UC Berkeley
CE 123 – Spring 2012
Instructor: Alan Kren

Name:

CE 123 - Reinforced Concrete
Mid-Term Examination No. 2

Instructions:

- Read these instructions. Do not turn the exam over until instructed to do so.
- Work all problems. Pace yourself so that you have time to work on each problem. Reasonable assumptions and approximations should be made where necessary.
- Show all relevant work ***including calculations. You must show equations with numeric values for variables.*** Credit will not be given for key elements of the solution that are not apparent.
- Partial credit will be given if procedures are outlined clearly.
- Work the solutions for each of the problems on separate sheets, working on one side of each sheet of paper. One problem solution may span more than one sheet. However, do not show the work for more than one problem on any given sheet. Staple the solution sheets to this cover sheet, problem 1 first, then problem 2, etc.
- If you have any questions, or need any paper or other materials, walk to the front of the classroom and ask the exam proctor. Do not raise your hand to get the proctor's attention, and do not call out questions from your seat.
- Neatness is expected and counts 10% of your grade. Therefore, write neatly and organize your solutions to make checking as easy as possible.
- Unless otherwise stated, all problems use the ACI 318-2011 strength design method, and all concrete is normal weight.
- When instructed, read the entire exam. Do not begin working out the solutions; rather, think about the problems and how you will solve them. You will have 5 minutes to think about the problems and to organize your thoughts.
- When instructed, begin working the problems.

UC Berkeley
CE 123 – Spring 2012
Instructor: Alan Kren

Name: ______________________________

Problem 1.

The precast concrete column tree shown elevation and cross section in the attached drawings has been proposed by your colleague as one of many used in a concrete frame building. She has asked you to verify and complete portions of her design. Her concept is to have the column trees coupled at their bases to rigid grade beams to form a rigid moment connection. (Details of the coupling are not part of your task.) Precast concrete girders will then attach to the "branches" at Level 2 and at Level Roof. Imposed *factored* dead and live load magnitude and point of application are shown.

Column and beam sizes, reinforcement, and material properties are shown on the attached sketches.

a. What are the column dimensions?
b. What is the column's gross area?
c. What is total area of longitudinal (vertical) column reinforcement?
d. Does the column longitudinal reinforcement satisfy ACI code requirements for minimum and maximum amounts in a column? Show by equation your answer.
e. What is the column tie size and spacing?
f. Does the column tie size and spacing satisfy ACI code requirements for size and spacing? Explain your answer.
g. Do the column longitudinal reinforcement and ties satisfy ACI code configuration requirements? Explain your answer.
h. What is f'_c for the column tree?
i. What is the column's capacity Pn_0? **Show your calculation with numeric values.**
j. What is the total factored axial load Pu at the bae of the column, immediately above the grade beam? **Show your calculation.**
k. What is the total factored moment Mu at the base of the column, immediately above the grade beam? **Show your calculation.**

For the following questions, assume As_1 is the reinforcement layer furthest away from the compression face of the concrete, and As_2 is the reinforcement layer closest to the compression face of the concrete:

l. What is the total area of reinforcement for As_1?
m. What is the distance d_1 measured from the centroid of As_1 to compression face the concrete?
n. What is the total area of reinforcement for As_2?
o. What is the distance d_2 measured from the centroid of As_2 to compression face the concrete?
p. What is β_1 for the proposed f'_c for the column tree?
q. What are the column capacities Pn and Mn at $\varepsilon_{s1} = 0.00207$? **Show your calculation with numeric values.**
r. What is φ for $\varepsilon_{s1} = 0.00207$? (It is acceptable to round to the value of φ for ε_s =0.0020.)
s. What is the capacity of the column under pure tension? **Show your calculation with numeric values.**
t. What is φ for a column under pure tension?

Based on your work above:

u. Plot an interaction diagram for the column using the graph on the attached sheet based on the calculated capacities.
v. Does the column have the capacity to support the imposed loads? Show Pu and Mu on the interaction diagram.

Name: ____________________________

Problem 2

Continuing on with the work requested by your colleague:

a. Consider the column longitudinal reinforcement. Is a tension lap or a compression lap required? (Assume that the column tree does not have a front or a back so that the imposed loads could be mirrored about the column centerline, i.e. the moment could reverse.)
b. Assuming that the column longitudinal reinforcement requires a tension lap, is a Class A or Class B lap splice required? Explain your answer.
c. Assuming that a Class B tension lap splice is required, what lap length is required? Do not reduce the required length by $As_{req'd}/As_{provided}$. It is acceptable to use the "short" equation for calculating the lap length.

The following questions refer to the Roof Level beam on the right side of the column.

d. Assume that the beam requires 5.67 in^2 of top reinforcement for the moment it imposes on the column. Can the top reinforcement be developed into the beam? Show your calculation supporting your answer. It is acceptable to use the "short" equation for calculating the embedment length.
e. Assuming the top reinforcement cannot be developed into the beam, could a hooked bar be used to develop the reinforcement into the beam? Verify your answer by calculation. (Hint: you don't necessarily have to check for the absolute minimum length hooked bar.)
f. Can a headed bar terminator be used to develop the top reinforcement into the beam? Verify your answer by calculation.
g. Assume a square headed bar terminator can be used to develop the reinforcement into the beam, what is the minimum size head that can be used? Give the dimensions of the head.
h. The top reinforcement extends through the column and into the beam on the opposite side. Will this develop the top reinforcement? Verify your answer by calculation.

