Design Data for a Brick Manufacturing Plant

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Abstract: This paper presents results of compression resistance measurements of common construction bricks manufactured in México. Pre-formed and dried bricks, obtained from three local manufacturers, were fired in a controlled temperature furnace. Thus, effects of brick's composition and firing temperature and time were investigated. On these basis, comments are given regarding the fulfillment of resistance requirements of Mexican norms.

Introduction: Almost 100% of construction bricks employed to build houses in Mexico are fabricated from a mixture of clay and some organic materials in hand crafted kilns. Mixture compositions vary from kiln to kiln and are obtained by a trial and error procedure by kiln owners. Bricks are fired in batches, under very poorly controlled conditions, and for periods of time set by owners experience. This causes a great variation in brick's quality and failure to fulfill construction norms set by various government agencies. The poor development of this industry in Mexico has precluded the generation of technical information regarding the basic process, and this project started as an effort to alleviate this problem.

Experimental Procedures: The first step undertaken to meet the objective was to obtain some preliminary data by measuring product properties and process conditions of a typical manufacturing plant. The main property of bricks is their compression resistance, which was measured in a universal testing machine. With this information as a basis, the effect of mixture composition, time and firing temperature on brick resistance were investigated. Sample's resistance was measured after firing in a temperature controlled furnace for specified time periods. Samples, pre-formed and dried but unfired bricks, were obtained from three manufacturers, in order to evaluate brick's composition effects.

Since the field measured furnace temperatures were about 1100 °C, and this value may be regarded as the maximum possible temperature for the bricks under process, temperatures of 1000 °C, 900 °C and 800 °C, were used in the investigation. Although the whole process lasts about 24 hours, the observed evolution of furnace temperatures suggested that the time in which the bricks are subjected to high temperatures is not very large. This was corroborated by a few preliminary tests which showed that bricks resistance reaches its final value in about two hours. On these basis, resistance tests were performed on specimens maintained at each temperature level for time periods of: 20, 45, 70, 95 and 120 minutes.

Results and Discussion: Analysis of data about brick's resistance and typical process conditions proved that, as expected, there are important effects of temperature and firing time. These were in evidence by a marked difference in brick's resistance with position with respect to kiln furnace in both lateral and upwards directions, with maximum values for bricks located near the center and at the bottom of the kiln proper. Since the furnace is located under and at approximately the center of the kiln, edge bricks are at a lower temperature, while bricks at the upper region of the kiln are burned for shorter periods of time. Although measurements were taken in a single manufacturing facility, results may be regarded as typical, since variations among facilities are relatively few and unimportant for the process.

Brick's resistance of test specimens fired under controlled conditions are shown in Figures 1 and 2. Resistance is presented as a function of time of firing for each of the three set temperature levels. Each figure corresponds to samples from one of the selected manufacturers.

