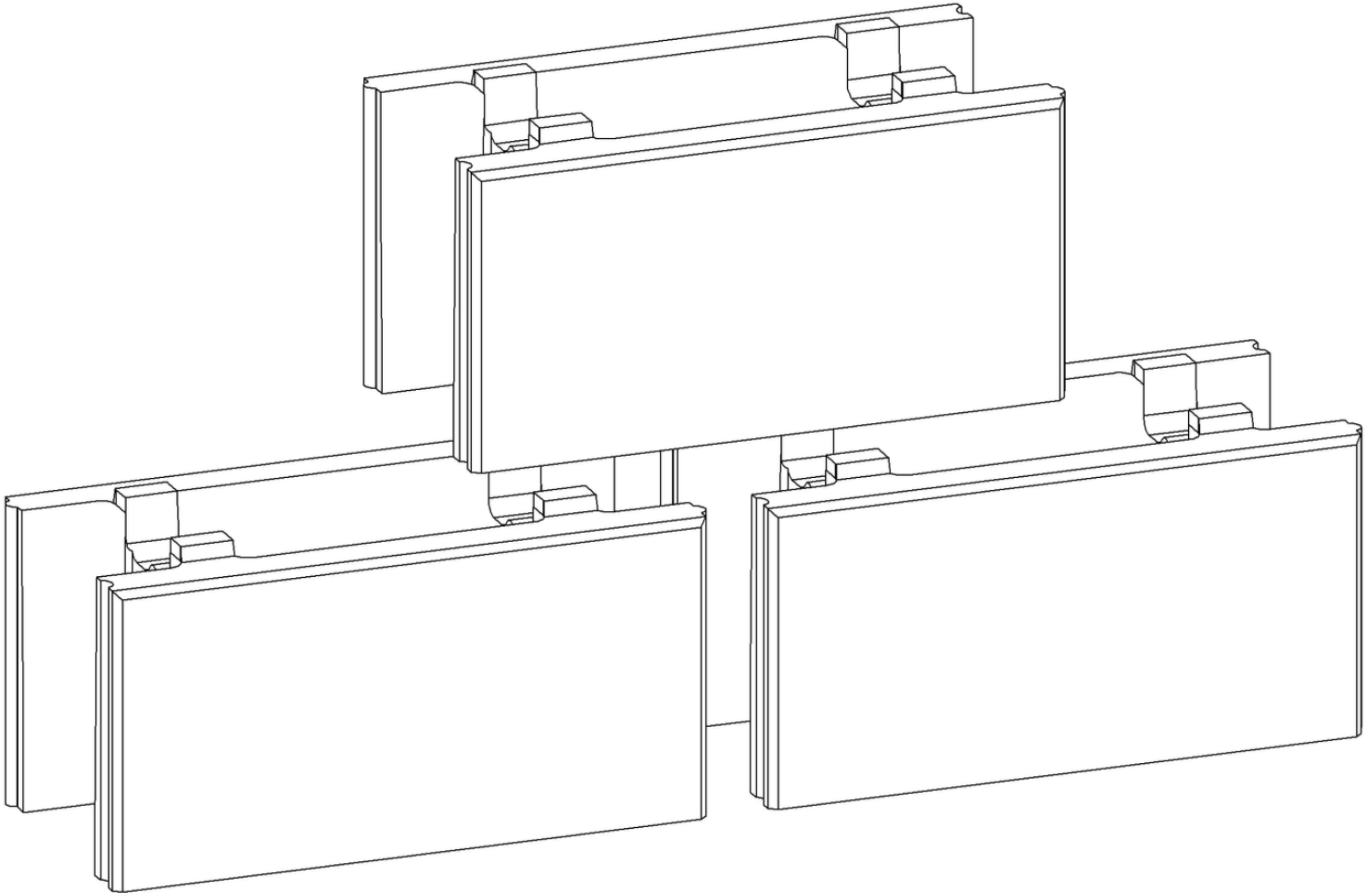
# TYPICAL ENGINEERING INFORMATION

# DIY WALL BLOCKS

*"No mortar, no fuss"*



# TYPICAL ENGINEERING INFORMATION

- CONSTRUCTION NOTES
- RETAINING WALL DETAILS – WITH FENCE
- FENCE POST DETAILS & SECTIONS
- RETAINING WALL DETAILS – WITHOUT FENCE
- DIY WALL CORNER DETAILS
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- CMAA FENCE DETAILS – BUILT ON CONCRETE PIERS
- CMAA FENCE DETAILS – BUILT ON CONCRETE FOOTINGS

# CONSTRUCTION NOTES

## SOIL TYPE DESCRIPTIONS

### TYPE (A) SOILS

Includes soft and firm clay, fine sands, silty clays.
Internal Friction Angle ≥ 20° - 24°

### TYPE (B) SOILS

Includes stiff sandy clays and gravelly clays
Internal Friction Angle ≥ 25° - 30°

1. The following assumptions have been made regarding soil properties:
   a. Infill Soil Types – As Above: Internal Friction Angle ≥ 20o - 30o+
   b. Bearing Pad – Compacted density angle: at least 18.6 kg/m3
   – Effective internal friction angle: at least 37°
   – Effective Cohesion: at least 5kPa
2. Caution is required when using heavy or dry clays as retained soil or backfill.
3. Surcharge loads are as follows: Domestic Vehicles –500 kg/m2 (5 kPa)
   Heavy Vehicles –To be separately assessed
4. Drainage shall be supplied in the form of a slotted P.V.C. ag-pipe with geotextile sock drain (fall at 1:100 min. to S/W disposal system) or with weep holes.
   A 300mm drainage layer shall be provided behind the wall.
5. Max height for core filling Up to 1.8m per pour
7. For backslope conditions greater than 1 in 4, seek specific engineering advice.
   Vehicle traffic should be allowed no closer than 1 metre behind the wall.

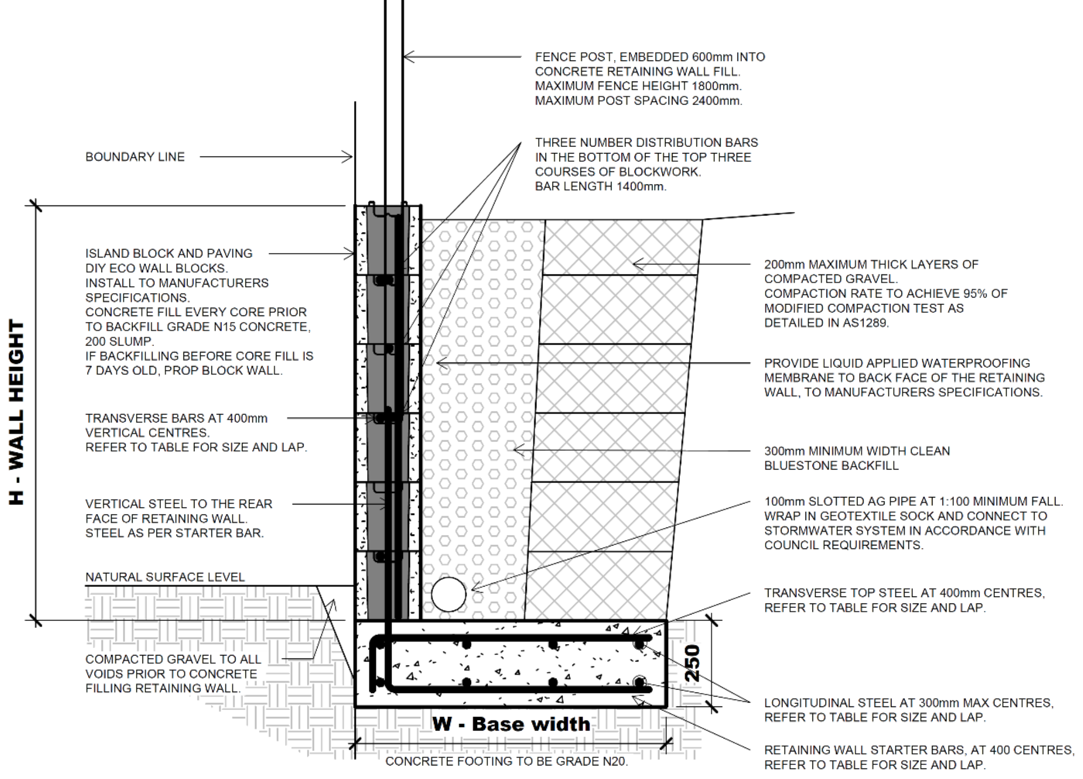
**Engineering - To comply with most council requirements, please seek specific engineering advice for walls over 1 metre high ,low walls in proximity to boundary or carrying vehicle traffic, etc.**

# TYPICAL ENGINEERING (RETAINING WALL WITH FENCE)

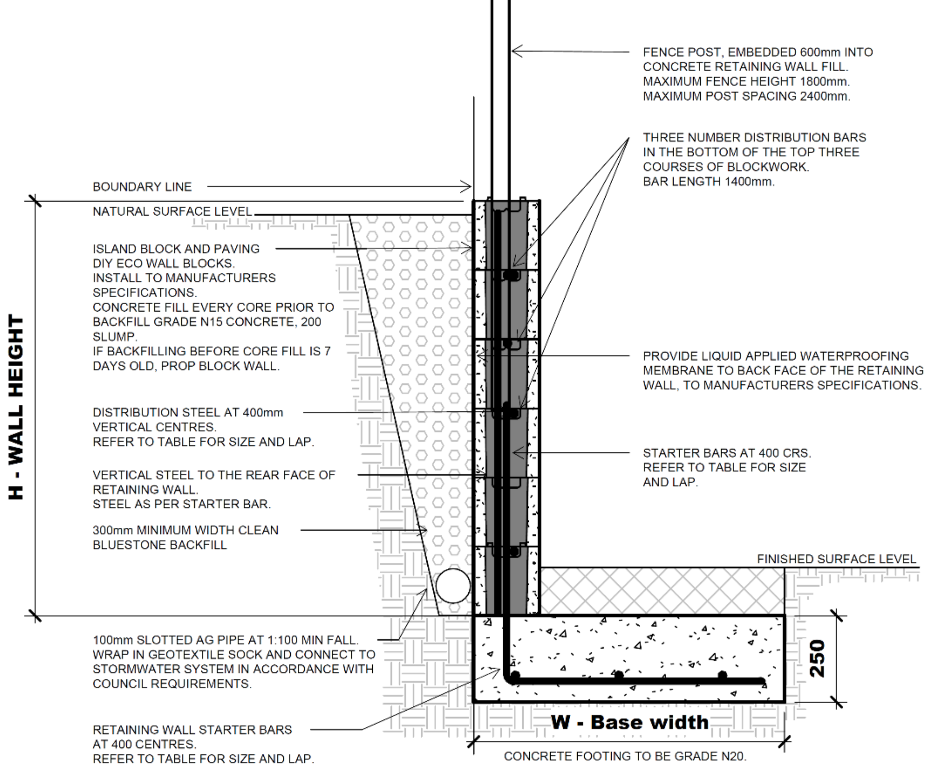
| H - Wall height (m) | W - Base width (m) | Starter bar type | Bar lap min (mm) | Transverse bar type | Longitudinal bar type | Soil type |
|---|---|---|---|---|---|---|
| 0.60 | 0.9<br>0.9 | N12<br>N12 | 500<br>500 | N12<br>N12 | N12<br>N12 | Type A<br>Type B |
| 1.00 | 0.9<br>0.9 | N12<br>N12 | 700<br>700 | N12<br>N12 | N12<br>N12 | Type A<br>Type B |
| 1.40 | 1.5<br>1.3 | N16<br>N16 | 700<br>700 | N16<br>N16 | N16<br>N16 | Type A<br>Type B |
| 1.80 | 1.6<br>1.4 | N16<br>N16 | 700<br>700 | N16<br>N16 | N16<br>N16 | Type A<br>Type B |

**RETAINING WALL HEIGHT, WIDTH AND REINFORCEMENT REQUIRED**

SOIL TYPE A - SOFT AND FIRM CLAY, FINE SANDS AND SILTY CLAYS.
SOIL TYPE B - STIFF SANDY CLAYS, GRAVELLY CLAYS, ROCK, SANDSTONE AND GRAVEL.



