



Activity 6.2c – More Engineering Problems

Purpose

In Principles of Engineering there is a need for word problems that cover the different aspects of the strength of materials. What follows is a sampling of many types of problems which can be used as practice. As an aid to the idea of “practice,” many types of problems are repeated with different scenarios.

Note: When solving these problems, 3.14 was used as an approximation for π , and all “long running” decimals were rounded to the nearest thousandths place. Your answers may not exactly match the answers given; however, when you have rounded to the correct significant digit, you should be in agreement.

Equipment

Word®
PowerPoint®
Access to internet

Procedure

To be a successful word problem solver, one must develop a strategy. There are as many strategies as there are people who successfully solve problems. There are, however, a couple of simple, easy steps that you should follow to make your quest for a solution a bit easier. All the solutions given in this document follow these steps:

- 1) First, read the problem carefully.
- 2) Make a sketch of the information, even if a picture is already given. This gives the left side of your brain a chance to communicate with the right side of your brain. It also allows you to begin to organize and synthesize the given information. This is a clear illustration of the phrase that “a picture is worth a thousand words.”
- 3) Make a list of what you know (the given information) and what you don’t know (things you need to determine).
- 4) Using the information given, work towards the solution to the problem.

Common Variable Names:

Δ = the change in

δ = total deformation

σ = stress (force per unit area)

ϵ = strain

E = modulus of elasticity, Young's Modulus

P = axial force

A = cross section area

L = length

r = radius of a circle

d = diameter of a circle

Press = Pressure

Formulae you might use are:

$$\sigma = P/A$$

$$\epsilon = \delta/L$$

$$\delta = PL/AE$$

$$E = \sigma/\epsilon$$

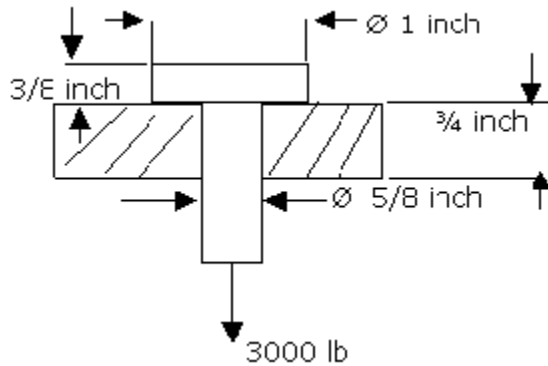
$$A = \pi r^2 \text{ (area of circle when given using the radius)}$$

$$A = .7854d^2 \text{ (area of circle when using the diameter)}$$

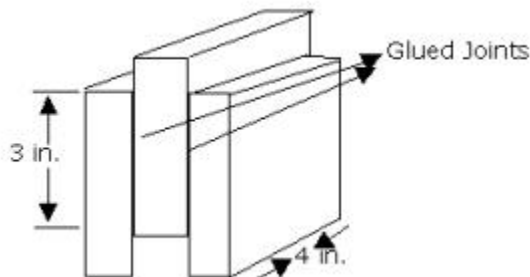
$$\text{Press} = P/A$$

Section 1 - Problems Involving Tensile, Compressive and Shear Stress:

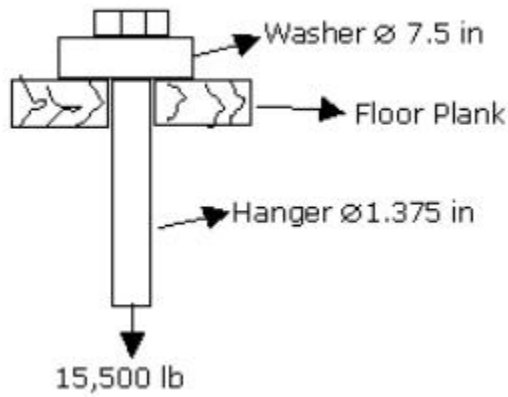
- 1) Compute the tensile stress developed in a steel bar 3 inches by 3.5 inches, if it is subjected to an axial tensile load of 105 kips.
- 2) Using the fact that the structural steel in question has a cross sectional area of 27.7 in², find the tensile stress if the member under test is a structural steel W27x94 and the load is 95.6 kips.
- 3) A round aluminum tube, used as a short compression member, has a wall thickness of .125 inches and an outside diameter of 1.75 inches. If the axial load applied to the member is 25.5 kips, what is the axial stress?
- 4) What is the compressive stress in a pressure treated wooden post 250 mm by 250 mm, if it supports a compressive load of 425 kN?
- 5) Steel rod suspenders are to support water pipes in an electricity generating plant. If the rods are 3/8 inch in diameter and have an allowable axial tensile stress of 25,500 psi, what is the allowable axial tensile load in the rods?
- 6) The following members are subjected to axial tensile loads of 35,000 lb. Determine the stress induced for each: (a) A square steel bar 3.5 inches on a side. (b) W14 x 90 (cross sectional area = 26.5 in²). (c) An eight-inch diameter wooden post (unfinished).
- 7) The figure shows a bolt passing through a plate. Calculate the tensile stress in the bolt and the shear stress in the head.



