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An axiomatics for adhesive interfaces

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In this communication a fairly general format for the study of adhesive surface contact in the presence of damage, viscous dissipation, and friction, is proposed. Consider two rigid bodies glued together along a planar interface, and take as independent variables the normal and tangential components u, v of the relative displacement of the two bodies, plus a state variable α recording the significant information about the past histories of u and v. In the rate-independent case, that is, in the absence of viscous dissipation, the variables u ,v, α determine two functions of state, $\Psi(u,v,\alpha)$ and $\Delta(\alpha)$, which provide the current values of the elastic strain energy and of the dissipation, respectively. In the rate-dependent case the dissipation is not anymore a function of state, and the dissipation rate is provided by a dissipation potential which is a function of α and of its time derivative.

The evolution of a state under a given deformation process $t \mapsto (u(t); v(t))$ from a given initial state ($u(0)$, $v(0)$, $\alpha(0)$) is determined by two basic assumptions, which reflect the two fundamental laws of thermodynamics:

(i) the work done by the external forces σ, τ in a given time interval is equal to the variation of $\Psi + \Delta$ in the same interval,

(ii) the variation of Δ in any time interval is non-negative.

Once this evolution is known, it is immediate to determine the evolutions of Ψ, of Δ, and of the normal and tangential forces σ, τ. A basic tool in determining the evolution of the system is the law of conservation of the energy. In most cases, this law is used in its first-order incremental form, called the power equation. In some special cases, however, higher-order terms are required. Special cases originate from two constraints in the form of inequalities: the non-interpenetration condition $u \geq 0$ and the dissipation inequality $\dot{\alpha} \geq 0$. Together, they generate unilateral contact conditions of the Signorini type. Friction only occurs when $u = 0$, that is, when the unilateral contact conditions are active.