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考虑应力路径的黏土弹塑性固结问题的
耦合分析方法

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摘要　提出多路径条件下黏土的弹塑性固结问题的简化耦合分析方法。基于数值建模方法建立不同初始固结条件下的黏土弹塑性本构关系，并结合Biot固结理论，建立该类问题的增量形式控制方程。将增量化的扩散方程简化为Poisson方程，由于模型可以提供每一增量步下的体变量作为右端项，故在方程中可直接耦合土的变形场和孔隙水压力场，因而比传统的扩散方程更为精确，求解过程比Biot方程更为简单，且可以考虑体应变 与剪应变 之间的相互作用。推导出该Poisson方程孔压基本解，建立此类流－固耦合问题的半解析半数值解答体系，实现从建立本构关系到固结问题数值模拟的完全数值化。通过2种不同应力路径下的固结算例对比分析表明，该方法简单有效，并能考虑土的应力路径、荷载作用域等条件对地基水平位移、沉降变形及孔压变化的影响，特别是应力路径对固体域变形场的影响。

关键词　数值方法；本构模型；弹塑性固结理论；半解析半数值方法；平面应变；应力路径；黏土

分类号

COUPLING ANALYSIS METHOD FOR ELASTOPLASTIC CONSOLIDATION OF CLAY CONSIDERING STRESS PATHS

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Abstract

A simplified coupling analysis method for elastoplastic consolidation problem of clay under different stress paths is presented. An elastoplastic constitutive model of clay is constructed on different initial conditions based on numerical modeling method and it can be adopted with Biot consolidation theory. Then the incremental governing partial differential equations are established for plane strain consolidation problem. Based on the constitutive models，a Poisson equation for pore water pressure is derived and the

basic solution is obtained. Because the volumetric strain can be acquired as the right term of the equation by the constitutive model straightly; the deformation field of soil skeleton and pore water pressure field are coupled directly. Thus the Poisson equation is more accurate than the classic diffusion equation and it is easier for solving than the Biot functions. Moreover, the interaction between the volumetric strain and shear strain is considered. A semi-analytical and semi-numerical method for the nonlinear consolidation equations with the coupling fluid-solid issue is presented and its finite element program is given. Moreover, a systematic numerical approach from numerical modeling through simulation for soil consolidation is established. The computational results of some examples under different stress paths show that this approach is simple and able to reflect the influences of some facts, such as stress paths and load scope, on displacement, settlement and pore water pressure of foundation. Especially, stress path affects the solid deformation field evidently.

Key words numerical method; constitutive model; elastoplastic consolidation theory; semi-analytical and semi-numerical method; plane strain; stress path; clay

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