ELASTIC BUCKLING OF SIMPLY SUPPORTED STIFFENED STEEL PLATES WITH A CIRCULAR OPENING UNDER UNIAXIAL COMPRESSION

By

Sarah Ibrahim Mahmoud Ibrahim

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Structural Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Key Words:
Perforated plates; Elastic local buckling; stiffeners.

Summary:

Steel plates are widely used in many structures. Openings may exist for maintenance or inspection purposes in addition to creating paths for different fixtures such as air conditioning, pipes, etc. The structural performance of plates with openings is different from that of solid plates when subjected to axial compressive load. Openings will affect local buckling, lateral torsional buckling and shear of plates. Adding stiffeners around openings is a common engineering practice to strengthen plates. However, different design codes do not provide design formulas for the effect of such openings on the axial buckling strength. In the current research, a parametric study has been performed using general purpose finite element software ANSYS to study the effect of using stiffeners around circular opening in simply supported axially loaded plates on the elastic buckling behavior. Different parameters were considered including aspect ratio of plate, opening diameter, opening position in both horizontal and vertical directions, and stiffener's dimensions. The results of the extensive parametric study are used to propose an empirical design formula considering the different parameters.

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Hoping this thesis would be a step towards a better understanding of our current needs and a better development of our country.

Sarah I. M.

Dedication

To my Mother,
The reason of what I become today,
Thank you for your love, support, advice and care.

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Abstract

Steel plates are used as the main components of steel structures such as ship decks, platforms on oil rigs, and plate and box girders. Openings in such steel plates may be required to provide access for inspection, maintenance, or simply to reduce weight. However, the presences of such openings in plate elements lead to variations in buckling characteristics of the plate element, and accordingly, change the local buckling coefficient factor. Wide variety of geometrical parameters, loading and boundary conditions and addition of stiffeners are all of great importance to be studied to provide a practical equation to calculate the buckling coefficient factor (K) in case of unstiffened and stiffened perforated plates.

A parametric study was held up to study the effect of different parameters of unstiffened and stiffened plates with opening on local buckling behavior. Circular openings having different diameters were considered in this study. Finite element linear models were constructed using general purpose finite element software ANSYS and finite element results have been verified with analytical results discussed in literature review. The unstiffened and stiffened plates with opening studied were simply supported plates subjected to in-plane linearly uniaxial compressive pressure.

An extensive parametric study is performed to study the effect of plate's aspect ratio (α), the width to thickness ratio (λ), openings diameter, opening distance with respect to X and Y axes on the elastic buckling strength of unstiffened and stiffened plates. Afterwards, the results are analyzed to infer key parameters. Accordingly, a formula is developed to estimate the elastic buckling coefficient of unstiffened and stiffened plates with circular openings.