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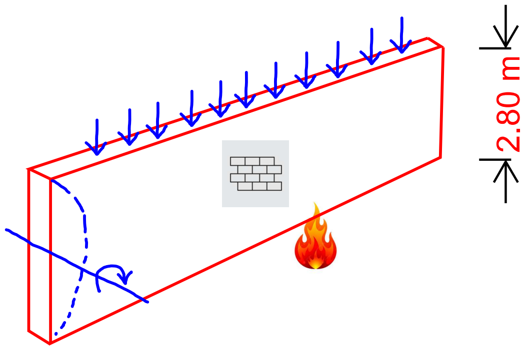
Masonry Design Verification

This example verifies RKALC's implementation of the AS 3700 design provisions for non-reinforced masonry walls using an independently prepared reference calculation. The verification follows the complete design process, including material property determination, capacity reduction factors, compression, bending, shear and fire resistance assessments. The close agreement confirms that RKALC consistently applies the Australian Standard the full masonry design workflow, providing transparent and reproducible calculations

Non-Reinforced Masonry Wall - AS 3700

Wall Height = 2800 mm (for wall spanning vertically - most common)
Length between vertical supports = not used, wall is spanning vertically

Type of Masonry Unit
20.01 concrete block units (user may select any unit from drop down menu), Table 3.1
wall is grouted using 20 MPa concrete Table 6.1
Bedding Type = Full
Mortar Class = M3
fuc = 15 MPa
fy = not applicable (non reinforced wall)



Corresponding Km = 1.4 Table 3.1
fi = 0.6 (from table 4.1, use Solid or cored compression, this also works for flexure)
Kc = 1.2 (use this factor for all other masonry types, conservatively, otherwise use 1.4)
kh = 1.3 (see table 3.2) 7.3.2
f'm = kh * f'mb = 1.3 x 5.42 = 7.05

Reference Tables
refer to AS3700
for full details

TABLE 3.1

CHARACTERISTIC COMPRESSIVE STRENGTH OF MASONRY (f'_{mb})

Type of masonry unit	Bedding type	Mortar class (see Note 2)	Characteristic unconfined compressive strength of unit (f'_{uc}) MPa: 5	10	15	20	25	30	40	≥50	Compressive strength factor (k_m)
Clay	Full	M2	2.5	3.5	4.3	4.9	5.5	6.0	7.0	7.8	1.1
Clay	Full	M3	3.1	4.4	5.4	6.3	7.0	7.7	8.8	9.9	1.4
Clay	Full	M4	4.5	6.3	7.7	8.9	10.0	10.9	12.7	14.1	2.0
Clay	Face shell	M3	3.6	5.1	6.2	7.2	8.0	8.8	10.1	11.3	1.6
Concrete	Full	M3	3.1	4.4	5.4	6.3	7.0	7.7	8.8	9.9	1.4
Concrete	Face shell	M3	3.6	5.1	6.2	7.2	8.0	8.8	10.1	11.3	1.6
Calcium silicate	Full	M3	3.1	4.4	5.4	6.3	7.0	7.7	8.8	9.9	1.4
Calcium silicate	Full	M4	4.5	6.3	7.7	8.9	10.0	10.9	12.7	14.1	2.0

TABLE 3.2

JOINT THICKNESS FACTOR (k_h)

Ratio of masonry unit height to mortar bed joint thickness	0.0	3.3	7.6	9.0	11.9	16.2	19.0
Joint thickness factor (k_h)	0.00	0.78	1.00	1.05	1.14	1.24	1.30

TABLE 4.1

CAPACITY REDUCTION FACTORS

Type of masonry or accessory and action effect	Capacity reduction factor (ϕ)
(a) Unreinforced masonry:	
(i) Compression	
(A) Solid or cored	0.75
(B) Hollow	0.50
(C) Grouted	0.60
(ii) Flexure	0.60
(iii) Shear	0.60
(iv) Other actions	0.60
(b) Reinforced and prestressed masonry	0.75

alfa v (slenderness coefficient) = 1

a_v = vertical slenderness coefficient
= 0.75 for a wall laterally supported and partially rotationally restrained at both top and bottom
= 0.85 for a wall laterally supported at top and bottom and partially rotationally restrained at one of them
= 1.0 for a wall laterally supported at both top and bottom
= 1.5 for a wall laterally supported and partially rotationally restrained at the bottom and partially laterally supported at the top
= 2.5 for a freestanding wall
The situations shown and described in Figures 7.1(A) to 7.1(E) are deemed to provide the required values.

