
# PRODUCTION OF GREEN BRICKS FROM CONSTRUCTION AND DEMOLITION WASTE (WITHOUT FIRING)

By

**ASMAA NABIL AL MAMLOUK**

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

**Mining Engineering**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

Prof. Dr. Hassan Fahmy Imam

.....

Professor of Rock mechanic engineering
Mining and Petroleum Department
Faculty of Engineering, Cairo University

Dr. Ayman El Midany

.....

Assistant Professor
Mining and Petroleum Department
Faculty of Engineering, Cairo University

Dr. Shakinaz Ali El Sherbiny

.....

Assistant Professor
Chemical Department
Faculty of Engineering, Cairo University

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Approved by the
Examining Committee

_____

Prof. Dr. Hassan Fahmi Imam — Thesis Main Advisor
Mining, Petroleum and Metallurgy Department
Faculty of Engineering, Cairo University

_____

Dr. Ayman Abd Elhameed Midany — Supervisor
Mining, Petroleum and Metallurgy Department
Faculty of Engineering, Cairo University

_____

Dr. Shakinaz Ali El Sherbiny — Supervisor
Chemical Engineering Department
Faculty of Engineering, Cairo University

_____

Prof. Dr. Yehia Saad Eldin Mohamed — Internal Examiner
Mining, Petroleum and Metallurgy Department
Faculty of Engineering, Cairo University

_____

Prof. Dr. Mohamed Ibrahim Sayed Ahmed — External Examiner
Prof . , National Research Centre

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT

2016

**Engineer's Name:** Asmaa Nabil Al Mmlouk
**Date of Birth:** 2/6/1981
**Nationality:** Egyptian
**E-mail:** Asmaalmamlouk@hotmail.com
**Phone:** 0100-5713392
**Address:** 285a Hadaek Al Ahram, Giza

**Registration Date:** 1/10/2012
**Awarding Date:** …./…./2016
**Degree:** Master of Science
**Department:** Mining and Petroleum and Metallurgy Engineering

**Supervisors:**
Prof. Hassan Fahmy Imam
Prof. Ayman El Midany
Dr. Shakinaz Ali El Sherbiny

**Examiners:**
Porf. Hassan Fahmi Imam (main advisor)
Dr. Ayman Abd Elhameed Midany (co-advisor)
Dr. Shakinaz Ali El Sherbiny (co-advisor)
Prof. Yehia Saad Eldin Mohamed (Internal examiner)
Prof. Mohamed Ibrahim Sayed (External examiner)
Prof., Nationl Research Centre

**Title of Thesis:**

Production of Green Bricks from Construction and Demolition Waste (without firing)

**Key Words:**
Construction and demolition waste (C&D)

**Summary:**

This thesis is devoted to utilize the construction and demolition(C&D) waste for producing low-cost non-bearing green bricks (without firing). To achieve that goal, C&D will be mixed with various ratios of additives to the optimum mix to increase workability. Results obtained started with testing the C&D alone and C&D with additives that improved the produced brick characteristics. Comparison of produced Brick mechanical and physical properties with other marketing bricks including fired bricks proved to be engineering wise accepted & also in terms of their economic value.

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**Asmaa Nabil Al Mamlouk**

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# Abstract

Construction and demolition wastes (C&D) represent one of the major environmental problems not only in Egypt but also in developed and developing countries. Currently, C&D is one of the largest waste sources in Egypt without an effective management system.

Recently, many research works focus on finding a method to utilize these wastes and reduce their disposal area. However, it is not an easy task to find a method that fulfill the environmental regulations and at the same time economically feasible.

This thesis is devoted to utilize the C&D for producing low-cost non-bearing green bricks (without firing). To achieve that goal, different ratios of C&D to sand and fly ash were tested. In addition, various additives were added to the optimum mix to increase the workability and the homogeneity of the mix. Silica gel, silica fume, red bricks, stone powder, blast furnace slag, ecocole polymer and straw are among the used additives.

Literature survey covers the C&D problem and their importance as well as their effect on the environment in terms of health, air, water and solid pollution. In addition, previous efforts for solving this problem in different parts of the world were reviewed

The experimental setup includes the characterization of the C&D, preparing the used mixture for brick forming, curing the produced bricks and determination of physical and mechanical properties such as density, shrinkage, soaking and compressive strength, was presented in details.

The results of this study started with testing the C&D alone, C&D with sand, C&D with sand and fly ash. These tests indicated that the presence of fly ash which generated by coal combustion is important.

By choosing the main components of the mix (C&D+ sand + fly ash), the additives were tested one by one to screen them and find the most suitable ones. To reach the most appropriate mix components and ratios, different stages were proposed which are exploratory, preliminary and final tests were conducted.

