For updated version, please click on http://ocw.ump.edu.my

Universiti Malaysia PAHANG
Engineering • Technology • Creativity

REINFORCED CONCRETE DESIGN 1

Design of Column (Examples and Tutorials)

by

Dr. Sharifah Maszura Syed Mohsin
Faculty of Civil Engineering and Earth Resources
maszura@ump.edu.my

Communitising Technology

Example 1: Classification of slenderness

Figure 1 show the layout floor view of a building frame, whereas the elevation view is shown in the same figure. The building has reinforced concrete slab from ground floor to the roof floor. The main dimensions, structural features, loads, materials etc. are also set out below.

Calculate the slenderness of the column at B/2 on Ground floor and classify the column whether slender or non-slender (short). The column is considered braced with provision of bracing system at certain location.

Example 1: Classification of slenderness

Column B/2: Ground floor to Level 1

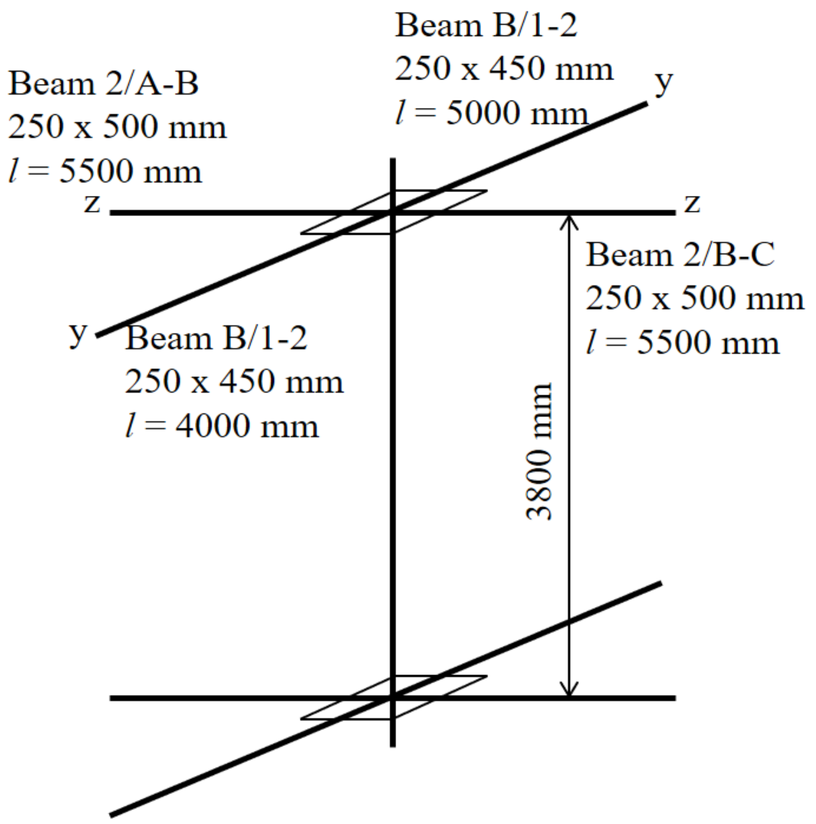


Figure 1

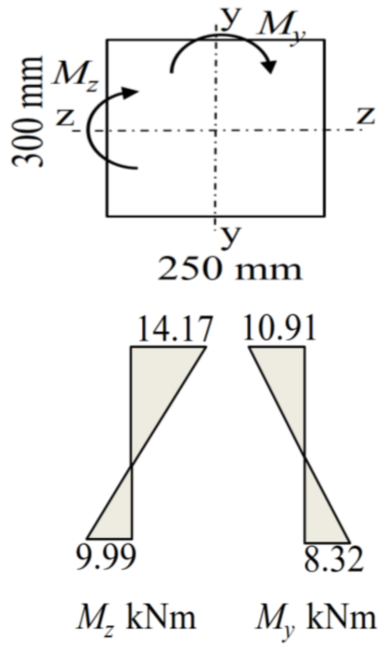
Material,

f_{ck} = 25 N/mm^2

f_{yk} = 25 N/mm^2

N_{ed} = 800 kN

Moments



Example 1: Classification of slenderness

Dimension and size:

Beam:

B/1-3, b x h = 250 x 450 mm

L_{1-2} = 4.0 m

L_{2-3} = 5.0 m

2/A-C, b x h = 250 x 500 mm

L_{A-B} = 5.5 m

L_{B-C} = 5.5 m

Column: b x h = 250 x 300 mm

l_z = 3800 – 450 = 3350 mm

l_y = 3800 – 500 = 3300 mm

Example 1: Classification of slenderness

Effective length, l_o = *factor x clear height*

x-axis: End condition Top = 1
Bot = 1

Beam at both sides, $h_b > h_c$
450 > 300

Factor = 0.75
l_o = 0.75 x 3350 = 2513 mm

y-axis: End condition Top = 1
Bot = 1

Beam at both sides, $h_b > h_c$
500 > 250

Factor = 0.75
l_o = 0.75 x 3300 = 2475 mm

Example 1: Classification of slenderness

Radis of gyration = $(I/A)^{1/2}$

$i_z = (5.63 \times 10^8 / 75000)^{1/2} = 87$ mm

$i_y = (3.91 \times 10^8 / 75000)^{1/2} = 72$ mm

Slenderness ratio, $\lambda = l_o/i$

$\lambda_z = 2513 / 87 = 28.9$

$\lambda_y = 2475 / 72 = 34.4$

Slenderness limit, $\lambda_{lim} = 20.A.B.C/n^{1/2}$

$A = 1/(1 + 0.2\varphi_{eff}) = 0.7$ (φ_{eff} not known)

$B = (1 + 2\omega)^{0.5} = 1.1$ (ω not known)

$C = 1.7 - r_m$ where $r_m = M_{o1}/M_{o2}$

z-axis: $r_m = 9.99 / 14.17 = 0.71$

$C_z = 1.7 - 0.71 = 0.99$

y-axis: $r_m = 8.32 / 10.91 = 0.76$

$C_z = 1.7 - 0.76 = 0.94$

Example 1: Classification of slenderness

$n = N_{Ed}/(A_c f_{cd})$

$A_c = 250 \times 300 = 75000 \text{ mm}^2$

$f_{cd} = 0.85 f_{ck}/\gamma_c = 0.85 \times 25 / 1.5 = 14.17 \text{ N/mm}^2$

$n = 888.91 \times 10^3 / (75000 \times 14.17)$

$= 0.84$

z-axis: $\lambda_{lim,z} = 20 \times 0.7 \times 1.1 \times 0.99 / (0.84)^{1/2}$

$= 16.6 < \lambda_z = 28.9$

Slender column

y-axis: $\lambda_{lim,y} = 20 \times 0.7 \times 1.1 \times 0.94 / (0.84)^{1/2}$

$= 15.8 < \lambda_y = 34.4$

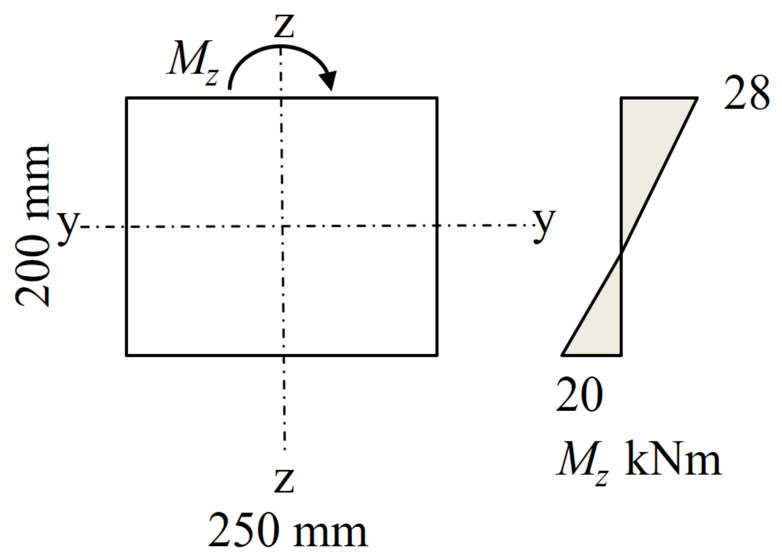
Slender column

Example 2: Short braced column bent about major axis

Design the longitudinal and transverse reinforcement of 200 x 250 mm column with 800kN ultimate axial load and bending moment values as shown in figure below. The moment is determined to bent about major axis with effective length of 3.1 m. This column is classified as non-slender column some bracing system in the frame. Specification of the structure is given as follows:

Exposure class XC1, Fire resistance = 1 hour, Design life 50 years. Consider concrete grade of C25/30 and steel reinforcement grade of 500.

