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Elaboration and Characterization of Composite Materials made of Plastic Waste and Sand: Influence of Clay Load

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Abstract: ***In the field of the construction, the trend since few years is to gradually replace of conventional materials by polymer matrix composite materials. It is in this context that this study proposes a technique of making composite materials with a polymer matrix, using plastic waste. During this study of mechanical tests (flexural and compressive strength), will be carried out on the samples in order to check the resistances. To expand the field of use, we added clay as a load to improve the resistances of the composite. The results obtained are satisfactory from the point of view of mechanical strength. It also appears that these resistances improve when clay is added as a load***

Keywords: Composite; Plastic waste; Low Density Polyethylene (LDPE); Load, Modulus of elasticity

I. Introduction

To set up an environmental protection policy, the fight against pollution is necessary; especially with regard to plastic waste.
It is in this context that reflection begins on the research of new materials, able to solve economic, technical and environmental problems in our African countries.
The reuse of the plastics wastes, which constitute an environmental discomfort, is currently the subject of much work. Among these works are the mostly incorporated plastic wastes in cementitious matrices (Guendouz et al, 2016; Kumaran, 2015).Some authors (Panyakapo et al in Guendouz et al, 2015), use low density polyethylene (LDPE) as a binder for the production of composite materials and this by converting the LDPE into resin in the presence of glycols.
This work aims to study the possibility of proposing an alternative method of using plastic waste (LDPE: low density polyethylene) for the conception of a new material.
In this study we will analyze and explain the influence of the proportion of LDPE and the incorporation of clay load on the mechanical properties of the new material.

II. Materials and methods

II.1 Raw materials

II.1.1 Sand

Sand is the main component of our material. The sand is extracted in the river which crosses the town of Belfort (France), named Savoureuse. We obtained the sand thanks to the BELFORT BETON company which extracts and uses it for its works.
The absolute density of the sand is 2.60 and the granulometry of the portion used is shown in fig. 1.

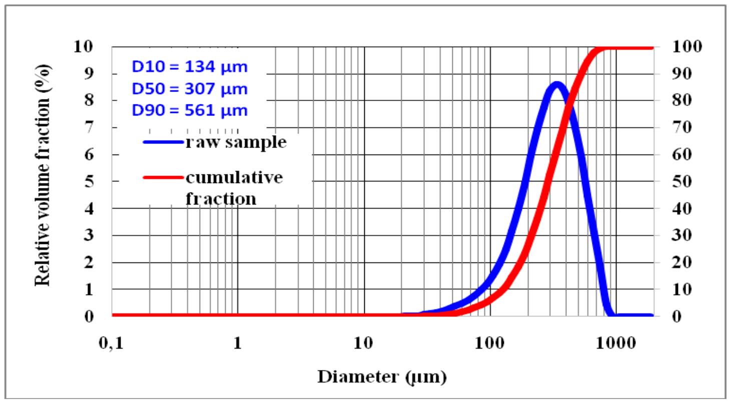

Fig. 1: Granulometric curve of sand

II.1.2 Low density polyethylene (LDPE)

The density of the low density polyethylene (LDPE) used is 0.93 and the results of its analysis at the DSC (Differential Scanning Calorimetry) are shown in fig. 2.

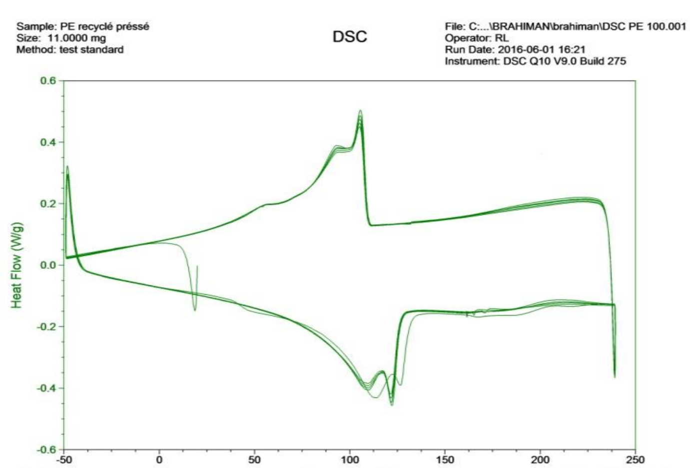

Fig. 2: DSC analysis of low density polyethylene (LDPE)

