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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	: REINFORCED CONCRETE DESIGN II
COURSE CODE	: BFC 32803
PROGRAMME CODE	: BFF
EXAMINATION DATE	: JUNE / JULY 2016
DURATION	: 3 HOURS
INSTRUCTION	: ANSWER **FOUR (4)** QUESTIONS ONLY DESIGN SHOULD BE BASED ON: BS EN1990:2002+A1:2005 BS EN1991-1-1:2002 BS EN1992-1-1:2004

THIS QUESTION PAPER CONSISTS OF **NINETEEN (19)** PAGES

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Q1 **Figure Q1** shows plan view and longitudinal section of two flights of a reinforced concrete staircase that connected ground floor to the first floor of a building. Flight 1 comprises of 6 steps while Flight 2 comprises of 10 steps. The overall depth of landing and waist is 150mm while the width of going and the height of riser are 260 mm and 160 mm respectively. Given the data as follows:

Variable action = 5.0 kN/m^2
Finishes and handrails = 0.75 kN/m^2
Characteristic strength of concrete = 30 N/mm^2
Characteristic strength of steel = 500 N/mm^2
Nominal concrete cover = 25 mm
Bar diameter = 10 mm
Mean value of axial tensile strength of concrete, f_{ctm} = 2.9 MPa

(a) Explain about the effective span consideration of a staircase.
(2 marks)

(b) Calculate average thickness of the staircase.
(3 marks)

(c) Determine the bending moment for both flight.
(6 marks)

(d) Design the flexural reinforcement of the staircase by considering the critical case and check the staircase for cracking.
(14 marks)

Q2 A modern three-storey hotel will be constructed at Cameron Highlands area. The building is considered as an unbraced frame. All beams are designed with the size of 250 x 350 mm and columns are designed with the size of 400 x 400 mm. **Figure Q2** shows a plan and side view of the building. Given data as follows:

l, = importance factor = 1.0
C_{fig}= aerodynamic shape factor for external pressure = 1.0
C_{dyn} = dynamic response factor = 1.0

(a) Define and sketch an unbraced frame for the building.
(2 marks)

(b) Calculate the design wind pressure by using the basic wind speed for this location based on MS1553: Section 2. Assume M_d, $M_{z,cat}$, M_s, M_h is equal to 1.0.
(3 marks)

(c) Calculate the design wind load for sub-frame 2/A-D and determine the horizontal load for each floor level.

(6 marks)

(d) i) Determine the centre of gravity of the building and column axial load.

(3 marks)

ii) Calculate the shear force in beams and columns at roof level due to the horizontal action.

(11 marks)

Q3 **Figure Q3(a)** shows front elevation while **<u>Figure Q3(b)</u>** shows part of plan view of first floor level of a ten-storey reinforced concrete building. The building will be built with bracing member to carry wind load. All beams and columns are designed with the size of 250 x 550 mm and 350 x 350 mm respectively.

(a) Define the failure and slenderness ratio of short and slender column.

(2 marks)

(b) Calculate the effective height about z-axis of column A/1 from ground floor to first floor by using simplified method in BS8110. Assume the connection between column to foundation are not designed to carry moment.

(3 marks)

(c) Determine whether the column is short or slender about z-axis. Assume φ_{eff}, ω and r_m are not known. Given the data as follows:

Axial force = 3260 kN
Design moment, M_z = 44.5 kNm
f_{ck} = 35 N/mm^2
f_{yk} = 500 N/mm^2
Radius of gyration about z-axis = 101.02 mm
Concrete cover = 35 mm
Bar diameter = 32 mm
Link diameter = 6 mm

(6 marks)

(d) Hence, design all reinforcements of column A/1 from ground floor to first floor considering the column as a short column bent about major axis.

(14 marks)

Q4 Two columns, A and B with cross-section of 350 x 350 mm is located in one line with the distance of 3.0 m centre-to-centre. The ultimate load of column A and B are 2000 kN and 1600 kN respectively while the soil bearing capacity is 200 kN/m^2. Initial calculation shows that combined footing is suitable to carry the load from both column. Given the data as follows:

Characteristic strength of concrete, $f_{ck} = 35\ N/mm^2$
Characteristic strength of steel, $f_{yk} = 500\ N/mm^2$
Concrete cover = 40 mm
Bar diameter = 12 mm
Use factor 1.45 to change from ultimate load to service load
Mean value of axial tensile strength of concrete, $f_{ctm} = 3.21$ MPa

(a) Give **TWO (2)** factors of selection of a pile type.
(2 marks)

(b) Calculate the total service load from both columns.
(3 marks)

(c) By using width of foundation, B as 2.5 m and height, h as 600mm, determine the length of the foundation, H.
(6 marks)

(d) Based on the bending moment diagram in **Figure Q4**, design all necessary main reinforcement of the footing.
(14 marks)

Q5 (a) Describe briefly **TWO (2)** types of failure in retaining wall.
(2 marks)

(b) **Figure Q5** shows a cross section of a retaining wall. The surcharge of 2.0 kN/m^2 is imposed to the backfill behind the wall. The soil has a density, $\gamma = 18\ kN/m^3$, angle of internal friction, $\phi = 32^o$ and cohesion, $c = 0$. The material under the wall has a safe bearing pressure 80 kN/m^2, friction coefficient is 0.5 and concrete density is 25 kN/m^3.

(i) Explain the behaviour of the various elements of this retaining wall to resist the designed moments and shear forces.
(3 marks)

(ii) Determine the total horizontal load and moment of the retaining wall.

(6 marks)

(iii) Check for stability of the wall against overturning and sliding. Partial safety factors are shown in Table 1. Give your reason and comment if the stability is not adequate.

