1.051 Structural Engineering Design

QUIZ 2

Open Book & Notes – 90 minutes

QUESTION 1. – REINFORCED CONCRETE SHORT COLUMNS (30%)

A reinforced concrete short column with a square cross-section (22x22 in^2) shown in the figure below is reinforced with 4#11 rebars. The material properties are: $f_c' = 4$ ksi, $f_y = 60$ ksi, $E_s = 29000$ ksi

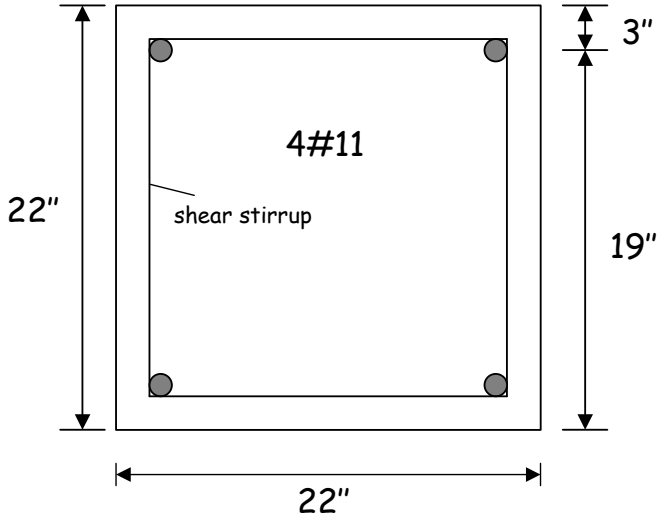


Figure 1

(a) How can you describe the failure behavior of this column under combined axial load and bending moment effects for practical design? BRIEFLY explain with the help of a sketch, indicating behavioral characteristics (No calculations required)

(b) Compute the axial load capacity, (P_o) of this column when a concentric load is applied (e=0, M=0). Assume $A_c=A_g$.

(c) For balanced failure condition, determine the nominal axial load (P_b) and bending moment (M_b), and the corresponding eccentricity (e_b).

(d) Estimate, with a minimum of calculation, the nominal moment capacity, M_n, of the column under the axial load of $P_n=(P_o+P_b)/2$. (Reinforced concrete analysis not required)

QUESTION 2 – TENSION MEMBERS (20%)

For the bolted connection shown in Figure 2,

(a) Compute the design strength $f_t P_n$, neglecting block shear.

The angle is made of A36 steel (f_y=36 ksi, f_u=58 ksi)
Bolts are 1 in diameter
Assume U=0.9

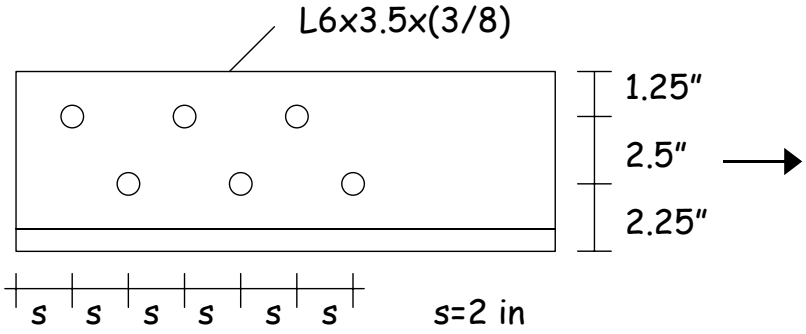


Figure 2

BONUS (10%)

(b) Assuming that the fracture of the net section controls failure, what must be the minimum horizontal spacing, s, in order to maximize the fracture design strength of the connection? (Do not consider yielding of the gross section.)

QUESTION 3 – COMPRESSION MEMBERS (25%)

The axially loaded member shown in Figure 3(a) has a cross section as shown in Figure 3(b). Using F_y=50 ksi, determine the design strength, $f_c P_n$, for this member.

