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# Influence Of Marine Sedıments On The Rheologıcal Properties Of Brıcks

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**Abstract.** The practices of dredging constitute a challenge for the development and maintenance of port activities. Millions of cubic meters are regularly extracted from the Algerian ports, it is necessary to value them. This study focuses on the valorization of marine sediments from the port of Bethioua for making bricks. A rheological characterization was performed with great care for these marine sediments and for the brick slip. The rheological study was conducted for different concentrations using the rheometer using a measurement geometry coaxial cylinder. The study of the rheological parameters of the brick slip , marine sediments and the brick slip with addition of these marine sediments has enabled to determine the ideal composition and concentrations ideal for making bricks. The results of the rheological parameters obtained from these marine sediments show a percentage of valorization recovery up to 15% which allows that these sediments can be valued in the field of manufacture of brick.

***Keywords.*** Marine sediments; Dredging; Valorization; Brick slip; Characterization.

## INTRODUCTION

During the last decades, the manufacture of bricks was evaluated using the marine and river sediments throughout the world (Hamer and Karius., 2002; Lafhaj et al., 2008; Samara and Lafhaj, 2009; Xu et al., 2014; Mezencevova et al., 2002). The rheology of marine sediment has been used in this area (Romero et al., 2008; Pouv et al., 2010). The rheological characterization of the clay used to make bricks is primarily concerned with the effects of the initial concentration and the addition of material to be recovered (marine sediments). It aims at explory two lines of research applied to reduce the tonnage of dredged material and to value them in the manufacture of brick.

Most building materials are heterogeneous. These materials can accommodate different kinds of inorganic waste treated (Benamar et al., 2012; Levachie and Duan, 2011; Allal et al., 2011; Loustau cazalet, 2012) or untreated (Scordia, 2008). These past few years several studies have been conducted, by adding sludge treatment and sewage sludge (Dubois, 2006), the waste of natural stones (Samara, 2007; Lions, 2004; Weng et al., 2003), coal waste (Lin et al., 2006; Acchar et al., 2006; Menezes et al., 2005; Garcia et al., 2005; Lin, 2006; Olgum et al., 2005)metallurgical waste (Lingling et al., 2005; Balgaranova et al., 2003; Cheeseman et al., 2003; Dondi et al., 2002, sandy cuttings (Dondi et al., 2002)

## MATERIALS AND METHODS

The studied sediments were collected using a mechanical dredge which is fundamentally a mechanical shovel mounted on a pontoon in the port of "Bethioua "(Fig.1). This port is classified as oil zone, which shows the much hydrocarbon content in these sediments. The dredged material was conserved in clean waterproof bags and transferred the same day of dredging to different laboratories. This study includes a rheological properties (flow testing) of marine sediments, clay brick, brick slip and of brick slips with additions of marine sediments.

Fig. 1. Sampling Site of sediments (Port of BETHIOUA).

### Rheological Properties

This part of study is devoted to the rheological characterization of marine sediments, clay, brick slip (mixture of clay brick+sand+water) and brick slip with the addition of marine sediments to have an idea of the mechanical behavior. The rheological study was conducted for different mass concentrations using a rheometer (Thermo Haake RS600 RheoStress) with imposed speed. The coaxial cylinder geometry (Z40 DIN) including the gap of 8 mm was used. The disruptive effects, such as sliding, digging, evaporation and fracturing were well controlled.

### Flow Testing

The three materials (clay, brick slip and marine sediments) were studied with different mass concentrations from 10% to 55% at ambient temperature 20 °C using a thermostatic bath type (DC30). The complete homogenization was achieved by stirring the respective mixtures (clay + water, marine sediments + water, brick slip + water) for 24 hours with a magnetic stirrer.

Figures 2, 3 and 4 show the shear stress (τ) as a function of shear rate ($\dot{\gamma}$). The shear stress is shown to increase as a function of the mass concentration of the samples at constant speed. These rheometric curves are modeled using the Herschel-Bulkley model (Equation1) for the three materials.

$\tau = \tau_0 + K\dot{\gamma}^{\,n}$ *(1)*

where ($\tau_0$) is the yield stress in Pa, (K) the consistency index in Pa.$s^n$ and (n) in the flow index.

