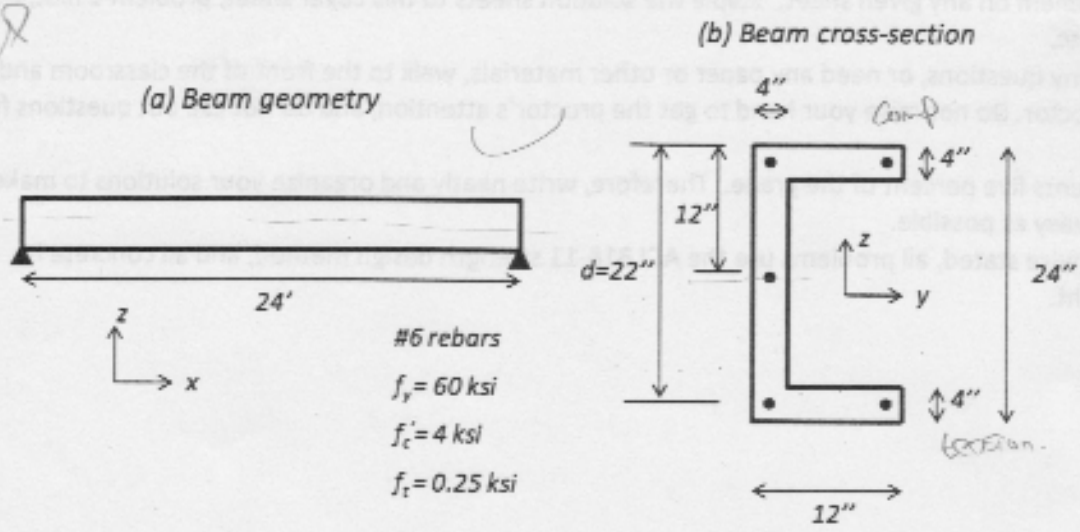
Problem 1 (30/100)

A 24-ft long simply supported RC beam with the cross-section shown below is considered. Assume that all segments of the channel section are fully effective. The compressive, f_c', and tensile, f_t, strength of concrete as well as the yield strength, f_y, of steel are given in Figure 1. The beam is subjected to a uniformly distributed load w that is factored and includes the self weight of the beam. Assume that the beam has adequate shear strength.

1. Calculate the nominal flexural strength M_{ny} of the section for bending about the y axis (moment in the xz plane). Ignore the contribution of steel in compression as well as the contribution of concrete in tension. **(15 points)**
2. Calculate the cracking flexural strength of the section for bending about the y axis. Can the beam support its own self-weight without cracking? **(10 points)**
3. Without calculating the nominal flexural strength M_{nz} for bending about the z axis (moment in the xy plane) explain in three lines (maximum) why it cannot be larger than M_{ny}. **(5 points)**



Note 1: all rebars are # 6

Note 2: The distance of the centroid of all bars to the nearest edge of the section is 2"

Figure 1.

Problem 2 (30/100)

Consider the 12' long simply supported RC beam shown in Figure 2. It is given that $f_c' = 4$ ksi and $f_y = 60$ ksi. The beam supports a uniformly distributed load w that is already factored and includes the self weight of the beam.

1. Design the beam to carry the maximum possible load ***w*** and at the same time to satisfy flexural and shear design requirements of ACI. What is the maximum value of w the beam can resist? **(24 points)**
2. Draw a sketch of the section as well as a side view of your beam showing both the longitudinal and transverse reinforcement details of your design. **(6 points)**

Assume an effective depth ***d*** (distance from the extreme compressive fiber to the centroid of tension reinforcement) of 28". For the shear design consider the critical section to be at the support.

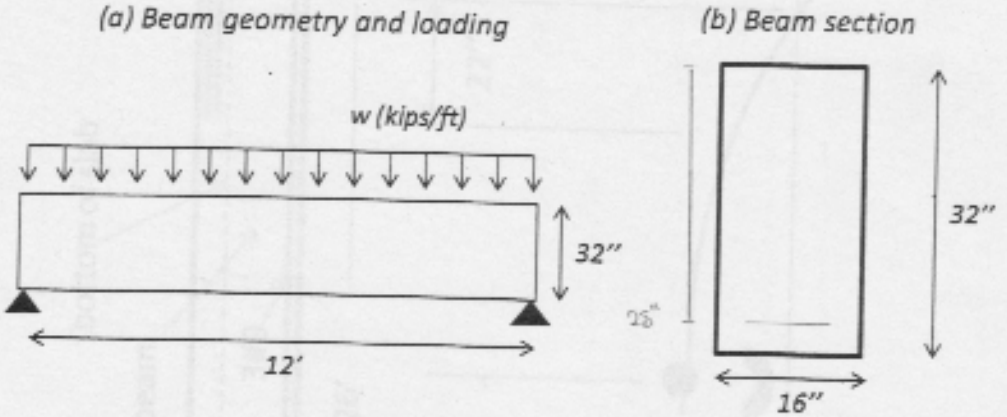


Figure 2.

