Uniaxial Tension Testing

Purpose

In this laboratory we will conduct tension tests on steel rebar and a steel and aluminum specimens cut according to ASTM E8 standard.
These materials have unique characteristics, including ultimate strength, yield strengths, modulus of elasticity and elongation properties. These properties will be measured by conducting tension tests with precision data acquisition equipment using the loading frame described in the appendix. The data acquisition equipment will collect data on displacement, strain and load and store them for later use in a text file.

Experimental Procedure

1) Measure the diameter/width/thickness and the ridge-to-ridge length of each specimen. The diameter/width/thickness will be used to calculate stress given load and the length will be used to measure final elongation, which will often not be captured by the strain-measuring device.
2) After each specimen has been broken, note the peak load and measure the final ridge-to-ridge distance to determine total elongation.
3) Observe each sample's failure surface.
4) After the lab is complete, download the data for each of the four materials from the Web for later use in Excel.

Analysis

1) Using Excel, convert force to stress using a formula and the measured initial diameter. Plot each pair of stress-strain curves. **Use a common axis scale** for all plots so that they can be directly compared.
   The data from the tests is arranged in 3 columns: displacement (mm) and load (kN), and strain. The load is read directly as a change in voltage in the load cell. The displacement is the actual distance the lower grip moves downward during a test. It is important to note that this device will not record "neck-off" in the gage length, and thus the total extension of the sample may not be directly available from the data acquisition device.
2) Calculate the peak stress and total elongation in terms of strain for each sample.
3) Calculate the 0.2% offset strength for each specimen. Compare this value to the ultimate strength.
4) Find the elastic modulus, E, in kPa, for each specimen.
5) Work done is defined as force•distance, usually given in terms of kN•m. This value can be found for the various samples tested in this experiment by taking the area under the force vs. displacement curve, which is linearly related to the stress vs. strain curves already plotted. Calculate the work done to fracture for each sample. Please list some applications where the ability to adsorb energy would be a critical design consideration.

Report Requirements

Your report should provide an introduction, an explanation of the experimental procedures, the results of these experiments including a tabulation of the central results (such as strength), and conclusions and observations, including answers to the various questions asked in the analysis section above.

Please include in the appendix any sample computations needed to provide backup for your spreadsheet calculations. Make sure to clearly mention all appendix contents in the body of the report and to label all appendix items clearly. It is never appropriate to include items in the appendix which are not mentioned in the report.

APPENDIX I

Schematic view of the main components and controls of a servohydraulic uniaxial testing rig

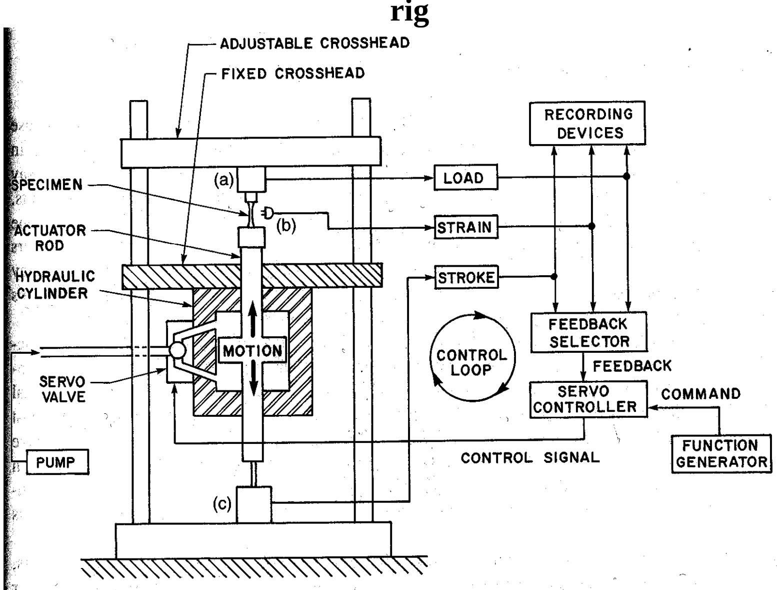
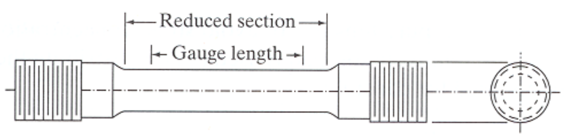
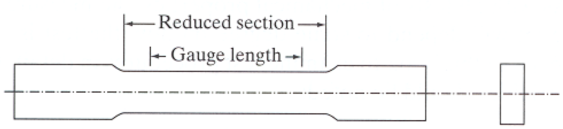


Figure 4.4 Modern closed-loop servohydraulic testing system. Three sensors are employed: (a) load cell, (b) extensometer, and (c) LVDT. (Adapted from [Richards 70]; used with permission.)

