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) i.e., 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 \( f'_{cg} \) of 20.0 MPa. Note the maximum value of grout strength \( f'_{cg} \) used for design is 1.3 times \( f'_{uc} \), i.e., \( 1.3 \times 15.0 = 19.5 \) 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.

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 mortar 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 mortar 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)
  \[ = \phi \left( \frac{f'_{mb}}{\sqrt{1.3}} \right) \frac{f'_{cg}}{A_b} \] for grouted walls cl 7.3.2(2)

Where:

- \( \phi \) = 0.5 Hollow including grouted T4.1
  - 0.75 Solid or Cored T4.1
  - 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.
### TABLE 1  Wall Properties and Compressive Load Capacity

#### WALL PROPERTIES

<table>
<thead>
<tr>
<th>Wall thickness, $t_w$ (mm)</th>
<th><strong>90</strong></th>
<th><strong>110</strong></th>
<th><strong>140</strong></th>
<th><strong>190</strong></th>
<th><strong>290</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit type</td>
<td>Double</td>
<td>Brick brick</td>
<td>15.01</td>
<td>20.01</td>
<td>30.925</td>
</tr>
<tr>
<td>$\theta$ (mm)</td>
<td>0.5</td>
<td>0.75</td>
<td>0.75</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>$h_u$ (mm)</td>
<td>190</td>
<td>76</td>
<td>162</td>
<td>190</td>
<td>190</td>
</tr>
<tr>
<td>$A_b$ (m$^2$/m)</td>
<td>0.050</td>
<td>0.110</td>
<td>0.110</td>
<td>0.070</td>
<td>0.056</td>
</tr>
<tr>
<td>$f'_{uc}$ (MPa)</td>
<td>15.01</td>
<td>10.01</td>
<td>10.01</td>
<td>15.801</td>
<td>20.01</td>
</tr>
<tr>
<td>$f'_{mb}$ (MPa)</td>
<td>6.20</td>
<td>4.43</td>
<td>4.43</td>
<td>6.20</td>
<td>6.20</td>
</tr>
<tr>
<td>$k_b$</td>
<td>1.30</td>
<td>1.00</td>
<td>1.24</td>
<td>1.30</td>
<td>1.30</td>
</tr>
<tr>
<td>$f'_{m}$ (MPa)</td>
<td>8.06</td>
<td>4.43</td>
<td>5.49</td>
<td>8.06</td>
<td>8.06</td>
</tr>
<tr>
<td>$F_o$ (kN/m)</td>
<td>201</td>
<td>365</td>
<td>454</td>
<td>282</td>
<td>453</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Wall thickness, $t_w$ (mm)</th>
<th><strong>90</strong></th>
<th><strong>110</strong></th>
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<td>Brick brick</td>
<td>15.01</td>
<td>20.01</td>
<td>30.925</td>
</tr>
<tr>
<td>Load on side of wall</td>
<td>2400</td>
<td>84</td>
<td>185</td>
<td>231</td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>2700</td>
<td>70</td>
<td>171</td>
<td>213</td>
<td>132</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>–</td>
<td>149</td>
<td>186</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>3300</td>
<td>–</td>
<td>127</td>
<td>159</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>3600</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>4200</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>4800</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>5400</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>6000</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

| Concrete slab on wall     | 2400   | 84      | 185    | 231    | 143    |
|                           | 2700   | 70      | 171    | 213    | 132    |
|                           | 3000   | –       | 149    | 186    | 115    |
|                           | 3300   | –       | 127    | 159    | 98     |
|                           | 3600   | –       | –      | –      | 96     |
|                           | 4200   | –       | –      | –      | 78     |
|                           | 4800   | –       | –      | –      | –      |
|                           | 5400   | –       | –      | –      | –      |
|                           | 6000   | –       | –      | –      | –      |

| Other loads on wall       | 2400   | 51      | 138    | 173    | 105    |
|                           | 2700   | 34      | 120    | 150    | 86     |
|                           | 3000   | –       | 92     | 116    | 66     |
|                           | 3300   | –       | 66     | 92     | 47     |
|                           | 3600   | –       | –      | –      | 62     |
|                           | 4200   | –       | –      | –      | 38     |
|                           | 4800   | –       | –      | –      | –      |
|                           | 5400   | –       | –      | –      | –      |
|                           | 6000   | –       | –      | –      | –      |

| Load on side of wall      | 2400   | –       | –      | –      | 13     |
|                           | 2700   | –       | –      | –      | 12     |
|                           | 3000   | –       | –      | –      | 12     |
|                           | 3300   | –       | –      | –      | 11     |
|                           | 3600   | –       | –      | –      | 10     |
|                           | 4200   | –       | –      | –      | –      |
|                           | 4800   | –       | –      | –      | –      |
|                           | 5400   | –       | –      | –      | –      |
|                           | 6000   | –       | –      | –      | –      |
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.

