1.054/1.541 Mechanics and Design of Concrete Structures (3-0-9)

Exam #1

Date: Tuesday, March 16, 2004 **Time:** 2:30pm~4pm

Note: This is an open-book and open-note exam.
This exam is designed to test your knowledge of the concepts. Be brief and specific in your discussions.

A high-rise building is being designed using an innovative concept for the columns. The columns have no reinforcement bars but are confined by thin steel shells, which also perform a function of formwork for the concrete. High strength concrete in conjunction with conventional steel is being used with the following properties:

Concrete

Uniaxial compressive strength of concrete: f_c'= 8100 *psi*;

Uniaxial splitting tensile strength of concrete: $f_t^{'} = 7\sqrt{f_c^{'}}\,(psi)$; and

Young's Modulus: $E_c = 40000\sqrt{f_c^{'}} + 1.0\times10^6\,(psi)$

Steel

Yield stress: f_y = 60 *ksi*

Young's modulus: E_s = 29x10^6 *psi*

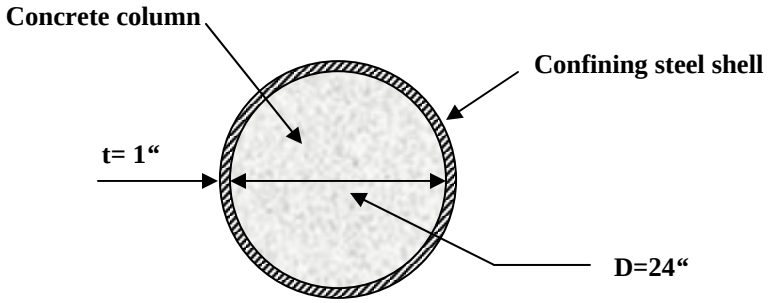

Figure 1. Concrete column confined by thin steel shell

Question 1 – Confinement Effect (30%)

(a) Consider the column section shown in Fig. 1. Assuming that the axial strength of the concrete increases with confinement in a similar way as for the conventional concrete, compute the maximum concentrically applied load that can be carried by the column. You may assume:

- at failure steel yields and concrete strength reaches the peak value;
- the concrete is perfectly bonded to the steel.

(b) Briefly discuss the effect of varying axial load on the confinement.

Question 2 – Behavior in Combined Stress (30%)

(a) Consider that the column section shown in Fig. 1 is subjected a concentrically applied axial load of P = 8,000 kips, and a simultaneous moment. Based on your knowledge of concrete in combined stress, compute the value of the moment that causes first cracking in this beam-column member. For simplification, you may assume:

- Before cracking, there is a transverse confinement level of, for example, 5000 psi and that this confinement is valid in the tension zone of section as well.
- Before cracking, concrete and steel are in elastic regime and that the principle of superposition is valid.

(Hint: For simplicity use the concept of transformed area and transformed moment of inertia for this composite section.)

(b) For a more accurate analysis, briefly discuss the factors influencing the interaction between the confinement and the applied bending moment. Comment on the presence of simultaneously applied axial force.

Question 3 – Creep and Shrinkage (25%)

Consider the column in Fig. 1 under a sustained concentric axial load of P = 8,000 kips.

(a) Compute the final stress value in the concrete after one year. Assume that the creep coefficient $C_t = 0.9$ for 1 year. Indicate whether the final stress is tensile or compressive and explain.
(b) How would this applied load influence the shrinkage behavior of concrete during that time?

Question 4 – Ductility (15%)

(a) Describe very briefly, with no calculations, ductility for
(i) a reinforced concrete flexural member;
(ii) a reinforced concrete beam-column;
(iii) a reinforced concrete building.

(b) Briefly comment on the importance of ductility for the building in an earthquake region.