A Vegetation Damage Estimation Tool for Saturated Peat Soil by use of a Hybrid Finite - Discrete Element Terrain Model.

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Abstract

The aim of this paper is a description of the terrain damage caused by a Biomass Harvesting Device (BHD) developed in a Danish biomass project. Though not a limitation to this work, the BHD is in this study assumed to be wheeled. The objective is to reduce the damage on the vegetation and roots, for a faster rehabilitation of the plant. Extreme saturated Peat soil is designated as the worst-case terrain for the BHD. Peat soil is partly humified organic materials with a high water content. A sample of the modeled soil is illustrated in Figure 1.

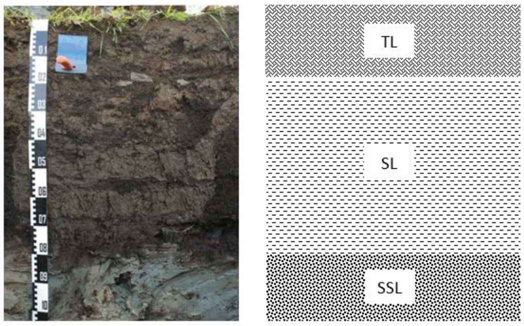

Figure 1: Soil profile of Peat soil. [1]

The combination of the nonlinear material properties, hydraulic properties and the reinforcement caused by the grass layer leads to a demand for development of a numerical tool that can qualitatively investigate the soils resistance to machine soil interaction damage. The soil sample is split into three layers, illustrated in Figure 1. The top-layer (TL) contains peat reinforced by a grassmat and accompanying rooting. This relatively dry layer is simulated using Discrete Elements (DE) including water bridges. The TL is in direct interaction with the wheel and the damage will occur as compaction and/or by wheel intersection of the underlying sub-layer (SL).

The sub-layer (SL) is characterized as peat with homogeneous material properties and a high water content. Finite Elements (FE) are applied for the SL where super elements with voids are applied to model the presence of water. An algorithm describes the motion of water in the SL in accordance with increased pressure under the tire. The algorithm applies loads to the nodes associated with the internal voids in affected elements during the iterative procedure. The sub-sub-layer (SSL) as consist primarily of clay and is a stable foundation for the overlying layers. The SSL is implemented as a fixed boundary in the vertical direction for the bottom nodes of the FE layer. The FE and DE layer are connected through a FE-DE interaction algorithm which couples the stiffness of the two layers. Increased efficiency of the terrain damage estimation is achieved through the combination of FE and DE.

The model is validated by physical experiments where water content, soil properties and stiffness of the grass mat are evaluated. The physical test is reproduced virtually and the numerical model is calibrated to fit the measured properties. It can be concluded that the model is capable of representing the physical behaviour of the peat soil with sufficient fidelity for evaluation of different BHD designs.

References

[1] H. Breuning-Madsen, T. Balstrøm, M. H. Greve, and N. H. Jensen. "Jordbund." Geologi og Geografi, 2013: 4-5.