**CEEN 3320 - Behavior & Properties of Engineering Materials**
**Laboratory Experiment No. 3 – Tension, Shear and Impact Resistance of Metals**

**OBJECTIVES:** To give students the opportunity to conduct tension and shear testing for common steel and aluminum specimens, to examine the behavior of these metals when subjected to stress, and to experimentally determine mechanical properties of these materials which are suitable for design. The student will also be given the opportunity to observe Charpy Impact Testing and to apply experimental data for design and analysis.

**EQUIPMENT:** Riehle universal tension-compression, extensometer, shear testing apparatus, data collection equipment, Charpy Tester.

**REFERENCE:** Textbook Chapters 2 – 4, Appendix Experiments 2 & 4.

**PROCEDURES:**

**Tension Testing**

1. Measure and record the diameter of the reduced section of each tensile specimen.
2. Place two marks, approximately 2 inches apart, centered on the reduced portion of the specimen and record this dimension as the gauge length. Mount the tensile specimen within the testing machine and affix the extensometer within the reduced portion of the tensile specimen. Zero all readings.
3. Apply the tensile load at a strain rate between 0.05 and 0.50 in/in per minute. Continue loading until 10 % strain has been observed. Remove extensometer and continue loading until failure.
4. After specimen failure, fit the fractured ends together carefully and measure both the distance between the gauge marks and the reduced diameter of the specimen to the nearest 0.01 in. If the reduced shape is elliptical, the reduced area may be calculated by $\pi d_1 d_2/4$, where $d_1$ and $d_2$ are the major and minor diameters, respectively.
5. Repeat steps 2 through 4 for each remaining tensile specimen.

**Shear Testing**

1. Measure and record the diameter and length for each shear specimen.
2. Mount each shear specimen in the shear apparatus for <u>double shear</u> and load at approximately 0.10 inches per minute. Record the maximum load prior to failure for each test.
3. Observe and record the characteristics of the failure surface of each specimen.

**Charpy Impact Testing**

1. Measure and record the temperature of the control medium.
2. Carefully remove the test specimen and mount in the impact testing machine. Release the pendulum and record the energy required to break and the fracture surface appearance.

**Tension Rod Testing**

1. Apply a load, P, to the simple pin connected test frame, as illustrated in Figure 1, and record the strain induced in the 6061-T6 aluminum tension rod.
2. Successively increase the loading on the test frame and record the strains induced in the tension rod.

