GX514

OLLSCOIL NA hÉIREANN, GAILLIMH

THE NATIONAL UNIVERSITY OF IRELAND, GALWAY

SUMMER EXAMINATIONS, 2000

B.E. DEGREE EXAMINATION

ADVANCED CONCRETE DESIGN

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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.

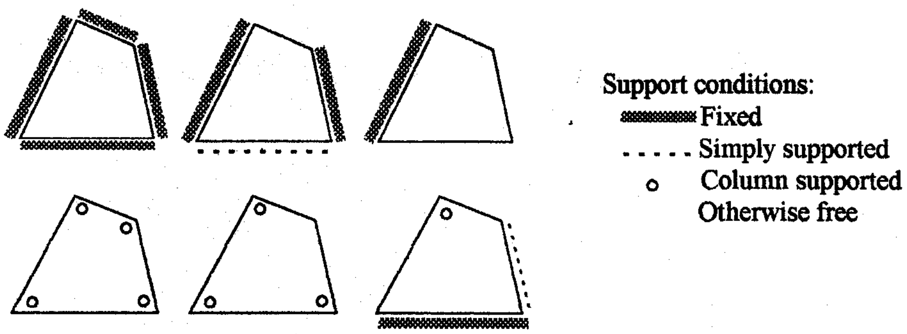


Fig. Q1a

(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.

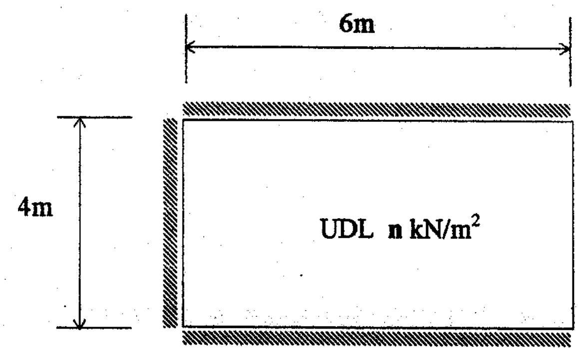
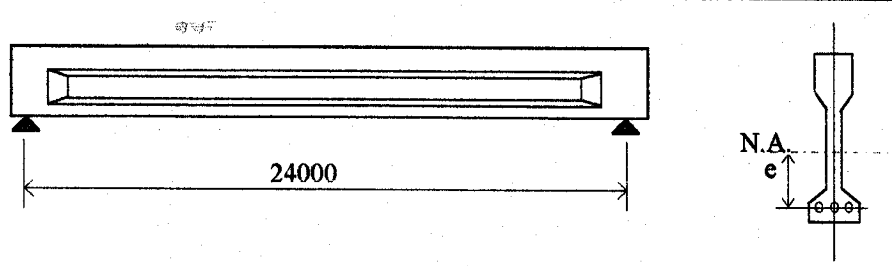


Fig. Q1b

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.

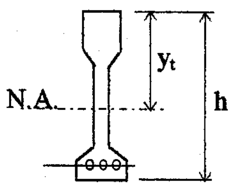
Material properties

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:

$A = 2.4 \times 10^5$ mm^2

$I = 4.97 \times 10^{10}$ mm^4

$y_t = 614$ mm

$h = 1200$ mm

Loading

$G_k = 12$ kN/m

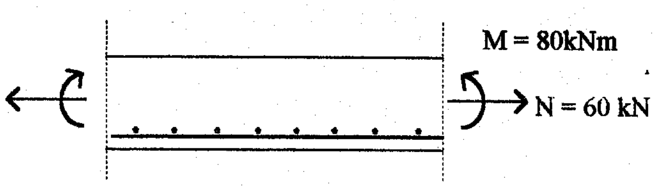
$Q_k = 35$ kN/m

Span

$L = 14$m

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:

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

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)