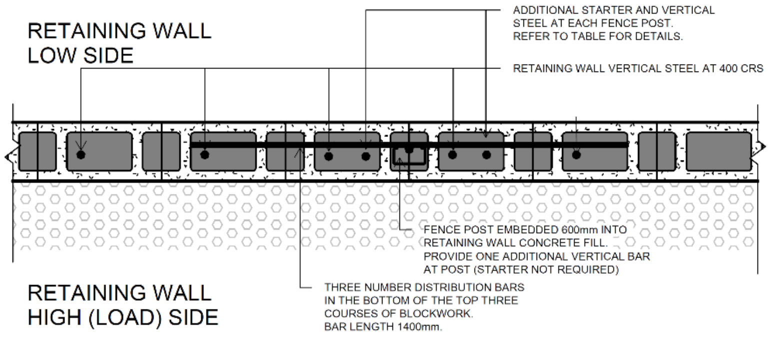

**RETAINING WALL DETAIL - WITH FENCE**



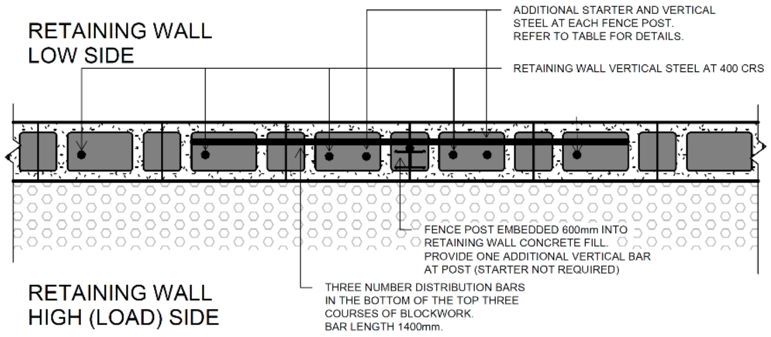

**RETAINING WALL DETAIL - WITH FENCE**

# TYPICAL DETAIL

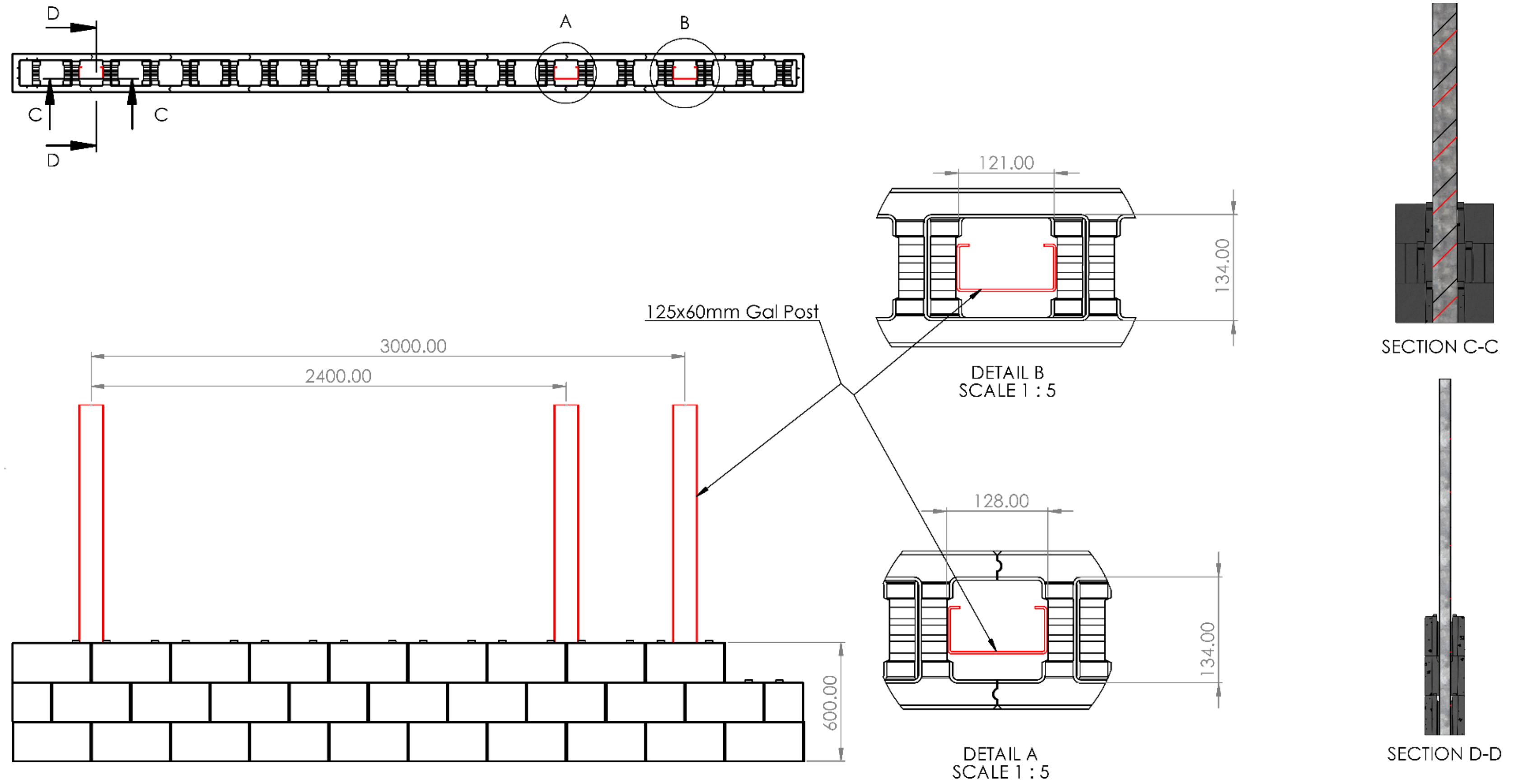
## (DIY BLOCKS WITH FENCE POST OPTION)




**PLAN DETAIL AT FENCE POST**
**C100mm PURLIN SECTION FENCE POST**




**PLAN DETAIL AT FENCE POST**
**COLORBOND PROPRIETARY SYSTEM FENCE POST**

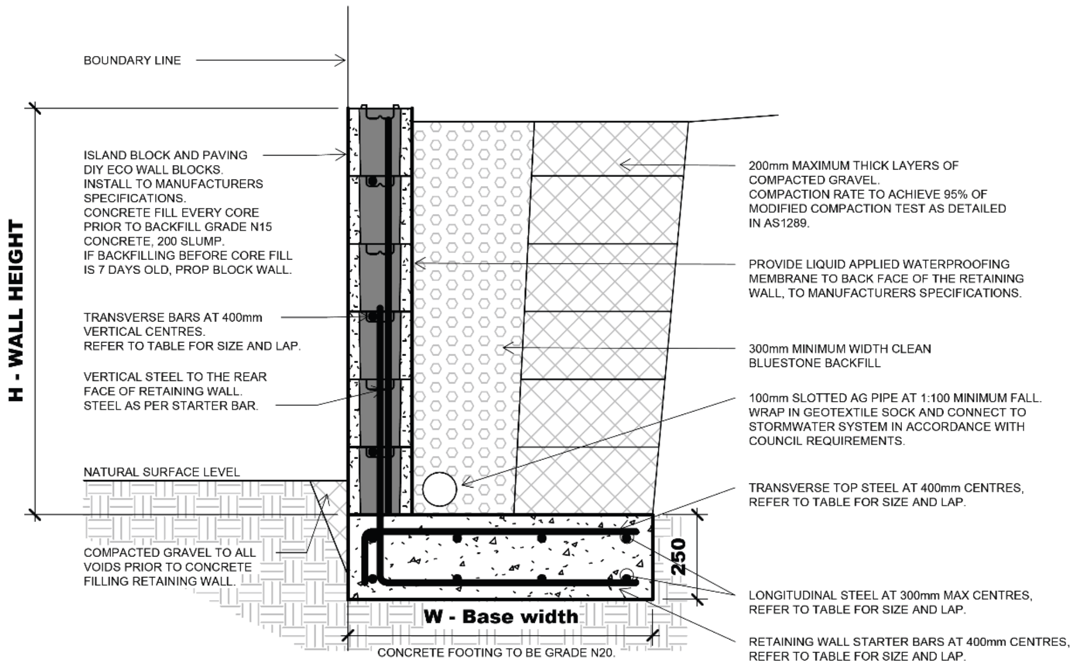


# TYPICAL ENGINEERING (RETAINING WALL WITHOUT FENCE)

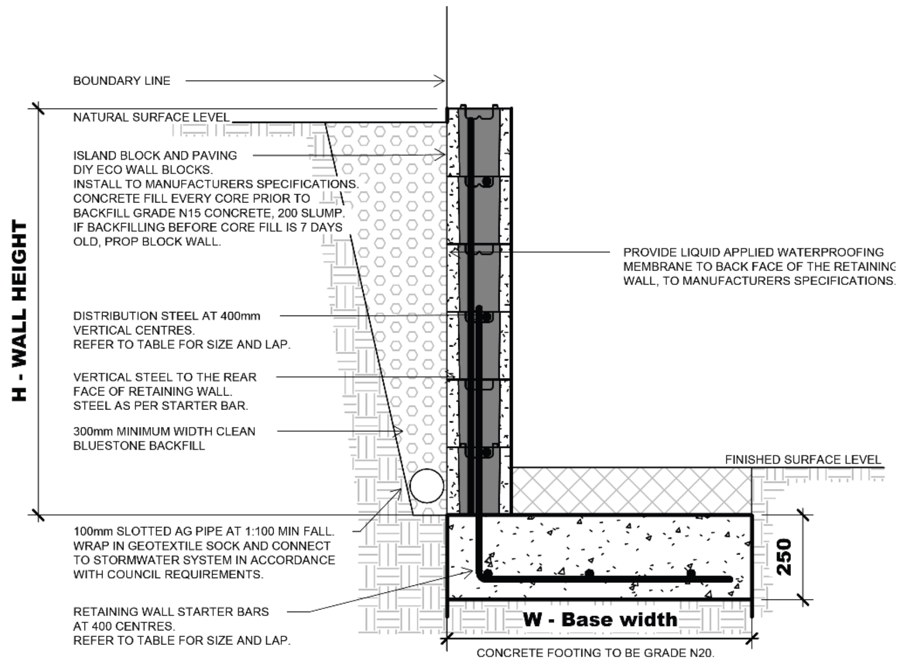
| H - Wall height (m) | W - Base width (m) | Starter bar type | Bar lap min (mm) | Transverse bar type | Longitudinal bar type | Soil type |
|---|---|---|---|---|---|---|
| 0.60 | 0.6 | N12 | 500 | N12 | N12 | Type A |
| | 0.6 | N12 | 500 | N12 | N12 | Type B |
| 1.00 | 0.9 | N12 | 700 | N12 | N12 | Type A |
| | 0.9 | N12 | 700 | N12 | N12 | Type B |
| 1.40 | 1.5 | N16 | 700 | N16 | N16 | Type A |
| | 1.3 | N16 | 700 | N16 | N16 | Type B |
| 1.80 | 1.6 | N16 | 700 | N16 | N16 | Type A |
| | 1.4 | N16 | 700 | N16 | N16 | Type B |

**RETAINING WALL HEIGHT, WIDTH AND REINFORCEMENT REQUIRED**

SOIL TYPE A - SOFT AND FIRM CLAY, FINE SANDS AND SILTY CLAYS.
SOIL TYPE B - STIFF SANDY CLAYS, GRAVELLY CLAYS, ROCK, SANDSTONE AND GRAVEL.



