Abstract

The work presented in this dissertation describes the static and dynamic instability (simple and combination resonances) behaviour of both isotropic and laminated composite flat and curved panels with central circular cutout under non-uniform in-plane conservative (compressive and tensile) and non-conservative follower edge loading with the effects of damping. The non-uniform edge loading and the discontinuities in the panel produce complex non-uniform initial (pre-buckle) in-plane stress state within the panel. The nature of initial stress distribution plays a very important role in both static and dynamic stability behaviour of the curved panels.

The work presented in this dissertation mainly deals with the problem of the occurrence of combination resonances in contrast to simple resonances in parametrically excited isotropic and laminated composite flat and curved panels. Bolotin's approach cannot be used to obtain the combination resonance instability regions, so the method of multiple scales (perturbation method) is used to obtain analytical expressions for the simple and combination resonance (sum and difference) instability regions. It is shown that other cases of the combination resonance (sum and difference) can be of major importance and yield a significantly enlarged instability region in comparison to the principal instability region. The effects of non-uniform edge loading, centrally located circular cutout and damping on dynamic instability (simple and combination resonances) behavior of isotropic and laminated composite curved panels are studied.

The results show that under localized edge loading (conservative or non-conservative), the combination resonance (sum and difference) instability zones are as important as simple resonance instability zones. The effects of damping show that there is a finite critical value of the dynamic load factor for each instability region below which doubly curved panels cannot become dynamically unstable. A central circular cutout has the destabilizing effect on the dynamic stability behavior of isotropic and laminated composite curved panels subjected to non-uniform edge loading. It is also found that the combination resonances of the sum type and difference type can exist in the isotropic and laminated composite flat and curved panels, when these panels are subjected to non-

uniform non-conservative follower forces. This example of simultaneous excitation of two modes, each oscillating steadily at its own natural frequency, may be of considerable interest in vibration testing of actual structures.

The theory used for the formulation of the problem is the extension of dynamic shear deformable theory according to Sanders' first approximation for doubly curved shells, which can be reduced to Love's and Donnell's theories by means of tracers. The first order shear deformation theory (FSDT) is used to model the curved panels, considering the effects of transverse shear deformation and rotary inertia. To discretize the continuum and then to use finite element approach, an eight-node curved isoparametric quadratic element is employed in the present analysis with five degrees of freedom per node. Since the stress field is non-uniform, due to arbitrary nature of the applied in-plane load and due to the presence of opening in the panel, plane stress analysis has been carried out using the finite element method to determine the state of in-plane stress distribution. This state of stress is then used to generate the geometric stiffness matrix.

Analytical results are presented to show the effects of geometry, edge loading (conservative or non-conservative), boundary conditions, central circular cutout, damping and other important parameters on static and dynamic instability (simple resonance instability or combination resonance instability) of isotropic and laminated composite flat and curved panels. Comparison of the results has been made with the available literature, wherever possible. Conclusions are drawn highlighting the important findings of the study.

The thesis has been organized into six chapters.

Chapter 1: It includes the general introduction and importance of the present work, which is presented in this dissertation.

Chapter 2: The review of literature confirming to the scope of present study has been highlighted in it. The important works done and the general methods of solution of static and dynamic instability (simple and combination resonances) problems of plates and shells under conservative and nonconservative force systems have been briefly indicated in this chapter after critical discussions of the references.

Chapter 3: It comprises of the mathematical formulation of the problem based on Hamilton's principle. Finite element technique has been used for the development and solution of the problem for evaluating the vibration, buckling, parametric instability (simple resonance instability) and flutter characteristics of the curved panels. Analytical expressions are developed to obtain the simple and combination resonance instability regions by using the method of multiple scales (perturbation method).

Chapter 4: The problems considered for the analysis are briefly explained in this chapter. The descriptions about the geometry of panels, loading types, boundary conditions and material properties are given in this chapter.

Chapter 5: The detailed results and discussions on vibration, static and dynamic instability (simple and combination resonances) behaviour of flat and curved panels with central circular cutout subjected to non-uniform conservative and non-conservative follower forces with or without effects of damping are presented in this chapter.

Chapter 6: The important conclusions drawn from the present investigation and possible scope of extension of the present work have been presented in this chapter.

A list of important reference books, papers and articles are listed in **Bibliography** section.

Key words: Combination resonance instability, plate and curved panels, the method of multiple scales, finite element method, non-conservative follower force, composite laminate, cutout, damping.