CHAPTER I

INTRODUCTION

1.1 General

An important class of problems encountered in geomechanics is concerned with the study of interactions between a circular elastic plate and an elastic half-space due to its useful application in civil engineering. For example , the plate-elastic half-space model can be used to study the working load response of surface or embedded foundations , anchor plates resisting uplift loads and theoretical modelling of some in-situ testing methods. The representation of a soil domain as an ideal elastic half-space may not be totally accurate because a soil medium is generally a two-phased material consisting of a solid skeleton with voids filled with water. Such a material is commonly known as a poroelastic material and widely considered as a much more realistic representation for soils and rocks than an ideal elastic material. Moreover, natural soil profiles are normally layered in character. Therefore, the representation of a soil domain as a multi-layered poroelastic half-space should be employed for the problem mentioned above.

In this thesis , the system of a circular elastic plate resting on the surface of a multi-layered poroelastic half-space subjected to a centrally applied force P_0 and uniformly distributed load of intensity q_0 as shown in Fig 1.1 is considered by adopting a variational scheme associated with discretization technique (Rajapakse, 1988) together with the exact stiffness matrix mehtod (Senjuntichai and Rajapakse, 1995) .

1.2 Literature Reviews

A number of problems related to the interaction between an elastic plate and an elastic half-space have been considered by many researchers in the past. The problem of a circular elastic plate resting on the surface of an isotropic or a transversely isotropic half-space has been solved by employing a variety of analytical and numerical techniques such as integral equation method (Palmov,1960), power series techniques (Brown,1969), a finite difference method based on displacement compatibility between plate and an elastic half-space (Barden,1965), variational methods (Selvadurai,1979 ; Selvadurai,1980) and the finite element method (Hooper,1974 ; Hooper,1975). In addition , Rajapakse(1988) and Rajapakse and Selvadurai(1991) presented numerical solutions for a plate buried at a finite depth below the free surface of a half-space by using a constraint variational scheme and associated discretization technique. In the paper by Rajapakse(1988) , the displacement of the plate is represented by an admissible function of the radial coordinate containing a set of generalized coordinates. The contact pressure corresponding to each term of the assumed displacement function is evaluated by dividing the contact surface into several concentric annular rings with uniform pressure distribution and then solving a flexibility equation for the half-space. The influence functions which are required to establish the flexibility equations correspond to vertical displacements due to unit vertical pressure acting over an annular region on the half-space . Thereafter , the total potential energy functional of the plate - half-space system can be derived by using the assumed displacement function and the representation for the contact pressure. Finally, the minimization of the total potential energy functional with respect to generalized coordinates results in a system of linear simultaneous equations. These equations are solved numerically to obtain values of generalized coordinates and then the flexural behaviour of the plate can be determined.

However , all solutions mentioned above considered a soil domain as a dry elastic material whereas soil is generally water-saturated and therefore undergoes a consolidation settlement under applied loadings . Biot(1941) presented the general theory of soil consolidation by adopting Terzaghi's concepts (1925) . Over the last four decades , Biot's theory has been the basis for analysis of a variety of geomechanic problems involving poroelastic region , e.g., soil consolidation (McNamee and Gibson , 1960 ; Rajapakse and Senjuntichai , 1993) , borehole problems (Detournay and Cheng,1988 ; Rajapakse,1993), etc.. Recently, Senjuntichai and Rajapakse(1995) developed a computationally efficient and numerically stable exact stiffness matrix scheme to evaluate quasi-static response of a multi-layered poroelastic half-space with compressible constituents by using the general solutions presented by Rajapakse and Senjuntichai(1993). Fourier expansion, Laplace transforms and Hankel transforms with respect to the circumferential, time and radial coordinates,respectively, are used in the formulation. The exact stiffness matrices describing the relationship between generalized displacement and force vectors of a finite layer and a half-space are derived explicitly in the transform space. The global stiffness matrix of a multi-layered half-space is assembled by considering the continuity conditions of tractions and fluid flow at the interface between the adjacent layers. The solution of the global stiffness equation system results in the displacement and pore pressure at the layer interfaces.

