مادة: الطرق الحسابية للتحليل اللاخطي

إمتحان الفصل الدراسي الثاني دراسات عليا

2017-2016

دكتور المادة

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BENHA UNIVERSITY
SHOUBRA FACULTY OF ENGINEERING
CIVIL ENGINEERING DEPARTEMENT
Master of Science (M.Sc)
Code: **STR602**

Final Term Exam
Saturday 03/06/2017
Computation of Nonlinear Analysis
Duration: 3.0 hours
No. of questions: 2

Total Mark: 60 Marks   **Closed Book Exam**   **The Exam consists of two pages**

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* Answer all the following questions
*Systematic arrangement of calculations and clear neat sketches are essential.

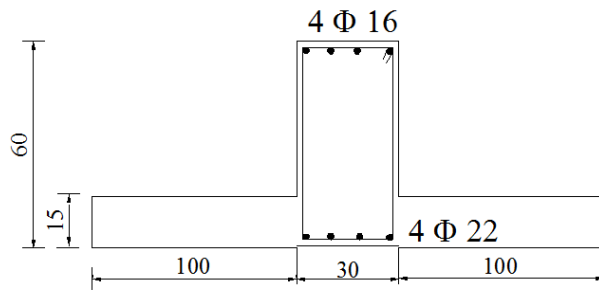**Question (1): Discuss the following items   (30 Marks)**

    (1) Compression softening.
    (2) Strain hardening.
    (3) Tension stiffening.
    (4) Linear Analysis.
    (5) Non-Linear Analysis.
    (6) Types of nonlinearity.
    (7) Importance function and purpose of the nonlinear analysis of R.C elements.
    (8) The basic assumptions considered throughout the nonlinear analysis of the R.C plane frames.
    (9) The major factors causing nonlinear behavior of R.C elements.
    (10) The causes and factors leading to the difference in the nonlinear analysis of R.C structures.
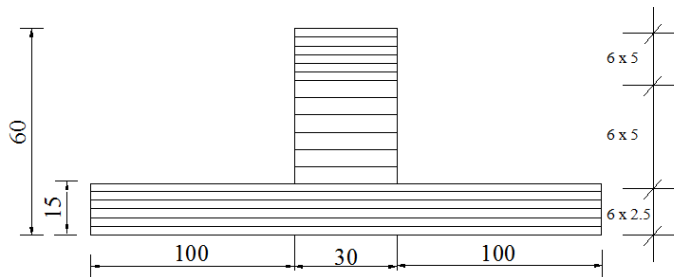   (11) Loading techniques.

Question (2)   (30 Marks)

For the given section shown in Figure 1, the axial strain at mid height of the section $\epsilon_0 = -0.0009$ and the slope $\varphi = -0.0001$ (d`= d`` = 2.5 cm). Using the given stress-strain curves for steel and concrete in tension and compression, it is required to:
    (a) Calculate and draw the strain distribution;
    (b) Calculate and draw the stress distribution;
    (c) Calculate axial, coupling and flexural stiffness's (A,B and D) using the secant modulus of elasticity;
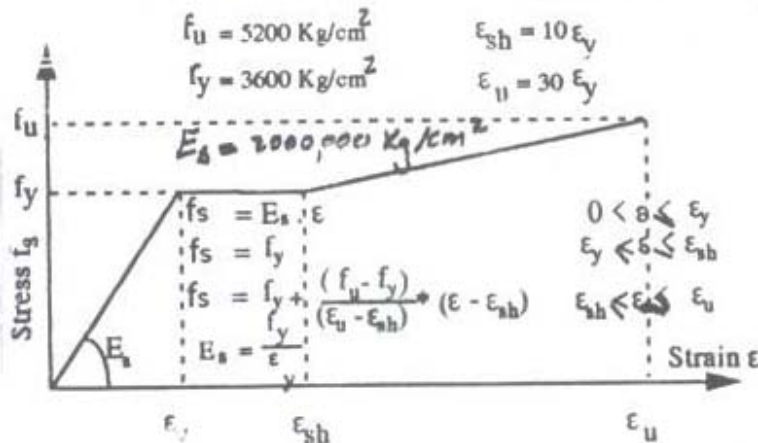   (d) Calculate section capacity (M and N);

4 Φ 16

4 Φ 22

60

15

100   30   100

Beam Section
(d` = d`` = 2.5 cm)

