CHAPTER I

INTRODUCTION

1.1 Introduction

Concrete shrinkage is an increasing concern when it comes to maintaining structural durability. Over time, shrinkage can induce cracking or further widening of pre-existent cracks which could decrease life expectancy of structures. These volume changes are usually attributed to the drying of concrete over a certain period of time. However, recent researches are now also focusing on early age or plastic drying problems.

Concrete at its fresh state allows for the occurrence of plastic shrinkage. Plastic shrinkage cracks develop from a volumetric change after concrete is placed and before it attains any significant strength. This results in an unsightly and non-uniform appearance on the concrete surface.

Plastic shrinkage cracking is typically attributed to the loss of water from evaporation that leads to the build-up of tensile shrinkage stress when concrete is subjected to sufficient restraint. Similarly, ACI Committee 305 also stated that the principal cause of plastic shrinkage cracking of Portland cement concrete is the excessive and rapid rate of evaporation and the inability or lack of bleed water to replace the evaporating water. When the rate of water loss due to evaporation exceeds the bleeding rate of water within the concrete matrix, negative capillary pressures form. This results to volumetric changes in the concrete. Tensile stresses in the paste form due to the negative capillary pressure and the development of strength in the concrete. These events lead to the formation of plastic shrinkage cracks, observed to be almost always straight, without any definite pattern.

Plastic shrinkage cracks can occur in concrete slabs, pavements, and flatworks and has been known on occasion to penetrate the whole depth. These cracks vary from about 25mm to the full depth of a section, if not controlled. Daily or seasonal fluctuations in external factors such as humidity and temperature might further widen existing cracks, or worse, may even propagate new cracks. It could facilitate the access for chlorides, sulfates, and carbon dioxide to enter the concrete matrix. Some studies say that the width of cracks induced by plastic shrinkage does not usually vary with time, and that these dormant cracks may be blocked by hydration products or by the self-healing characteristic of concrete while hardening (Sanjuan and Moragues, 1996). However, the effective self-healing process of concrete would still be dependent on proper mix proportions, curing, and other factors. Overall, if not controlled, plastic shrinkage cracks could lead to a reduction in both strength and durability of structural members.

Because it is difficult to measure cracks in its plastic state without disturbing the fresh concrete, most researches rely on measuring these cracks after the termination of the testing period. Some procedures in measuring make use of pins and threads to measure the cracks and visualize crack propagation. However, this particular type of method would mean taking the specimen out of the testing equipment and spending about fifteen (or more) minutes per specimen just to measure the cracks. Because of this, some other freshly formed cracks might occur in that span of time. In addition, if the test specimen would not experience continuous exposure to environmental conditions if taken out of the test chamber for longer periods of time (to measure cracks). This would mean probable inaccurate or insufficient data will be acquired and time would also be wasted. As an answer to this issue, this study would make use of Image Analysis. Image Analysis would allow for minimal time to take images of the test specimens with the use of digital cameras. In addition, data would be recorded and stored for further analysis which would allow for faster transition of testing.

1.2 Objectives of the Research

This study was focused mainly to evaluate the effects of pozzolan on the plastic shrinkage cracking of concrete. To evaluate such properties, the study aimed to:

1. To determine the effect of pozzolan on plastic shrinkage cracking of concrete in terms of crack area, maximum crack width, average crack width, and cracking reduction ratio with the aid of Image Analysis; and,
2. To observe the behavior of plastic shrinkage cracks after 28 days under different curing conditions.

1.3 Scope of the Research

This research focused on the use of the pozzolanic material, Mae Moh fly ash and silica fume in pelletized form, as replacement for cement in the mix design. For fly ash, replacement from 0 to 50 percent by weight of cement was used. Silica fume concrete was mixed with 3 and 5 percent replacement by weight of cement. Type I Portland cement was utilized with water-binder ratio of 0.30, 0.40, and 0.50. The maximum size of aggregate was 19 mm.

The plastic shrinkage cracking procedure was based on ASTM C1579-06 with some modifications done in the testing chamber in order to be able to control the evaporation rate at approximately 1.0 kilogram per square meter surface area of water per hour ($kg/m^2 \cdot h$) for all specimens tested.

The use of Image Analysis technique would be applied in acquiring and analyzing data for this study.

1.4 Significance of the Research

Ravina and Shalon (1968) said that the term "surface cracks" could be very misleading as widespread plastic shrinkage cracks observed in buildings extend all the way through slabs with depths up to 23 cm and widths of 0.1 to 3.0 mm. Crack widths, if big enough, would induce problems on permeability. Consequently, unless these cracks are shallow and narrow, they weaken the structure and permit penetration of harmful substances (such as further ingress of chlorides, sulfates, and carbon dioxide). As a result, serviceability, durability, performance, and the aesthetic qualities of the concrete structure would be reduced. Thus, controlling plastic shrinkage cracking is essential in developing more durable and longer-lasting concrete structure at a minimum life-cycle cost.

The use of pozzolan in the concrete industry has been increasing due to its ability to make concrete mixtures more economical, reduce permeability, increase strength, or influence other concrete properties. Despite its reduction in the rate of development of strength when used individually, its ability to reduce permeability shows promise in being a possible means to control plastic shrinkage cracking in concrete. For instance, the use of fly ash as partial replacement of Portland cement has been reported to have a 7- 10-fold reduction in permeability (Higginson, 1966) due to the continuing formation of hydrates that fill the pores and also because of the free lime that which could be leached out. Results of this research results would also provide better understanding of plastic shrinkage cracking properties of pozzolan.