

Solution - Design Example V3

Slenderness ratio:

$$\begin{aligned}\text{Effective thickness of inner leaf, } t_{ef} &= t_{ef} = \sqrt[3]{t_1^3 + t_2^3} \\ &= t_{ef} = \sqrt[3]{(102,5^3 + 140^3)} = 156 \text{ mm}\end{aligned}$$

$$\text{Effective height} = 0,75 \times 3000 = 2250 \text{ mm}$$

$$\frac{h_{ef}}{t_{ef}} = \frac{2250}{156} = 14,4$$

Eccentricity of 1st floor loading, (10 kN/m) = $t/6$

Hence eccentricity of design vertical load, $e_i = (M_{id} / N_{id}) + e_{he} \pm e_{init} \geq 0,05t$

Therefore $e_i = 1,8 + 0 + 5,0 = 6,8 \text{ mm}$ (i.e. $0,049t$)

$$\text{where } M_{id}/N_{id} = (10 \times 140) / (130 \times 6) = 1.80 \text{ mm}$$

$$e_{he} = 0 \text{ (horizontal loads effect)}$$

$$e_{init} = h_{ef}/450 = (3000 \times 0,75) / 450 = 5,0 \text{ mm}$$

e_i is $0,05 t$ at top and bottom of the wall which are the minimum eccentricity design values to be used

Therefore $\phi_i = 1 - 2(e_i / t) = 1 - 2(0,05t / t) = 0,9$

And eccentricity of design vertical load, $e_m = (M_{md} / N_{md}) + e_{hm} \pm e_{init} \geq 0,05t$

Therefore $e_{mk} = e_m + e_k = 0 + 0 + 5,0 = 5,0 \text{ mm}$ (i.e. $0,036t$)

$$\text{where } M_{md}/N_{md} = 0 \text{ (point of contraflexure of double curvature strut)}$$

$$e_{hm} = 0 \text{ (horizontal loads effect)}$$

$$e_{init} = h_{ef}/450 = (3000 \times 0,75) / 450 = 5,0 \text{ mm}$$

$$e_k = 0 \text{ (creep effect)}$$

e_{mk} is $0,05 t$ at mid-height of the wall which is the minimum eccentricity design value to be used

Hence for $E = 1000f_k$ Part 1.1 Annex G equations or Figure G1 gives:

$$\Phi_m = 0,76$$

Design resistance per unit length $N_{Rd} = \Phi_{min} t f_d$

Where design strength, $f_d = \frac{f_k}{\gamma_m}$

$$N_{Rd} = 0,76 \times 140 \times f_k / 2,3 = 130 \text{ kN/m run}$$

Hence f_k required = 2,81 N/mm²

$$f_k = K f_b^\alpha f_m^\beta$$

$$\text{Therefore } 2,81 = 0,55 \times f_b^{0,7} \times 4^{0,3}$$

$$f_b^{0,7} = 3,371 \quad \text{i.e. } f_{bmin} = \sqrt[0,7]{(3,371)}$$

$$f_{bmin} = 5,7 \text{ N/mm}^2 \text{ min.}$$

Normalised compressive strength, $f_b = \text{compressive strength} \times \delta \times \text{conditioning factor}$

Using a 215mm high by 140mm wide masonry unit, δ , the shape factor from BS EN 772-1, Table A.1 is 1,30 for the air dry condition compressive testing regime

$$\begin{aligned} \text{Therefore masonry unit compressive strength required} &= 5,7 / (1,30 \times 1,0) \\ &= 4,4 \text{ N/mm}^2 \end{aligned}$$

Choose for convenience a concrete block masonry unit with a compressive strength (non-normalised) of 7,3 N/mm², (represents a normalised compressive strength (f_b) of 9,5 N/mm² when masonry unit is conditioned for testing air dry).

$$\text{Therefore actual } f_k \text{ achieved} = f_k = K f_b^\alpha f_m^\beta = 0,55 \times 9,5^{0,7} \times 4^{0,3} = 4,03 \text{ N/mm}^2$$

$$f_d = \frac{f_k}{\gamma_m}$$

And actual wall vertical load capacity:

$$N_{Rd} = 0,76 \times 140 \times 4,03 / 2,3 = 186 \text{ kN/m run}$$

Wall will carry a design vertical load of 186 kN/m run (> 130 kN/m applied)