1. A column is constructed from high-strength concrete (E_{con}=30GPa) and four A-36 steel (E_{st}=200GPa) reinforcing rods as shown in figure 1. If the column is subjected to an axial load, determine the required diameter of each rod so that one-fourth of the load is carried by the steel rods and three-fourths by the concrete. (20%)

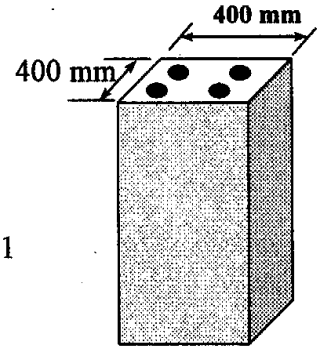


Figure 1

2. A circular bar with a diameter of 2 cm made of a ***brittle material*** is subjected to a torque ***T*** as shown in figure 2a. The bar eventually breaks due to a torque at 400 N•cm.

(a) Determine the maximum shear stress, tensile and compressive stresses of the bar while breaking and show these stresses on stress elements with proper orientation. (8%)

(b) What would the broken bar look like after break? Does the broken bar look like figure 2b or figure 2c? (3%)

(c) Does the bar break due to tensile stress or due to shear stress? (3%)

(d) Draw a Mohr's circle to describe the state of stress of the bar. Give the stress values obtained in (a) on Mohr's circle and indicate the point on Mohr's circle at which break takes places. (6%)

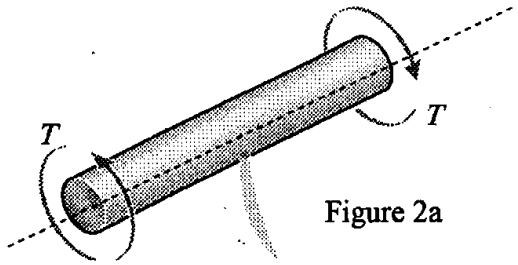


Figure 2a

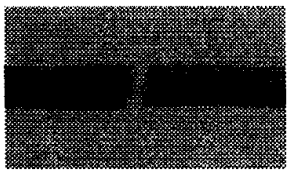


Fig. 2b

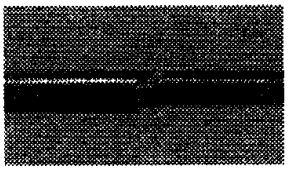
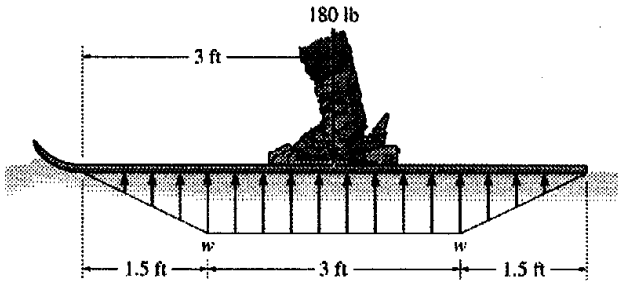


Fig. 2c

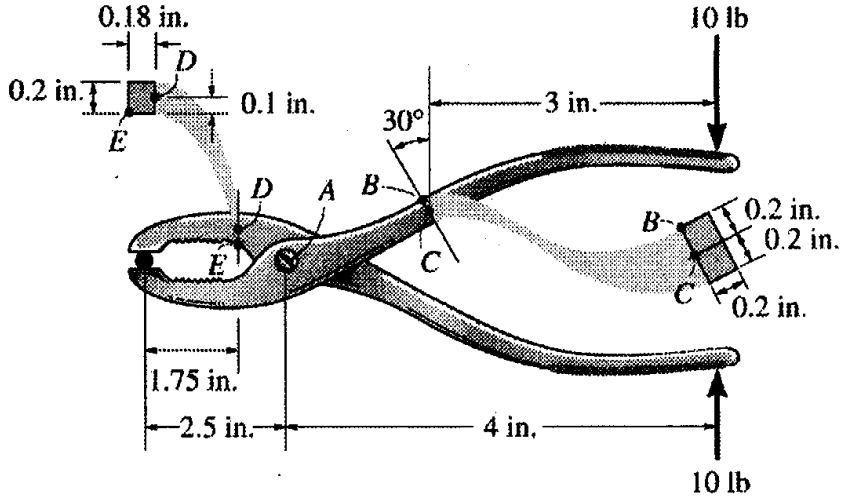
3. The ski in figure 3 supports the 180-lb weight of a man.
(a) If the snow loading on its bottom surface is trapezoidal as shown in figure 3, determine the intensity *w*, and then draw the shear and bending moment diagrams for the ski. (15%)
(b) If the thickness and width of the ski are 0.5 in. and 12 in. respectively, determine the maximum bending stress on the ski. (5%)

Figure 3



4. The pliers in figure 4 are made from two steel parts pinned together at A. If a smooth bolt is held in the jaws and a gripping force of 10 lb is applied at the handles, determine the state of stress developed in the pliers at point B and C. Here the cross section is rectangular, having the dimensions shown in figure 4. (20%)

Figure 4



5. A shear force **V** is exerted on one end of a shaft having a circular cross section as shown in figure 5. The radius of the shaft is ***r***.

(a) Determine the maximum shear stress in the shaft. By what factor is the maximum shear stress larger than the average shear stress acting over the cross section? (10%)

(b) Determine the mathematical expression of the shear stress distribution along the y axis over the cross section of the shaft in terms of **V**, ***r*** and **y**. Plot the shear stress distribution schematically. (10%)

Figure 5