DOWNLOAD PDF WAVE PROPAGATION IN INFINITE DOMAINS

Chapter 1 : Wave propagation - Wikipedia

Wave propagation in infinite or unbounded domains is often encountered in scientific and engineering applications. Theoretical fundamentals and applications of a new numerical model which has the ability to simulate such wave propagation are presented.

 Abstract Exact time domain solutions for displacement and porepressure are derived for waves emanating from a pressurized spherical cavity, in an infinitely permeable poroelastic medium with a permeable boundary. Cases for blast and exponentially decaying step pulse loadings are considered; letter case, in the limit as decay constant goes to zero, also covers the step uniform pressure. Solutions clearly show the propagation of the second slow p-wave. Furthermore, Biot modulus Q is shown to have a pronounced influence on wave propagation characteristics in poroelastic media. Results are compared with solutions in classical elasticity theory. Introduction Cavity pressurization problems circular and spherical constitute one of the basic problems of wave mechanics and since early s considerable scientific work has been published on cavity problems in classical elasticity theory [1 â€" 5]. These problems generally are amenable to exact solution and the analytical solutions cast new light onto the nature of wave propagation in solid media. The problem has practical applications in geophysics, seismology, and, tunnel and mining engineering, like earthquake sources, underground detonation and seismic probing. The exact solutions of such simple problems serve to understand more complex wave motions; moreover, these solutions can also be used as benchmark problems to assess the accuracy of numerical methods FEM, BEM, FDM, etc. Being a relatively new extension of classical elasticity theory, the corresponding work exact time or frequency domain solutions in poroelasticity is rare. Notable efforts are the Laplace domain solution of circular cavity problem [7 , 8] and frequency domain solution of suddenly pressurized spherical cavity [9]; an analytical solution in Laplace domain for a dynamically loaded poroelastic column [10 , 11] is also available. Fundamental solutions of poroelastodynamics can be found in [12 â€" 15]. The reader is referred to the review article [17] for a compendium of other analytical and numerical solutions. This work concerns time domain analytical solution of dynamic pressurization of a spherical cavity in an infinite poroelastic medium with permeable boundary and quiescent initial conditions. Time domain solutions are derived by analytical inverse Fourier Transform using complex residue theorem. Since finite permeability renders frequency domain equations extremely difficult to invert, infinite permeability is assumed in the medium. Infinite permeability is a reasonable approximation for coarsely grained media like gravely soils or pebbles. The analytical solutions are derived for Dirac blast , exponentially decaying step pulse as well as constant uniform Heaviside pressure. The developed solutions clearly show the existence of a second pressure wave, the so-called slow wave. Biot introduced his linear quasistatic theory in [18] and later extended it to cover the dynamic range [19 , 20]. An extensive review of quasistatic poroelasticity can be found in [21 , 22]. The constitutive equations of linear-isotropic poroelasticity are summation convention applies where are the strains in the solid and are components of solid displacement vector and total stress tensor, is the fluid pressure, is the variation of fluid volume per unit reference volume, and is the Kronecker delta. Here, tensile and are positive, while pore pressure is positive when being compressive. The four material constants of poroelastic media are: Let , , and be the spherical components of solid displacements. Because the cavity is spherically symmetric and we assume a time varying but spherically symmetric pressure inside, waves emanating from such a source will have spherical symmetry; that is, The Fourier Transform and its inverse on time variables are defined as The governing equations of 3D poroelasticity in Fourier Transform Space FTS or frequency domain in this case reduce to the following the reader is referred to [9] for derivation: Here, denotes the only nonzero displacement for simplicity, that is, radial component , is a coefficient defined as The stress components are related to the radial displacement as Figure 1: Description of problem, pressurized spherical cavity in infinite poroelastic medium. Boundary Conditions Among various possible combinations of traction, displacement, pore pressure, and fluid flux, only the permeable boundary condition will be considered here; that is, where is the amplitude strength of the force and is the time variation of the stress on the boundary, and here, two cases will be considered: Thus, the solution for latter boundary condition will also include the step Heaviside pressure as a special case. Analytical Solution in Frequency Domain The complete analytical solution of this problem in frequency domain [9] is.

