H.W. #1-1.

Problem 1

A weightless structure is subjected to lateral load. The beams and columns are both provided with longitudinal and transverse reinforcement. You may assume the following:

- The ACI strength reduction and load factors are satisfactory.
- Nominal strengths accurately represent mean expected strengths in flexure and shear. Furthermore, available dimensions, material properties, and rebar sizes are unlimited so that you will be able to select cross sections exactly matching desired sections. Of course, in practice you will be restricted in these aspects so that overstrengths will not be unusual.
- The upper bound to flexural resistance will be approximately 1.4 times nominal flexural strength for any member subjected to large deformations. The lower bound to shear resistance at this deformation level will be 0.75 times nominal shear resistance. (These subjects will be discussed further during later parts of the course.)
- Member strengths are checked at the faces of connections and along the span. Strength within the joint will be assumed adequate, even though this assumption frequently is incorrect.

(a) Assume the lateral load is due to a live load effect. Calculate required nominal flexural and shear strengths for the beam and columns, referring only to the maximum values along a member span.

(b) Assume the lateral load is due to an earthquake effect. Do not reduce the load shown to account for inelastic deformations. Provide strengths so that significant inelastic action will be restricted to beam flexure. Calculate required nominal flexural and shear strengths for the beam and columns, referring only to the maximum values along a member span.

(c) Tabulate results.

Required nominal strengths

Loading Case	Beam		Column	
	Moment, k-in.	Shear, k	Moment, k-in.	Shear, k
(a) Live Load				
(b) Earthquake				

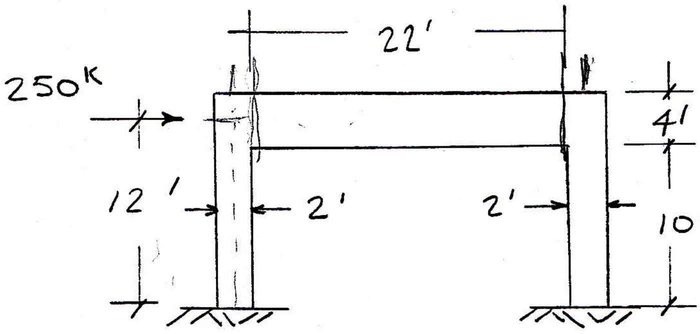
H.W. #1-2.

Problem 2

A #11 grade 60 bar is bent around a pin having a diameter equal to eight times the diameter of the #11 bar.

(a) Using standard bending theory, calculate the maximum tension strain in the bar. Do not get fancy: Simply assume plane sections remain plane, stress-strain relation in compression is equal to that in tension, and ignore any second-order effects such as Poisson's ratio.

(b) I anticipate that you will find a strain in part (a) much beyond the minimum elongation requirement for a #11 grade 60 bar (see ACI reference paper). And although a typical bar will break in a tension test at a strain not much exceeding the minimum elongation requirement, the bar bent around the pin will probably not break. Why?



Sketch for Problem 1

H.W. #2.

Problem 3 (Summarize all answers on this sheet in space provided, and include as the first sheet of the homework submission.)

Consider a normal weight concrete having a 28-day design strength of 4000 psi. The plant where the concrete is produced has standard deviation of compressive strength equal to 500 psi for this mix design. ....

(a) What true tensile strength should be counted on in design for this concrete?

(b) What mean 28-day compressive strength is likely for the concrete if it was produced so that less than one in one hundred samples will have strength less than 500 psi below the design concrete strength? (Note: Codes actually have more detailed requirements.) ....

(c) Suppose concrete cylinders prepared and stored according to the standard ASTM procedures test out at 4000 psi at 28 days. What mean strength would you expect from 3-in. by 3-in. cylinders cored from the structure at 28 days? ......

(d) For the same concrete described in part (c), what strength would you expect from 6-in. by 12-in. lab cured cylinders at age of 7 days? ....

