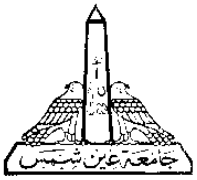

AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Structural Engineering

Performance of Fiber Reinforced Geopolymer Concrete and Mortar

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Civil Engineering

(Structural Engineering)

By

Mohamed Gamal Ahmed Khalil El-Sayed

Bachelor of Science in Civil Engineering

(Structural Engineering)

Faculty of Engineering, Ain shams, 2014

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Cairo - 2019

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STATEMENT

This thesis is submitted as partial fulfillment of Master of Science in Civil Engineering (Structural Engineering), Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Signature

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ACKNOWLEDGEMENTS

First of all, I want to express my profound gratitude to **ALLAH**, for giving me the patience and the effort to complete my work.

It was a great honor to work under the supervision of **Dr. Hany El-Shafei,** Professor of Properties and Testing of Materials, Structural Engineering Department, Faculty of Engineering, Ain Shams University.

Words are not enough to express my gratitude for **Dr. Fareed Elgabbas**, Assistant Professor, Structural Engineering Department, Faculty of Engineering, Ain Shams University, I really appreciate his patience and continuous support. I would like to thank him for his concentrated effort to finalize our work in a tight time frame and also to thank him for the technical knowledge he gave to me as he guided me how to organize my work, how to express my ideas and how to create professional output.

I would like to thank **Dr. Muhammad S. El-Feky**, Researcher in the Civil Engineering Department, National Research Centre, he directed me to a new interesting research area. I really appreciate his consideration and critical support to complete my research. I would like to thank him for the technical knowledge I gain from him.

I would like to share the successfulness of my research with my wonderful wife **Sahar**. She was there as a friend, assistant, and mentor. She helped me in my research from day one so I dedicate this success to her. She encouraged me to improve my personal and technical skills. I am very grateful for the materialistic and spiritual support she gave me.

Needless to mention the support I got from my **Dad**, **Mum,** and **my Brother.** I would like to thank them for the caring they gave me during my research and the spiritual support they provided to me. I would like to thank them for the effort they provided me to finalize my work.

THESIS SUMMARY

Recently, the application of green concrete as an alternative for conventional concrete has become trendy worldwide. The production of innovative concrete is based on utilizing waste materials as one of the concretes components. Therefore, in recent years witnessed an enormous increase in the studies that investigate Geopolymer's properties. The previous studies show that workability loss, the need for heat curing and rapid setting time are the main constraints that restrict Geopolymers cast in place applications. First of all, this study owes to reach the optimum activator ratios which achieve the maximum strength with acceptable fresh properties, then study the effect of incorporating different types and quantities of fibers on the fresh and the hardened properties. The experimental program was held on two consecutive phases. Phase (I) owes to reach the optimum activator ratios which achieve the maximum compressive strength with acceptable workability. In Phase (II) three different types of fibers (Glass Fiber 6 mm, Glass Fiber 18 mm, Polypropylene 18 mm) were incorporated in the optimum Geopolymer mixture (achieved from Phase (I)) with three percentages 1%, 2% and 3% (by volume) and was evaluated in terms of fresh and hardened properties. At the end of each phase statistical analysis was conducted to assess the significance of the variable, obtain estimation equation to predict the value of the responses (compressive strength, flexural strength, tensile strength, and workability) for further researches and choose the optimum mixture in light of the results obtained.

Keywords: Geopolymer composites, Ground granulated blast furnace slag, Metakaolin, Optimum mix design, Fresh properties, Hardened properties, Fiber reinforced Geopolymer mortar.

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CHAPTER 1. INTRODUCTION

1.1.General

Portland cement is the main ingredient in concrete. It varies in dosages from 1400 kg/m^3 to 75 kg/m^3 for rich and poor concrete, respectively [Mindess et al. 2014] with an average of 400 kg for one cubic meter of concrete. In fast-growing markets and owing to various applications that concrete is involved in cement become vital material as oil with annual production costs billions of dollars. Statista estimates that in 2020 the total world cement production will become 4.4 billion tons. Nowadays, the Portland cement industry produces 1.5 billion tons per year. It is worth mentioning that production of one ton of cement emits about one ton of CO_2 [Davidovits et al. 1994] and a very high-temperature more than (1300 ºC) is involved in such process [Kakooei, et al. 2012]. In addition to the emission of harmful gases and the high energy required to produce ordinary Portland cement, cement production has a significant influence on the natural resources (quarries) too, as the manufacturing of cement starts from the quarrying of raw materials especially limestone and clay quarry. Consequently, it is necessary to rely on Geopolymer concrete as a new alternative for Portland cement with better technical and environmental performance, to conserve energy and protect the environment [Toparak et al. 2014 and Pacheco et al. 2014]. Recently, the application of green concrete as an alternative for conventional concrete has become more popular worldwide. The production of innovative green concrete is based on using waste materials as one of its components. Geopolymer is considered as green concrete, this is because Geopolymer is cementless composite which based on waste materials such as; Slag, Fly Ash (FA), Metakaolin..etc. Therefore, recent years witnessed an immense increase in the studies that investigate Geopolymer's fresh and hardened properties. The previous studies show that workability loss, the need for heat curing and rapid setting time are the main constraints that restrict Geopolymer concrete

applications. Geopolymer concrete as well as ordinary Portland cement concrete shows brittle behavior, this behavior has a significant negative effect on large scale applications The previous studies show that fiber reinforcement of ordinary concrete and Geopolymer concrete controls the brittle behavior, improve fracture toughness, flexural strength, impact strength, abrasion strength, tensile ductility, and tensile strength, consequently, the reinforcement of concrete and Geopolymer with fibers gain high recognition recently. The target of the first phase of this study is to reach to the parameters that can control the fresh and the hardened properties of Geopolymer composites. Later on, the second phase the fresh and the hardened properties were evaluated for different fiber reinforced Geopolymer mixtures.

1.2.Research Objectives

Many studies investigate different ways to improve Geopolymers fresh properties and assess the hardened properties as well. It was observed that the different activator ratios and concentrations have a great effect on the Geopolymer's fresh and hardened properties. This thesis owes to reach solid activator parameters which affect directly the fresh and hardened properties. The main challenge is to eliminate the need for heat curing and to produce workable Geopolymer mortar with high strength. Later on, this study owes to assess the effect of adding different types and quantities of fibers on the mechanical properties. The following are the main objective of the study:

1- Study the mechanical properties of Geopolymers mortar with different base material and activator ratios.

2- Investigate the consequences of adding water on the fresh and hardened properties.

3- Optimize the activator ratios in terms of workability and compressive strength in light of the statistical analysis conducted.