Fact Sheet

US Army Corps of Engineers
Cold Regions Research and Engineering Laboratory

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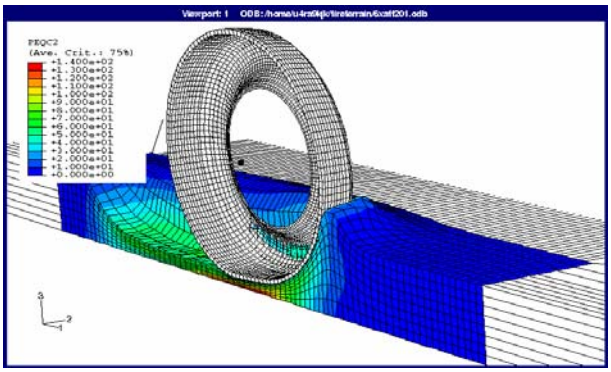
High Resolution Tire-Terrain Modeling

Purpose: To provide accurate, efficient, modeling of tire and terrain dynamic interactions to predict vehicle mobility and terrain degradation.

Background: Vehicle mobility on unpaved surfaces is important to the military and for agriculture, forestry, mining, and construction industries. Problems associated with off-road vehicle use can be grouped into two major categories: 1) predicting vehicle performance on terrain over a wide range of weather and surface conditions (will it get stuck, how much traction is available to climb or pull, what are the power requirements); and, 2) determining the consequences of vehicle trafficking (rut formation, shearing/tearing of roots, soil compaction, and the effects of these on vegetation and erosion). A three-dimensional model of a deformable tire on a deformable surface was developed for predicting vehicle mobility, terrain deformation under vehicle loads, off-road tire design and tire specification for specific off-road machinery. Material constitutive models of the mechanical behavior of snow and thawing soil have been developed and validated in the laboratory and the field.

Facts: The major features of this model are that it provides for the deformable nature of both the tire and terrain, simulates the important three dimensional characteristics of the interaction and has an efficient tire model to allow efficient tire rolling simulations. Since both the terrain and tire are highly deformable a rigid approximation of either is a gross oversimplification which yields erroneous contact conditions critical to the solution. A three-dimensional analysis is important because it allows a highly deformable surface material (mud, snow or soft soil) to realistically contact and resist tire movement similar to actual conditions. This contact has been shown to have a significant impact on the rolling resistance. Our tire model uses an empirically determined composite material property to simulate the tire rather than modeling individual tire components (tread, sidewalls, reinforcement, etc). The result is an efficient model that enables the tire to accurately roll over obstacles and/or distances of 20 meters in only minutes of computational time. This type of three-dimensional simulation has been extremely difficult, but recent advancements in finite element tire-terrain contact formulations, faster computers, and tire modelling efficiencies have made this type of simulation possible. Results of the model have been compared to field measurements of tire forces, deflection and contact area for both hard and deformable winter surfaces (snow and thawing soil) with very good results.

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