COLLOCATION METHOD FOR VIBRATION ANALYSIS OF LAMINATED COMPOSITES

Alexander Pysarenko
associate professor, PhD, Odessa State
Academy of Civil Engineering and Architecture
ORCID: 0000-0001-5938-4107

Internet address of the article on web-site:
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The numerical analysis of static deformations and free vibrations of shear flexible plates often uses the differential quadrature method [1]. In addition, the mechanical properties of isotropic and laminated plates are determined by the collocation method of an asymmetric radial basis function [2]. Not only a laminated composite plate, but also piezo-laminated samples and laminate samples with distributed actuators can serve as working models for this type of analysis. The advanced computational models presented in this paper have the main objective of exploiting the potential associated with the use of wavelet bases and multiscale methods in the analysis of composite plate problems [3, 4]. The use of such bases leads, on the one hand, to the development of methods of arbitrarily high order, and on the other hand, they exhibit local behavior. Therefore, they can take into account the presence of singularities by locally refining the approximation space. Moreover, they provide a singularity detection tool that has been successfully used in developing efficient adaptive schemes for the numerical solution of several classes of differential equations.

The method used in this paper for the numerical solution is a collocation method based on the Deslauriers-Dubuc interpolation basis in a hierarchical form, which is the first necessary step to apply the adaptive wavelet collocation method to this class of problems. This collocation algorithm can be considered as a very efficient meshless method. The numerical model used a collocation method based on interpolating Delaurier-Dubuc wavelets. Uniform discretization was considered for the model. However, it should be noted that although the collocation method does not require a uniform grid a priori, it can be easily adapted to the case of non-uniform grids of dyadic points. The theory of first-order shear deformation allows to introduce both transverse displacement and angular displacements for rotation around perpendicular axes for the description of vibration characteristics of laminated composites. Transverse and angular displacements are independently interpolated due to the break of the connection between in-plane displacements and bending displacements for symmetrically laminated plates. The equations can be easily obtained from the following. The calculation model is based on the equations of motion for free vibrations of laminated plates, which are modified in the next stage into equations for isotropic plates of laminated composites.

The presence of oscillatory processes in the volume of the laminated composite was investigated under the following boundary conditions: an arbitrary edge with simply supported, clamped or free. The governing equations were written for normal and tangential directions of loading at the edge. The following were subsequently determined: normal bending moment, torque, shear force at the edge of the plate; rotation about axes parallel to the tangential and normal directions at the edge of the plate. At the layer boundaries, continuity of transverse shear stress is required for laminates with different materials along the thickness direction. According to the first-order shear strain assumptions, the transverse shear strain is constant across the thickness, which is a rough approximation to the actual variation even for a uniform cross-section. For uniform cross-sections, the shear strain is usually assumed to be a parabolic function of the normal coordinate. Therefore, a shear correction factor was used to approximate the transverse strain energy on an average basis.

In the first computational study, a square isotropic composite plate with simple supports was considered, which were subjected to a uniform force load. The central node of the plate was characterized by a set of finite number of normalized displacements and normal mechanical stresses. For the second numerical study, a square plate with simple supports was chosen. The plate consisted of a composite material and included four identical layers oriented at an angle of [00/900/900/00]. The plate was under a sinusoidal vertical pressure. In-plane displacements, transverse displacements, normal stresses, and in-plane transverse shear stresses were presented in normalized form.

The improved numerical method produces close to exact displacements for thinner laminated composite plates. The results for thick plates differ from the exact solution due to the absence of normal transverse strain. It should be noted that the obtained solutions are in good agreement with the finite element solutions. The method also produces highly accurate normal stresses. It should be noted that the presented study of static deformations and free vibrations of shear flexible isotropic and layered composite plates corresponds to the results of the first-order shear deformation theory. The numerical method developed in this work allowed us to analyze vibrations in local volumes of isotropic laminated composite plates, as well as in sandwich plates. The numerical experiments conducted allow us to conclude that this method can be used to describe static deformations and free vibrations in composite and sandwich plates.

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АВТОМАТИЗОВАНА СИСТЕМА ДЖОНС-ПОЛЯРИМЕТРІЇ БІОЛОГІЧНИХ ШАРІВ

Бурмич Іван Васильович
магістрант факультету інформаційних електронних систем,
Вінницький національний технічний університет

Інтернет-адреса публікації на сайті:
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Анотація
Розроблено архітектуру інформаційно-вимірювальної системи для лазерної Джонс-матричної мікроскопії біологічних шарів. Запропонована система забезпечує вимірювання та аналіз розподілів дійсних елементів і фазових кутів матриці Джонса біологічних зразків. Автоматизовані алгоритми аналізу дозволяють підвищити точність діагностики біологічних тканин, включаючи епітеліальні та м’язові тканини, до 90%.
Ключові слова: джонс-матриця, лазерна мікроскопія, біологічні тканини, поляриметрія, автоматизація.
Abstract
The architecture of an information and measurement system for laser Jones matrix microscopy of biological layers has been developed. The proposed system provides measurement and analysis of the distributions of real elements and phase angles of the Jones matrix of biological samples. Automated analysis algorithms allow to increase the accuracy of diagnostics of biological tissues, including epithelial and muscle tissues, up to 90%.
Keywords: jones matrix, laser microscopy, biological tissues, polarimetry, automation.

Вступ

Сучасна медицина і біотехнології дедалі більше інтегрують новітні досягнення в оптиці та фотоніці для вирішення складних завдань діагностики та аналізу біологічних тканин. Одним із найбільш перспективних підходів є використання лазерної Джонс-матричної мікроскопії, яка дозволяє детально досліджувати анізотропні властивості біологічних об'єктів, таких як двопроменезаломлення, дихроїзм і деполяризація [1-3]. Ці властивості безпосередньо пов’язані зі структурними та функціональними особливостями тканин і можуть бути використані для раннього виявлення патологічних змін.