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MASONRY WALL PANEL DESIGN (EN1996-1-1:2005 + A1:2012)

In accordance with EN1996-1-1:2005 + A1:2012 incorporating Corrigenda February 2006 and July 2009 and the UK national annex

Masonry panel details

Panel with opening example - Unreinforced masonry wall with openings

Panel length; L = **4200** mm

Panel height; h = **2650** mm

Panel support conditions

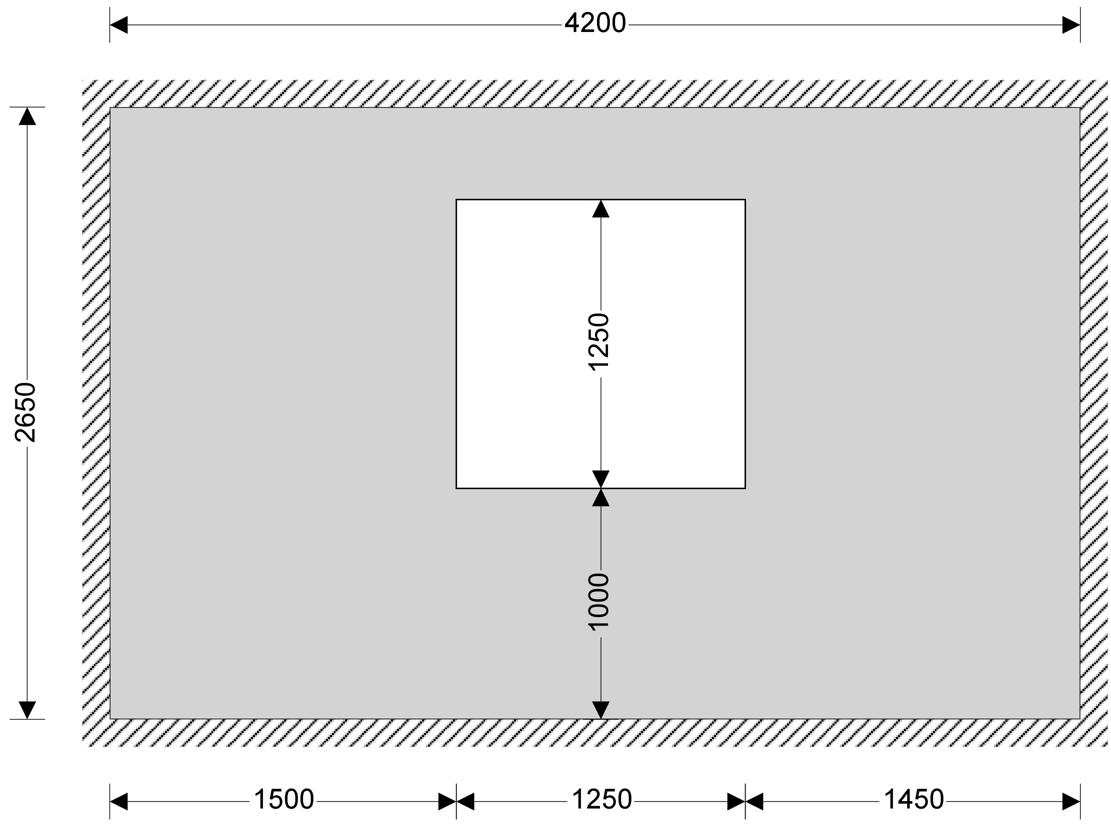
Outer leaf; **All edges supported, top and bottom continuous**