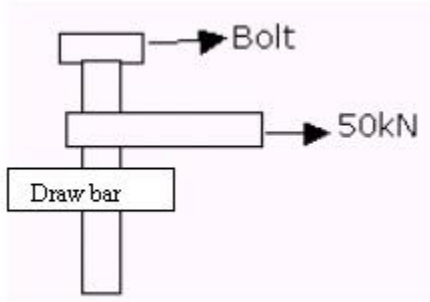
- 8) A punch press punches out round washers with an inside diameter of 5 mm and an outside diameter of 15 mm. If the stock that the washers are being punched out of is 2 mm thick and requires a force of 225 kN, what is the (a) compressive stress in the punch and the (b) shear stress in the plate?
- 9) A punch press punches out square washers with an outside dimension of 1 inch on a side and a circle in the center with a diameter of $\frac{3}{8}$ inch. If the stock that the washers are being pressed out of is $\frac{1}{4}$ inch thick, and requires a force of 330 kips, what is the (a) compressive stress in the punch and the (b) shear stress in the plate?
- 10) Three pieces of wood are glued together to form an assembly, as shown. A load of 21000 lb is applied. Find the average shear in each joint.



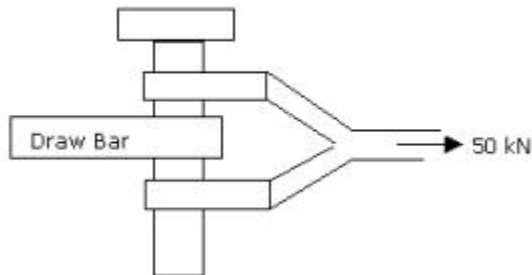
- 11) Compute the force required to punch a 1.25-inch diameter hole through a $\frac{1}{2}$ inch boilerplate. The ultimate shear stress for the material is 42000 psi.
- 12) A floor plank supports the round hanger rod as shown. If the load on the rod is 15,500 lb, (a) find the tensile stress in the rod and (b) the bearing stress between the round washer and the floor plank.



- 13) A concrete column with a diameter of 12.5 inches supports an axial compressive load of 10 kips, including the weight of the column. A square concrete footing with a depth of $\frac{1}{2}$ foot and measuring 30 inches on each side supports the column. Find (a) the compressive stress in the column and (b) the bearing stress on the soil. (Concrete weighs 150 lb/ft^3 .)
- 14) A tractor draw bar is connected to an implement as shown. The tractor pulls with a force of 50 kN that must be transmitted by the shear bolt. If the bolt diameter is 25 mm, calculate the shear stress.



- 15) Assume the same details as told in problem #14, except the connection is as shown here. What is the shear stress in the bolt in this case?



