

EPSc 353: EARTH FORCES
Elastic Flexure Experiment

Introduction

Treating the Earth's lithosphere as a thin elastic plate can explain a number of geologic phenomena. Elastic bending of lithospheric plates is observed at various geologic settings around the globe. For example, surface loads, such as the Hawaiian Islands, bend the surrounding lithosphere. There is also observational evidence of elastic bending of the lithosphere at subduction zones. The purpose of this lab is to simulate the flexure of a lithospheric plate with strips of acrylic plexiglass. We will consider a particular type of elastic bending – bending due to a concentrated vertical load. We will place a load V_a at some length L onto a strip of plexiglass and measure the vertical displacement $w(x)$ of the strip. The equation which describes the vertical displacement in this case is

$$w(x) = \frac{V_a x^2}{2D} \left(L - \frac{x}{3} \right)$$

$w(x)$ = vertical displacement

V_a = applied load = mass*gravitational acceleration/width of ruler

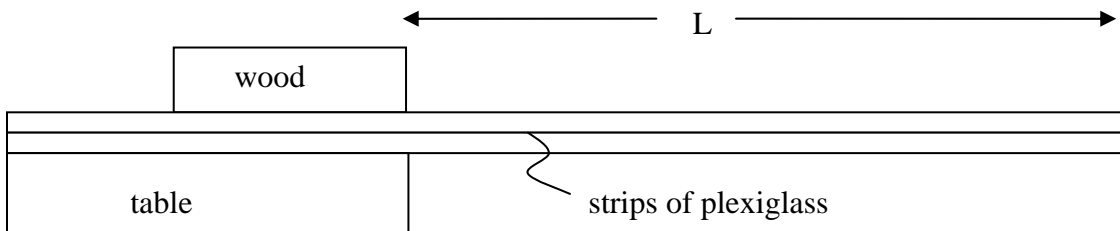
x = horizontal distance

L = length of the ruler

D = flexural rigidity

Procedure

This experiment will be carried out on strips of plexiglass with different thicknesses in order to determine the dependence of flexural rigidity on the thickness. Pick two strips of plexiglass of equal thickness. Measure the thickness to two significant figures. Place the two strips of plexiglass back to back and clamp them to the edge of a lab table using a block of wood so that the block of wood is in line with the edge of the table and the hole located at the end of the strip hangs off the edge of the table.



The two strips of plexiglass should now be hanging off of the edge of the table some distance L . Make sure that the deflection between the two strips of plexiglass is initially zero. Tape a flexible measuring tape to the top of the upper strip so that the zero point is at the edge of the block of wood and the table. For the thinner sheets of plexiglass, position the strips so that $35 < L < 40$. For the thicker strips, $40 < L < 45$. Measure this

distance L . Now apply a load to the end of the lower strip by either filling a metallic bucket with sand and hanging it through the drilled hole at the end of the strip with an S-hook or hanging the weights directly to the drilled hole at the end of the strip. The deflection at the end of strip should be $\sim 10\text{cm}$ for the thicker strips of plexiglass and $\sim 15\text{cm}$ for the thinner strips. Now, quantify the amount of deflection $w(x)$ by measuring the distance between the bottom of the upper strip and the top of the lower strip at close intervals a distance x away from the edge of the wood block. Do this so you have enough measurements to estimate the flexural rigidity D . After measuring the deflection, weigh and record the mass of the applied load (bucket + sand). Describe what happens to the lower plate after removing the load. Once you have performed the above procedure for one thickness, grab two strips of the other thickness and repeat.

Analysis

1. By way of a dimensional analysis, calculate the units of D , the flexural rigidity. Show your work.
2. Estimate the value of D for both the thin sheet of plexiglass and the thick sheet.
3. The flexural rigidity, D , of a material is equal to the thickness of the material, h , raised to an integer power times k where k is a constant dependent on the physical properties of the material.

$$D = kh^n \text{ where } k = \frac{E}{12(1-\nu^2)}$$

D = flexural rigidity

h = thickness

E = Young's Modulus

ν = Poisson's ratio

What integer power of h best satisfies this equation? Show your work.

4. What happens to the lower sheet of plexiglass after removing the load V_a from the end of the strip? Does it return to its initial position? What does this say about the assumption used to derive the flexure equation that the material is perfectly elastic? How does this affect the calculations made in problem three? What other sources of error can you think of?