ANALYTICAL AND EXPERIMENTAL ASSESSMENT OF NONLINEAR BEHAVIOR FOR CIRCULAR STEEL HOLLOW SECTIONS UNDER BENDING

By

Eslam Yehia Mohamed El-Sayed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
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STRUCTURAL ENGINEERING

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Under the Supervision of

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Title of Thesis:

Analytical and Experimental Assessment of Nonlinear Behavior for Circular Steel Hollow Sections under Bending

Key Words:
Circular Steel Hollow Sections, Finite Element Analysis, Experimental Assessment, bending moment, Eigen Buckling Analysis, full nonlinear analysis, ovalisation and local buckling

Summary:

This thesis presents an analytical and experimental assessment of the behavior of circular steel hollow sections under bending. Three dimensional non-linear finite element models have been established by ANSYS11 Finite element program to assess the allowable bending strength and D/t limits which separate between the sections types (compact, non-compact, slender). Several parameters are studied; Diameter to thickness (D/t) ratio, length to diameter (L/D) ratio, load conditions, boundary conditions, and variation of steel profile. Nine full-scale circular beams were tested to verify the finite element models; seven specimens were tested in cantilever models and two specimens were tested in simple beam with two concentrated loads. An analytical equation was proposed to predict the allowable bending stress in circular steel tubes. The equation was verified by a parametric study.

Acknowledgment

I would like to express my sincere gratitude to my advisors **Prof. Dr. Sherif Ahmed Mourad** and **Assoc**. **Prof. Dr. Maheeb M. E. Abdel-Ghaffar** for their guidance, support, encouragement, valuable discussions during the course of this work, and great efforts to accomplish the thesis objectives.

I would like also to thank **Eng. Basel Mohamed El-Samman** for his support by providing and helping in using the computer program ANSYS11.

I am also indebted to **Prof. Magdy Kassem**, Director of the concrete Research Lab, Cairo University, Faculty of Engineering for performing the bending tests for the steel tubes. I am also thankful for the help provided by **Monier**, **Sayed** and **Abdel-Tawaab**, Lab Technicians, for their hard and honest work in fixing and constructing the tested models. I am also grateful for **Prof. Khalid El-Zahaby**, Director of Housing and Building National Research center HBRC in Egypt, in addition **Eng. Shady** for performing the tensile tests for the steel coupons.

The financial support to fund the experimental testing was provided by the Civil Engineering Center, Faculty of Engineering, Cairo University. The funding provided by the center and its directors, **Prof. Dr Ahmed Farahat** and **Assoc. Prof. Dr. Hatem Mostafa** is gratefully acknowledged.

I wish also to thank my father, mother, brother and sisters who are always behind me for the success. I could not have achieved this work without their help and participation.

Dedication

To my parents, my dear brother and sisters with love

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Nomenclature

D	Outside diameter of tubes
D_i	Inside diameter of tubes
E	Modulus of elasticity of steel
E_t	Tangent modulus
F_y	Steel yield stress
F_u	Ultimate tension strength of steel
L	Length of sample
M	Bending moment
M_p	Plastic bending moment
M_{pt}	Plastic bending moment according to measured dimensions
M_y	Yield bending moment
M_r	Moment when the relative angle of rotation is 60 degrees
M_{theory}	Predicted ultimate moment capacity
M_u	Ultimate bending moment
S	Elastic section modulus
SF	Shape factor
t	Thickness of steel pipe
Z	Plastic section modulus
$Z_{ovalized}$	Plastic section modulus of an ovalised tube.
α	Slenderness parameter
β	End rotation
β_y	Yield end rotation
κ	Curvature
κ_p	Curvature corresponding to M_p
ε	Constant $(275/F_y)^{0.5}$
λ_s	Generalized section slenderness