Inner leaf; **All edges supported, top and bottom continuous**

Effective height of masonry walls - Section 5.5.1.2

Reduction factor; ρ_2 = **1.000**

Effective height of wall - eq 5.2; $h_{ef} = \rho_2 \times h$ = **2650** mm



Panel opening details

Spacing length; L_1 = **1500** mm

Opening width; w_1 = **1250** mm

Height to underside of lintel; h_1 = **2250** mm

Height of opening; o_1 = **1250** mm

Cavity wall construction details

Outer leaf thickness; t_1 = **100** mm

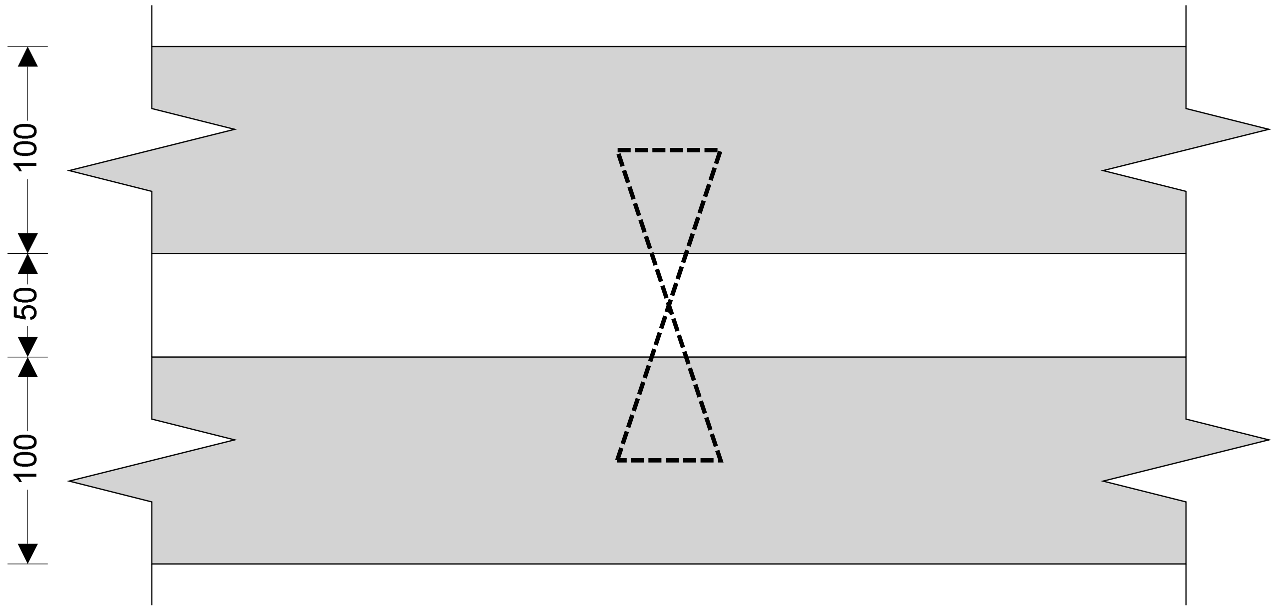
Cavity thickness; t_c = **50** mm

Inner leaf thickness; t_2 = **100** mm

Effective thickness of masonry walls - Section 5.5.1.3

Relative E factor; k_{tef} = **1.000**

Effective thickness - eq 5.11; $t_{ef} = (k_{tef} \times t_1^3 + t_2^3)^{1/3}$ = **126** mm



Masonry outer leaf details

Masonry type; **Clay with water absorption between 7% and 12% - Group 1**

Mean compressive strength of masonry unit; f_{b1} = **5.2** N/mm^2

Density of masonry; γ_1 = **20** kN/m^3

Mortar type; **M4 - General purpose mortar**

Compressive strength of masonry mortar; f_{m1} = **4** N/mm^2

Compressive strength factor - Table NA.4; K = **0.50**

Characteristic compressive strength of masonry - eq 3.1

$f_{k1} = K \times f_{b1}^{0.7} \times f_{m1}^{0.3} = \mathbf{2.403}$ N/mm^2

Characteristic flexural strength of masonry having a plane of failure parallel to the bed joints - Table NA.6

$f_{xk11} = \mathbf{0.4}$ N/mm^2

Characteristic flexural strength of masonry having a plane of failure perpendicular to the bed joints - Table NA.6

$f_{xk21} = \mathbf{1.1}$ N/mm^2

Masonry inner leaf details

Masonry type; **Aggregate concrete - Group 1**

Mean compressive strength of masonry unit; $f_{b2} = \mathbf{7.5}$ N/mm^2

Density of masonry; $\gamma_2 = \mathbf{20}$ kN/m^3

Mortar type; **M4 - General purpose mortar**

Compressive strength of masonry mortar; $f_{m2} = \mathbf{4}$ N/mm^2

Compressive strength factor - Table NA.4; $K = \mathbf{0.75}$

Characteristic compressive strength of masonry - eq 3.1

$f_{k2} = K \times f_{b2}^{0.7} \times f_{m2}^{0.3} = \mathbf{4.658}$ N/mm^2

Characteristic flexural strength of masonry having a plane of failure parallel to the bed joints - Table NA.6