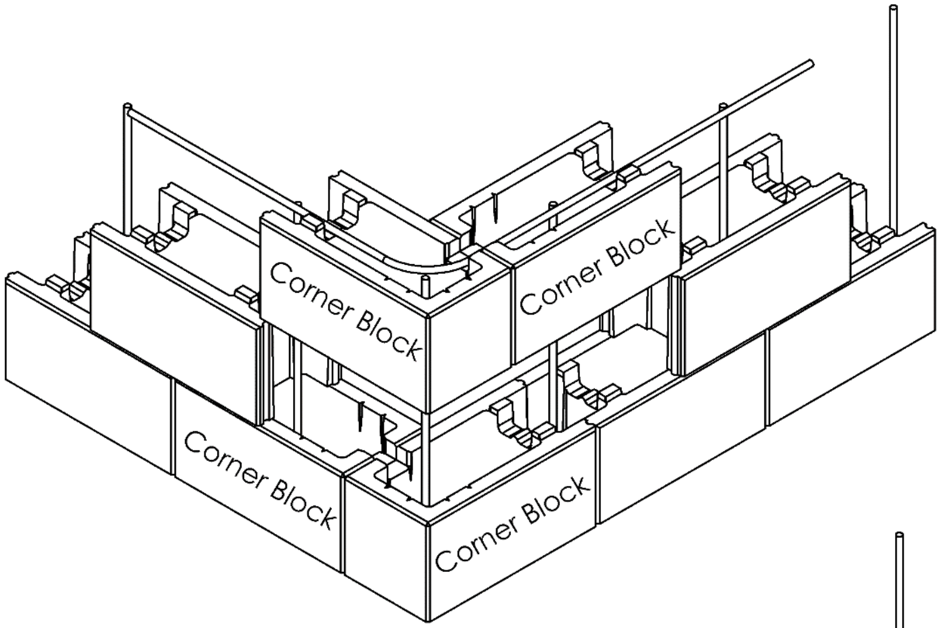

**RETAINING WALL DETAIL - WITHOUT FENCE**



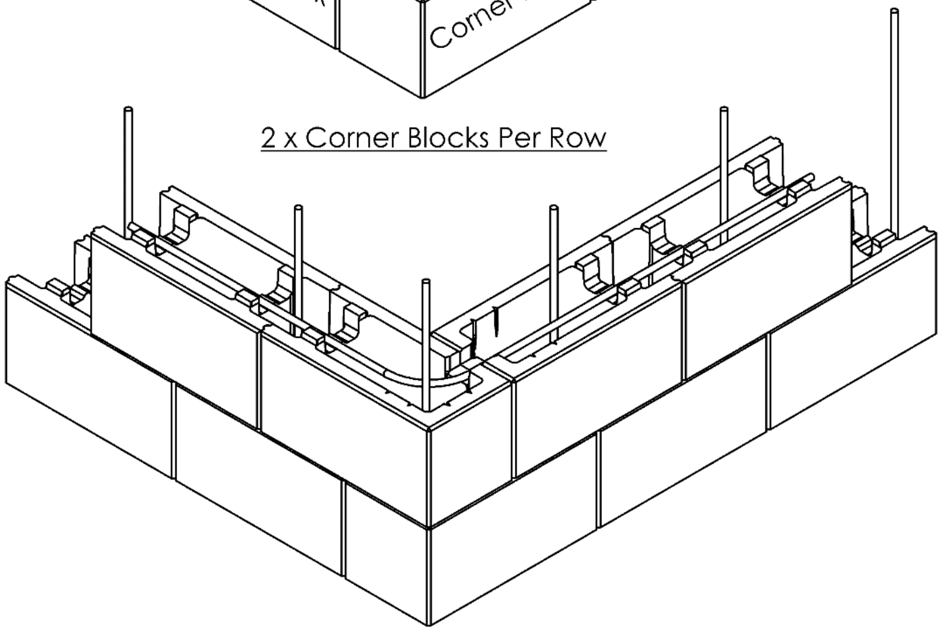

**RETAINING WALL DETAIL - WITHOUT FENCE**

# TYPICAL ENGINEERING

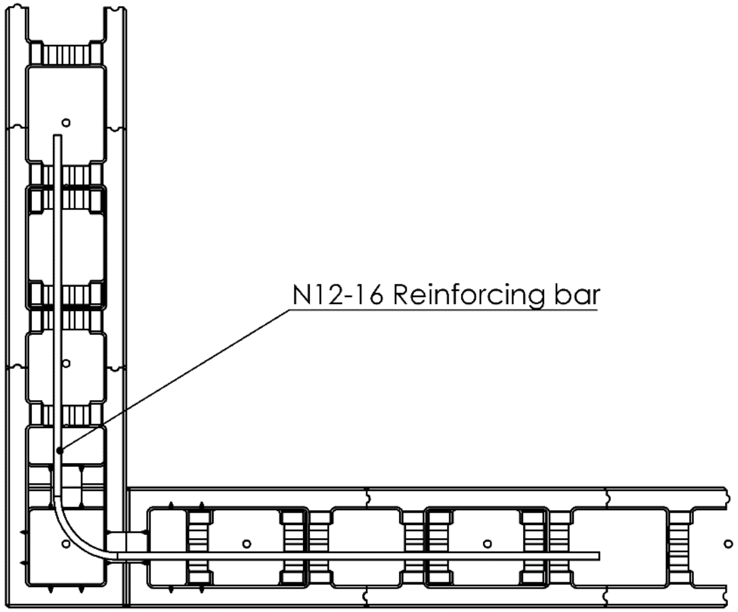
## (CORNER DETAIL)

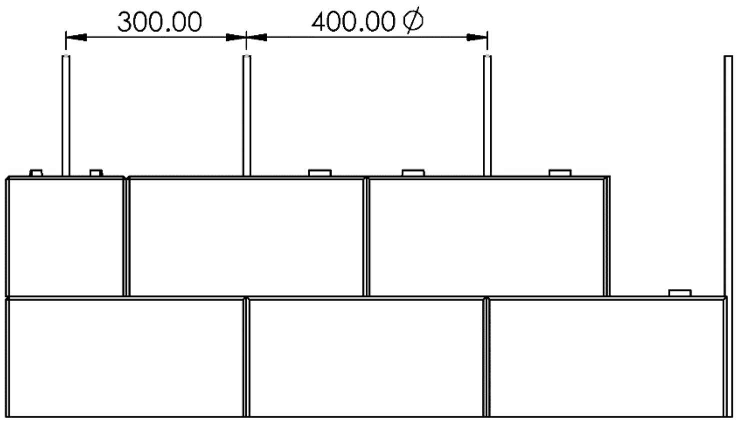



2 x Corner Blocks Per Row



Corner Set Out



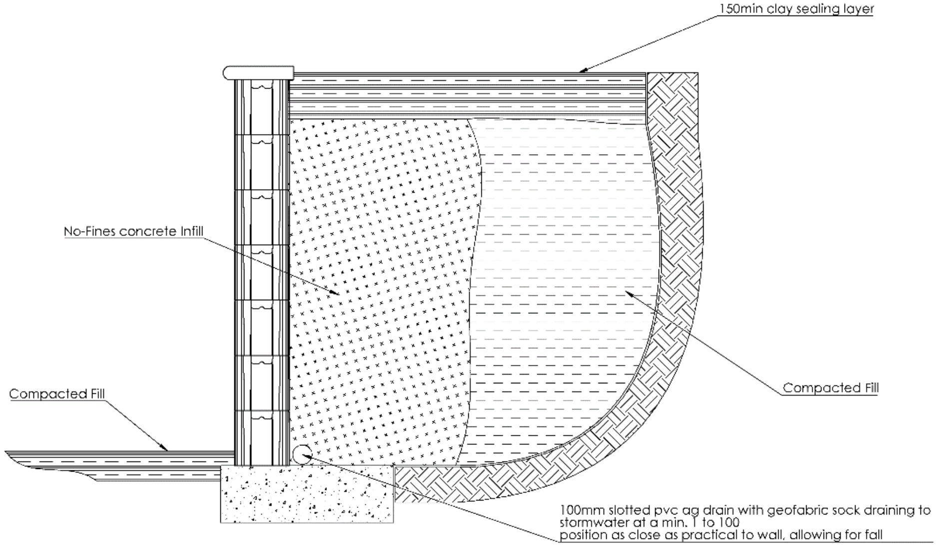




Vertical steel set out

# TYPICAL ENGINEERING

(GRAVITY WALL)
(NO-FINES CONCRETE BACKFILL)

| Maximum Wall Height 'H' (m)* | | | | |
|---|---|---|---|---|
| Backslope Conditions/ Loadings | Wall Height (m) | Base thickness (m) | Width of no fines concrete<br>Width of no fines concrete backfill behind blocks | |
| | | | Type A | Type B |
| Level with: No Surcharge | 1.0 | 0.20 | 0.35 | 0.3 |
| | 1.25 | 0.20 | 0.45 | 0.45 |
| | 1.5 | 0.25 | 0.65 | 0.65 |
| | 1.75 | 0.30 | 0.95 | 0.95 |
| | 2.0 | 0.35 | * | 1.15 |
| Domestic Vehicles | 1.0 | 0.15 | 0.55 | 0.45 |
| | 1.25 | 0.20 | 0.65 | 0.65 |
| | 1.5 | 0.25 | 0.95 | 0.75 |
| | 1.75 | 0.30 | 1.25 | 1.05 |
| | 2.0 | 0.35 | 1.55 | 1.35 |
| 1:4 Backslope | 1.0 | 0.15 | 0.65 | 0.55 |
| | 1.25 | 0.20 | 0.85 | 0.75 |
| | 1.5 | 0.25 | 1.45 | 1.15 |
| | 1.75 | 0.30 | * | 1.55 |
| | 2.0 | 0.35 | * | 1.75 |




## NO-FINES CONCRETE BACKFILL/INFILL SPEC.

No-fines concrete infill placed behind retaining walls shall be free-draining, allowing water to pass readily through it to the drainage system. In its unhardened state, no-fines concrete shall have low slump and shall not exert a lateral pressure in excess of 4 kPa per metre depth on the retaining wall facing restraining it. No-fines concrete used to provide enhanced stability to a retaining wall shall have a bulk density not less than 1800 kg./m3. No-fines concrete shall form a coherent mass, capable of adhering to the retaining wall facing.

**No-fines concrete shall meet the following specs:**

- Aggregate to GP cement ratio shall be not greater than 6 : 1
- Aggregate shall be GP (poorly graded) nominal 20mm crushed rock.
- Compressive strength shall be not less than 10 MPa.

**Construction Notes**

1. Blocks should be backfilled with no-fines concrete every 3 courses (600mm) high, blocks should be filled first prior to backfilling behind the wall to reduce pressure.
2. Blocks should be wetted prior to core filling to increase flow of no-fines concrete.
3. At least 25% of DIY block wings should be removed from the rear of the blocks prior to backfilling.

## CONCRETE MASONRY FENCES

**This data sheet is applicable to any free-standing, cantilever fence or wall for residential or commercial applications.**

## PART A: CONCRETE MASONRY FENCES BUILT ON REINFORCED CONCRETE PIERS

### 1 INTRODUCTION

Free-standing concrete masonry fences and boundary walls must be designed and constructed to withstand a range of loads, and in particular, wind loads. This data sheet provides guidance to qualified and experienced structural engineers on the selection of pier dimensions and masonry details for free-standing reinforced concrete masonry fences and walls, subject to a range of wind loads and set in a variety of soils.

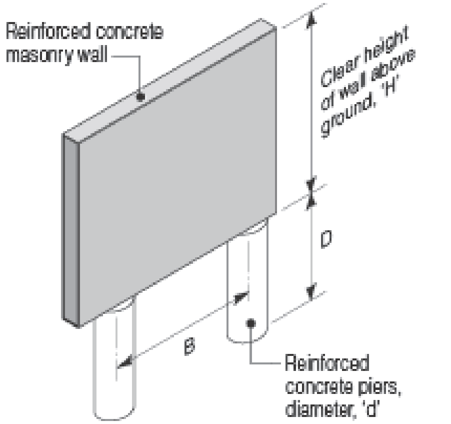

**How to Navigate this Data Sheet**

Any words in brown can be clicked to take you to it.

To return to where you were, click the *Previous View Button* in your Acrobat Reader

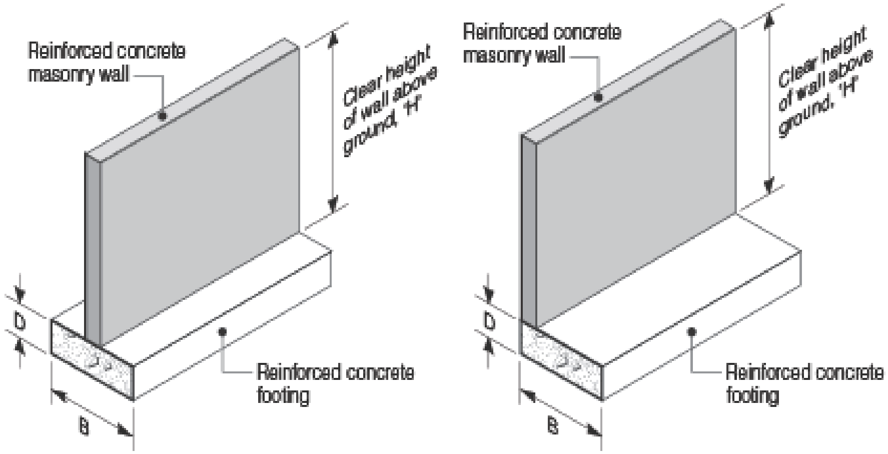

### 2 STANDARD DESIGNS

There are many possible designs for concrete masonry fences and boundary walls. Two common arrangements are shown in **Figures 1** and **2**.




