A Centre of Excellence

TECHNICAL UNIVERSITY OF MOMBASA (TUM)

UNIVERSITRY REGULAR EXAMINATIONS FOR:

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECV 4501: STRUCTURAL DESIGN III

REGULAR EXAMINATION
SERIES: 2024/2025
TIME: 2 HOURS

Instructions to Candidates:

1. You should have answer booklet for this examination.
2. This paper contains **FOUR** questions
3. Answer **ANY THREE** questions.
4. Marks for each question are indicated in the parenthesis.
5. Examination duration is 2 **Hours**

QUESTION ONE (25 MARKS)

Design of a Slender Column with Reinforcement from Design Charts

A non-sway column of 400×500 mm cross-section resists, at the ultimate limit state, an axial load of 2000 kN and end moments of 80 kNm and 20 kNm causing double curvature about the minor axis YY. The column's effective heights are $l_{0y} = 7.0$ m and $l_{0z} = 8.0$ m, with characteristic material strengths $f_{ck} = 25$ N/mm^2 and $f_{yk} = 500$ N/mm^2. The effective creep ratio is $\phi_{ef} = 0.87$.

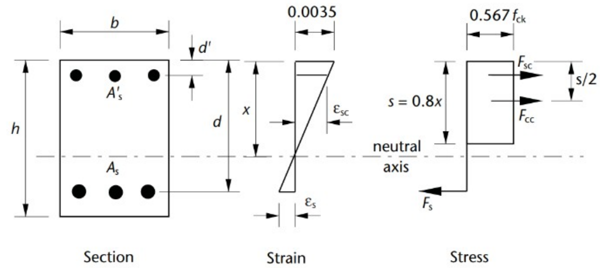
Determine:

- Eccentricities
- Limiting slenderness ratio
- *Actual Slenderness Ratios*
- *Equivalent Eccentricity*
- Total Eccentricity and Moment

Reinforcement from Design Chart

Chart Design

Figure 9.7
Column section



The basic equations derived for a rectangular section as shown in figure 9.7 and with a rectangular stress block are:

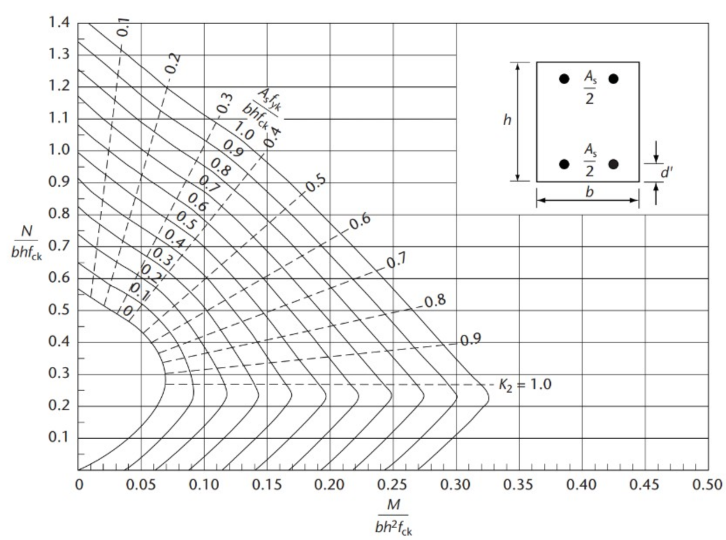
$$N_{Ed} = F_{cc} + F_{sc} + F_s \tag{9.5}$$
$$= 0.567 f_{ck} bs + f_{sc} A'_s + f_s A_s$$

$$M_{Ed} = F_{cc}\left(\frac{h}{2} - \frac{s}{2}\right) + F_{sc}\left(\frac{h}{2} - d'\right) - F_s\left(d - \frac{h}{2}\right) \tag{9.6}$$

where

N_{Ed} = design ultimate axial load
M_{Ed} = design ultimate moment
s = the depth of the stress block = $0.8x$
A'_s = the area of longitudinal reinforcement in the more highly compressed face
A_s = the area of reinforcement in the other face
f_{sc} = the stress in reinforcement A'_s
f_s = the stress in reinforcement A_s, negative when tensile.

Figure 9.8
Rectangular column
($d'/h = 0.20$)



QUESTION TWO (25 MARKS)

Design of Circular Tanks

Specification

- **Internal Radius (R):** 10 m
- **Height (h):** 5 m
- **Wall Thickness (t):** 250 mm
- **Unit Weight of Water (γ):** 10 kN/m³
- **Concrete Strength (fck):** 25 MPa
- **Steel Strength (fyk):** 460 MPa
- **Design Crack Width:** 0.2 mm

Determine the following

1. Parameter Calculation (h^2 / Rt):

2. Shear Force (V):

3. Bending Moment (M):

4. Ring Tension (T):

5. Circumferential Moment (M_{circ}):

6. Reinforcement Design:

QUESTION THREE (TWENTY FIVE MARKS)

Stress Calculation at SLS

Figure 3.1 shows a cantilever wall, part of a water tank, retaining water to a depth of 3.5 m. The base is 400 mm thick and reinforced with H12 bars at 100 mm centers. This question requires calculation of the stresses in concrete and steel at the Serviceability Limit State (SLS) and checks the moment of resistance at the Ultimate Limit State (ULS). Given:

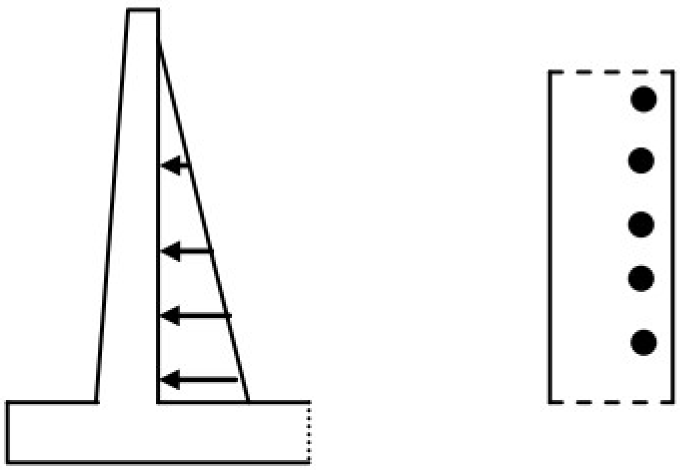


Fig. 19.1 A cantilever wall.