Section 2 - Problems Involving Design and Factor of Safety

- 1) A rod supports an axial force of 45 kN. If the compressive stress in the bar is not to exceed 80 MPa, determine the diameter of the rod.
- 2) A square metal rod must support an axial compression load of 1550 N. The allowable stress in the rod is 175 MPa. Find the dimensions of the rod.
- 3) Calculate the required diameter of an aluminum rod subjected to an axial tensile load of 45.5 kN, if the allowable tensile stress is 135 MPa.
- 4) What is the allowable axial tensile load that may be applied to a 22 mm diameter solid steel cable, if the allowable axial tensile stress is 152 MPa?
- 5) A steel column sits on a square steel base plate which in turn rests on a poured concrete footing. The steel column supports an axial compressive load of 85 kips. The allowable compressive stress in the steel is 15.5 ksi and the allowable bearing stress in the concrete footing is 725 psi. Determine the required cross sectional area of the column and the length of the sides of the steel base plate.
- 6) A boilerplate has an ultimate shear strength of 290 MPa. Compute the force required to punch a 20 mm diameter hole, if the steel plate thickness is 15 mm. Assume that the shear stress is uniformly distributed.
- 7) Find the factor of safety based on the (a) yield stress and (b) tensile strength, if the test results of an ASTM A36 steel specimen indicated an ultimate tensile strength of 75,000 psi and an ultimate yield stress of 36,000 psi. According to the design specifications, the allowable tensile stress is 25,000 psi.
- 8) A loading platform at a factory is to be supported by 9 concrete posts. The maximum estimated load expected is 150 tons. If the compressive strength of the concrete is 3500 psi, what diameter should the concrete posts be? Since concrete is a very brittle material, design your posts with a factor of safety of 15. (1 ton = 2000 lb)
- 9) Design a 12 foot rod which will be subjected to a tensile load of 17,500 lb. Using a factor of safety of 1.5 based on the yield stress, calculate the required rod diameter if it is to be made of steel with a yield stress of 50,000 psi.
- 10) A dual-tracked military vehicle is being designed to operate on the desert with shifting sands due to the winds. According to design specifications, the bearing pressure under the tracks cannot exceed 12 psi. The vehicle will weigh no more than 35 tons and each of the 2 tracks will be 22 inches wide. Determine the minimum required contact length for each of the 2 tracks.

Section 3 - Problems Involving Deformation, Stress, Strain, and the Modulus of Elasticity (Young's Modulus)

Note: For the following problems, assume the modulus of elasticity for steel to be 30,000,000 psi (207 000 MPa) and the proportional limit to be 34,000 psi (234 MPa).

- 1) A short compression member with a cross sectional area of 22.3 in^2 , and 7 inches long is subjected to a 45,000 pound compressive load. As a result, the length of the member is shortened to 6.45 inches. Find the strain in the member.
- 2) A concrete test cylinder 12 inches in diameter and 15 inches high is loaded in compression. As a result of the load, the cylinder is shortened by 0.015 inches. Find the strain in the member.
- 3) The diameter of a 75 foot long rod is $\frac{3}{4}$ of an inch. The total elongation is 0.9 of an inch. Calculate the average strain.
- 4) A cable is used on a pulley. If the maximum strain in the cable is 0.0075, what is the deformation for 52 m of this cable?
- 5) A 15 inch bar with a cross-sectional area of 1.5 in^2 is subjected to an axial load of 1 ton. Compute the stress, the strain and the total elongation if the bar materials are: (a) steel, (b) aluminum (modulus of elasticity = $E_{AL} = 10,000,000 \text{ psi}$) and (c) wood (modulus of elasticity = $E_W = 1,500,000 \text{ psi}$).
- 6) A steel tube having an O.D of $\frac{7}{8}$ inch and I.D of $\frac{1}{2}$ inch is subjected to an axial load of 4500 lb. It has a length of 24 inches. Compute the tensile stress in the tube and the total axial deformation.
- 7) A weight of 7500 N is to be suspended by a steel wire 8.25 m in length. The tensile stress in the wire must not exceed 145 MPa and the total elongation must not exceed 4.5 mm. Find the required diameter of the wire (ignore the weight of the wire itself).
- 8) A 125 foot surveyor's steel tape with a cross-sectional area of 0.005 in^2 is subjected to 10 lb pull when in use. Find the total elongation of the tape and the tensile stress developed in the tape.
- 9) A 1 inch steel rod, 75 feet long is hanging vertically. Find the total elongation due to the rod's own weight and a suspended 7500 lb load applied at its free end. (The weight of steel is 490 pcf.)
- 10) A short square steel tube with wall thickness of $\frac{3}{4}$ inch is being used as a structural support under a floor. The height of the tube is 18 inches and has a width of 8 inches. The allowable compressive stress is 24,000 psi and the allowable axial deformation is 0.005 in. Find the allowable load.
- 11) A rectangular bar with dimensions of 20 mm by 85 mm elongates 3.25 mm in a length of 1.75 m when subjected to an axial load of 245 kN. The material has a proportional limit of 240 mPa. Determine the axial stress in the bar and the modulus of elasticity (Young's modulus).
- 12) A steel wire is suspended at one end from the ceiling of a warehouse. The wire is 375 feet long and has a diameter of $\frac{3}{16}$ in. (The unit weight of steel is 490 pcf.) Find (a) the maximum tensile stress due to the weight of the wire and (b) the

maximum load that the wire can hold at the lower end of the wire. (Use the allowable tensile stress of 24,000 psi.)