**REFER DATA SHEET 5A**

**Figure 1** *Reinforced Concrete Masonry Wall with Reinforced Concrete Piers*




**REFER DATA SHEET 5B**

**Figure 2** *Reinforced Concrete Masonry Wall on Reinforced Concrete Strip Footings*

**Reinforced concrete masonry wall with reinforced concrete piers**

In most circumstances, the most economical form of construction for free-standing concrete masonry fences and boundary walls is as follows (**Figure 1**):

- The wall consists of 190-mm hollow concrete blockwork, with a reinforced bond beam and capping block at the top and a reinforced bond beam at the bottom. The bond beams should include a single horizontal N16 reinforcing bar, set in 20.20 knock-out bond beam blocks.
- The wall is supported, at centres ranging from 1.8 m to 3.0 m, by 450 mm diameter reinforced concrete piers, constructed in holes bored to the required depths and spacings. Table A sets out the recommended depths of 450mm piers, for various combinations of pier spacing, soil type (internal friction angle), wall heights and wind classifications. Each pier should include one (or more) reinforcing bar, which extends to the top bond beam and is grouted into the 190-mm concrete blockwork.
- The required number of vertical bars depends on the spacing of the piers, the wall height and wind classification. Table B sets out the recommended vertical reinforcement for 190 mm reinforced concrete masonry.

# TYPICAL ENGINEERING

(CMAA DATA SHEET 5A)

(FENCES BUILT ON REINFORCED CONCRETE PIERS)

## 3 WIND LOADS

Wind loads on free-standing concrete masonry fences and boundary walls should be calculated using AS/NZS 1170.2. However, designers often associate these structures with the design of houses to AS 4055. Strictly speaking, boundary walls and fences are outside the scope of AS 4055, although the nomenclature used therein is useful in classifying the wind exposure of housing sites for wind loads on such structures.

The nomenclature used in this Data Sheet for the "Wind Classification for Free-Standing Fences and Walls" ($N1_f$ to $C4_f$) has been adopted to differentiate it from the corresponding nomenclature, "Wind Classification for Housing" (N1 to C4), which is set out in AS 4055 for houses. Although the resulting ultimate free-stream gust dynamic wind pressures, designated $q_{zu}$, are the same, their derivation is different. The worked example below demonstrates the derivation for a "Wind Classification for Free-Standing Fences and Walls" of $N1_f$.

**Table 1** *Wind Classification for Free-Standing Fences and Walls*

| Wind Classification | Design gust wind speed at height 'h' $V_{zu}$ (m/s) | Ultimate free-stream gust dynamic wind pressure $q_{zu}$ (kPa) | Ultimate net wind pressure on free-standing wall $p_{nu}$ (kPa) |
|---|---|---|---|
| $N1_f$ | 34 | 0.69 | 0.83 |
| $N2_f$ | 40 | 0.96 | 1.15 |
| $N3_f$ $C1_f$ | 50 | 1.50 | 1.80 |
| $N4_f$ $C2_f$ | 61 | 2.23 | 2.68 |
| $N5_f$ $C3_f$ | 74 | 3.29 | 3.94 |
| $N6_f$ $C4_f$ | 86 | 4.44 | 5.33 |

Note: Design pressure is based on an aerodynamic shape factor, $C_{fig}$, of 1.20

## 4 SOIL PROPERTIES

Soil properties used to determine the resistance to overturning of the piers for free-standing concrete masonry fences and boundary walls should be based on reduction factors given in AS 4678 and "cautious estimates of the mean" density, internal friction angle and cohesion as defined in AS 4678.

## 5 PIER RESISTANCE

The resistance of piers of free-standing concrete masonry fences and boundary walls to overturning of the piers will be based on the principles for laterally-loaded piles set out in AS 2159. In particular, the resistance of a single isolated pier will be taken as three times the calculated passive resistance based on the factored mean internal angle of friction.

**Figure 3** shows the distribution of pressures resisting the overturning moments and **Table 2** the assumed forward movement of the pier .

**Table 2** *Assumed Forward Movement of Piers*

| Position | Movement |
|---|---|
| Bottom of pier | Zero movement. There is a reactive force against the base "kicking back" into the soil. The magnitude of the force is relatively large, and a function of the passive pressure at the base of the pier. Although spread over a small increment of depth, it is assumed to be a point reaction. |
| Mid-height of pier | Movement assumed to be same as that which would occur under a uniformly-distributed horizontal force, equal in magnitude to the total passive resistance. |
| Top of pier | Movement assumed to be twice the movement at mid-height. |

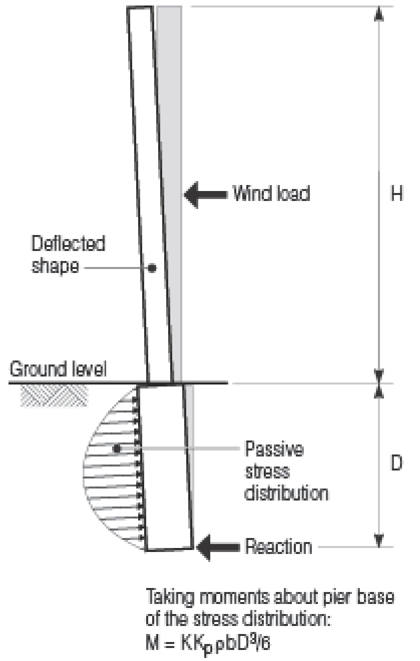



**Figure 3** *Distribution of Pressures Resisting the Overturning Moments*

## 6 DESIGN TABLES

Tables A and B set out the required depths of 450 mm diameter piers for free-standing fences and walls and required connection reinforcement between piers and 190-mm reinforced concrete masonry respectively.

# TYPICAL ENGINEERING

## (CMAA DATA SHEET 5A)

### (FENCES BUILT ON REINFORCED CONCRETE PIERS)

**Table A** *Required Depth of 450 mm Diameter Piers for Free-Standing Fences and Walls*

| Pier spacing, B (m) | Soil friction angle | Wall height, H (m) | Required depth of piers, D (m), for wind loads | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | $N1_f$ | $N2_f$ | $N3_f$ | $N4_f$ | $N5_f$ | $N6_f$ |
| 3.00 | 25° | 1.80 | 1.01 | 1.20 | 1.50 | 1.80 | 2.13 | 2.40 |
| | | 1.60 | 0.92 | 1.11 | 1.39 | 1.67 | 1.98 | 2.24 |
| | | 1.40 | 0.84 | 1.01 | 1.27 | 1.54 | 1.83 | 2.08 |
| | | 1.20 | 0.75 | 0.91 | 1.15 | 1.39 | 1.67 | 1.90 |
| | | 1.00 | 0.65 | 0.80 | 1.02 | 1.24 | 1.50 | 1.72 |
| | 30° | 1.80 | 0.94 | 1.11 | 1.39 | 1.67 | 1.97 | 2.22 |
| | | 1.60 | 0.86 | 1.02 | 1.29 | 1.55 | 1.84 | 2.08 |
| | | 1.40 | 0.77 | 0.93 | 1.18 | 1.42 | 1.70 | 1.93 |
| | | 1.20 | 0.69 | 0.84 | 1.06 | 1.29 | 1.55 | 1.76 |
| | | 1.00 | 0.60 | 0.74 | 0.94 | 1.15 | 1.39 | 1.59 |
| | 35° | 1.80 | 0.87 | 1.03 | 1.29 | 1.54 | 1.83 | 2.06 |
| | | 1.60 | 0.79 | 0.95 | 1.19 | 1.43 | 1.70 | 1.92 |
| | | 1.40 | 0.72 | 0.87 | 1.09 | 1.32 | 1.57 | 1.78 |
| | | 1.20 | 0.64 | 0.78 | 0.98 | 1.20 | 1.43 | 1.63 |
| | | 1.00 | 0.56 | 0.69 | 0.87 | 1.07 | 1.28 | 1.47 |
| 2.40 | 25° | 1.80 | 0.91 | 1.08 | 1.35 | 1.62 | 1.92 | 2.16 |
| | | 1.60 | 0.83 | 1.00 | 1.25 | 1.51 | 1.79 | 2.02 |
| | | 1.40 | 0.75 | 0.91 | 1.14 | 1.38 | 1.65 | 1.87 |
| | | 1.20 | 0.67 | 0.82 | 1.03 | 1.26 | 1.50 | 1.72 |
| | | 1.00 | 0.59 | 0.72 | 0.92 | 1.12 | 1.35 | 1.55 |
| | 30° | 1.80 | 0.84 | 1.00 | 1.25 | 1.50 | 1.78 | 2.00 |
| | | 1.60 | 0.77 | 0.92 | 1.16 | 1.39 | 1.66 | 1.87 |
| | | 1.40 | 0.70 | 0.84 | 1.06 | 1.28 | 1.53 | 1.73 |
| | | 1.20 | 0.62 | 0.76 | 0.96 | 1.16 | 1.39 | 1.59 |
| | | 1.00 | 0.54 | 0.67 | 0.85 | 1.04 | 1.25 | 1.43 |
| | 35° | 1.80 | 0.78 | 0.93 | 1.16 | 1.39 | 1.65 | 1.85 |
| | | 1.60 | 0.71 | 0.85 | 1.07 | 1.29 | 1.53 | 1.73 |
| | | 1.40 | 0.65 | 0.78 | 0.98 | 1.19 | 1.41 | 1.61 |
| | | 1.20 | 0.58 | 0.70 | 0.89 | 1.08 | 1.29 | 1.47 |
| | | 1.00 | 0.50 | 0.62 | 0.79 | 0.96 | 1.16 | 1.33 |
| 1.80 | 25° | 1.80 | 0.80 | 0.95 | 1.19 | 1.42 | 1.68 | 1.90 |
| | | 1.60 | 0.73 | 0.87 | 1.10 | 1.32 | 1.57 | 1.77 |
| | | 1.40 | 0.66 | 0.80 | 1.00 | 1.21 | 1.45 | 1.64 |
| | | 1.20 | 0.59 | 0.72 | 0.91 | 1.10 | 1.32 | 1.51 |
| | | 1.00 | 0.51 | 0.63 | 0.80 | 0.98 | 1.18 | 1.36 |
| | 30° | 1.80 | 0.74 | 0.88 | 1.10 | 1.32 | 1.56 | 1.76 |
| | | 1.60 | 0.68 | 0.81 | 1.02 | 1.22 | 1.45 | 1.64 |
| | | 1.40 | 0.61 | 0.74 | 0.93 | 1.12 | 1.34 | 1.52 |
| | | 1.20 | 0.55 | 0.66 | 0.84 | 1.02 | 1.22 | 1.39 |
| | | 1.00 | 0.48 | 0.59 | 0.74 | 0.91 | 1.10 | 1.26 |
| | 35° | 1.80 | 0.68 | 0.81 | 1.02 | 1.22 | 1.44 | 1.63 |
| | | 1.60 | 0.63 | 0.75 | 0.94 | 1.13 | 1.34 | 1.52 |
| | | 1.40 | 0.57 | 0.68 | 0.86 | 1.04 | 1.24 | 1.41 |
| | | 1.20 | 0.50 | 0.61 | 0.78 | 0.94 | 1.13 | 1.29 |
| | | 1.00 | 0.44 | 0.54 | 0.69 | 0.84 | 1.01 | 1.16 |

Notes:

Calculations are based on 190 mm reinforced concrete masonry

Wall height is the clear height of the wall above ground surface.

Design pressure is based on an aerodynamic shape factor, $C_{fig}$, of 1.20

**Table B** *Required Vertical Reinforcement for Piers and 190-mm Reinforced Concrete Masonry for Free-Standing Fences and Walls*

| Pier spacing, B (m) | Wall height, H (m) | Required number and size of vertical bars, per pier, for wind loads | | | | | |
|---|---|---|---|---|---|---|---|
| | | $N1_f$ | $N2_f$ | $N3_f$ | $N4_f$ | $N5_f$ | $N6_f$ |
| 3.00 | 1.80 | 1-N16 | 1-N16 | 1-N20 | 2-N20 | 3-N20 | 4-N20 |
| | 1.60 | 1-N16 | 1-N16 | 1-N20 | 2-N20 | 3-N20 | 4-N20 |
| | 1.40 | 1-N16 | 1-N16 | 1-N16 | 2-N20 | 2-N20 | 3-N20 |
| | 1.20 | 1-N16 | 1-N16 | 1-N16 | 2-N20 | 2-N20 | 3-N20 |
| | 1.00 | 1-N16 | 1-N16 | 1-N16 | 1-N20 | 2-N20 | 2-N20 |
| 2.40 | 1.80 | 1-N16 | 1-N16 | 1-N20 | 2-N20 | 2-N20 | 4-N20 |
| | 1.60 | 1-N16 | 1-N16 | 1-N16 | 2-N20 | 2-N20 | 3-N20 |
| | 1.40 | 1-N16 | 1-N16 | 1-N16 | 1-N20 | 2N20 | 2-N20 |
| | 1.20 | 1-N16 | 1-N16 | 1-N16 | 1-N20 | 2-N20 | 2-N20 |
| | 1.00 | 1-N16 | 1-N16 | 1-N16 | 1-N20 | 2-N20 | 2-N20 |
| 1.80 | 1.80 | 1-N16 | 1-N16 | 1-N16 | 1-N20 | 2-N20 | 2-N20 |
| | 1.60 | 1-N16 | 1-N16 | 1-N16 | 1-N20 | 2-N20 | 2-N20 |
| | 1.40 | 1-N16 | 1-N16 | 1-N16 | 1-N16 | 2-N20 | 2-N20 |
| | 1.20 | 1-N16 | 1-N16 | 1-N16 | 1-N16 | 1-N20 | 2-N20 |
| | 1.00 | 1-N16 | 1-N16 | 1-N16 | 1-N16 | 1-N20 | 2-N20 |

Notes:

Calculations are based on 190 mm reinforced concrete masonry

Height is the clear height of the wall above ground surface.

