Reinforced Concrete Block Walls

This training package provides information on single-leaf reinforced concrete blockwork walls, including reinforcement, mortar, grout and roof anchors, for village infrastructure and houses common in south-east Asia and the south Pacific region.

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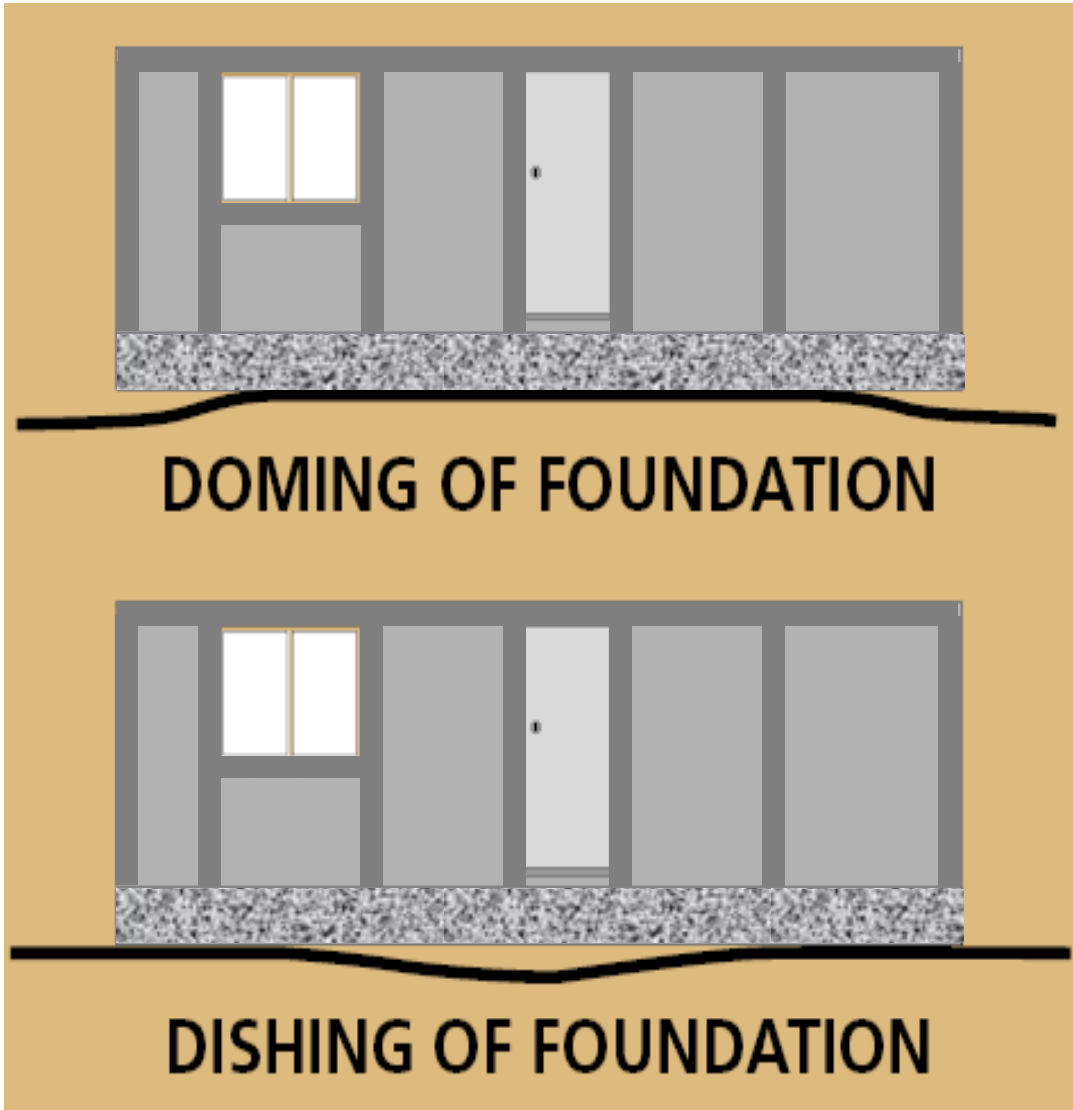
Single leaf reinforced hollow concrete masonry superstructures

Single leaf reinforced hollow concrete masonry walls, built integrally with the concrete footings, with steel starter bars, vertical “wide spaced” reinforcement and a continuous horizontal bond beam behave like a “stiff box”, without significant deflection or cracking.

