

ABSTRACT

The mathematical model representing the classical Terzaghi's (1925) one-dimensional consolidation theory was developed on the premises of a few drastic idealizations. With the advancement in computational flexibilities and vast researches on soil mechanics, most of the involved assumptions in the conventional approach of settlement estimation appear inconsequential. The present thesis revisits Terzaghi's (1925) one-dimensional consolidation theory, from the following few perspectives: (a) initial condition associated with the load-imposed excess pore pressure, (b) boundary condition connected to the drainage boundaries, (c) governing differential equations related to the loading pattern, velocity-gradient relationship, stress-induced heterogeneities, and saturation states, and (d) coupling of the stress-deformation alongwith the pore pressure dissipation equation. The classical Terzaghi's one-dimensional linear parabolic diffusion equation is sufficiently modified and used for performing the consolidation analysis of saturated soil. The entire numerical analyses are conducted by using the Crank-Nicolson finite difference scheme

An attempt has been made to study the consolidation of homogeneous and two-layered soil by considering ten different spatial distributions of initial excess pore water pressure (u_0) profiles. The variation of normalized pore pressure isochrones and the trend of the consolidating curves for different distributions of u_0 are extensively evaluated and critically analyzed. A new approach has been developed to study the consolidation phenomenon through the locus of the maximum point of the isochrones.

Next, a study is conducted to understand the consequences of stress-dependent permeability and compressibility on the consolidation of inherently homogenous clays. The

importance of stress- and spatial-gradient of permeability in the consolidation analysis is established. Furthermore, permeability variation is integrated with non-Darcian flow models under ramp loading. The spatial and temporal permeability variation (k -isochrones) are also plotted to explain the variation in the consolidation curves.

In contrast to the traditional uncoupled consolidation, coupled methods, which integrate pore water pressure dissipation with soil deformation, provide more reliable solutions, especially for time-dependent loading and other complicated conditions. A detailed one-dimensional coupled consolidation is performed to investigate the combined influence of semipermeable drainage boundaries, non-Darcian fluid flow, and periodic loading. The non-Darcian flow is realized by employing the exponential and threshold gradient-based non-linear model. Traditionally, to simplify the numerical scheme, the hydraulic gradient in the exponential term is evaluated at the previous (known) time state, which converts the nonlinear equation into a linear equation. By adopting Newton-Raphson technique, an effort has been initiated to solve the actual nonlinear equation by computing the gradients at the current (unknown) time state.

The construction of geotechnical structures frequently occurs under partially saturated conditions. The unsaturated consolidation is governed by Fredlund and Rahardjo (1993)'s classical diffusion equations. The present thesis re-evaluates the impact of initial pore pressure condition, drainage boundaries, and velocity-gradient relations on the transient flow. To provide flexibility in the drainage, mixed drainage boundary conditions for the air and water phases are applied at the top and bottom boundary surfaces. A series of numerical experimentations are carried out. The results offer valuable insights for geotechnical engineering applications in various environmental conditions.