AN APPROXIMATE STABILITY ANALYSIS OF A TANGENTIALLY LOADED COLUMN SUPPORTED BY MAXWELL-TYPE VISCOELASTIC FOUNDATION

by

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INTRODUCTION

During recent years, the study and analysis of elastic systems with follower forces has become very important. There are many examples of todays' engineering problems in this category; cantilever pipes conveying fluid [1], aerodynamic flutter of panels [2], vertical take-off and landing aircraft [3,4,5], and pod-mounted jet engines [6]. Under certain conditions, chemical or electromagnetic energy can also induce follower type forces into a system [7].

All these systems are subjected to forces which follow the motion of the system in some prescribed manner. The presence of the follower forces causes the system to be nonconservative. The nonconservative system has two modes of instability, static and dynamic. Static instability, which is called buckling or divergence, occurs when the system assumes a new equilibrium position close to the original configuration of the system. Dynamic instability, or flutter, results when a small disturbance about an equilibrium position causes oscillations which increase without bound. The static method produces conditions of instability for conservative systems but does not provide any information about the dynamic instabilities of the nonconservative systems.

There have been many researchers who have worked on the analysis of the nonconservative systems. Beck [9] was the first to obtain the correct solution of the linear elastic cantilevered Euler's column under the action of a concentrated tangential force. This system is referred to as

Beck's problem. Nemat-Nasser [10] used the Timoshenko beam theory to develop the equation of motion. He found the resulting critical load to be less than that based on the Euler-Bernoulli beam theory. Ziegler [11] used a cantilever column made of a viscoelastic material. His results showed that under certain conditions small internal viscous damping affected the stability of stable system. Then Prasad and Herrmann [12] and Nemat-Nasser and Herrmann [13] showed that the flutter load found for an undamped elastic system subjected to follower forces is the upper bound for systems with slight internal damping.

External damping plays an uncertain role in the stability of non-conservative systems as well. This has been shown by Plaut and Infante [14], Anderson [15], and Pedersen [16]. They found that the flutter load increases with external viscous damping but only to an asymptotic value. Therefore, the damping plays an uncertain role on the system of stability.

The problem of stability has also included several boundary conditions on the free end. Rigid or elastic end supports used by Bartz [17] and Sundararajan [18] with no stabilizing effect. Pedersen [16] used a concentrated tip mass, a linear elastic spring, and a partial follower force and described their effects on the flutter load.

Elastic and viscoelastic foundations have been used to design support for nonconservative systems in order to prevent failures. Anderson [20] discussed the effect of an elastic foundation on the stability of cantilever columns subjected to uniformly and linearly distributed tangential forces. Peterson [21], Smith and Herrmann [22], and Sundararajan [23] added a continuous elastic support to the column and found that the flutter frequency increased but the flutter load remained unchanged. Wahed [24]