CHAPTER 1

INTRODUCTION

1.1 General

Brick is one of the most important construction elements. For thousands of years, bricks have been made from clay. The history of brick manufacturing goes back 8000 years when the fabrication of the earliest sun dried clay bricks was discovered. The water treatment plant sludge is extremely close to brick clay in chemical composition. So, the sludge could be a potential substitute for brick clay. The water treatment plant sludge is generated from the treatment of water with alum, as a coagulant, during the production of drinking water. The process generates a sludge that must be disposed of in an environmentally sound manner. The sludge generated in nearly all of the treatment systems around the world is discharged into the nearest watercourse, lagoon, town sewerage systems, or it is ultimately disposed in a landfill. The discharging of sludge into watercourses leads to accumulative rise of aluminum concentrations in water, aquatic organisms, and human bodies. Some researchers have linked aluminum's contributory influence to occurrence of Alzheimer's disease and children Mental Retardation. The disposal of alum sludge in a landfill results in the loss of a valuable asset, which is the alum, and at the same time depletes the capacity of the landfill. The dewatering and disposal of alum sludge adds significantly to the cost of treating water. Alum recovery and reuse could reduce those costs. Recovering and reusing the alum, at the drinking and sewage treatment plants, may reduce both raw material and disposal costs if the needed technology is available. However, this recovered alum, if reused as a coagulant, has a trihalomethane formation potential during chlorination stage of water treatment, because of the additional quantity of algae that contained in the reused sludge. The trihalomethanes are suspected carcinogens. Among all that options, the use of sludge in manufacturing of constructional elements is considered to be the most economic and environmentally sound option. There are many industrial and agricultural wastes, which are amorphous and contain high silica content, might be incorporated with water treatment plant sludge in brick manufacturing. These industrial and agricultural wastes usually have some serious negative environmental impacts and need to be disposed of in an environmentally sound manner. Some of these waste materials are silica fume and rice husk ash. So, this trend also provides an environmentally sound manner to reuse some of the agricultural and industrial wastes, such as rice husk ash (RHA) and silica fume (SF).

1.2 Scope of the Study

This study provided serious trials to produce bricks from water treatment plant sludge incorporated with two of the hazardous waste materials as a modern way for sludge reuse. Because of the similar mineralogical composition of clay and water treatment plant sludge, this study focused on the use of sludge in clay-brick making. The study investigated the complete substitution of brick clay with sludge incorporated with silica fume and/or rice husk ash as high silica waste materials. This trend was adopted to approach the maximum allowable proportion of water treatment plant sludge to be used in the brick sinter. The sludge samples used in the study were taken from Giza Water Treatment Plant, Giza Governorate, Greater Cairo, whereas the used clay samples were brought from a local brick factory at Imbabah, Giza Governorate, Greater Cairo. On the other hand, the rice husks used in this study was obtained from a local rice thresher at El-Qanater, Kalyobya Governorate, Greater Cairo. The silica fume (SF) used in this study was the commercially available silica fume in the Egyptian market, which is produced as a by product of producing silicon metal or ferrosilicon alloys in smelters using electric arc furnaces. At first, the performed trials involved the preparation of a lab scale brick-production unit and the manufacturing of 100% clay brick to be used as a comparative control brick type, produced under the same circumstances of the experiment. The produced clay brick were fired at 900, 1000, 1100, and 1200^{o}C, which were the selected temperatures for the research. The study then investigated the complete substitution of brick clay by water treatment plant sludge incorporated with silica fume (SF). In this trend, three different series of sludge to silica fume proportioning ratios were tried, which exclusively involved the addition of sludge with ratios 25, 50, and 75 % of the total weight of sludge-silica fume (SF) mixture. Each series involved the firing of bricks at 900, 1000, 1100, and 1200 ^{o}C, giving 12 different brick types. In the subsequent stage, the incorporation of sludge with rice husk ash (RHA) in brick manufacturing was investigated. Three different series of sludge to rice husk ash (RHA) proportions were tried, which involved the addition of sludge with ratios 25, 50, and 75 % of the total weight of sludge- rice husk ash (RHA) mixture. Each series involved the firing of bricks at the same temperatures (900, 1000, 1100, and 1200 ^oC), giving another 12 different brick types. In the last stage of the experimental program, the incorporation of water treatment plant sludge with both silica fume and rice husk ash was investigated. As in the last two stages, three different series of sludge to silica fume (SF) to rice husk ash (RHA) proportions were tried, which were (25: 50: 25 %), (50: 25: 25 %), and (25: 25: 50 %), respectively, giving more 12 different brick types. The properties of the produced 36 brick types were then evaluated according to E.S.S. The evaluation procedure was based on evaluating the basic physical and mechanical properties of the manufactured brick, which are water absorption, initial rate of suction, apparent specific gravity, apparent porosity, loss on ignition, firing shrinkage, moist air expansion, efflorescence, and compressive strength. The test results were evaluated according to **E.S.S. No. 1524/ 1993** for specifications of normal clay brick, unless the test method itself is not specified in the Egyptian Standard Specifications. The results was then compared to that of the 100% clay research brick and two of the commercial clay brick types available in the Egyptian market. A main conclusion was then provided to use the water treatment plant sludge, silica fume, and rice husk ash in brick manufacturing. Finally, recommendations were given for further research.

1.3 Outline of the Thesis

A review of literature is presented in Chapter 2. The review was more concerned with summarizing the modern procedures of surface water treatment and the water treatment plant sludge sources. Interest was largely directed to the water treatment plant sludge management options, especially the use of sludge in brick manufacturing. Also, great scrutiny was directed to the management and reusing options of silica fume (SF) and rice husk ash (RHA).

In Chapter 3, the program of study is presented. The analysis of the used materials, materials gathering, and materials preparation methods are described.

In Chapter 4, steps of developing the manufacturing procedures and methods of testing the final product are presented. The proportions of the different manufactured brick types were also outlined.

To evaluate the performance of the produced brick types, the physical and mechanical properties of the brick samples were determined and discussed. Chapter 5 presents the results of these tests, the evaluation criteria and the product behavior charts. In this chapter, the results of the performed experiments were discussed and demonstrated.

The overall conclusions of the study were abstracted in chapter 6, and the optimum recommended sludge, silica fume, and rice husk ash ratios to be used in brick making were also outlined. Recommendations for further research to achieve more utilization of water treatment plant sludge were also proposed.