✓ (e) A slab of concrete is cast and cured in a manner similar to a standard cylinder, so that its in-situ uniaxial compressive strength is 4000 psi. The slab is loaded under biaxial principal stresses f_1 and f_2.

i. The loading plan is to increase f_2 to 2000 psi while f_1 is held at 0, and then increase f_1. When do you expect failure? .... f_1 =

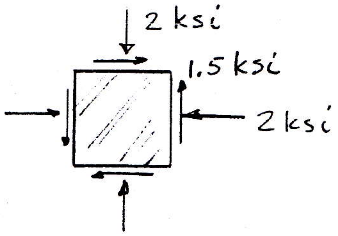
ii. The loading plan is to increase f_2 to 5000 psi while f_1 is held at 0, and then increase f_1. When do you expect failure? .... f_2 =

(f) A plain concrete column is subjected to hydrostatic confining stresses of 1000 psi in all three principal directions. A load is then applied to the column along one principal axis. At what stress in addition to the hydrostatic stress will the column fail? (Assume the concrete has exactly 4000-psi uniaxial compressive strength in the column.) ....

✓ (g) If the concrete in part (c) is cycled for 1 million cycles between 1000 psi compression and some maximum stress, what maximum stress will result in failure?

(h) What true tensile strengths are expected for the concrete described in part (c) if it is 120 pcf lightweight concrete? ....

Mohr Circle ✓ (i) A finite element analysis results in the following stresses at a point. If the concrete is that which is described in part (c), will it fail? ....

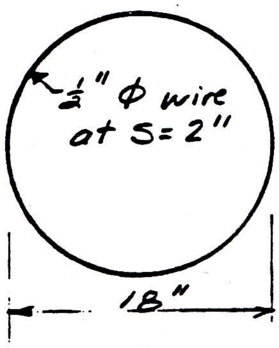


✓ - diagrams

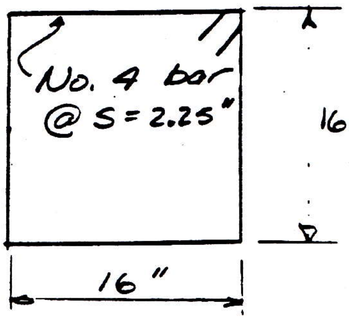
H.W. #3.

Problem 4

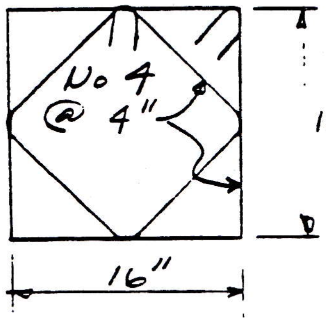
The figure below shows five confined concrete cores. The cores may be assumed to be those occurring in full-scale construction. For each, $f'_c = 4000$ psi and steel has actual yield stress of 60,000 psi. For each section, compute the total transverse steel ratio, estimate the average compressive strength f_{cmax} that could be assumed to act over the entire core cross section, and estimate the axial compressive strain at fracture of the transverse reinforcement. Plot stress-strain relations for plain concrete and for each of the sections on a single graph. Beneath the plot, tabulate the transverse steel ratio, f_{cmax}, and ϵ_{cmax}.



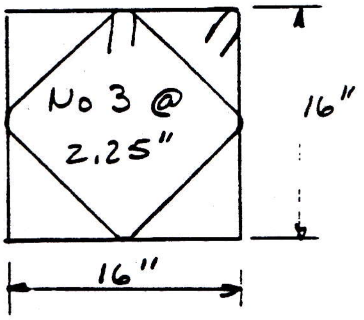
(a)



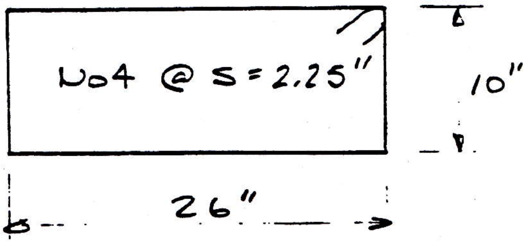
(b)



(c)



(d)