The exploratory tests studied the mixture from C&D and other additives such as (lime, slag, silica fume, silica gel, glass waste, and many other additives to reach good visual as well as physical and mechanical properties of the produced bricks. Among these experiments, some uses C&D waste only, some using C&D with fly ash or lime or red brick powder. Some other additives have been experimented individually with C&D waste such as slag, sand, glass powder, silica gel, silica fume and ecocole and indicated that is better to use more than one additive to the C&D waste in order to produce acceptable nonbearing green bricks.

The preliminary tests have been done in order to reach a more precise mix composition as well as testing other ratios of the used additives. Thus, all the trials performed here were somehow basic; even the brick dimensions differed from

standards. Visual appearance and molding performance is good. Measurement carried out during experimentation on produced brick of different mixtures showed that shrinkage is 1 mm. When adding high quantities of lime and examined the samples visually it is found that it made granules that didn't interlock to each other especially when they left to be naturally dried without heating, Therefore, the lime was excluded as an additive due to its negative effect on the bricks mechanical properties.

The final mix composition as derived from previous experiments either in the exploratory tests or in the preliminary test. The main target of these tests to improve the mechanical properties of the final mix to be compared to standard bricks.

The ecocole was used as a main additive in these series of experiments beside the main mixture components (C&D, sand and fly ash), the effect of different combinations of final mix by adding various additives improved the physical and mechanical properties of this mix.

From previous tests, the final tests were conducted to enhance the mechanical properties of the final mix and produced bricks. It was indicated that the presence of silica components such as red brick, silica gel, silica fume enhances the mechanical properties. Furthermore, addition of straw improves the compressive strength and increases it 50-80% more.

Moreover, the produced bricks were compared to ASTM and Egyptian standards. Such comparison revealed that our product (final mix.) gave good results and not far from the standards although it may less than the standard of compressive strength required, it has an economic value.

The most interesting that the preliminary feasibility study indicated that the produced bricks can compete with the market bricks not only in terms of the physical and mechanical properties but also in terms of their economic value.

Finally, the results revealed that the strength increases by controlling the grain size, the kind and proportion of the additives used and many other conditions. Results have been gained showed acceptable.

# CHAPTER I

# INTRODUCTION

## 1.1. Overview

Construction and demolition (C&D) wastes is generated in a huge amount in Egypt daily. This waste problem has become a severe social and environmental issue in the territory. The possibility of waste recycling from the construction industry is thus of increasing importance. Waste recycling provides several benefits, which could be determined in reducing the demand on land for disposing as an important environmental benefit. It also serves in conservation of natural resources and reduces the cost of waste treatment prior to disposal. C&D wastes are normally composed of concrete, bricks and tiles, sand and dust, timber, plastics, cardboard , paper, and metals.

C&D waste represents a high percentage in concrete rubble. It has been proved that crushed C&D wastes, after separation and sieving, can be used as a substitute for natural coarse aggregates in bricks. This type of recycled material is called recycled aggregate.

Several application of recycled aggregate in construction projects has been succeeded in some European and American countries. It has shown that the optimum use of recycled aggregate in structural bricks could be up to 50% of the mixture used.

Present work presents a recent study at Cairo University, Faculty of Engineering, which aims to introduce a technique for utilizing recycled aggregates to produce a green non-bearing molded bricks. The bricks are cured up to 28-days to achieve a compressive strength of not less than 15Kg/Cm2 according to the requirement of Egyptian code for masonry units. Laboratory trials were carried out to prepare the molded specimens with various dimensions of (25*12*6) cm and interlock specimen of dimension (12*12*6) cm, with ranging of 75- 100% by weight of the natural aggregates (both coarse and fine) replaced by recycled aggregates.

Reported attempts have been done to incorporate fly ash & other additives into the production of bricks and blocks. Laboratory results of several properties just like density, compressive strength, curing, water absorption and shrinkage of the specimens were determined. In addition to the laboratory trials, a plant trial was conducted to test the feasibility of using recycled aggregates in producing molded bricks in real industrial production conditions.

Solid waste was a problem even before water and air pollution issues attracted the notice of human civilization. The quantities and characteristics of waste generated in any region are functions of the lifestyle and living standards of the region’s citizens and the type of the region’s natural resources. Excessive quantities of waste are generated from a society from inefficient production processes, lack awareness of sustainable consumption of natural resources as well as low durability of goods [1].

Construction wastes represent one of the solid wastes that increase day by day due to increase the human population on the Earth. The generation of huge amount of construction and waste demolition represents a major obstacle for achieving the sustainability of construction goals as indicated in Fig.1.1 in 2005.

