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Fire Resistance and Durability of Concrete Buildings Strengthened with FRP Sheets "Review Analysis"

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Abstract

Sustainability is the way or the method to improve the human life by using the natural resources. There are three basic aspects of the sustainability which are; Social aspect, Economical aspect, and Environmental aspect. As result of that, civil engineers now days try to find new materials and methods to reach and apply the sustainability concept. For example, in the materials aspect, there are many ingredients such as Fibers, polymers, lightweight aggregates, fly ash, and slice fume were added in the concrete mix to have better durability. Concrete is one of the most commonly used materials in building construction projects. Many scientists and professionals continue to find new ways to improve the strength of concrete material and reduce its weight/volume ratio to the preserve natural materials and reduce energy. One of the most important factors in concrete structures is the stability of the structure against external forces such as earthquakes, wind loads, fires and etc. The Fiber Reinforced Polymers (FRP) sheets are externally bonded to the concrete surfaces to enhance the performance of the concrete structures. Several studies were conducted to investigate the compressive strength of the concrete that wrapped with FRP composite when they are exposed to harsh environment factors such as elevated temperature, freeze-thaw cycles, high humidity and etc. However, there are many studies which cover and study the effects of the extreme conditions at concretes wrapped with FRP which could help the engineers in the future to avoid fatal results such as structures failures. The main goal of this paper is to collect information about durability and fire resistance of concretes wrapped with FRP polymers and that will be done by reviewing different journals which cover these points. The experimental programs of the journals will be explained and supported by the figures.

Index terms— construction material, fire resistance, impact of fire on structures, structural performance.

Fire Resistance and Durability of Buildings Strengthened with FRP Sheets "Review Analysis" Year 2014 E Abstract-Sustainability is the way or the method to improve the human life by using the natural resources. There are three basic aspects of the sustainability which are; Social aspect, Economical aspect, and Environmental aspect. As result of that, civil engineers now days try to find new materials and methods to reach and apply the sustainability concept. For example, in the materials aspect, there are many ingredients such as Fibers, polymers, lightweight aggregates, fly ash, and slice fume were added in the concrete mix to have better durability. Concrete is one of the most commonly used materials in building construction projects. Many scientists and professionals continue to find new ways to improve the strength of concrete material and reduce its weight/volume ratio to the preserve natural materials and reduce energy. One of the most important factors in concrete structures is the stability of the structure against external forces such as earthquakes, wind loads, fires and etc. The Fiber Reinforced Polymers (FRP) sheets are externally bonded to the concrete surfaces to enhance the performance of the concrete structures. Several studies were conducted to investigate the compressive strength of the concrete that wrapped with FRP composite when they are exposed to harsh environment factors such as elevated temperature, freeze-thaw cycles, high humidity and etc. However, there are many studies which cover and

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1 Introduction

iber reinforced polymer are materials that present the future in the civil engineering and construction industry. The FRP composites materials industry still does not provide enough codes and standards for civil engineers so that many tests and experiments should be done to have more knowledge about composite materials. These materials could provide to the structural building many important aspects such as freedom of design, high strength-to-weight ratio, excellent durability, minimum maintenance and excellent fire resistance. FRP composite materials have very high Author ? ?: Abu Dhabi, ADCO, Drilling function, Al Ain Tower 10 th floor. e-mail: ghakas90@gmail.com good strength comparing with other construction materials such as mild steel. Fig (**??**) explains the stressstrain behavior curves for some composite materials; GFRP and CFRP with mild steel and shows the brittle behavior of FRP composites and the ductile behavior of mild steel.

2 Curves

For External FPR reinforcement system, it is useful for beams and other unusual shapes. However, the shape of the cross section and the spacing of FRP straps can directly impact the effectiveness of the External FPR reinforcement and it also has many applications such as maintain the beams and slabs that contain cracks and increase the surface life for the columns, beams, and slabs. Externally strengthening techniques of shear deficient are: Fibers applications, strengthening with externally applied clamps, jacketing, and external bonding of steel plates with epoxy. For strengthening shear deficient, many different tests have been applied and proven that composite materials are an excellent way to be used as external reinforcing [2]. There are two kinds of FRP sheets: Pre-cured laminates: This considers a rigid plate and is applied on flat surfaces. They are usually applied to the beams to increase the flexural capacity or reducing deflection where normally attached to the bottom. Thin/flexible sheets: The main function of them is to wrap them around beams, columns and slabs. This type of sheet increases the shear and flexural capacities for different structural members with different cross sections.

