A SIMPLE CONSTITUTIVE MODEL OF SOIL-STRUCTURE INTERFACE USING SOIL PLASTICITY

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Abstract

The response of some soil-structure systems such as lined tunnels, retaining walls and etc. can be affected by the soil-structure interface behavior. Interacting forces induced at the soil-structure interface is influenced by the existence of interfaces defined as thin layers of soil in which stresses are transferred from one medium to another. Therefore, the numerical simulation of soil-structure interaction problem requires proper modelling of the interface. Using the similarity between the soil behavior and interface deformations the classical soil plasticity is employed to develop an interface constitutive to include deviatoric hardening/softening, compaction and dilatancy and ultimate states. The predictions of the model are first presented and then compared with available experimental data from various interface tests. The model was successfully used to predict the behaviour of some interfaces with different soil parameters.

Keywords: Soil-Structure Interface, Soil Plasticity, Constitutive Model.

1. INTRODUCTION

Interfaces usually play a major role in the definition of the mechanical behaviour of engineering structures having interaction with the soil. The rigorous analysis of soil-structure systems, such as shallow foundations, tunnels, and retaining walls, requires a good simulation of the soil-structure interfaces behavior. The numerical modelling of the soil-structure interface therefore have attracted great attention by researchers and many experiments have also been conducted in order to examine the applicability of developed interface constitutive models. Different experiments including direct shear test, simple shear test, and ring torsional tests (e.g., Desai et al.,1985 [1]; Kishida and Uesugi, 1987 [2]; Boulon, 1989 [3]; Evgin and Fakharian, 1996 [4]) have been conducted to study the interface behaviour under different loading phases. These investigations revealed that besides the roughness of the contact body, grading characteristics of soil, the soil density, and the normal pressure are the most important factors affecting the interface behaviour.

The interface behaviour has also been numerically studied presenting some interface constitutive models, mostly assumed that the behaviour of interface is between granular soils and metal. The first developed constitutive models were based on results concerning the modelling of rock joints, assumed the material of the interface is supposed to be elastic in the normal and tangential directions. The elastic models can be classified as linear or non-linear elasticity models with a stress–displacement relationship of hyperbolic type. Although the elastic constitutive models are simple, they could not simulate the real behavior of many interfaces during different loading phases, such as the failure condition, the hardening/softening and dilatancy as well. Accordingly, the traditional relation extensively known in soil mechanics dictated by the Mohr–Coulomb failure criterion was used in modelling of interfaces behavior. More complex models, incorporating the concepts of dilatancy, compaction and damage, have been also proposed within this theoretical framework. Using theory of plasticity, elastic-plastic models have been developed and due to their flexibility used to predict the important states of interface during different stress states such as cyclic loading and softening. Along with a new definition of the kinematic state variables,