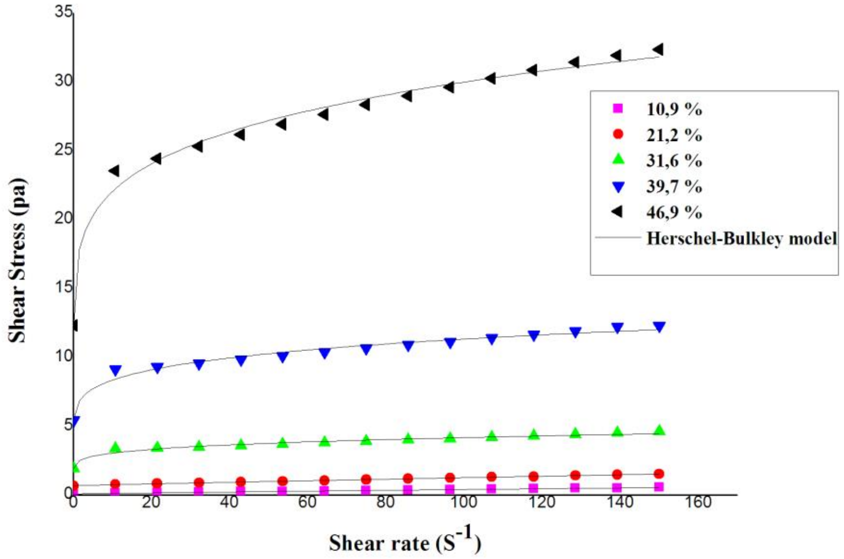


Fig. 2. Shear stress as a function of shear rate at different mass concentrations of clay brick.

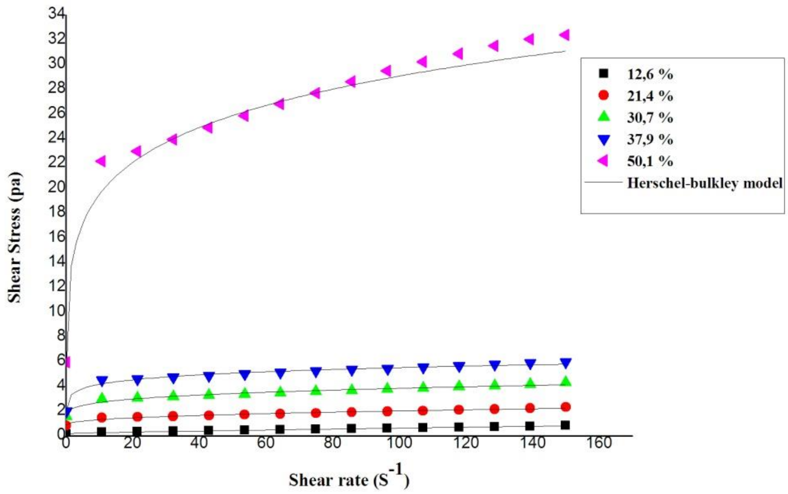


Fig. 3. Shear stress as a function of shear rate at different mass concentrations of brick slip.

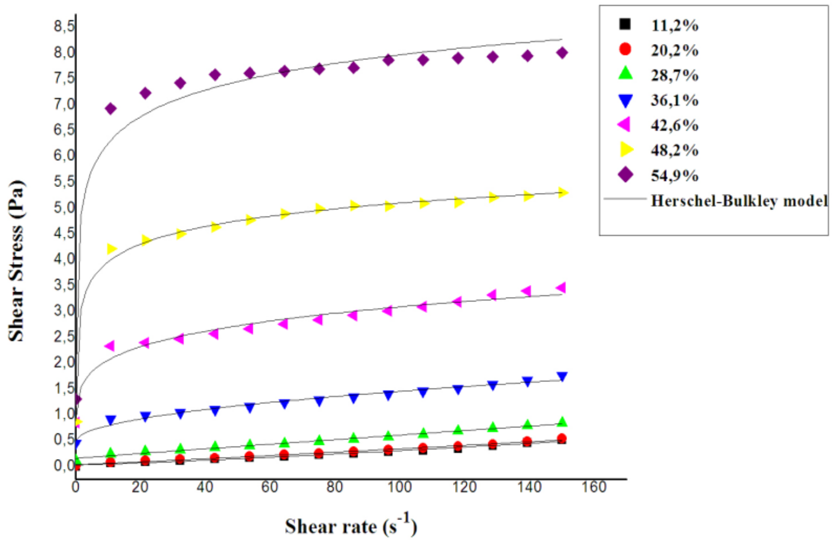


Fig. 4. Shear stress as a function of shear rate at different mass concentrations of marine sediments.

## RESULTS AND DISCUSSION

### Evolution of the shear stress as a function of shear rate under the effect of the addition of marine sediments

Five mass concentrations were used to perform the rheological tests. The five formulations prepared are shown in Table 1.

Figure 5 shows the evolution of the shear stress as a function of shear rate for the brick slip and brick slips with additions of marine sediments. The rheological model has been remains the same for the five concentrations (Herschel-Bulkley (Equation1)).