Design pressure is based on an aerodynamic shape factor, $C_{fig}$, of 1.20

Where more than two bars are specified, it may be preferable to use external 'posts' rather than maintaining the 'post' within the 190-mm thickness of the wall.

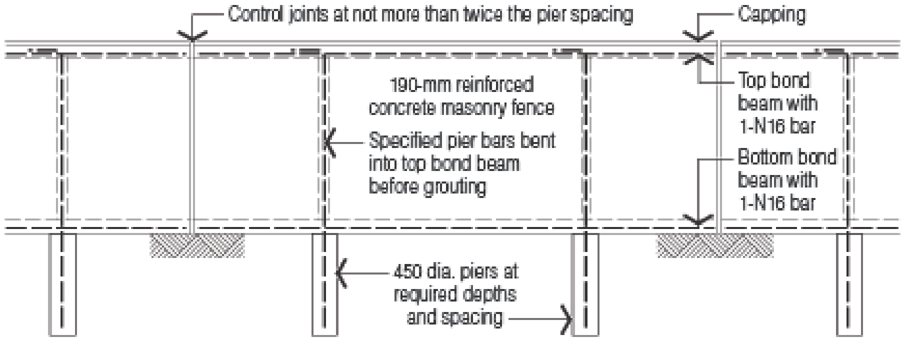



**Figure 4** *Typical Reinforcement Details and Control Joint locations*

## 7 TYPICAL DETAILS

The vertical bars between the piers and 190-mm reinforced concrete masonry fence should be carried up to the top bond beam and bent down before grouting (**Figure 4**).

Where more than two bars are specified, it may be preferable to use external 'posts' rather than maintaining the 'post' within the 190 mm thickness of the wall (**Figure 5**).

It is recommended a control joint be placed centrally between piers at not more than twice the pier spacing (**Figure 4**).

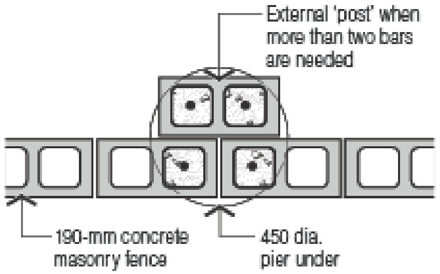



**Figure 5** *External 'Post' Detail*

## 8 WORKED EXAMPLE

Set out following is a worked example, the purpose of which is to:

- Demonstrate the method by which free-standing concrete masonry fences and cantilever walls may be designed for a particular wind and soil; and
- Serve as a test for any software developed for designing concrete masonry fences and cantilever walls.

# TYPICAL ENGINEERING

**(CMAA DATA SHEET 5A)**

**(FENCES BUILT ON REINFORCED CONCRETE PIERS)**

**DESIGN BRIEF**

Design a 1.8 m high free-standing concrete masonry boundary wall located in a Sydney suburb, on a gentle slope (with 60 metres upwind distance to the crest of a 4.0 m hill) and shielded by houses of 3.0 m roof height and 7.0 m width. The piers will be set in "insitu" sandy-clay material, with cautious estimates of the means of density 20 kN/m$^3$, internal angle of friction 30° and cohesion 5.0 kPa.

**WIND LOAD USING AS/NZS 1170.2:2002**

Region A

Degree of hazard 2

Location Non-cyclonic

Design event for safety 1 in 500

Regional wind speed

$V_R$ = 45 m/s *AS/NZS 1170.2 Table 3.1*

Regional wind multiplier

$M_d$ = 1.0 *AS/NZS 1170.2 Clause 3.3.1*

Terrain category multiplier

$M_{z,cat}$ = 0.91 For h < 3.0 m *AS/NZS 1170.2 Table 4.1(A)*

Number of upwind shielding buildings within a 45° sector of 20 h radius

$n_s$ = 2

Average roof height of shielding buildings

$h_s$ = 3.0 m

Average spacing of shielding buildings

$l_s = h(10/n_s + 5)$

$= 1.8([10/2] + 5)$

= 18.0 m

Average breadth of shielding buildings

$b_s$ = 7.0 m

Shielding parameter

$s = l_s/(h_s\ b_s)^{0.5}$ *AS/NZS 1170.2 Clause 4.3.3*

$= 18.0/(3.0 \times 7.0)^{0.5}$

= 3.93

Shielding multiplier

$M_s$ = 0.830 *Interpolated from AS/NZS 1170.2 Table 4.3*

Heigth of the hill, ridge or escarpment

H = 4.0 m

Horizontal distance upwind from the crest of a hill, ridge or excarpment to a level half the height below the crest

$L_u$ = 60.0 m

Windward slope

$H/2L_u = 4.0/(2 \times 60.0)$

= 0.033 < 0.05

Topography multiplier

$M_t$ = 1.00 *AS/NZS 1170.2 Clause 4.4.2*

Ultimate design gust wind speed

$V_{zu} = V_R M_d (M_{z,cat}\ M_s\ M_t)$

$= 45.0 \times 1.0 \times 0.91 \times 0.830 \times 1.0$

= 34.0 m/s

Ultimate free stream gust dynamic wind pressure

$q_{zu} = 0.0006 V_{zu}^2$ *AS/NZS 1170.2 Clause 2.4.1*

$= 0.0006 \times 34.0^2$

= 0.694 kPa

*Notes:*

*This pressure is taken to represent a Wind Classification for Free-Standing Fences and Walls of $N1_f$*

***The corresponding Wind Loads for Housing (on the same site) can be derived using AS 4055***

*Region*

*A AS 4055 Fig 2.1 For Sydney*

*Terrain Category*

*TC 3 AS 4055 Clause 2.3*

*For numerous closely spaces obstructions the size of houses*

*Average slope*

$\phi_s$ = *4 : 60*

= *1 : 15*

*Topography*

*T1 For $\phi_s$ < 1 : 10*

*AS 4055 Clause 2.4, Table 2.3*

*Shielding*

*Partial Shielding (PS) AS 4055 Clause 2.5*

*Classification*

*N1 AS 4055 Clause 2.2, Table 2.2*

# TYPICAL ENGINEERING

(CMAA DATA SHEET 5A)

(FENCES BUILT ON REINFORCED CONCRETE PIERS)

*Ultimate design gust wind speed*

*$V_{hu}$ = 34.0 m/s* *AS 4055 Clause 2.1, Table 2.1*

*Ultimate free stream gust dynamic wind pressure*

$q_{zu} = 0.0006\, V_{zu}^2$

$= 0.0006 \times 34.0^2$

$= 0.694$ kPa

*Note*

*For convenience, design tables will be prepared using the the ultimate design gust wind speed, $V_{hu}$, and the resulting ultimate free-stream gust dynamic wind pressure, $q_{zu}$, determined using AS 4055. This will enable the use of a wind classification nomenclature similar to that used in AS 4055. As indicated above, this may lead to small errors in the determination of pressure, but these are not considered significant.*

**Structure Geometry**

Height of wall

h = 1.8 m

Solid height of wall

c = 1.8 m

Total length of wall

b = 9.0 m

Length/solid height

b/c = 9.0/1.8

= 5.0

Solid height/total height

c/h = 1.8/1.8

= 1.0

Angle of incident wind (Normal = 0)

$\Phi = 0$

Porosity reduction factor

$K_p = 1 - (1 - \delta)^2$ *AS/NZS 1170.2 D2.1*

$= 1 - (1 - 1)^2$

$= 1.0$

Length of wall between vertical supports

B′ = 2.4 m

**Wind loads**

Net pressure coefficient

$C_{pn} = 1.3 + 0.5(0.3 + \log_{10}(b/c])\ (0.8 - c/h)$ *AS/NZS 1170.2 Table D2(A)*

$= 1.3 + 0.5\ (0.3 + \log_{10}(5.0])\ (0.8 - 1.0)$

$= 1.20$

*Note:*

*If $b < 2c$, $C_{pn}$ will increase from 1.2 to 1.3*

Aerodynamic shape factor

$C_{fig} = C_{pn} K_p$ *AS/NZS 1170.2 D2.1*

$= 1.20 \times 1.0$

$= 1.20$

*Note*

*For convenience, design tables will be prepared using the aerodynamic shape factor, $C_{fig}$, of 1.20*

*This may lead to small errors in the determination of pressure, but these are not considered significant.*

Ultimate net wind pressure on free-standing wall *AS/NZS 1170.2 Clause 2.4.1*

$p_{nu} = C_{fig}\, q_{zu}$

$= 1.20 \times 0.695$

$= 0.833$ kPa

**LOAD FACTORS AND CAPACITY REDUCTION FACTORS**

Load factor on overturning wind pressure

$G_w = 1.0$ *AS 1170.0 2002 Clause 4.2.1(b)(iv)*

Load factor on restoring forces

$G_r = 0.8$ *AS 4678 2002 Clause J3(c)*

# TYPICAL ENGINEERING

(CMAA DATA SHEET 5A)

(FENCES BUILT ON REINFORCED CONCRETE PIERS)

**SHEAR FORCE AND BENDING MOMENTS AT THE BASE OF WALL**

Shear force at base support of exposed wall

$V_b = G_w\, p_{nu}\, B'\, h$

$= 1.0 \times 0.834 \times 2.4 \times 1.80$

$= 3.60$ kN

Bending moment at base of support of exposed wall

$M_b = 0.5\, G_w\, p_{nu}\, B'\, h^2$

$= 0.5 \times 1.0 \times 0.834 \times 2.4 \times 1.80^2$

$= 3.22$ kN.m

**FOUNDATION SOIL**

The piers will be set in "insitu" sandy-clay material with the following properties.

Any over-excavation should be filled with compacted cement-stabilised road base.

Design will be to the principles set out in AS 4678.

Density (cautious estimate of mean)

$\rho_f = 20$ kN/m$^3$

Internal angle of friction (cautious estimate of the mean)

$\phi_f = 30°$

Cohesion (cautious estimate of mean)

$c_f = 5.0$ kPa

**Design properties of soil**

Foundation soil partial factor on $\tan(\phi_f)$

$\Phi_{\tan(\phi_f)} = 0.85$

Foundation soil partial factor on cohesion

$\Phi^*_{cf} = 0.70$

Foundation soil design internal friction angle

$\phi^*_f = \tan^{-1}[\Phi_{\tan(\phi_f)} \tan(\phi_f)]$

$= \tan^{-1}[0.85 \tan(30°)]$

$= 26.1°$

Foundation soil design cohesion

$c^*_f = \Phi_{cf}\; c_f$

$= 0.70 \times 5.0$

$= 3.5$ kPa

Passive pressure coefficient of foundation soil

$$K_p = \frac{1 + \sin(\phi^*_f)}{1 - \sin(\phi^*_f)}$$

$$= \frac{1 + \sin(26.1°)}{1 - \sin(26.1°)}$$

$= 2.58$

**PIER DETAILS**

Total depth of pier

$D = 0.900$ m

Pier diameter

$d_{pier} = 0.450$ m

*Note*

*The following calculations convert a circular pier to an equivalent square pier of the same overall cross-sectional area. By using this effective square section, the designer can have confidence in the calculated weight of pier, and the effective horizontal lever arms from an assumed point of rotation.*

Effective pier thickness perpendicular to the wall

$T_p = (3.1416/4)^{0.5}\, d_{pier}$

$= (3.1416/4)^{0.5} \times 0.450$

$= 0.399$ m

Effective pier length along the wall

$L_p = (3.1416/4)^{0.5}\, d_{pier}$

$= (3.1416/4)^{0.5} \times 0.450$

$= 0.399$ m

Multiplier to account for lateral resistance of piers pushing into a body of soil

$k_{pier} = 3.0$

**OVERTURNING ANALYSIS**

As the horizontal force increases, the wall support will rotate about its base, pushing forward into the soil. The movement will vary linearly from the maximum at the ground surface to zero at the bottom of the support.

The resistance to this movement is provided by the passive resistance of the soil in front of the support. Under uniform movement, the passive pressure varies uniformly from zero at the surface to a maximum at the base of the support.

