CHAPTER I

INTRODUCTION

1.1 Background

Concrete is widely used as a primary structural material in construction due to numerous advantages, such as strength, durability, ease of fabrication, and non-combustibility properties, it possesses over other construction materials. Concrete structural members when used in buildings have to satisfy appropriate fire safety requirements specified in building codes (ACI 216.1, ACI-318, EN 1991-1-2, EN, 1992-1-2). This is because fire represents one of the most severe environmental conditions to which structures may be subjected; therefore, provision of appropriate fire safety measures for structural members is an important aspect of building design.

Exposure to elevated temperatures which is mainly caused by accidental fire, represents one of the more severe exposure conditions of buildings and structures. The fire resistance and post heat exposure behavior of structural members depend on thermal and mechanical properties of the materials composing these members. Elasticity is one of the major material properties which play an essential role in the structural behavior of reinforced concrete members both before and after high temperatures exposure (Shallal, 2007).

Fire safety measures to structural members are measured in terms of fire resistance which is the duration during which a structural member exhibits resistance with respect to structural integrity, stability, and temperature transmission (A. H. Buchanan, 2012). Concrete generally provides the best fire resistance properties of

any building material (Kodur, 2010). This excellent fire resistance is due to concrete's constituent materials (i.e., cement and aggregates) which, when chemically combined, form a material that is essentially inert and has low thermal conductivity, high heat capacity, and slower strength degradation with temperature. It is this slow rate of heat transfer and strength loss that enables concrete to act as an effective fire shield not only between adjacent spaces but also to protect itself from fire damage.

The behavior of a concrete structural member exposed to fire is dependent, in part, on thermal, mechanical, and deformation properties of concrete of which the member is composed. Similar to other materials the thermo-physical, mechanical, and deformation properties of concrete change substantially within the temperature range associated with building fires. These properties vary as a function of temperature and depend on the composition and characteristics of concrete. The strength of concrete has significant influence on its properties at both room and high temperatures.

Concrete is available in various forms and it is often grouped under different categories based on weight (as normal weight and light weight concrete), strength (as normal strength, high strength, and ultrahigh strength concrete), presence of fibers (as plain and fiber-reinforced concrete), and performance (as conventional and high performance concrete). Fire safety practitioners further subdivide normal-weight concretes into silicate (siliceous) and carbonate (limestone) aggregate concrete, according to the composition of the principal aggregate. Also, when a small amount of discontinuous fibers (steel or polypropylene) is added to a concrete batch mix to improve performance, this concrete is referred to as fiber-reinforced concrete (FRC). In this section, the various properties of concrete are mainly discussed for

conventional concrete. The effect of strength, weight, and fibers on properties of concrete at elevated temperatures is highlighted (Kodur, 2014).

Traditionally, the compressive strength of concrete used to be around 20 to 50 MPa, which is classified as normal-strength concrete (NSC). In recent years, concrete with a compressive strength in the range of 50 to 120 MPa has become widely available. When compressive strength exceeds 120 MPa, it is often referred to as ultrahigh performance concrete (UHP). The strength of concrete degrades with temperature and the rate of strength degradation is highly influenced by the compressive strength of concrete (Kodur, 2014).

Fiber reinforced concrete (FRC) may be defined as a composite materials made with Portland cement, aggregate, and incorporating discrete discontinuous fibers. Now, why would we wish to add such fibers to concrete? Plain, unreinforced concrete is a brittle material, with a low tensile strength and a low strain capacity. The role of randomly distributes discontinuous fibers is to bridge across the cracks that develop provides some post- cracking “ductility”. If the fibers are sufficiently strong, sufficiently bonded to material, and permit the FRC to carry significant stresses over a relatively large strain capacity in the post-cracking stage (Chan).

