Mobility Analysis Using Highly Parallelized DEM and SPH

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ABSTRACT

Vehicle simulations based on terramechanics allows for performance prediction in the vehicle prototype stage as well as the testing and evaluation stage. Terramechanics problems are among the most challenging in geotechnical engineering especially for soil deformation caused by a wheel or track. Soil deformation caused by a wheel or track is typically large and discontinuous which complicates the mathematics of the simulation. For this reason, the ERDC has developed two highly parallelized particle-based models for high-fidelity terramechanics modelling. The Discrete Element Method (DEM) analysis code was developed for very large-scale simulations of dry sand utilizing novel parallel techniques. Many parallel techniques for the DEM consists of simple domain decomposition which does not efficiently address many of the complications of terramechanics simulations. The simple domain decomposition approach also provides limited partitioning options, ill-suited for irregular domains or large processors counts, and is highly susceptible to load imbalancing. To alleviate many of these problems, the ERDC has developed a sophisticated parallelization design in which space is no longer tied to a processor, but rather ties space to particles themselves. The ERDC has also developed a novel technique for initialization of DEM simulations which utilize spatial sampling techniques.

The Smoothed Particle Hydrodynamics (SPH) method has many attractive properties for simulating soil but has nevertheless not been used extensively as finite element modelling or DEM for simulating soil. The ERDC has developed a highly parallel SPH analysis code for very large-scale simulation for cohesive soil. Simulating cohesive soil with SPH provides several advantages compared to other soil simulation methods such as not requiring remeshing during high-strain, large displacements events and constitutive relationship for the soil can be directly accounted for. To highlight the capabilities of this set of tools for large-scale simulations for terramechanics, cone index tests and direct shear tests were conducted. These tests provide indexes and soil strengths for simulating performance testing for vehicle-cone index and slope climbing and simulating slope embankment studies. The implementation of the DEM and the SPH, the novel parallel techniques, and the mobility analysis applications will be presented.