GX514

OLLSCOIL NA hÉIREANN, GAILLIMH

THE NATIONAL UNIVERSITY OF IRELAND, GALWAY

SUMMER EXAMINATIONS, 2000

B.E. DEGREE EXAMINATION

ADVANCED CONCRETE DESIGN

Professor R. A. Falconer;

Professor P. O'Donoghue;

E. Cannon, BE DipIng DIC MSc;

Time allowed: ***Two*** hours

Answer ***three questions*** in all

Notes:

- All dimensions are in mm. unless noted otherwise;
- Some expressions relating to Question 4 appear at the end of the paper.

1. (a) State the basic rules relating to the development of yield lines, and indicate probable yield line patterns for the slabs shown in Fig. Q1a.

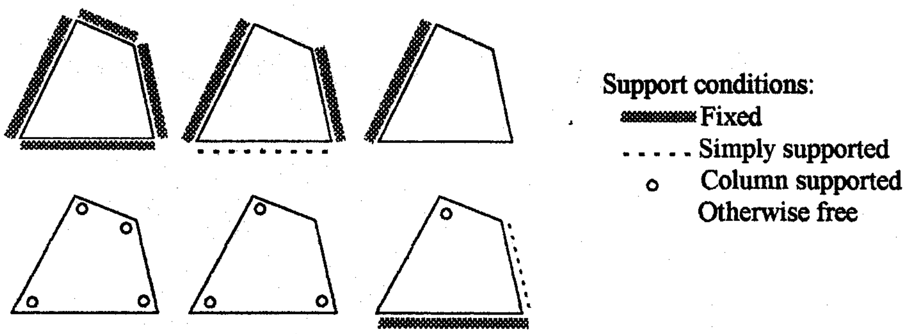


Fig. Q1a

(b) The rectangular slab shown in fig. Q1b is fully fixed on three sides and free along one of the shorter sides. It supports a uniformly distributed load, **n** kN/m^2, and is isotropically reinforced. Determine bending moments for the slab using the Hillerborg approach. State clearly any simplifying assumptions.

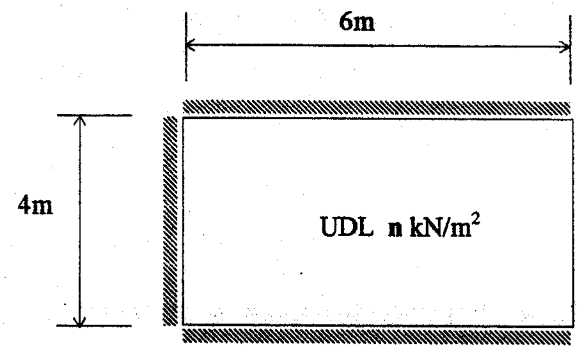
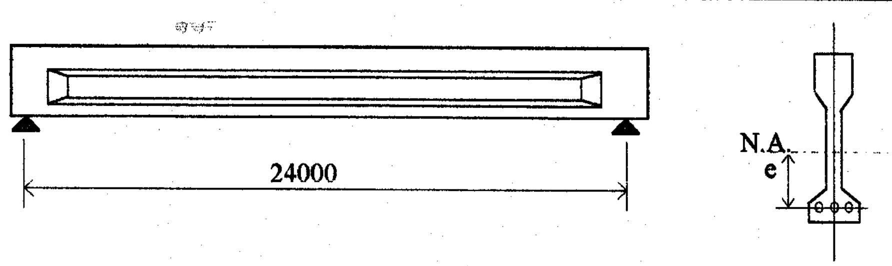


Fig. Q1b

2. The post-tensioned beam shown in Fig. Q2 is stressed by 4 tendons with a parabolic profile. The total initial prestressing force is 8400kN and the total characteristic strength of the tendons is 12000kN. Calculate prestressing losses at midspan due to :