Table 10. Formulations with addition of marine sediments from 0 to 20%.

| | Marine sediment (%) | Clay brick | Sand |
|---|---|---|---|
| Brick slip | 0 | 75 | |
| Formulation 1 (F1) | 5 | 70 | |
| Formulation 2 (F2) | 10 | 65 | 25 |
| Formulation 3 (F3) | 15 | 60 | |
| Formulation 4 (F4) | 20 | 55 | |

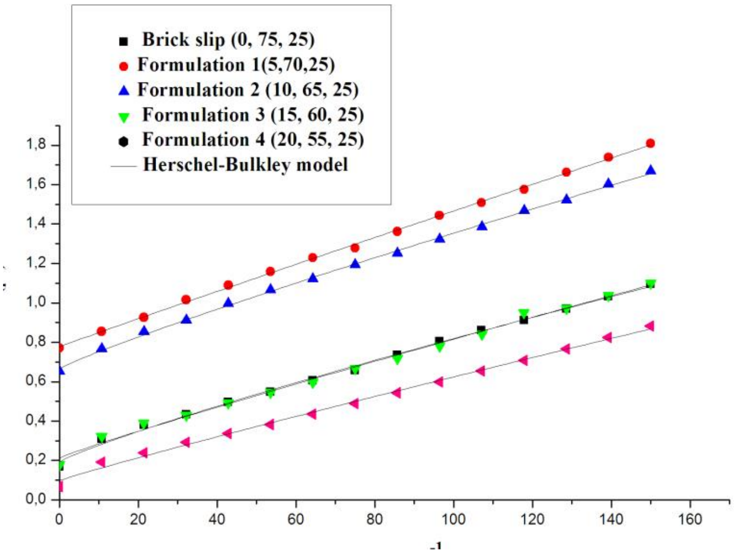


Fig. 5. Shear stress as a function of shear rate at different mass concentrations of brick slip and brick slip with addition of marine sediments.

**Evolution of the yield stress as a function of the mass concentration under the effect of the addition of marine sediments**

Figure 6 shows the evolution of the yield stress as a function of different addition concentrations of marine sediments.

The brick slip with addition of 5% and 10% of marine sediments has been given a significantly higher yield stress compared to the reference brick slip (in the order of four times). For the concentration of marine sediments of 20%, the yield stress decreases to a value of four times smaller than that of the reference brick slip.

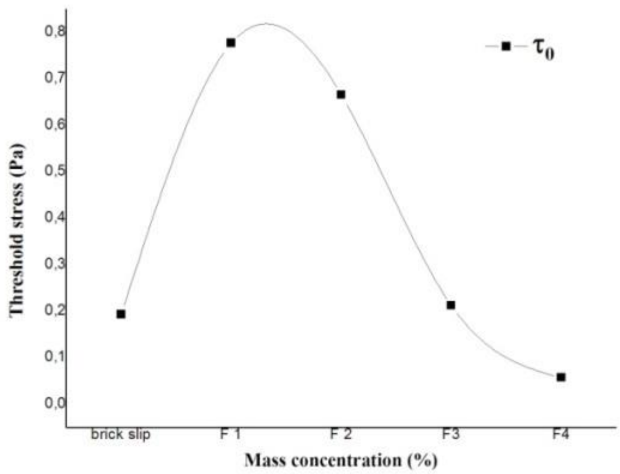


Fig. 6. Evolution of yield stress as a function of mass concentration of valorization for the different formulations.

**Evolution of the consistency index and the flow index of the brick slip under the effect of the additions of marine sediments**

Figure 7 shows the variation of the consistency index (K) and the flow index (n) of the brick slip as a function of concentrations with addition sediment. The results obtained show a significant increase in the consistency index when the additions concentration increases, on the other hand a decrease in the flow index was observed.

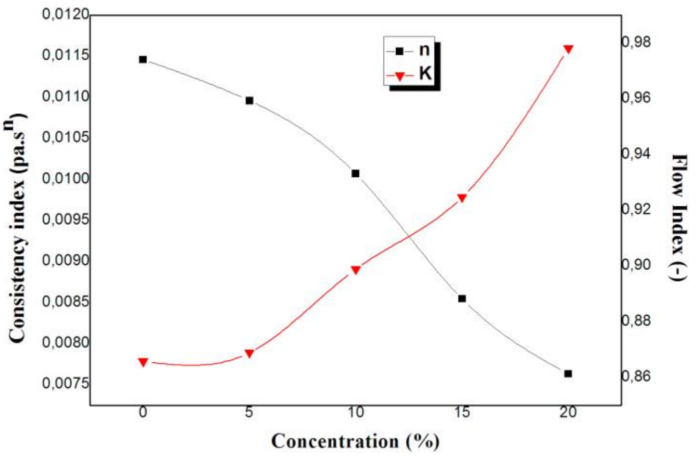


Fig. 7. Evolution of the consistency index and flow index of the brick slip as a function of concentration with addition marine sediments.