- 190 mm hollow concrete blockwork.
- N12 steel reinforcement starter bars and N12 vertically reinforced cores at a maximum of 2,000 mm centres
- Continuous bond beam, with 2-N12 reinforcing bars, one top and one bottom.
- Articulation joints are not required.
- The system must have sufficient bending and shear strength, particularly at door and window openings.



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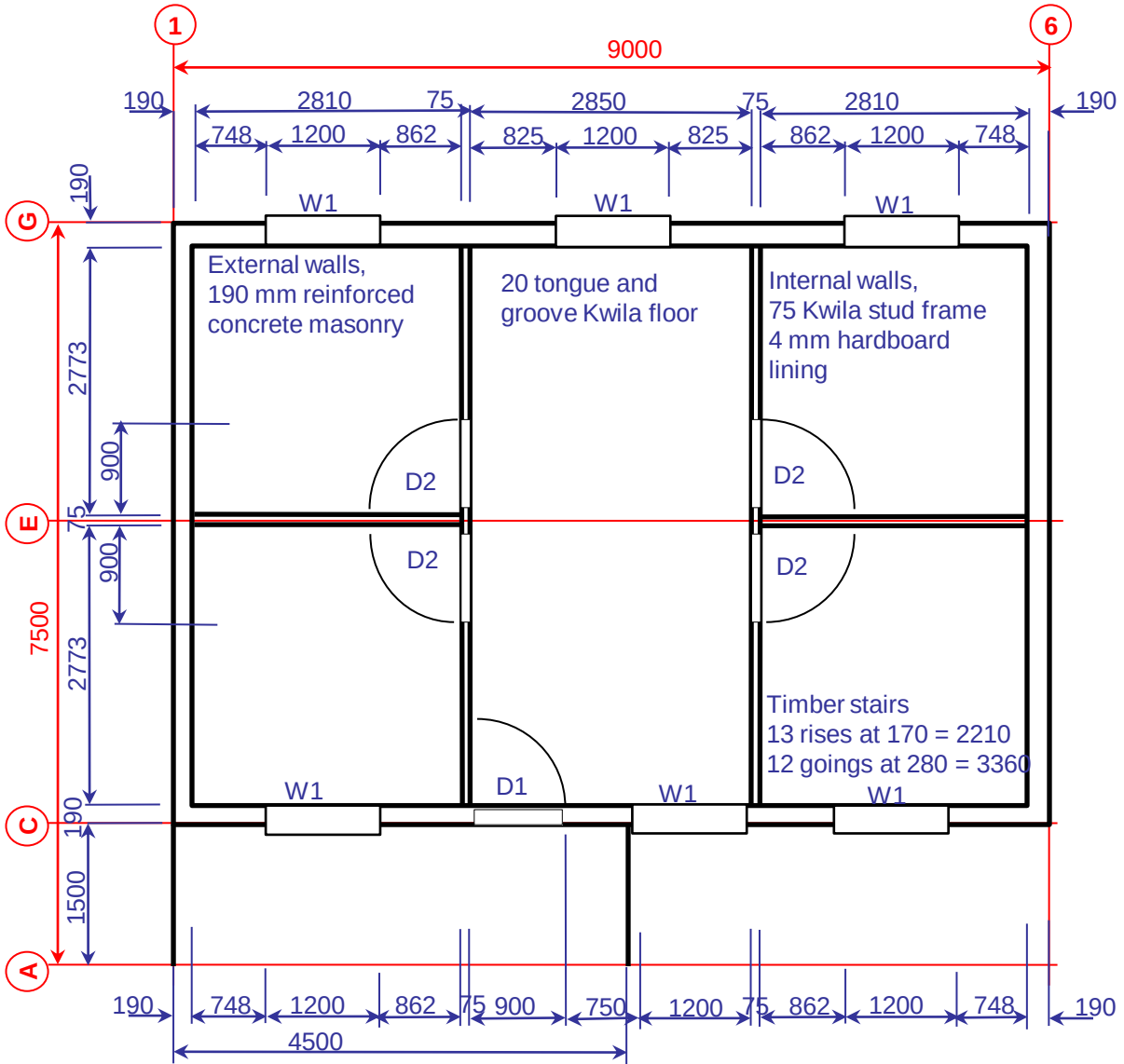
Typical Concrete Masonry House - Floor Plan



