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Note

Peeling from Soft Adherends

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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, I 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 spent not only on bending R and extending I but also on that

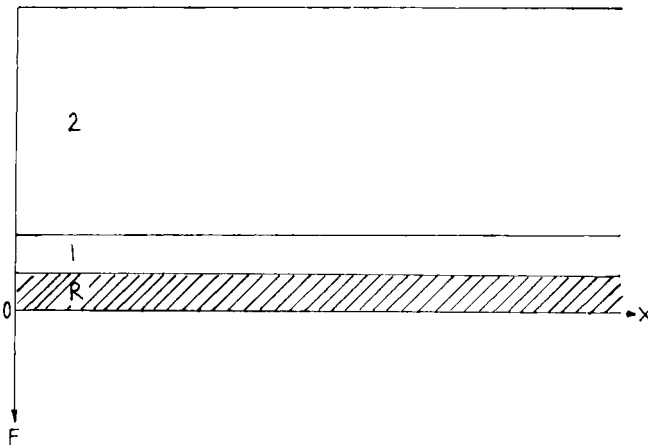


FIGURE 1 Peeling from a soft adherend. 1: adhesive film; 2: soft adherend plate; R; flexible ribbon; F: stripping force.

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 I 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

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

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 (g/sec^2) independent of x . With this hypothesis, the initial stripping force F_m becomes

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

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

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

which is the equation derived¹ 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 available⁶ 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.

References

1. Bikerman, J. J. *J. Appl. Phys.* **28**, 1484 (1957).
2. Bikerman, J. J. *The Science of Adhesive Joints* (Academic Press, New York, 1968), 2nd ed., p. 242.
3. Hetenyi, M. *Beams on Elastic Foundation* (Univ. of Michigan Press, Ann Arbor, 1946), p. 179.
4. Vlasov, V. Z. and N. N. Leont'ev, *Beams, Plates and Shells on Elastic Foundations* (Israel Program for Sci. Transl., Jerusalem, 1966), p. 25.
5. Bikerman, J. J. *J. Adhesion* **2**, 307 (1970).
6. Dahlquist, C. A. in *Aspects of Adhesion* (D. J. Alner, ed.) **5**, 183 (1969).