DOWNLOAD PDF WAVE PROPAGATION IN INFINITE DOMAINS

Chapter 2 : Wave propagation in 2D random granular media â€" University of Illinois at Urbana-Champaign

Note: Citations are based on reference standards. However, formatting rules can vary widely between applications and fields of interest or study. The specific requirements or preferences of your reviewing publisher, classroom teacher, institution or organization should be applied.

Received Oct 18; Accepted Dec Abstract Exact time domain solutions for displacement and porepressure are derived for waves emanating from a pressurized spherical cavity, in an infinitely permeable poroelastic medium with a permeable boundary. Cases for blast and exponentially decaying step pulse loadings are considered; letter case, in the limit as decay constant goes to zero, also covers the step uniform pressure. Solutions clearly show the propagation of the second slow p-wave. Furthermore, Biot modulus Q is shown to have a pronounced influence on wave propagation characteristics in poroelastic media. Results are compared with solutions in classical elasticity theory. Introduction Cavity pressurization problems circular and spherical constitute one of the basic problems of wave mechanics and since early s considerable scientific work has been published on cavity problems in classical elasticity theory [1 â€" 5]. These problems generally are amenable to exact solution and the analytical solutions cast new light onto the nature of wave propagation in solid media. The problem has practical applications in geophysics, seismology, and, tunnel and mining engineering, like earthquake sources, underground detonation and seismic probing. The exact solutions of such simple problems serve to understand more complex wave motions; moreover, these solutions can also be used as benchmark problems to assess the accuracy of numerical methods FEM, BEM, FDM, etc. Being a relatively new extension of classical elasticity theory, the corresponding work exact time or frequency domain solutions in poroelasticity is rare. Notable efforts are the Laplace domain solution of circular cavity problem [7 , 8] and frequency domain solution of suddenly pressurized spherical cavity [9]; an analytical solution in Laplace domain for a dynamically loaded poroelastic column [10 , 11] is also available. Fundamental solutions of poroelastodynamics can be found in [12 â€" 15]. The reader is referred to the review article [17] for a compendium of other analytical and numerical solutions. This work concerns time domain analytical solution of dynamic pressurization of a spherical cavity in an infinite poroelastic medium with permeable boundary and quiescent initial conditions. Time domain solutions are derived by analytical inverse Fourier Transform using complex residue theorem. Since finite permeability renders frequency domain equations extremely difficult to invert, infinite permeability is assumed in the medium. Infinite permeability is a reasonable approximation for coarsely grained media like gravely soils or pebbles. The analytical solutions are derived for Dirac blast , exponentially decaying step pulse as well as constant uniform Heaviside pressure. The developed solutions clearly show the existence of a second pressure wave, the so-called slow wave. Biot introduced his linear quasistatic theory in [18] and later extended it to cover the dynamic range [19 , 20]. An extensive review of quasistatic poroelasticity can be found in [21 , 22].

DOWNLOAD PDF WAVE PROPAGATION IN INFINITE DOMAINS

Chapter 3 : Spherical Wave Propagation in a Poroelastic Medium with Infinite Permeability: Time Domain S

Wave propagation in unbounded domains is one of the important engineering problems. There have been many attempts by researchers to solve this problem. This paper intends to shed a light on the finite point method, which is considered as one of the best methods to be used for solving problems of wave propagation in unbounded domains.