The consolidation problems of a plate resting on a homogeneous poroelastic medium has lately been investigated by employing Biot's theory of poroelasticity. Selvadurai and Yue(1994) and Yue and Selvadurai(1995) studied the interaction problem between a rigid plate and a homogeneous poroelastic half-space by applying integral transform techniques. The finite element method has also been employed to study the quasi-static behaviour of a raft foundation (Small and Zhang,1994). A review of literature indicates that the interaction between an elastic plate and a multi-layered poroelastic half-space has not been considered in the past .

1.3 Objectives and Scopes of Present Study

This thesis is concerned with the flexural behaviour of a circular elastic plate resting on the surface of a multi-layered poroelastic half-space under axisymmetric loadings as shown in Fig. 1.1 . The displacement and bending moment of the plate are determined by using the numerical solution scheme proposed by Rajapakse(1988) and Senjuntichai and Rajapakse(1995) . A computer program based on these methods is developed and the accuracy and numerical stability of the present solution scheme are verified . Finally , the influence of various parameters on the quasi-static behaviour of the plate is investigated.

1.4 Basic Assumptions

The following assumptions are employed in the present study.

1) A circular elastic plate behaves according to the classical Kirchhoff theory.

2) Each layer of a multi-layered poroelastic half-space is homogeneous, isotropic and behaves acccording to Biot's theory of poroelasticity.

3) The contact surface between the plate and the multi-layered half-space is assumed to be smooth and fully permeable.

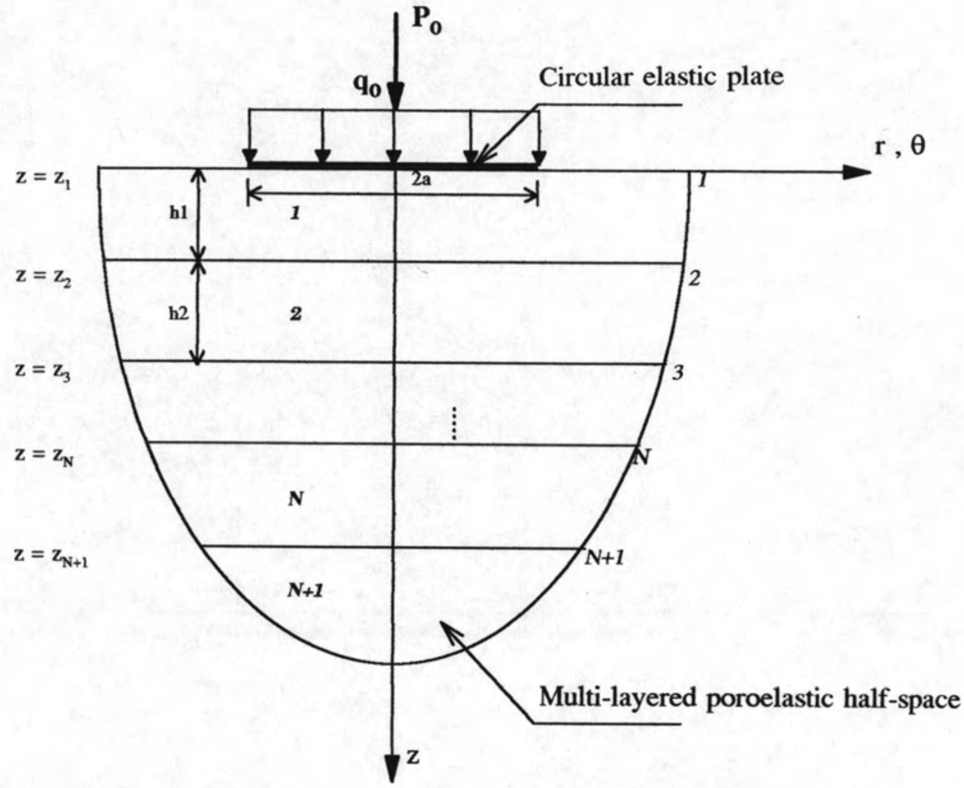

Figure 1.1 : Geometry of the problem considered in this study

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