

Improved Complex Mode Theory and Its Truncating Acceleration Technique

†Yaping Zhao, Yiming Zhang

Department of Mechanical Engineering and Automation, Northeastern University, China.

†Corresponding and presenting author: zhyp_neu@163.com

Abstract

The traditional complex mode theory is substantially improved. The physical parameters of the system, such as the mass, stiffness, and damping, can be mapped to be the dynamical parameters: the natural frequency, the damping ratio, and the complex vibration shape via a generalized eigenvalue problem. In this sense, the natural frequency should be the function with respect to not only the mass and rigidness but also the damping although the influence of the damping is always relatively slight. Based on the improved complex mode theory suggested, the dynamical response of the system with general linear viscous damping can conveniently be worked out by virtue of the superposition of the complex vibration shapes. Due to employing the approach to separate the real and imaginary parts of the complex eigenvalue and eigenvector, the response computation is easier to be implemented on a computer by programming. With the aid of the complex mode expansion of the flexibility matrix discovered, an acceleration method after the truncation during superposing the complex modes is proposed. Numerical examples show that such method is effective for both the narrow and wide band external excitations. Owing to the difference between the inherent frequencies, the state ordinary differential equations often display the stiffness to some extent. In comparison with the classical methods for the stiff ordinary differential equation, e.g. the implicit Runge-Kutta method with varying step size and the Gear method, the complex mode acceleration technique can usually give rise to a steady-state solution with better accuracy.

Keywords: Complex mode, Generalized eigenvalue problem, Vibration shape truncation and acceleration, Mode expansion, Superposition of vibration shape