

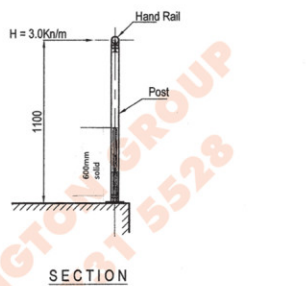
# Balustrade System to 3.0kN/m

60.3 x 3.9mm stainless tube

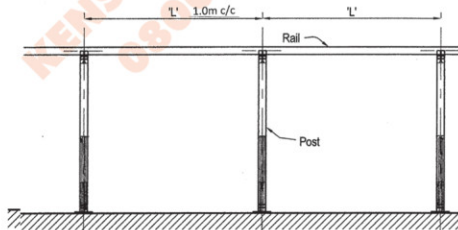
**Do not risk your professional indemnity  
 - use appropriate materials**

## HANDRAIL & POST DESIGN

### BALUSTRADING DESIGN



SECTION



ELEVATION

60.3CHS x 3.9 + 600mm high solid 50mm dia. Spiggot

- 1 -

MATERIAL - stainless steel grade 1.4401 (316) [ $p_y = 220 \text{ N/mm}^2$ ]

Horizontal load 'H' applied at 1.10m above base plate level.

$$H = 3.00 \text{ kN/m}$$

$$\gamma_f = 1.60$$

HANDRAIL



L = centres of posts

$$I_{xx} = \frac{\pi (60.3^4 - 52.5^4)}{64} = 276114.86 \text{ mm}^4$$

$$Z_{xx} = \frac{\pi (60.3^3 - 52.5^3)}{32 \times 60.3} = 9158.04 \text{ mm}^3$$

$$S_{xx} = 0.167 [60.3^3 - (60.3 - 2 \times 3.9)^3] = 12450.37 \text{ mm}^3$$

$$\epsilon = 1.22 \quad D/t = 15.46 = (13.73 \epsilon^2) \quad \text{section is Class 1 - plastic}$$

$$0.2\% \text{ proof stress } p_y = 220 \text{ N/mm}^2$$

$$\text{Factored lateral load applied to handrail} = 3.0 \times 1.6 = 4.80 \text{ kN/m}$$

$$\text{Applied } M = \frac{4.80 \times L^2}{8} = 0.60 L^2 \text{ Knm}$$

$$\text{Allowable } M_c = \frac{220 \times 12450.37}{10^6} = 2.74 \text{ Knm}$$

$$\text{or } M_c = \frac{1.2 \times 220 \times 9158.04}{10^6} = 2.42 \text{ Knm}$$

$$0.60 L^2 = 2.42$$

$$\therefore L = \sqrt{\frac{2.42}{0.60}} = 2.01 \text{ m}$$

Deflection

Limiting deflection to 25mm

$$L = \sqrt{\frac{25 \times 384 \times 200 \times 10^3 \times 276114.86}{5 \times 3.00 \times 10^{12}}} = 2.44 \text{ m}$$

MAXIMUM ALLOWABLE SPAN 2.0m

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## HANDRAIL & POST DESIGN

(60.3 x 3.9CHS post with 50mm dia solid Spiggot 600mm high)

MATERIAL - stainless steel grade 1.4401 (316) [ $p_y = 220 \text{ N/mm}^2$ ]

Horizontal load 'H' applied at 1.10m above base plate level.

$$H = 3.00 \text{ kN/m} \quad \gamma_f = 1.60$$

POST



L = centres of posts

$$I_{xx} = \frac{\pi (60.3^4 - 52.5^4)}{64} = 276114.86 \text{ mm}^4$$

$$Z_{xx} = \frac{\pi (60.3^3 - 52.5^3)}{32 \times 60.3} = 9158.04 \text{ mm}^3$$

$$S_{xx} = 0.167 [60.3^3 - (60.3 - 2 \times 3.9)^3] = 12450.37 \text{ mm}^3$$

$$\epsilon = 1.22 \quad D/t = 15.46 = (10.39 \epsilon^2) \quad \text{section is Class 1 - plastic}$$

$$0.2\% \text{ proof stress } p_y = 220 \text{ N/mm}^2$$

$$\text{Allowable } M_c = \frac{220 \times 12450.37}{10^6} = 2.74 \text{ Knm}$$

or

$$M_c = \frac{1.2 \times 220 \times 9158.04}{10^6} = 2.42 \text{ Knm}$$

Applied moment 500mm below handrail

$$M = 4.8 \times L \times 0.5 = 2.40 L \text{ Knm}$$

$$L = \frac{2.42}{2.40} = 1.01 \text{ m}$$

deflection for post at 1.00m c/c

$$\delta = \frac{3.0 \times 1.0 \times 10^3 \times 0.5^3 \times 10^9}{3 \times 200 \times 10^3 \times 276114.86} = 2.24 \text{ mm} \quad \therefore \text{satisfactory}$$