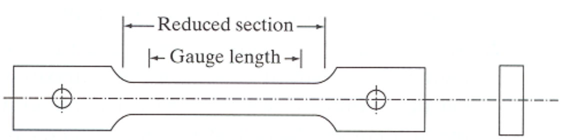
Typical specimen geometry for metallic materials



(a) Cylindrical specimen, threaded ends



(b) Flat test specimen, plain ends



(c) Flat test specimen, pin ends

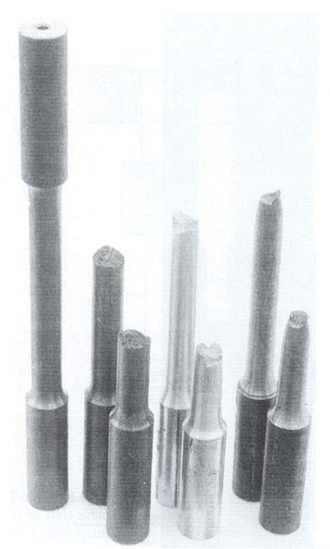


Figure 5.7
Typical tensile specimen geometries: (a) cylindrical specimen, threaded ends; (b) flat test specimen, plain ends; (c) flat test specimen, pin ends.

Figure 4.5 Tensile specimens of metals (left to right): untested specimen with 9 mm diameter test section, and broken specimens of gray cast iron, aluminum alloy 7075-T651, and hot-rolled AISI 1020 steel. (Photo by R. A. Simonds.)

APPENDIX II

Typical behavior of metallic materials

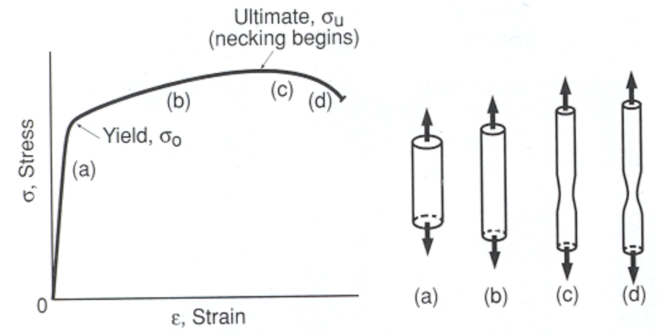


Figure 4.9 Schematic of the engineering stress-strain curve of a typical ductile metal that exhibits necking behavior.

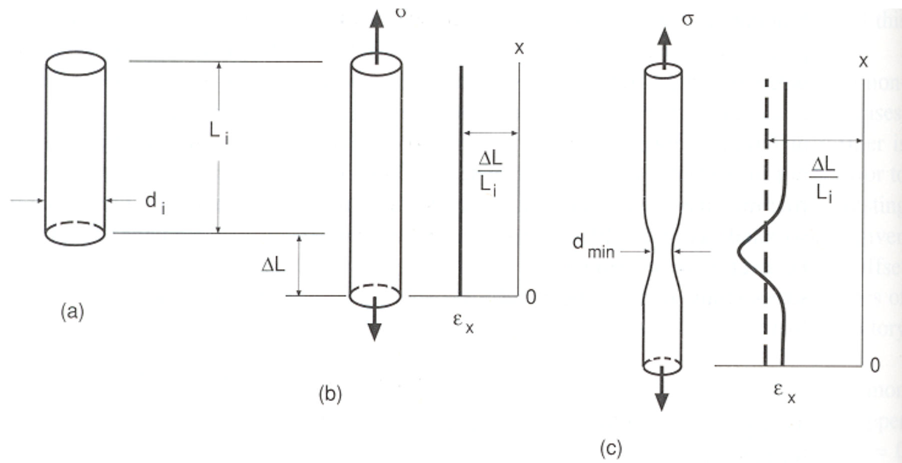


Figure 4.12 Deformation in a tension test of a ductile metal: (a) unstrained, (b) after uniform elongation, and (c) during necking.

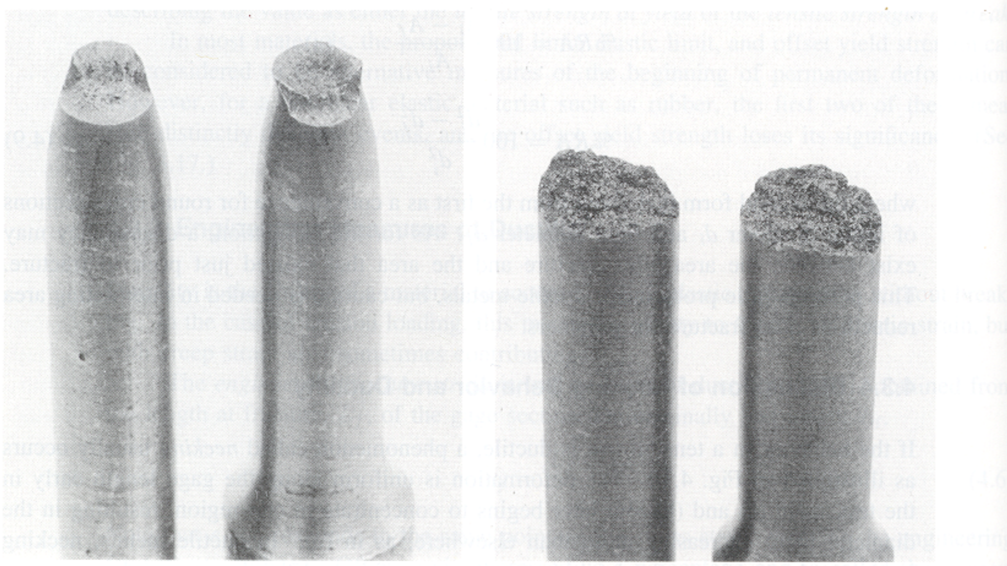


Figure 4.13 Fractures from tension tests on 9 mm diameter specimens of hot-rolled AISI 1020 steel (left) and gray cast iron (right). (Photos by R. A. Simonds.)