-friction
-elastic shortening
-creep
-shrinkage
-relaxation



Section properties

Concrete:
$A_c = 6.3 \times 10^5$ mm^2
$I_c = 24 \times 10^{10}$ mm^4
$E_c = 31$ kN/mm^2 (at transfer)
e = 600 mm at midspan
e = 0 mm at supports

Steel (prestressing)
$A_{st} = 6 \times 10^4$ mm^2
$E_{st} = 205$ kN/mm^2

Losses

friction coefficient $\mu = 0.20$
wobble factor $K = 17*10^{-4}$ /metre
(friction losses = $P_0\,(1-e^{-(\mu x/r\ +kx)})$
where r is radius of curvature of tendons)
creep coefficient $\phi = 1.8$
shrinkage $\varepsilon_{sh} = 300*10^{-6}$
relaxation 8%

Fig. Q2 Post-tensioned beam

3. (a) Derive the Magnel equations ($1/P_0$ vs. e) for design in prestressed concrete.

(b) The data in Fig. Q3 refers to a simply supported prestressed beam with a 14m span. At transfer, the beam is required to carry only dead load, G_k. All loads are uniformly distributed over the span. Using the Magnel approach, determine a suitable combination of initial prestressing force and eccentricity for the midspan section of the beam. Sketch the variation in profile over the span.

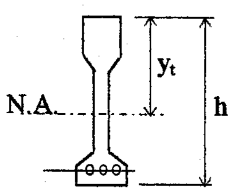
Material properties

Concrete:

f_{cu} = 50 N/mm^2

f_{c14} = 40 N/mm^2

(transfer at 14 days)



Allowable stresses in concrete

at transfer:

f'_{max} = 0.5 f_{c14}

f'_{min} = -1 N/mm^2

in service:

f_{max} = 0.33 f_{cu}

f_{min} = 0 N/mm^2

Assume 30% losses in prestressing after transfer

Section properties

Concrete:

A = 2.4 x 10^5 mm^2

I = 4.97 x 10^{10} mm^4

y_t = 614 mm

h = 1200 mm

Loading

G_k = 12 kN/m

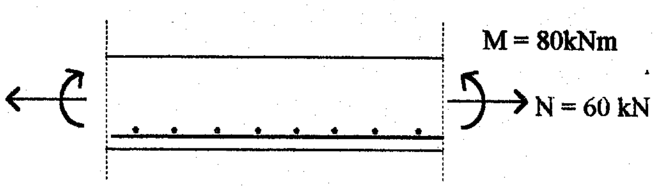
Q_k = 35 kN/m

Span

L = 14m

Fig. Q3 Post-tensioned beam data

4. The section of reservoir wall shown in Fig. Q4 is subjected, under service conditions, to a horizontal bending moment of 80 kNm combined with a direct tensile force of 60 kN, per metre height of wall. The wall is 400 thick and is reinforced horizontally with T16 bars at 125 centres on the principal tensile face. Determine if the design satisfies the requirements of BS8007 for 0.1mm design surface crack width.



f_{cu} = 35 N/mm^2

f_y = 460 N/mm^2

cover = 40mm

Fig. Q4

Expressions relating to Question 4:

Reinforced concrete sections in bending and direct tension

(i) with bending predominant:

$$\left(\frac{100A_s}{bd}\right)_{effective} = \left(\frac{100A_s}{bd}\right)\left(\frac{e+\frac{h}{2}-d}{e+\frac{h}{2}-\frac{x}{3}}\right)$$

with:

A_s	area of steel adjacent to tensile face
b	breadth of section
h	overall depth of section
d	depth to centroid of steel area A_s
x	depth to neutral axis
e	is the eccentricity M/N where N is the axial force and M is the initial bending moment (referred to the centroidal axis)

(ii) with direct tension predominant:

$$f_{s1} = \frac{1}{2A_{s1}}\left(N + \frac{M}{d-\frac{h}{2}}\right) \quad \text{and} \quad f_{s2} = \frac{1}{2A_{s2}}\left(N - \frac{M}{d-\frac{h}{2}}\right)$$

additional terms in the above are:

A_{s1}	area of steel at face which is *most* heavily stressed in tension
f_{s1}	stress in steel area A_{s1}
d	depth to centroid of steel area A_{s1}
A_{s2}	area of steel at face which is *least* heavily stressed in tension
f_{s2}	stress in steel area A_{s2}
d'	depth to centroid of steel area A_{s2} (take d'= h-d)

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SUMMER EXAMINATIONS 2000

FINAL CIVIL ENGINEERING EXAMINATIONS

Structural Analysis II

Professor R. Falconer
Professor P. E. O'Donoghue
Dr. K. McNamara

Time allowed: **two hours**

Answer **3** Questions

1. (a) For a two dimensional planar system with coordinate directions x and y, the compatibility equation in terms of stresses is
$\nabla^2(\sigma_x + \sigma_y) = 0$
Use this equation to develop the governing differential equation for the Airy stress function $\phi(x,y)$.

(b) A simply supported unit wide beam, of depth d, is subjected to uniform vertical loading, q, along the lower edge across the complete span of 2L.
With the origin at the centre of the beam and the x axis along the length of the beam, determine if the Airy stress function
$\phi = A(-4y^5 + 20x^2y^3 - 15x^2yd^2 - 20y^3L^2 + 2y^3d^2 + 5x^2d^3)$
satisfies compatibility (A constant).
Establish expressions for the stresses and determine if the boundary conditions are valid for this problem.
What is the value of the constant A.
Compare the stresses with simple bending theory.

2. (a) Discuss the form of the different boundary conditions that would be encountered in typical plate bending problems.

(b) Show that

$$\frac{d}{dr}\left\{\frac{1}{r}\frac{d}{dr}\left(r\frac{dw}{dr}\right)\right\}=\frac{Q}{D}$$

is the governing differential equation for the vertical deflection of a symmetrically loaded circular plate where Q is the shear force and D is the flexural rigidity.

3. (a) Discuss the requirements associated with the displacement constraints on an externally statically determinate space truss

(b) For the space truss in Figure 1,

(i) Take moments about the x, y and z axes respectively through node 4

(ii) Sum the force components in the x, y and z directions respectively.

From these six equations, evaluate the reactions of the space truss.

Establish which members have zero force.

Use equilibrium to determine the forces in the members that meet at node 3.

