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# Compressive Load Capacity of Concrete Masonry

**This data sheet has been prepared by the Concrete Masonry Association of Australia for use by qualified and experienced structural engineers. The information is based on limit state design and is applicable specifically to concrete masonry with properties as set out in Clause 1 and loads set out in Clause 2.**

## 1 Masonry Properties

The design tables are based on masonry components with the following properties:

- Masonry units having a characteristic unconfined compressive strength ($f'_{uc}$), for units with face-shell bed, of 15.0 MPa and for units with full-bedding, of 10 MPa when tested in accordance with AS/NZS 4456.4.
- Mortar is of type M3 (or refer Table 5.1 AS 3700 if required for durability) ie, for type M3, either a C1:L1:S6 mix or a C1:S5 mix plus *methyl cellulose* water thickener or equivalent.
- Grout is to have a characteristic cylinder compressive strength ($f'_c$) of 20.0 MPa. Note the maximum value of grout strength ($f'_{cg}$) used for design is 1.3 times $f'_{uc}$ ie, 1.3 x 15.0 = 19.5 MPa.

  Where possible pre-mixed grout should be used and, when ordering, specified that it is for grouting blockwork incorporating reinforcement; a minimum cement content of 300 kg/m$^3$ is required. If the grout is to be site-mixed, it should be mixed in a tilting drum paddle mixer and must flow freely without separation of the aggregate. The aggregate should be rounded gravel where available and preferably 5 mm to 10 mm in size. The following proportions should be used:

  | | |
  |---|---|
  | Cement | 1 part |
  | Hydrated lime | up to 1⁄10 part |
  | Mortar sand | 3 parts |
  | Aggregate | 2 parts |

- Reinforcement is to be N-grade with a yield strength ($f_{sy}$) of 500 MPa.

## 2 Design Basis

The loads, load combinations and load factors are in accordance with:

- AS/NZS 1170.0 *General Principles*
- AS/NZS 1170.1 *Permanent, imposed and other actions*
- AS/NZS 1170.2 *Wind actions*.

The design properties and strength-reduction factors are in accordance with AS 3700 *Masonry structures*.

## 3 Compressive Load Capacity

The compressive load capacity (Table 1) has been derived using slenderness reduction factors given in Australian Standard AS 3700 2011, Clause 7.3.3 *Design by simple rules*. Slenderness-reduction factors for three load conditions have been used to generate the load capacities in Table 1 for various wall types and heights.

The values are all based on walls being unreinforced in compression. These also apply to walls containing reinforcement that is not effectively restrained in both directions. If the reinforcement can be effectively tied in both directions then there will be an increase in load capacity, not only from the reinforcement, but also from an increase in the value of $\phi$.

Table 1 gives values of:

$h_u$ = height of unit (from which the value of $k_h$ is determined)

$A_b$ = bedded area of masonry unit (m$^2$/m)

$f'_{mb}$ = basic characteristic compressive strength of masonry for a ratio of masonry unit height to motar joint thickness of 7.6

$k_h$ = compressive strength factor from Table 3.2 of AS 3700 for a ratio of masonry unit height to motar joint thickness for other than 7.6

$f'_m$ = characteristic compressive strength of masonry (MPa)
= $k_h \, f'_{mb}$ *cl.3.3.2*

$F_o$ = basic compressive capacity (kN/m)
= $\phi \, f'_m \, A_b$ for ungrouted walls *cl 7.3.2(1)*

$$= \phi \left[ f'_m A_b + k_c \sqrt{\frac{f'_{cg}}{1.3}} A_c \right]$$ for grouted walls *cl 7.3.2(2)*

Where: $\phi$ = 0.5 Hollow including grouted *T4.1*
= 0.75 Solid or Cored *T4.1*
$k_c$ = 1.4 for masonry density > 2000 kg/m$^3$
$f'_{cg}$ = 19.5 Mpa

$F_d$ = maximum design compressive strength (kN/m)
= $k \, F_o$
Where: $k$ = reduction factor for slenderness and eccentricity from *Table 7.1 of AS 3700*.

