CHAPTER I

INTRODUCTION

1.1 General

The mechanism of load transfer from an elastic bar to an elastic half-space has received wide attention over the last four decades due to its useful applications in civil engineering. For example, the basic model of an embedded elastic bar can be used to serve as useful approximations for an axially loaded elastic pile, a reinforcing rod in concrete and analytical models used for in-situ testing methods.

The problem of load transfer from an axially loaded elastic pile to the surrounding soil is investigated in this study. Previous studies of this problem are usually based on the assumptions that the soil behaves as an elastic material and its profile is homogeneous. These assumptions are not entirely accurate since natural soil is normally a porous elastic solid filled with water and multilayered in character. Therefore, a multilayered poroelastic medium should be considered instead of a homogeneous elastic or poroelastic half-space in order to represent a much more realistic approximation to the problem.

In this thesis, a variational formulation is used to formulate the total potential energy functional for the system of an elastic bar and a multilayered poroelastic half-space. By minimizing the total potential energy functional, the time dependent behavior of the bar can be predicted.

1.2 Literature Review

The fundamental work related to the load transfer from a cylindrical elastic inclusion of infinite length to an elastic medium was first examined by Muki and Sternberg[1]. Muki and Sternberg[2] also investigated the problem of an axially loaded elastic bar of finite length and circular cross section embedded in bonded contact with an elastic half-space. This investigation is based on the assumption that the bar behaves as a one-dimensional elastic continuum. Such assumption is valid for situations in which the length-to-diameter of the bar is comparatively large.

Selvadurai and Rajapakse[3] later investigated the problem of an axially loaded elastic bar partially embedded in an isotropic homogeneous elastic medium by using a variational formulation together with Muki and Sternberg's assumptions[1],[2]. In their paper[3], the deformation of the bar was assumed to be one-dimensional and specified by a function with a set of unknown constants in order to formulate the total potential energy functional of the bar-elastic medium system. Thereafter, the minimization of the total potential energy functional was used to determine these constants and the axial displacement of the bar was finally obtained.

In order to study the effect of poroelasticity, Niumpradit and Karasudhi[4] and Apirathvorakij and Karasudhi[5] investigated the quasi-static behavior of a cylindrical elastic bar partially embedded in a homogeneous poroelastic half-space with incompressible constituents by adopting Muki and Sternberg's schemes[2]. In their papers, the bar is subjected to an axial load[4] and a lateral force together with a moment at the top end[5], respectively.

The papers mentioned in the foregoing paragraph consider only the case where the half-space is a homogeneous medium whereas natural soil profiles are normally layered in character. A number of researchers in the past have studied static and quasi-static responses of a multilayered half-space. Muki and Dong[6] and Rajapakse and Karasudhi[7] employed the finite element approach combined with the far-field behavior of elastic fields to study the response of a layered ideal elastic half-space. Vardoulakis and Harnpattanapanich[8] used the conventional method based on the determination of a set of arbitrary functions in Fourier or Hankel transform space to evaluate the quasi-static response of a layered poroelastic medium with incompressible constituents. However, incompressibility of constituents is an approximation which is valid mainly for soils but not for porous rocks.

Recently, Senjuntichai and Rajapakse[9] developed a computationally efficient and numerically stable exact stiffness matrix scheme to evaluate quasi-static response of a multilayered poroelastic medium with compressible constituents from the general solutions presented by Rajapakse and Senjuntichai[10]. In their approach[9], the Laplace-Hankel transforms of displacements and pore pressure at layer interfaces are considered as the basic unknowns and the general solutions are used to construct explicitly the stiffness matrix which describes the relationship between the generalized displacement and force vectors of a layer. The global stiffness matrix of the multilayered half-space is assembled by considering the continuity conditions of tractions and fluid flow at the interfaces between the adjacent layers.

1.3 Objective and Scope of Present Study

The objective of this thesis is to determine quasi-static behavior of an axially loaded elastic bar with circular cross section embedded in a multilayered poroelastic half-space by adopting Selvadurai and Rajapakse's scheme(3) and the exact stiffness matrix method proposed by Senjuntichai and Rajapakse (9). The effect of considering a soil medium as a multilayered half-space instead of a homogeneous half-space is also investigated. A computer program was developed for evaluating the time dependent response of the bar.

1.4 Basic Assumptions

The investigation of load transfer from an axially loaded elastic bar to a multilayered poroelastic medium in this thesis is based on the following assumptions:

1. Each layer of the multilayered medium is considered as a homogeneous poroelastic material and behaves according to Biot's theory of poroelasticity(11).

2. The bar behaves as a one-dimensional elastic continuum.

3. The contact surface between the bar and the multilayered medium is perfectly bonded and fully permeable.