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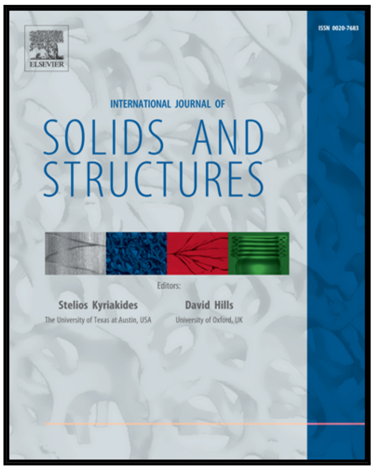

Coupled Lateral And Axial Soil-Pipe Interaction And Lateral Buckling

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COUPLED LATERAL AND AXIAL SOIL-PIPE INTERACTION AND LATERAL BUCKLING Part II: Solutions

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Abstract

This paper presents techniques for constructing numerical solutions for some of the problems formulated in Part I. An algorithm to search for periodic solutions is developed and implemented in software. It is shown that there exist a finite number of discrete well defined periodic solutions for the lateral buckling problem of a straight pipeline under constant pressure and temperature. It is also shown that periodic solutions are unstable. A second numerical algorithm is developed for solving lateral buckling problem for an initially straight semi-infinite pipeline terminating at a sliding manifold under constant or varying temperature profiles. The resulting boundary value problem requires special numerical methods due to the stiffness of the governing differential equations. Algorithm is applied to find the solutions of problems for three different size pipelines; an 8.625 inch, a 16 inch, and a 32 inch diameter. Multiple stable chaotic solutions corresponding to distinct but extremely close initial conditions are revealed. The characteristics of these solutions match with the characteristics of the periodic solutions. This suggests that unstable periodic solutions act as separatrix between narrow zones containing stable chaotic solutions. It is seen that chaotic solutions can relieve a significant portion of the thermal and pressure loads without inducing excessive pipeline displacements. The results show that the pipeline end expansion is significantly less than the value given by common engineering methods. It is also shown that pipeline operating conditions and soil-pipe interaction parameters influence the stability and bifurcations of solutions.

2.1 Introduction

The main objective in Part II is to develop algorithms to construct numerical solutions for two of the Boundary Value Problems (BVP) formulated in part I. In this paper, the formulation developed in Part I is referred as “coupled” problem, formulation, or model. The second goal of this paper is to demonstrate the scope and capabilities of the coupled formulation by applying the developed solution algorithms to example problems. Another major aim is to study the characteristics of the coupled model solutions such as their stability, their domains of existence, and bifurcations.

Next section describes the selection of example pipeline problems utilized to demonstrate the solution algorithms and to highlight the important characteristics of solutions for various problems. Section 2.3 presents a numerical algorithm to construct periodic solutions of the coupled problem. A search algorithm based on optimization techniques is implemented on Mathematica software platform (Wolfram 2016)[1] utilizing DynPac, a dynamical systems package developed on Mathematica software