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## HANDRAIL & POST DESIGN

(60.3 x 3.9CHS post with 50mm dia solid Spiggot 600mm high)

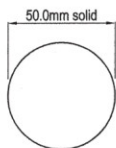
MATERIAL - stainless steel grade 1.4401 (316) [ $p_y = 220 \text{ N/mm}^2$ ]

Horizontal load 'H' applied at 1.10m above base plate level.

$$H = 3.00 \text{ kN/m}$$

$$\gamma_f = 1.60$$

SPIGGOT



L = centres of posts

$$I_{xx} = \frac{\pi 50^4}{64} = 306835.94 \text{ mm}^4$$

$$Z_{xx} = \frac{\pi 50^3}{32} = 12273.44 \text{ mm}^3$$

$$\text{say } S_{xx} = 1.7 \times 12273.44 = 20864.85 \text{ mm}^3$$

$$0.2\% \text{ proof stress } p_y = 220 \text{ N/mm}^2$$

$$\text{Allowable } M_c = \frac{220 \times 20864.85}{10^6} = 4.59 \text{ Knm}$$

or

$$M_c = \frac{1.2 \times 220 \times 12273.44}{10^6} = 3.24 \text{ Knm}$$

at 500mm below handrail

load resisted by post -  $W_1$  load resisted by spiggot -  $W_2$

$$W_1 - W_2 = \frac{(3.0 \times 1.0) \times 1.1}{0.6} = 5.50 \text{ Kn}$$

and

$$\frac{W_1}{276114.86} = \frac{W_2}{306835.94}$$

$$\therefore W_1 = 2.61 \text{ Kn} \quad \& \quad W_2 = 2.89 \text{ Kn}$$

$$\text{Applied moment to post} = 2.61 \times 0.6 \times 1.6 = 2.51 \text{ Knm}$$

$$\text{Applied moment to spiggot} = 2.89 \times 0.6 \times 1.6 = 2.77 \text{ Knm}$$

deflection for post at 1.00m c/c

$$\delta = \frac{2.61 \times 10^3 \times 0.6^3 \times 10^9}{3 \times 200 \times 10^3 \times 276114.86} = 3.37 \text{ mm} \quad \therefore \text{satisfactory}$$

$$\text{relative deflection at top of post} \quad \delta = \frac{1.42 \times 10^3 \times 1.1^3 \times 10^9}{3 \times 200 \times 10^3 \times 276114.86} = 11.29 \text{ mm}$$

PROVIDE 60.3CHS x 3.9 POST WITH 600mm SOLID 50mm dia. SPIGGOT AT 1.00m c/c

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## POST BASEPLATE

MATERIAL - stainless steel grade 1.4401

Horizontal load 'H' applied at 1.10m above base plate level.

$$H = 3.00 \text{ kN/m} \quad (\text{posts at } 1.00 \text{ m c/c})$$

$$\gamma_f = 1.60$$

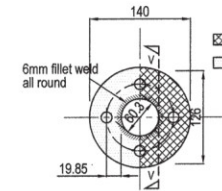
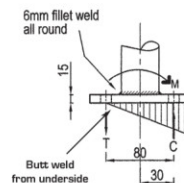
$$M = 4.80 \times 1.0 \times 1.1 = 5.28 \text{ Knm}$$

$$\text{Lever Arm} = 80 \text{ mm}$$

$$T = C = \frac{5.28 \times 10^3}{80} = 66.00 \text{ Kn}$$

i) Compression

Assuming rotation due to compression about V-V



Area in compression

Area in tension

$$Z_{xx} = \frac{126 \times 15^2}{6} = 4725 \text{ mm}^3$$

$$0.2\% \text{ proof stress } p_y = 220 \text{ N/mm}^2$$

$$M_c = \frac{1.2 \times 220 \times 4725}{10^6} = 1.25 \text{ KNm}$$

$$\text{Moment in plate due to compression} \quad M = 66.00 \times 0.4(70 - 30.15) \times 10^3 = 1.05 \text{ KNm} \quad \therefore \text{satisfactory}$$

MAXIMUM ALLOWABLE POST CENTRES 1.00m

i) Tension

$$0.2\% \text{ proof stress } p_y = 220 \text{ N/mm}^2$$

$$\text{Moment in plate due to bolt tension} \quad M = 66.00 \left( \frac{19.85 - 6}{10} \right)^2 \times 10^3 = 0.91 \text{ KNm} \quad \therefore \text{satisfactory}$$

MAXIMUM ALLOWABLE POST CENTRES 1.00m