Tensile Testing of Structural Metals

Standards
- *ASTM E8: Tension Testing of Metallic Materials*

Purpose
- To obtain the material's stress-strain relationship.
- To determine the following structural properties: modulus of elasticity, yield strength, ultimate tensile strength, failure strength, and strain to failure.
- To determine the reduction of cross-sectional area.

Equipment and Materials
- *Tinius-Olsen* load frame (Figure 1.1.1)
- Computer with *LabVIEW*®
- Extensometer
- Caliper to measure original dimensions of specimen
- Permanent marker
- Specimens: 1018 steel, annealed 1018 steel and 6061-T6 aluminum
- Safety glasses

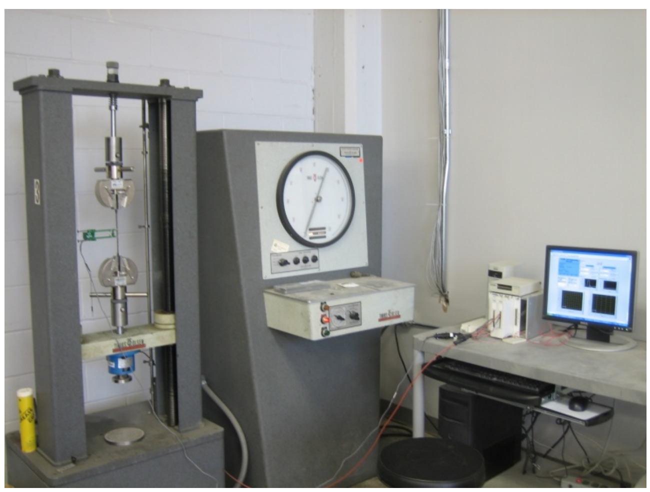

Figure 1.1.1. Lab setup

Experimental Procedure
1. Label each specimen with your group's initials and an identification number (i.e., #1, #2, etc.) on each end.

2. Using the caliper, take approximately five measurements of both the width and the thickness and average each dimension to calculate the cross-sectional area. Measure the length of the test section between fillets. *[See worksheet at the end of this lab.]*

3. With the zero-pin in place, attach the extensometer to the specimen.

4. Carefully place the specimen in the grips of the testing machine (figure 1.1.2).

Figure 1.1.2. Specimen inserted into grips.

5. Carefully remove the zero-pin by rolling it back and forth.

6. Set the crosshead speed of the load frame to 0.500 cm/min

7. Type initial data into the tensile test program (figure 1.1.3). Click Run.

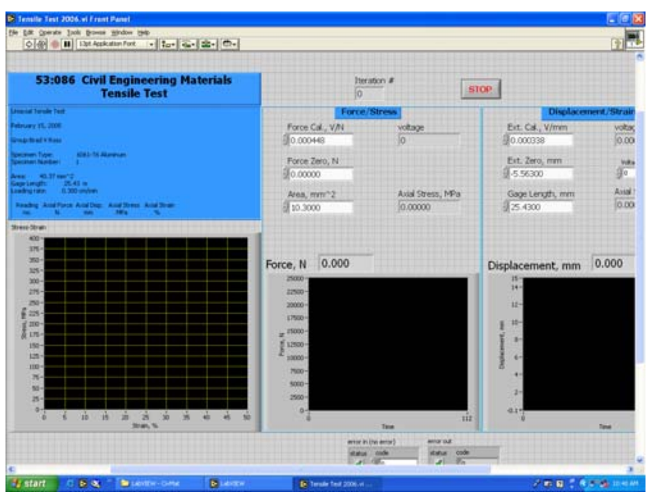

Figure 1.1.3. Screenshot of program.

8. After the *LabVIEW*® program has started collecting data, start the testing machine. (We will go over this in more detail in class.)

9. Continue applying the load until the specimen fails. At this point, stop *LabVIEW®*.

10. Obtain the data/results file from the computer and copy it to your own disk.

Analysis and Results

- Plot the stress versus strain curve.

- Determine yield strength, $\boldsymbol{\sigma_{yd}}$, using the 0.2% offset method.

- Calculate (or use your stress-strain plot) the ultimate tensile strength.

$$\sigma_{t,ult} = \frac{P_{max}}{A_0} \tag{1.1.1}$$

Where:

$\sigma_{t,ult}$ ≡ ultimate tensile strength, MPa (psi)
P_{max} ≡ maximum load carried by the specimen during the test, N (lb)
A_0 ≡ original cross-sectional area of specimen, mm^2 ($in.^2$)

- Calculate the strain to failure, or elongation.

$$\%\text{Elongation} = \frac{(L_f - L_0)}{L_0} \times 100 \tag{1.1.2}$$

Where:

L_f ≡ gauge length after failure, mm (in.)
L_0 ≡ original gauge length, mm (in.)

For elongation > 3.0%, fit the ends of the fractured specimen together and measure L_f as the distance between two gauge marks. For elongation < 3.0%, fit the fractured ends together and apply an end load along the axis of the specimen sufficient to close the fractured ends together, then measure L_f as the distance between gauge marks.

- Calculate the modulus of elasticity.

$$E = \frac{\sigma}{\varepsilon} \tag{1.1.3}$$

where:

E ≡ modulus of elasticity, MPa (psi)
σ ≡ stress, MPa (psi)
ε ≡ corresponding strain, mm/mm (in./in.)

- Calculate (or use your stress-strain plot) the failure strength.

$$\sigma_f = \frac{P_f}{A_0} \tag{1.1.4}$$

where:

$\sigma_f \equiv$ failure strength, MPa (psi)
$P_f \equiv$ final load carried by the specimen during the test, N (lb)
$A_0 \equiv$ original cross-sectional area of specimen, mm^2 (in.^{2})

- Calculate the reduction of cross-sectional area.

$$\%\text{Reduction} = \frac{(A_0 - A_f)}{A_0} \times 100 \tag{1.1.5}$$

where:

$A_f \equiv$ cross-section after failure, mm^2 (in.^{2})

To calculate the cross-section after failure, fit the ends of the fractured specimen together and measure the mean diameter or width and thickness at the smallest cross-section.

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Tension Test Worksheet

Group:____ Date:____________________

		Before Test		After Test		From Data					
Spec. #	**Material**	A_0	L_0	A_f	L_f	σ_{yd}	$\sigma_{t, ult}$	σ_f	E	%Elong.	%Red. Area
1											
2											
3											
4											
5											
6											
7											
8											
9											