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Assessment of some locally produced Egyptian ceramic wall tiles

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KEYWORDS

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Abstract Due to the fact that there are various types of wall tiles in the Egyptian market, of different qualities and prices, the aim of this research paper is to evaluate the properties and characteristics of tiles obtained from the local Egyptian market and attempt to identify the reasons for such differences. In other words, investigate the reasons why some tiles are more superior in quality than others. Test specimens were obtained from the local Egyptian market for fourteen factories. The mechanical properties (namely flexural strength) and physical properties (namely water absorption and apparent porosity) were measured, as they reflect the strength, the endurance during handling, as well as, the conditions to which the tiles are expected to be exposed to during use. The impact resistance and hardness were tested as well. Also, the phases (both major and minor) developed during the firing (maturing) step of manufacturing were identified. A correlation was made between the measured properties and the formed phases. The results showed that samples which yielded high physical and mechanical properties are those that constituted mainly the major phases, specifically, mullite and quartz, while those that contained impurities in the raw materials inevitably resulted in the development of minor phases, in addition to the major phases, had a negative effect on the measured properties. Consequently, it is feasible to obtain tiles that satisfy the requirements of ISO 13006 specification provided that the used raw materials are free (as much as possible) from impurities such as hematite, magnesium, and calcium.

Introduction

Many sources independently verify that the actual known history of clay-based tiles (and the known usage of wall and floor coverings) can be traced back as far as the fourth millennium BC (4000 BC) to Egypt.

Ceramic tiles are primarily hygiene products as this is evident from their varied usage from bathrooms, kitchens, to medical centers, labs, schools, public conveniences, and shopping malls [1]. Ceramic tiles (floor and wall) have proved to be one of the very fast growing heavy clay-based industries in the last three decades in Egypt. The experience and technological skills acquired during these decades encouraged several investors and manufacturers to enter this industry. The increasing and continuous demands, either locally or internationally, inspired several businessmen to lay down more investments

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Table 1 Summary of test results of water absorption, apparent porosity, apparent relative density and bulk density.

Factories	Absorption (%)	Apparent porosity (%)	Apparent relative density	Bulk density (gm/cm^3)
1	9.56	18.99	2.46	1.99
2	9.47	18.19	2.35	1.92
3	11.0	20.75	2.38	1.89
4	9.39	17.20	2.23	1.84
5	11.85	22.03	2.39	1.86
6	13.08	24.29	2.45	1.86
7	11.81	22.0	2.39	1.86
8	11.24	21.05	2.37	1.87
9	9.91	18.07	2.30	1.87
10	12.30	22.79	2.40	1.85
11	11.46	21.33	2.37	1.86
12	15.75	27.50	2.41	1.75
13	11.17	20.73	2.34	1.86
14	11.11	20.72	2.35	1.86

to establish ceramic tile factories. It is not expected now to find any of the newly founded towns in Egypt (and sometimes old ones) that do not encompass one of these factories. The greatest progress in the manufacturing of ceramic tiles was made in Africa, specifically the north of the continent, where production increased most notably in Egypt and Morocco. Egypt has doubled its manufacturing output in the last five years, reaching 200 million square meters in 2009. Egypt produces, consumes, and exports more tiles than any other African country. Use of tiles in Africa is concentrated in four countries; Egypt, Morocco, South Africa, and Algeria. Egypt, alone, is responsible for 38 percent of Africa's tile consumption with 180 million square meters of product purchased there in 2009. Also, Egypt is Africa's major exporter as it exported 23 million square meters in 2009 [2]. One of the major motivations of ceramic production in Egypt is the availability of the raw materials, as well as their low cost which results in making production of ceramic tiles a highly profitable business. The terms pottery, whitewares or triaxial ceramics include not only domestic tableware, but also wall and floor tiles, sanitary ware and electrical porcelain. The raw materials used in the pottery industry are mainly clays (backbone of ceramics), fillers (usually quartz sand), and fluxes (feldspars).

Clay supplies the workability of the green ceramic mixtures which simplifies the manufacture of clayware and also accounts for the dry strength of the unfired article and consequently assists in reducing handling losses. The properties of any particular clay are dependent on a number of factors including the type and amount of the used clay mineral, the particle size and size distribution of the clay and the other minerals present in the raw mineral mixture. The most important clay mineral for potters is Kaolinite which is seen by the electron microscope to crystallize into minute hexagonal plates. The ease with which these platey particles can slide over one another, particularly when lubricated with water, accounts for the plasticity, and the closeness with which they can pack accounting largely for the dry strength.

Fillers usually have a high melting temperature and are chemically resistant inorganic materials whose main function is to reduce the ceramic body's tendency to warp or distort when fired to temperatures which result in the formation of relatively large amounts of molten glass in the body. They also play an important role in determining the thermal expansion of the fired ceramic body. Free silica in the form of quartz, is by far the most common filler used in whitewares. In most sands and sandstones, quartz is the predominant mineral. However, many sand stones contain iron compounds that affect the color of the product. Most of the iron oxide associated with sand is present as a thin film covering each individual grain. It is possible to remove the bulk of this impurity by acid treatment, but this will increase the cost of the product.

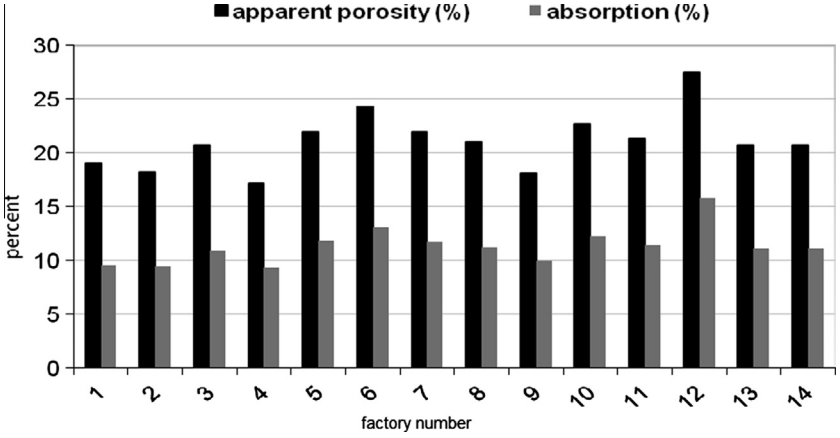

Fig. 1 Comparison between absorption and apparent porosity of factories for ceramic walls.