ABSTRACT

Dynamic stability analysis of structural members subjected to periodic load to predict the regions of dynamic stability plays a significant role in the design phase of structural members of mechanical, aerospace, automobile, civil and other structural systems. An attempt is made in this work to contribute towards the improved understanding of the dynamic stability behavior of the structural members subjected to an end concentrated axial periodic load for beams and uniform edge periodic load for plates and shells using the energy methods. These loads, from now onwards are called as periodic loads.

The beam is one of the basic elements of an engineering structure. It is used in various structural systems of the aforementioned fields of engineering. The dynamic stability behavior of uniform, slender beams, subjected to periodic load is investigated initially for various boundary conditions using simple and standard single term trigonometric admissible functions. It is observed that the general dynamic stability formula developed is independent of the boundary conditions.

Further, the effect of one and two parameter elastic foundations on the dynamic stability regions of a simply supported beam subjected to a periodic load is investigated. The existence of the first transition foundation, for the change of mode shape for buckling is also studied. The general analytical formula for predicting the dynamic stability behavior of beams (uniform and non uniform) subjected to an axial

periodic load and a static tensile load is developed. The dynamic stability of a square plate subjected to a load in one direction and a compressive static load in the perpendicular direction is also investigated.

A simple master formula is developed for the evaluation of natural frequencies of initially loaded structural members, which is useful to determine the fundamental frequency. This is later, required as a reference value to define the non-dimensional values of the applied frequency in the dynamic stability analysis.

The most novel contribution in this thesis is the existence of a master dynamic stability formula, till now not recognized by the other researchers, to predict the dynamic stability regions, applicable to all structural members, right from the beams to shells with complicating effects, subjected to periodic loads. Numerical results for the beams, plates and shells are presented in the analogue and digital forms along with the classical solutions of other researchers, to conclusively bring out the effectiveness of the master dynamic stability formula. Further, two more simple master dynamic stability formulas for the structural members subjected to periodic loads using different non-dimensional parameters are developed. The standard and the effective stiffness, considering the static part of the periodic load, are used to obtain the non-dimensional parameters, involved in these master dynamic stability formulas. An interesting novel concept of the dynamic stability point for the structural members subjected to periodic load with effective stiffness, combining the static and periodic part of the load in the stiffness is proposed.

Later, the work is extended, by including the effect of geometric nonlinearity to predict the nonlinear dynamic stability behavior, of shear flexible beams subjected to a periodic load. A master geometric nonlinear dynamic instability formula is obtained, which is the same as the linear master dynamic stability formula, when the proper reference frequency and buckling load are used for both the linear and nonlinear problems, to non-dimensionalize the applied frequency and the load (combination of concentrated static and periodic parts) respectively.

The results obtained in the present study are validated through a number of demonstration problems available in the literature and a good agreement between these results is seen. The effectiveness of these master dynamic stability formulas are brought out, beyond doubt, through these problems.

The present work is considered to be unique because of the recognition and validation of the several simple master dynamic stability formulas that can be confidently used for the linear and nonlinear dynamic stability analysis of several structural members. The simplicity of the master formula developed here is demonstrated when compared to the highly complex mathematical treatment used by many researchers working in this field for solving the dynamic stability problems till now.