MASONRY WALL PANEL DESIGN (EN1996-1-1:2005)

In accordance with EN1996-1-1:2005 incorporating Corrigenda February 2006 and July 2009 and the recommended values

Masonry panel details

Single-leaf wall example - Unreinforced masonry wall without openings

Panel length; L = **4800** mm

Panel height; h = **2200** mm

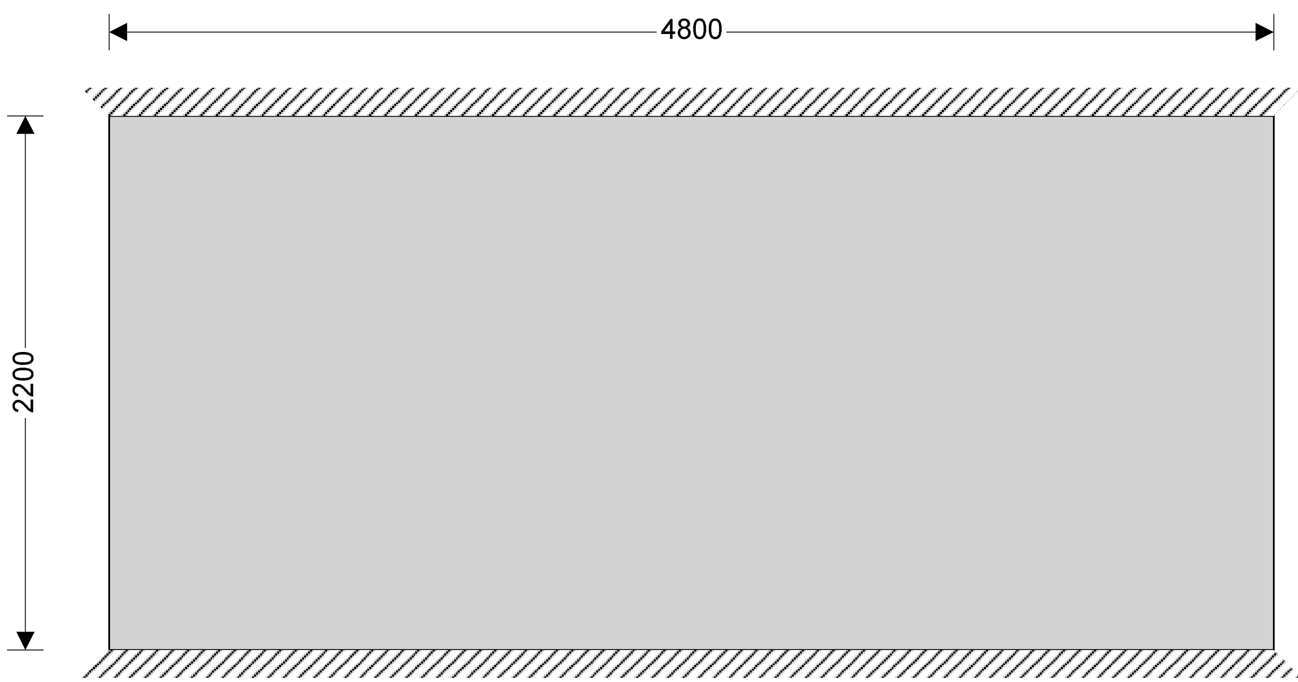
Panel support conditions

; **Top and bottom supported**

Effective height of masonry walls - Section 5.5.1.2

Reduction factor; ρ_2 = **1.000**

Effective height of wall - eq 5.2; $h_{ef} = \rho_2 \times h$ = **2200** mm



Single-leaf wall construction details

Wall thickness; t = **200** mm

Effective thickness of masonry walls - Section 5.5.1.3

Effective thickness; t_{ef} = t = **200** mm

Masonry details

Masonry type; **Clay - Group 1**

Mean compressive strength of masonry unit; f_b = **20** N/mm^2

Density of masonry; γ = **20** kN/m^3

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

Compressive strength of masonry mortar; f_m = **4** N/mm^2

Compressive strength factor - Table 3.3; K = **0.55**

Characteristic compressive strength of masonry - eq 3.2

$f_k = K \times f_b^{0.7} \times f_m^{0.3}$ = **6.787** N/mm^2

Characteristic flexural strength of masonry having a plane of failure parallel to the bed joints - cl 3.6.3

f_{xk1} = **0.1** N/mm^2

Characteristic flexural strength of masonry having a plane of failure perpendicular to the bed joints - cl 3.6.3

f_{xk2} = **0.2** N/mm^2

Lateral loading details

Characteristic wind load on panel; W_k = **1.120** kN/m^2

Vertical loading details

Permanent load on top of wall; G_k = **22.5** kN/m;

Variable load on top of wall; Q_k = **12.5** kN/m; at an eccentricity of 20 mm

Partial factors for material strength

Category of manufacturing control; **Category I**

Class of execution control; **Class 1**

Partial factor for masonry in compressive flexure; γ_{Mc} = **1.70**

Partial factor for masonry in tensile flexure; γ_{Mt} = **1.70**

Partial factor for masonry in shear; γ_{Mv} = **1.70**

Slenderness ratio of masonry walls - Section 5.5.1.4

Allowable slenderness ratio; SR_{all} = **27**

Slenderness ratio; $SR = h_{ef} / t_{ef}$ = **11.0**

PASS - Slenderness ratio is less than maximum allowable

Unreinforced masonry walls subjected to lateral loading - Section 6.3

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

Length to thickness ratio; L / t = **24**

Limiting height to thickness ratio - Annex F; 30

Height to thickness ratio; h / t = **11**

PASS - Limiting height to thickness ratio is not exceeded

Partial safety factors for design loads

Partial safety factor for variable wind load; γ_{fW} = **1.50**

Partial safety factor for permanent load; γ_{fG} = **1.00**

Design moments of resistance in panels

Self weight at middle of wall; $S_{wt} = 0.5 \times h \times t \times \gamma$ = **4.4** kN/m