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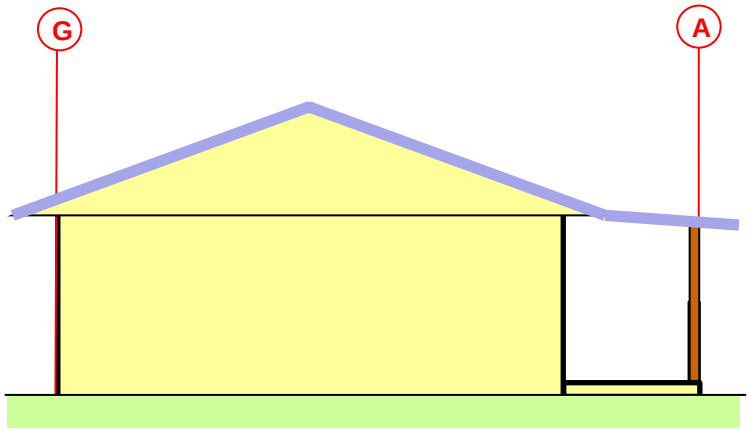
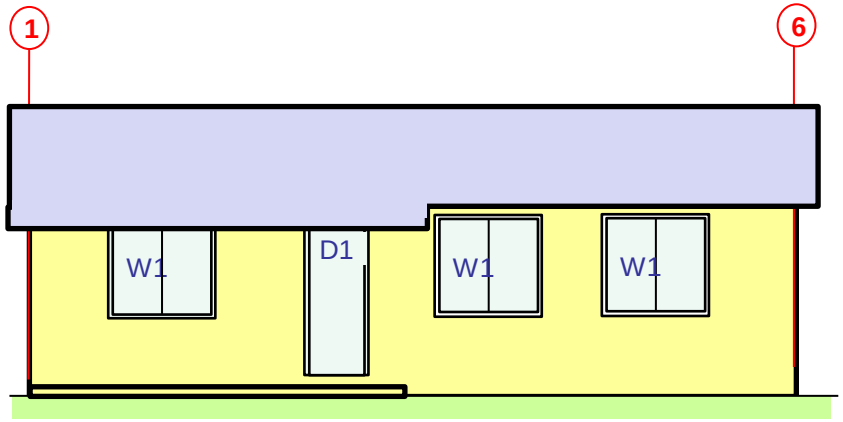
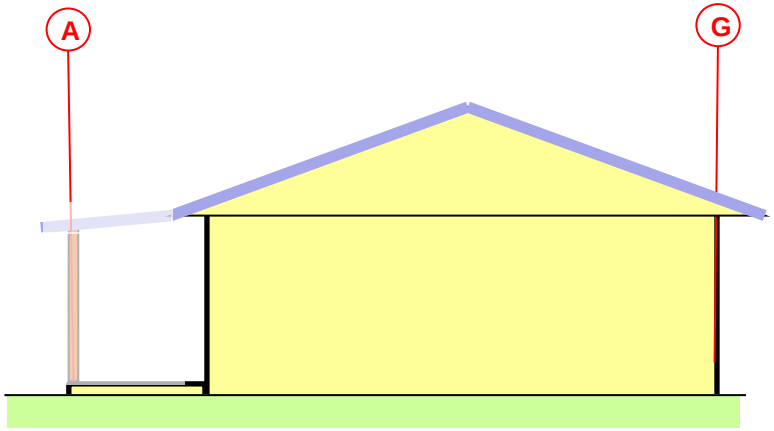
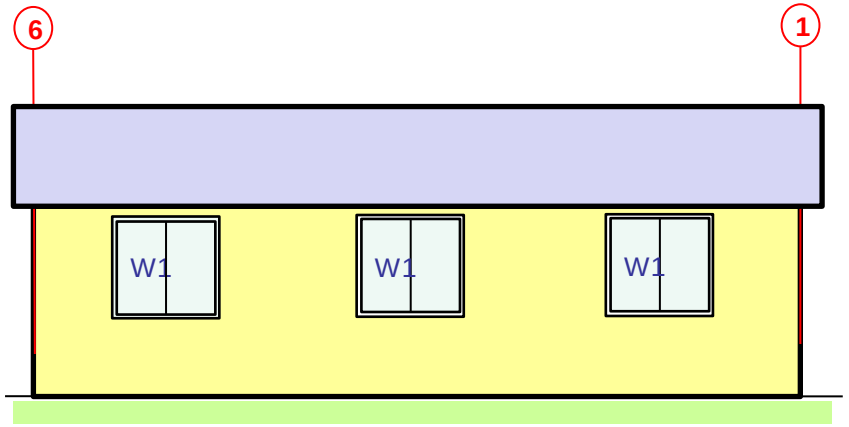
Typical Concrete Masonry House - Elevations