7.3.4.3

Kt = 1 (pier coefficient) , no piers in wall

TABLE 7.2

THICKNESS COEFFICIENTS (k_t) FOR WALLS STIFFENED BY MONOLITHICALLY ENGAGED PIERS

Pier spacing/pier width (see Note 1)	Thickness coefficient (k_t)		
	Pier thickness ratio (t_{wp}/t)		
	1	2	3
6	1.0	1.4	2.0
8	1.0	1.3	1.7
10	1.0	1.2	1.4
15	1.0	1.1	1.2
20 or more	1.0	1.0	1.0

NOTES:
1 Pier spacing is taken as the distance between centre-lines of piers.
2 Linear interpolation may be used.

Table 7.2

eccentricity = 10 mm

7.3.4.4

7.3.3.4

Srs (Slenderness Reduction factor) = 1 x 2800 / 1 / 190 = 14.7368

7.3.3.4 *Simplified slenderness ratio (S_{rs})*

The simplified slenderness ratio (S_{rs}) of a member about a given principal axis shall be calculated from the following equation:

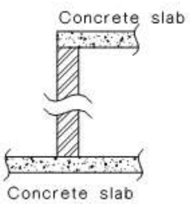
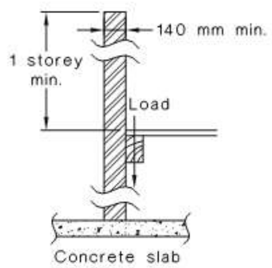
$$S_{rs} = \frac{a_v H}{k_t t} \qquad \ldots 7.3.3.4$$

k (reduction factor for slenderness and eccentricity) = 0.67
(wall is supporting concrete slab)

7.3.3.3
Table 7.1

TABLE 7.1

REDUCTION FACTOR (k) FOR SLENDERNESS AND ECCENTRICITY FOR DESIGN BY SIMPLE RULES

S_{rs}	Reduction factor (k)		
			
≤8	0.67	0.67	0.067
10	0.67	0.67	0.067
12	0.67	0.63	0.067
14	0.67	0.58	0.067

Compression Capacity Calcs

7.3.2

7.3.2 Basic compressive capacity

The basic compressive capacity of the cross-section (F_o) shall be taken as follows:

(a) For ungrouted masonry:

$$F_o = \phi f'_m A_b \qquad \ldots 7.3.2(1)$$

(b) For grouted masonry:

(i) If no testing is done:

$$F_o = \phi\left[\underbrace{f'_m A_b}_{\text{shell capacity}} + \underbrace{k_c\left(\frac{f'_{cg}}{1.3}\right)^{(0.55+0.005 f'_{cg})} A_g}_{\text{grout capacity}}\right] \qquad \ldots 7.3.2(2)$$

shell capacity = 0.6 * 7.05 * 98138mm² / 1000 =

Shell capacity = 415.12 KN

Ab= 98138 mm²
from block datasheet

grout capacity = 0.6 * 1.2 * 91862 mm² *(20/1.3)^(0.55+0.005*20)/1000

Grout capacity = 390.908 KN

Ag= 91862 mm²
from block datasheet

Therefore compression capacity of wall section = 415+391 = 806 KN

add slenderness effect : Fd = 806KN * (Srs = 0.66) = 532 KN

Therefore

MEMBER CAPACITY ON COMPRESSION = 532 KN / m length

Flexural Capacity Calcs

wall is spanning vertically, bending about horizontal axis in mid height, non reinforced
fmt = 0.2 MPa

3.3.3

3.3.3 Flexural tensile strength

The characteristic flexural tensile strength (f'_{mt}) for unreinforced, reinforced and prestressed masonry shall be as follows:

(a) Under actions resulting from wind, earthquake loads or similar forces of a short-term, transient nature, and where any simultaneous force due to vertical loads (F_d) is not a negative value (that is, not a net tension force):

(i) At mortar joints:

(A) For clay, concrete and calcium silicate masonry (except special masonry), a value not greater than 0.20 MPa.

(B) For AAC masonry with thin-bed joints (except special masonry), a value not greater than 0.26 MPa.

