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The experimental and numerical research of soil and root composites

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ABSTRACT

To ensure the stability of shallow landsliding, vegetation roots have been considered to act as an important soil reinforcement. The study of roots reinforcement on shallow soil protection has become widespread. In this paper, the macro-characterization of soil-root composites has been studied by experiment and Finite Element (FE) method.

Taking the soil-root composites as a periodic material, the homogenization method is used to model a Representative Volume Element (RVE) which consists of roots and soil. As roots are long and arranged comparatively regular and parallel, any cross-section of the composites could be considered as in the generalized plane strain state, that is, the strain field is invariant along the fibre axis. Thereafter, this RVE is discretized by a 2-D FE mesh in this paper. In addition, a special formulation is established, so that this 2-D mesh is capable of describing three-dimensional deformations. In this new type of element, the displacement field is described by average strain field $\boldsymbol{E}$ and the fluctuation displacement field $\boldsymbol{u}^*$. The fluctuation displacement field must satisfy the periodic boundary condition. The overall properties, especially the limit loads, of the soil-root composites can be obtained by analyzing this RVE with incremental FE method or standard limit analysis method. In the analysis, the soil matrix complies with Drucker-Prager criterion; the root fibre complies with von Misses criterion.

The important effect of debonding on the interface between the fibre and the soil matrix is also considered. To satisfy the periodic condition, a kind of special interface element based on fluctuation displacement field has been developed. The pressure and shearing stress are obtained in the interface. For the weak interface between soil and root, the interface criterion based on these stresses is introduced to control the debonding.

The properties of the roots and the natural soil were obtained from experimental tests for the numerical computation. Three axial tests were conducted, where the soil-root composites was subjected to the axial and lateral pressures. In the test, all samples contain more than 100 roots to assure the periodic condition. The fibre volume fraction

is 0.5% and 1%, which is close to the natural condition. Good agreement of limit loads has been achieved between the numerical and the experimental results. It is observed that the strength of the soil is enforced obviously by the root fibre. The weak interface between the soil and root are much important to affect the properties of the composites.

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