Recent Advances in Plate Vibration Research in The University of Hong Kong

Y. K. Cheung
Dept. of Civil Engineering, The University of Hong Kong, Hong Kong

D. Zhou
Dept. of Mechanics and Engineering Science, Nanjing University of Science and Technology, China

ABSTRACT

The Ritz method is a powerful tool in the vibration analysis of structures. Historically, one of the most successful applications of the Ritz method is the vibration analysis of rectangular plates, using the beam vibrating functions as basic functions. It is well known that the accuracy and the applicability of the Ritz method greatly depend on the basic functions used. However, to date, no general approach to develop the suitable basic functions has been presented, and to a large extent, basic functions are experimentally selected. Therefore, customarily the basic functions in vibration analysis are also referred to as trial functions or admissible functions.

In this paper, the recent advances of study on plate vibrations in The University of Hong Kong are introduced. The research work includes three parts. The first part is the study on two-dimensional vibrations of thin plates and shear deformable plates using the static beam functions as the basic functions. The second part is the study on three-dimensional vibrations of thick plates, based on exact elasticity theory and using the Chebyshev polynomials as the basic functions. And the third part is the study on plate-liquid interaction. In the two-dimensional vibration analysis of thin plates and shear deformable plates, attention is focused on rectangular plates with various complexities such as line supports, point supports, tapered thickness and elastic edge constraints etc. A strip with unit width taken from the plate under consideration in a direction parallel to the edge of the rectangular plates is used to derive the basic functions when the strip is acted upon by a series of distributed static loads such as sinusoidal loads for uniform plates and Taylor polynomial loads for tapered plates. Using the static beam functions as basic functions in the Ritz method, two distinct advantages have been demonstrated. One is the high accuracy and rapid convergence in the eigenfrequency computations. The other is the more accurate internal force distribution because the natural boundary conditions of a plate and the discontinuity of shear forces at the line supports are simultaneously considered in the basic functions. In the three-dimensional vibration analysis of thick plates, in addition to the common rectangular plates, circular plates and cylinders, research work has been extended to tori, triangular plates and skew plates etc. by selecting suitable coordinate system or coordinate transformation to describe the plate domain. In comparison with the simple algebraic polynomials, the selection of Chebyshev polynomials as the basic functions not only yields higher accuracy and exhibits numerical robustness but also maintains simplicity in mathematical expression and programming. In the analysis of plate-liquid interaction, a semi-analytical method is developed. Namely, the analytical method is applied to analyze the liquid motion while the Ritz or Galerkin method is applied to analyze the plate vibration. Both the bulging modes and the sloshing modes are simultaneously considered. Attention is mainly focused on vertical rectangular plates, rectangular and circular container bottom plates and flexural rectangular tanks etc. Small computational cost and high accuracy have been demonstrated.

Keywords: plate; two-dimensional vibration; three-dimensional vibration; eigenfrequency; plate-liquid interaction