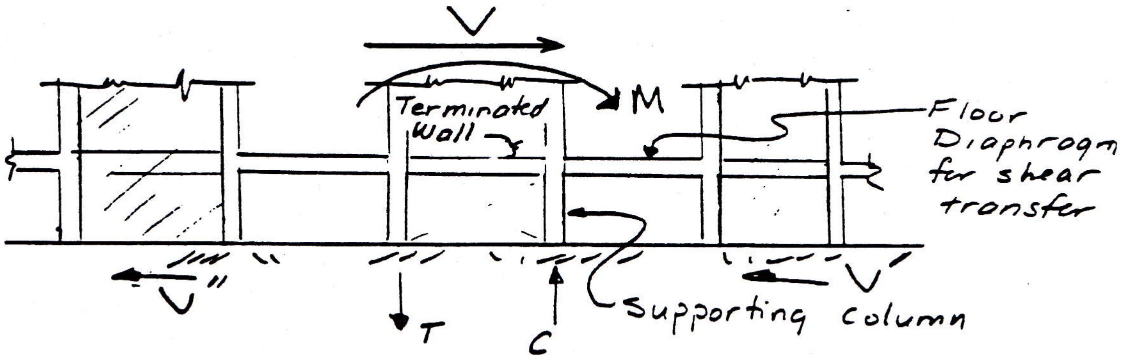
(e)

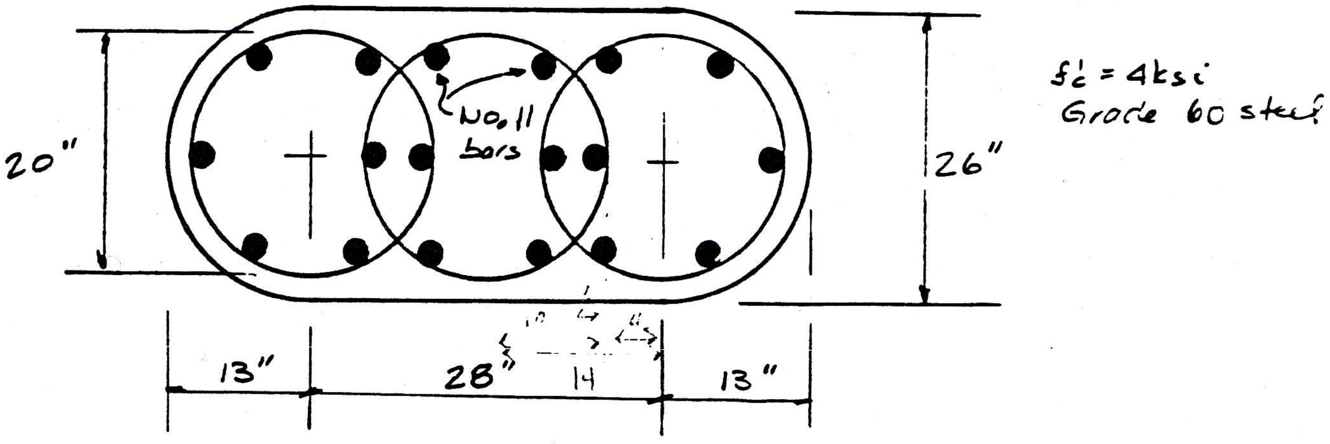
H.W. #4.

Problem 5

A multi-story building is to be constructed in downtown Berkeley. Owing to architectural considerations, it is necessary for one of the structural walls to be terminated, leaving an open bay in the first story with a structural wall above. In such a situation (which the engineer certainly should importune the architect to avoid), it is necessary (though not always sufficient) to ensure that both shears and overturning moments in the wall at the second floor level be transferred to the foundation level. As shown below, the structural engineer has selected to transfer shears through the floor diaphragm to a wall in another bay, and to transfer overturning moments through axial forces in columns supporting the wall. The column cross section is shown.

Discuss in a brief paragraph your objectives in design of the column, and your assumptions regarding behavior. Following the paragraph, determine a design (spacing and wire diameter) for the spiral reinforcing. Plot the relation between axial force and axial strain for the column, identifying points corresponding to first spalling, completion of spalling, yield of longitudinal steel, and onset of strain-hardening in longitudinal steel by the letters "a", "b", "c", and "d", respectively. Use the stress-strain relation shown in MacGregor for Grade 60 steel (Chapter 3). Assume that standard cylinders at the time of the earthquake break at 4000 psi.





Column Cross Section

H.W. #5.

