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Inelastic Buckling of Plates Having Step Variation in Thickness using modified B3-Spline Finite Strip Method

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Abstract

In this paper, inelastic buckling of unstiffened and stiffened having step variation in thickness arbitrarily in both directions is presented. The problem is accomplished using the Ramberg-Osgood stress-strain relationship for the material and the deformation theory of elasticity for capturing the inelastic behavior is adopted. The 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 modifies the shape functions on the steps positions making the method versatile enough 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: Inelastic buckling, B3-spline finite strip method, stepped plate, multiple knots.

1. INTRODUCTION

Either stiffened or unstiffened plates are widely used in various structures such as bridges, aircrafts, submarines and so forth. Evidently, the structures are subjected to different environmental loadings, which amongst them in-plane loads may be more important than other types. Therefore, the structure may be on the prone of buckling as a direct result of these inplane loads leading to failure. That's why within the previous decades, this subject has been the main attraction of many researchers. However, most of them address the buckling problem of the ones having a uniform thickness. Meanwhile, the technique of varying thickness of plates locally is rather attractive, as it gives higher values of buckling strength of the structures. In addition, more cost efficient structures can be achieved. Thus, this abrupt change in the thickness of the plate may intensify the difficulty of the problem.

Several approaches have been presented for such plates. Whittrick and Ellen [1] studied the problem of buckling of a variable thickness rectangular plate. Linear and exponential variation in thickness in one direction was considered in their study. A perturbation technique was employed by Chehil and Dua [2] to determine the critical buckling stress of a simply supported rectangular plate with general variation in thickness. Mizusawaet al. [3] used B-spline functions and the Rayleigh-Ritz procedure to analyze vibration and buckling of plates of abruptly varying stiffness with arbitrary boundary. 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 were 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] used a set of C1 continuous functions as the longitudinal interpolation functions in the finite strip method to study buckling analysis of plates with abrupt changes in thickness and complex support conditions. The exact buckling and vibration solution for stepped rectangular plates was presented by Xian and Wang [7]. In their proposed method, the plate is assumed to have two opposite edges simply supported while the other two edges can take any combination of free, simply supported and clamped conditions. 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 a method for the linear elastic buckling and vibration analysis of such plates.

These studies have been done for elastic buckling of the plates; nonetheless, the importance of the subject can be manifolded when it comes to inelastic buckling of such plates, which less has been investigated by