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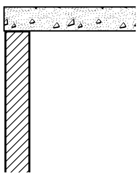
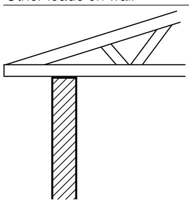
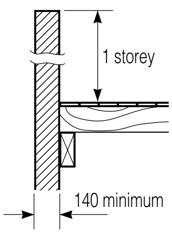
**Remember**, when working with cement and concrete/mortar or manufactured or prefabricated concrete products, ALWAYS follow the manufacturer's instructions and seek advice about working safely with the products from the manufacturer, your nearest WorkCover Authority or Worksafe Australia.

**TABLE 1** *Wall Properties and Compressive Load Capacity*

## WALL PROPERTIES

| | Wall thickness, $t_w$ *(mm)* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 90 | 110 | | | 140 | | | 190 | | 290 | |
| | Unit type | | | | | | | | | | |
| Property | 10.01 | Brick | Double brick | 12.01 | 15.01 | 15.01 grouted | 15.801 | 20.01 | 20.01 grouted | 30.925 | 30.925 grouted |
| $\phi$ | 0.5 | 0.75 | 0.75 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| $h_u$ *(mm)* | 190 | 76 | 162 | 190 | 190 | 190 | 190 | 190 | 190 | 190 | 190 |
| $A_b$ *($m^2/m$)* | 0.050 | 0.110 | 0.110 | 0.070 | 0.056 | – | 0.084 | 0.060 | – | 0.076 | – |
| $f'_{uc}$ *(MPa)* | 15 | 10 | 10 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| $f'_{mb}$ *(MPa)* | 6.20 | 4.43 | 4.43 | 6.20 | 6.20 | 6.20 | 6.20 | 6.20 | 6.20 | 6.20 | 6.20 |
| $k_b$ | 1.30 | 1.00 | 1.24 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 |
| $f'_m$ *(MPa)* | 8.06 | 4.43 | 5.49 | 8.06 | 8.06 | 8.06 | 8.06 | 8.06 | 8.06 | 8.06 | 8.06 |
| $F_o$ *(kN/m)* | 201 | 365 | 454 | 282 | 225 | 453 | 339 | 242 | 594 | 306 | 886 |