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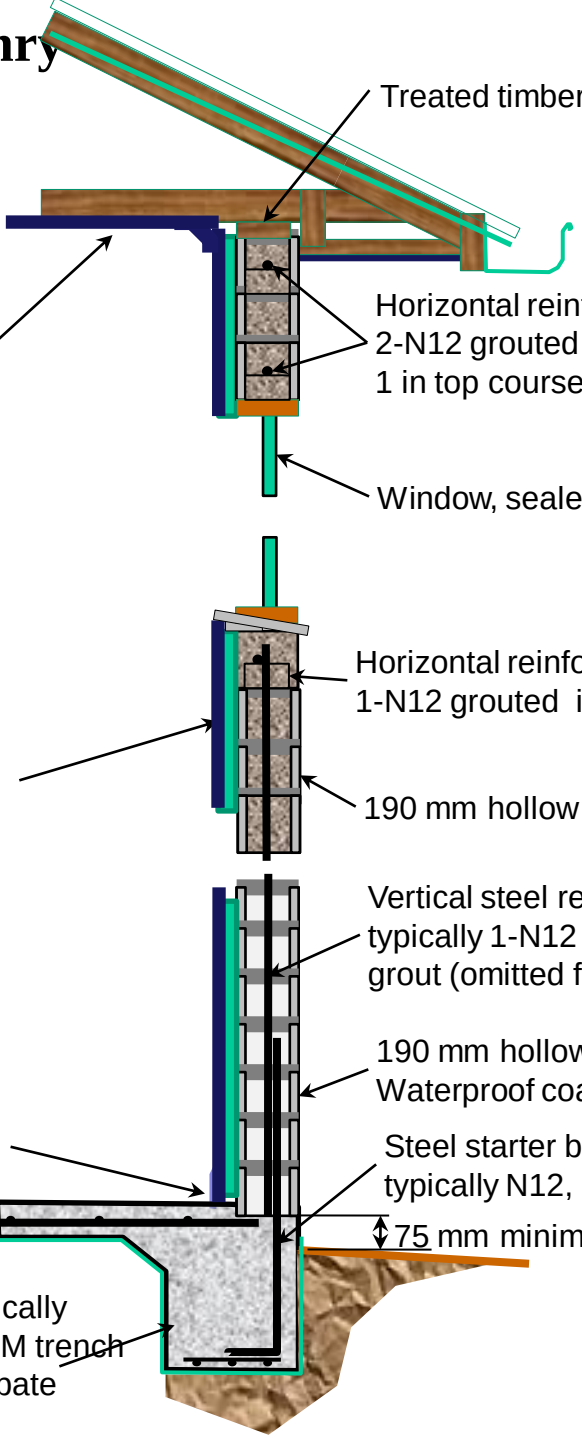
Partially Reinforced Concrete Masonry



Light gauge steel furring channels, fixed by steel clips with thermal break (omitted for clarity), insulation to requirements of building regulations and 10 mm plasterboard lining . This may be omitted if not required by the designer or by the regulations.

