YAMANASHI UNIVERSITY OF JAPAN

DYNAMIC RESPONSE OF POROELASTIC HALF-PLANE UNDER SURFACE MOVING EXCITATIONS

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(Abstract)

On the basis of Biot's dynamical theory of poroelasticity, the disturbances produced by an impulsive line load applied normal to the surface , impulsive shearing stress , impact loads and other type of loadings in a porous elastic half-space are studied. Three cases are considered: (a) Subsonic Case (b) Supersonic Case (c) Transonic Case . Laplace-Fourier transform is utilized for solving displacement and stress potentials in terms of which the displacements and sresses in the transformed space are expressible . The expressions for the displacements and stresses in the interior of the half-space are obtained by Cagniard's technique . In each case , the expressions for displacements and stresses are obtained . The displacements and stresses are expressed in terms of six algebraic terms :- three of which are identified as the disturbances due to specific wave fronts and the others represent the head wave contribution . Fatt's values for poroelastic parameters are utilized in the numerical calculations . Lastly comparisons are made to the disturbances produced by the classical elastic material .

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1. INTRODUCTION.

The problem of dynamical and moving loads on the surface of poroelastic material is of considerable practical and theoretical interest in connection with soil mechanics, petroleum prospecting and flow of fluids through sand. The wave produced by moving vehicles, impacts and other types of dynamical loads on a foundation of poroelastic materials in nature fall into this category.

Poroelastic materials are two-phase systems consisting of a porous, elastic solid phase filled with a Newtonian viscous fluid phase.

The theory of poroelastic media has its origins in the one-dimensional theory of soil consolidation formulated by Terzaghi which was later generalized by Biot in a series of papers. Studies by Biot (1956) of the field equations governing the propagatio of small-amplitude disturdances in an isotropic, elastic, liquid-filled porous medium have revealed the existence of three body waves - an equivoluminal wave (shear, transverse, distortional or secondary) and two dilatational waves (longitudinal, compressional, irrotational or primary). The two dilatational waves are called the dilatational wave of the first kind and the dilatational wave of the second kind. In the absence of dissipation, these waves are elastic in nature, the propagation being at constant velocity and with undiminished amplitude. If friction at the solid-liquid interface is taken into account, each of the wave is dispersive and dissipative, i.e, the velocity is a function of the frequency and the amplitude under spatial attenuation (for a given frequency). In this paper only the earlier one is considered, A number of authors have utilized and applied the dynamical theory of Biot to some special problems. For examples, Deresiewicz, Deresiewicz and Rice, and Jones have applied it to study the effect of boundaries on wave propagation in a fluid-filled porous solid for various cases. Paul has investigated the problem of the displacement produced by a doubly infinite line load applied normally to the bonding surface with impulsive time dependence. P.C. Pal has investigated the disturbance produced by an impulsive shearing stress acting on the surface which is assumed to move with a uniform velocity after creation. Paul has evaluated the displacement in the solid but not numerically. On the other hand, P.C. Pal has evaluated the surface displacement numerically.

In this paper, the dynamic response due to the following type of loadings are investigated;

1. A doubly infinite line load applied normally to the bonding surface with impulsive time dependence.
2. An impulsive shearing stress acting on the surface which is assumed to move with a uniform velocity after creation.
3. Impact Loads.
4. Stop load after moving at any time interval.

Further, three more cases are considered for each type of loadings mentioned above, characterized by the velocity of the moving loads.

a. The load is moving more slowly than either the equivoluminal or dilatational wave speeds of the poro-elastic medium (Subsonic Case).

b. The load speed is greater than either wave speed (Super-sonic Case).

c. The load speed is between the two wave speeds(Transonic Case).

In the analysis, the displacements and stresses are expressed in terms of four displacement potentials as in Deresiewicz and Rice followed by the application of the Laplace-Fourer transform to solve the displacement and stress potentials in the transform space. The Cagniard's technique modified by Gakenheimer is used to evaluate the displacements and stresses. The displacements of solid and fluid and stresses are obtained.

Finally, numerical formulas are explored numerically, using values of material constants computed from experimental data reported by Fatt for a kerosene-filled sandstone . The exact closed solutions of each case of moving velocities such as subsonic, supersonic and transonic cases are obtained and typical examples of numerical results with the passage of time after the load starting to act are shown. The numerical results obtained are compared, whichever possible, with those of the classical elastic case which were investigated by K.Hirashima and N.Niguchi and discuss the differences observed.