Using of Cement Kiln Dust in the Production of Interlocking Paving Units

By
Eng. Ahmed Mohamed Ali Abo Elela

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
Structural Engineering

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Title of Thesis: Using of Cement Kiln Dust in the Production of Interlocking Paving Units

(**Key words:** Cement kiln dust, Interlocking Paving Units, Strength, Durability)

Summary:

The aim of this thesis is to study the effect of using (CKD) in the production of interlocking paving units as a partial replacement by up to 60% of cement weight or addition to cement by 20% of cement weight in order to reduce the output of these dust pollution methods for safe disposal instead of burial and also reduce the amount of cement used in the manufacture of these units. The physical and mechanical properties and durability of paving units were determined and compared with the standard specifications for up to 12 months.

Acknowledgments

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Abstract

A large amount of cement kiln dust (CKD) as a solids waste are generated in Egypt from cement industry because of using the dry process in the majority of cement plants. The amount of theses waste is about 3 million tons per year according to ministry of environmental. This accumulation of large quantities of cement kiln dust (that contains a high percentage of chlorides) leads to companies, human health problems and environmental problems.

Some researches have been carried out to study the possibility of using or reusing cement kiln dust in different applications, including its use as a filler in asphalt mixtures, in concrete mixes, as soil improvement material, ……etc.

This thesis aims to study the possibility of using cement kiln dust (CKD) as a partial replacement of cement at 10%, 20%, 40% and 60% of cement weight or as an addition to cement at 20% by weight of cement in the production of interlocking paving units. The physical, mechanical and durability properties of the produced paving units were determined and compared with the control mix without CKD. The physical properties included water absorption, abrasion resistance, and skid resistance, while the mechanical properties included compressive strength. Durability of paving units was determined by exposing paving units to wet-dry cycles, 1% HCl, and 3% HCl for 11 months and compare the results with those for specimens left in air. Tests result indicates that CKD could be used to replace up to 60% of cement in the manufacturing of paving units.

Chapter 1: Introduction

1.1 General

Cement industry grew up in Egypt in the last thirty years. Since 1975 up to new, the number of factories increased from four to twenty-three factories with capacity of 53 million tons per year. Harmful emissions are generated from cement plants with varied quantities, composition and hazard due to differences in the production process and the nature of work in the plant. As a result of using the dry process instead of the wet process, significant amount of cement kiln dust (CKD) is generated causing health, environmental and economical problems.

In Egypt, the total amount of cement kiln dust (CKD) produced by the dry production lines is over 3000 tons per day generated in Greater Cairo only. From the health point of view, even in the 21st century, millions of people are working daily in a dusty environment. They are exposed to different types of health hazards such as fume, gases and dust, which are risk factors in developing occupational disease. Cement kiln dust causes lung function impairment, chronic obstructive lung disease, restrictive lung disease, pneumoconiosis and carcinoma of the lungs, stomach and colon. Recent studies have shown that cement kiln dust may enter into the systemic circulation and thereby reaches the essentially all the organs of body and affects the different tissues including heart, liver, spleen, bone, muscles and hair and ultimately affecting their microstructure and physiological performance. From the economical point of view, CKD costs hundreds of millions of pounds in order to be disposed in healthy and safe way. Moreover, these residues are buried in large areas surrounding cement factories. This negatively affects the soil and its salinity. The only solution to overcome CKD disposal problem is the recycling and reusing of CKD. This thesis was carried out study the feasibility of using CKD in the production of interlocking paving units.

1.2 Scope and Objectives of the Thesis

This study aims to investigate the effect of using high percentages of cement kiln dust up to 60% as a partial replacement of portland cement, as well as adding 20% of cement kiln dust to cement in the production of interlocking paving units. The physical, mechanical and durability tests were carried out on the manufactured paving units and results were compared with the relevant standards to investigate the possibility of using this waste in the Egyption market. **The main objectives of this thesis can be outlined as follows:**

1- The conversion of CKD from being a waste material to a value added product.
2- Protecting the environment from pollution generated from the disposal of cement kiln dust.
3- Saving dump-sites used for disposing cement kiln dust.
4- Conservation of cement by recycling of cement kiln dust as a partial replacement of cement, and hence, the conservation of natural resources and energy used in cement production.

1.3 Thesis Outline

The thesis consists of 5 chapters summarized as follows:

Chapter (1): This chapter includes a general introduction, scope, objectives and outline of the thesis.

Chapter (2): This chapter contains a literature review, which provides a presentation of cement industry and its environmental impact. In addition, the impact of the cement kiln dust on the surrounding environment, its applications in various fields and its effects on the properties of cementation materials will be presented.

Chapter (3): Includes the experimental program, which provides a presentation of the experimental procedure, material characterization, mixes design, mixing procedure, and testing methods.

Chapter (4): This chapter includes a presentation of the obtained results from the experimental work and discussion of these results.

Chapter (5): This chapter presents the conclusions drawn from the experimental study as well as recommendations for area needed researches in future works.

Chapter 2: Literature Review

2.1 General

Cement is the most commonly used material in the construction field. Therefore, cement production has been increased in recent years. Cement industry is involved in the construction industry because it is the basic ingredient of concrete used in constructing modern edifices and structures. Cement is the material which has a property of coherence and contiguity, and has the ability to bind rock particles (aggregates) and building materials to form integrated mass.

Portland cement (PC) is a hydraulic cement that hardens in water to form a water-resistant compound. The name portland cement comes from the fact that the color and quality of the resulting concrete are similar to portland stone, a kind of limestone found in England. Portland cement is a fine powder, gray or white in color, which consists primarily of a mixture of calcium silicates, aluminates and aluminoferrites. More than 30 raw materials are known to be used in the manufacturing of portland cement, and these materials can be divided into two classes: calcareous (limestone, chalk or marl) and argillaceous (clay or shale). Portland cement consist of different types of lime, silica, alumina and iron oxide with varying proportions [1]. These materials are combined through pyroprocessing and subjected to subsequent mechanical processing operations to form portland cement. Portland cement manufacturing plants are part of hydraulic cement manufacturing, which also includes natural, masonry, and pozzolanic cement.

2.2 Manufacture of Portland Cement

The raw materials required for manufacturing of portland cement are calcareous materials such as limestone, chalk and clay materials such as clay or shale. The process of cement manufacturing consists of grinding the raw materials, mixing them in certain proportions depending upon their purity, and burning them in a kiln at a temperature of about 1250 to 1450°C. These materials sinters and partially fused to form clinker which is subsequently cooled and ground to fine powder with addition of about 3 to 5% of gypsum to form portland cement [2]. Figure (2-1) illustrates the process of cement production. In general, there are two main processes for cement manufacturing; wet process and dry process.

2.2.1 Dry process

In this method, the raw materials are crushed and ground in their dry state. The raw materials are crushed and fed into a grinding mill, where they are dried and reduced in size to a fine powder. The dry powder “raw meal” is then pumped to a blending silo and adjustment is made in the proportions of the materials required for the manufacture of cement. To obtain a uniform mixture, the raw meal is blended in the silo usually by means of compressed air. The blended meal is sieved and fed into a rotating dish called granulator**.** Water weighing about 12% of the meal is being added at the same time [3].