Passive force over the total depth, D

$P_p = G_r\, k_{pier}\, K_p\, \rho\, L_p\, D^2/3$

$= 0.9 \times 3.0 \times 2.58 \times 19.6 \times 0.399 \times 0.900^2/3$

$= 14.71$ kN.m

Lever arm of passive force

$y_p = D/2$

$= 0.900/2$

$= 0.450$ m

Restoring moment about the base of passive force

$M_p = P_p\, y_p$
$= 14.71 \times 0.450$
$= 6.62$ kN.m

Factored weight of wall

$P_{vw} = G_r\, \rho_w\, h\, t\, b$
$= 0.8 \times 16.0 \times 1.8 \times 0.19 \times 2.4$
$= 10.5$ kN

Lever arm of wall weight

$y_w = T_p(0.5 - 0.167)$
$= 0.399(0.5 - 0.167)$
$= 0.133$ m

Restoring moment about centroid due to wall weight

$M_w = P_{vw}\, y_w$
$= 10.5 \times 0.133$
$= 1.40$ kN.m

Factored weight of pier/footing

$P_{vf} = G_r\, \rho_f\, T_f\, L_f\, D$
$= 0.8 \times 23.5 \times 0.399 \times 0.399 \times 0.9$
$= 2.69$ kN

Lever arm of pier/footing

$y_f = T_p(0.5 - 0.167)$
$= 0.399\,(0.5 - 0.167)$
$= 0.133$ m

Restoring moment about centroid due to pier/footing weight

$M_f = P_{vf}\, y_f$
$= 2.69 \times 0.133$
$= 0.36$ kN.m

Total restoring moment

$M_R = M_p + M_w + M_f$
$= 6.62 + 1.40 + 0.36$
$= 8.38$ kN.m

Bending moment at base of pier from wind

$M_b = G_w\, p_{nu}\, B'\, h\, (h/2 + D)$
$= 1.0 \times 0.828 \times 2.40 \times 1.80 \times (1.80 / 2 + 0.900)$
$= 6.48$ kN.m
$< 8.38$ kN.m OK
ie, wall is stable

**REINFORCED MASONRY 'POSTS'**

- Concrete blocks: Width 190 mm, strength grade 15 MPa
- Blockwork will be built continuous for a length of 2.4 m, with a pier located at the centre and articulation joints at each end.
- Main reinforcement, 1-N16 bar in the centre of the pier

**Masonry Properties**

Masonry unit characteristic unconfined compressive strength

$f'_{uc} = 15.0$ MPa

Units are hollow

Block type factor

$k_m = 1.6$

Equivalent brickwork strength

$f'_{mb} = k_m (f'_{uc})^{0.5}$
$= 1.6(15.0)^{0.5}$
$= 6.20$ MPa

Mortar joint height

$h_j = 10$ mm

Masonry unit height

$h_b = 190$ mm

Ratio of block to joint thickness

$h_b/h_j = 190/10$
$= 19.0$

Block height factor

$k_h = 1.3$

Characteristic masonry strength

$f'_m = k_h\, f'_{mb}$
$= 1.3 \times 6.20$
$= 8.06$ MPa

**Concrete Grout Properties**

*Concrete grout specification:*
*Concrete grout shall comply with AS 3700 and have:*

- *minimum portland cement content of 300 kg/cubic metre;*
- *10 mm maximum aggregate size;*
- *sufficient slump to completely fill the cores; and*
- *minimum compressive cylinder strength of 20 MPa.*

Specified characteristic grout cylinder strength
$f'_c = 20$ MPa
$> 12$ MPa OK
*AS 3700 Clause 11.7.3*

Design characteristic grout strength
$f'_{cg} = \min[(1.3 \times f'_{uc}),\ 20.0]$
*AS 3700 Clause 3.5*
$= \min[(1.3 \times 15),\ 20.0]$
$= \min[19.5,\ 20.0]$
$= 19.5$ MPa

**Main Reinforcement Properties**
Main reinforcement yield strength
$f_{sy} = 500$ MPa

Main reinforcement shear strength (dowel action)
$f_{sv} = 17.5$ MPa

Number of main tensile reinforcing bars
$N_t = 1$

Diameter of main tensile reinforcing bars
$D_{dia.t} = 16$ mm

Area of main reinforcment
$A_{st} = N_t(3.1416\ D_{dia.t}^2/4)$ (approx)
$= 1 \times 3.1416 \times 16^2/4$
$= 200\ mm^2$

**Dimensions**
The most adverse loading is on the pier near the middle of the wall

Width of pier (along the wall)
$B = 390$ mm

Depth of pier (through the wall)
$D = 190$ mm

Density of reinforced concrete masonry
$\rho_{mas} = 2{,}200\ kg/m^3$

Modulus of elasticity
$E = 1{,}000\ f'_m$
$= 1{,}000 \times 8.06$
$= 8{,}060$ MPa

Second moment of area of reinforced concrete masonry pier
$I = B\ D^3/12$
$= 390 \times 190^3/12$
$= 222.9 \times 10^6\ mm^4$

**Main Reinforcement**
Effective depth of reinforcement
For centrally located reinforcement:
$d = D/2$
For reinforcement near one face shell:
$d = D - d_1 + D_{dia.t}/2$
$= 190/2$
$= 95$ mm

Effective width of reinforced section
$b = \min(4D$ or
$2D +$ length to structural end)
$= 4 \times 190$
$= 760$ mm *AS 3700 Clause 8.5*

Shear width of reinforced section
$b_v = 200$ mm
*Note: Only one core is grouted*

Design area of main tensile reinforcement
$A_{sd} = \min[0.29(1.3 f'_m) b\, d/f_{sy},\ A_{st}]$
$= \min[(0.29 \times 1.3 \times 8.06 \times 760$
$\times 95 / 500),\ 200]$
$= \min[462,\ 200]$
$= 200\ mm^2$

**Fitments**
There are no shear reinforcement fitments required in this type of construction, which incorporates a single vertical reinforcing bar

Fitment yield strength
$f_{sy.f} =$ NA

Fitment area
$A_f =$ NA

Fitment spacing
$s =$ NA

**Reinforced Masonry Capacity**

Shear capacity *AS 3700 Clause 8.8*

$\phi V = \phi(f'_{vm}\, b_w\, d + f_{vs}\, A_{st} + f_{sy.f}\, A_{sv}\, d/s)$

$= 0.75[(0.35 \times 200 \times 95) + (17.5 \times 200) + 0]/1000$

$= 0.75(6.65 + 3.50 + 0)$

$= 7.61$ kN

Bending Moment Capacity *AS 3700 Clause 8.6*

$\phi M = \phi\, f_{sy}\, A_{sd}\, d[1 - 0.6\, f_{sy}\, A_{sd}\, d/(1.3\, f'_m\, b\, d)]$

$= 0.75 \times 500 \times 200 \times 95[1 - (0.6 \times 500 \times 200)/(1.3 \times 8.06 \times 760 \times 95)]/10^6$

$= 6.56$ kN.m

Height of cantilever wall above the piers

$L_c = 1.800$ m

Limiting deflection

$\Delta_a = L_c/50$

$= 1{,}800/50$

$= 36$ mm

Load capacity (limited by shear)

$W_{vu} = 1.0\, \phi V/(B'\, L_c)$

$= 1.0 \times 7.61/(2.400 \times 1.800)$

$= 1.76$ kPa

Load capacity (limited by bending moment)

$W_{mu} = 2\, \phi M/B' L_c^2$

$= 2 \times 6.56/(2.400 \times 1.800^2)$

$= 1.69$ kPa

Load capacity (limited by deflection)

$W_{\Delta u} = \Delta_a\, E\, I/48\, L_c^4\, B')$

$= [36 \times 8{,}060 \times 222.9 \times 10^6/(48 \times 1.800^4 \times 2.400)]10^{-9}$

$= 53.5$ kPa

Load capacity (limited by shear, bending moment or deflection)

$W_{lu} = \min(W_{vu},\ W_{mu},\ W_{\Delta u})$

$= \min(1.76,\ 1.69,\ 53.5)$

$= 1.69$ kPa

$> 0.834$ kPa OK

## CONCRETE MASONRY FENCES

**This data sheet is applicable to any free-standing, cantilever fence or wall for residential or commercial applications.**

## PART B: CONCRETE MASONRY FENCES BUILT ON CONCRETE STRIP FOOTINGS

### 1 INTRODUCTION

Part B of this data sheet applies to 190mm wide partially reinforced concrete masonry walls located in the center of the footing or at the edge of the footing depending on the property boundary requirements.

Free standing concrete masonry fences and boundary walls must be designed and constructed to withstand a range of loads, and in particular, wind loads. This manual provides guidance to qualified and experienced structural engineers on the selection of strip footing dimensions, wall steel spacing and masonry details for free standing reinforced concrete masonry fences and walls subject to a range of wind loads.

There are many possible designs for concrete masonry fences and boundary walls. Two common arrangements are shown in **Figures 1** and **2**.

The vertical bars are N16 diameter and their spacing depends on the wall height and wind classification.

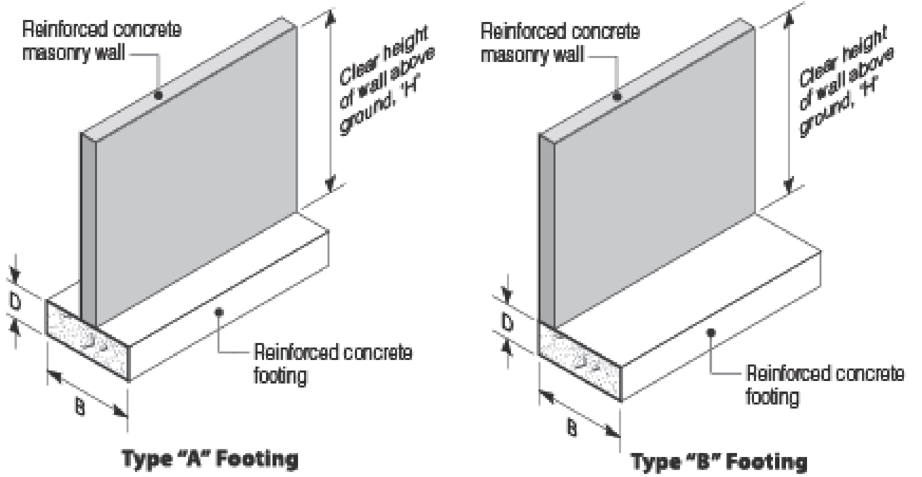



**Figure 1** ***Reinforced Concrete Masonry Wall on Reinforced Concrete Strip Footings***

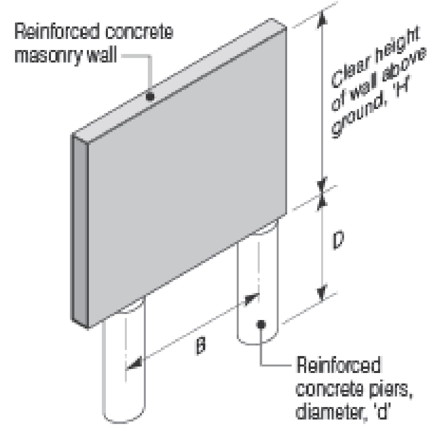



**Figure 2** ***Reinforced Concrete Masonry Wall with Reinforced Concrete Piers***

### 2 WALL CONSTRUCTION

The walls are built from 190 mm partially reinforced hollow concrete block work structurally tied to reinforced concrete strip footings at their base and with a reinforced bond beam at the top.

## 3 WIND LOADS

Wind loads on free-standing concrete masonry fences and boundary walls should be calculated using AS/NZS 1170.2. However, designers often associate these structures with the design of houses to AS 4055.

Strictly speaking, boundary walls and fences are outside the scope of AS 4055, although the nomenclature used therein is useful in classifying the wind exposure of housing sites for wind loads on such structures.

The nomenclature used in this Data Sheet for the "Wind Classification for Free-Standing Fences and Walls" ($N1_f$ to $C4_f$) has been adopted to differentiate it from the corresponding nomenclature, "Wind Classification for Housing" (N1 to C4), which is set out in AS 4055 for houses. Although the resulting ultimate free-stream gust dynamic wind pressures, designated $q_{zu}$, are the same, their derivation is different. The worked example below demonstrates the derivation for a "Wind Classification for Free-Standing Fences and Walls" of $N1_f$.

Refer to Table 1

## 4 WALL RESISTANCE TO OVER TURNING

The resistance to overturning is provided by the combined weight of the wall acting about an assumed point of rotation close to the toe of the footing. The distance from the toe to the point of rotation depends on the bearing capacity of the foundation soil, including its compaction. If the soil is firm with a high bearing capacity, the point of the rotation will be close to the toe. If the soil is soft with a low bearing capacity, the point of rotation will move closer to the centre of the footing. A reasonably conservative assumption is that the point about which the footing rotates is approximately B/3 from the toe of the footing, where B is the total footing width. This conservative approach has been used in this Data Sheet and as such customary bearing failure analysis has not been performed, however, if it is considered bearing failure analysis is necessary eg. low friction angle or poor quality soil) Please refer to typical CMAA manual, MA 51 Reinforced Concrete Masonry Canitilever Retaining Walls for guidance.