Problem 3 (40/100)

The two-story RC frame building of Figure 3 is considered. Each slab carries a uniformly distributed load ***q*** (in units of kips / ft^2). Consider this load already factored and that includes the self-weight of the slab. Ignore the self weight of the beams. It is given that $f_c' = 4$ ksi and $f_y = 60$ ksi. The slab in the x direction is reinforced with #4 rebars @ 12" both top and bottom, see also Figure 3(d).

1) What is the nominal flexural strength of the T-beam B1B2, the cross section of which is shown in Figure 3(d) for negative moment (top reinforcement in tension)? It is given that the nominal flexural strength of beam B1B2 for positive moment is M_n = **400 kips-ft. (20 points)**

2) What is the maximum force per unit length, ***w*** (in kips / ft) that beam B1B2 can resist? All beams are assumed to be fixed to the columns. The bending moment diagram of beam B1B2 subjected to a uniform load ***w*** is shown in Figure 3(e). Find the maximum load per unit of area, ***q***, the slab can support.

3) Given the longitudinal reinforcement details of beam B1B2 shown in Figure 4 check if the beam can carry the load ***w*** you calculated in question 2. Check the anchorage and the bar termination. All the bars are uncoated. Normal weight concrete is used.

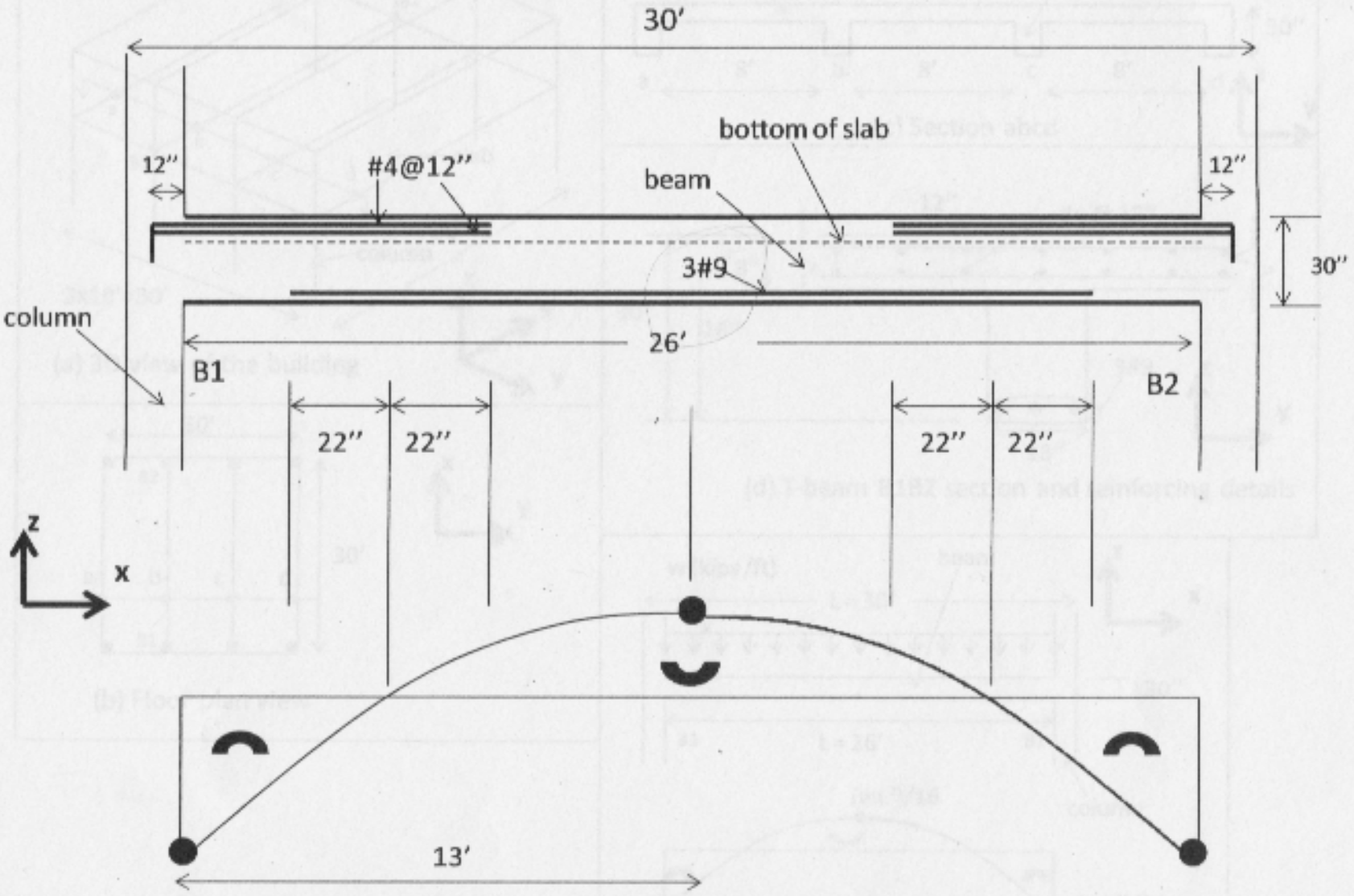


Figure 4. Side view of longitudinal reinforcement details of beam B1B2.

