APPLICATION

Materials Testing

Stress–Strain Curve I

Strength testing of materials often involves a *tensile test* in which a sample of the material is held between two mandrels while increasing force—actually, *stress* (i.e., force per unit area)—is applied. A stress-vs.-strain curve for a typical ductile material is shown in Figure 3.48.

During the test, the sample first stretches reversibly (A to B). Then irreversible stretching occurs (B to D). Finally, the sample breaks (point D).

Point C is called the material's *ultimate stress*, or *tensile strength*, and represents the greatest stress that the material can endure (with deformation) before coming apart. The *strain* is the amount of elongation of the sample (mm) divided by the original sample length (mm).

The reversible stretching portion of the curve (A to B) is linear, and the proportionality constant relating stress and strain in this region is called *Young's modulus*, or the *modulus of elasticity*.

Tensile test data on a soft, ductile sample are listed in Table 3.2 (available electronically at http://www.chbe.montana.edu/Excel).

To analyze the data we will want to

1. Plot the tensile test data as a stress-vs.-strain graph.
2. Evaluate the tensile strength from the graph (or the data set).
3. Create a second graph containing only the elastic-stretch (linear) portion of the data.
4. Add a linear trendline to the new plot to determine the modulus of elasticity for this material.

First, the data are entered into the worksheet (Figure 3.49). Then, an XY Scatter graph is prepared as shown in Figure 3.50. The ultimate tensile stress can be read from the graph or the data set, as shown in Figure 3.50.

Finally, another graph (Figure 3.51) is prepared, containing only the linear portion of the data (the first eight data points).

A linear trendline with the intercept forced through the origin has been added to the graph in Figure 3.48. We will use the slope from the equation for the trendline

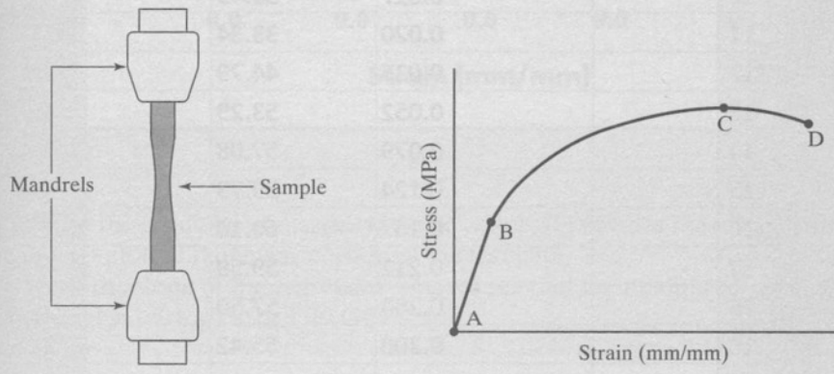


Figure 3.48
Tensile test.

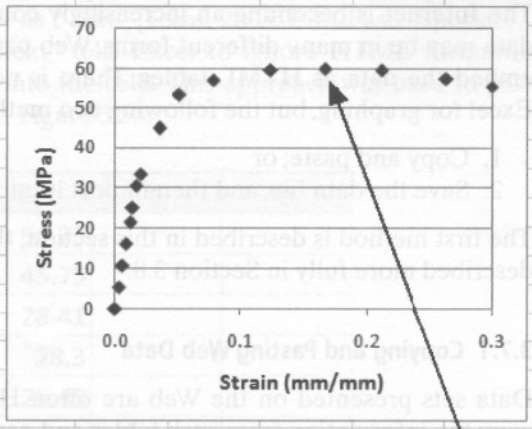
Table 3.2 Tensile Test Data

Strain (mm/mm)	Stress (MPa)
0.000	0.00
0.003	5.38
0.006	10.76
0.009	16.14
0.012	21.52
0.014	25.11
0.017	30.49
0.020	33.34
0.035	44.79
0.052	53.29
0.079	57.08
0.124	59.79
0.167	60.10
0.212	59.58
0.264	57.50
0.300	55.42

	A	B	C	D
1	**Stress–Strain Curve I**			
2				
3		Strain (mm/mm)	Stress (MPa)	
4		0.000	0.00	
5		0.003	5.38	
6		0.006	10.76	
7		0.009	16.14	
8		0.012	21.52	
9		0.014	25.11	
10		0.017	30.49	
11		0.020	33.34	
12		0.035	44.79	
13		0.052	53.29	
14		0.079	57.08	
15		0.124	59.79	
16		0.167	60.10	
17		0.212	59.58	
18		0.264	57.50	
19		0.300	55.42	
20				

Figure 3.49
Strain and stress data.

	A	B	C
1	Stress–Strain Curve I		
2			
3		Strain (mm/mm)	Stress (MPa)
4		0.000	0.00
5		0.003	5.38
6		0.006	10.76
7		0.009	16.14
8		0.012	21.52
9		0.014	25.11
10		0.017	30.49
11		0.020	33.34
12		0.035	44.79
13		0.052	53.29
14		0.079	57.08
15		0.124	59.79
16		0.167	60.10
17		0.212	59.58
18		0.264	57.50
19		0.300	55.42
20			



Ultimate tensile stress, 60.1 MPa

Figure 3.50
Stress–strain curve.

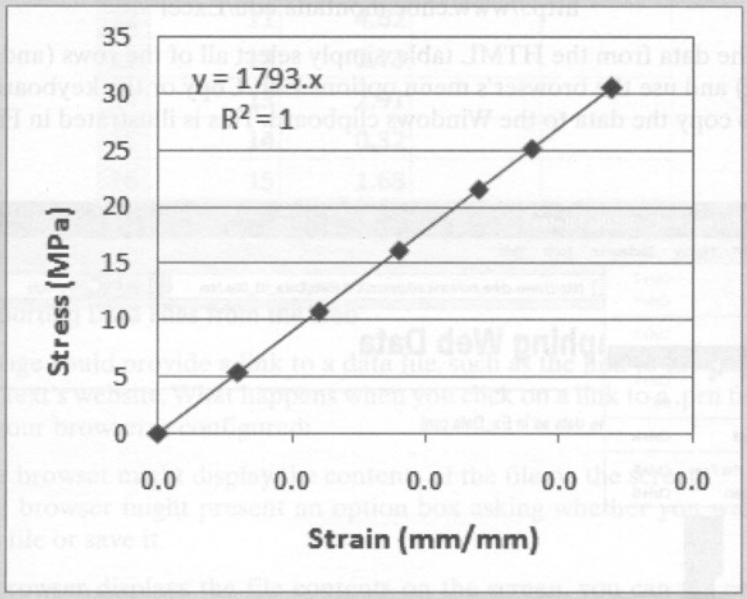


Figure 3.51
The linear portion of the stress–strain curve, with trendline.

to compute the modulus of elasticity; the R^2 value, 1, provides reassurance that we have indeed plotted the linear portion of the test data.

From the slope of the regression line, we see that the modulus of elasticity for this material is 1793 MPa, or 1.79 GPa.