The following question refers to the column.

i. Can the hooks at the top of the column longitudinal reinforcement develop the #11 bars for the imposed moment? Assume that $As_{req'd} = 3.30\ in^2$. (Hint: you don't necessarily have to check every possible reduction factor.)

C Berkeley
CE 123 – Spring 2012
Instructor: Alan Kren

Name: ______________________________

Extra Credit

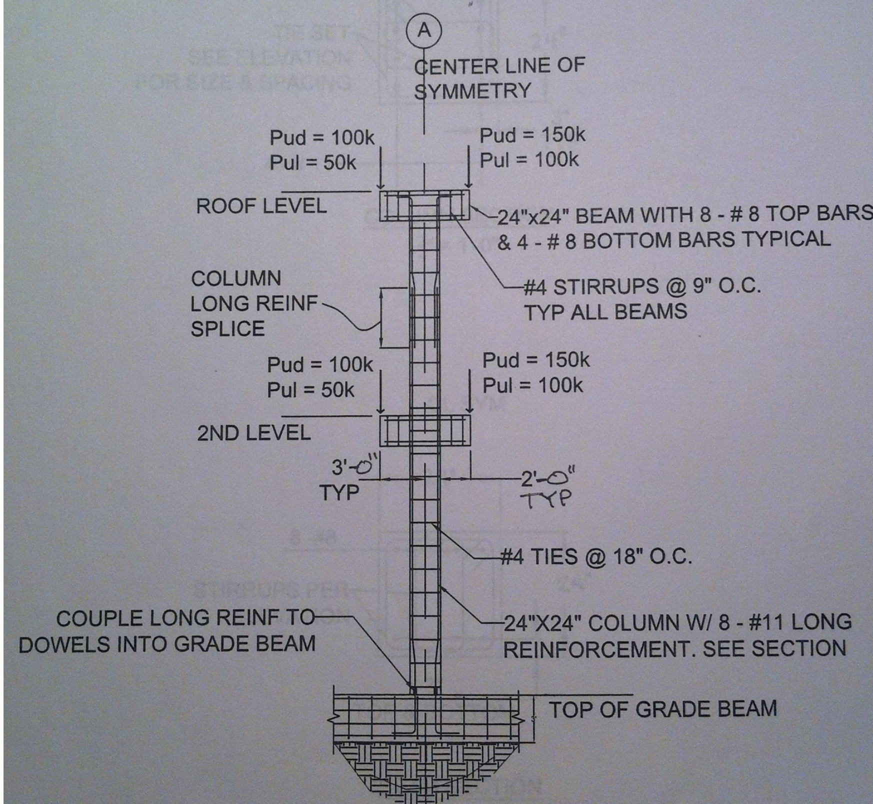
Assume that the 50 kip live loads on the beams on the left side of column were removed, i.e. both 50 kip live loads are removed. Could the column support the remaining loads?

UNIVERSITY OF CALIFORNIA AT BERKELEY
CIVIL AND ENVIRONMENTAL ENGINEERING

CE 123
MID-TERM 2
PROBLEMS 1 & 2

ALAN KREN
INSTRUCTOR

COLUMN AND BEAM PROPERTIES:
Fy = 60 ksi
f'c = 6.0 ksi, NORMAL WEIGHT CONCRETE
DISTANCE FACE OF CONCRETE TO CENTER OF LONGITUDINAL REINFORCEMENT (BEAM AND COLUMN) = 3"
BEAMS AND COLUMN ARE "WEIGHTLESS" FOR THIS PROBLEM
ALL LOADS ARE FACTORED

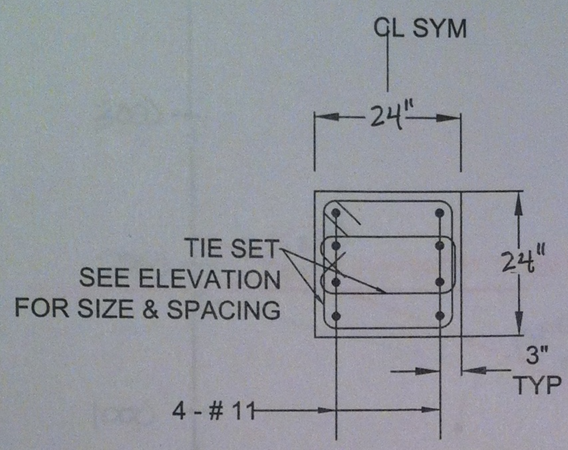


ELEVATION @ COLUMN TREE
$\frac{1}{8}$"=1'-0"

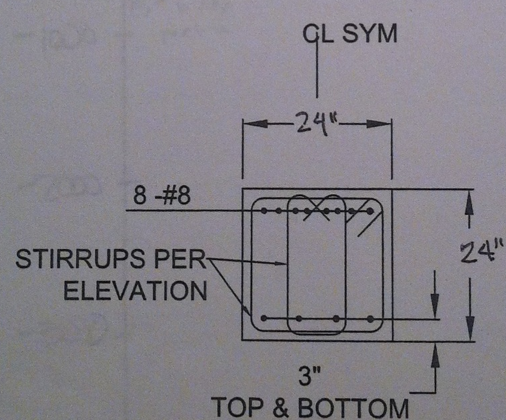
UNIVERSITY OF CALIFORNIA AT BERKELEY
CIVIL AND ENVIRONMENTAL ENGINEERING

CE 123
MID-TERM 2
PROBLEMS 1 & 2

ALAN KREN
INSTRUCTOR



COLUMN SECTION
$\frac{1}{2}$" = 1'-0"



BEAM SECTION
$\frac{1}{2}$" = 1'-0"