GEEN 1201 - Flexure Test (ASTM D790-15)

EXPERIMENT: Three Point & Four Point Bend Test (Flexture Test)

Objective:

The bend (flexure) test method measures behavior of materials subjected to simple beam loading. It is also called a transverse beam test with some materials. The test is used to determine the flexural properties of unreinforced and reinforced plastics, including high modulus composites and electrical insulating materials.

Experimental setup and apparatus

The testing equipment is a universal testing machine (UTM) (Figure 1). The flexure tests are performed according to ASTM D790 - 15 “Standard Test Methods for Flexural Properties of unreinforced and reinforced plastics and electrical insualting materials”. This standard specifies the method for determining the ability of polymer matrix composite materials to undergo plastic deformation in bending. Applies to the bend test of test pieces taken from composite materials as specified in the relevant standard.

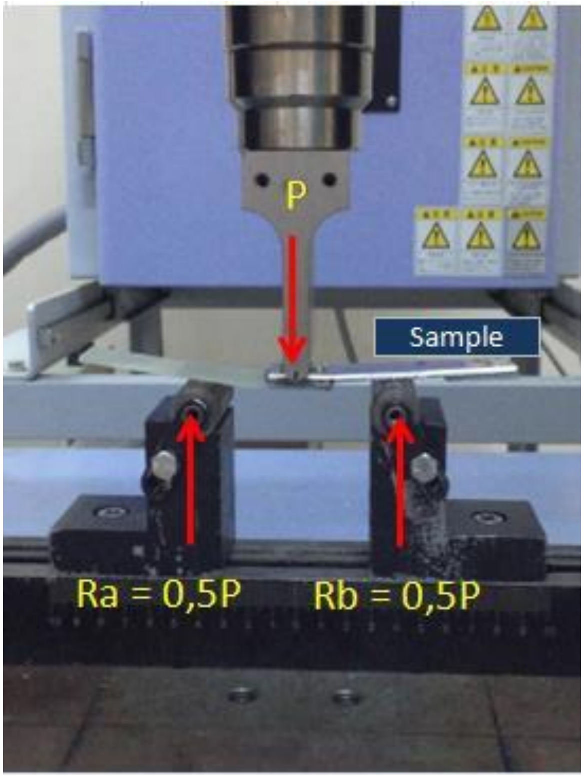

Figure 1. Tensile testing machine with bending apparatus

A) THEORY

If a beam is simply supported at the ends and carries a concentrated load at the center, the beam bends concave downwards. The distance between the original position of the beam and its position after bending is different. This difference is called ‘deflection’. In the case which occurring bending, takes places maximum deflection at the center along the length.

In the flexure (bend) test, maximum stress and maximum strain are calculated for increments of load. Results are plotted in a stress-strain diagram. Flexural strength is defined as the maximum stress in the outermost fiber. This is calculated at the surface of the specimen on the convex or tension side. Flexural modulus is calculated from the slope of the stress vs. deflection curve. If the curve has no linear region, a secant line is fitted to the curve to determine slope.

There are two test types; three point bent test four point bend test. In a three point test the area of uniform stress is quite small and concentrated under the center loading point. In a fourpoint test, the area of uniform stress exists between the inner span loading points (typically half the outer span length).

The three point bend test (Figure 2) is a classical experiment in mechanics, used to measure the Young’s modulus of a material in the shape of a beam. The beam, of length L, rests on two roller supports and is subject to a concentrated load P at its centre (Figure 2).

