

Solution - Design Example V4

$$\text{Dead load, } G_k = 127,5 \text{ kN/m}$$

$$\text{Imposed load, } Q_k = 15,0 \text{ kN/m}$$

Design load = $1,35 G_k + 1,5 Q_k$ (conservatively treating Q_k as a single variable load)

$$\text{Design dead load} = \gamma_f G_k = 1,35 \times 127,5 = 172,1$$

$$\text{Design imposed load} = \gamma_f Q_k = 1,5 \times 15 = 22,5$$

$$\text{Total} = 194,6 \text{ kN/m}$$

Enhanced restraint at top and bottom of wall:

$$\text{Effective height, } h_{ef} = 2500 \times 0,75 = 1875 \text{ mm}$$

$$\text{Effective thickness, } t_{ef} = \text{actual thickness} = t = 140 \text{ mm}$$

$$\text{Slenderness ratio, } h_{ef}/t_{ef} = 1875 / 140 = 13,4$$

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

Therefore $e_i = 0 + 0 + 4,2 = 4,2 \text{ mm}$ (i.e. $0,03t$)

where $M_{id}/N_{id} = 0$ (no applied eccentricity at wall head)

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

$$e_{init} = h_{ef}/450 = (2500 \times 0,75) / 450 = 4,17 \text{ mm}$$

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 $e_{mk} = e_m + e_k = 0 + 0 + 4,2 = 4,2 \text{ mm}$ (i.e. $0,03t$)

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

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

$$e_{init} = h_{ef}/450 = (2500 \times 0,75) / 450 = 4,17 \text{ mm}$$

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

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:

$$\Phi_m = 0,78 \text{ governs design}$$

Assuming category II masonry units and class 2 execution control, $\gamma_m = 3,0$

$$\text{Design resistance per unit length } N_{Rd} = \Phi t f_d$$

$$\text{Where } f_d = f_k / \gamma_m$$

$$\text{Therefore } f_k = N_{Rd} \gamma_m / \Phi_{min} t$$

$$f_k = 194,6 \times 3,0 / 0,78 \times 140 = 5,35 \text{ N/mm}^2$$

Required block masonry unit must have an f_k value $\geq 5,35 \text{ N/mm}^2$

Group 1 Concrete Masonry Unit:

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

$$\text{Therefore } 5,35 = 0,75 \times f_b^{0,7} \times f_m^{0,3}$$

$$f_b^{0,7} = 4,71$$

$$f_b = \sqrt[0,7]{(4,71)} = 9,15 \text{ N/mm}^2$$

Group 2 Concrete Masonry Unit:

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

$$\text{Therefore } 5,35 = 0,70 \times f_b^{0,7} \times f_m^{0,3}$$

$$f_b^{0,7} = 5,04$$

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$$f_b = 0,7\sqrt{5,04} = 10,08 \text{ N/mm}^2$$

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

Using a 190 mm high by 140 mm wide masonry unit, δ , the shape factor from BS EN 772-1, Table A.1 is 1,24 for the air dry condition compressive testing regime

$$\begin{aligned} \text{Therefore masonry unit compressive strength required} &= 10,08 / (1,24 \times 1,0) \\ &= 8,1 \text{ N/mm}^2 \end{aligned}$$

Use a Group 1 or Group 2 concrete block masonry unit with a compressive strength (non-normalised) of say 10,4 N/mm² minimum, (represents a normalised compressive strength of 12,9 N/mm² minimum when masonry unit is conditioned for testing air dry).