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Durable Structural Extruded Earth Masonry Units

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1 Introduction

The manufacturing process of fired clay bricks prior to firing is suitable, without any significant modification, for the production of unfired earth bricks. Morton (2006) demonstrated an 86% saving in embodied energy through not firing bricks but producing unfired earth masonry. Commercial extrusion allows for a greater control over quality and reduced unit costs compared to compressed earth blocks.

Heath et al. (2012) showed the structural potential for commercially extruded bricks to remain unfired. The loss of strength with increasing Moisture Content (MC) is identified as limiting the adoption of unfired earth bricks into the mainstream construction sector (Heath et al., 2012).

This paper discusses some methods of stabilisation that are suitable for modern extruded earth bricks. Since durability of the bricks is key to the adoption, an appropriate additive has been defined by in this study as one sufficient to maintain 1MPa compressive strength after 24 hours of full submersion. The mechanism used for the manufacture of geopolymers (Duxson et al., 2007) was investigated as a possible means of achieving the required durability.

2 Materials and Methods

2.1 Materials

A soil that is used for commercial fired extruded brick manufacture was used. The soil can be described as a dark brown sandy SILT with a plasticity classification of a low plasticity clay (BS5930:1999, 2010). The physical properties and particle grading was determined by the methodology provided by BS 1377-2:1990 (1998), with the mineralogical content of the soil determined by XRD, as shown in Table 1.

The principal additive used in the production of geopolymers is an alkali metal hydroxide. Sodium Hydroxide (NaOH) flakes with a purity of 98% were used. The solids were mixed with distilled water to make the required solution.

Table 1: Soil Properties

Properties	%
Physical Properties	
Liquid Limit	24
Plasticity Index	8
Linear Shrinkage	6
Particle Grading	
Sand	33
Silt	46
Clay	16
Mineral Content	
Siderite	2
Hematite	3
Smectite	3
Chlorite	6
Illite	16
Kaolinite	31
Quartz	39

2.2 Sample Preparation

The NaOH flakes were mixed with distilled water. This was allowed to cool and then added to the soil that was subsequently mixed for 10 minutes. The samples were manufactured immediately after mixing, using a laboratory scale extruder (Fig. 1) producing bricks measuring 72mm by 34mm by 22mm. This produces bricks with similar properties to full scale bricks (Fig. 2).

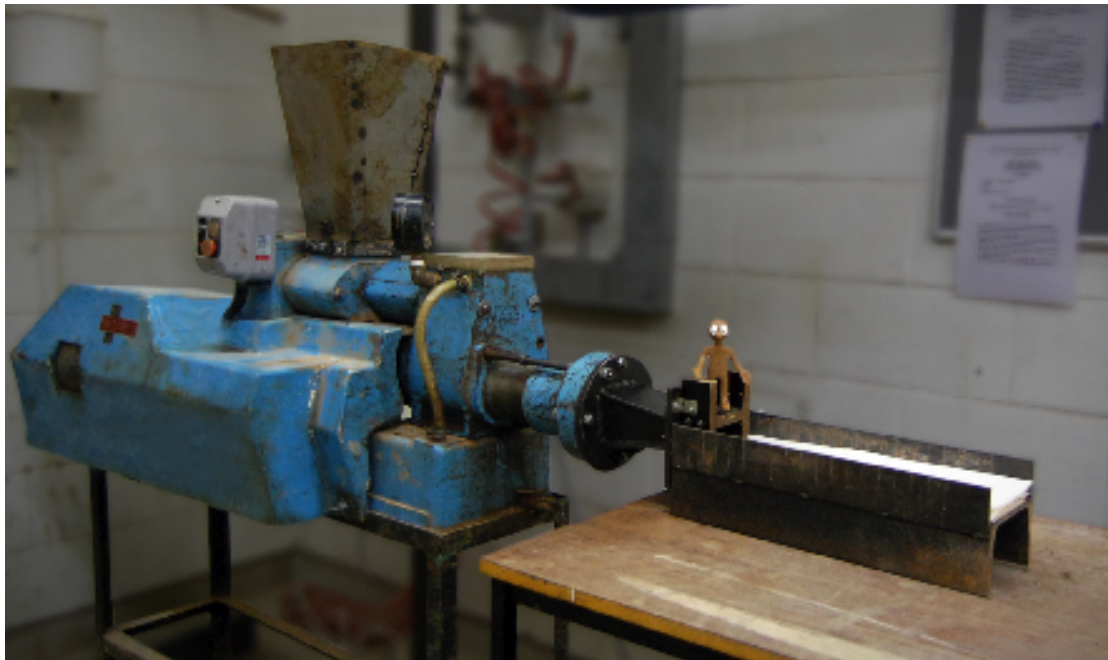


Fig. 1: Laboratory extruder



Fig. 2: Small scale brick specimens

All of the bricks were dried within the laboratory for two days, following that the drying procedure varied. Random samples of bricks continued to be dried in the laboratory environment (average of 21.5°C at 61% relative humidity) while the drying of other bricks was accelerated. One sample of bricks was artificially dried in an oven at 60°C with another sample dried at 105°C. Following two days within the ovens the specimens were removed and stored within the laboratory until testing. To investigate the development of strength through drying, bricks were tested at 7 14, and 28 days after extrusion.

Samples of the bricks will be tested dry and after 24 hours of submersion in water. Compressive strengths were measured by crushing specimens in their normal aspect without any capping. The peak load was measured with an applied constant displacement rate of 2.5mm/min. The results from six specimens were averaged for each testing method.