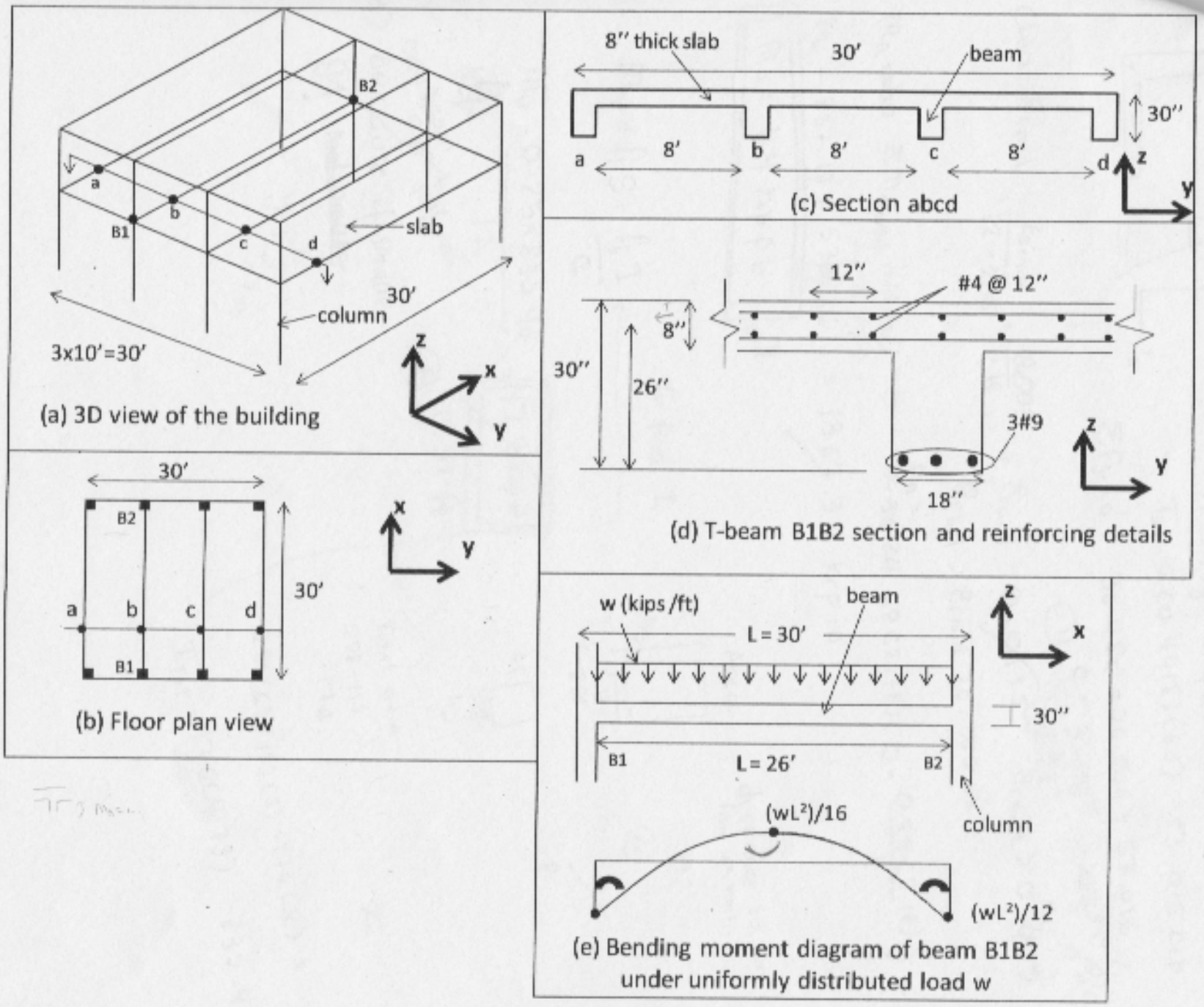

B2
a
b
B1
c
d
slab
column
30'
3x10'=30'
z
x
y
(a) 3D view of the building
30'
B2
a
b
c
d
B1
30'
x
y
(b) Floor plan view
8'' thick slab
30'
beam
30''
a
8'
b
8'
c
8'
d
z
y
(c) Section abcd
12''
#4 @ 12''
8''
30''
26''
3#9
18''
z
y
(d) T-beam B1B2 section and reinforcing details
w (kips /ft)
beam
L = 30'
z
x
30''
B1
L = 26'
B2
column
(wL²)/16
(wL²)/12
(e) Bending moment diagram of beam B1B2
under uniformly distributed load w

Figure 3.