Zd = 1000 x 190² / 6 = 6016666.667 mm³

7.4.2
7.4.3.3

fd = stress under compression, say from own weight = 2.21KPa*2.8*1 *1000 / 190=
= 0.0325 MPa

2.21KPA is weight of block
190 is thickness

2.8 is height

7.4.2 Design for vertical bending

The design of an unreinforced masonry wall, or part thereof, to withstand vertical bending from actions of a short-term transient nature, which include out-of-plane wind loads, earthquake loads or similar forces, shall be such that the following relationship is satisfied under each combination of simultaneously acting design vertical bending moment (M_{dv}) and design compressive force acting on the cross-section of a member (F_d) under consideration:

$$M_{dv} \leq M_{cv} \quad \ldots 7.4.2(1)$$

where

M_{dv} = the design vertical bending moment resulting from transient out-of-plane forces acting on the member in vertical-spanning action

M_{cv} = the vertical bending moment capacity of the member as follows:

(a) Where $f'_{mt} > 0$

M_{cv} = the lesser of—

(i) $M_{cv} = \phi\, f'_{mt} Z_d + f_d Z_d$; and $\quad \ldots 7.4.2(2)$

(ii) $M_{cv} = 3.0\, \phi\, f'_{mt} Z_d$ $\quad \ldots 7.4.2(3)$

(b) Where $f'_{mt} = 0$

$M_{cv} = f_d Z_d$ $\quad \ldots 7.4.2(4)$

where f_d shall not be taken as greater than 0.36 MPa

and where

ϕ = the capacity reduction factor (see Clause 4.4)

f'_{mt} = the characteristic flexural tensile strength of the masonry (see Clause 3.3.3)

Z_d = the section modulus of the bedded area

f_d = the minimum design compressive stress on the bed joint at the cross-section under consideration (see Clause 7.4.3.3)

Mcv = min (3*0.6*0.2*Zd , 0.6*0.2*Zd + fd*Zd) = min(2.166, 0.917) = 0.92KN.m

MEMBER CAPACITY ON Bending = 0.92 KN.m / m length

Shear Capacity Calcs

Fms = 1.25 * fmt = 1.25 * 0.2 = 0.25 MPa < 0.35

3.3.4 (a)

3.3.4 Shear strength

The design characteristic shear strength (f'_{ms}) shall be as follows:

(a) For shear in the horizontal direction in continuous horizontal mortar joints:

(i) For masonry constructed with clay, concrete or calcium silicate units, the design characteristic shear strength (f'_{ms}) shall be taken as $1.25\,f'_{mt}$ but not greater than 0.35 MPa, nor less than 0.15 MPa.

(ii) For AAC masonry with thin-bed mortar, the design characteristic shear strength (f'_{ms}) shall be taken as $0.67\,f'_{ut}$.

Kv = 0.3

Table 3.3

3.3.5 Shear factor

The shear factor (k_v) for calculating the frictional component of shear capacity in accordance with Clause 7.5.4 shall be as given in Table 3.3.

TABLE 3.3

SHEAR FACTOR (k_v)

Type of masonry	Location	k_v
Clay, concrete or calcium silicate	At mortar bed joints	0.3
AAC	At thin-bed mortar joints	0.12
All	At membrane-type DPCs, flashings and similar locations where the	

Vo = 0.6*0.25 * 190 000 / 1000 = 28.5 KN / m
V1 = 0.3 * 0.0325 * 190 000 / 1000 = 1.8525 KN / m
Vd = 28.5 + 1.85 = 30.35

7.5.4.1

7.5.4.1 *Horizontal planes*

The shear resistance on a horizontal plane can result from both shear bond (or resistance to rupture) and shear friction. At the base of arches, the shear bond shall be taken as zero or a value substantiated by tests.

The design of an unreinforced masonry member to withstand horizontal shear forces, with or without simultaneous compressive forces acting across the shear plane, shall be such that the following relationship is satisfied under each combination of simultaneously acting design shear force (V_d) and design compressive stress acting at the cross-section under consideration (f_d):

$$V_d \le V_o + V_1 \qquad \ldots 7.5.4.1$$

where

V_o = the shear bond strength of the section

$= \phi f'_{ms} A_d$

ϕ = the capacity reduction factor (see Clause 4.4)

f'_{ms} = the characteristic shear strength (see Clause 3.3.4)

A_d = the design cross-sectional area of the shear-resisting portion of the member (see Clause 4.5.6)

V_1 = the shear friction strength of the section

$= k_v f_d A_d$

k_v = the shear factor as given in Table 3.3

f_d = the minimum design compressive stress on the bed joint at the cross-section in a member (see Clause 7.5.5) but not greater than 2 MPa

MEMBER CAPACITY ON SHEAR = 30.35 KN/ m length

Fire Design

7.3.2

Srf (slenderness on fire) = 0.75 * 2800 / 190 = 11.05 6.3.2.2(1)

6.3.2.2 *Slenderness ratio*

The slenderness ratio of a member about a given principal axis shall be as follows:

(a) For a wall that has no lateral support on its vertical edges—

$$S_{rf} = \frac{a_{vf} H}{t} \quad \ldots 6.3.2.2(1)$$

Structural Adequacy = 240 minutes (see table) Table 6.1

MAXIMUM SLENDERNESS RATIOS FOR STRUCTURAL ADEQUACY

Type of masonry unit	Fire-resistance period, min					
	30	60	90	120	180	240
1 Unreinforced masonry:						
(i) Clay units	25.0	22.5	21.0	20.0	18.0	17.0
(ii) Calcium silicate units with basaltic aggregate—						
(A) less than 45% of the total aggregate weight; or	20.5	19.0	18.0	17.5	16.5	15.5
(B) at least 45% of the total aggregate weight	25.0	22.5	21.0	20.0	18.0	17.0
(iii) Concrete units with basaltic aggregate—						
(A) less than 45% of the total aggregate weight; or	19.5	18.0	17.0	16.0	15.5	15.0
(B) at least 45% of the total aggregate weight	25.0	22.5	21.0	20.0	18.0	17.0
2 Reinforced masonry	36.0	36.0	36.0	36.0	36.0	36.0

NOTE: The term 'basaltic' shall be taken to apply to all basic rock types, gabbro, basalt, dolerite, diorite, trachyte, and similar rocks that contain less than 10% quartz.

Insulation

Table 6.3

TABLE 6.3

MATERIAL THICKNESS FOR INSULATION OF WALLS WITH FILLED PERPEND JOINTS

Type of masonry unit	Material thickness of wall, mm — Fire-resistance period, min					
	30	60	90	120	180	240
Clay	60	90	110	130	160	180
Calcium silicate	50	70	90	110	135	160
Concrete with density:						
(a) >1800 kg/m³	55	80	100	120	150	180
(b) ≤1800 kg/m³	55	75	90	110	135	160

RKALC Inputs

Inputs

Materials

Unit Type	Concrete
Basaltic Aggregate %	0 - 44%
Bedding Type	Full
Mortar Class	M3
f'uc *(MPa)*	15
fy *(MPa)*	500
km *(table 3.1)*	1.4
Φ *(table 4.1)*	0.60
Kc *(7.3.2) (8.5.1)*	1.2
αr *(8.5.1)*	1.0

Wall Geometry (mm)

Wall Height	2800
Length or Dist. Bet'n Supports	4000
αv Slenderness Coeff. (7.3.4.3)	1.00

Laterally supported at both top and bottom

Kh *(table 3.2)*	1.3
Kt *(table 7.2)*	1
e (Weak Dir) *(see 7.3.4.4)*	10
Srs Slenderness (7.3.3.4)	14.74
Wall is Supporting:	Conc. Slab
K Reduction (7.3.3.3)	0.66
Kes Reduction (8.5.1)	0

Masonry Units

Masonry Unit	20.01
Thickness (mm)	190
Height (mm)	190
Length (mm)	390
Block Weight (Kg)	16.362
Wall Weight (KPa)	2.21
Total Area mm²/m	190000
Ab mm²/m *(52%)*	98138
Grout mm²/m *(48%)*	91862
Grouted?	Yes
f'cg (MPa) - Grout	20
Reinforced?	No
As mm²/m (Vertical)	0
As mm²/m (Horizontal)	0

Calculate

RKALC Results

Results

Compression Capacity		
f'm Mpa *(3.3.2)*	7.05	
Shell Capacity KN *(51%)*	415	
Grout Capacity KN *(49%)*	391	
Reo Capacity KN *(0%)*	0	
Fo - Section Capacity KN	806	
Fd Member Capacity KN	**532**	See Page 4
Vertical Bending Capacity		
f'mt Mpa *(see 3.3.3)*	0.2	
fd MPa *(see 7.4.3.3)*	0.032	
Reo Area working on Bending mm²	0	
Effective Depth of Reo mm	30	
Asd *(See 8.6)*	0	
Mcv Unreinforced Capacity KN.m/m	0.91	See Page 5
Md Reinforced Capacity KN.m/m	N/A	
Horizontal Shear Capacity		
f'ms Horizontal *(see 3.3.4-a)*	0.25	
Kv Shear Factor *(T3.3)*	0.3	
Wall Type *(see 8.7.2 & 8.7.3)*	Long Wall	
Unreinforced Capacity KN/m	30.32	See Page 6
Reinforced Capacity KN/m	N/A	
Fire		
Srf Slenderness *(6.3.2.2-1)*	11.05	
αvf Slenderness Coeff	0.75	
Reo Dist. to Exposed Face *(T 6.2)*	N/A	
Struct. Adequacy (minutes) (T6.1)	240	See Page 7
Material Thk. of Wall *(6.5.2)*	190	
Insulation *(T6.3)* *(Minutes)*	240	See Page 7

ALL RESULTS ARE MATCHING WITH HAND CALCULATIONS