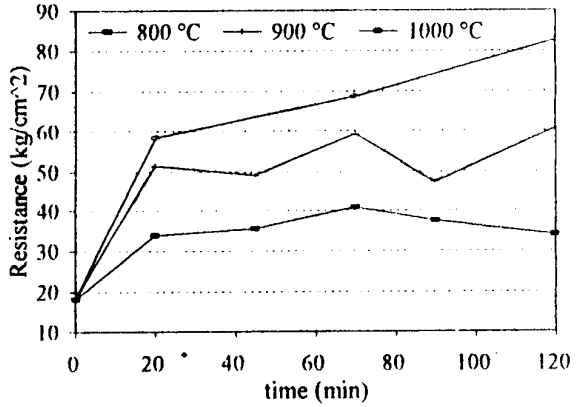

Figure 1. Resistance of Sample 1

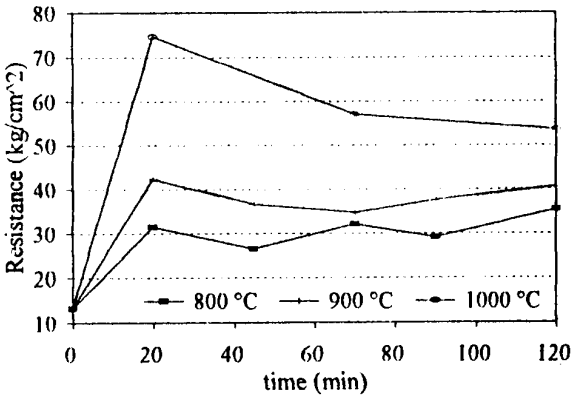

Figure 2.- Resistance of Sample 3

The first noteworthy fact is that sample two results are not given, because the product was to brittle and handling procedures render them unusable. Since treatments were the same, the only difference among samples which could explain these fact was soil composition. According to ASTM Standard D2487, soils were found to be almost equal, and classified at the border line between ML and CL types. However, they had different amounts of added organic material in the form of wood shavings. The soil with the minimum amount of organic material produced the unusable bricks.

The most stringent norms in México set three levels of brick quality, A, B and C, and demand their compression resistance to be 70, 60 and 50 kg/cm^2 respectively. Evaluation of the brick's resistance of figures 1 and 2 shows that, at the lowest temperature, the minimum resistance set by the norms is not met by either of the samples at any of the firing times. At the medium temperature, it can be seen that sample one barely reaches the minimum value of resistance required by the norm, and that sample two does not. It is also noticeable that firing time increments will not aid to raise brick's resistance, since for both of the lower temperatures the curves flatten out after the first 20 minutes. Finally, the highest quality set by the norm was met by both samples at the maximum tested firing temperature, with times particular to each sample. It should be noted that sample three shows a drop in resistance when fired for more than 20 minutes, while the resistance of sample one continues to increase with time. Although the mechanisms of interaction of organic matter in brick's composition have not yet been found, they are probably the cause of differences, since the amount of added organic matter was larger for sample one that for sample three.

Conclusions and Future Work: Tests of brick's resistance, as produced by varying firing conditions, showed that a temperature above 900 °C is required to meet values set by Mexican norms. Results also lead to the conclusion that firing times do not need to be very large but, since firing time and temperature were carefully controlled, measures should be taken to ensure kiln loads attain the prescribed conditions. To be able to design a kiln which works in these conditions information about heat transfer and pressure drop coefficients occurring between hot gases and bricks is essential, and subject of the continuing efforts of this project. In view of the effect of organic matter on brick's resistance, there are also plans to pursue investigations in this regard.

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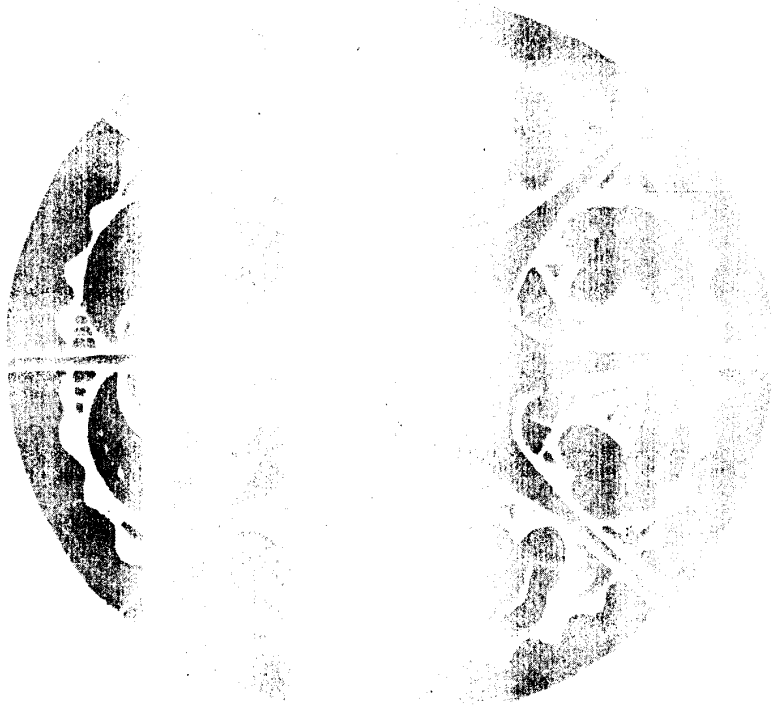
PROCEEDINGS



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