- Concrete strength: $f_{ck} = 30$ MPa
- Steel strength: $f_{yk} = 500$ MPa

Material Properties

- Short-term concrete modulus: $E_{cm} = 22(0.8 + 0.1f_{ck})^{0.3} = 32.84$ GPa
- Creep coefficient: $\varphi(x, t_0) = 1.5$
- Long-term concrete modulus: $E_{c,\text{long term}} = \frac{E_{cm}}{1+\varphi(x,t_0)} = \frac{32.84}{2.5} = 13.2$ GPa
- Steel modulus: $E_s = 200$ GPa
- Modular ratio: $\alpha_e = \frac{200.0}{13.2} = 15.2$

Section Properties (1 m Length of Wall)

- Steel area: $A_s = 1131\ \text{mm}^2/\text{m}$ (H12 bars at 100 mm c/c)
- Width: $b = 1000$ mm

- Total depth: $h = 400$ mm
- Cover: 40 mm
- Effective depth: $d = 400 - 40 - \frac{12}{2} = 354$ mm

Calculate:

(a) Neutral Axis Depth at SLS

(b) Moment at Base at SLS

(c) Stresses at SLS

(d) Moment at ULS

(e) Neutral Axis Depth at ULS

(f) Moment of Resistance at ULS

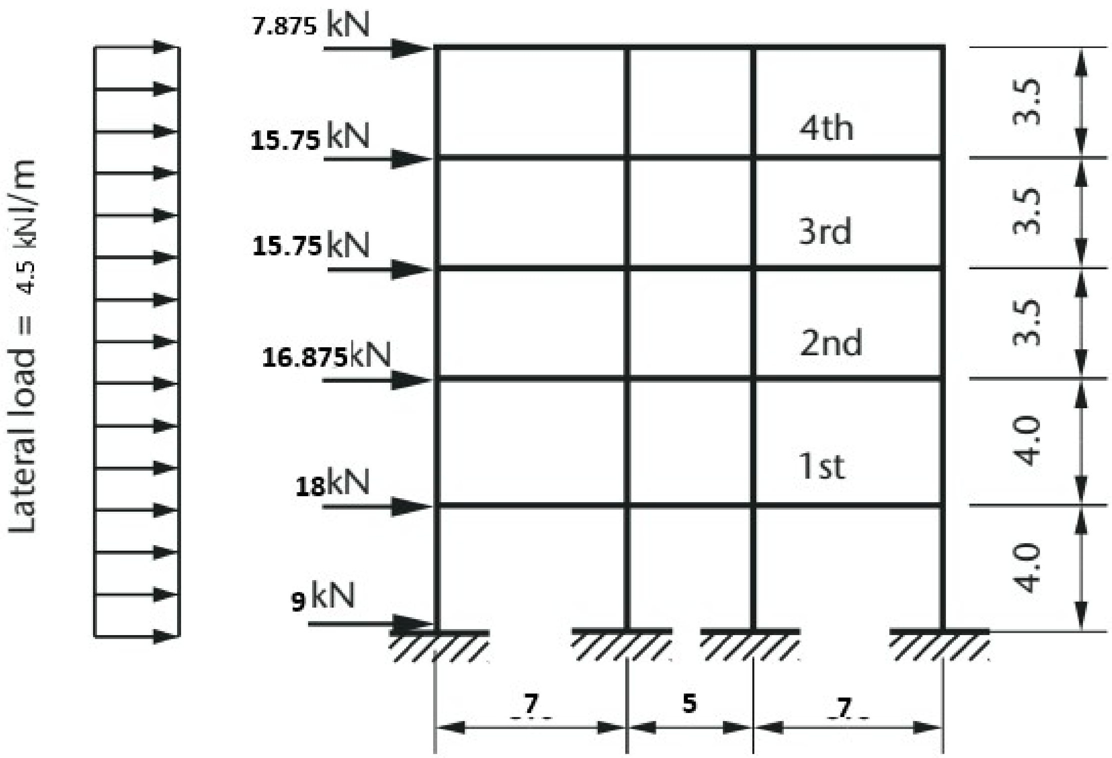
QUESTION NUMBER FOUR (TWENTY FIVE MARKS)

Simplified Analysis for Lateral Loads - Cantilever Method

Figure 4.1 shows a building frame subjected to a characteristic wind action of 4.5kN per meter height, transferred as concentrated loads at each floor level (see figure).

Parameters

- Wind action: 4.5 kN per meter height
- Exterior spans: 7.0 m each
- Interior span: 5.0 m
- Total width: 7.0 m + 5.0 m + 7.0 m = 19.0 m



Analysis at Ultimate Limit State

Assumptions

- Tension in the two left columns, compression in the two right columns
- Axial forces proportional to distance from the frame's centerline
- Exterior column : Interior column = 9.5:4.5 (based on distances from centerline)

Analyze:

- Axial column forces at all floors
- Vertical Shearing Forces in Beams
- Horizontal shearing forces in Columns
- Beam shears to all floors
- Column shears to all floors
- Bending moments for the entire structure

ECV 4501: STRUCTURAL DESIGN III