

Solution - Design Example V5

Loading to ground floor level:

	<u>Dead</u>		<u>Imposed</u>	
Roof:	$6,0 \times 0,5 \times 3,8$	$= 11,4$	$6,0 \times 0,5 \times 0,75$	$= 2,25$
3 floors:	$6,0 \times 0,5 \times 4,0 \times 3$	$= 36,0$	$6,0 \times 0,5 \times 3,5 \times 3$	$= 31,50$
4 storeys: of walling	$2,9 \times 2,5 \times 4$	<u>$= 29,0$</u>		<u>$= 0,0$</u>
Total		76,4 kN/m		33,75 kN/m

$$\begin{aligned}\text{Design load} &= 1,35 G_k + 1,5 Q_k \\ &= (1,35 \times 76,4) + (1,5 \times 33,75) \\ &= 153,8 \text{ kN/m}\end{aligned}$$

Eccentricity of Load:

Building Research Digest No. 246 gives guidance on the assessment of eccentricity. For an end wall with a concrete floor supported over the whole wall leaf thickness the centre of action of the force should be taken as 1/6 of the wall thickness from the centreline. However, where the floor is of very short span or very stiff it may be reasonable to regard the load as axial without applied eccentricity.

If the span to wall thickness ratio less than 30 then consider the load acting axially

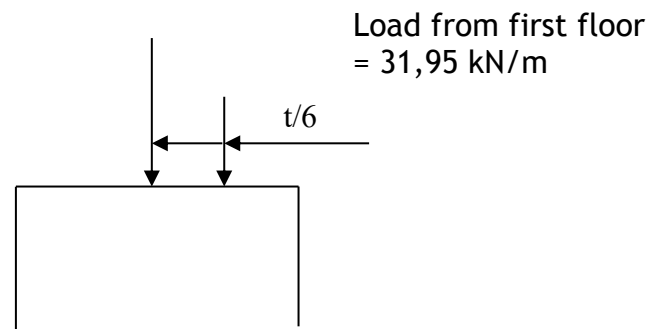
$$\text{For this example } \frac{\text{span}}{\text{thickness}} = \frac{6000}{140} = 43$$

Therefore load from first floor acts at $t/6$ while the loads from the upper floors act axially.

$$\text{Load from first intermediate floor} = (1,35 \times 12) + (1,5 \times 10,5) = 31,95 \text{ kN/m run}$$

$$\text{Load of the bottom wall} = 1,35 \times 29/4 = 9,79 \text{ kN/m}$$

$$\begin{aligned} &\text{Load from upper} \\ &\text{floors + roof} \\ &= (153,8 - 31,95 - 9,79) \\ &= 112,06 \text{ kN/m} \end{aligned}$$



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

$$\text{Effective height of wall, } h_{ef} = 0,75 \times 2900 = 2175 \text{ mm}$$

$$\text{And } h_{ef}/t_{ef} = (2175 / 156) = 13,94$$

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

$$\text{Therefore } e_i = 6,65 + 0 + 4,83 = 11,48 \text{ mm (i.e. } 0,08t)$$

$$\text{where } M_{id}/N_{id} = (31,95 \times 140) / (112,06 \times 6) = 6,65 \text{ mm}$$

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

$$e_{init} = h_{ef}/450 = (2900 \times 0,75) / 450 = 4,83 \text{ mm}$$

e_i is 0,08 t at top and bottom of the wall which are the minimum eccentricity design values to be used

$$\text{Therefore } \phi_i = 1 - 2(e_i / t) = 1 - 2(0,08t / t) = 0,84$$

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

$$\text{Therefore } e_{mk} = e_m + e_k = 0 + 0 + 4,83 = 4,83 \text{ mm (i.e. } 0,035t)$$

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

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

$$e_{init} = h_{ef}/450 = (2900 \times 0,75) / 450 = 4,83 \text{ mm}$$

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

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:

$$\Phi_m = 0,77 \text{ governs design}$$

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

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

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

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

$$f_k = 153,8 \times 3,0 / 0,77 \times 140 = 4,28 \text{ N/mm}^2$$

Required block masonry unit must have an f_k value $\geq 4,28 \text{ N/mm}^2$

Group 1 Solid Masonry Unit:

$$f_k = K f_b^a f_m^b$$

$$\text{Therefore } 4,28 = 0,75 \times f_b^{0,7} \times 4^{0,3}$$

$$f_b^{0,7} = 3,76$$

$$f_b = \sqrt[0,7]{(3,76)} = 6,6 \text{ N/mm}^2$$

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

Using a 190mm high by 140mm 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

$$\text{Therefore masonry unit compressive strength required} = 6,6 / (1,24 \times 1,0)$$

$$= 5,3 \text{ N/mm}^2$$

Use a Group 1 concrete block masonry unit with a compressive strength (non-normalised) of say $7,3 \text{ N/mm}^2$ minimum, (represents a normalised compressive strength of 9 N/mm^2 minimum when masonry unit is conditioned for testing air dry).

Note: The calculation for wall capacity will need to be repeated for full design dead and imposed loading coming from the first intermediate floor construction onto the wall head level combined with minimum design dead loading from the walling, floors and roof construction above this level. This will give a maximum wall head eccentricity load case, but with minimum vertical design loading. Usually this design case does not govern, but alternative load cases should be tested.