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II.1.3 Clay

The clay used as a load is obtained by grinding in the laboratory of Geomateriaux in Abidjan (Côte d'Ivoire). It is a clay extracted on the site of Dabou (Côte d'Ivoire), with a density of 2.61 and its specific surface area is 3286 cm^2/g. It is a clay constitued of clay minerals (Kaolinite and illite) which are associated with quartz and anatase (Kouadio, 2010).

The granulometric analysis of the portion used is shown in fig.3.

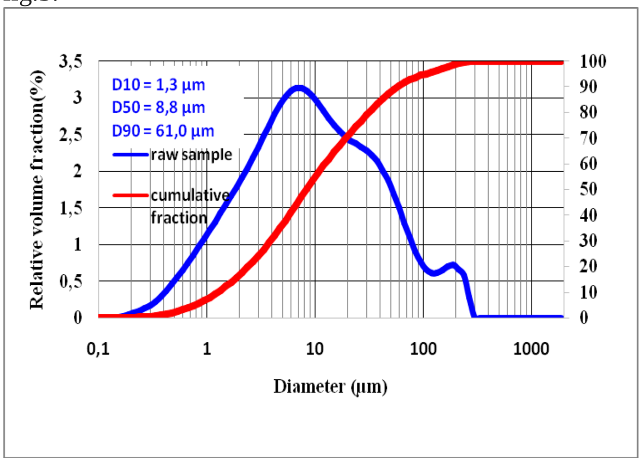

Fig. 3: Granulometric Curve of the clay

II.2 Equipments

For mixing sand and plastic we have developed a mold (Figure 4-a). We also use a thermopress (Figure 4-b) to melt plastic and compress our material. Mixing is done with a drill (figure 4-b).

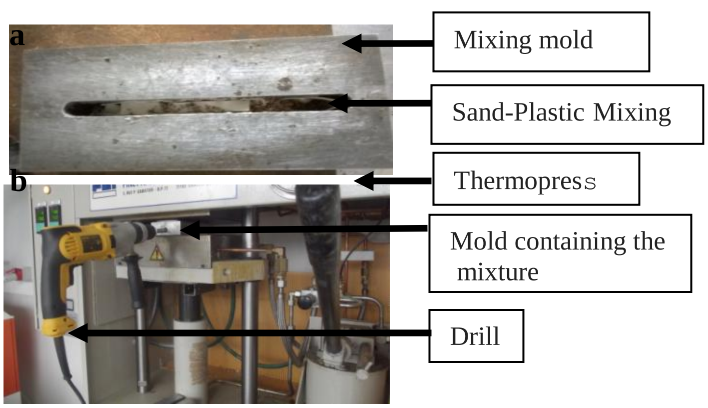

Fig. 4: Thermopress and mold

II.3 Methods

After mixing, the sand-plastic or sand-plastic-clay assembly is heated by the thermopress at 170 ° C for five (5) minutes. During heating the mixture is made simultaneously, by the drill.

The material thus obtained is named PASTIB (Plastic Clay Sand Traore brahiman). After this step the PASTIB material is placed in a mold, followed by a thermocompression at 170 ° C with a pressure of 10 MPa for five (5) minutes. Then the cooling takes place under the same pressure up to 30 ° C. The diagram in figure 5 shows the methodology used for making samples made of plastic, clay and sand. When the addition of clay is removed, the diagram of samples made of plastic and sand is obtained.