As with any other type of concrete, the mix proportions for SFRC depend upon the requirements for a particular job, in terms of strength, workability, and so on. Several procedures for proportioning SFRC mixes are available, which emphasize the workability of the resulting mix. However, there are some considerations that are particular to SFRC. In general, SFRC mixes contain higher cement contents and higher ratios of fine to coarse aggregate than do ordinary concretes, and so the mix

design procedures the apply to conventional concrete may not be entirely applicable to SFRC. Commonly, to reduce the quantity of cement, up to 35% of the cement may be replaced with fly ash. In addition, to improve the workability of higher fiber volume mixes, water reducing admixtures and, in particular, superlasticizers are often used, in conjunction with air entrainment (Chan).

The use of spread steel fiber wires can be considered as a solution to control cracking and to increase the strength and ductility of concrete. Since the exposure to high temperature causes different changes in concrete, which lead to the initiation and opening of many cracks, this study was directed to investigate the influence of steel fibers on the elastic modulus of concrete after high temperature exposure (Shallal, 2007).

The addition of steel fibers to a reinforced concrete beam is known to increase its shear strength and, if sufficient fibers are added, a brittle shear failure can be suppressed in favor of more ductile behavior. (ACI, 1997, Adebar, 1997 in Yoon-Keun Kwak, 2002). The main advantage for using fiber reinforcing systems as opposed to conventional reinforcing systems is realized in the fabrication processes. Fiber reinforced concrete is either cast or sprayed, thereby eliminating the labor-intensive activity of placing reinforcement. Fiber reinforced concretes are best suited for thin- section shapes where correct placement of conventional reinforcement would be extremely difficult (Portland Cement Association, 1991).

Additionally, A very few investigations have been conducted to provide experimental results about the effect of fibers on the properties of concrete at high temperature Purkiss, (1984); Faiyadh, (1986) and (1989); were a little that have

reported the research on this issue, it is necessary to make additional studies on the effect of elevated temperature on properties of SFRC using different types of steel fibers and volume contents of SFRC. In this study an investigation is going to be carried out on the effect of high temperature on the compressive strength and modulus of elasticity of SFRC by difference fiber volume fractions under high different temperature condition.

1.2 Research Problems

Based on a description of the background of what has been mentioned above, the researcher is interested in formulating the problems as follows:

1. How the compressive strength and modulus of elasticity as well as flexural strength of steel fiber reinforced concrete on volume fractions of 1 % fiber at three temperature levels of 200°C, 400°C and 600°C.
2. How the compressive strength and modulus of elasticity of steel fiber reinforced concrete on volume fractions of 1.5% fiber by four temperature levels of 200°C, 400°C and 600°C?
3. How to get the comparison of the compressive strength and modulus of elasticity at concrete without fiber on the same temperature?

1.3 Research Scope

This study is limited to investigate the compressive strength and modulus of elasticity of steel fiber reinforced concrete, both before and after exposure to high different temperature. Three fiber volume fractions of 0%, 1% and 1.5 % will be

used. Three temperature levels of 300°C, 600°C and 900°C will be adopted in addition to room temperature.

1.4 Research Objectives

The aim of this study is to investigate the strength and modulus of elasticity progress of steel fiber reinforced concrete under different temperature condition on difference fibers volume fractions:

1. To analyze the compressive strength and modulus of elasticity of steel fiber reinforced concrete on volume fractions of 1% fiber at three temperature levels of 200°C, 400°Cand 600°C.
2. To analyze the compressive strength and modulus of elasticity of steel fiber reinforced concrete on volume fractions of 1.5% fiber at three temperature levels of 200°C, 400°C and 600°C.
3. To analyze the comparison of the compressive strength and modulus of elasticity at concrete without fiber on the same temperature.

1.5 Research Outcomes and Significance

The significance of this study is to provide useful input into the issue of the fire resistance rating to use for SFRC and so that a fire resistance for SFRC can be added to the rating list.

From the research and testing is expected to produce a product that is beneficial as following implications:

1. Theoretical Benefits

Optimize the use of steel fiber on concrete production especially, as an effort to improve the modulus of elasticity and compressive strength in concrete.

2. Practical Benefits

The use of steel fiber concrete as additive on concrete that can provide a solution for concrete problems on the mechanical properties of concrete.