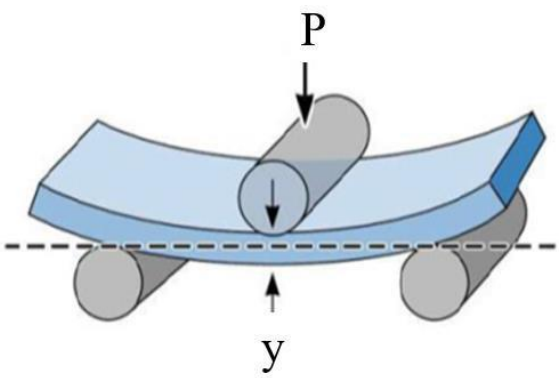

Figure 2. The three point bend test

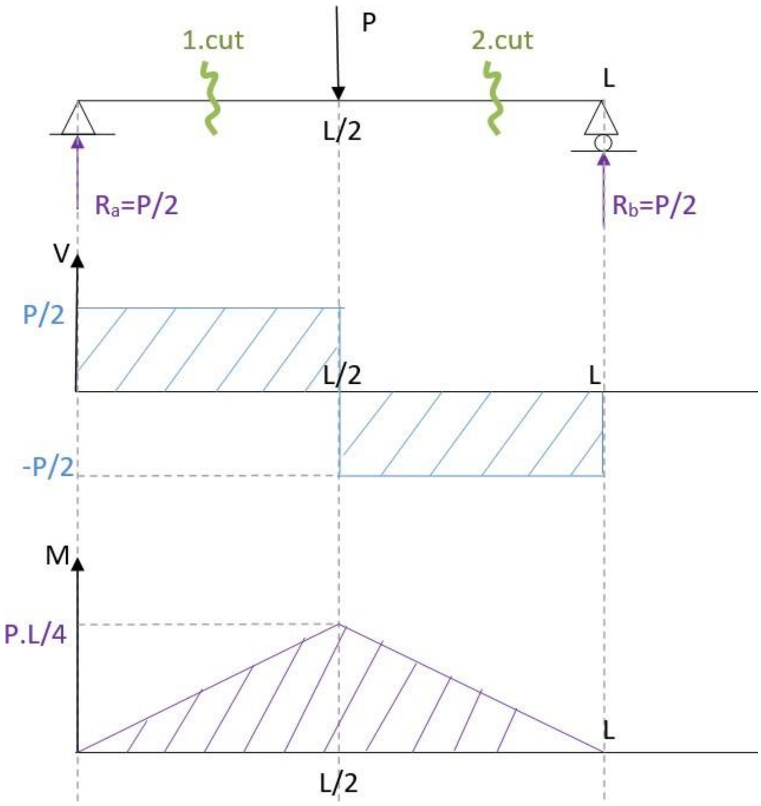

Figure 3. Schematic of the three point bend test (top), with graphs of bending moment M, shear force V

B) EXPERIMENTAL PROCEDURE:

1. Measure the width and thickness of the specimen.
2. Mark on the locations where the load will be applied under three-point bending. Note the length between supports.
3. Place the sample carefully on to the stage of 3-point bending fixture of a universal testing machine
4. Make sure that the loading point is placed on to the marked location.
5. Carry out the bend test

C) Calculation

Flexural Stress (σ_f):

$$\sigma_f = 3PL/2bd^2$$

where:
σ = stress in the outer fibers at midpoint, MPa (psi),
P = load at a given point on the load-deflection curve, N (lbf),
L = support span, mm (in.),
b = width of beam tested, mm (in.), and
d = depth of beam tested, mm (in.).

Flexural Strain, ε_f—Nominal fractional change in the length of an element of the outer surface of the test specimen at midspan, where the maximum strain occurs. It may be calculated for any deflection using the following equation:

$$\varepsilon_f = 6Dd/L^2$$

where:
ε_f = strain in the outer surface, mm/mm (in./in.),
D = maximum deflection of the center of the beam, mm (in.),
L = support span, mm (in.), and
d = depth, mm (in.) of beam tested

D) ASSIGNMENTS

1. Calculate the Flexure Strain and Flexure stress (MPa) using the above equations.
2. What is the flexure strength of the specimen.
3. Plot the Stress Vs Strain curve (Use Excel)
4. Write a small report on the findings.