Concrete slab/footing/pier system, including sand bed, reinforcement, membrane etc, designed to AS 2870. Typically edge beams and cross beams, 300 x 300 mm with 3-11TM trench mesh. 100 mm concrete slab with SL72 mesh, 20 mm rebate

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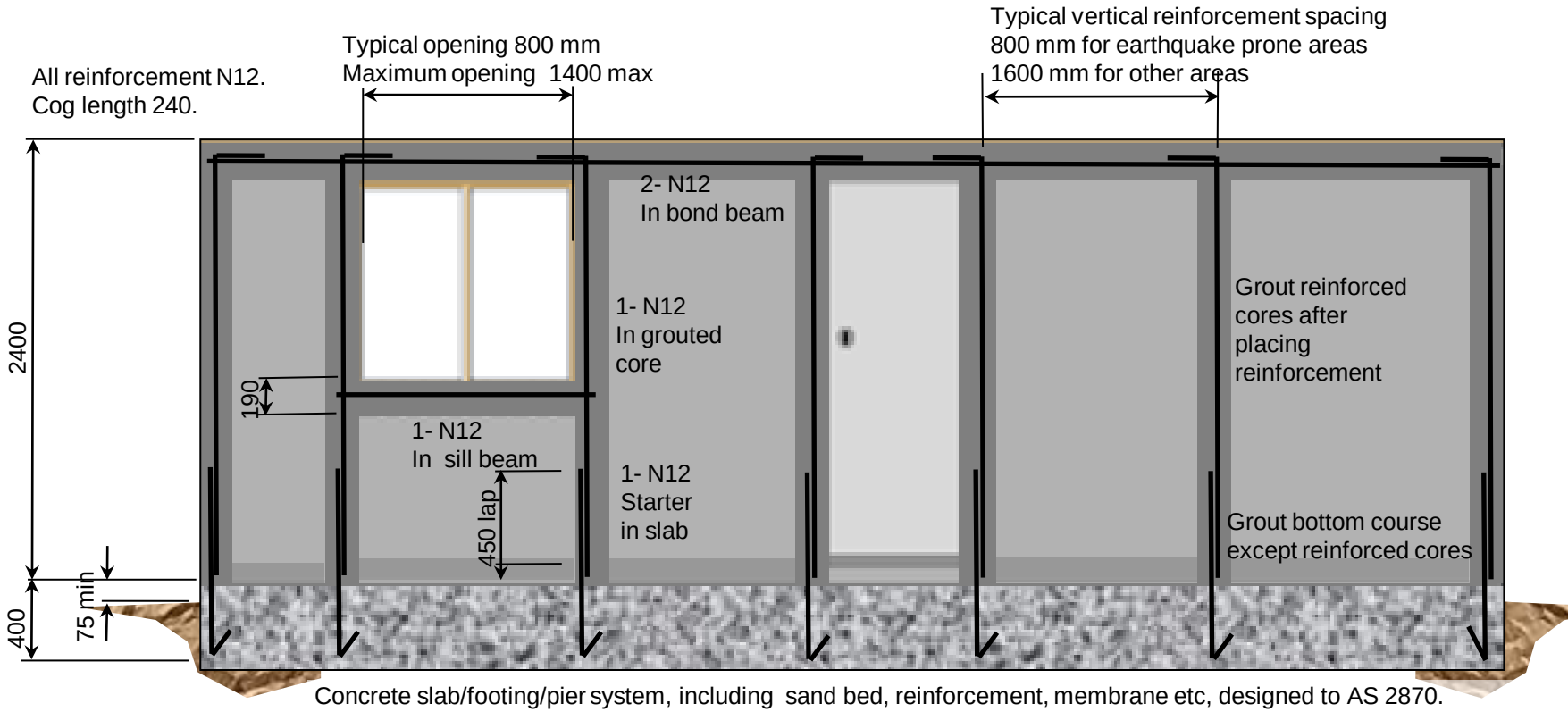
Typical design of single leaf reinforced hollow concrete masonry superstructures



Concrete slab/footing/pier system, including sand bed, reinforcement, membrane etc, designed to AS 2870.
Typically edge beams and cross beams, 300 x 300 mm, 3-11TM trench mesh. 100 mm concrete slab,SL72 mesh.

