RATE- AND STATE-DEPENDENT FRICTION MODEL FOR RUBBER-METAL CONTACT BASED ON THE ELASTOPLASTIC FORMULATION

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ABSTRACT

It is widely known that a rubber friction shows not only a rate- and state-dependency but also a pressure-dependency, which is induced by surface roughness [1]. A friction model capable of properly describing above-mentioned dependency is an essential to conduct numerical simulations of frictional contact boundary value problems. One of authors has been proposed the rate- and state-dependent friction model based on the elastoplastic analogy formulation [2]. In addition, its validity was also verified by comparing with experiments [2]. In the formulation, however, Coulomb's frictional criterion, i.e. the constant friction coefficient, was adopted, and thus, the pressure-dependency cannot be described.

In this study, we propose the rate- and state-dependent friction model based on the elastoplastic formulation, in which the pressure-dependent frictional criterion is incorporated. In the formulation, we also prescribe evolution rules for microscopic sliding and rate-dependency. Furthermore, to demonstrate the validity of proposed model, we compare frictional responses with the experiment of sliding contact between rough rubber surface and rigid smooth plane [1].

In the formulation, we focus on only an adhesion friction. Then, we assume the isotropic sliding surface in traction space (frictional criterion) as follows:

$$\|\mathbf{f}_t\| = \tau S_r(\|\mathbf{f}_n\|, \|\bar{\mathbf{u}}^p\|, \phi)\,, \tag{1}$$

where $\mathbf{f}_t$, τ and S_r are the tangential traction vector, the shear stress of adhesion and the ratio of real contact area to the apparent contact area, respectively. As shown in Eq.(1), S_r is the function of $\mathbf{f}_n$, $\bar{\mathbf{u}}^p$ and ϕ. Here, $\mathbf{f}_n$ is the normal traction vector, $\bar{\mathbf{u}}^p$ is the plastic (nonreversible) sliding displacement, and ϕ is the state variable (, which corresponds to time). To describe the microscopic sliding due to the change of traction inside the sliding surface, we adopt the concept of unconventional plasticity [2] and incorporate the subloading-sliding surface as follows:

$$\|\mathbf{f}_t\| = R\tau S_r(\|\mathbf{f}_n\|, \|\bar{\mathbf{u}}^p\|, \phi)\,, \tag{2}$$

where $R\ (0 \le R \le 1)$ is called the normal-sliding ratio.

Figure 1 shows variation of friction force with elapsed time under several normal load conditions. It is confirmed that the pressure-dependency of friction can be described by the present model.

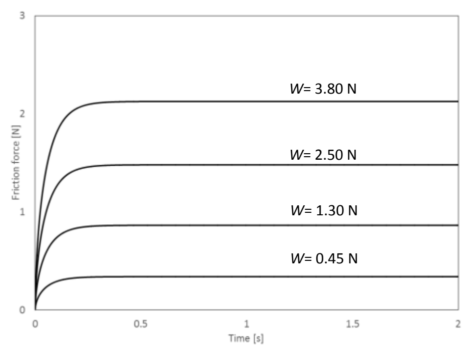

Fig.1 Time changes in friction force (pressure-dependency).

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