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3D Finite Element Analysis for Mechanics of Soil-Tool Interaction

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Abstract : This paper is part of a study to develop robots for farming. As such power requirement to operate equipment attach to such robots become an important factor. Soil-tool interaction play major role in power consumption, thus predicting accurately the forces which act on the blade during the farming is prime importance for optimal designing of farm equipment. In this paper a finite element investigation for tillage tools and soil interaction is described by using an inelastic constitutive material law for agriculture application. A 3-dimentional (3D) nonlinear finite element analysis (FEA) is developed to examine behavior of a blade with different rake angles moving in a block of soil, and to estimate the blade force. The soil model considered is an elastic-plastic with non-associated Drucker-Prager material model. Special use of contact elements are employed to consider connection between soil-blade and soil-soil surfaces. The FEA results are compared with experiment ones, which show good agreement in accurately predicting draft forces developed on the blade when it moves through the soil. Also, a very good correlation was obtained between FEA results and analytical results from classical soil mechanics theories for straight blades. These comparisons verified the FEA model developed. For analyzing complicated soil-tool interactions and for optimum design of blades, this method will be useful.

Keywords : finite element analysis, soil-blade contact modeling, blade force, mechanical engineering
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