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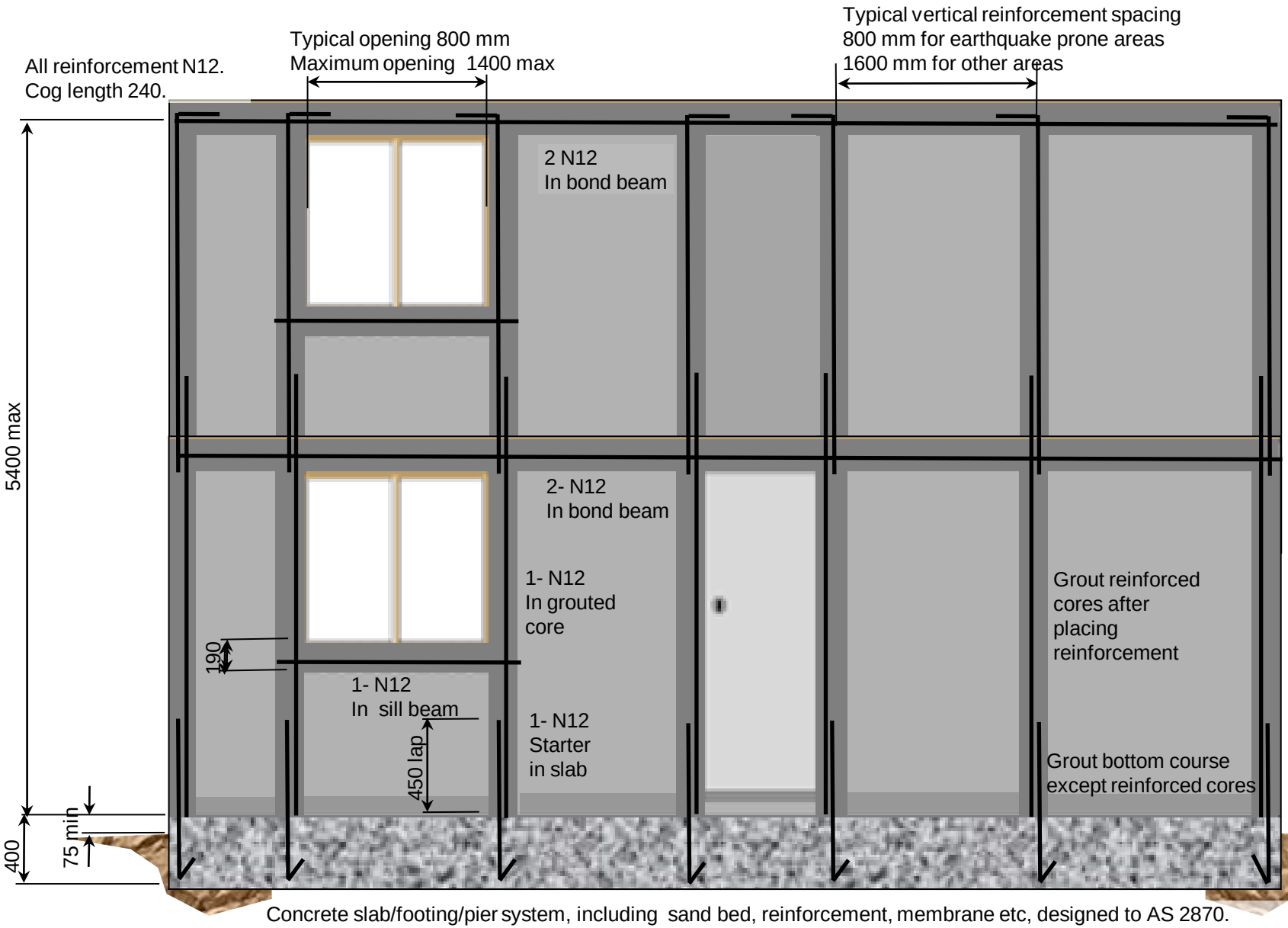
Typical Arrangement of Reinforcement

Typical design of single leaf reinforced hollow concrete masonry superstructures



Concrete slab/footing/pier system, including sand bed, reinforcement, membrane etc, designed to AS 2870.
Typically edge beams and cross beams, 400 x 300 mm, 3-11TM trench mesh. 100 mm concrete slab,SL72 mesh.

