Modelling of the Tire-Soil-Water Interaction at Fluid-Infiltrated Roads via a Hierarchical Sequential Poromechanical ALE Formulation

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In case of off-road driving on fluid-infiltrated soils or on porous and permeable pavements, the interaction between the solid and the fluid constituent inside the underground influences the tire-subsoil interaction. In order to capture the hydro-mechanical coupling effect at the tire-subsoil interaction, this contribution presents a hierarchical sequential arbitrary Lagrangian-Eulerian (ALE) model for predicting the tire-soil-water interaction at finite deformations. The ALE formulation of rolling tires introduces a reference frame that moves with the tire through the space. In case of steady state rolling tires and a subsoil, which is homogeneous in driving direction, the deformation state of the tire and the subsoil with respect to the moving reference frame becomes time-independent, which enables a numerically efficient description of the tire-subsoil interaction.

The hydro-mechanical coupling effect is captured via poro-elasticity theory, whereby the poromechanical balance equations are formulated in the ALE frame to ensure consistency at the later coupling to the tire. The fully saturated soil is considered as two-phase (solid-fluid) continua. The poromechanical ALE model is solved via a finite element (FE) formulation in an operator split scheme. Thereby, different split assumptions (drained, undrained, semi-drained) are investigated for the solid step. This staggered solid-fluid iteration is implemented into a coupled tire-subsoil interaction model, which is solved via a sequential iteration scheme as well. Thus, the whole tire-soil-water interaction is solved in a hierarchical operator split scheme. The introduced formulation is validated and a coupled tire-soil-water computation demonstrates the influence of the present fluid on the soil deformation at tire overrun [1].

REFERENCES

[1] I. Wollny, W. Sun and M. Kaliske, A hierarchical sequential ALE poromechanics model for tire-soil-water interaction on fluid-infiltrated roads. *Int. J. Numer. Meth. Engng.*, Vol. **112**, pp. 909–938, 2017.