(14 marks)

-END OF QUESTIONS-

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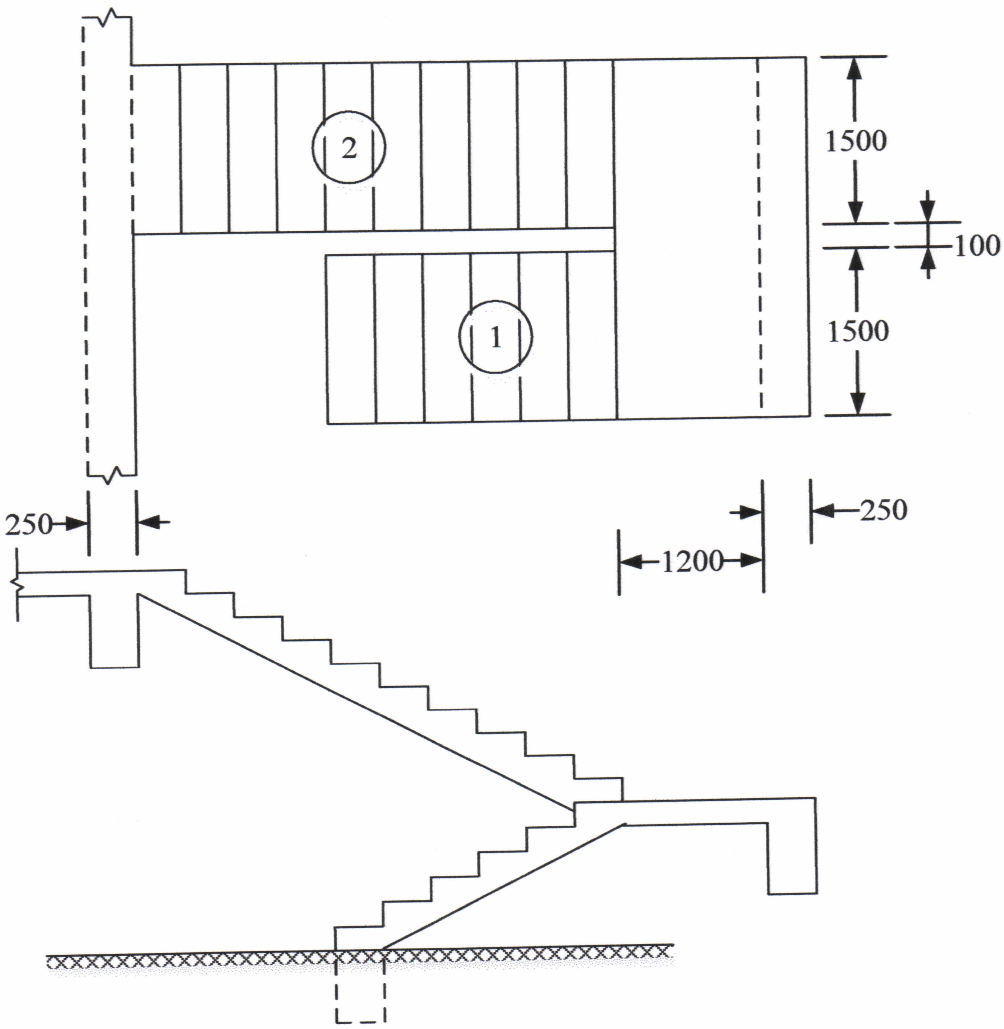

All unit in mm

FIGURE Q1

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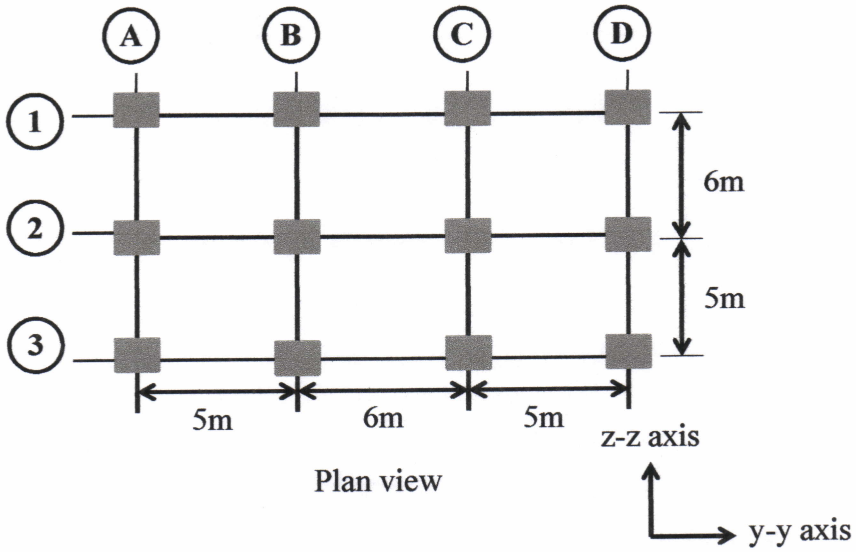
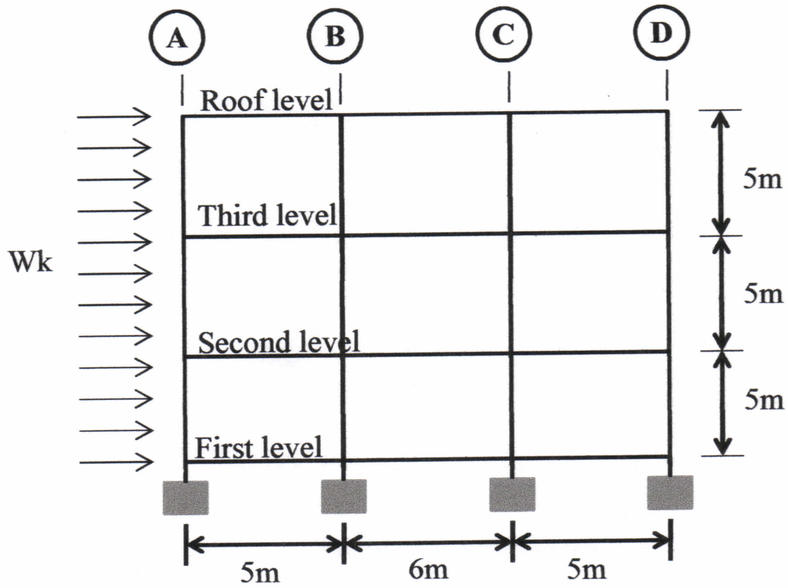


