LAB 1: TENSION TEST OF STEEL & ALUMINIUM

1. Standards

- ASTM E8 – Standard Test Methods for Tension Testing of Metallic Materials
- ASTM E111 – Standard Test Method for Young's Modulus, Tangent Modulus, and Chord Modulus

2. Purpose

For each of the metal specimens loaded in tension, you have:

- To determine the stress-strain relationship;
- To determine the yield strength;
- To determine the tensile strength;
- To determine the elongation and reduction of cross-sectional area;
- To determine the modulus of elasticity
- To determine the Modulus of Resilience and Toughness and;
- To determine the rupture strength

3. Material

- Hot-rolled steel specimen
- Cold-rolled steel specimen
- Aluminium specimen

4. Apparatus

- Universal testing machine
- Micrometer callipers
- Gauge marker
- 50 mm gauge length Extensometer

5. Procedure

1. For each specimen, determine the mean cross-sectional dimensions from 5-μm readings taken near the centre.
2. For each specimen, mark off a 200-mm total gauge length at 25 mm intervals for punching on the flat side of the specimens. Do not make the gauge marks too deep; this may lead to a weakened section and a possible brittle fracture. Measure the actual distance between gauge marks from 5-μm readings.

3. Insert the specimen in the test machine. For wedge grips, the specimen should extend through the grips in order to ensure adequate gripping surface. An extensometer will be placed at the middle of the specimen to measure the deformation.
4. The extensometer will record the specimen elongation (deformation) for each load increment up to failure. You can verify that the proportional (elastic) limit has been reached by looking at the load-elongation curve provided by the testing machine.

   Continue the loading until the specimen ruptures. Record the maximum load and the load at fracture. After rupture, measure the change in all the gauge distances and the specimen cross-sectional area at the rupture section by holding the two pieces together.

6. Results

1. Calculate and plot the stress σ against strain ε for all the specimens tested and for all the readings taken by the testing machine up to failure. These results will be sent to you through e-mail by your TA. Calculate the stress σ corresponding to each of the strain readings according to:

$$\sigma = \frac{P}{A_o} \tag{1}$$

   where P = applied load (N) and A_o = original cross-sectional area (mm^2).

   The strain values are the deformation values (ΔL) sent by your TA divided by the extensometer height of 50 mm (Lo). Label all curves as to specimen type.

2. From the results in 1, plot the stress σ (ordinates) against strain ε (abscissa) to a large scale.
3. From the curves, obtain the Young's modulus of elasticity *E*, the modulus of resilience (area under the stress-strain curve corresponding to the elastic region), the proportional limit, and the yield stress σ_y (both upper and lower yield strengths in the case of some mild steels.) For the aluminium specimen, calculate the 0.2% offset yield stress. Label all curves as to specimen type.
4. From the graphs obtained in 3, calculate the modulus of toughness (area under the stress-strain curve up to failure.) Indicate on the graphs the tensile strength (stress corresponding to the maximum load) and the rupture strength (stress corresponding to final load).
5. From the measurements taken after the rupture of the specimens, calculate the percent elongation over the 200-mm gauge length as well as the percent elongation for each of the 25-mm intervals of the total 200-mm gauge length according to:

$$\%\,\text{elongation} = \frac{L_f - L_o}{L_o} \times 100 \tag{2}$$

where L_f = gauge length after rupture (mm). Tabulate your results. Plot all the percent elongation values (ordinates) against the centre of the appropriate gauge distance (abscissa.)

6. Calculate the percent reduction in area of the fracture according to:

$$\%\ \text{reduction in cross section} = \frac{A_o - A_f}{A_o} \times 100 \qquad (3)$$

where A_f = cross-sectional area after rupture (mm^2).

7. Discussion

In addition to reporting all the calculated values, compare all the results for the steel and aluminium specimens. Compare your test results with those given in your textbook or other references (provide full details of references used.) Explain fully any differences from expected behaviour. Discuss the differences if any in the tensile strength and ductility of the steel specimens.