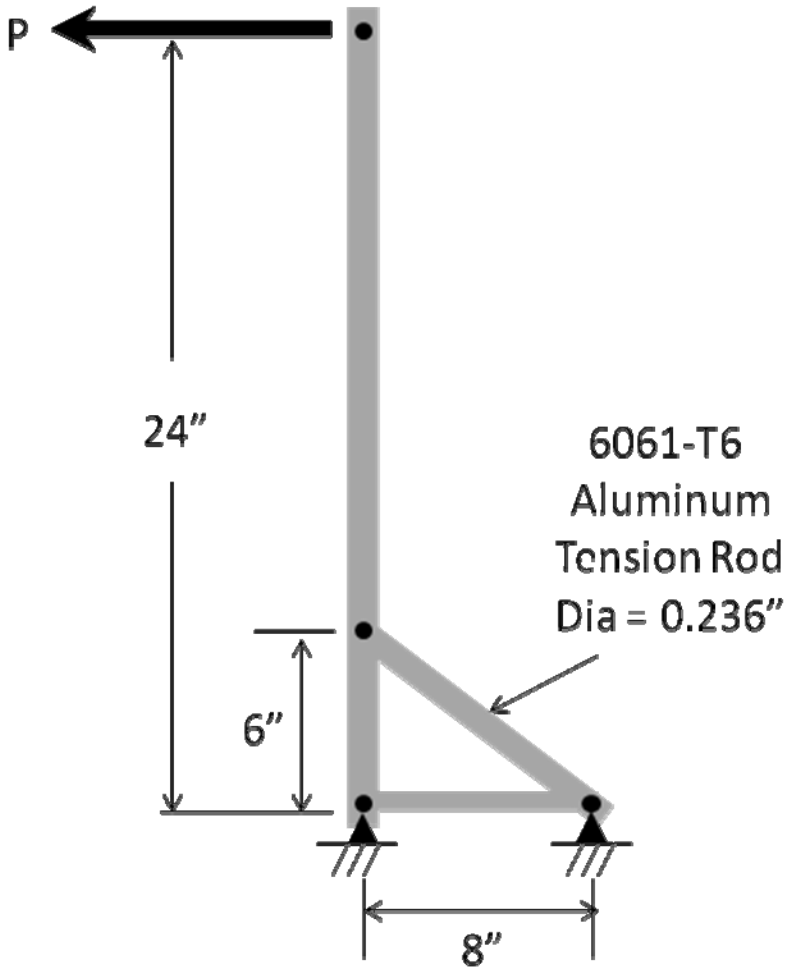


**Figure 1: Schematic Illustration of Load Test Frame**

**CEEN 3320 - Behavior & Properties of Engineering Materials**
**Laboratory Experiment No. 3 - Tension and Shear of Metals**

## CALCULATIONS

### Part A – Tension Testing

1. Compute the tensile strength of each material: $\sigma_{ut} = \frac{P_u}{A_o}$
2. Compute the percentage elongation of each specimen: $100\left[\frac{L_f - L_o}{L_o}\right]$
3. Compute the percent reduction in area for each specimen: $100\left[\frac{A_f - A_o}{A_o}\right]$
4. Compute the modulus of elasticity (MOE) for each material: $E = \frac{P/A_o}{\varepsilon}$. Use appropriate stress and strain values consistent with the ease in which the yield point can be seen in the experimental data.
5. Compute the yield strength of each material: $\sigma_{yt} = \frac{P_y}{A_o}$

### Part B – Shear Testing

1. Calculate the ultimate shear strength for each specimen tested in double shear: $\sigma_{ut} = \frac{P_u}{2A_o}$

### Part C – Charpy Impact Testing

1. Develop plots of the fracture energy and % ductile failure versus temperature and determine the ductile-to-brittle transition temperature zone for each criterion.

### Part D – Load Frame Testing

1. Using the calculated MOE for the 6061-T6 Aluminum rod, compute the expected strain in the tension rod under the applied loads used in lab. Compare these values to those obtained during lab and comment on the similarities/differences.

2. What is the maximum load that can be applied to the test frame while maintaining a factor of safety of 1.7 against the limit state of yielding of the aluminum tension rod?

**CEEN 3320 - Behavior & Properties of Engineering Materials**
**Laboratory Experiment No. 3 - Tension and Shear of Metals**

## DATA SHEET 1 - TENSION TESTS

| | **A-36 Steel** | **6061-T6 Aluminum** |
|---|---|---|
| Initial Diameter; $d_o$ | | |
| Initial Gauge Length (in.); $L_o$ | | |
| Final Diameter (in.); $d_f$ | | |
| Final Gauge Length (in.); $L_f$ | | |
| Peak Load (kips); $P_u$ | | |

## DATA SHEET 2 – SHEAR TESTS

| **Specimen Type** | **Diameter in** | **Maximum Load, lbs** | **% Ductile Shear** |
|---|---|---|---|
| **A36 Steel** | | | |
| **6061-T6 Aluminum** | | | |

**CEEN 3320 - Behavior & Properties of Engineering Materials**
**Laboratory Experiment No. 3 - Tension and Shear of Metals**

## DATA SHEET 3 – CHARPY TESTS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Medium Temperature, C | | | | | | | |
| Fracture Energy | | | | | | | |
| Failure Surface Appearance | | | | | | | |

## DATA SHEET 4 – LOAD FRAME TESTS

| | | | | |
|---|---|---|---|---|
| **Load, lb** | | | | |
| **Strain, x10$^{-6}$** | | | | |