Plan view



Side view

FIGURE Q2

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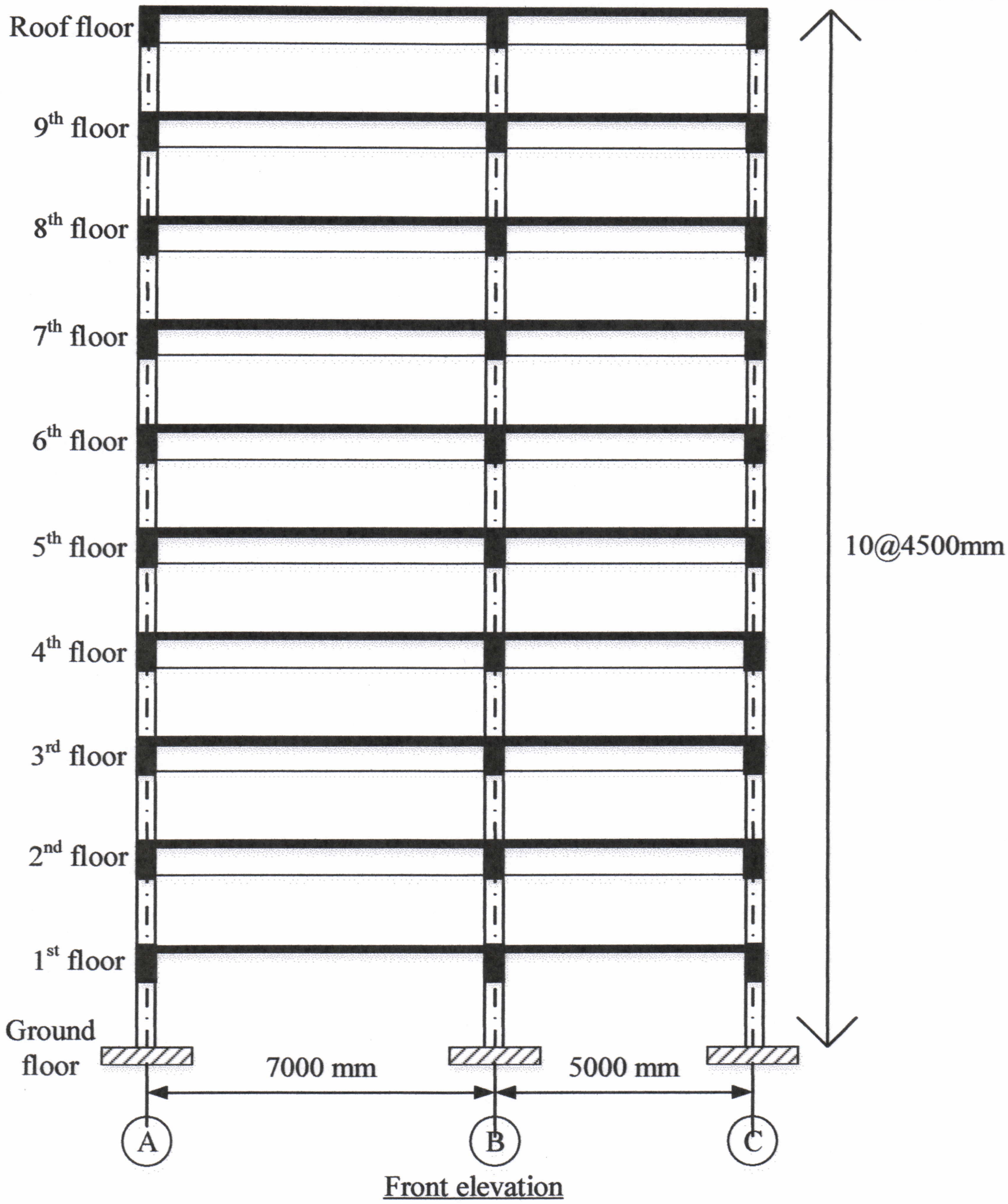

FIGURE Q3(a)