The most common FRP composite used are CFRP and GFRP so that they will be studied and analyzed in depth in this paper II.

3 Cfrp -gfrp Sheets

For (CFRP), carbon fibers structures consist of a mixture between amorphous carbon and graphitic carbon. This shape of graphitic carbon comes from the high tensile modulus, in which the particles of carbon are set in an engineering hexagonal form of parallel layers as shown in the Fig (2). The bond between the carbon particles is strong, but it is weak in the layers because of the van der Waals-type forces [3].

Figure **??** : Arrangement of Carbon atoms in a graphite crystal [4] Glass Fiber Reinforced Polymer (GFRP) chemical compositions are [5], [6], [7]:? SiO2: 54.3%, ? Al2O3 & Fe2 O3: 15.2% ? CaO:17.3%, ? Na2O/K2O 0.6% ? B2O3: 8% to 10%

According to these elements, the function of GFRP sheets could be affected against the environmental factors such as alkalinity, moisture, and temperature. For example, alkalinity can cause hydrolysis for the glass fiber by hydroxide ions. a) Glass Transition Temperature Glass transition temperature is the temperature in non-crystalline solids where the material start changing its behavior and it becomes rubbery instead of being glassy. When the material is rubbery that means it's a flexible material and elastic while glassy means brittle material [8]. The reason of the changing from glassy to rubbery is the temperature of the material and the temperature needed to rearrange the molecules in the material. In case where the material has a high temperature which is above the transition temperature the molecules will have the ability to move while the molecules will be frozen if the temperature is below the transition temperature.

4 III.

5 Case Studies a) Tensile properties of carbon fibers and carbon fiberpolymer composites in fire

Carbon fiber tensile properties and strength are directly affected by the increase of temperature. When exposing the carbon fibers to fire with the application of tensile stress, you will see that the fiber modulus decreases with the increase amount of fire. Decreasing the fiber modulus will soften the carbon fibers at the surface, which will lead to a decrease in the overall tensile strength of the fibers. The authors said that the fiber modulus is not affected when carbon fiber subjected to fire in nitrogen atmosphere, and that because of the absence of oxygen. In regular atmosphere oxidation will occur. Reduction in tensile strength when the fibers are exposed to fire will occur regardless the presence oxygen or not. The tensile strength of carbon fibers will be reduced by 50%

when exposing the fibers to a temperature in the range of 400-700 degree Celsius, also regardless the presence of oxygen. Finally the carbon fiber laminates at the surface of structures, aircrafts, and ships thermally decompose and become thinner due to oxidization when a temperature exceeds 400 Celsius. The surface and subsurface fibers will decrease in strength regardless the presence of oxygen [9].

b) The effect of different passive fire protection systems on the fire reaction properties of GFRP pultruded profiles for civil construction Glass fiber reinforced polymers (GFRP) are light, stiff, strong, low thermal conductive material, durable under aggressive environment, and needs lower maintenance, but concerning their fire behavior, GFRP when heated with fire of a range temperature between 100-200 degrees Celsius it soften and creep, causing considerable loss in strength and stiffness. According to the authors, when subjected to higher temperatures between 300-500 degrees Celsius their organic matrix decomposes and produces heat, smoke, and toxic volatiles. Using good flame retardants, self reaction of GFRP under fire exposal can be avoided, but unfortunately the structural requirements for elements performance under (60-90 min) of fire can't be achieved. Most of flame retardants cause an instant decrease in the mechanical properties of FRP materials. There are some commercially available GFRP materials that can avoid the instant flexural strength loss when exposed to fire, but in longer periods of fire exposal protected and unprotected GFRP flexural loss will be the same. Temperatures measured during the test shows that all protective material used shows a reduction in overall temperatures of the GFRP laminates. All GFRP reaction to fire reduces after using the insulation and protective materials [10].

IV.

6 Concluding Remarks

Elevated Temperature level and durability are very critical properties for any constriction material that is used in civil engineering. Since FRP is used now very often in the construction world, it is important to understand the mechanical behavior of these materials to apply them by efficient way. This paper gives the basic understand of the fire resistance and durability of FRP materials and how the strength can be affected due them. Also this paper explains the chemistry change of FRP materials and the chemical reaction that are happened under high temperature. [1] [2]

Figure 1: Figure 1 :

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