60

15

100   30   100

6 x 5

6 x 5

6 x 2.5

Layered System

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$$f = f_c' \left[\frac{2\varepsilon}{\varepsilon_0} - \left(\frac{\varepsilon}{\varepsilon_0} \right)^2 \right] \qquad 0 < \varepsilon < \varepsilon_{cu}$$

$$f = 0 \qquad \varepsilon > \varepsilon_{cu}$$

$$E_{ti} = \frac{2 f_c'}{\varepsilon_0}$$

$$\varepsilon_0 = 0.003$$
$$\varepsilon_{cu} = 0.004$$
$$f_c' = 300 \ Kg/cm^2$$
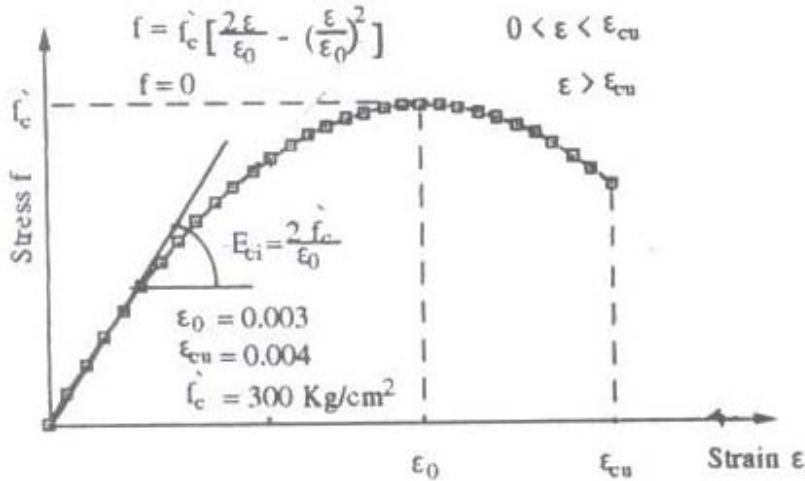
Concrete Stress- Strain Curve in Compression

$$f_u = 5200 \ Kg/cm^2 \qquad \varepsilon_{sh} = 10 \, \varepsilon_y$$
$$f_y = 3600 \ Kg/cm^2 \qquad \varepsilon_u = 30 \, \varepsilon_y$$

$$E_s = 2000,000 \ Kg/cm^2$$

$$f_s = E_s \cdot \varepsilon \qquad\qquad 0 < \varepsilon \leq \varepsilon_y$$
$$f_s = f_y \qquad\qquad \varepsilon_y \leq \varepsilon \leq \varepsilon_{sh}$$
$$f_s = f_y + \frac{(f_u - f_y)}{(\varepsilon_u - \varepsilon_{sh})} (\varepsilon - \varepsilon_{sh}) \qquad \varepsilon_{sh} \leq \varepsilon \leq \varepsilon_u$$
$$E_s = \frac{f_y}{\varepsilon_y}$$

**Trilinear Idealized Stress-Strain Curve for Steel
Reinforcement in Tension and Compression**

$$f = E_t \cdot \varepsilon_t \qquad\qquad\qquad\qquad for \quad 0 \leq \varepsilon_t \leq \varepsilon_{cr}$$
$$f = \frac{2}{3} f_t \cdot \frac{(\varepsilon_a - \varepsilon_t)}{(\varepsilon_a - \varepsilon_{cr})} + \frac{1}{3} f_t \quad for \quad \varepsilon_{cr} \leq \varepsilon_t \leq \varepsilon_a$$
$$f = \frac{1}{3} f_t \cdot \frac{(\varepsilon_b - \varepsilon_t)}{(\varepsilon_b - \varepsilon_a)} \qquad for \quad \varepsilon_a \leq \varepsilon_t \leq \varepsilon_b$$

$$\varepsilon_{cr} = 0.1 \, \varepsilon_0$$
$$\varepsilon_a = 3 \, \varepsilon_{cr} = 0.3 \, \varepsilon_0$$
$$\varepsilon_b = 10 \, \varepsilon_{cr} = \varepsilon_0$$
$$f_t = the \ Tensile \ Stress$$
$$E_t = \frac{f_t}{\varepsilon_{cr}}$$

$$\varepsilon_0 = 0.003$$
$$f_t = 20 \ Kg/cm^2$$
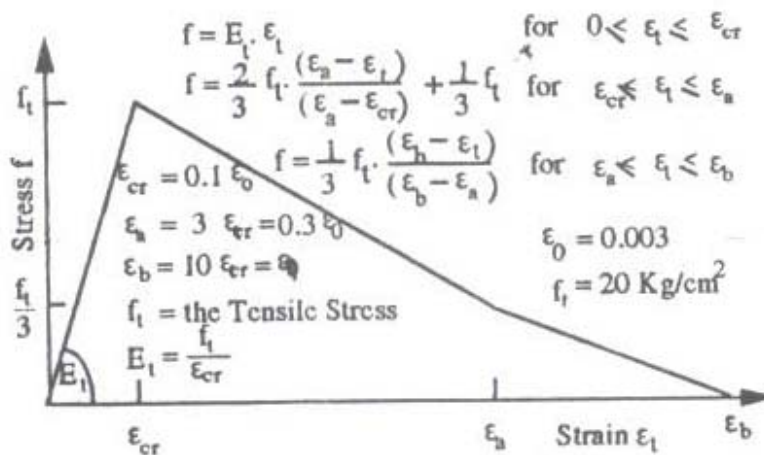
**Trilinear Model (Bilinear Softening) for Concrete
in Tension**