$f_{xk12} = \mathbf{0.25}$ N/mm^2

Characteristic flexural strength of masonry having a plane of failure perpendicular to the bed joints - Table NA.6

$f_{xk22} = \mathbf{0.6}$ N/mm^2

Lateral loading details

Characteristic wind load on panel; $W_k = \mathbf{0.480}$ kN/m^2

Shear loading details

Vertical loading details

Permanent load on top of outer leaf; $G_{k1} = \mathbf{4.8}$ kN/m;

Variable load on top of outer leaf; $Q_{k1} = \mathbf{4.2}$ kN/m;

Partial factors for material strength

Category of manufacturing control; **Category I**

Class of execution control; **Class 1**

Partial factor for masonry in compressive flexure; $\gamma_{Mc} = \mathbf{2.30}$

Partial factor for masonry in tensile flexure; $\gamma_{Mt} = \mathbf{2.30}$

Partial factor for masonry in shear; $\gamma_{Mv} = \mathbf{2.50}$

Slenderness ratio of masonry walls - Section 5.5.1.4

Allowable slenderness ratio; $SR_{all} = \mathbf{27}$

Slenderness ratio; $SR = h_{ef} / t_{ef} = \mathbf{21.0}$

PASS - Slenderness ratio is less than maximum allowable

Unreinforced masonry walls subjected to lateral loading - Section 6.3

Limiting height and length to thickness ratios for walls under the serviceability limit state - Annex F

Length to thickness ratio; L / t_{ef} = **33.335**

Limiting height to thickness ratio - Figure F.1; 63.329

Height to thickness ratio; h / t_{ef} = **21.033**

PASS - Limiting height to thickness ratio is not exceeded

Design moments of resistance in panels

Considering outer leaf

Self weight at top of wall; S_{wt1} = **0** kN/m

Design compressive strength of masonry; $f_{d1} = f_{k1} / \gamma_{Mc}$ = **1.045** N/mm^2

Design vertical compressive stress; $\sigma_{d1} = \min(\gamma_{fG} \times (G_{k1} + S_{wt1}) / t_1, 0.15 \times f_{d1})$ = **0.048** N/mm^2

Design flexural strength of masonry parallel to bed joints

$f_{xd11} = f_{xk11} / \gamma_{Mc}$ = **0.174** N/mm^2

Apparent design flexural strength of masonry parallel to bed joints

$f_{xd11,app} = f_{xd11} + \sigma_{d1}$ = **0.222** N/mm^2

Design flexural strength of masonry perpendicular to bed joints

$f_{xd21} = f_{xk21} / \gamma_{Mc}$ = **0.478** N/mm^2

Elastic section modulus of wall; $Z_1 = t_1^2 / 6$ = **1666667** mm^3/m

Moment of resistance parallel to bed joints - eq.6.15

$M_{Rd11} = f_{xd11,app} \times Z_1$ = **0.37** kNm/m

Moment of resistance perpendicular to bed joints - eq.6.15

$M_{Rd21} = f_{xd21} \times Z_1$ = **0.797** kNm/m

Considering inner leaf

Self weight at top of wall; S_{wt2} = **0** kN/m

Design compressive strength of masonry; $f_{d2} = f_{k2} / \gamma_{Mc}$ = **2.025** N/mm^2

Design vertical compressive stress; $\sigma_{d2} = \min(\gamma_{fG} \times (G_{k2} + S_{wt2}) / t_2, 0.15 \times f_{d2})$ = **0** N/mm^2

Design flexural strength of masonry parallel to bed joints

$f_{xd12} = f_{xk12} / \gamma_{Mc}$ = **0.109** N/mm^2

Apparent design flexural strength of masonry parallel to bed joints

$f_{xd12,app} = f_{xd12} + \sigma_{d2}$ = **0.109** N/mm^2

Design flexural strength of masonry perpendicular to bed joints

$f_{xd22} = f_{xk22} / \gamma_{Mc}$ = **0.261** N/mm^2

Elastic section modulus of wall; $Z_2 = t_2^2 / 6$ = **1666667** mm^3/m

Moment of resistance parallel to bed joints - eq.6.15

$M_{Rd12} = f_{xd12,app} \times Z_2$ = **0.181** kNm/m

Moment of resistance perpendicular to bed joints - eq.6.15

$M_{Rd22} = f_{xd22} \times Z_2$ = **0.435** kNm/m

Design moment in panels

Calculate design wind load acting on each leaf

Outer leaf design wind load - parallel; $W_{k11} = M_{Rd11} \times W_k / (M_{Rd11} + M_{Rd12}) = \mathbf{0.322}$ kN/m^2

