CHAPTER (1)

INTRODUCTION

1-1 General:

Reinforced concrete regarded to be the most popular construction material that been used for buildings and other structures. This worldwide application is due to its good properties regarding structural, constructional economical aspects. However many reinforced concrete structures may suffer damage due to material deterioration, environmental effects, misuse, overloading or accidents. These structures cannot fall or reconstructed due to economic reasons. In addition, some old buildings are of historical value, should be preserved. Therefore, there is need for repair and strengthening of structural elements to carry extra load applied on them. In the past years, FRP materials have been successfully used for repair and strengthening of reinforced concrete elements such as slabs beams and columns. This is due to its high strength, easy, and fast application. Fiber reinforced polymer (FRP) materials are made of continuous fiber (glass, armid, carbon or other) embedded in a resin matrix. The resin allows fibers to work together as a single element.

The (FRP) composites have offered several desirable attributes. However, FRP materials have some disadvantages. Some (FRP) laminates have small tensile elastic modulus compared with steel and the cost of (FRP) laminates may not be competitive with the conventional ones in some applications. Another problem is that (FRP) composites have low fire resistance, in occurrence of fire.

Polymer material and epoxy adhesive, the glass transition temperature(Tg), is defined as the temperature at which polymer materials change from relatively hard, elastic, glass like, to relatively rubbery materials, ranges between 60-80^{o}C, during the fire, if temperature gets higher than the glass transition point (Tg) of resins, it may seriously damage the bond between the FRP and the concrete surface. To overcome this problem, the FRP materials must be developed by coating layers.

The scope of this research work is to introduce and investigate the effect of the different fire protection layers for the reinforced concrete beams which strengthened by external application of (FRP), and to study the effect of high temperature on the behavior of these strengthened beams after exposure to high temperature with or without the protection system.

1-2 Problem Statement:

In the presence of a fire, the relatively low glass transition temperature of the epoxy (generally less than $100^{o}C$) is easily exceeded and the structural integrity of the FRP severely compromised. As fire burn much hotter, the effectiveness of the FRP can be assumed to be lost. The strength and stiffness of the FRP degrades at high temperature and there is a loss of bond. The fire endurance limit of the FRP is therefore the time taken for the glass transition of the epoxy to be reached. In the presence of fire the FRP is ineffective, however, the endurance of the existing plain (unstrengthened) concrete element under fire conditions but be sufficient to resist service load. It is therefore important to evaluate the endurance of the existing structure to fire.

The FRP system is difficult to be protected against fire due to its low glass transition temperature. The damaging effect of fire can however be reduced by applying a coat of cementitious materials or vermiculite. Fire resistance can be increased by phenolic resins and special fire resistance additives to the resins.

1-3 Research Objectives:

The main objective of this research is reaching the best way to protect the reinforced concrete beams strengthened with (FRP) laminates under the influence of high temperature. To arrive to the best way the author studied the effect of high temperature on the behavior of reinforced concrete strengthened with (FRP) while changing the following variables:

- Temperature.
- Duration of exposure to high temperature.
- Types of protective coating material.

Determining the best protection layer is by evaluating and comparing the residual strength of beams strengthened with (FRP) laminates after exposure to high temperature. The residual strength must be able to asses the safety of (FRP) strengthened elements (beams) after being subjected to high temperature.

The main aim in this research is to protect the FRP system from high temperature and the coating material can prevent the temperature of FRP system from reaching the T_g of the resin. The following materials are used in this research work for coating to protect the FRP system (perlite – vermiculite – ordinary Portland cement mortar – ceramic fiber – Aswan clay – rock wool – glass wool – calcium silicate).

1-4 Research Program:

The research work is accomplished through four steps which are:

1- Reviewing previous researches in the field of protection of reinforced concrete elements strengthened with (FRP) laminate from high temperature and fire.

2- Presenting the properties of concrete, (FRP) and coating materials, especially the thermal properties. Also, the structural behavior and failure of different materials when subjected to high temperatures associated with fires.

3- An experimental program consisting 2 phases has been suggested and carried out to study the effect of protection layer on the strength of RC beam strengthened by (FRP) and subjected to high temperature. The residual strength of FRP strengthened beam which were exposed to high temperature and the efficiency of coating material were investigated.

4- Analysis of results had been undertaken. Conclusions, recommendations for practical applications and future research work presented.

1-5 Thesis Layout:

The present thesis divided into six chapters as follows:

Chapter 1 serves as an introduction to this study presents the scope objective and layout of thesis.

Chapter 2 presents a survey of the available previous research work carried out to study the effect of high temperature and fire on mechanical properties of reinforced concrete beams with and without (FRP) reinforcement. It covers also the behaviour of reinforced concrete beams strengthened with (FRP) reinforcement. This chapter also includes heat transfer analysis, determination of fire resistance of reinforced concrete elements and protective coating materials against elevated temperature and fire.

Chapter 3 presents the experimental program designed and carried out in this research work. Material properties presented as well as the adopted experimental program and its details such as the test setup, the testing machines, burning furnace, thermocouples, data logger. Thermal conductivity tests and universal machines are also presented.

Chapter 4 assigned to present the results of the experimental program carried out. It presents the results of the two experimental phases of the program.

Chapter 5 presents the detailed discussion and analysis of the results obtained. It also develops the conclusions obtained from this study.

Chapter 6 summarizes the conducted research, provides the conclusions derived from this study and the recommended areas for future research related to this study.

Finally, a list of reference is give at the end.