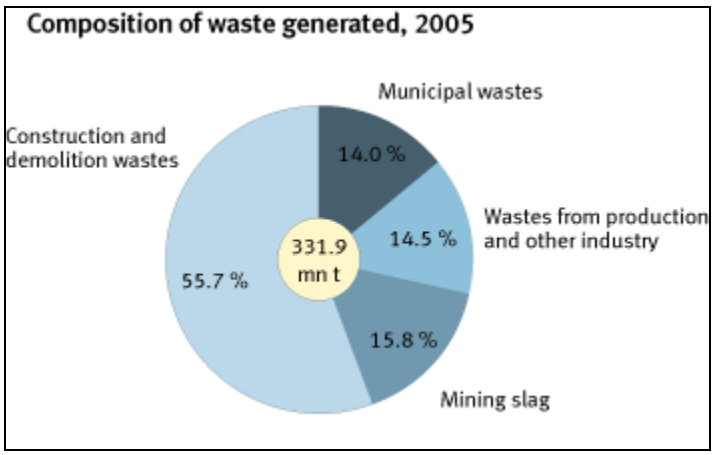


Fig. 1.1 Composition of waste generated
[destatis ,2007] [2]

The recent definition adopted for demolition they are heterogeneous mixtures of building materials such as aggregate, concrete, wood, paper, metal, insulation, glass that are usually contaminated with paints, fasteners, adhesives, wall coverings, insulation materials, and dirt [3]. Fig.1.2 illustrates the different types of wastes that may be generated from the removal of demolition of structures. Such processes could be man-made or due to natural disasters (earthquakes, hurricanes, wind, floods, etc). Construction waste varies worldwide depending on the structure being built, materials used and construction methods employed.

According to reported results of studies carried out by [4] which states that In Canada and the United States, they build their homes by using wooden frames while most of European build theirs by clay bricks. Estimated study has been done in US reported that most residential construction and demolition wastes have the following percentage of wastes: wood (42%), followed by gypsum wallboard (27%), brick (6%), roofing (2%) and metals (2%). A further 15% was made up of miscellaneous materials such as plastics.

Various investigations showed that construction waste is usually 20 to 30 times less than demolition waste and consists primarily of off-cuts and trimmings. Gypsum board as a lower value construction material will often be used more wastefully during the construction process than high value ones. In such case according to studies of [4] those showed that providing storage space for surplus material until reusing it again is often more expensive than disposing it in such cases. It should be noted though that regional differences in construction methods and choice of building materials will affect the quantities and variety of construction waste produced. Trends in building techniques also alter construction waste over time.

It is obvious that the amount of the demolition wastes and its composition greatly depend on the removed or demolished structure, age of structure and building materials. Fig.1.2 shows an example of such demolition wastes.

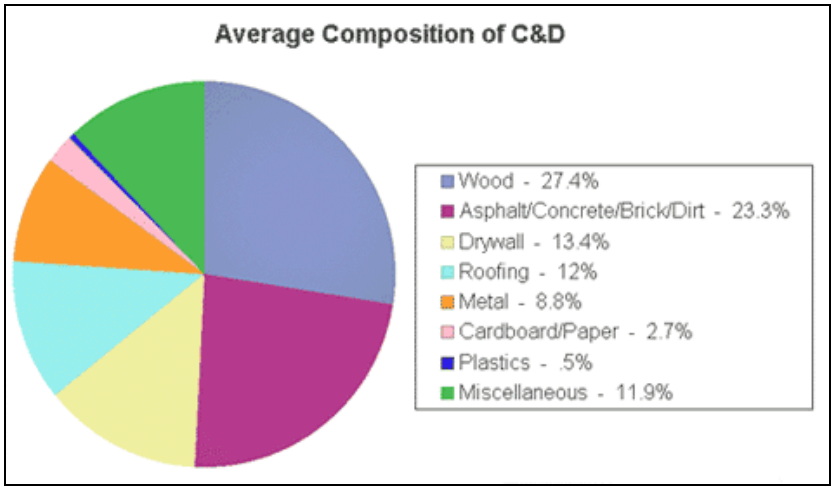


Fig.1.2 Construction and Demolition Waste in California [5].

As for residential buildings, the quantity of resulting demolition wastes is approximately 1.3-1.6 ton/m2 of the ground floor area of the structure being removed. While that for the industrial structures is estimated to be 1.5-2.0 ton/m2 of the demolished area. General speaking, the amount of demolition wastes ranges from 1.3-2.0 ton/m2 of the ground floor area of the structure being removed [3].

The construction industry produces vast amounts of waste. These wastes are produced throughout the different phases of the construction process starting from the extraction of virgin materials and their manufacturing process to the construction process itself and, finally, the demolition and disposal of the materials in landfills.

As bricks, wood, steel, and the like; the type of material found depends on each country's environmental factors.

In order to sustain the sustainable construction concept, therefore, it is necessary to increase the use of recycled materials in addition to decreasing construction and demolition waste during the whole construction process [6].