Inner leaf design wind load - parallel; $W_{k12} = M_{Rd12} \times W_k / (M_{Rd11} + M_{Rd12}) = \mathbf{0.158}$ kN/m^2

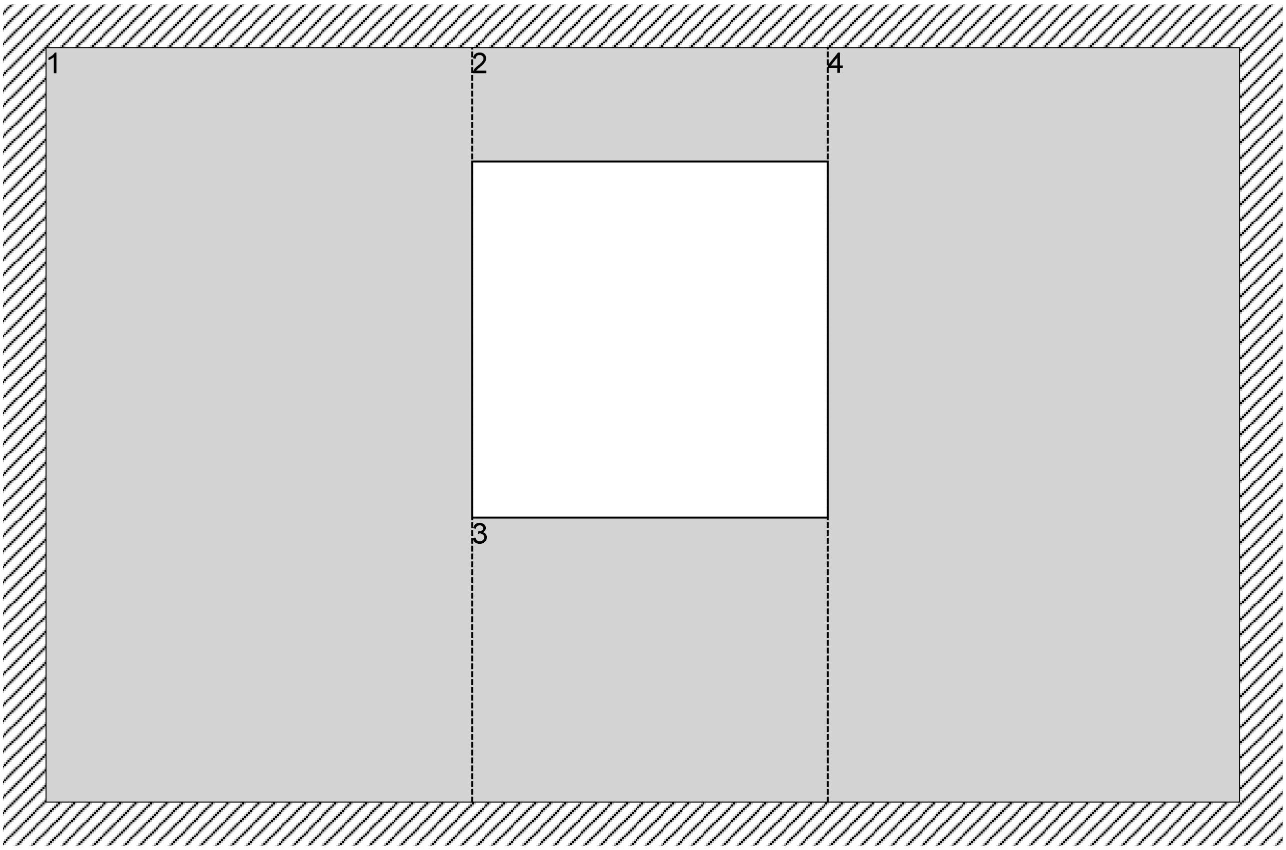
Outer leaf design wind load - perpendicular; $W_{k21} = M_{Rd21} \times W_k / (M_{Rd21} + M_{Rd22}) = \mathbf{0.311}$ kN/m^2