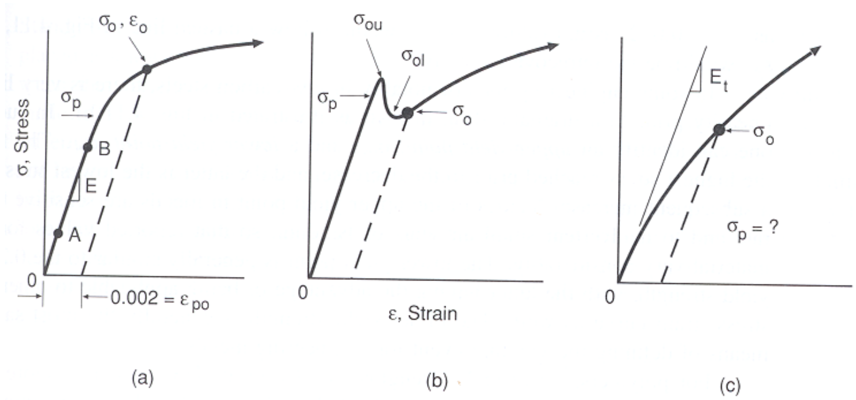


Figure 4.11 Initial portions of stress-strain curves: (a) many metals and alloys, (b) material with yield drop, and (c) material with no linear region.

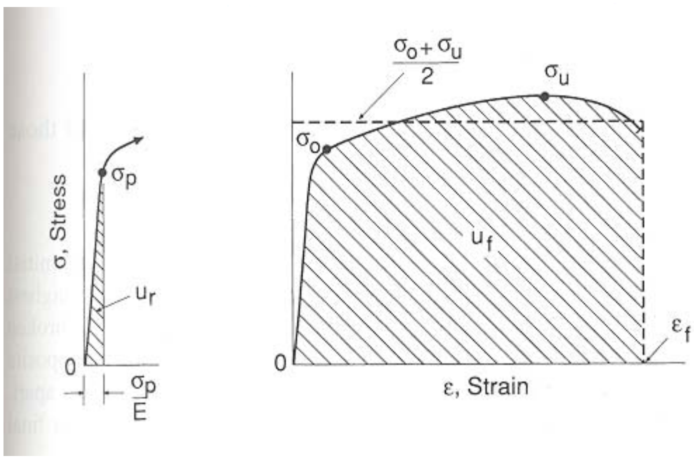


Figure 4.14 Areas under engineering stress-strain curves corresponding to resilience u_r and tensile toughness u_f.

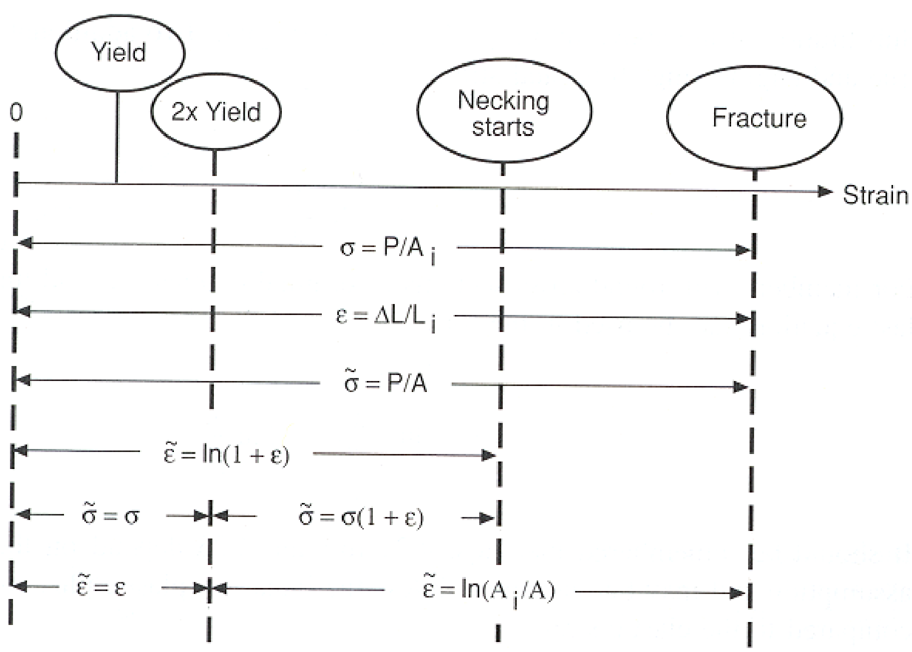


Figure 4.20 Use and limitations of various equations for stresses and strains from a tension test.