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SHEAR STRENGTHENING OF REINFORCED CONCRETE T-BEAMS USING ANCHORED FRP WRAPS

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STATEMENT

The thesis is submitted to Ain Shams University, Cairo, Egypt, in partial fulfilment of the requirements for the degree of Master of Science in Civil Engineering (Structural).

The Work included in this thesis was carried out by the author at Properties and Testing of materials Laboratory, Faculty of Engineering, Ain Shams University.

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Dedication

I dedicate this thesis to the people who devoted their lives for making me a successful person, my Father, my Mother, my Sister and my Brother. Gratitude and appreciation cannot describe my feelings towards them.

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ABSTRACT

Fiber-reinforced polymer (FRP) composites are used as repair and strengthening material for reinforced concrete (RC) members. The main purpose for use of FRP sheets is to debond when loads reach to the ultimate capacity this reason prompted researchers to investigate various approaches and designs increase the efficiency of FRP strengthening systems. Various types of anchor systems, wrapping techniques, and clamps have been searched to postpone and/or delay the debonding process which results in premature failure. FRP anchors are of particular advantage because it has the same material properties as the FRP sheets that are installed for strengthening or repair of the RC member.

This research studies and investigates the effectiveness of using commercially manufactured FRP anchors to secure FRP sheets installed to strengthen and repair RC beams in shear. Thirteen shear critical RC beams were strengthened in shear with U-wrapped FRP sheets. The test variables include the type of FRP sheets (CFRP), type of FRP anchors (GFRP), and spacing between U-wrapped FRP sheets. The number and the spacing of anchors placed inside the slab are many times more effective than those placed horizontally inside the web. Anchors of similar geometrical characteristics (e.g. embedment length) display similar effectiveness and strengthening configuration. The test results of the shear critical RC beams detected that the installation of FRP anchors are improved partially wrapping of FRP sheets on shear strengthening. Applied FRP anchors improved the shear strength by 15 % where compared to unanchored beams and delayed typical shear failure in beams. Using FRP anchors allowed the FRP sheets to increase their tensile capacity.

Additionally, as the width of a partially wrapping FRP sheet was increased; larger increase in strength was obtained when FRP anchors were used. The use of FRP anchors allowed the FRP sheets to develop their full tensile strength. Premature failure by CFRP debonding was not eliminated with the presence of FRP anchors; rather the critical failure zone was shifted from the bottom soffit of the slab to the concrete/steel rebar interface. The effective strain in the FRP sheet was predicted and compared with the experimental results.

The efficiency of FRP anchors were defined as the ratio of effective strain in the FRP sheet with and without anchors and was related to the increase in strength in beams. A good correlation was established between the FRP anchor efficiency and the increase in strength. A step-by-step FRP anchor installation procedure was developed and a model to predict the number of FRP anchors required to secure FRP sheet was proposed. This is the most comprehensive examination of beams strengthened with FRP sheets and FRP anchors. This study provides the engineers engineer with the basic understanding of the behaviour and failure modes of beams strengthened with FRP sheets and anchors

Keywords: *CFRP; anchors; T-section; Strengthening; Beams; shear; Wrapping; sheets.*

Chapter 1
INTRODUCTION

1.1 General

Strengthening or rehabilitation using CFRP (Carbon Fiber Reinforced Polymers) is a convenient material for RC structures because of its light-weight, flexibility and easy installation techniques. Epoxy is used to make full bonding between concrete and FRP.

1.2 Problem Statement

CFRP, in case was fails in debonding of the sheet, it prevents the increase of the ideal capacity of the material, which leads to precocious failure. CFRP anchors provides a solution to many types of failure. This research concentrates on studying the behavior of using CFRP sheets and anchors on shear strengthening of reinforced concrete beams.

1.2.1 Necessity of Rehabilitation

Restoration and strengthening techniques are very important and needs. Whereas commutation or demolishing may be a main and constant solution. In many conditions, destroying old structures cost such that rehabilitation could be an applicable solution. These constructions are necessary to rehabilitated when they approach the end of their service life. Bridges and structures require restoration and repair from excessive size, traffic loads, and damages resulting from the corrosion of reinforcing steel (Noel & Soudki, 2011).

The promotion of fiber-reinforced polymer (FRP) composites as a repair and strengthening material for reinforced concrete (RC) beams, slabs and columns in structural engineering has increased during the previous twenty years (Cao, et al., 2005; Triantfillou &Antonopoulos, 2000; Bank, 2006; American Concrete