Example 2: Short braced column bent about major axis



Assumed: $\emptyset_{link} = 6$ mm

$\emptyset_{bar} = 20$ mm

Example 2: Short braced column bent about major axis

DURABILITY, BOND AND FIRE RESISTANCE

Min. cover with regard to bond, $C_{min,b}$ = 20 mm

Min. cover with regard to durability, $C_{min,b}$ = 15 mm

Min. required axis distance for R60 fire resistance

a_{sd} = 36 mm

Min. concrete cover with regard to fire,

$C_{min} = a_{sd} - \emptyset_{link} - \emptyset_{bar}/2$ = 36 – 6 – 20/2 = 20 mm

Allowance in design for deviation, ΔC_{dev} = 10 mm

Nominal cover,

$C_{nom} = C_{min} + \Delta C_{dev}$ = 20 + 10 = 30 mm

Use: C_{nom} = 30 mm

Example 2: Short braced column bent about major axis

DESIGN MOMENT

For non-slender column the design moment,

$M_{Ed} = \text{Max}\{M_{02}, M_{min}\}$

where,

$M_{02} = M + N_{Ed}.e_i$

$M = \text{Max}\{|M_{top}|, |M_{bot}|\} = 28 \text{ kNM}$

$e_i = l_o/400 = 3100 / 400 = 7.8 \text{ mm}$

$M_{02} = 28 + (800 \text{ x } 0.0078) = 34.24 \text{ kNm}$

$M_{min} = N_{Ed}.e_o$

$e_o = 250 / 30 = 8.3 \text{ mm} \geq 20 \text{ mm}$

$M_{min} = 800 \text{ x } 0.02 = 16 \text{ kNm}$

➔ $M_{Ed} = 34.24 \text{ kNm}$

Example 2: Short braced column bent about major axis

REINFORCEMENT

$d_2 = C_{nom} + \emptyset_{link} + \emptyset_{bar}/2 = 30 + 6 + 20/2 = 46$ mm

$d_2/h = 46 / 250 = 0.18$ (Use chart 0.2)

$N / bhf_{ck} = 800 \times 10^3 / (200 \times 250 \times 25)$

$= 0.64$

$M / bh^2 f_{ck} = 34.24 \times 10^6 / (200 \times 250^2 \times 25)$

$= 0.11$

$A_s f_{yk} / bhf_{ck} = 0.53$

$A_s = 0.53\, bhf_{ck} / f_{yk}$

$= 0.53\, (200 \times 250 \times 25) / 500$

$= 1325\ \text{mm}^2$

Example 2: Short braced column bent about major axis

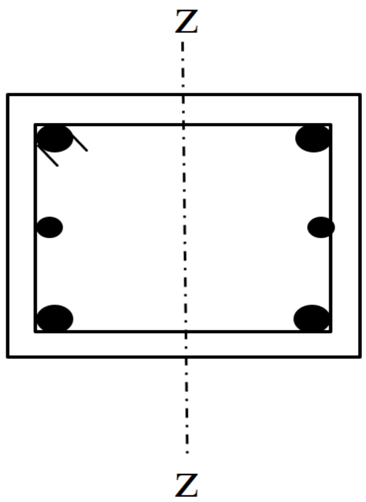
$A_{min} = 0.1\ N_{Ed} / f_{yd} = 0.1\ N_{Ed} / (0.87 f_{yk})$
$= 0.1 \times 800 \times 10^3 / (0.87 \times 500)$
$= 184\ \text{mm}^2$ or $0.002\ A_c = 100\ \text{mm}^2$

$A_{max} = 0.04\ A_c = 2000\ \text{mm}^2$

Use:

4H20 + 2H12

(1483 mm²)