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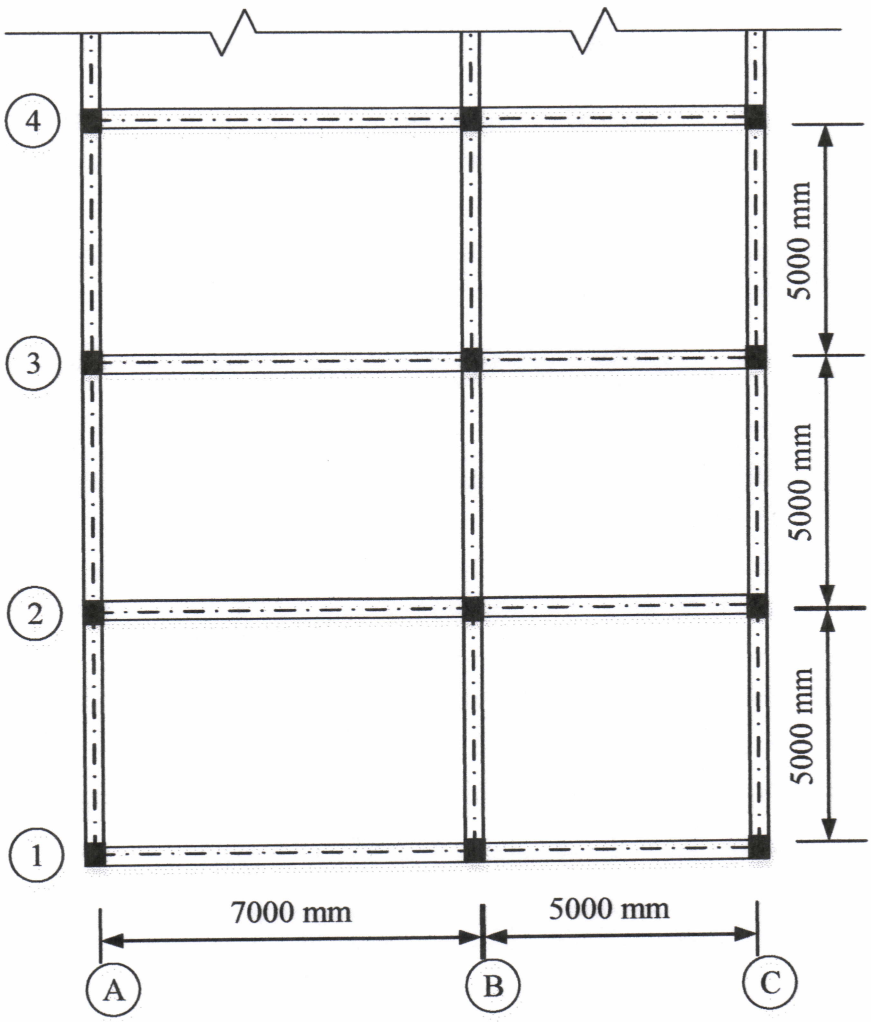

Plan view

FIGURE Q3(b)

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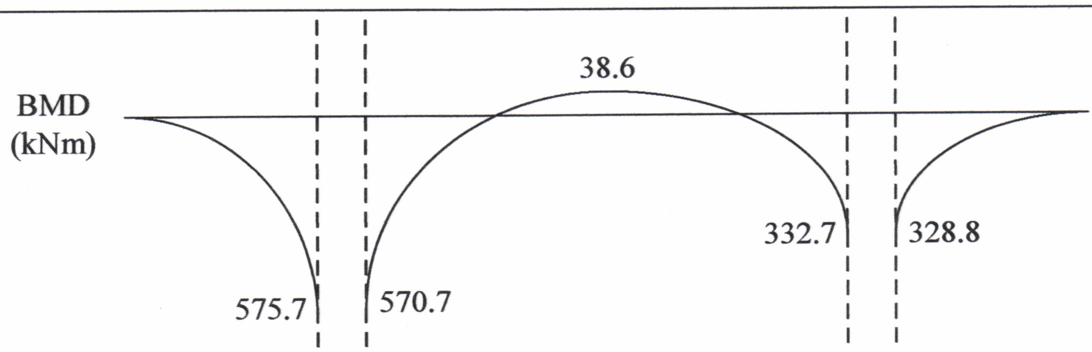