Problem 6: Cracking in Tension Member

A reinforced concrete tension member is shown. $f'_c = 4$ ksi, $f_t = 400$ psi, $f_y = 60$ ksi, and assume an average uniform bond stress of 500 psi is available. For tensile force of 30, 60, 90, and 120 kips:

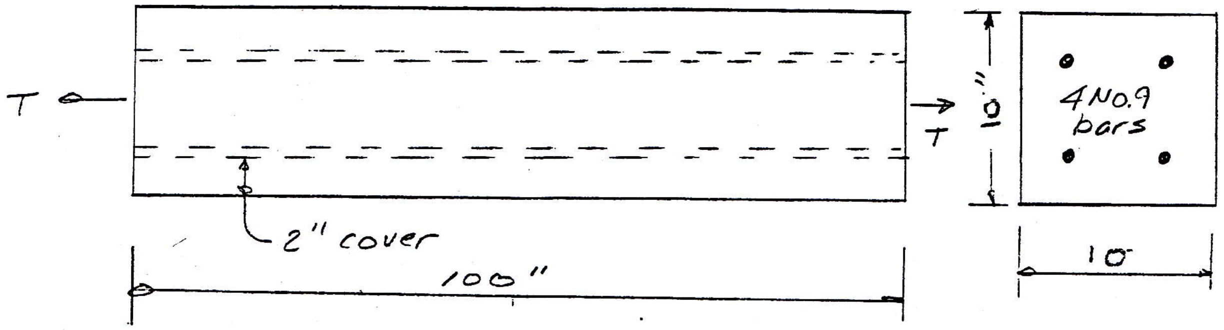
$a = \frac{f_t A_c}{u \pi d_b}$

(a) Estimate mean crack spacings.

(b) Estimate maximum surface crack width.

(c) Estimate elongation over 100-inch length, expressed first in inches, and then as a fraction of elongation based on fully-cracked section properties.

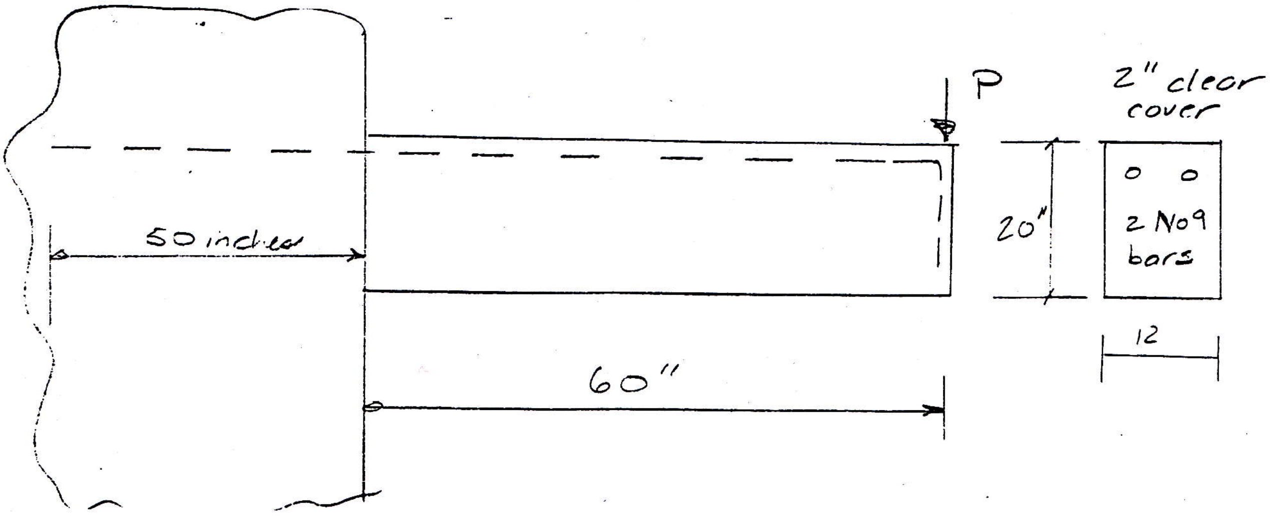
(d) Tabulate your answers.



