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Verification of Trapdoor Discrete Element Method Simulation

Umair Ali[1], Masahide Otsubo[2], and Reiko Kuwano[3]

[1] Institute of Industrial Science, The University of Tokyo, Tokyo, Japan, umairali@iis.u-tokyo.ac.jp
[2] Institute of Industrial Science, The University of Tokyo, Tokyo, Japan, otsubo@iis.u-tokyo.ac.jp
[3] Institute of Industrial Science, The University of Tokyo, Tokyo, Japan, kuwano@iis.u-tokyo.ac.jp

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Stress distribution on buried structures (e.g. box culverts) varies sensitively with the settlement of surrounding subsoil. Kuwano and Ebizuka [1] conducted a series of trapdoor experiments using Toyoura sand and reported that the stress concentration becomes significant as the ratio of the burial depth to width of the buried structure (H/B) increases. They also highlighted that the available design codes underestimate the pressure increase on buried structures considerably.

Discrete Element Method (DEM) is a powerful tool to link the overall response of the model ground to the particle scale responses. In this study, 3-D DEM simulations for trapdoor tests have been carried out using LAMMPS [2], and large-scale simulations were run using the Oakforest-PACS system in Joint Centre for Advanced High-Performance Computing. DEM simulation model ground used alkaline glass beads parameters with particle diameters of 1.2 – 2.2 mm. The dimensions of simulation box were 150×40×H mm; H ranges from 44 to 348 mm, where lateral periodic boundaries with fixed bottom walls were used.

The simulation results exhibit greater values of the normalized vertical pressure distribution on the fixed centre plate (while lowering the side plates), especially for higher H/B values. The shear pressure distribution on the fixed centre plate exhibits clear peaks at the boundary between the fixed plate and the lowering side plates. The evolution of the 2nd order contact fabric tensors illustrate more contacts in the vertical direction on the fixed plate while the fabric tensor in the horizontal direction dominates at both sides.

The DEM simulation results agree with equivalent experimental observations using Toyoura-sand [1]. To verify the applicability of this method as a virtual model test, equivalent laboratory tests were conducted using spherical glass beads having the same material properties and particle sizes. The overall observations of the laboratory model tests are in good agreement quantitively with the DEM results.

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