

Local parallel free generation and dynamic affine transformation method for soil three-dimensional pore structure information model

Chunhui Lan^{a,b}, Ziyu Tao^{a,b}, Yongtao Wu^{a,b}, Guangjun Cui^{a,b,c}, Zhen Liu^{a,b,*}, Cuiying Zhou^{a,b,*}

^a School of Civil Engineering, Sun Yat-sen University, No.135 XinGangXiLu, Guangzhou 510275, China

^b Guangdong Engineering Research Centre for Major Infrastructure Safety, Sun Yat-sen University, Guangzhou 510275, China

^c Institute of Estuarine and Coastal Research/Guangdong Provincial Engineering Research Center of Coasts, Islands and Reefs, School of Ocean Engineering and Technology, Sun Yat-sen University, Guangzhou 510275, China

* Correspondence: liuzh8@mail.sysu.edu.cn (Zhen Liu), +8613826087505

Abstract: The soil three-dimensional (3D) pore structure information model has become a new hotspot in the research of cross-scale disposal of information such as ecology, engineering, and geology. It can solve problems such as the intelligent evaluation of ecological water-soil-air-plant feedback, intelligent risk control of foundation compression deformation, and multiscale intelligent disaster prediction and prevention. However, the current soil 3D pore structure model primarily draws on the global one-time static generation in simulation software, leading to low reliability, low stability of multiple generations, poor variability, difficulty in real-time transformation, high consumption of computing resources, and long generation time, making it challenging to meet the requirements of the rapid processing of information models. Therefore, this study adopts the 3D Drawing Protocol (WebGL) technology and implements the scaling, rotation, and translation transformation of 3D pore structures based on the principle of dynamic affine transformation. The random generation and distribution of pores are realized using the improved Monte Carlo method, and the loading response efficiency of the system is optimized. The dynamic interactive operation of arbitrary increasing and decreasing of pore model is realized using the ray and plane intersection detection principle. Finally, this information system established a visual correlation between the content and reaction time of water-retaining agents and soil porosity and pore distribution through tests on the impact of water-retaining agents on soil pore changes. The information system achieved the real-time tracking of soil pore changes under the action of water-retaining agents. This research solves the problems of static and low generation efficiency of the soil mesopore structure in traditional models and realizes the real-time characterization and visualization of dynamic changes and the distribution of the soil pore structure under the influence of external conditions, which can provide an intuitive visualization platform for mesogeological structure research.

Keywords: Soil pores; Affine transformation; Monte Carlo method; Information model; Interactive operation