COULOMB FRICTION AND JOINT CONSTRAINTS IN MULTI-BODY DYNAMICS USING ABAQUS

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Joint constraints model the connections between rigid and/or deformable bodies; typically, they represent a point-to-point idealization of a complex mechanism (revolute joint, universal joint, constant-velocity joint, etc.) in which both large relative translations and rotations may be present. Frictional energy dissipation in the joints severely alters the dynamic response of a multi-body dynamic system, particularly when stick-slip occurs. Coulomb-like friction in joint constraints for multi-body dynamics is available for general-purpose finite element analysis in ABAQUS.

Coulomb-like frictional dissipation in a joint constraint requires the identification of a contact force (usually a non-trivial combination of joint geometry and constraint forces and moments), a friction law (a coefficient of friction that may be dependent on slip rate, contact pressure, and state variables), a stick-slip criterion, and a tangent force or moment direction in which frictional slipping may occur. This paper highlights the following computational challenges:

- Formulation of kinematic joint constraints in a finite element code that accounts for large deformation and nonlinear material response;
- Inclusion of kinetic response in the unconstrained degrees of freedom in the joints;
- A wide variety of contact force definitions;
- A Lagrange multiplier or augmented-Lagrangian implementation of Coulomb friction in the joint degrees of freedom.

The implementation in ABAQUS is validated with several joint friction-influenced instabilities simulations including a robot arm and flexible-arm deployment of a conceptual satellite.