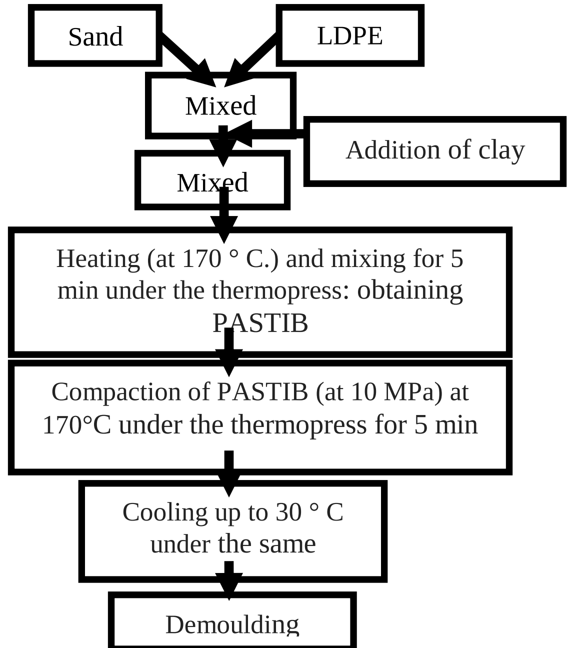

Fig. 5: Sample preparation methodology

After demolding we obtain samples of dimensions 160 X 15 X 3.5 mm^3 (Figure 6). For the compression test we make samples of dimensions 20X10X10 mm^3 corresponding to a slenderness two (2) according to standard 13225(Bavelard and Beinish, 2006) and for the three-point flexural test, we prepare samples of dimensions 80 X 10 X 3.5 mm3 according to ASTM D790.

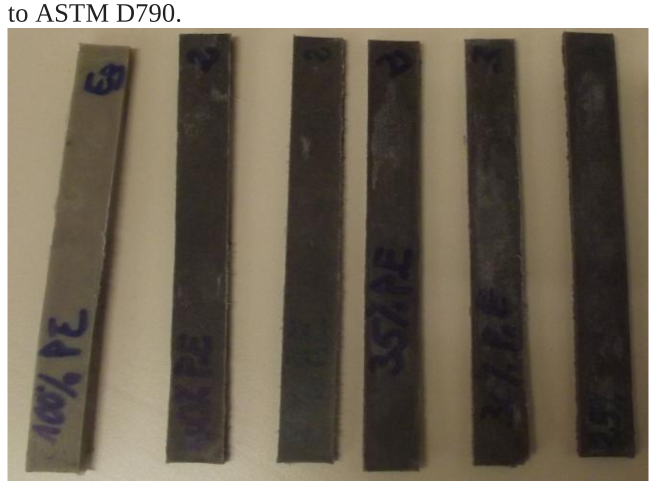

Fig. 6: Image of samples

III. Results and discussion

Flexural and compression tests are made with the device Universal testing Analyser (TA-XT2i).

III.1 Flexural strength and modulus of elasticity

The results obtained are shown in figs. 7 and 8.

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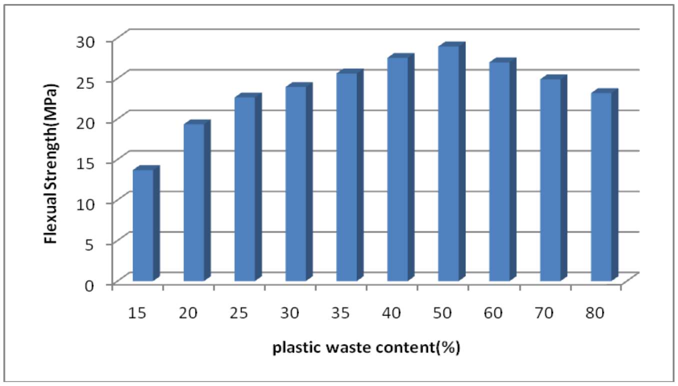