Example 2: Short braced column bent about major axis

Links, $\emptyset_{min}$ = the larger of

= 0.25 x 20 = 5 mm

or 6 mm

$S_{v,max}$ = the lesser of

= 20 x 12 = 240 mm

or 200 mm

or 400 mm

Use: H6 – 200

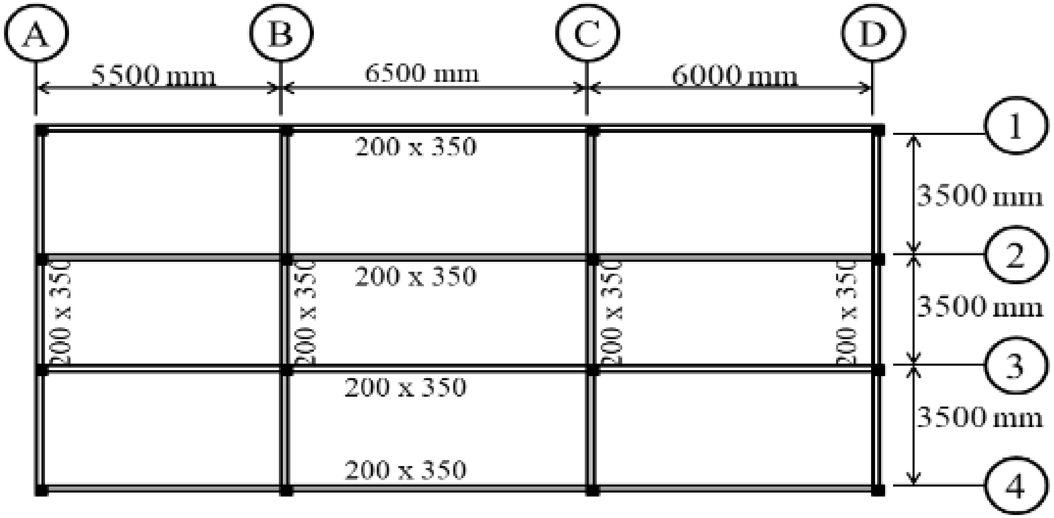
At section 250 mm below and above beam and at lapped joints, $S_{v,max}$ = 0.6 x 200 = 120 mm

Use: H6 – 120

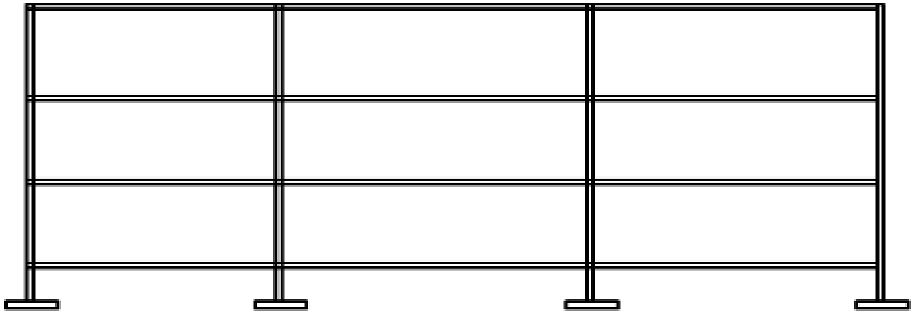
Tutorial 1: Column slenderness

Figure 2 shows a plan view and cross-section view of a three-storey reinforced concrete building. The building is considered braced with the provision of bracing elements at certain locations. The size of the column is designed to be 250 x 250 mm, whereas the size of the beam is taken as 200 x 350 mm. The height of each floor is 3.6 m. Calculate the slenderness of the column at D/4 on the 1st Floor and classify the column whether slender or non-slender (short).

Tutorial 1: Column slenderness



Plan view



Cross-section view

Figure 2

Tutorial 2: Short column uniaxial bending

A rectangular column carries an ultimate moment of 33 kNm bend about minor axis. The column effective height is 3.55 m with a cross-section area of 250 mm x 300 mm. This column is classified as non-slender column and is subjected to ultimate axial load of 1150 kN. The column is to be designed for 1 hour fire resistance and at least 50 years design life. The exposure class considered is XC1.

Tutorial 2: Short column uniaxial bending

a) By using C25/30 grade concrete and steel reinforcement grade of 500, calculate the design moment for the column bend about minor axis. Assume that the diameter of the main bar and link is 20 mm and 6 mm, respectively.

b) Calculate and design the longitudinal and shear reinforcement required for the column. Comment on your answer and give appropriate suggestions.

c) Construct detail of the reinforcement (longitudinal and shear reinforcement) obtained in (b) for the column.

End of Examples and Tutorials