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Research paper

Development of expandability charts for Ankara Kalecik Clay

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ABSTRACT

The main aim of this study is to establish optimum working conditions and to propose expandability charts for Kalecik Clay using expansion ratio versus unit volume weight values via a statistical computer program (Design Expert 7.0). First of all, some suitable samples were collected from the Kalecik County (Ankara, Turkey). Later, the samples were crushed and milled up to 200 μm clay size in the laboratory. Then, pellets with a 10 mm diameter were dried in ovens and heated inside a furnace to expand in different temperatures. One heating operation began with 900 °C and ended with 1200 °C. In addition to that, the holding time periods were selected as 5, 10, 15 or 20 min for each operation. In the final stage, the unit volume weight and expansion ratio of the produced aggregates were determined.

As results of this study, both the optimum furnace holding time and furnace temperature values for the samples were determined in order to maximize the expansion ratio values and minimize the unit volume weight for Kalecik Clays. Some expandability charts were proposed for Kalecik Clay by using the findings.

The charts allow one to assign expansion ratio and unit volume weight values in different working conditions including holding time inside the furnace and furnace temperature. The proposed charts are expected to be quite useful for more efficient production of expanded clay aggregates in construction industry.

1. Introduction

Lightweight aggregates are defined as natural or artificial materials, which are granular, porous and lightweight (Cougny, 1990). They can originate from different natural sources such as volcanic rocks (pumice, volcanic tuffs), sedimentary rocks (clayey diatomite) and metamorphic rocks (claystones, slates, shales), and from waste material or industrial by-products such as recycled flat glass and fly ash (Fakhfakh et. al., 2007).

The lightweight aggregates are used as a loose material — for example in back wall fillers and in agronomic applications — or, with a binder, in the manufacture of plaster, asphalt and lightweight concrete thermo-acoustic insulators, as well as in lightweight structural concrete production. Lightweight expanded aggregates can be formed by a quick heating at high temperature of some rocks which are able to bloat. The raw material must contain substances that develop gas upon heating and, at the same time, the material must transform into a highly viscous plastic mass able to expand by virtue of gas entrapment (de Gennaro et. al, 2007).

There are a lot of studies about the production of expanded clay aggregates (Decleer and Viaene, 1993; Bragdon, 1996; Fragoulis et. al., 2004; Pioro and Pioro, 2004; Rattanachan and Lorprayoon, 2005; Fakhfakh et. al., 2007; de Gennaro et. al, 2007; Ozguven, 2009; Bartolini et al, 2010).

As can be seen from the literature, there are some important studies on the parameters, taken one by one, affecting the expansion of the clays for producing lightweight expanded clay aggregates. However, so far no study has been carried out to investigate the combined influence of working parameters (holding time in the furnace and furnace temperature) on expansion efficiency parameters, jointly expansion ratio and unit volume weight, to determine the optimum working conditions and also to develop the expandability charts with expansion ratio and unit volume weight. For this reason, the purpose of this study is to determine the optimum working conditions and also to develop expandability charts for Kalecik Clay with respect to expansion ratio and unit volume weight by using a special statistical program (Design Expert 7.0) providing the factorial design of the experiment which is very important in the optimization of the experimental results.

2. Material and method

The methodology of this study is composed of four steps.

1 Sampling and preparation of the samples
2 Sampling of clay in a constant pellet size of 10 mm and clay grain size of 200 μm.
3 Expansion tests
4 Statistical assessment of the test results

Considering these four steps, the expansion operation methodology and the work followed in this study are given in detail in Fig. 1.