Design compressive strength of masonry; $f_d = f_k / \gamma_{Mc}$ = **3.993** N/mm^2

Design vertical compressive stress; $\sigma_d = \min(\gamma_{fG} \times (G_k + S_{wt}) / t, 0.2 \times f_d)$ = **0.135** N/mm^2

Design flexural strength of masonry parallel to bed joints

$f_{xd1} = f_{xk1} / \gamma_{Mc}$ = **0.059** N/mm^2

Apparent design flexural strength of masonry parallel to bed joints

$f_{xd1,app} = f_{xd1} + \sigma_d$ = **0.193** N/mm^2

Design flexural strength of masonry perpendicular to bed joints

$f_{xd2} = f_{xk2} / \gamma_{Mc}$ = **0.118** N/mm^2

Elastic section modulus of wall; $Z = t^2 / 6$ = **6666667** mm^3/m

Moment of resistance parallel to bed joints - eq.6.15

$M_{Rd1} = f_{xd1,app} \times Z$ = **1.289** kNm/m

Moment of resistance perpendicular to bed joints - eq.6.15

$M_{Rd2} = f_{xd2} \times Z$ = **0.784** kNm/m

Design moment in panels

Using elastic analysis to determine bending moment coefficients for a vertically spanning panel

Bending moment coefficient; α = **0.125**

Design moment in wall; $M_{Ed} = \gamma_{fW} \times \alpha \times W_k \times h^2$ = **1.016** kNm/m

PASS - Resistance moment exceeds design moment

Unreinforced masonry walls subjected to mainly vertical loading - Section 6.1

Partial safety factors for design loads

Partial safety factor for permanent load; γ_{fG} = **1.35**

Partial safety factor for variable imposed load; γ_{fQ} = **1.50**

Check vertical loads

Reduction factor for slenderness and eccentricity - Section 6.1.2.2

Design bending moment at top or bottom of wall; $M_{id} = \gamma_{fG} \times G_k \times e_G + \gamma_{fQ} \times Q_k \times e_Q$ = **0.4** kNm/m

Design vertical load at top or bottom of wall; $N_{id} = \gamma_{fG} \times G_k + \gamma_{fQ} \times Q_k$ = **49.1** kN/m

Initial eccentricity - cl.5.5.1.1; $e_{init} = h_{ef} / 450$ = **4.9** mm

Eccentricity due to horizontal load; $e_h = M_{Ed} / N_{id}$ = **20.7** mm

Eccentricity at top or bottom of wall - eq.6.5; $e_i = \max(M_{id} / N_{id} + e_h + e_{init}, 0.05 \times t)$ = **33.2** mm

Reduction factor at top or bottom of wall - eq.6.4; $\Phi_i = \max(1 - 2 \times e_i / t, 0)$ = **0.668**

Design bending moment at middle of wall; $M_{md} = \gamma_{fG} \times G_k \times e_G + \gamma_{fQ} \times Q_k \times e_Q$ = **0.4** kNm/m

Design vertical load at middle of wall; $N_{md} = \gamma_{fG} \times G_k + \gamma_{fQ} \times Q_k + t \times \gamma \times h / 2$ = **53.5** kN/m

Eccentricity due to horizontal load; $e_{hm} = M_{Ed} / N_{md}$ = **19** mm

Eccentricity at middle of wall due to loads - eq.6.7; $e_m = M_{md} / N_{md} + e_{hm} + e_{init}$ = **30.9** mm

Eccentricity at middle of wall due to creep; e_k = **0** mm

Eccentricity at middle of wall - eq.6.6; $e_{mk} = \max(e_m + e_k, 0.05 \times t)$ = **30.9** mm

From eq.G.2; $A_1 = 1 - 2 \times e_{mk} / t$ = **0.691**

Short term secant modulus of elasticity factor; K_E = **1000**

Modulus of elasticity - cl.3.7.2; $E = K_E \times f_k$ = **6787** N/mm^2

Slenderness - eq.G.4; $\lambda = (h_{ef} / t_{ef}) \times \sqrt{(f_k / E)}$ = **0.348**

From eq.G.3; $u = (\lambda - 0.063) / (0.73 - 1.17 \times e_{mk} / t)$ = **0.519**

Reduction factor at middle of wall - eq.G.1; $\Phi_m = \max(A_1 \times e_e^{-(u \times u)/2}, 0)$ = **0.604**

Reduction factor for slenderness and eccentricity; $\Phi = \min(\Phi_i, \Phi_m)$ = **0.604**

Verification of unreinforced masonry walls subjected to mainly vertical loading - Section 6.1.2

Design value of the vertical load; $N_{Ed} = \max(N_{id}, N_{md})$ = **53.525** kN/m

Design compressive strength of masonry; $f_d = f_k / \gamma_{Mc}$ = **3.993** N/mm^2

Vertical resistance of wall - eq.6.2; $N_{Rd} = \Phi \times t \times f_d$ = **482.471** kN/m

PASS - Design vertical resistance exceeds applied design vertical load