**Table 1** *Wind Classification for Free-Standing Fences and Walls*

| Wind Classification | Design gust wind speed at height 'h' $V_{zu}$ (m/s) | Ultimate free-stream gust dynamic wind pressure $q_{zu}$ (kPa) | Ultimate net wind pressure on free-standing wall $p_{nu}$ (kPa) |
|---|---|---|---|
| $N1_f$ | 34 | 0.69 | 0.83 |
| $N2_f$ | 40 | 0.96 | 1.15 |
| $N3_f$ $C1_f$ | 50 | 1.50 | 1.80 |
| $N4_f$ $C2_f$ | 61 | 2.23 | 2.68 |
| $N5_f$ $C3_f$ | 74 | 3.29 | 3.94 |
| $N6_f$ $C4_f$ | 86 | 4.44 | 5.33 |

Note: Design pressure is based on an aerodynamic shape factor, $C_{fig}$, of 1.20

# TYPICAL ENGINEERING

## (CMAA DATA SHEET 5B)
## (FENCES BUILT ON REINFORCED STRIP FOOTINGS)

**Table 2** *Strip Footing Width And Wall Reinforcement Spacing*

| Wind Classification | Fence Height 'H' | Strip footing width Type A or B 'W' | Wall reinforcement maximum spacing 'S' (m) | 190mm wall reinforcement size |
|---|---|---|---|---|
| $N1_f$ | 1.80 | 1.1 | 2.0 | N16 |
| | 1.60 | 1.0 | 2.0 | N16 |
| | 1.40 | 0.9 | 2.0 | N16 |
| | 1.20 | 0.8 | 2.0 | N16 |
| | 1.0 | 0.7 | 2.0 | N16 |
| $N2_f$ | 1.80 | 1.3 | 2.0 | N16 |
| | 1.60 | 1.2 | 2.0 | N16 |
| | 1.40 | 1.0 | 2.0 | N16 |
| | 1.20 | 0.9 | 2.0 | N16 |
| | 1.0 | 0.8 | 2.0 | N16 |
| $N3_f$ | 1.8 | 1.7 | 1.2 | N16 |
| | 1.6 | 1.5 | 1.6 | N16 |
| | 1.4 | 1.4 | 2.0 | N16 |
| | 1.2 | 1.2 | 2.0 | N16 |
| | 1.0 | 1.0 | 2.0 | N16 |
| $N4_f$ | 1.8 | 2.1 | 1.2 | N16 |
| | 1.6 | 1.9 | 1.6 | N16 |
| | 1.4 | 1.7 | 2.0 | N16 |
| | 1.2 | 1.5 | 2.0 | N16 |
| | 1.0 | 1.3 | 2.0 | N16 |
| $N5_f$ | 1.8 | 2.7 | 1.0 | N16 |
| | 1.6 | 2.4 | 1.2 | N16 |
| | 1.4 | 2.1 | 1.6 | N16 |
| | 1.2 | 1.9 | 2.0 | N16 |
| | 1.0 | 1.6 | 2.0 | N16 |
| $N6_f$ | 1.8 | 3.1 | 0.8 | N16 |
| | 1.6 | 2.8 | 1.0 | N16 |
| | 1.4 | 2.5 | 1.2 | N16 |
| | 1.2 | 2.5 | 1.6 | N16 |
| | 1.0 | 1.9 | 2.0 | N16 |

# TYPICAL ENGINEERING

**(CMAA DATA SHEET 5B)**

**(FENCES BUILT ON REINFORCED STRIP FOOTINGS)**

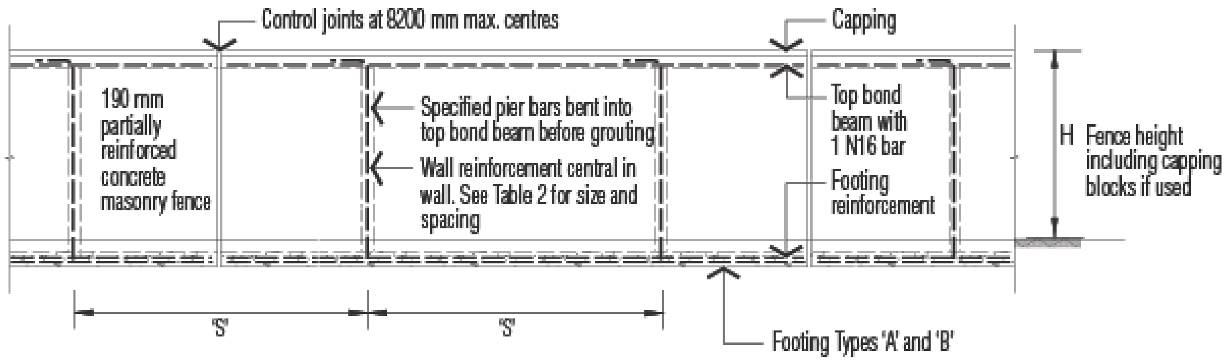



**Figure 3** *Typical Reinforcement Details and Control Joint Locations*

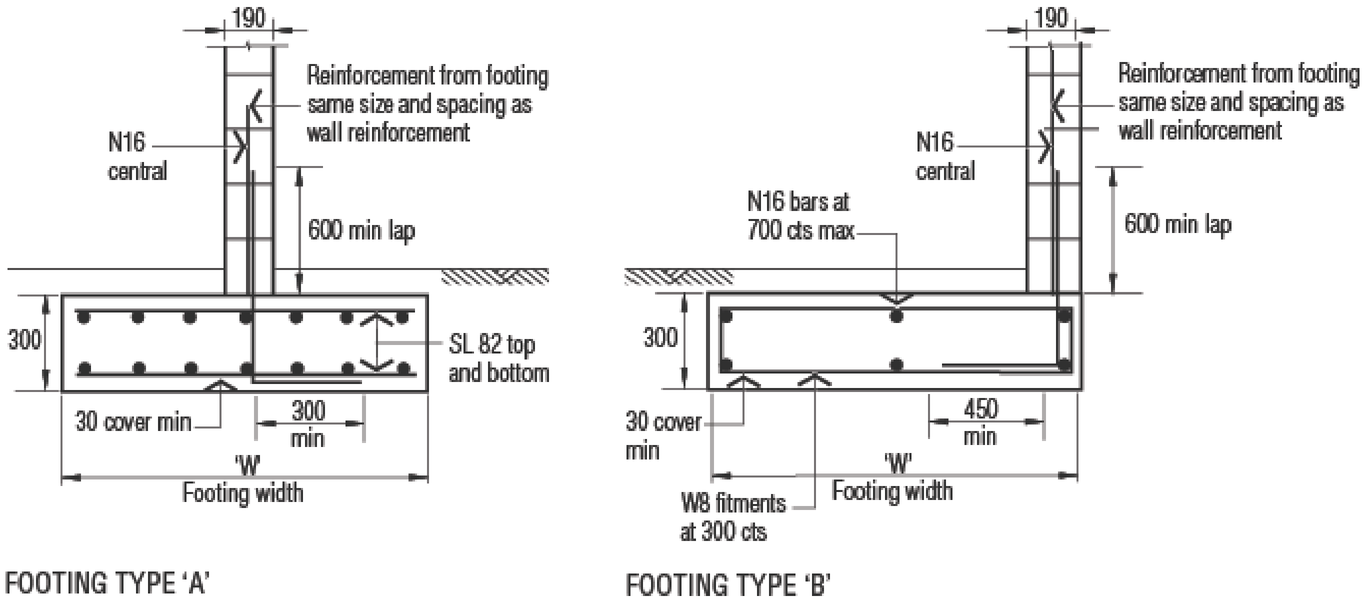



**Figure 4** *Typical 'A' And 'B' Footing Details*

# TYPICAL ENGINEERING

(CMAA DATA SHEET 5B)

(FENCES BUILT ON REINFORCED STRIP FOOTINGS)

**DESIGN BRIEF**

Design a 1.8 m high free-standing concrete masonry boundary wall located in a Sydney suburb, on a gentle slope (with 60 metres upwind distance to the crest of a 4.0 m hill) and shielded by houses of 3.0 m roof height and 7.0 m width. The wall is to be partially reinforced with N16 reinforcing steel at S = 2.0 m vertical centres. The footing is to be strip footing Type A. i.e., with the wall stem located in the centre of the footing width B.

**WIND LOAD USING AS/NZS 1170.2:2002**

Region A

Degree of hazard 2

Location Non-cyclonic

Design event for safety 1 in 500

Regional wind speed
$V_R = 45$ m/s *AS/NZS 1170.2 Table 3.1*

Regional wind multiplier
$M_d = 1.0$ *AS/NZS 1170.2 Clause 3.3.1*

Terrain category multiplier
$M_{z,cat} = 0.91$ For h < 3.0 m *AS/NZS 1170.2 Table 4.1(A)*

Number of upwind shielding buildings within a 45° sector of 20 h radius
$n_s = 2$

Average roof height of shielding buildings
$h_s = 3.0$ m

Average spacing of shielding buildings
$l_s = h(10/n_s + 5)$
$= 1.8([10/2] + 5)$
$= 18.0$ m

Average breadth of shielding buildings
$b_s = 7.0$ m

Shielding parameter
$s = l_s/(h_s\ b_s)^{0.5}$ *AS/NZS 1170.2 Clause 4.3.3*
$= 18.0/(3.0 \times 7.0)^{0.5}$
$= 3.93$

Shielding multiplier
$M_s = 0.830$ *Interpolated from AS/NZS 1170.2 Table 4.3*

Heigth of the hill, ridge or escarpment
H = 4.0 m

Horizontal distance upwind from the crest of a hill, ridge or excarpment to a level half the height below the crest
$L_u = 60.0$ m

Windward slope
$H/2L_u = 4.0/(2 \times 60.0)$
$= 0.033 < 0.05$

Topography multiplier
$M_t = 1.00$ *AS/NZS 1170.2 Clause 4.4.2*

Ultimate design gust wind speed
$V_{zu} = V_R M_d (M_{z,cat}\ M_s\ M_t)$
$= 45.0 \times 1.0 \times 0.91 \times 0.830 \times 1.0$
$= 34.0$ m/s

Ultimate free stream gust dynamic wind pressure
$q_{zu} = 0.0006 V_{zu}^2$ *AS/NZS 1170.2 Clause 2.4.1*
$= 0.0006 \times 34.0^2$
$= 0.694$ kPa

*Notes:*
*This pressure is taken to represent a Wind Classification for Free-Standing Fences and Walls of $N1_f$*

***The corresponding Wind Loads for Housing (on the same site) can be derived using AS 4055***

*Region*
*A* *AS 4055 Fig 2.1 For Sydney*

*Terrain Category*
*TC 3* *AS 4055 Clause 2.3*
*For numerous closely spaces obstructions the size of houses*

*Average slope*
*$\phi_s = 4 : 60$*
*$= 1 : 15$*

*Topography*
*T1* *For $\phi_s < 1 : 10$*
*AS 4055 Clause 2.4, Table 2.3*

*Shielding*
*Partial Shielding (PS)* *AS 4055 Clause 2.5*

*Classification*
*N1* *AS 4055 Clause 2.2, Table 2.2*

# TYPICAL ENGINEERING

## (CMAA DATA SHEET 5B)

### (FENCES BUILT ON REINFORCED STRIP FOOTINGS)

*Ultimate design gust wind speed*

$V_{hu}$ = *34.0 m/s* — *AS 4055 Clause 2.1, Table 2.1*

*Ultimate free stream gust dynamic wind pressure*

$q_{zu} = 0.0006\, V_{zu}^2$

$= 0.0006 \times 34.0^2$

$= 0.694$ *kPa*

*Note*

*For convenience, design tables will be prepared using the the ultimate design gust wind speed,* $V_{hu}$, *and the resulting ultimate free-stream gust dynamic wind pressure,* $q_{zu}$, *determined using AS 4055. This will enable the use of a wind classification nomenclature similar to that used in AS 4055. As indicated above, this may lead to small errors in the determination of pressure, but these are not considered significant.*

**Structure Geometry**

Height of wall

h = 1.8 m

Solid height of wall

c = 1.8 m

Total length of wall

b = 9.0 m

Length/solid height

b/c = 9.0/1.8

= 5.0

Solid height/total height

c/h = 1.8/1.8

= 1.0

Angle of incident wind (Normal = 0)

