Discrete Modeling of Geotextile-wrapped Soil under Simple Shear

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ABSTRACT

In recent decades, geosynthetic reinforcement structure is widely used in infrastructure projects for technical and economical reasons, e.g. retaining wall and road/railway subgrade [1, 2, 3]. Despite of the worldwide usage, the basic mechanism of such reinforcement remains obscure, owing to its discontinuous and heterogeneous nature. This paper focuses on the numerical modeling of the geotextile-wrapped soil (soilbag), giving explicit description on its macro and micro mechanical characteristics under shear loading conditions.

The Discrete Element Method (DEM) is used for this purpose. The orthogonal structure of a woven geotextile bag was considered by using remote stretch springs and imaginary spherical particles [4, 5]. A void ratio specified packing was generated in the periodic boundary condition to calibrate the parameters of the simplified Hertz-Mindlin contact model. The same packing was used repeatedly as the Representative Volume (RV) for preparing the backfilled Toyoura sand in the bag. After filtered by an assumed soilbag boundary, the backfill soil attained the same initial void ratio as in the original RV through a well-controlled radii expansion process. This discrete model of soilbag was validated against a group of simple shear test results. The global/local stress states and the fabric anisotropies of the geotextile-wrapped soil were examined primarily for better understanding the reinforcement mechanism from geosynthetic enclosure on granular soil.

The macroscopic response of the soilbag model under simple shear was found well agreed with the previous experimental results. Major findings from the simulations are summarized as follows. 1) Phase transformation stage of the normal strain from contractive to dilative was observed, similar to the test results. The mechanical fabric anisotropies decreasing after the transformation, indicates the onset of confinement from the wrapping geotextile during shear. With greater vertical dead load, the magnitude of fabric anisotropies decreased, suggesting greater attainable confinement comes with higher normal load. 2) Global stress path during simple shear firstly approaches the critical state line then heads towards soilbag's compression line. Interesting loading-reloading paths were observed in the middle part of the soilbag, which could explain high damping inside soilbag. It can be concluded that soilbag's confinement does not only take place during loading at normal direction (unconfined and triaxial compression), shear loading facilitates the development of the confinement effect as well, resulting in the reduced slope of the critical state line and better control on the dilatancy of soil.

This work is a part of an ongoing research for the scientific design of soilbag earth reinforcement as sustainable solutions to geotechnical problems. Future work will cover a comparative study on the behavior and mechanism of the geosynthetic reinforced soil in the form of soilbag and others.

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