AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

SHEAR BEHAVIOR OF CONCRETE FILLED GRP TUBES

BY

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Thesis Title: Shear Behavior of Concrete Filled GFRP Tubes

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Abstract of MSc Thesis submitted by

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Title of thesis:

SHEAR BEHAVIOR OF CONCRETE FILLED GRP TUBES

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ABSTRACT

The main objective of this research is to describe the shear capacity of Concrete-Filled FRP Tubes (CFFT). A total of nine beams are tested by applying a concentrated load at the mid span with various shear span-to-depth ratios (a/D). Tested beams are divided into two main groups; the first group consists of four tubes filled with plain concrete, while the second group consists of five concrete filled tubes provided with extra longitudinal steel reinforcement.

An elaborated Strut-and-Tie (S&T) truss model was adopted to model the shear behaviour of tested CFFT beams. Geometry of the tension ties and compressive struts is established to present the tension fields in the external FRP shell and compression fields in the concrete core, respectively. The adopted model can closely model the internal force flow and predict the most probable failure mode.

A parametric study was carried out based on the adopted strut-and-tie model for further understanding of the influence of beam size, a/D, concrete compressive strength, FRP reinforcement ratio and the laminate structure of the FRP jacket on the shear capacity of CFFT beams.

Current research verified the potentiality of concrete-filled GFRP tubes as a structural member to provide significant shear strength. Based on the experimental program and the analytical study mentioned in this thesis, it can be concluded that Bernouli's beam theory is not valid for deep and short CFFT beams. Shear capacity of such beams can be predicted based on a strut-and-tie model.

KEYWORDS: CFFT, Concrete filled tubes, Glass fibers, Shear behavior, Confinement, Shear stresses

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STATEMENT

This thesis is submitted to Ain Shams University, Cairo, Egypt, on July 2010 for the Degree of Master of Science in Civil Engineering (Structural).

The analytical work included in this thesis was carried out by the author. The experimental work included in this thesis was carried out by the author in the Reinforced Concrete Laboratory of Ain Shams University and the Reinforced Concrete Laboratory of Construction Research Institute (CRI) – National Water Research Center, from February 2006 to August 2006.

No part of this thesis has been submitted for a degree or qualification at any other University or Institute.

Date	: 21 / 07 / 2010
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Table of contents

List of Symbols

A = Cross sectional area of the member.

A_c = Area of circle segment located above the neutral axis (i.e. compression zone)

A_{ds} = Effective area for inclined strut as calculated using equation 4.10a.

A_{dt} = Effective area of inclined tie

A_{dt} = Effective area for inclined tie as calculated using equation 4.10.

A_f = Area of the FRP shell located in the tension zone ≅ 0.5 cross-sectional area of the pipe.

A_{fc} = Area of the FRP shell located in the compression zone ≅ 0.5 cross-sectional area of the pipe (refer to assumption No. 2).

A_g = the gross area of concrete section.

A_i = Area of a layer (i).

A_s = Area of reinforcement steel bars or steel tube.

a/D = Shear-span-to-depth ratio

b = In plan width of the inclined tie (Figure 4.5).

b_s = Effective out of plan width

c = Statistical parameter presents the intercept of the straight line predicted from regression analysis.

C = Compressed depth of concrete (i.e. the location of the neutral axis measured from the top of the section)

D = Width or diameter of a tube section.

dA = Differential cross-sectional area of the member

d_s = In plan width of the inclined strut (Figure 4.5).

E_t = Modulus of elasticity in the longitudinal direction of the GFRP shell

$\bar{F}$ = Normal stress at the center of Mohr's circle.

$F_{avarage}$= Average induced principal tensile stress in the FRP shell.

f'c = the unconfined concrete strength

F_c = Concrete strength or equivalent constant stress as mentioned in section 4.4.

f'cc = the confined concrete strength

F_{fc} = Compressive strength of the FRP shell in the longitudinal direction.

F_i = Resultant axial force at the center of the layer (i).

F_{max} = Maximum induced principal tensile stress in the FRP shell.

FOS_{Least}= Least factor of safety for the members.

F_P = Tensile strength of FRP shell in a particular inclined direction.

fr = the ultimate confining stress

F_r = Tensile strength of the FRP shell in the hoop direction.

fs = the tensile strength of the tube in the hoop direction

Fs = Steel yield stress

F_t = Tensile strength of the FRP shell in the longitudinal direction.

$f_{45\pm\theta_i}$ = the ultimate tensile strength at the angle θ_i.

h = Truss height

l = Circumference of the inclined ellipse $\cong \pi \frac{(D+b)}{2}$.

l_B = length of the bearing plate at support point.

l_k = effective length of a CFT column

M = Statistical parameter presents the slop of the relation

M_i = Induced moment due to F_i for a certain layer (i).

${}_cN_c$ = allowable strength of a concrete column

N_{c1} = allowable strengths of a CFT column

${}_sN_c$ = allowable strength of a steel tube column

N_{dR} = Ultimate resistance of the inclined strut (Force)

N_r = Ultimate resistance (Fore) of the horizontal strut

n_w = the total number of winding angles

P_d = Dummy concentrated load applied at the mid-span of the beam

$P_{ultimate}$ = Ultimate concentrated load could be resisted by the beam at the mid-span (Force)

R = Radius of Mohr's circle

t = Pipe thickness

T = Total induced force in a member.

T_{dR} = Ultimate resistance of the inclined tie (Force)

t_j = the lamina thickness for each winding angle

T_{LR} = Ultimate resistance of the horizontal tie (Force)

ts = the thickness of the tube

Vc = the contribution of concrete in shear capacity of the section.

Vj = Contribution of FRP shell in shear capacity of the section.

$Y_{c.t}$ = Moment lever arm (i.e. distance between compression and tension forces)

$Y_{N.A}$ = The distance between the center of the layer to the neutral axis

α = Inclination angle of the strut to the horizontal direction

γ = Correction factor accounts for the reduced shear resisting mechanism of concrete with increased ductility

ε_{Bottom}= Tensile strain in the longitudinal direction at the bottom of the section

ε_{i} = Longitudinal strain at the center of the layer (i).

ε_{t} = Ultimate tensile strain in the longitudinal direction of the GFRP shell

ζ = Correction factor to account for nonlinear stress distribution

η = Correction factor = 0.5

θ = inclination angle of the inclined tie to the longitudinal axis of the beam

σ = Induced stress.

σ_{i} = Induced axial stress at the center of the layer (i) due to strain (ε_{i}).

$90 - \theta$ = inclination angle of the inclined plane to the longitudinal axis of the beam = Inclination angle of the plan of failure to the beam axis

List of Tables

List of Figures