Problem 7: Reinforcement Pullout

(a) Use classical bond theory with an average uniform bond stress of 500 psi to estimate the crack width at the top surface of the cantilever at the face of the support. Note: The crack width is determined partly by slip from the beam and partly by slip from the anchorage.

Assume steel stress of 24 ksi at the face of the support, and $f'_c = 4{,}000$ psi.

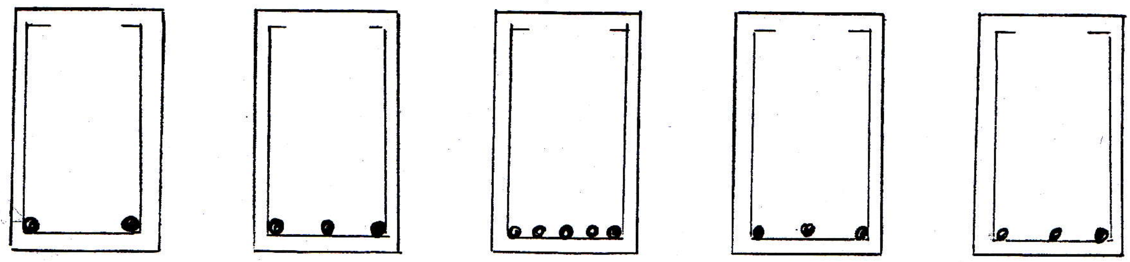


(b) Estimate tip deflection due to slip of rebar from cantilever when $f_s = 24$ ksi.

H.W. #6-1.

Problem 8

The cross sections shown below are those occurring along a beam span. The bars shown must be developed for yield strength. Calculate and tabulate the required development lengths using ACI Comm. 408 recommendations. f'c = 4000 psi. Grade 60 reinforcement. Also tabulate the area of longitudinal steel for each case. Comment on the trends.



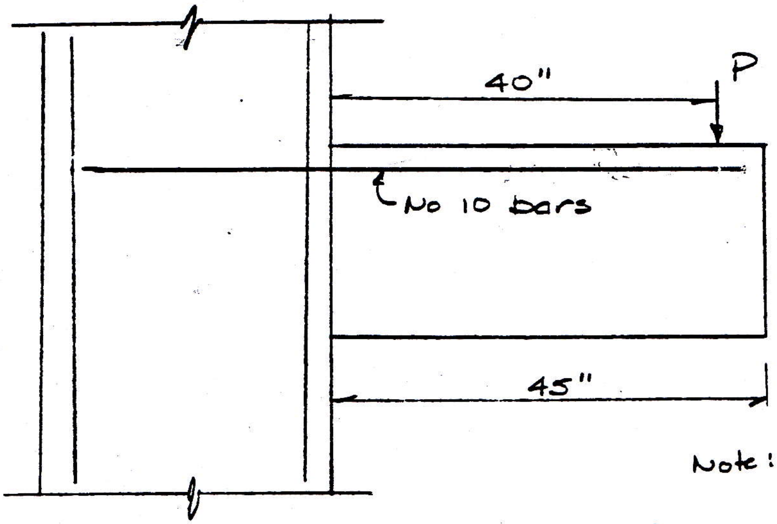
2 #11	3 #9	5 #7	3 #9	3 #9	longitudinal
#3 @ 10"	#3 @ 10"	#3 @ 10"	#3 @ 5"	#4 @ 5"	transverse

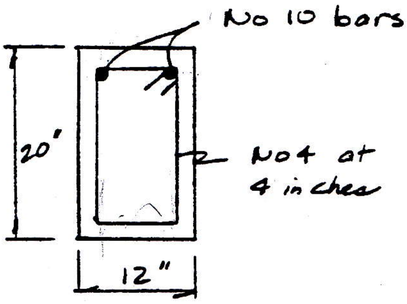
All beams have 24" × 16" cross section.
with 2" clear cover to longitudinal steel.

H.W. #6-2.

