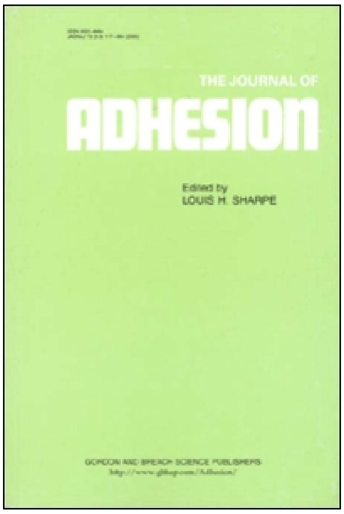

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Note

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The equations[1,2] proposed for the resistance to peeling are valid, if at all, only if the bulk adherend (*2* in Figure 1) is completely rigid. In this figure, *1* is the adhesive, *R* the flexible ribbon, and *F* the force applied to the edge of the ribbon. If the bulk adherend also is deformed during the stripping, the work is spend not only on bending *R* and extending *1* but also on that

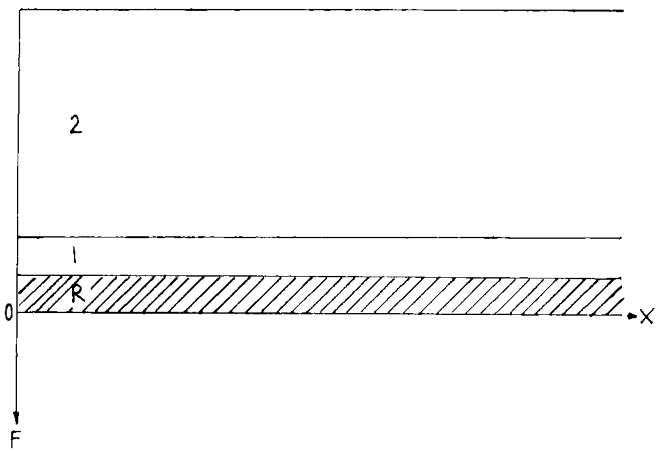

FIGURE 1 Peeling from a soft adherend. 1: adhesive film; 2: soft adherend plate; R; flexible ribbon; F: stripping force.

deformation, and the force F_m required to start (or to propagate) peeling would be expected to be greater than for a rigid plate *2*.

The above equations were derived on the basis of the theory of beams on elastic foundation; R is the beam, and *1* is the elastic foundation. Some attempts to extend the theory so as to include two-layer foundations (i.e., solids *1* and *2*) are known[3,4] but they contain so many arbitrary assumptions and arbitrary constants that it proved impossible to use them for a discussion of peeling amenable to an experimental testing. Consequently, a more physical (i.e., less mathematical) method was tried out and afforded the following results.

At any moment, the external force F is balanced by the sum of the reactive forces which act in the strained adhesive film. This is true whatever the rigidity (or the modulus E_2 of elasticity) of plate *2*. However, the value of E_2 influences the shape of the adhesive film deformed by a given force F. When $E_2 = \infty$, the expression for the absolute extension of the film contains a term e^{-nx}; thus the distance between R and *2* decreases when x (i.e., the distance from the point of application of force) increases, and this decrease is steeper the greater the factor n. This is equal to

$$n = \left(\frac{3E_1}{E\delta^3 h_1}\right)^{0.25}; \tag{1}$$

E and E_1 are the moduli of elasticity of the ribbon and the adhesive, δ is the ribbon thickness, and h_1 is the initial thickness of the adhesive film. The dimension of n is, of course, cm^{-1}.

When E_2 is not too great, plate *2* acts as a continuation of film *1* so that the effective thickness of the film is greater than h_1. It is impossible to say, how much greater, but it is clear that the additional thickness must be smaller the higher the modulus of elasticity E_2. The simplest hypothesis is, that this additional thickness is equal to k/E_2, k being a tension ($\mathrm{g/sec^2}$) independent of x. With this hypothesis, the initial stripping force F_m becomes

$$F_m = \frac{w\sigma_m}{2}\left(\frac{EE_2\delta^3 h_1 + E\delta^3 k}{3\,E_1 E_2}\right)^{0.25}; \tag{2}$$

w is the width of the ribbon (in the direction perpendicular to the plane of drawing and σ_m is the tensile strength of the adhesive (assuming that the adhesive breaks down rather than the ribbon or the bulk adherend). When $E_2 = \infty$, this expression reduces to

$$F_m = \frac{w\sigma_m}{2}\left(\frac{E\delta^3 h_1}{3\,E_1}\right)^{0.25} \tag{3}$$

which is the equation derived[1] for a rigid adherend. A slightly better approximation would be obtained by substituting $2(1 - \nu^2)/(1 - \nu_1)$ for 2 in the above expressions; ν and ν_1 are the Poisson ratios of the ribbon and the cement.

Equation (2) is a quantitative formulation of an earlier remark.[5] When it will be compared with experimental data, it will be possible to understand the meaning of the tension k better. The data available[6] are insufficient for this comparison; it is necessary to know also σ_m, E, E_1, E_2, h_1, and δ in addition to F_m/w which is too often the only quantity measured.

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