Analysis of rut formation using particle-based terrain simulation

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ABSTRACT

The possibility of simulating realistic rut formation from heavy terrain vehicles with 3D dynamics simulation is investigated [1]. The used simulation technology combines rigid multibody dynamics for the machine and the discrete element method for the terrain. A number of virtual soil beds are created with different microscopic model parameters, which control the interaction between the pseudo-particles of the soil. Simulated cone penetrometer and triaxial test are performed to determine macroscopic mechanical properties, i.e., the soil's cone index, internal friction, and cohesion, for each soil bed. Next, a quarter-vehicle with a two-wheeled bogie is driven repeatedly over the different terrains and the rut depth is measured after each passage.

A soil with cone index 400 kPa, internal friction angle of 25° and cohesion 8 kPa was studied in particular. The weight of the quarter vehicle without load was 4.4 tons and with a load 5.5 tons, causing a rut depth that is about 25% larger. The simulated rut depth evolution is in good agreement with established models for rutting, expressed as functions of the vehicle's geometry, weight, and the soil's cone index. From the simulation results, it is also possible to study the soil compaction and stress distribution through the terrain, as well as the vehicle's slip and torque when traversing it. Preliminary results from a tracked bogie are demonstrated.

In the present form, the model is limited to soils with relatively low content of moisture and sedimentary soil. The computational time and memory usage depend on the number of pseudo-particles in the soil model. Therefore, the spatial resolution of the terrain is limited by practical restrictions. In the study carried out, the particle size ranged between 20 to 40 mm.

The conclusion is that the examined simulation technique is useful for studying the rut formation from forest machines and how the rut depends on the geometric design, weight and control of the machine.

REFERENCES

[1] V. Wiberg, M. Servin, and T. Nordfjell. Particle-based terrain - a validation study. Technical Report UMINF 06.05 ISSN-0348-0542, Dept. of Computing Science, Umeà University, Mar. 2006.