- **Floor area** = 8.0 m²
- **Roof area** = 20.0 m²

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**MASONRY PROPERTIES**

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

- **Width of masonry unit**
  - *tu* = 90 mm

- **Face-shell thickness**
  - *tfs* = 25 mm

- **Bedded area**
  - \( A_b = 2 \times tfs \times l = 2 \times 25 \times 1000 = 50,000 \text{ mm}^2/\text{m} \)

- **Block height**
  - *hu* = 190 mm

- **Mortar joint thickness**
  - *tj* = 10 mm

- **Height ratio**
  - \( \frac{h_u}{t_j} = \frac{190}{10} = 19.0 \)

- **Compressive strength factor**
  - \( k_h = 1.3 \)

- **Masonry factor for face-shell bedded concrete units**
  - \( k_m = 1.6 \)

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

- **Area of grout cross section**
  - \( A_c = 0 \)  
  - Ungrooved walls

- **Characteristic unconfined unit strength**
  - \( f'_{uc} = 15 \text{ MPa} \)

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**SECTION A-A**

- **Floor area** = 8.0 m²
- **Roof area** = 20.0 m²
- **Contributory area**
  - **Wall to be designed**

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**PART PLAN AT LEVEL 1**

- **Wall to be designed**

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**CONT...**
### DESIGN BY SIMPLIFIED RULES 7.3.3

**Vertical slenderness coefficient**

\[ \alpha_v = 1.0 \] 

7.3.4(1)

**Clear height**

\[ H = 2.70 \text{ m} \]

**Clear length**

\[ L = 3.70 \text{ m} \]

**Thickness coefficient**

\[ k_t = 1.0 \]

Table 7.2

**Slenderness ratio**

\[ S_{rs} = \frac{\alpha_v \cdot H}{k_t \cdot t} \]

\[ = \frac{1.0 \times 2700}{1.0 \times 90} \]

\[ = 30.0 \]

7.3.3.4(1)

**Slenderness and eccentricity factor**

\[ k = 0.67 - 0.02 \left( S_{rs} - 14 \right) \]

\[ = 0.67 - 0.02 (30.0 - 14) \]

\[ = 0.35 \]

or from Table 7.1

7.3.3.3(a)(i)

**Design capacity**

\[ F_d = k \cdot F_o \]

\[ = 0.35 \times 201 \]

\[ = 70.4 \text{ kN/m} \]

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

### Characteristic confined masonry strength

\[ f'_{nb} = k_m f'_{uc} \] 

3.3.2(a)(i)

\[ = 1.6 \times \frac{15}{8} \]

\[ = 6.20 \text{ MPa} \]

### Characteristic unconfined masonry strength

\[ f'_{m} = k_h f'_{nb} \] 

3.3.2(a)(i)

\[ = 1.3 \times 6.20 \]

\[ = 8.06 \text{ MPa} \]

### Characteristic grout cylinder strength

\[ f'_c = 20 \text{ MPa} \] 

11.7.3

\[ > 12 \text{ MPa} \]

### Design characteristic grout strength

\[ f'_{cg} = 1.3 f'_{uc} \]

\[ = 1.3 \times 15 \]

\[ = 19.5 \text{ MPa} \]

\[ < 20 \text{ MPa} \] 

3.5

### Capacity reduction factor

\[ \phi = 0.5 \] 

Table 4.1

### Density factor

\[ k_c = 1.4 \text{ for density 2180 kg/m}^3 \] 

7.3.2

\[ > 2000 \text{ kg/m}^3 \]

### Basic compressive capacity

\[ F_o = \phi \left[ f'_m A_n + k_c \left( f'_{cg} \right) A_c \right] \] 

7.3.2(2)

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

\[ = 201 \text{ kN/m} \]