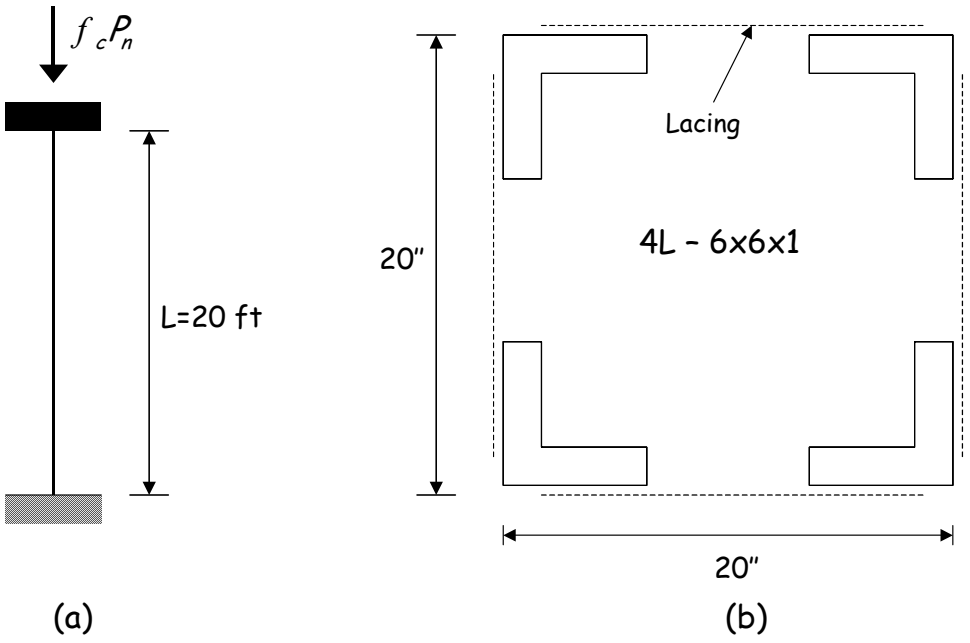
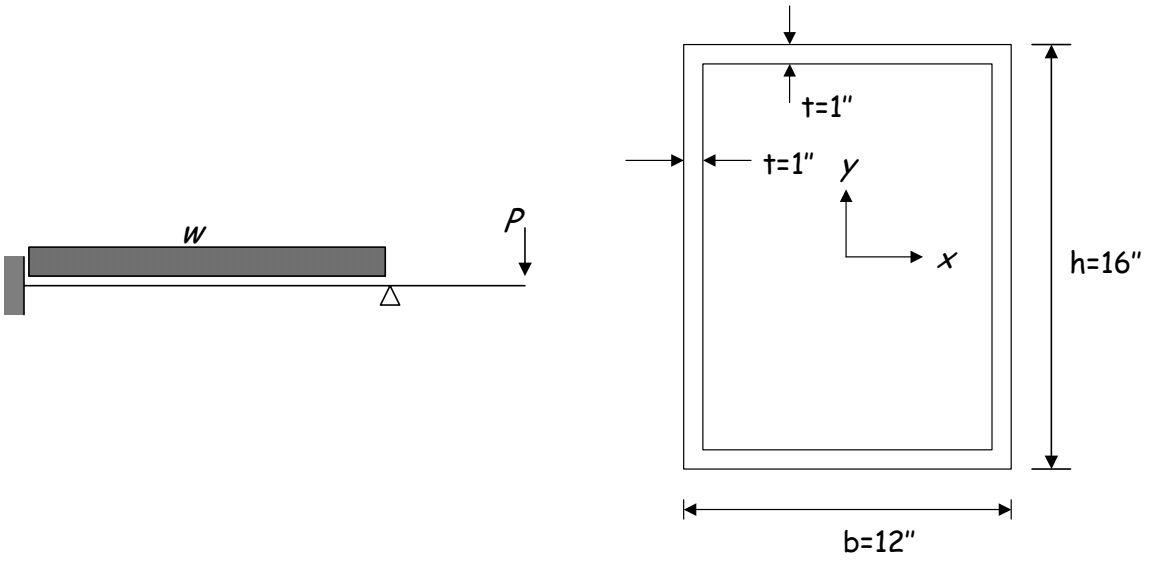


Figure 3

QUESTION 4 – STEEL BEAMS (25%)

(a) For the beam section shown in Figure 4(b), find the section modulus, S, the plastic modulus, Z, and the shape factor, X. Assume the section is compact.

(b) If the yield strength of steel is 50 ksi, what are the yield moment, M_y, and plastic moment, M_p, for the beam?



(a) (b)

Figure 4

BONUS (10%)

(c) For generic values of w, and P, sketch two alternative collapse mechanisms for the beam shown in Figure 4(a), showing the locations of the plastic hinges.