FIGURE Q4

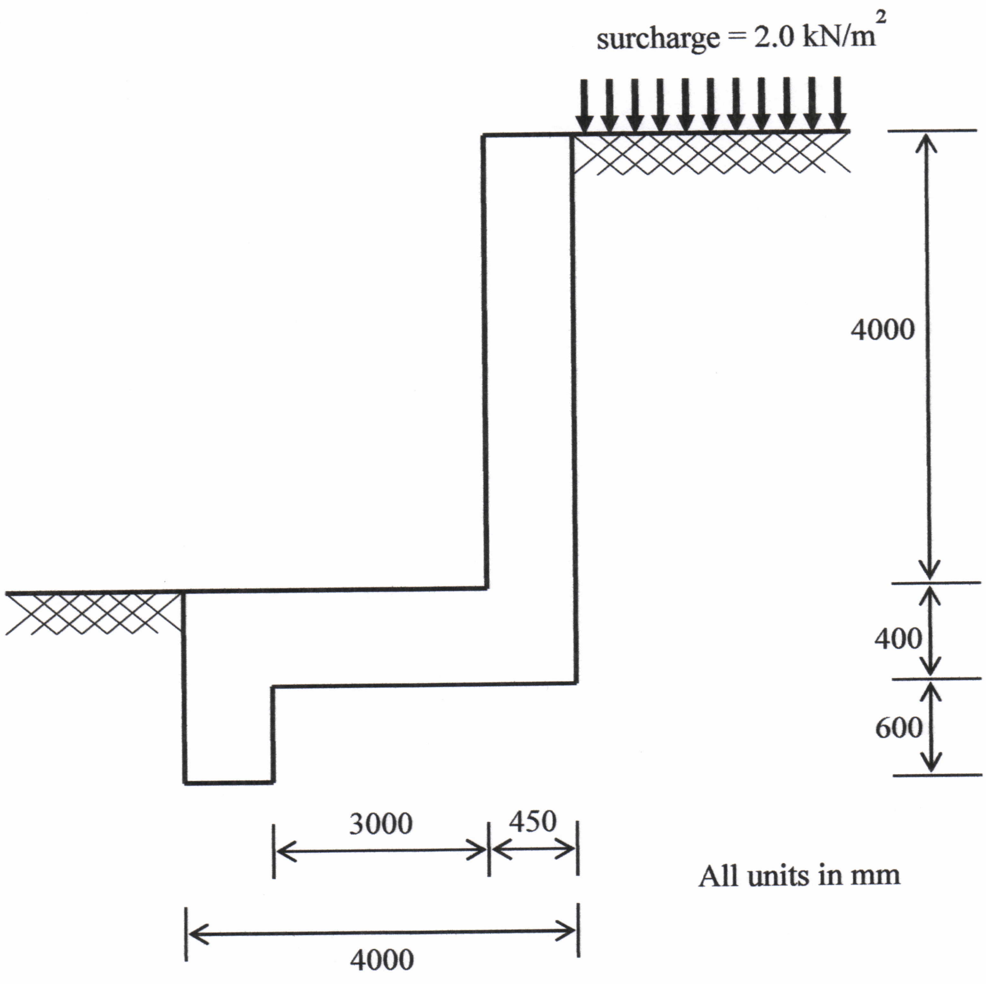

FIGURE Q5

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APPENDIXES

Table 1: Partial safety factor at the ultimate limit state

Situation	Imposed	Stabilizing
Overturning	1.4	1.0
Sliding	1.4	-

Table 2: Values of β for braced columns (Table 3.19, BS8110)

End condition at top	End condition at bottom		
	1	2	3
1	0.75	0.80	0.90
2	0.80	0.85	0.95
3	0.90	0.95	1.00

Table 3: Values of β for unbraced columns (Table 3.20, BS8110)

End condition at top	End condition at bottom		
	1	2	3
1	1.2	1.3	1.6
2	1.3	1.5	1.8
3	1.6	1.8	-
4	2.2	-	-

Column end conditions (BS8110, Cl.3.8.1.6.2 BS 8110):

a) *Condition 1*: The end of column is connected monolithically to beams on either side which are at least as deep as the overall dimension of the column in the plane considered. Where the column is connected to a foundation structure, this should be of a form specifically designed to carry moment.

b) *Condition 2*: The end of the column is connected monolithically to beams or slabs on either side which are shallower than the overall dimension of the column in the plane considered.

c) *Condition 3*: The end of the column is connected to members which, while not specifically designed to provide restraint to rotation of the column will, nevertheless, provide some nominal restraint.

d) *Condition 4*: The end of the column is unrestrained against both lateral movement and rotation (e.g. the free end a cantilever column in unbraced structure).

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Table 4: Cross Sectional Area (mm^2) according to Size and Numbers of Bar

Bar Size (mm)	Number of Bar								Perimeter (mm)
	1	2	3	4	5	6	7	8	
6	28.3	56.6	84.9	113	141	170	198	226	18.9
8	50.3	101	151	201	251	302	352	402	25.1
10	78.6	157	236	314	393	471	550	629	31.4
12	113	226	339	453	566	679	792	905	37.7
16	201	402	603	805	1006	1207	1408	1609	50.3
20	314	629	943	1257	1571	1886	2200	2514	62.9
25	491	982	1473	1964	2455	2946	3438	3929	78.6
32	805	1609	2414	3218	4023	4827	5632	6437	100.6
40	1257	2514	3771	5029	6286	7543	8800	10057	125.7

Table 5: Cross Sectional Area (mm^2) for every meter width at distance between Bar

Bar Size (mm)	Distance between Bar (mm)								
	50	75	100	125	150	175	200	250	300
6	566	377	283	226	189	162	141	113	94
8	1006	670	503	402	335	287	251	201	168
10	1571	1048	786	629	524	449	393	314	262
12	2263	1509	1131	905	754	647	566	453	377
16	4023	2682	2011	1609	1341	1149	1006	805	670
20	6286	4190	3143	2514	2095	1796	1571	1257	1048
25	9821	6548	4911	3929	3274	2806	2455	1964	1637
32	16091	10728	8046	6437	5364	4598	4023	3218	2682
40	25143	16762	12571	10057	8381	7184	6286	5029	4190