## WALL COMPRESSIVE LOAD CAPACITY, $F_d$ (kN/m)

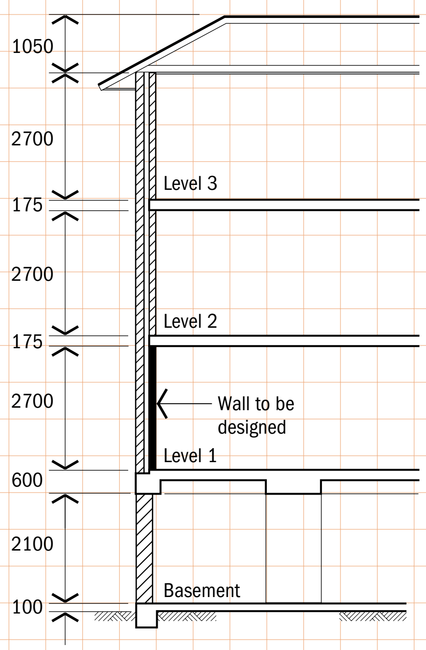
| | | Wall thickness, $t_w$ *(mm)* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wall | Wall design | 90 | 110 | | | 140 | | | 190 | | 290 | |
| | | Unit type | | | | | | | | | | |
| loading condition | height, H *(mm)* | 10.01 | Brick | Double brick | 12.01 | 15.01 | 15.01 grouted | 15.801 | 20.01 | 20.01 grouted | 30.925 | 30.925 grouted |
| Concrete slab on wall | 2400 | 84 | 185 | 231 | 143 | 137 | 276 | 205 | 162 | 397 | 205 | 593 |
|  | 2700 | 70 | 171 | 213 | 132 | 128 | 255 | 191 | 162 | 397 | 205 | 593 |
| | 3000 | – | 149 | 186 | 115 | 119 | 236 | 176 | 153 | 376 | 205 | 593 |
| | 3300 | – | 127 | 159 | 98 | 110 | 216 | 162 | 145 | 357 | 205 | 593 |
| | 3600 | – | – | – | – | 96 | 197 | 147 | 137 | 338 | 205 | 593 |
| | 4200 | – | – | – | – | 78 | 158 | 118 | 122 | 302 | 202 | 585 |
| | 4800 | – | – | – | – | – | – | – | 107 | 264 | 189 | 548 |
| | 5400 | – | – | – | – | – | – | – | 92 | 226 | 176 | 512 |
| | 6000 | – | – | – | – | – | – | – | 76 | 188 | 165 | 475 |
| Other loads on wall | 2400 | 51 | 138 | 173 | 105 | 111 | 222 | 166 | 145 | 3583 | 205 | 593 |
|  | 2700 | 34 | 120 | 150 | 86 | 98 | 198 | 147 | 136 | 335 | 205 | 593 |
| | 3000 | – | 92 | 116 | 66 | 86 | 174 | 130 | 126 | 312 | 202 | 580 |
| | 3300 | – | 66 | 92 | 47 | 74 | 150 | 112 | 117 | 288 | 194 | 563 |
| | 3600 | – | – | – | – | 62 | 125 | 93 | 107 | 265 | 186 | 540 |
| | 4200 | – | – | – | – | 38 | 76 | 57 | 88 | 217 | 171 | 494 |
| | 4800 | – | – | – | – | – | – | – | 70 | 171 | 154 | 448 |
| | 5400 | – | – | – | – | – | – | – | 51 | 120 | 138 | 403 |
| | 6000 | – | – | – | – | – | – | – | 31 | 77 | 123 | 356 |
| Load on side of wall | 2400 | – | – | – | – | 13 | 27 | 21 | 16 | 40 | 20 | 58 |
|   | 2700 | – | – | – | – | 12 | 25 | 18 | 15 | 40 | 20 | 58 |
| | 3000 | – | – | – | – | 12 | 23 | 17 | 15 | 37 | 20 | 58 |
| | 3300 | – | – | – | – | 11 | 22 | 16 | 14 | 35 | 20 | 58 |
| | 3600 | – | – | – | – | 10 | 20 | 14 | 13 | 34 | 20 | 58 |
| | 4200 | – | – | – | – | – | – | – | 12 | 30 | 20 | 58 |
| | 4800 | – | – | – | – | – | – | – | 11 | 26 | 18 | 54 |
| | 5400 | – | – | – | – | – | – | – | – | – | 17 | 51 |
| | 6000 | – | – | – | – | – | – | – | – | – | 16 | 47 |

## 4 Worked Example

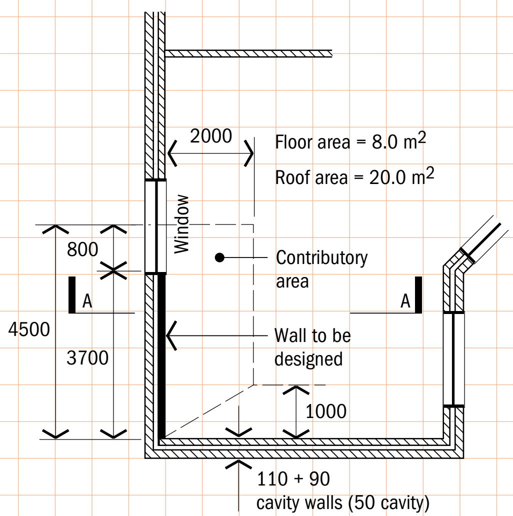
The purpose of the following worked example is to demonstrate the steps to be followed when performing manual calculations or when preparing computer software for the analysis and design of masonry.
The worked example is not intended to analyse or design all parts of the particular structure. It deals only with enough to demonstrate the design method.

