Solution - Design Example V3

Slenderness ratio:

Effective thickness of inner leaf, $t_{ef} = \sqrt{\frac{1}{t_1 + t_2^3}}$

\[ = t_{ef} = \sqrt[3]{\frac{1}{10^2,5^3 + 140^3}} = 156 \text{ mm} \]

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

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

Eccentricity of 1st floor loading, $(10 \text{ kN/m}) = \frac{t}{6}$

Hence eccentricity of design vertical load, $e_i = \frac{M_{id}}{N_{id}} + e_{he} \pm e_{init} \geq 0.05 t$

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

where $\frac{M_{id}}{N_{id}} = \frac{(10 \times 140)}{(130 \times 6)} = 1,80 \text{ mm}$

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

\[ e_{init} = \frac{h_{ef}}{450} = \frac{(3000 \times 0,75)}{450} = 5,0 \text{ mm} \]

$e_i$ 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, $e_m = \frac{M_{md}}{N_{md}} + e_{hm} \pm e_{init} \geq 0,05 t$

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

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

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

\[ e_{init} = \frac{h_{ef}}{450} = \frac{(3000 \times 0,75)}{450} = 5,0 \text{ mm} \]

\[ e_k = 0 \text{ (creep effect)} \]

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

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

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Φ₀ₘ = 0,76

Design resistance per unit length  \( N_{Rd} = Φ_{min} t f_d \)

Where design strength, \( f_d = \frac{f_k}{Y_m} \)

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

Hence \( f_k \) required = 2,81 N/mm²

\( f_k = Kf^b f_b^8 \)

Therefore 2,81 = 0,75 x \( f_b^{0,7} \times 4^{0,3} \)

\( f_b^{0,7} = 2,472 \)  i.e. \( f_{b\min} = 0,7\sqrt{2,472} \)

\( f_{b\min} = 3,64 \text{ N/mm}^2 \) min.

Normalised compressive strength, \( f_b = \) compressive strength \( \times \delta \times \) conditioning factor

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

Therefore masonry unit compressive strength required = \( 3,64 / (1,30 \times 1,0) \)

\( = 2,8 \text{ N/mm}^2 \)

Choose for convenience a concrete block masonry unit with a compressive strength (non-normalised) of 2,9 N/mm², (represents a normalised compressive strength \( (f_b) \) of 3,77 N/mm² when masonry unit is conditioned for testing air dry).

Therefore actual \( f_k \) achieved = \( f_k = Kf_b^b f_m^8 = 0,75 \times 3,77^{0,7} \times 4^{0,3} = 2,88 \text{ N/mm}^2 \)

\( f_d = \frac{f_k}{Y_m} \)

And actual wall vertical load capacity:

\( N_{Rd} = 0,76 \times 140 \times 2,88 / 2,3 = 133 \text{ kN/m run} \)

Wall will carry a design vertical load of 133 kN/m run (> 130 kN/m applied)