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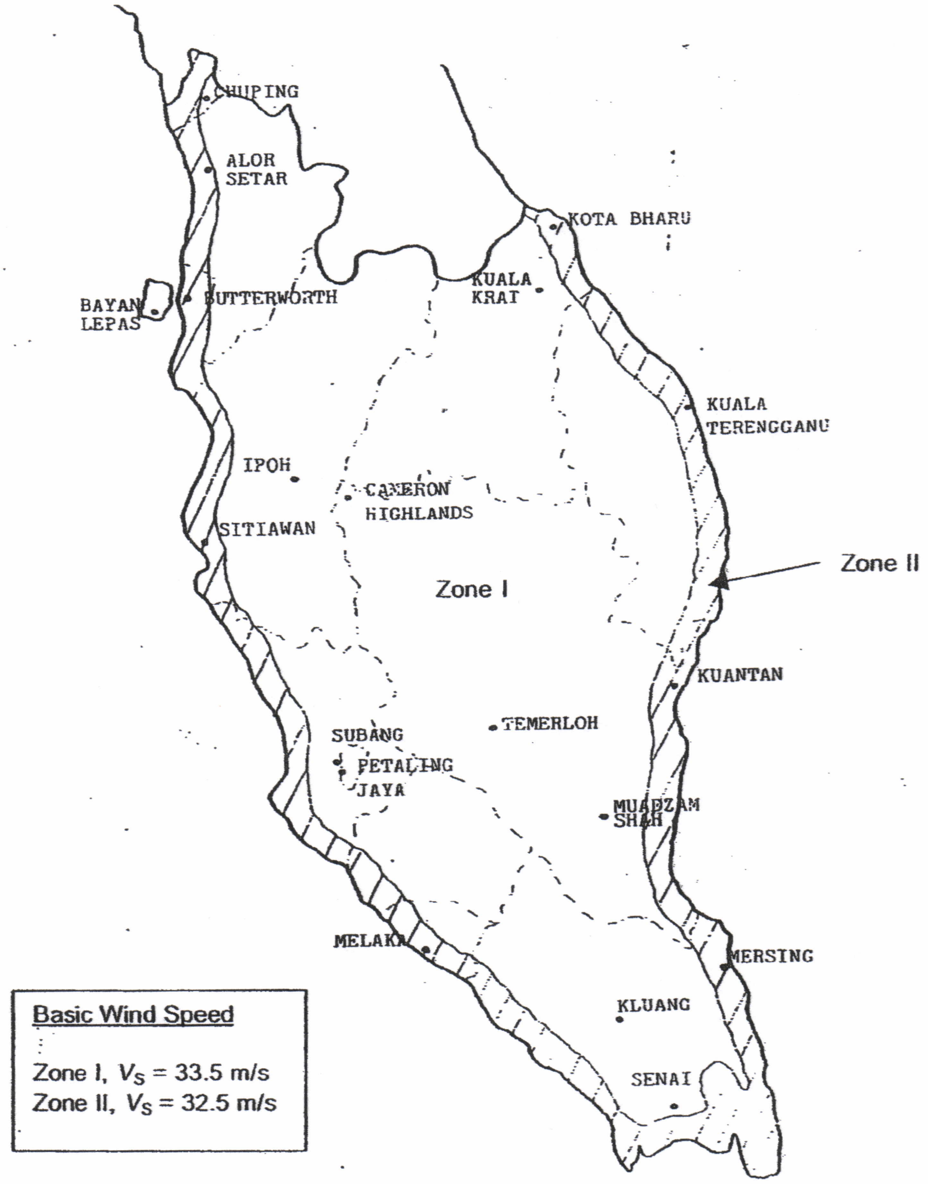
MS1553:2002



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5.8.3 Simplified criteria for second order effects

5.8.3.1 Slenderness criterion for isolated members

(1) As an alternative to 5.8.2 (6), second order effects may be ignored if the slenderness λ (as defined in 5.8.3.2) is below a certain value λ_{lim}.

Note: The value of λ_{lim} for use in a Country may be found in its National Annex. The recommended value follows from:

$$\lambda_{lim} = 20 \cdot A \cdot B \cdot C / \sqrt{n} \qquad (5.13N)$$

where:

A = $1 / (1+0{,}2\varphi_{ef})$ (if φ_{ef} is not known, A = 0,7 may be used)

B = $\sqrt{1+2\omega}$ (if ω is not known, B = 1,1 may be used)

C = $1{,}7 - r_m$ (if r_m is not known, C = 0,7 may be used)

φ_{ef} effective creep ratio; see 5.8.4;

ω = $A_s f_{yd} / (A_c f_{cd})$; mechanical reinforcement ratio;

A_s is the total area of longitudinal reinforcement

n = $N_{Ed} / (A_c f_{cd})$; relative normal force

r_m = M_{01}/M_{02}; moment ratio

M_{01}, M_{02} are the first order end moments, $|M_{02}| \geq |M_{01}|$

If the end moments M_{01} and M_{02} give tension on the same side, r_m should be taken positive (i.e. $C \leq 1{,}7$), otherwise negative (i.e. $C > 1{,}7$).

In the following cases, r_m should be taken as 1,0 (i.e. C = 0,7):
- for braced members in which the first order moments arise only from or predominantly due to imperfections or transverse loading
- for unbraced members in general

(2) In cases with biaxial bending, the slenderness criterion may be checked separately for each direction. Depending on the outcome of this check, second order effects (a) may be ignored in both directions, (b) should be taken into account in one direction, or (c) should be taken into account in both directions.

5.8.3.2 Slenderness and effective length of isolated members

(1) The slenderness ratio is defined as follows:

$$\lambda = l_0 / i \qquad (5.14)$$

where:

l_0 is the effective length, see 5.8.3.2 (2) to (7)

i is the radius of gyration of the uncracked concrete section

(2) For a general definition of the effective length, see 5.8.1. Examples of effective length for isolated members with constant cross section are given in Figure 5.7.

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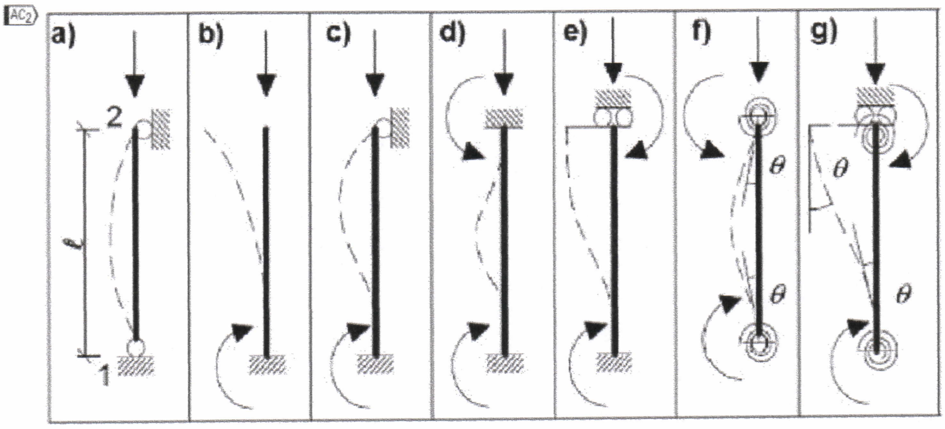

a) $l_0 = l$ b) $l_0 = 2l$ c) $l_0 = 0,7l$ d) $l_0 = l/2$ e) $l_0 = l$ f) $l/2 < l_0 < l$ g) $l_0 > 2l$ AC2