Fig. 7: flexural strength as function of the plastic content

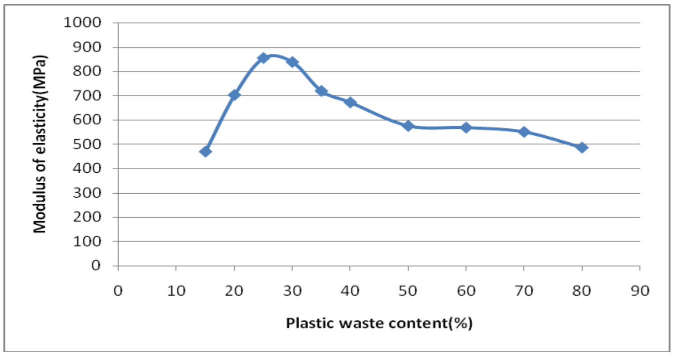

Fig. 8: Variation of modulus E as function of the plastic content

The flexural strength increases (13 to 28 MPa) from 15 to 50% plastic (LDPE). Then decreases (26 to 23 MPa) when one passes from 60 to 80% of LDPE.

When the plastic content increases, we are increasingly getting a mixture containing an amount sufficient to bind the grains of sand.

Above 50% LDPE, the resistance drops because the mixture contains too much plastic, causing defects in the material. These results are agreement with the results of Rakotosaona et al, 2014.On the other hand; we obtain superior results which are due to the applied pressure (10 MPa) in our methodology. This pressure will strengthen the cohesion between the plastic and the sand particles.

Some authors (Praveen al, 2013; Guendouz et al, 2016; Ganiron Jr, 2014 ; Ghernouti et al, 2011) which use plastic waste as coarse aggregates and in the form of fibers (Balaji et al, 2016), in cementitious matrices also get results where the resistance increases to the ideal proportion before falling.

The results we have obtained are always higher compared to these authors because, they use plastic in the form of aggregates. We will then have the shape of the grains which will increase the rate of vacuum which will reduce the compactness and the strength of the material (Ghernouti, 2011).

Modulus of elasticity E in flexion increases up to 25% of LDPE before falling .This is because from this level of plastic, we obtain a material containing enough LDPE. The material will then have a modulus E which holds out towards that of the LDPE which is weak.

III.2 Compressive strength

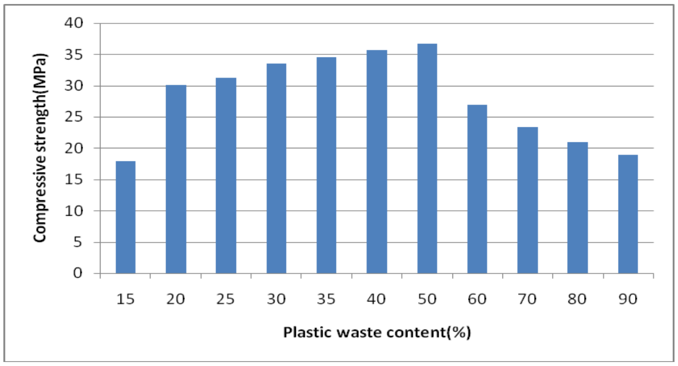

Fig. 9: compressive strength as function of the plastic content

The compressive strength also increases to the maximum rate (50%) before decreasing. As in flexion the resistance is going to grow with the proportion of the plastic because, more there is plastic, more grains of sand are coated or bound. After the ideal proportion (50%), the resistance will decrease to tend towards the resistance of the plastic.

Ohemeng(2014), Batayneh et al. (2006) which introduced plastic in granulated form into concrete with cementitious matrix, obtained a decrease in strength when the plastic content increases. This is because the increase of the plastic in the mixture will decrease the plastic adhesion with the cementitious paste thus inducing the reduction of the resistance

III.3 Effect of clay as load on flexural and compressive strength

We present the results of the effect of clay loading on the flexural strength (Figure 10) and compression strength (Figure 11) of the material.

