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Static interaction of arbitrary shaped solid plate and transversely isotropic half-space

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Abstract

Increase in the number of newly constructed industrial structures and the importance of structural design of the foundations during the last decade has led researches to solve the contact problem of solid plate with infinite half-spaces. Assuming the half-space having engineering characteristics very similar to that of the transversely isotropic materials, logically assures the solution to be more reliable. Furthermore, solving this contact problem for an arbitrary shaped solid plate gives the engineers the opportunity to choose the foundation's shape from various types.

In this research, after writing the equations of equilibrium in the polar coordinates for a transversely isotropic media, a method of potential functions accompanied with integral transforms is applied to derive displacement and stresses Green's functions for a half-space. Then, the integrals indicating the displacement will be calculated in such a way that adaptive gradient elements to be applied for evaluation of the integrals for arbitrary shapes of rigid foundations. For the ease of calculations for the structural engineering purposes, the solution is derived for a unit radius circle. At the end, the displacements and stresses will be easily calculated and graphically shown. By comparison with the results reported in the literature for isotropic half-spaces, the validity and accuracy will be proved.

Keywords: Elasticity, Contact problem, Transversely isotropic, Arbitrary shaped solid plate

1. INTRODUCTION AND LITERATURE REVIEW

Studying mechanical problems has always been in consideration of the engineers, as they had become aware how important it was to design instruments and structures not only precisely, but also efficiently. As a consequence of such interests; mathematicians, alongside the engineers who were also interested in practice and testing to solve problems, started to investigate solutions by means of applications of physical and mathematical theories. Scientists who were interested in such approach proposed that the solutions may be more precise if the solution be exact and presented analytical solutions to differential equations. After some times, numerical methods also applied to the problems. Assuming the characteristics of the mathematical model be more similar to that of the real materials and more precise mathematical solutions to the problems, were two approaches to gain more realistic solutions to the problems. If there exists a plane such that every plane perpendicular to it is a plane of symmetry, then the material is called a transversely isotropic material. That plane is called the plane of isotropy and its normal direction is the axis of transverse isotropy [1]. That the engineering properties in the plane of isotropy differs from that of the normal direction, allows engineers to model soil with isotropic materials in mathematical models, for instance the consolidated clay soil has such behaviour; hence, the contact problem of a rigid plate with a transversely isotropic half-space is of interest to the structural engineers. On the dynamic interaction of a rigid disc with an isotropic medium, some researches are available as in Reissner and Sagoci [2], Arnold et al. [3], Bycroft [4], Awajobi and Grootenhuis [5], Robertson [6], Gladwell [7], Luco and Mita [8], and Pak and Gobert [9] in which many contact problems are approached. Furthermore, Eringen and Șuhubi [10] and Kausel [11] worked on some fundamental solutions to the wave equation in the homogenous media in one-, two- and three dimensions; whilst the first ones presented some solutions based on the Eigen function expansion and variation principles and the second one presented solutions of the half- and full-space and also by methods of integral transforms in polar and Cartesian coordinates. Their solutions includes both analytical and numerical. When it comes to the transversely isotropic media, book by Ding, Chen and Zhen [12] is eye-catching where they present some general solutions to the transversely isotropic problems by method of displacement in Cartesian, cylindrical and spherical coordinates. They not only solve the buried force problem, but also work on half-space and layered media. Point load in these set of problems are both normal to the half-space, tangential to that surface or assumed to be an interior point force. Moreover, thermal stresses in dynamic and static problems are also