$\Phi = 0$

Porosity reduction factor — *AS/NZS 1170.2 D2.1*

$K_p = 1 - (1 - \delta)^2$

$= 1 - (1 - 1)^2$

$= 1.0$

Length of wall used for calculations

B′ = 1.0 m

**Wind loads**

Net pressure coefficient — *AS/NZS 1170.2 Table D2(A)*

$C_{pn} = 1.3 + 0.5\,(0.3 + \log_{10}(b/c])\,(0.8 - c/h)$

$= 1.3 + 0.5\,(0.3 + \log_{10}(5.0])\,(0.8 - 1.0)$

$= 1.20$

*Note:*

*If* $b < 2c$, $C_{pn}$ *will increase from 1.2 to 1.3*

Aerodynamic shape factor — *AS/NZS 1170.2 D2.1*

$C_{fig} = C_{pn} K_p$

$= 1.20 \times 1.0$

$= 1.20$

*Note*

*For convenience, design tables will be prepared using the aerodynamic shape factor,* $C_{fig}$, *of 1.20*

*This may lead to small errors in the determination of pressure, but these are not considered significant.*

Ultimate net wind pressure on free-standing wall — *AS/NZS 1170.2 Clause 2.4.1*

$p_{nu} = C_{fig}\, q_{zu}$

$= 1.20 \times 0.695$

$= 0.834$ kPa

**LOAD FACTORS AND CAPACITY REDUCTION FACTORS**

Load factor on overturning wind pressure — *AS 1170.0 2002 Clause 4.2.1(b)(iv)*

$G_w = 1.0$

Load factor on restoring forces — *AS 4678 2002 Clause J3(c)*

$G_r = 0.8$

# TYPICAL ENGINEERING

## (CMAA DATA SHEET 5B)

## (FENCES BUILT ON REINFORCED STRIP FOOTINGS)

**SHEAR FORCE AND BENDING MOMENTS AT THE BASE OF WALL**

Shear force at base support of exposed wall

$V_b = G_w p_{nu} B' h$

$= 1.0 \times 0.834 \times 1.0 \times 1.80$

$= 1.50$ kN/m

Bending moment at base of support of exposed wall

$M_b = 0.5\, G_w\, p_{nu}\, B'\, h^2$

$= 0.5 \times 1.0 \times 0.834 \times 1.0 \times 1.80^2$

$= 1.35$ kN/m

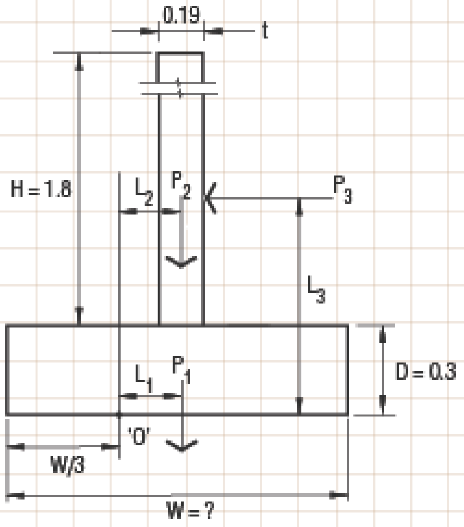
**OVERTURNING ANALYSIS**

As the horizontal force increases, (i.e., normally from wind) the wall will rotate about its base.
The resistance to this movement is provided by the weight and width of base and wall stem providing restoring moments about a point assumed to be one third along the base from either end (toe) depending on which side of wall the wind is blowing. Note one third base location is conservative and will provide adequate bearing capacity for most average strength soils.

**METHOD TO FIND STRIP FOOTING WIDTH B**

To find the required base width 'W' for any given wind pressure and known 300 mm base depth D. Set up either a quadratic equation or an iterative process to solve for 'W'.

**STRIP FOOTING DETAILS**




$N_{1f}$ wind pressure

$p_{nu} = 0.83$ kN/m²

Density of Partially reinforced wall

$\rho_W = 16.0$ kN/m³

Density of concrete footing

$\gamma_f = 23.5$ kN/m³

$P_1$ factored weight of base

$= G_r \gamma_f D W$

$= 0.9 \times 23.5 \times 0.3 \times W$

$P_1 = 6.35$ W

$L_1$ lever arm base

$= \frac{W}{2} - \frac{W}{3}$

$L_1 = \frac{W}{6}$

Base restoring moment about point 'O'

$M_B = P_1 \times L_1$

$= 6.35\ W \times W/6$

$= 1.06\ W^2$ kNm/m

$P_2$ factored weight of wall

$= G_r \gamma_w H\ t$

$= 0.9 \times 16.0 \times 1.8 \times 0.19$

$P_2 = 4.92$ kN/m

$L_2$ lever arm of wall weight about point 'o'

$= \frac{W}{2} - \frac{W}{3}$

$L_2 = \frac{W}{6}$

Wall restoring moment about point 'O'

$M_w = P_2 \times L_2$

$= 4.92 \times W/6$

$= 0.82$ W kNm/m$P_3$ factored

wind force per meter run of wall

$= G_w\, p_{nu}\, H\ 1.0$

$= 1.0 \times 0.83 \times 1.8 \times 1.0$

$P_3 = 1.49$ kN/m

$L_3$ lever arm of wind force about point 'O'

$= H/2 + D$

$= 1.8/2 + 0.3$

$L_3 = 1.2$ m

Wind force overturning moment about point 'O'

$M_w = P_3 \times L_3$

$= 1.49 \times 1.2$

$= 1.79$ kNm/m

Sum of moments about point 'O' = 0

$M_B + M_w - M_w = 0$

$1.06\ W^2 + 0.82W - 1.79 = 0$

Quadratic equation

$$= \frac{-B \pm \sqrt{B^2 - 4ac}}{2a}$$

$$= \frac{-0.82 \sqrt{0.82^2 - 4 \times 1.06 \times (-1.79)}}{2 \times 1.06}$$

$$= \frac{-0.82 + 2.87}{2.12}$$

∴ Base width W required = 0.96 m

But Say = 1.0 m

Check:

$1.06 \times 0.96^2 + 0.82 \times 0.96 - 1.79 = 0$ OK

*Notes :*

1. *A similar approach can be used to determined footing width W for strip footings with the wall stem located at the edge of the footing. (See Figure 1 Type B footing*
2. *The footing Type B width values shown in Table 2 are the same as footing Type A width values and hence are conservative*

**SPACING OF REINFORCED MASONRY 'POSTS'**

- Concrete blocks: Width 190 mm, strength grade 15 MPa
- Blockwork will be built continuous for a length of 2.4 m, with a pier located at the centre and articulation joints at each end.
- Main reinforcement, 1 N16 bar in the centre of the pier

**Masonry Properties**

Masonry unit characteristic unconfined compressive strength

$f'_{uc} = 15.0$ MPa

Units are hollow

Block type factor

$k_m = 1.6$

Equivalent brickwork strength

$f'_{mb} = k_m (f'_{uc})^{0.5}$

$= 1.6 (15.0)^{0.5}$

$= 6.20$ MPa

Mortar joint height

$h_j = 10$ mm

Masonry unit height

$h_b = 190$ mm

Ratio of block to joint thickness

$h_b/h_j = 190/10$

$= 19.0$

Block height factor

$k_h = 1.3$

Characteristic masonry strength

$f'_m = k_h f'_{mb}$

$= 1.3 \times 6.20$

$= 8.06$ MPa

**Concrete Grout Properties**

*Concrete grout specification:*

*Concrete grout shall comply with AS 3700 and have:*

- *minimum portland cement content of 300 kg/cubic metre;*
- *10 mm maximum aggregate size;*
- *sufficient slump to completely fill the cores; and*
- *minimum compressive cylinder strength of 20 MPa.*

Specified characteristic grout cylinder strength

$f'_c = 20$ MPa

> 12 MPa OK

*AS 3700 Clause 5.6*

Design characteristic grout strength

$f'_{cg} = \min[(1.3 \times f'_{uc}), 20.0]$

*AS 3700 Clause 3.5*

$= \min[(1.3 \times 15), 20.0]$

$= \min[19.5, 20.0]$

$= 19.5$ MPa

**Main Reinforcement Properties**

Main reinforcement yield strength

$f_{sy} = 500$ MPa

Main reinforcement shear strength (dowel action)

$f_{sv} = 17.5$ MPa

Number of main tensile reinforcing bars

$N_t = 1$

Diameter of main tensile reinforcing bars

$D_{dia.t} = 16$ mm

Area of main reinforcement

$A_{st} = N_t(3.1416\ D_{dia.t}^2/4)$ (approx)

$= 1 \times 3.1416 \times 16^2/4$

$= 200\ mm^2$

**Dimensions**

The most adverse loading is on the pier near the middle of the wall

Width of pier (along the wall)
$B = 390$ mm

Depth of pier (through the wall)
$D = 190$ mm

Density of reinforced concrete masonry
$\rho_{mas} = 2{,}200$ kg/m$^3$

Modulus of elasticity
$E = 1{,}000\, f'_m$
$= 1{,}000 \times 8.06$
$= 8{,}060$ MPa

Second moment of area of reinforced concrete masonry pier
$I = B\, D^3/12$
$= 390 \times 190^3/12$
$= 222.9 \times 10^6$ mm$^4$

**Main Reinforcement**

Effective depth of reinforcement
For centrally located reinforcement:
$d = D/2$
For reinforcement near one face shell:
$d = D - d_1 + D_{dia.t}/2$
$= 190/2$
$= 95$ mm

Effective width of reinforced section
$b = \min(4D$ or $2D +$ length to structural end)
$= 4 \times 190$
$= 760$ mm *AS 3700 Clause 8.5*

Shear width of reinforced section
$b_v = 200$ mm
*Note: Only one core is grouted*

Design area of main tensile reinforcement
$A_{sd} = \min[0.29(1.3 f'_m) b\, d / f_{sy},\ A_{st}]$
$= \min[(0.29 \times 1.3 \times 8.06 \times 760 \times 95 / 500),\ 200]$
$= \min[462, 200]$
$= 200$ mm$^2$

**Fitments**

There are no shear reinforcement fitments required in this type of construction, which incorporates a single vertical reinforcing bar

Fitment yield strength
$f_{sy.f} =$ NA

Fitment area
$A_f =$ NA

Fitment spacing
$s =$ NA

**Reinforced Masonry Capacity**

From Table 2 maximum spacing of the N16 reinforcing steel is 2.0m

*Clause 8.6 (a) AS 3700*

$\phi = 0.75$ *AS 3700 Clause 4.4*

$f'_{vm} = 0.35$ *AS 3700 Clause 8.8*

Shear capacity

$\phi V = \phi(f'_{vm} b_w d + f_{vs} A_{st} + f_{sy.f} A_{sv} d/s)$

$= 0.75[(0.35 \times 200 \times 95) + (17.5 \times 200) + 0]/1000$

$= 0.75(6.65 + 3.50 + 0)$

$= 7.61$ kN

Bending Moment Capacity

$\phi M = \phi f_{sy} A_{sd} d[1 - 0.6 f_{sy} A_{sd} d/(1.3 f'_m b d)]$

$= 0.75 \times 500 \times 200 \times 95[1 - (0.6 \times 500 \times 200)/(1.3 \times 8.06 \times 760 \times 95)]/10^6$

$= 6.56$ kN.m

Check actual theoretical spacing of reinforcing steel

$\phi M = p_{nu} S H H/2$

$S = \dfrac{2\phi M}{p_{nu} H^2}$

$= \dfrac{2 \times 6.56}{0.83 \times 1.8^2}$

$= 4.9$ m

$\therefore$ *> 2.0 allowed*

$S = 2.0$ m OK

Height of cantilever wall above the strip footing base

$H_c = 1.800$ m

Limiting deflection

$\Delta_a = H_c/50$

$= 1{,}800/50$

$= 36$ mm

Load capacity (limited by shear)

$W_{vu} = 1.0\, \phi V/(B' H_c)$

$= 1.0 \times 7.61/(1.0 \times 1.800)$

$= 4.22$ kPa

Load capacity (limited by bending moment)

$W_{mu} = 2\, \phi M/B' H_c^2$

$= 2 \times 6.56/(1.0 \times 1.800^2)$

$= 4.04$ kPa

Load capacity (limited by deflection)

$W_{\Delta u} = \Delta_a E I/48 H_c^4 B')$

$= [36 \times 8{,}060 \times 222.9 \times 10^6/(48 \times 1.800^4 \times 1.0)]10^{-9}$

$= 128$ kPa

Load capacity (limited by shear, bending moment or deflection)

$W_{lu} = \min(W_{vu}, W_{mu}, W_{\Delta u})$

$= \min(4.22, 4.04, 128)$

$= 4.04$ kPa

$> 0.834$ kPa OK