Ain Shams University

Faculty of Engineering

Structural Engineering Department

ULTIMATE BUCKLING LOAD OF STIFFENED NON-RECTANGULAR PLATES WITH INITIAL IMPERFECTION

by

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A Thesis

Submitted in partial fulfilment for the requirements of the degree of Master of Science in Structural Engineering

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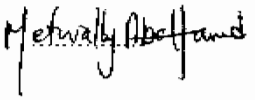
1. *Prof. Dr. Metwalli Abu-Hamad* Prof. of Steel Structures Cairo University	
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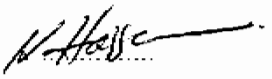
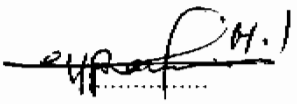
3. *Prof. Dr. Kamal Hassan Mohamed (Supervisor)* Prof. of Steel Structures Head of Structural Department Ain Shams University	
4. *Prof. Dr. Mahmoud Ibrahim El-Banna (Supervisor)* Prof. of Steel Structures Ain Shams University	

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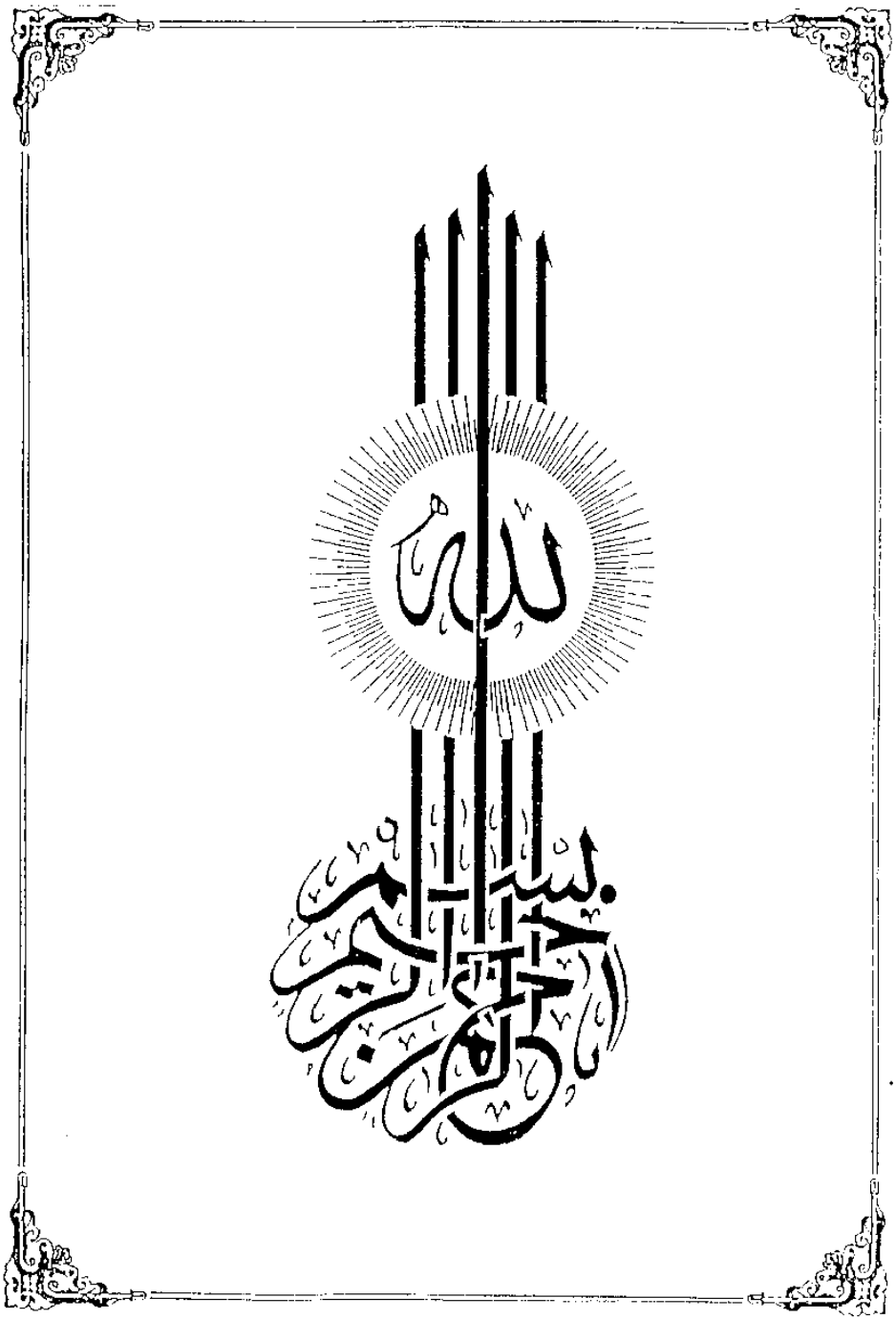

TO MY MOTHER

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of the MASTER OF SCIENCE in Structural Engineering.

The work included in this thesis was carried out by the author in the department of Structural Engineering, Ain Shams University, from October 1990 to September 1993.

No part of this thesis has been submitted for a degree or a qualification to any other university or institution.

