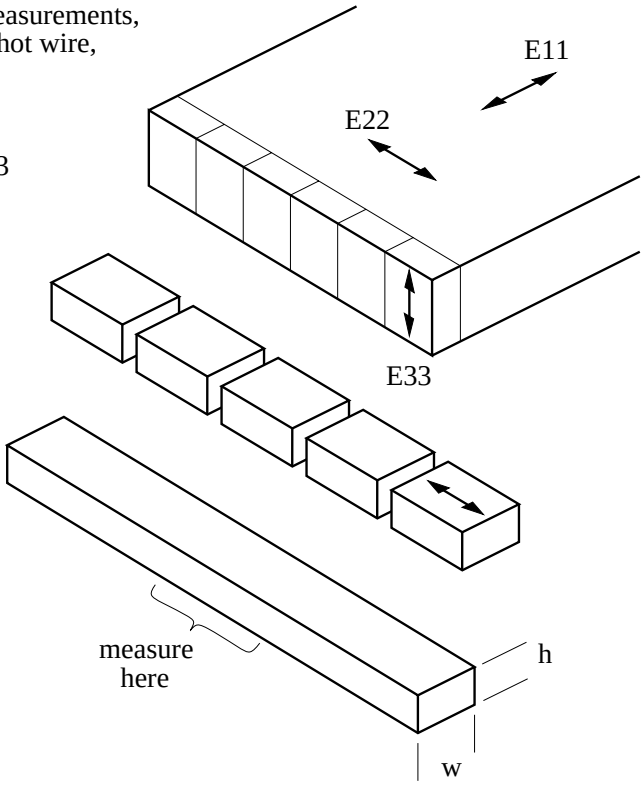
Measuring Elastic Modulus via 3−Point Bending Test

Test beam preparation

Make a beam of constant cross−section from the material to be tested. For materials with directional properties, cut the beam so that the direction to be tested is along the beam. Three separate beams will be needed for the three principal moduli E11, E22, E33.

For foam, a cross−section of roughly 1.0"x 0.5" and a length of 18" works well. Raw sheets of extruded foam have a hard skin which will corrupt the measurements, so cut the beam from the interior of the sheet in this case. Do not use a hot wire, since this will also leave a melted skin, invalidating the results. Weigh the beam and compute the material density for reference.

For core material with directional properties, the transverse stiffness E33 is typically of interest. In this case it is necessary to build a beam with the transverse material direction along the beam length, as shown:

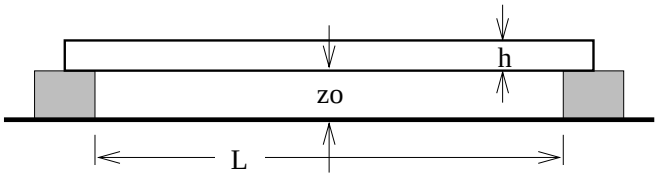


1) Cut blocks from the foam sheet, using bandsaw or long knife. (hot wire will leave a melted skin which will corrupt the results). Weigh the foam blocks and calculate their density before gluing.

2) Glue the blocks end to end with 5−minute epoxy. True the end faces if necessary to prevent large gaps. Small gaps can be filled with epoxy.

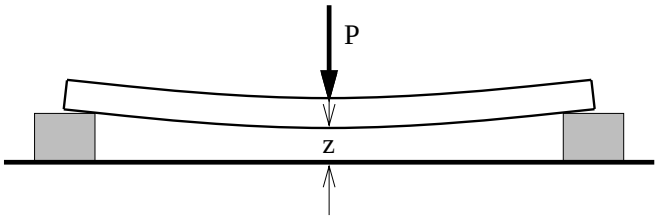
3) Sand the beam to a uniform cross−section if necessary. Measure the width w and height h accurately with caliper. If the beam is not perfectly uniform, take the measurements near the center of the beam, since this region dominates the overall beam stiffness.

Deflection measurement



1) Place beam on two supports near its ends. Accurately measure the distance L between the supports.

2) Measure the tare height zo between the beam and table at the beam center. Setting up near the edge of the table allows using the inside−measurement jaws of the caliper.



3) Put a compact weight P on the beam center, and measure the new center height z. The deflection is d = zo − z Adjust the weight to get a suggested deflection of roughly 0.001 L^2 / h . For foam, this will give a reasonably large d reading without the risk of yielding the foam.

4) When the weight is removed, the beam should spring back very close to its original tare position zo. If there is some permanent bending deformation, reduce the weight and repeat.

5) Compute elastic modulus (aka Young's modulus): E = P L^3 / (4 w h^3 d)

Units commonly used: a) P(lb), L w h d (in), E (psi)
b) P(N), L w h d (m), E (Pa)

MD 03 May 03