Inner leaf design wind load - perpendicular; $W_{k22} = M_{Rd22} \times W_k / (M_{Rd21} + M_{Rd22}) = \mathbf{0.169}$ kN/m^2

Orthogonal strength ratios

For outer leaf; $\mu_1 = f_{xk11} / f_{xk21} = \mathbf{0.36}$

For inner leaf; $\mu_2 = f_{xk12} / f_{xk22} = \mathbf{0.42}$



<u>Sub panel no. 1 - Top, bottom and left supported</u>

Ratio panel height to length; $h_{s1A} / L_{s1A} = \mathbf{1.77}$

Considering outer leaf

Parallel design moment of resistance; $M_{Rd11} = \mathbf{0.370}$ kNm/m

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient; $\alpha_{s11A} = \mathbf{0.323}$

Design moment in sub-panel; $M_{Ed11A} = \mu_1 \times \gamma_{fW} \times \alpha_{s11A} \times W_{k11} \times L_{s1A}^2$ = **0.128** kNm/m

PASS - Resistance moment exceeds design moment

Considering inner leaf

Parallel design moment of resistance; M_{Rd12} = **0.181** kNm/m

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient; α_{s21A} = **0.294**

Design moment in sub-panel; $M_{Ed21A} = \mu_2 \times \gamma_{fW} \times \alpha_{s21A} \times W_{k12} \times L_{s1A}^2$ = **0.065** kNm/m

PASS - Resistance moment exceeds design moment

Sub panel no. 2 - Right, left and top supported

Ratio panel height to length; h_{s2A} / L_{s2A} = **0.32**

Considering outer leaf

Perpendicular design moment of resistance; M_{Rd21} = **0.797** kNm/m

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient; α_{s12A} = **0.127**

Design moment in sub-panel; $M_{Ed12A} = \gamma_{fW} \times \alpha_{s12A} \times W_{k21} \times L_{s2A}^2$ = **0.092** kNm/m

PASS - Resistance moment exceeds design moment

Considering inner leaf

Perpendicular design moment of resistance; M_{Rd22} = **0.435** kNm/m

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient; α_{s22A} = **0.119**

Design moment in sub-panel; $M_{Ed22A} = \gamma_{fW} \times \alpha_{s22A} \times W_{k22} \times L_{s2A}^2$ = **0.047** kNm/m

PASS - Resistance moment exceeds design moment

Sub panel no. 3 - Right, left and bottom supported

Ratio panel height to length; h_{s3A} / L_{s3A} = **0.80**

Considering outer leaf

Perpendicular design moment of resistance; M_{Rd21} = **0.797** kNm/m

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient; α_{s13A} = **0.126**

Design moment in sub-panel; $M_{Ed13A} = \gamma_{fW} \times \alpha_{s13A} \times W_{k21} \times L_{s3A}^2$ = **0.092** kNm/m

PASS - Resistance moment exceeds design moment

Considering inner leaf

Perpendicular design moment of resistance; M_{Rd22} = **0.435** kNm/m

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient; α_{s23A} = **0.122**

Design moment in sub-panel; $M_{Ed23A} = \gamma_{fW} \times \alpha_{s23A} \times W_{k22} \times L_{s3A}^2$ = **0.048** kNm/m

PASS - Resistance moment exceeds design moment

Sub panel no. 4 - Top, bottom and right supported

Ratio panel height to length; h_{s4A} / L_{s4A} = **1.83**

Considering outer leaf

Parallel design moment of resistance; M_{Rd11} = **0.370** kNm/m

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient; α_{s14A} = **0.343**

Design moment in sub-panel; $M_{Ed14A} = \mu_1 \times \gamma_{fW} \times \alpha_{s14A} \times W_{k11} \times L_{s4A}^2$ = **0.127** kNm/m

PASS - Resistance moment exceeds design moment

Considering inner leaf

Parallel design moment of resistance; M_{Rd12} = **0.181** kNm/m

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient; α_{s24A} = **0.313**

Design moment in sub-panel; $M_{Ed24A} = \mu_2 \times \gamma_{fW} \times \alpha_{s24A} \times W_{k12} \times L_{s4A}^2$ = **0.065** kNm/m

PASS - Resistance moment exceeds design moment

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