It should be noted that we present the effect of the load on samples containing 20% LDPE.

The ideal load for samples containing 20% LDPE that we have determined in other studies is 5%.

On the graphs we also present the equations of the slopes of the different curves with the correlation.

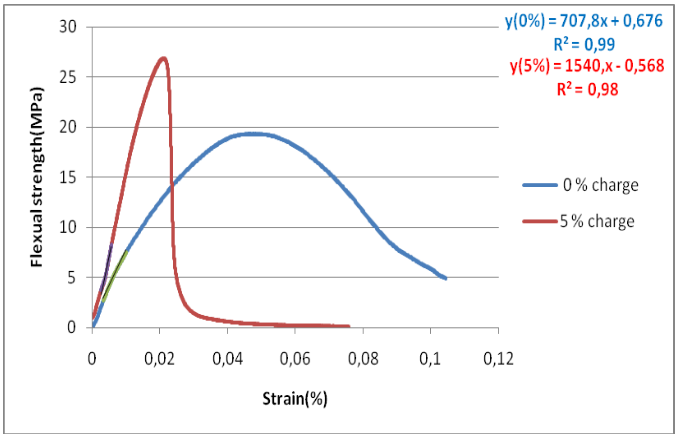

Fig. 10: Stress-strain curve of sample containing 20% LDPE

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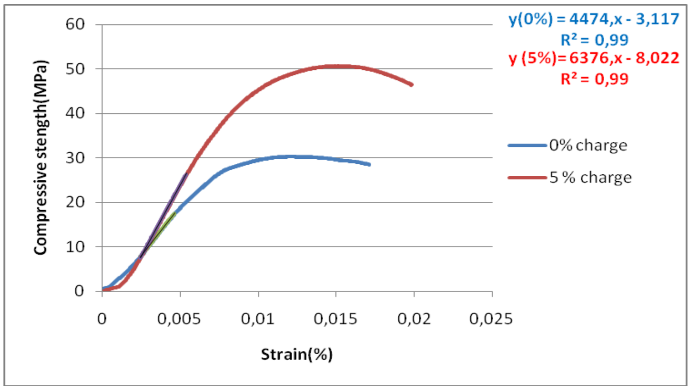

Fig. 11: Stress-strain curve of sample containing 20% LDPE

The 5% clay load brings in increased flexural strength and compressive strength. The resistances increase from 19.34 to 26.87 MPa for the flexual and from 30.39 to 50.70 MPa for the compression.This increase is explained by the fact that the clay particles will be charge carriers.

Stress forces will be distributed between grains of sand, clay and molten LDPE. There will then be a need for more force to break such a material relative to a material where forces are distributed only on sand grains and LDPE.

On the stress-strain curve (in flexion), we notice a decrease in the plastic deformation domain when adding clay. The slope of the flexural elastic domain (Modulus E) of this curve changes from 707.8 for a material no-loaded to 1540 for a material loaded with clay. Similarly, that of the compression goes from 4474 for a material without load to 6376 for a material loaded with clay.

Whith this result, we can then say that the load makes it possible to make the material rigid because according to Chateigner(2012), a high modulus value indicates high stiffness of material .

These results are according with those obtained by Tcharkhtchi et al(2001), Benbayer(2014), Dupuis et al (2007), Oddes et al (2008).

These authors obtained higher results because they use modified clays and compatibilizers to improve clay-plastic bonds.

IV .Conclusion and perspectives

The objective of this study is to valorize plastic waste and to study the effect of the clay load on the mechanical behavior of the materials obtained.

With the results obtained we can conclude that this method of valorization of waste is to be adopted. The addition of clay as load improves the mechanical strength of the material.

In order to widen the scope of application of materials obtain, of the studies complementary like the tests to fire , wear, thermal conductivity … must carried out.

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