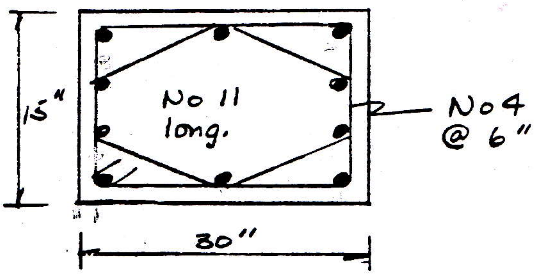
Problem 9

A design has been prepared for a cantilever which is attached to a column. Assume that the load P will be large enough to induce yield, and ignore self weight of the beam. Using recommended design provisions of ACI Committee 408, check the design and make any necessary changes to ensure adequate development lengths. Use Grade 60 steel and f'c = 3000 psi. Try not to change the size of the reinforcing bars. Do not change any overall dimensions.





Note: clear cover over No 10 in cantilever is 2 inches top and sides.



H.W. #7.-1

Problem 10

An idealized beam cross-section is shown. Estimate moment-curvature relations for the various material strengths and steel ratios indicated. Yield moments and curvatures are to be determined assuming elastic properties, even though the concrete may be overstressed. Ultimate moments and curvatures may be estimated using the Whitney stress block with $\epsilon_{cu} = 0.004$. Assume no strain hardening.

Beam A $f_y = 60$ ksi, $f'_c = 4$ ksi, $\rho = 0.02$, $\rho' = 0.0$

Beam B $f_y = 60$ ksi, $f'_c = 4$ ksi, $\rho = 0.01$, $\rho' = 0.0$

Beam C $f_y = 40$ ksi, $f'_c = 4$ ksi, $\rho = 0.02$, $\rho' = 0.0$

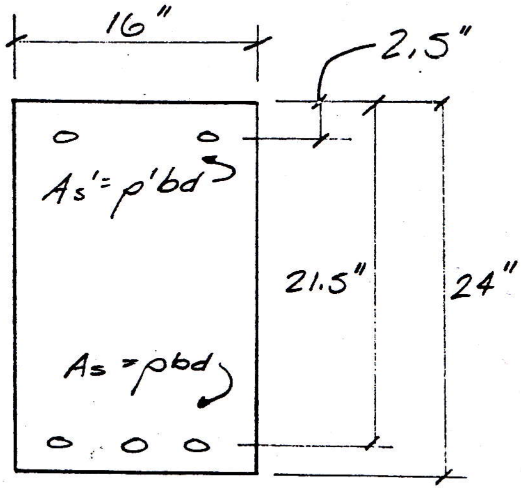
Beam D $f_y = 60$ ksi, $f'_c = 8$ ksi, $\rho = 0.02$, $\rho' = 0.0$

Beam E $f_y = 60$ ksi, $f'_c = 4$ ksi, $\rho = 0.02$, $\rho' =$ ~~0.2~~ → 0.02

(a) Tabulate values for M_{cr}, M_y, M_u, ϕ_{cr}, ϕ_y, ϕ_u, and ϕ_u/ϕ_y.

(b) Plot all M-ϕ diagrams on a single plot. Clearly identify the individual relations.

(c) In words, compare effects of varying parameters, using beam A as your standard for comparison.



H.W. #7-2

Problem 11

A beam cross-section is to be designed having the following:

(1) Grade 60 steel, f'_c = 4,000 psi.

(2) Minimum cover over longitudinal steel = 2 inches.

(3) Maximum overall depth of 24 inches.

(4) Theoretical flexural strength at least = 6,000 k-in.

(5) ϕ_u/ϕ_y = 15 with no more than 15% loss of strength at this curvature ductility.

Select an appropriate beam cross-section design, specifying all pertinent dimensions. Plot the complete M-ϕ relation until onset of buckling of compression steel, or ifyou have no compression steel, to ϕ_u/ϕ_y = 30.

Stirrup - #4 @ 4"

flexural strength - 0.9Mu.

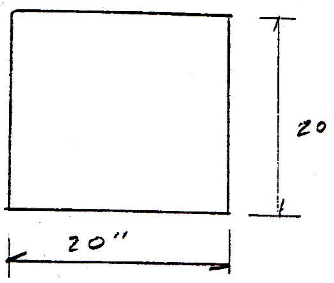
Capacity > Demand.

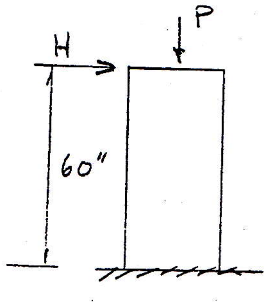
H.W. #8-1.

