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Buckling analysis of stiffened stepped plates with B-spline finite strip method

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Abstract

The elastic buckling analysis of unstiffened and stiffened plates with a step changing in thickness at arbitrary locations is presented. This analysis is based on the B3-spline finite strip method and in the context of the classical plate theory. Description is given by introducing the concept of multiple knots which makes the method versatile in dealing with any longitudinal change in thickness of the strip element. The problem can be overcome by inserting the multiple knots at the location of the changes. A number of examples are presented to show the accuracy and efficiency of the method.
Keywords: Stepped plate Stiffened plate,B3Spline,multiple knot.

1. INTRODUCTION

Plates with stiffened configuration are extensively used in various constructions of thin walled structures such as bridges, ships, submarines and aircrafts. They usually activate under harsh environmental loading conditions. Among them, the inplane loads are usually larger than other kinds of loading. So, under these conditions, buckling problem becomes one of the important failure mechanisms. Over the past decades, several studies and experimental investigations have been made on the buckling of stiffened plates. These studies deal with plates of constant thickness. The technique of varying the thickness of plates locally is rather attractive, since it brings to higher values of bucking strength of the structures. In addition, less cost pricing structures would be effectuated.

Several approaches have been presented for such plates. Whittrick and Ellen [1] studied the buckling of rectangular plate of varying thickness. Linear and exponential variations in one direction were considered in their study. A perturbation technique was employed by Chehil and Dua [2] to determine the critical buckling stress of a rectangular plate supported with general variation in thickness simply. Mizusawaet al. [3] used B-spline functions and the Rayleigh-Ritz (procedure) to analyze vibration and buckling of plates of abruptly varying stiffnesses with arbitrary boundary conditions. Harik and Andrade [4] presented a finite strip procedure to study the stability analysis of uni-directionally stepped plates. In their analysis, the differential equations of stability for each region are solved and the continuity conditions at the common boundaries as well as boundary conditions are then imposed. Singh and Dey [5] applied the finite difference method to the buckling analysis of bi-directionally stepped plates and presented some useful results. Cheung et al. [6] studied buckling analysis of plates with abrupt changes in thickness and complex boundary conditions by using C1continuous functions as the longitudinal interpolation functions in the finite strip method too .The exact buckling and vibration solution for stepped rectangular plates was presented by Xian and Wang [7]. Azhari, Shahidi and Saadatpour [8] presented a semi-analytical method for analyzing the post-buckling behavior of initially perfect unstiffened stepped plates (i.e., with varying, stepwise constant thickness). Xiang and Wei [9] developed an analytical method for the linear elastic buckling and vibration analysis of stepped rectangular plates.

But most of these work deals with unstiffened stepped plates. The only analytical approach in determining buckling strength of stiffened stepped plates is presented by Brubak and Hellesland [10]. They used an approximate method utilizing the approximate displacement magnifier, which results in buckling strengths that never exceed the elastic buckling loads.