Figure 5.7: Examples of different buckling modes and corresponding effective lengths for isolated members

(3) For compression members in regular frames, the slenderness criterion (see 5.8.3.1) should be checked with an effective length l_0 determined in the following way:

Braced members (see Figure 5.7 (f)):

$$l_0 = 0,5l \cdot \sqrt{\left(1+\frac{k_1}{0,45+k_1}\right)\cdot\left(1+\frac{k_2}{0,45+k_2}\right)} \tag{5.15}$$

Unbraced members (see Figure 5.7 (g)):

$$l_0 = l \cdot \max\left\{\sqrt{1+10\cdot\frac{k_1\cdot k_2}{k_1+k_2}}\ ;\ \left(1+\frac{k_1}{1+k_1}\right)\cdot\left(1+\frac{k_2}{1+k_2}\right)\right\} \tag{5.16}$$

where:

k_1, k_2 are the relative flexibilities of rotational restraints at ends 1 and 2 respectively:

k = $(\theta / M)\cdot(EI / l)$

θ is the rotation of restraining members for bending moment M; see also Figure 5.7 (f) and (g)

EI is the bending stiffness of compression member, see also 5.8.3.2 (4) and (5)

l is the clear height of compression member between end restraints

Note: $k = 0$ is the theoretical limit for rigid rotational restraint, and $k = \infty$ represents the limit for no restraint at all. Since fully rigid restraint is rare in practise, a minimum value of 0,1 is recommended for k_1 and k_2.

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7.3.3 Control of cracking without direct calculation

(1) For reinforced or prestressed slabs in buildings subjected to bending without significant axial tension, specific measures to control cracking are not necessary where the overall depth does not exceed 200 mm and the provisions of 9.3 have been applied.

(2) The rules given in 7.3.4 may be presented in a tabular form by restricting the bar diameter or spacing as a simplification.

Note: Where the minimum reinforcement given by 7.3.2 is provided, crack widths are unlikely to be excessive if:

- for cracking caused dominantly by restraint, the bar sizes given in Table 7.2N are not exceeded where the steel stress is the value obtained immediately after cracking (i.e. σ_s in Expression (7.1)).
- for cracks caused mainly by loading, either the provisions of Table 7.2N or the provisions of Table 7.3N are complied with. The steel stress should be calculated on the basis of a cracked section under the relevant combination of actions.

9.3.1 Flexural reinforcement

9.3.1.1 General

(1) For the minimum and the maximum steel percentages in the main direction 9.2.1.1 (1) and (3) apply.

Note: In addition to Note 2 of 9.2.1.1 (1), for slabs where the risk of brittle failure is small, $A_{s,min}$ may be taken as 1,2 times the area required in ULS verification.

(2) Secondary transverse reinforcement of not less than 20% of the principal reinforcement should be provided in one way slabs. In areas near supports transverse reinforcement to principal top bars is not necessary where there is no transverse bending moment.

(3) The spacing of bars should not exceed $s_{max,slabs}$.

Note; The value of $s_{max,slabs}$ for use in a Country may be found in its National Annex. The recommended value is:

- for the principal reinforcement, $3h \leq 400$ mm, where h is the total depth of the slab;
- for the secondary reinforcement, $3{,}5h \leq 450$ mm .

In areas with concentrated loads or areas of maximum moment those provisions become respectively:

- for the principal reinforcement, $2h \leq 250$ mm
- for the secondary reinforcement, $3h \leq 400$ mm.

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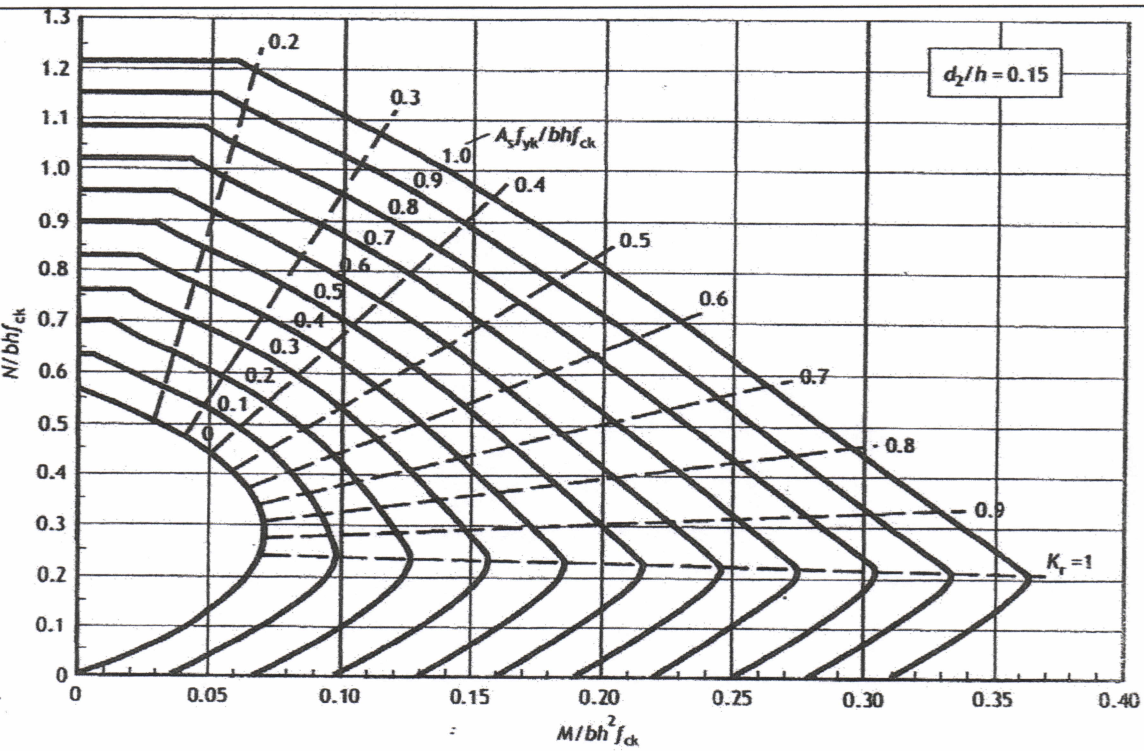