Problem 12

Hand

A pedestal is defined as a short concrete column without reinforcement. Resistance to overturning is due to self weight and concrete tensile strength. For the pedestal shown, compute and plot the axial load-horizontal load interaction diagram at strength for the loads as shown below. Include the effect of self weight in your calculations. Assume $f'_c = 5000$ psi.

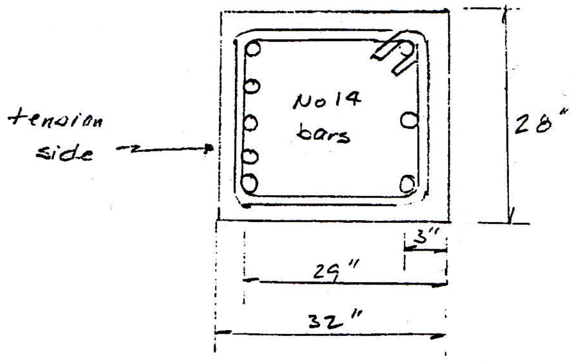




Problem 13

Hand.

Compute and plot the complete axial load-moment interaction diagram and the axial load-curvature diagram for maximum compression strain of 0.003 for the column section shown. Use $f'_c = 5000$ psi and $f_y = 50000$ psi.



H.W. #8-2.

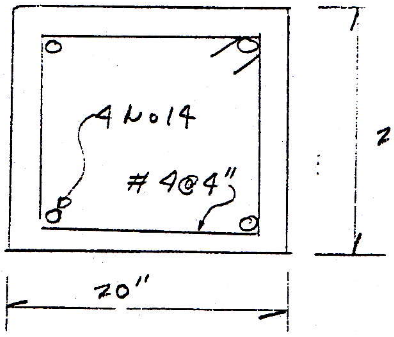
Problem 14

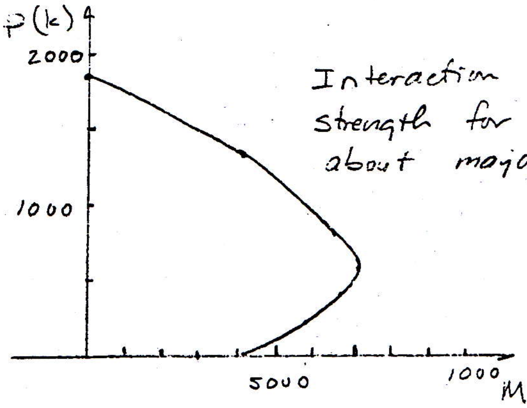
The column shown below carries a concentric axial load of 500 kips, and equal bending moments about each major axis. Assume $f'_c = 4000$ psi, and assume elasto-plastic reinforcement stress-strain relation with $f_y = 60000$ psi.

Hand → (a) Compute the moments about each axis corresponding to reaching peak strain of 0.003 in compression. Use direct calculation, not the Bresler method.

Hand → (b) Compute the moments about each axis using the Bresler method.

BIAX → (c) Plot the complete moment-curvature relation, accounting for confinement effects on behavior of concrete.





Interaction Diagram at strength for bending about major axis.

H.W. #9.

Problem a 15

Design the beam shown below using requirements of the ACI Building Code. For flexure, use strength reduction factor of 0.9. For shear use strength reduction factor of 0.85. The load shown is the factored design load. Show all necessary details. Ignore effect of self weight. Assume $f'_c = 4000$ psi, $f_y = 60{,}000$ psi.

Problem b 16

An existing structure has the detail shown below. Using the plastic truss analogy, calculate the maximum load P that will result in failure. Ignore self weight. Assume $f'_c = 4000$ psi, $f_y = 60{,}000$ psi.

Problem c 17

A short reinforced concrete shear wall carries lateral load that is distributed uniformly across the top of the wall. The load acts only in the direction shown. Assume $f'_c = 4000$ psi, $f_y = 60{,}000$ psi. Using concepts of truss models, (a) define and sketch a reasonable load path, and (b) determine required reinforcement for the wall considering all possible failure modes. Show details clearly on an engineering drawing.