, we find that,a slight decrease in thermal conductivity is the bricks modified with this method are somewhat more insulated flood event with rates between 12 and 18%. This parameter confirming the thermal resistance measurements (Fig. 22).

The measures presented in the histogram above as a comparison between the four bricks, we note that the thermal resistance increases in semi bricks-cooked with rates of 14.6 1 and 2% of HDPE and reaches 22% for bricks semi-cured at 3%[4]. That is to say, these bricks are less sensitive to temperature change. This increase in resistance is due to the thermal behavior recorded on calorimetric analyzes, HDPE absorbent it the temperature to create a phase transition (coutchoutique-glass).

CONCLUSION

According to the different mechanical and thermal tests carried out in the case of semi-cooked pulled out with: bricks semi-cooked treated with HDPE, on a condition of 8 h at 160°C this results in better compression compared to the treated green bricks. Unlike the resistance bending, only the treated brick samples with 1% HDPE present results better. It pence as other levels require more than temperature or longer to see the same influence by giving 1%. Bricks semi-mechanically and physically cooked are still low relative to the raw bricks but thermally improved thermal parameters is noted in this case.

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