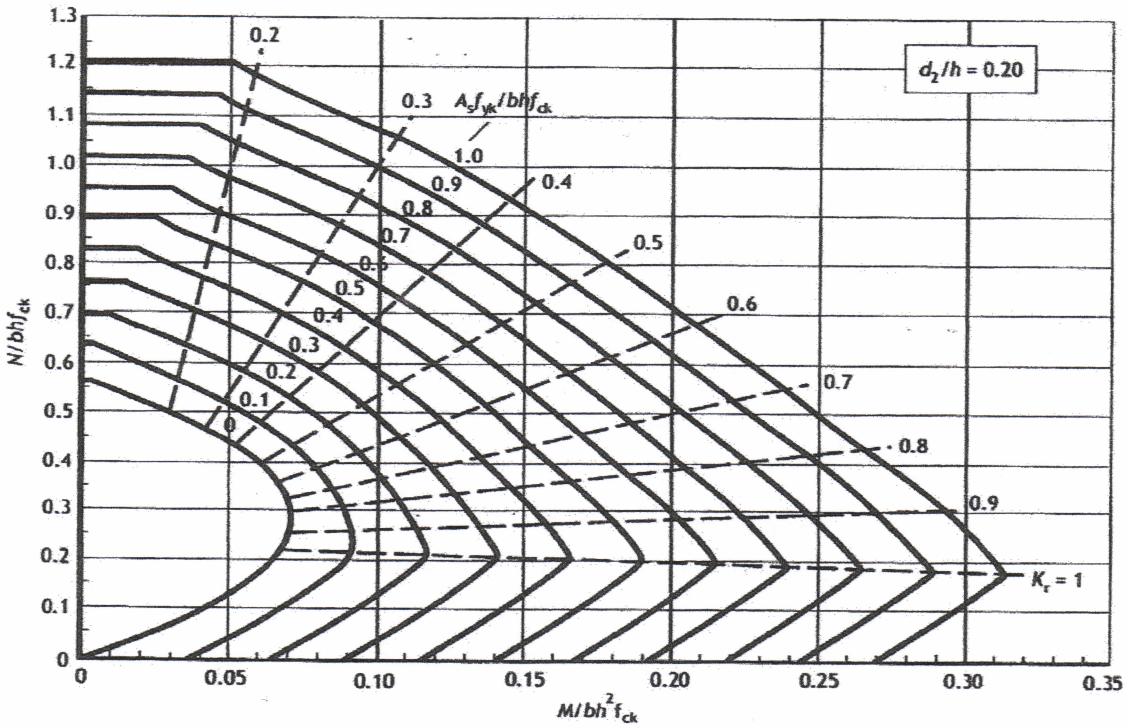

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FORMULAE

$$t = h\left[\frac{(G^2 + R^2)^{1/2}}{G}\right] + \frac{R}{2}$$

$$K = M/bd^2 f_{ck}$$

$$z = d\left[0.5 + \sqrt{0.25 - \left(\frac{K}{1.134}\right)}\right]$$

$$A_s = \frac{M}{0.87 f_{yk}\, z}$$

$$A_{s,min} = 0.26\left(\frac{f_{ctm}}{f_{yk}}\right)bd$$

$$A_{s,min} = 0.1N_{Ed}/0.87 f_{yk} < 0.002A_c$$

$$A_{s,max} = 0.04A_c$$

$$f_{cd} = 0.85 f_{ck}/\gamma_c$$

$$V_{Rd,c} = \left[0.12k(100\rho_1 f_{ck})^{1/3}\right]bd$$

$$k = 1 + \left(\frac{200}{d}\right)^{1/2} < 2.0$$

$$\rho_1 = \frac{A_s}{bd} \le 0.02$$

$$p = 0.613\ (V_{des})^2 C_{fig} C_{dyn}$$

$$V_{des} = V_{sit}\ I$$

$$V_{sit} = V_s\ M_d\ M_{z,cat}\ M_s\ M_h$$

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Effective height, $l_e = \beta l_o$

$$\lambda_{lim} = \frac{26.2}{\sqrt{N_{Ed}/\left[A_c \times (0.85 \times f_{ck}/1.5)\right]}}$$

Pressure, $P = \gamma z\left(\frac{1-\sin\phi}{1+\sin\phi}\right)$

$$P_{max} = \frac{\sum W}{A} \pm \frac{\sum M}{Z}$$

Active Force, $P_1 = 0.5\gamma H_1^2\left(\frac{1-\sin\phi}{1+\sin\phi}\right)$

Passive Force, $P_2 = 0.5\gamma H_2^2\left(\frac{1+\sin\phi}{1-\sin\phi}\right)$

$$K_a = \frac{1-\sin\emptyset}{1+\sin\emptyset}$$

$$K_p = \frac{1+\sin\emptyset}{1-\sin\emptyset}$$