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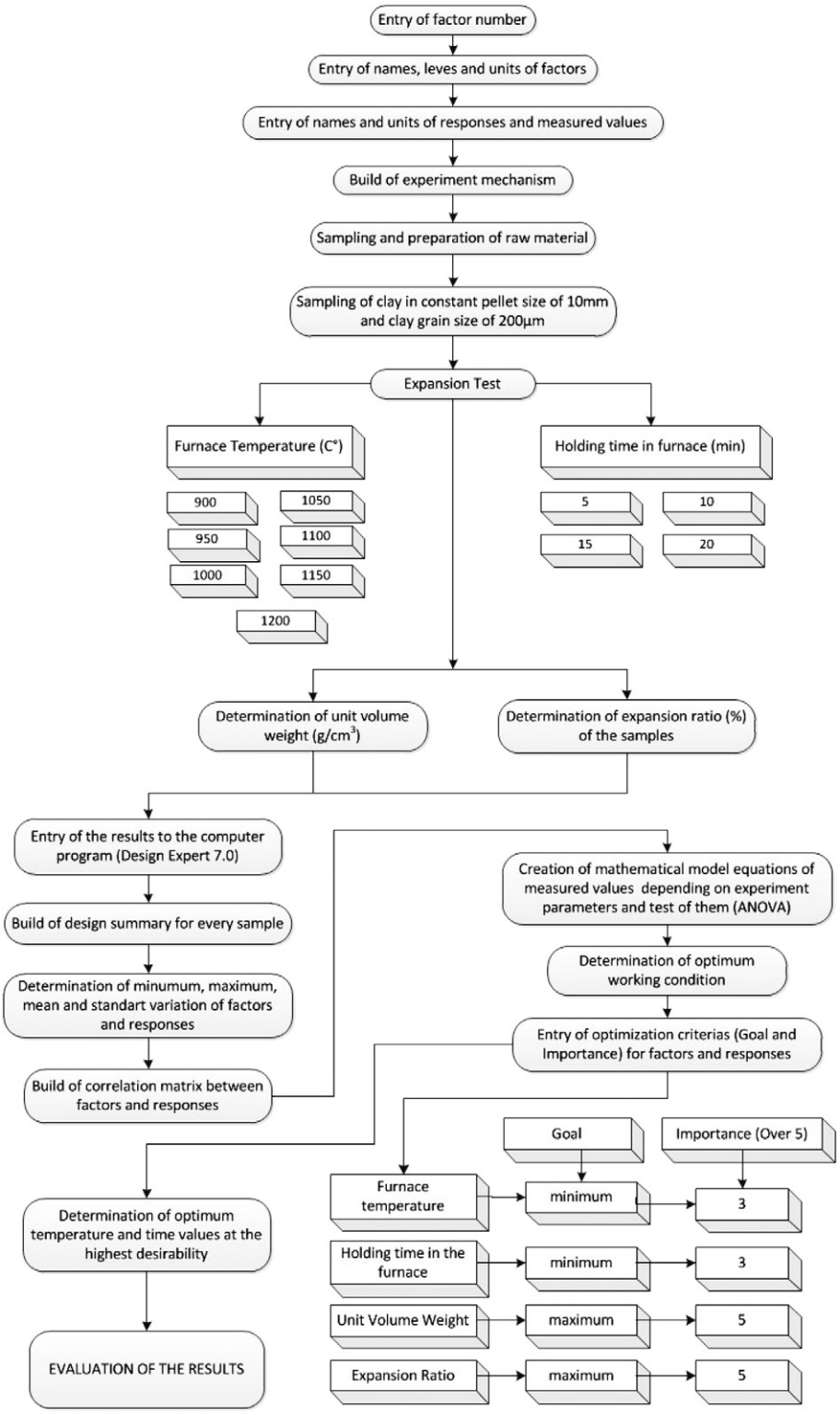

Fig. 1. Methodology followed in this study.

The studies were conducted in clays taken from the Ankara City's Kalecik County. From a geological point of view, of the expanding clay fields under study, the Ankara Kalecik field has a grayish metallic luster, while it is seen as dark gray-black when wet. Secondary calcite was developed in some places. It has sandstone-shale alteration with a schist-like view behind limestone lenses. This unit is overlain by grayish-gray color sandstone-shale faces. It is a unit exposed in macro-scale achieving 100 m from place to place along approximately a 1-km path in the form of 25–30 m lenses along the north–south direction.

X-ray diffraction pattern belonging to the samples obtained from the field under study is given in Fig. 2 and the result from the X-ray diffraction analysis is seen in Table 1.

Chemical analysis (Table 2) showed that the main constituents of the raw materials are silica, alumina, and iron oxides. Na_2O and K_2O contents are mainly attributed to the clay minerals and feldspars.