These results show that the marine sediments can be valued up to a concentration of 15%, knowing that in this case the rheological parameters are nearly identical to the reference slip. To explain this phenomenon, (Table 2) shows the chemical composition of major elements on one hand and the figures represent percentages in alumina and sulfates functions concentrations in marine sediments on the other hand (Fig. 8 and 9).

Table 2. Chemical composition of major elements in the mixtures of brick slip.

| **Oxide content (mass %)** | **$SiO_2$** | **$Al_2O_3$** | **$Fe_2O_3$** | **CaO** | **MgO** | **$SO_3$** | **$K_2O$** | **$Na_2O$** |
|---|---|---|---|---|---|---|---|---|
| Brick slip | 57.84 | 12.72 | 5.41 | 9.86 | 2.45 | 0.57 | 2.04 | 0.55 |
| Formulation 1 (F1) | 50.48 | 12.96 | 5.36 | 11.81 | 2.46 | 0.77 | 2.08 | 0.56 |
| Formulation 2 (F2) | 50.93 | 12.19 | 5.12 | 12.86 | 2.41 | 0.59 | 1.94 | 0.58 |
| Formulation 3 (F3) | 50.59 | 11.68 | 5.17 | 13.17 | 2.37 | 0.62 | 1.97 | 0.58 |
| Formulation 4 (F4) | 49.86 | 10.94 | 5.03 | 14.36 | 2.29 | 0.60 | 1.89 | 0.58 |

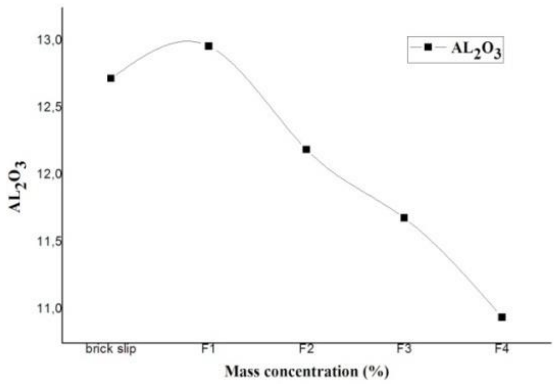


Fig. 8. Evolution of the sulfate ($SO_3$) as a function of the mass concentration.

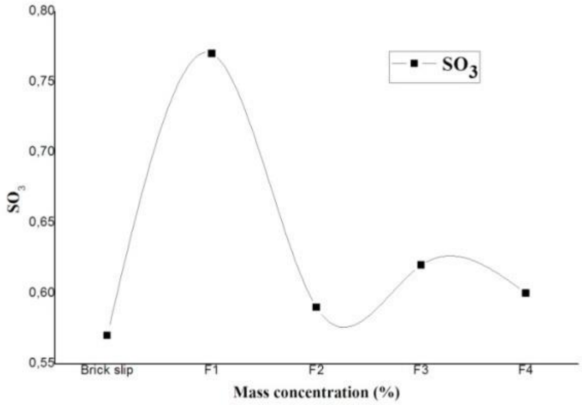


Fig. 9. Evolution of the alumina ($Al_2O_3$) as a function of the mass concentration.

The experimental results (Table 2) may be due to a distribution of the adsorption active sites on the surface of the solid material. The adsorption capacity, which corresponds to a maximum saturation of the clay monolayer brick of major elements in the blends of the brick slip , is higher for a 5% addition of marine sediments (F1) than for other formulations. Note that the alumina and sulfates follow the same variation as the yield stress, it is likely that these parameters have a direct effect on the yield stress.

## CONCLUSION

The rheological characterization shows that the valorization of 15% of marine sediments gives a threshold stress comparable with the threshold stress of the brick slip, whereas the threshold is higher for adding of 5% and 10% of sediments. The rheological parameters obtained show that these marine sediments can be valued up to 15%. The threshold stress drops for a value of 20% in sediments, so from this percentage the valorization becomes non-interesting. These sediments may be economic local materials.

Finally, it can be concluded that the bricks produced with marine sediments additions have satisfactory rheological properties. The prospect of this work is in order to see the relationship between the rheological study (Threshold stress) and the mechanical study (compressive strength).

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