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

Homework #2

Assigned: Thursday, February 26, 2004 **Due:** Tuesday, March 9, 2004

Creep in a Reinforced Concrete Building Column

Introduction

A typical interior column in a 3-story reinforced concrete building is to be investigated, considering the load increments during construction. From recorded dates of casting and form removal, the following load history was determined for the first floor column.

Time (days)	**Event**
0	Column cast
30	First floor shoring removed, ΔP = 300 kips
60	Second floor cast, ΔP = 200 kips
120	Penthouse and roof case, ΔP = 250 kips

The column is 30x30 inches and contains #8 bars (A_s = 6.32 in^2), the modulus of elasticity for the reinforcing steel is $E_s = 29 \times 10^6$ psi, and for the concrete $E_c = 2.9 \times 10^6$ psi. The attached data indicates the specific creep function for the concrete used in this question (See Attachment A).

Use the modified supervision method outlined in class to compute the creep strain effect on the concrete, the reinforcing steel, and the column. The attached summary of a numerical procedure is given as a concept. You may develop your own procedure and interpretation of the problem. (See Attachment B).

Questions

1. Consider only elastic and creep effects. Plot the following information at 30-day intervals.
   1.1) Column strain (stress-strain curve)
   1.2) Stress in the concrete (stress-time curve)
   1.3) Stress in the reinforcing steel (stress-time curve)

   To provide a basis for comparison, show on these plots the elastic stress-strain (σ–ε) history, neglecting creep effects. Continue the analysis for the first 180 days. The column is to be considered concentrically loaded for the purpose of this analysis. Also present your solution in a tabular format.

2. The exterior columns of the building are 10x20 inches. Discuss the effect of creep in this building, and the possible problems that could arise from it. Assume for the purpose of the discussion that the column will only be subjected to axial forces.

Attachment A

Specific creep, ε_{sp} (t, τ) X 10^{-6} (in/in/psi)

t (days) / τ (days)	15	30	45	60	75	90	105	120	135	150	165	180
15	0	0.563	0.657	0.712	0.754	0.787	0.813	0.835	0.852	0.867	0.880	0.891
30		0	0.364	0.424	0.460	0.487	0.508	0.525	0.539	0.550	0.560	0.568
45			0	0.276	0.322	0.349	0.370	0.386	0.399	0.410	0.418	0.426
60				0	0.229	0.267	0.289	0.307	0.320	0.331	0.339	0.347
75					0	0.200	0.233	0.253	0.268	0.280	0.289	0.297
90						0	0.181	0.211	0.229	0.242	0.253	0.261
105							0	0.168	0.196	0.212	0.225	0.253
120								0	0.159	0.185	0.201	0.213
135									0	0.152	0.177	0.192
150										0	0.147	0.171
165											0	0.143
180												0

Attachment B

Numerical procedures using modified supervision method:

$\Delta t_i =$ time step (i = time index)

$\tau =$ age of concrete at loading

$\rho' =$ reinforcement ratio, A_s / A_c

$t_i =$ age of concrete at step i

$m =$ modular ratio, E_s / E_c

Initial conditions:

$$\varepsilon_{column,-1} = 0, \qquad \sigma_{concrete,-1} = 0, \qquad \sigma_{steel,-1} = 0$$

Changes in free creep strain:

$$\delta\varepsilon_n^{creep} = \sum_{i=0}^{n-1} \Delta\sigma_{concrete,i} \times \left[\varepsilon_{sp}\left(t_n, \tau_i\right) - \varepsilon_{sp}\left(t_{n-1}, \tau_i\right) \right]$$

Correction strain and stress:

$$\delta\varepsilon_{column,n}^{creep} = \frac{\delta\varepsilon_n^{creep}}{1 + m \cdot \rho'}, \qquad \delta\sigma_{concrete,n}^{creep} = \frac{-\delta\varepsilon_n^{creep} \cdot E_c}{1 + \dfrac{1}{m \cdot \rho'}}, \qquad \delta\sigma_{steel,n}^{creep} = \frac{-\delta\sigma_{concrete,n}^{creep}}{\rho'}$$

Total change in strain and stress:

$$\Delta\varepsilon_{column,n} = \delta\varepsilon_{column,n}^{creep} + \Delta\varepsilon_{concrete,n}^{load}$$

$$\Delta\sigma_{concrete,n} = \delta\sigma_{concrete,n}^{creep} + \Delta\sigma_{concrete,n}^{load}$$

$$\Delta\sigma_{steel,n} = \delta\sigma_{steel,n}^{creep} + \Delta\sigma_{steel,n}^{load}$$

Current state of strain and stress:

$$\varepsilon_{column,n} = \varepsilon_{column,n-1} + \Delta\varepsilon_{column,n}$$

$$\sigma_{concrete,n} = \sigma_{concrete,n-1} + \Delta\sigma_{concrete,n}$$

$$\sigma_{steel,n} = \sigma_{steel,n-1} + \Delta\sigma_{steel,n}$$