**DESIGN BRIEF**

Design loadbearing wall indicated in the following drawings.




**SECTION A-A**




**PART PLAN AT LEVEL 1**

MASONRY PROPERTIES

*Note: All clause and table references to AS 3700.2011*

Width of masonry unit

$t_u = 90$ mm

Face-shell thickness

$t_{fs} = 25$ mm

Bedded area

$A_b = 2\ t_{fs}\ l$ *4.5.4*

$= 2 \times 25 \times 1000$

$= 50{,}000\ \text{mm}^2/\text{m}$

Block height

$h_u = 190$ mm

Mortar joint thickness

$t_j = 10$ mm

Height ratio

$\frac{h_u}{t_j} = \frac{190}{10}$

$= 19.0$

Compressive strength factor

$k_h = 1.3$ *Table 3.2*

Masonry factor for face-shell bedded concrete units

$k_m = 1.6$ *Table 3.1*

Mortar type M3 (1:0:5 )+ water thickener

Area of grout cross section

$A_c = 0$ Ungrouted walls

Characteristic unconfined unit strength

$f'_{uc} = 15$ MPa

*Cont...*

Characteristic confined masonry strength

$f'_{mb} = k_m \sqrt{f'_{uc}}$ *3.3.2(a)(i)*

$= 1.6 \sqrt{15}$

$= 6.20$ MPa

Characteristic unconfined masonry strength

$f'_m = k_h f'_{mb}$ *3.3.2(a)(i)*

$= 1.3 \times 6.20$

$= 8.06$ MPa

NOTE: This wall is not grouted. Where grout is used elsewhere, it is specified as:

Characteristic grout cylinder strength

$f'_c = 20$ MPa

$> 12$ MPa *11.7.3*

Design characteristic grout strength

$f'_{cg} = 1.3\ f'_{uc}$

$= 1.3 \times 15$

$= 19.5$ MPa

$< 20$ MPa *3.5*

Capacity reduction factor

$\phi = 0.5$ *Table 4.1*

Density factor

$k_c = 1.4$ for density 2180

$> 2000\ kg/m^3$ *7.3.2*

Basic compressive capacity *7.3.2(2)*

$$F_o = \phi \left[ f'_m A_b + k_c \sqrt{\left(\frac{f'_{cg}}{1.3}\right)}\ A_c \right]$$

$$= 0.5 \left[ \left(\frac{8.06 \times 50{,}000}{1000}\right) + 1.4 \sqrt{\left(\frac{19.5}{1.3}\right)} \times 0 \right]$$

$= 201$ kN/m

**DESIGN BY SIMPLIFIED RULES** *7.3.3*

Vertical slenderness coefficient (supports slab)

$a_v = 1.0$ *7.3.3.4(1)*

Clear height

$H = 2.70$ m

Clear length

$L = 3.70$ m

Thickness coefficient (no engaged piers)

$k_t = 1.0$ *Table 7.2*

Slenderness ratio

$$S_{rs} = \frac{a_v H}{k_t t}$$ *7.3.3.4(1)*

$$= \frac{1.0 \times 2700}{1.0 \times 90}$$

$= 30.0$

Slenderness and eccentricity factor

$k = 0.67 - 0.02\ (S_{rs} - 14)$ *7.3.3.3(a)(i)*

$= 0.67 - 0.02\ (30.0 - 14)$

$= 0.35$ *or from Table 7.1*

Design capacity

$F_d = k\ F_o$ *7.3.3.2*

$= 0.35 \times 201$

$= 70.4$ kN/m

*NOTE: If design capacity above is not sufficient to meet actual design loads, higher compressive capacity may be achieved using the Refined Calculation method. Refer to 7.3.4*