Stress Analysis of Soil Beneath Grouser Wheel for Planetary Rover by Using Discrete Element Method (PARTICLES 2021)

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ABSTRACT

Modeling the interaction between rover's wheel and soft terrain is of great importance in evaluating the wheel performance of a planetary rover. Wheel-soil interaction models based on BEKKER's theory [1] have been used for predicting or evaluating wheel performance. However, few models take into account the effects of grousers and soil behavior. To develop a new model that can address soil behavior, the analysis, which focuses on soil flow and deformation, is required. This study analyzes stress distribution inside the soil as a first step for modeling the interaction of a wheel with sandy terrain. For the stress analysis, we use the discrete element method (DEM) simulation, which considers the interaction between individual particles. The particle simulation tool "Sir partsival" [2] is used for the DEM simulation. Key performance indicators for a wheel are slip and sinkage. The relation between those and the soil flow velocity and the resulting stress in the soil are evaluated. The simulations are discussed from the viewpoint of wheel traction, sinkage, soil flow velocity, and stress inside the soil. The results show that the soil flowing velocity and the stress inside the soil increases with a higher slip ratio as shown in Figure 1. Furthermore, the wheel affects a wider range of soil. As a result, the wheel gets a larger drawbar pull at the higher slip ratio. The findings of this study contribute to the understanding of soil behavior underneath a wheel especially to the modeling of grouser-soil interaction mechanics.

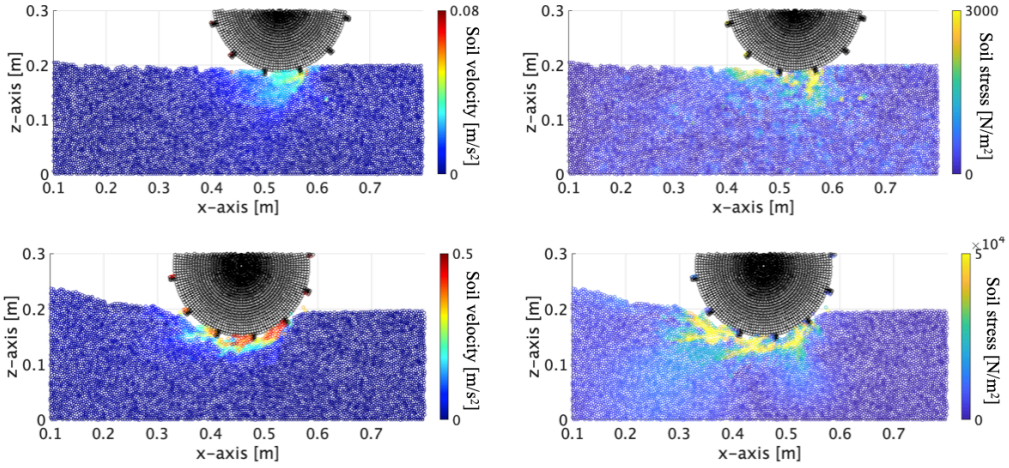

Figure 1: soil velocity (left) and soil stress (right) under different slip conditions: slip 20% (top), 80% (bottom)

REFERENCES

[1] M.G. Bekker, "Introduction to terrain-vehicle systems," University of Michigan Press, Ann Arbor (1969).
[2] R. Lichtenheldt, S. Kerler, A. Angerer, W. Reif, "partsival - Collision-based particle and many-body simulations on GPUs for planetary exploration systems," IMSD (2018).