Engineering Analysis with Boundary Elements 35 (2011) 1038–1053

Contents lists available at ScienceDirect

Engineering Analysis with Boundary Elements

journal homepage: www.elsevier.com/locate/enganabound

Buckling analysis of Reissner–Mindlin plates subjected to in-plane edge loads using a shear-locking-free and meshfree method

T.Q. Bui [a,*], M.N. Nguyen [b], Ch. Zhang [a]

[a] Chair of Structural Mechanics, Department of Civil Engineering, University of Siegen, Paul-Bonatz Strasse 9-11, D-57076 Siegen, Germany
[b] Institute of Computational Engineering, Department of Civil Engineering, Ruhr University Bochum, Bochum, Germany

ARTICLE INFO

Article history:
Received 25 September 2010
Accepted 13 April 2011
Available online 18 May 2011

Keywords:
Buckling analysis
Meshfree method
Moving Kriging interpolation
Reissner–Mindlin plate

ABSTRACT

Buckling study of plates subjected to uniformly uniaxial, biaxial in-plane compression and pure shear loads using an efficient novel meshfree method is presented in this paper. The moving Kriging (MK) interpolation technique satisfying the Kronecker delta function property is employed to construct the shape functions. To allow for the effect of transverse shear deformation on thick plates, the first-order Reissner–Mindlin plate theory (FSDT) is adopted. The new formulation enables us to eliminate shear-locking demonstrated by various numerical examples involving both thin and moderately thick plates. It is found that the results achieved by the present approach match well with those obtained by other existing numerical approaches and analytical solutions, which illustrates the applicability, the effectiveness and the accuracy of the method.

1. Introduction

As well recognized in the scientific community that when a plate structure is subjected to in-plane compression or shear loads, it may loss its stability once the load reaches a critical value, and the buckling phenomenon is often referred for this situation of the plate. The buckling load is usually termed for the corresponding critical load at which the plate starts becoming unstable. In this study, our attention focus on the buckling analysis of the Reissner–Mindlin plates based on the FSDT using the meshfree moving Kriging interpolation method which can eliminate the shear-locking completely. As a matter of fact, thick plates are very important structural elements and used in engineering applications such as civil, automobile, aeronautical, aerospace, marine structures, etc. There are a number of displacement-based theories for analysis of plates. Traditionally, the problems of plate stability have been often analyzed by the classical plate theory (CPT) and many contributions can be found in [1–3]. The significant inaccuracy of the CPT arises largely from the use of the Kirchhoff assumption that neglects the transverse shear deformation effects, which become more importance when the thickness of plates increases. This leads to the unsuitability of the CPT in analysis of thick plates and thus, various shear-deformation plate theories are accordingly developed, especially the first-order shear deformation plate theory (FSDT) or the Reissner–Mindlin theory [4–7] is often sufficient, quite accurate and commonly used for the buckling analysis of moderately thick plates. In terms of the use of the FSDT for analysis of plates, constant transverse shear strains along the thickness direction are assumed, which requires a shear correction factor to correct the discrepancy in the transverse shear stiffness. Some early considerations of the extension of the FSDT to analysis of plate buckling problems can be found in [8–14].

In fact, a large number of different approaches have been proposed and applied to the solution of various plate buckling problems including analytical and numerical methods. With respect to analytical solutions, several studies have been reported for this approach, see e.g. [15–18], on the other hand, numerical approaches developed in finding an approximate solution, such as the Rayleigth–Ritz method [14,19–24], finite strip method (FSM) [14,25–29], spline strip method (SSM) [30], spline finite strip method (SFSM) [31–35], differential quadrature method (DQM) [36–41], differential quadrature element method (DQEM) [42], moving least-squares differential quadrature method (MLSDQM) [43], hybrid-Trefftz element [44], boundary element method (BEM) [45–52], finite element method (FEM) [53–57], discrete singular convolution (DSC) method [58,59], etc. Due to the limitations of the analytical methods in finding an exact solution, the FEM is so far efficient, flexible for complicated geometry, and known as one of the most popular numerical techniques for analysis of plates. However, it is generally not an easy task to conveniently construct conformable plate elements of high-order required for thin plates, and there are some problems in re-meshing and large element

* Corresponding author. Tel.: +49 2717402836; fax: +49 2717404074.
E-mail addresses: bui-quoc@bauwesen.uni-siegen.de (T.Q. Bui), c.zhang@uni-siegen.de (Ch. Zhang).

0955-7997/$ - see front matter
doi:10.1016/j.enganabound.2011.04.001