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Dynamic Contact Problem Coupled with Rate-and-State Friction

Nadia Skoglund Taki

University of Bergen

nadia.taki@uib.no

Abstract: We are interested in dynamic problems related to rate-and-state friction for a linear viscoelastic material in contact with a foundation. The so-called rate-and-state friction law

$$\mu(|\dot{u}_\tau(t)|,\alpha(t)) = a\,\operatorname{arcsinh}\Big(\frac{|\dot{u}_\tau(t)|\mathrm{e}^{\frac{1}{a}(\mu_0+b\alpha(t))}}{2v_0}\Big) \qquad \text{and} \qquad \dot{\alpha}(t) = \frac{v_0\mathrm{e}^{-\alpha(t)} - |\dot{u}_\tau(t)|}{L} \tag{1}$$

is standard in geophysical applications dealing with earthquakes. Here, μ is the friction coefficient, $|\dot{u}_\tau|$ is the slip rate, α is the state variable, and a, b, μ_0, v_0, L are system parameters. The equations in (1) is a regularized form of the Dieterich law, where the second equation is referred to as an aging law. There is limited analytical work done on this law, where mostly Tresca friction is considered. However, coupling (1) and a dynamic problem with Coulomb friction causes analytical difficulties. We present an approximated form of the equations in (1) and prove that there exists a unique mild solution to a dynamical friction problem with normal compliance coupled with the approximation of the ODE in (1) in appropriate Banach spaces.