3 Results and Discussion

The results of the compression test are presented in Figs. 2 and 3. The unstabilised samples were extruded at a MC of 16% and resulted in a dry density of 1930kg/m³. The samples required more water to be extruded that resulted in an extrusion MC of 18% and produced specimens with a dry density of 1800 kg/m³.

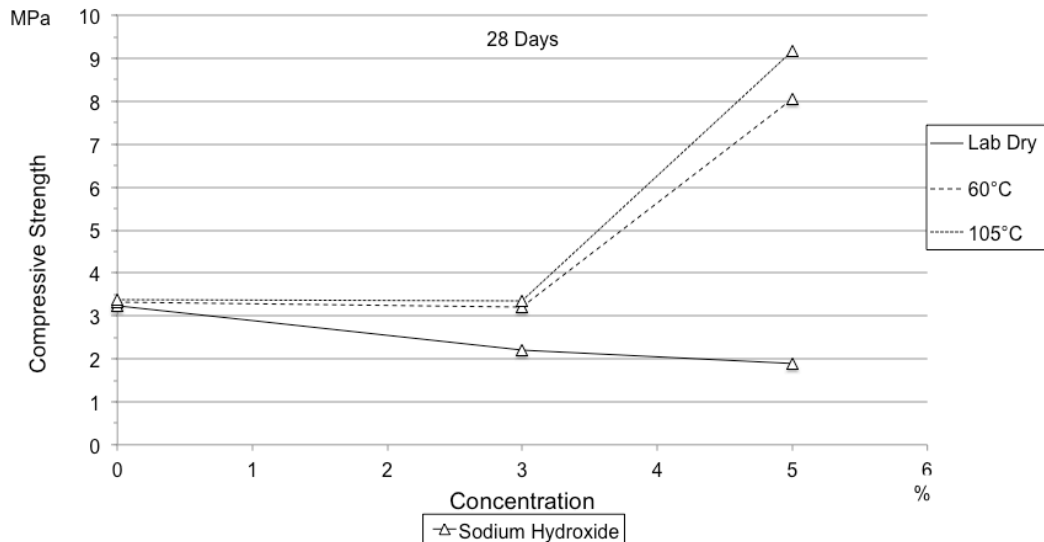


Fig. 3: Compressive Strength at 28 Days

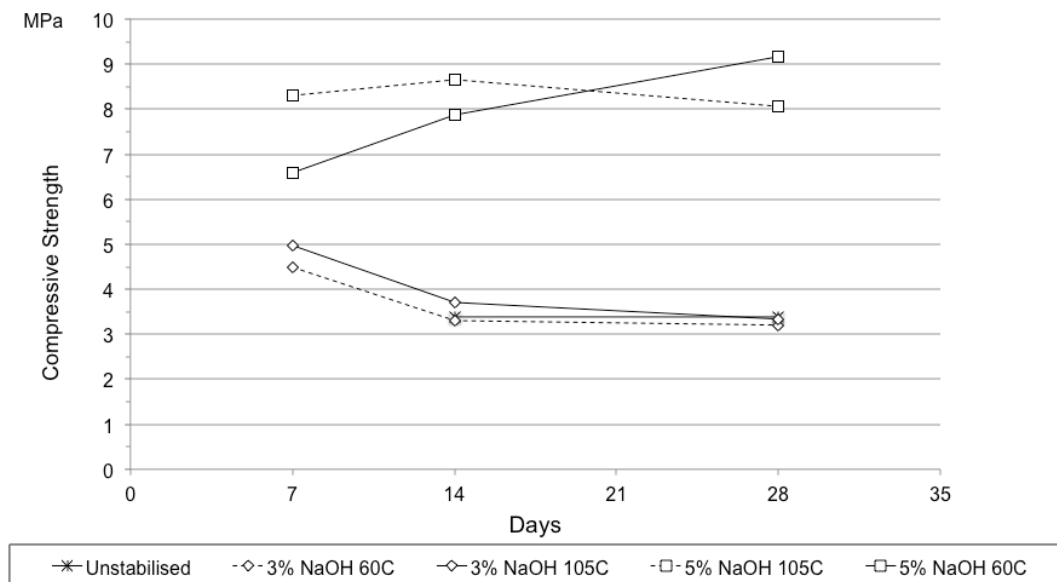


Fig. 4: Development of Strength for Specimens cured at 60°C and 105°C

The most significant factor with respect to strength gain is the concentration of the NaOH (Fig. 3). There is no increase in strength for 3% addition compared to the unstabilised samples. The strength gain due to the concentration is dependent on the temperature (Fig. 3), and therefore is not mutually exclusive of these independent variables. Strength gain is a result through only the interaction of the 5% NaOH and elevated temperatures (Fig. 4).

There is the similar relationship in strength gain for the bricks that were saturated prior to testing. Only the samples treated with 5% NaOH and cured at elevated temperatures were able to be tested. The other bricks disintegrated when fully submerged. The maximum compressive strength achieved was 0.5 MPa and was cured initially at 105°C and tested 28 days after extrusion. Although this is significant improvement in strength, it does not meet the 1MPa requirement.

4 Conclusions

Significant compressive strength gains can be achieved through the use of NaOH. This is dependent on the amount of NaOH as well as initial accelerated drying conditions; specifically using 5% NaOH and drying at a minimum of 60°C for two days. Otherwise it has been shown that the strength will decrease with increasing NaOH.

There is scope for further optimisation of the method of preparation. The amount of additive, temperature and curing length can be varied to investigate the potential lower bound of the variable.

The greatest saturated compressive strength was 0.5MPa. This is insufficient to allow for the structural use of unfired earth masonry. Further optimisation should focus on improvement of durability and saturated compressive strength.

5 References

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