 Abstract Wave propagation in unbounded domains is one of the important engineering problems. There have been many attempts by researchers to solve this problem. This paper intends to shed a light on the finite point method, which is considered as one of the best methods to be used for solving problems of wave propagation in unbounded domains. To ensure the reliability of finite point method, wave propagation in unbounded domain is compared with the sinusoidal unit point stimulation. Results indicate that, in the case of applying stimulation along one direction of a Cartesian coordinate, the results of finite point method parallel to the stimulation have less error in comparison with the results of finite element method along the same direction with the same stimulation. Introduction The rapid development of computers and computation power within the last decade encouraged researchers from different disciplines to show more interest in the usage of numerical methods. Wave propagation is one of those numerical modeling problems which have been a major focus of some of the researchers. However, it is only in recent years that physicists had acknowledged the nature of masses not just as particles but also as waves [1] and they emphasized the importance of the wave propagation modeling. The methods used to solve the differential equations have been categorized into two groups: Previous studies showed that using mesh in modeling the wave propagation may cause wave to emanate lead [3]. According to Fatahpour [3], this lead is caused by the shape of the elements and their positioning with respect to each other. In addition, Gerdes and Ihlenburg [4] and Harari and Nogueira [5] highlighted the effects of the shape function problem of the elements used for modeling wave propagation in unbounded domains in their studies. Furthermore, the finite element modeling of wave propagation resulted in the phase difference problems of response, numerical approximation, and pollution error [4]. Accordingly, based on the problems of network in wave propagation, there are two methods that can be used for solving the wave propagation problems. Meshless method offers solutions despite the problems associated with its use, such as singularity of stiffness matrices, nonstability, and difficulties in ensuring the accuracy of the number of points in the domain. On the other hand, finite difference method, which is one of the oldest numerical methods, can also be used to solve the problems caused by meshes in modeling wave propagations. This method is limited due to the need for a regular grid of points in an infinite domain. However, these problems can be resolved by using a special storage combination and replication in other parts of the environment. The following methods are often preferred to the ones mentioned earlier since they are very successful for large quantity of numerical modeling of unbounded domains. This method can further be classified into two subgroups: Therefore, boundary element method has been used successfully to solve the problems with unbounded equations [9 â€” 12]. However, there are disadvantages of this method which include the inaccessibility to basic functions of different problems, such as nonhomogeneous domains and complicated calculations that sometimes trigger the singularity of integrals. In addition, Zhao and Valliappan also developed the coupled method of finite and transient infinite elements for solving transient seepage flow, heat transfer, and mass transport problems involving semi-infinite and infinite domains [24 â€” 26]. Therefore, it is costly to simulate the full infinite domain. At a glance, this kind of simulation seems easy and simple to perform. But research conducted for the past thirty years has shown that such boundary simulation is hard to perform. In addition, the limited numerical solutions available so far also indicate existence of possible problems with such boundary simulations [27 â€” 29] and researchers do not have a consensus on this matter [30]. Therefore, recent studies are aimed at achieving better developed stimulations [31 â€” 34]. Absorbing layer or perfectly matched layer method was first introduced by Berenger in [35] upon completion of the nonreflecting boundaries. Recently, extensive studies have been conducted on how to develop this method for

DOWNLOAD PDF WAVE PROPAGATION IN INFINITE DOMAINS

2- and 3-dimensional domains [36]. In this research the method is further developed to solve the wave leading problem caused by element arrangement and shape functions. Stimulation and nonreflecting boundary. Materials and Methods 2. Elastic Wave Propagation in Unbounded Domain In this research work, finite point and finite element methods were used to study the wave propagation in unbounded domain [37]. The wave equations are given below: One of the uses of the above formula is the elastic wave propagation in which all functions and operators are written in vector format. To solve this equation, a Cartesian coordinate system is adopted, while the center of this coordinate system is used as the stimulation point. If is considered as is a Fourier transformation of , , and is the value of the stimulation frequency. Consequently, these values are substituted in 2 to obtain is a Fourier transformation of stimulation function of. According to the stimulation function shape, to solve this problem, symmetric and antisymmetric displacement condition can be used in the domain. Then the equation is given as follows: This study considers the importance of the reliability of the domain properties which can solve the problem. Therefore, the stimulation can be applied as a boundary condition and thereby 4 can be classified as part of homogeneous equations group with constant coefficients. As a result, one of the significant properties of the differential equations with constant coefficients, such as proportionality, is given in , , and are constant vector and two undefined scalars. The following equation is derived from the exponential function properties in the - and.

Chapter 4 : Lecture Notes | Wave Propagation | Mechanical Engineering | MIT OpenCourseWare

The problem of dynamic wave propagation in semi-infinite domains is of great importance, especially, in subjects of applied mechanics and geomechanics, such as the issues of earthquake wave propagation in an infinite half-space and soil-structure interaction under seismic loading.

Chapter 5 : Wave Propagation in Unbounded Domains under a Dirac Delta Function with FPM

In many fields of engineering an infinite or semi-infinite domain (unbounded structure) has to be analyzed. This kind of structure is considered in wave propagation problems such as soil-structure interaction, fluid-structure interaction, acoustics, electromagnetism and so on.

Chapter 6 : Lutz Lehmann (Author of Wave Propagation in Infinite Domains)

Abstract. This paper deals with the computational simulation of both scalar wave and vector wave propagation problems in infinite domains. Due to its advantages in simulating complicated geometry and complex material properties, the finite element method is used to simulate the near field of a wave propagation problem involving an infinite domain.