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LIST OF SYMBOLS

a , b_1 , b_2	parameters defining the plate dimension .
$b_{av.}$	average width of the plate .
c	opening size .
D	flexural rigidity of the plate .
E	modulus of elasticity .
e	opening eccentricity .
G_r	shear modulus of elasticity .
h	plate thickness .
K	dimensionless buckling coefficient .
k	shear correction factor .
N_k	shape function corresponding to nodal point k .
N_x, N_y	normal force in the global X,Y directions. (stress resultants) .
M_x, M_y, M_{xy}	moments in the global X,Y directions . (stress resultants) .
P	concentrated load acting on the plate .
p , p`	distributed loads acting on the plate .
p_{cr} , P_{cr}	critical buckling load (distributed and concentrated) .
Q_x , Q_y	shear force in the global X,Y direction . (stress resultants) .
U , V , W	global displacements in the X,Y,Z directions .
v^x_{1k} , v^y_{1k} , v^z_{1k}	components of the nodal coordinate v_1 at node k in the global X,Y,Z directions respectively .

LIST OF SYMBOLS 'd

v_{2k}^{x} , v_{2k}^{y} , v_{2k}^{z}	components of the nodal coordinate v_2 at node k in the global X,Y,Z directions respectively .
v_{3k}^{x} , v_{3k}^{y} , v_{3k}^{z}	components of the nodal coordinate v_3 at node k in the global X,Y,Z directions respectively .
X_1 , X_2 , X_3	global coordinate of any point .
$\bar{X}_1$, $\bar{X}_2$, $\bar{X}_3$	unit vectors in the global X,Y,Z directions .
$x_1^{`}$ , $x_2^{`}$, $x_3^{`}$	local coordinate of any sampling point within the element .
$\bar{x}_1^{`}$ , $\bar{x}_2^{`}$, $\bar{x}_3^{`}$	unit vector in the local coordinate directions.
α	ratio between buckling coefficient of trapezoi-dal plates to the coefficient of rectangular plates .
β_{1i} , β_{2l}	rotation of the normal at any point (l) .
$\varepsilon_{x^{`}}$, $\varepsilon_{y^{`}}$, $\varepsilon_{z^{`}}$	normal strain components defined with respect to local system of axes .
$\upsilon_{x^{`}}$, $\upsilon_{y^{`}}$, $\upsilon_{z^{`}}$	shear strain components defined with respect to local system of axes .
$\sigma_{x^{`}}$, $\sigma_{y^{`}}$, $\sigma_{z^{`}}$	noraml stress components defined with respect to local system of axes .
$\tau_{x^{`}y^{`}}$,$\tau_{x^{`}z^{`}}$,$\tau_{y^{`}z^{`}}$	shear stress components defined with respect to local system of axes .
υ	Poison 's ratio .
ξ, η, ζ	curvilinear coordinate of any point within the element

LIST OF SYMBOLS 'd

ξ_k , η_k , ζ_k	curvilinear coordinate of nodal point k for element
γ , β	ratios defining the plate geometry .
δ	opening size to plate average width ratio .
ω_i	weighting f actor for sampling point (i) .

LIST OF MATRICES

$\{ a_i^n \}$	displacements and rotations vector corresponding to load increment n at the ith. iteration .
$\{ \Delta a_i^n \}$	the required change in displacements and rotations vector to minimize the residual force .
$[B]$	strain - displacement matrix .
$[B_i]$	contribution of node i to the strain displacement matrix .
$[B_L]$	linear part of the strain displacement matrix .
$[B_{NL}]$	non-linear part of the strain displacement matrix .
$[D]$	elasticity matrix .
$\{ F^e \}$	nodal force vector .
$\{ F_p^e \}$	nodal force vector equivalent to the body force P per unit volume .
$\{ F_t^e \}$	nodal force vector equivalent to the surface force t per unit area .
$\{ F_{\varepsilon o}^e \}$	nodal force vector equivalent to initial strain .
$\{ f^n \}$	external applied force vector at load increment n .
$[G]$	matrix related to the geometric stiffness and strain displacement matrices .
$[J]$	Jacobian matrix .
$[K]$	tangential stiffness matrix .
$[K_o]$	linear part of the stiffness matrix .
$[K_\sigma]$	geometric stiffness matrix .

LIST OF MATRICES 'd

$[N]$	matrix relating displacements and rotations at any point to the nodal displacements and rotations.
$[N_k]$	contribution from node k to the global matrix N.
$\{ P \}$	body force per unit volume vector .
$\{ p_i^n \}$	internal force vector corresponding to load increment n at the ith. iteration .
$[S]$, $[R]$	matrices containing the partial derivatives of w with respect to x and y .
$\{ t \}$	in-plane force per unit area vector .
$\{ X \}$	global coordinates vector .
$\{ \bar{X} \}$	unit vectors in the global X , Y , Z directions .
$\{x_1\},\{x_2\},\{x_3\}$	local coordinate vectors .
$\{\bar{x}_1\},\{\bar{x}_2\},\{\bar{x}_3\}$	unit vectors in the local x , y , zdirections.
$\{ u_i \}$	displacements vector at any point within the element .
$\{ u_{ik} \}$	displacements at nodal point k .
$\{ u_* \}$	virtual displacements resulting from virtual nodal displacements .
$\{V_{1k}\},\{V_{2k}\},\{V_{3k}\}$	nodal coordinate vectors .
$\{\bar{V}_{1k}\},\{\bar{V}_{2k}\},\{\bar{V}_{3k}\}$	unit vectors in the nodal coordinate directions .
$[\theta]$	transformation matrix between local and global coordinate sets .
$\{ \psi_i^n \}$	residual force vector corresponding to load increment n at the ith. iteration .
$\{ \varepsilon \}$	strain components vector .