INFLUENCE OF TEMPERATURE ON THE POROSITY GENERATED IN CLAY–PWTP SLUDGE BISCUITS

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1. ABSTRACT

This study was undertaken to determine how the porosity generated in biscuits made up of red clay and sludges from potable water treatment plants (PWTPs) varied when they were fired from 300 to 900 ºC. The clay involved produced a biscuit with good mechanical strength when fired at 900 ºC. However, incorporating the sludge raised porosity, decreasing the biscuit's mechanical properties and increasing water absorption. At 10% or higher sludge content, the material was no longer appropriate for use. The results showed that, in the unfired mixtures, the mechanical strength of the clay–sludge system was greater than that of the clay itself, this being kept up to 500 ºC, precisely when the organic matter was burned out, giving rise to porosity, which decreased mechanical strength.

2. INTRODUCTION

The incorporation of sludges from potable water treatment plants (PWTPs) to replace part of the raw materials used in manufacturing bricks or ceramic tile biscuits has been addressed in different studies. It is assumed that, during firing, the organic part of the sludge is eliminated, leaving the inorganic part (clays, quartzes, and rheological additives) to provide the relevant properties. However, it has been verified that although the inorganic part is incorporated during firing, the organic part gives rise to gases that form pores which are not removed during sintering, leading in particular to impaired mechanical properties. The thermal and acoustic properties can clearly exhibit improvement but this does not offset the poorer mechanical properties (1, 2).

PWTP sludges can be readily mixed with clays, when the sludges are dry. In contrast, when the sludges are wet, it is difficult to achieve good mixing because they do not allow appropriate dispersion. For the mixture to be suitable the sludge needs to be dry and as finely milled as possible. Then, on adding water to obtain a plastic material, both the clay and the sludge will absorb water but the dispersion will already have been achieved and the properties of the unfired material will not alter until it is fired. This study examines when the mechanical properties change.

3. EXPERIMENTAL

The clay used had a maximum working temperature of 1200 ºC and it had the following composition: 56% SiO_2, 17% Al_2O_3, 3% CaO, 4% K_2O, 1% Na_2O, 4% MgO, and 5% Fe_2O_3, with 10% weight loss at 1000 ºC. On the other hand, the PWTP sludge had 60% weight loss at 1000 ºC, after it had previously been dried at 100 ºC for 24 hours. Its average composition was 21% SiO_2, 68% Al_2O_3, 6% Fe_2O_3, 1% MnO, 0.1% Na_2O, 0.5% K_2O, 0.1% CaO, and 3% P_2O_5.

A mixture of clay and 6 wt% sludge was used. This was mixed with water (20%) and test pieces were obtained by compression. These were fired between 300 and 800 ºC and their compressive strength was measured. The raw materials were also characterised by thermal analysis (DTA).

4. RESULTS AND DISCUSSION

Figure 1 shows the evolution of the modulus of elasticity and of the modulus of rupture (MOR) under compression at different firing temperatures.

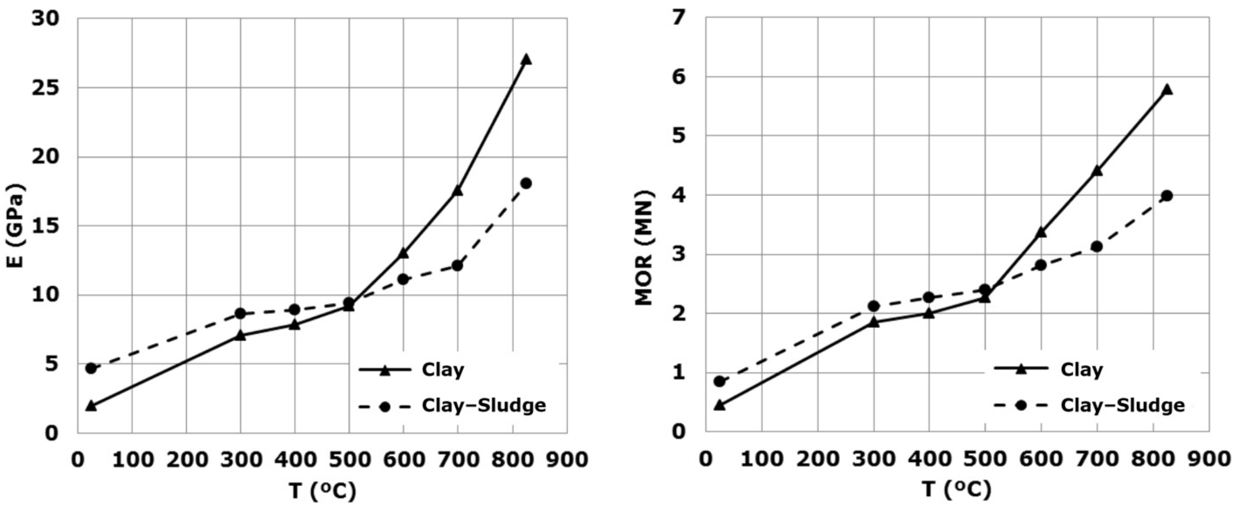

Figure 1. *(a) Modulus of elasticity and (b) MOR under compression of the fired pieces*

It may be observed that up to 500 ºC, the strength of the clay–sludge mixture was higher than that of the clay alone, as the organic matter (algae) in the sludge kept the particles together. However, from 600 ºC the situation was reversed owing to sludge organic matter burnout and the arsing porosity (3).

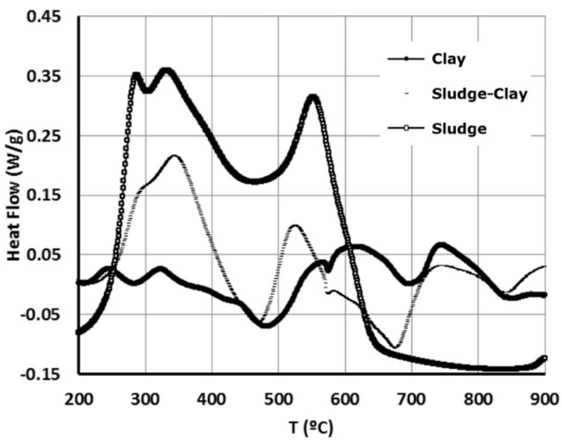

Figure 2. *DTA curves.*

Analysis of the DTA curves reveals that the sludge had two strong exothermic peaks; the clay had some weak endothermic peaks, and the mixture kept the exothermic peaks, though at 675 ºC there was quite a strong endothermic peak. The clay displayed exothermic peaks at 330 and 560 ºC, i.e. below the temperature at which the mechanical strength of the test piece was reversed. This indicates, as was to be expected, that while the organic matter in the sludge had not burned out the particles remained together (2).

The issue is therefore to try to modify the porosity generated in this first organic matter degradation step up to 600º and to try to add products that will fill up this porosity when the piece is fired at higher temperatures. This will be analysed in the next study.

5. CONCLUSIONS

The incorporation of sludge into clays to obtain construction materials leads to impaired mechanical properties under compression once the mixture has been fired. However, at low firing temperatures the mixture has greater mechanical strength owing to the presence of organic matter.

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