Ain Shams University
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Behavior of Bi-Axially Loaded Thin-Walled Tapered Beam-Columns with Doubly Symmetric Sections

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Structural Engineering.

The work included in this thesis has been carried out by the author in the Department of Structural Engineering, Ain Shams University, from December 2006 to October 2012.

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

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ABSTRACT

The behavior and ultimate strength of thin-walled tapered I-section members subjected to bi-axial loading are governed by many parameters; the local buckling of the plate elements forming the section, members' overall slenderness, tapering ratio, and interaction between loading types (axial loading, major axis bending, and minor axis bending). The local buckling pattern mainly depends on the interaction between the width-thickness ratio of the plate elements forming the member's cross section, along with the member slenderness ratio. The effect of this interaction on the behavior of bi-axially loaded tapered members has been studied theoretically in this work.

A verified nonlinear finite element model that allows for both material and geometric non-linearities was constructed for the study. Large numbers of tapered beam-columns having various values of flange and web width-thickness ratios along with different member lengths in order to draw complete ultimate strength-slenderness ratio curves and to study the different modes of failure, which are: local, interactive local-global and overall buckling.

The main aim of the present study is to investigate the effect of these parameters on the behavior of the slender tapered beam-column members subjected to bi-axial loading. To achieve this aim different cases are considered in this study, which are:

- Prismatic columns with constant cross section over the full length of column.
- Tapered columns with different tapering ratios.

For each case, the complete ultimate strength interaction curves was drawn as function of flange and web width-thickness ratio as well as the member overall slenderness ratio. The actual stress distribution at failure for each case was drawn along with the deformed shape all over the column length, and had been investigated to study the post local buckling phenomenon.

The response of the developed models is investigated for different beam-columns whether short, intermediate or long in order to examine the different modes of failure. A series of interaction curves are drawn that can be used for design purpose, also suggestions for future research work are provided.

Key Words:

Structural Engineering; Steel; Stability; Slender Sections; Tapered members; Local Buckling; Global Buckling; Bi-axial Loading; Ultimate Strength; Interaction Diagram.

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NOTATIONS

The following symbols are used in the present thesis; other symbols not listed below are defined where they are first used.

A: Area of the cross section;

A_{eff}: Effective Area of the cross section;

b_f : Flange width;

D : Flexural rigidity of plates;

E : Modulus of elasticity;

ex: Eccentricity in the major axis direction;

ey: Eccentricity in the minor axis direction;

F_y : Yield stress;

f_{max} : Maximum stress at the ends of the plates;

f_x: Compression stress in X-direction;

f_y: Compression stress in Y-direction;

f_{cr}: Critical elastic local buckling stress of plates;

h_w : Web height;

H_2 : Web height of the bigger end in tapered members;

H_1 : Web height of the smaller end in tapered members;

k : Elastic buckling factor of plates;

L : Overall length of the member;

M: Bending moments;

M_x: Ultimate major axis bending moment;

$M_{x[u]}$: Ultimate major axis bending moment for section subjected to major axis bending moment only;