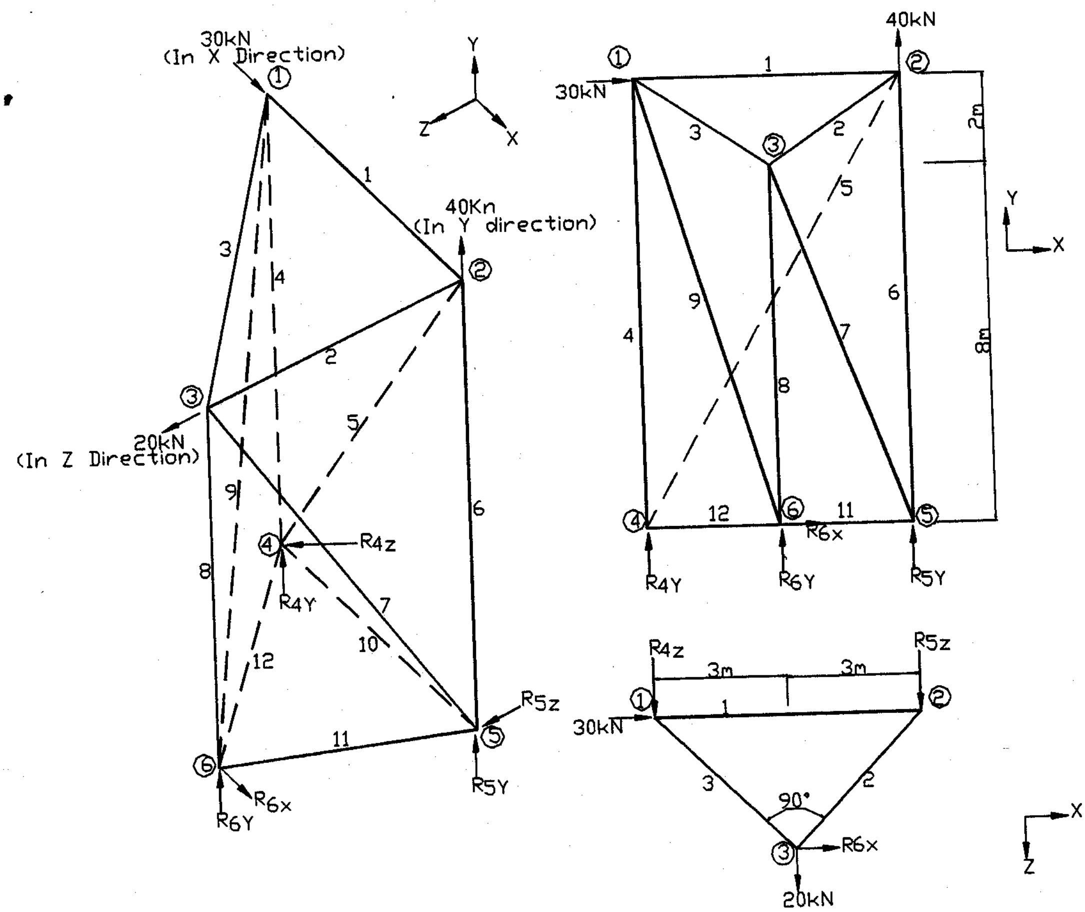

Figure 1

4. (a) Describe how Eurocode 1, Part 2.4, "Wind Actions" takes buffeting by the inherent turbulence in the atmospheric boundary layer into account for structures susceptible to dynamic excitation. (A diagram showing how to get from a gust spectrum to a response spectrum using aerodynamic admittance and mechanical admittance would be useful in the description).

(b) A steel chimney 30m high is of circular cross section and has a diameter at the top of 1.5m. For dynamic analysis it may be modelled as a lumped mass system as shown in Figure 2. If the mean design velocity at the top of the chimney is 40m/s, find out if vortex excitation may be a problem. The Strouhal No. $S_t = (fD)/V$ is 0.2 for a circular cross section where f is the frequency of vortex shedding, D is a diameter and V is the wind velocity.

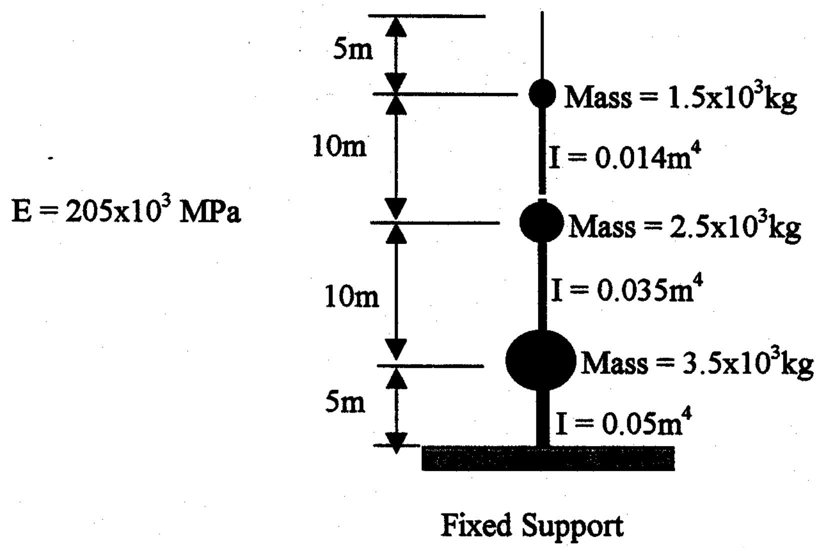

Figure 2