RUBBERLIKE ELASTICITY EXPERIMENT

Richard Greet and Robert Cobaugh
University of Southern Colorado

SUMMARY

Four rubber erasers from the campus bookstore, two green and two white, have been cut to have identical dimensions. These are loaded in compression with a mechanical test machine capable of applying cyclic loads and providing output to an X-Y plotter. The anelastic behavior of rubber as well as the relative stiffnesses of composite materials loaded transversely and longitudinally may be demonstrated to beginning students or used as input for computer analysis by advanced students.

DEMONSTRATION EXPERIMENTS

Anelasticity

In most instances, students are already familiar with the elastic behavior of metals--linear loading and unloading, without hysteresis loss. Figure 1 illustrates representative experimental behavior for the rubber erasers. Clearly seen is that the elastic deformation is highly non-linear with a large variation between loading and unloading consistent with the energy damping capacity of rubber materials. With the trade-mark identification still visible on the erasers, it is of interest to the students that such familiar everyday materials can behave in an unexpected way.

Relative Stiffness

Central to any mechanical testing program is to compare one material to another. This can be demonstrated to students by producing curves for the green and the white erasers on the same sheet of graph paper. Because the samples have been cut to have identical geometries, the comparison is immediate without the necessity of computations.

Composite Materials

Prototype composite materials can be constructed by stacking the erasers in different ways as shown in Figure 2. Compression of these stacked erasers demonstrates the different stiffness of composite materials loaded longitudinally and transversely. Again because of the identical geometry, the comparison is immediate, without computations.

QUANTITATIVE POSSIBILITIES

Data Generation

As a start to quantitative analysis, students can measure the dimensions of the samples and convert the various FORCE-DEFLECTION graphs obtained into STRESS-STRAIN curves. In the analysis mentioned below, individual points from the curves are required. These may be read off manually by the students, or two alternatives can be used to emphasize the engineer's use of computers in today's world. In one alternative, the graphs are put onto a digitizing pad and a mouse or cursor is used to generate numerical points directly into a microcomputer. In the other alternative, the machine output that drives the X-Y plotter is fed to a data collection device that is programmed to sample the voltages while the experiment is being run. The data sampling device has internal memory and can be subsequently connected to a microcomputer to transfer data.

Elastic Modulus

In addition to being a function of the strain, the elastic modulus of rubbery materials is several orders of magnitude lower than that of metals. To obtain numerical modulus values, students are directed to generate the stress-strain data along the center of the hysteresis loop. These points are then used with a least squares fit computer program to generate the coefficients of a quadratic or higher order fitted polynomial. The derivative of the polynomial is then interpreted as the instantaneous modulus during the experiment.

Damping Capacity

The area of the hysteresis loop represents the energy absorbed by the sample per unit volume per cycle of loading. To obtain this area, students must generate stress-strain numerical values for the loop itself. These numbers are then used with a computer program that performs Simpson's one third rule numerical integration to compute the area.

CONCLUDING REMARKS

The experiments described can address students at many levels. Without numerical computations, the experiments demonstrate qualitatively several aspects of materials behavior. For analysis, the computer is used and the analytical techniques themselves might be the emphasis of an instructor. Still another focus could be the data collection system itself--data sampling and/or real time analysis.

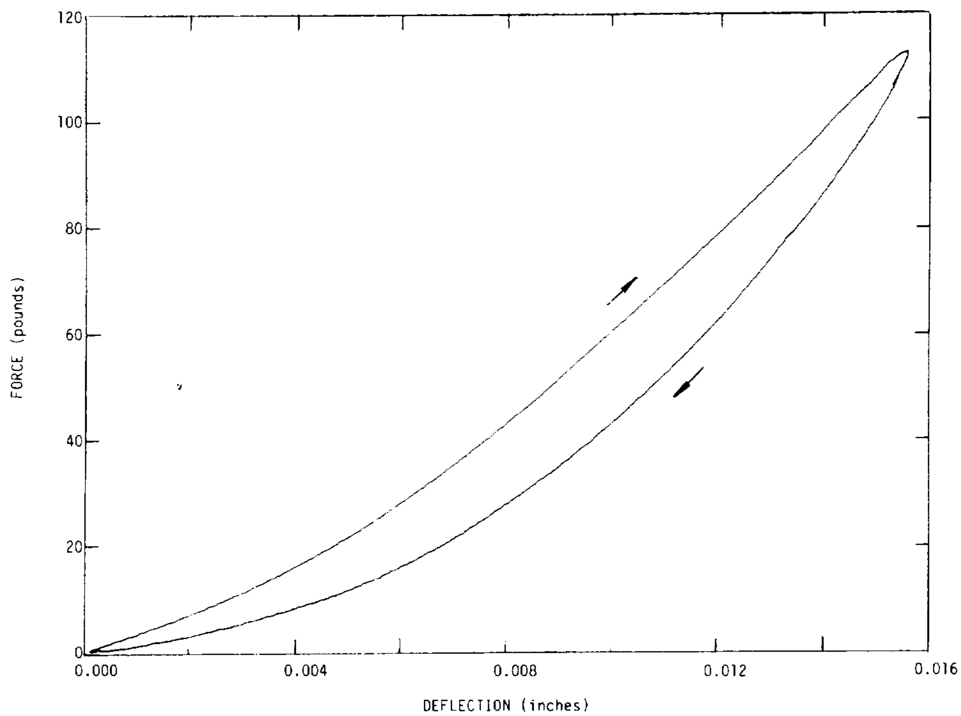

Figure 1: (Force) versus (Deflection) for rubber eraser undergoing cyclic compression.

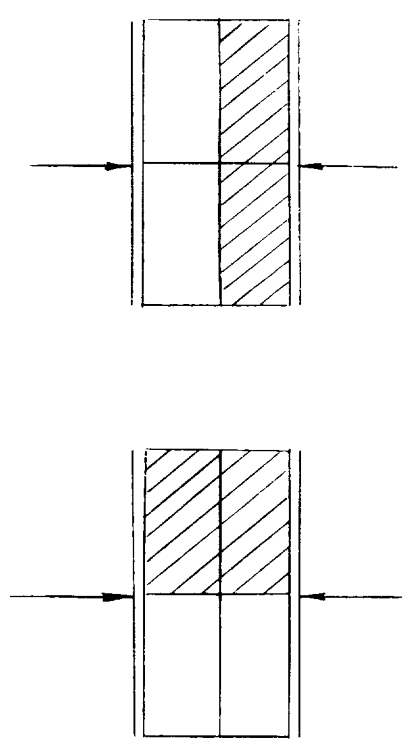

Figure 2: Stacking of erasers to simulate composite materials.