Typical Arrangement of Reinforcement

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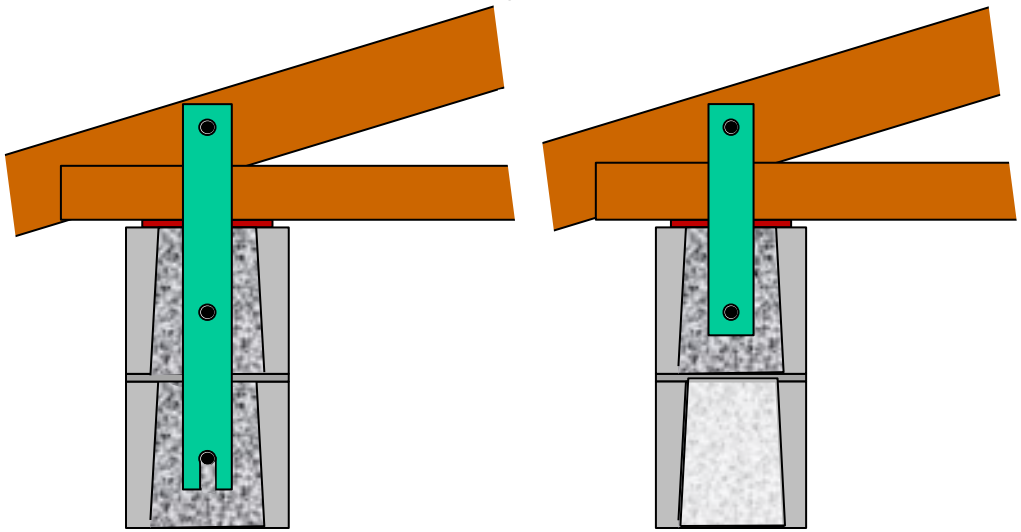
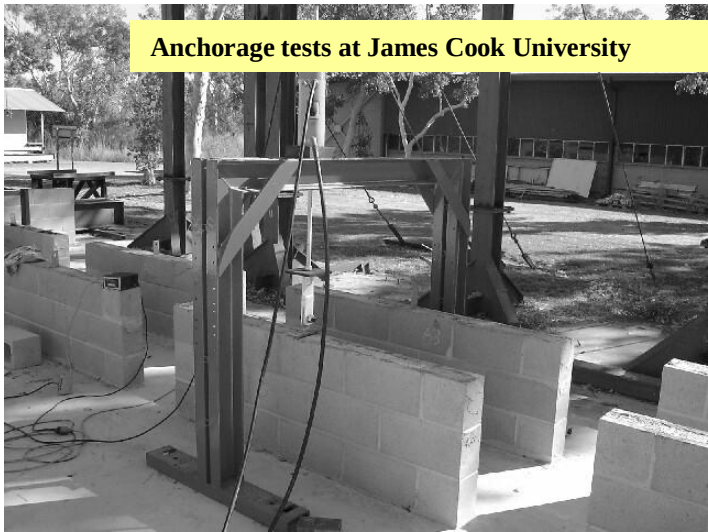
Roof Anchors for Reinforced Concrete Masonry Bond Beams

Cyclonic wind can suck the roof framing off concrete blockwork buildings if the roof anchorages are inadequate.

In reinforced hollow concrete block walls, use steel cleats to tie the roof framing to horizontal steel reinforcement in the reinforced concrete masonry bond beams.

Use the “Bond Beam Fishtail Anchorage Cleat” for bond beams consisting of two courses and the Bond Beam Single Anchorage Cleat” for bond beams consisting of one course. Depending on the roof arrangement, the cleats may need to be offset.





Anchorage tests at James Cook University

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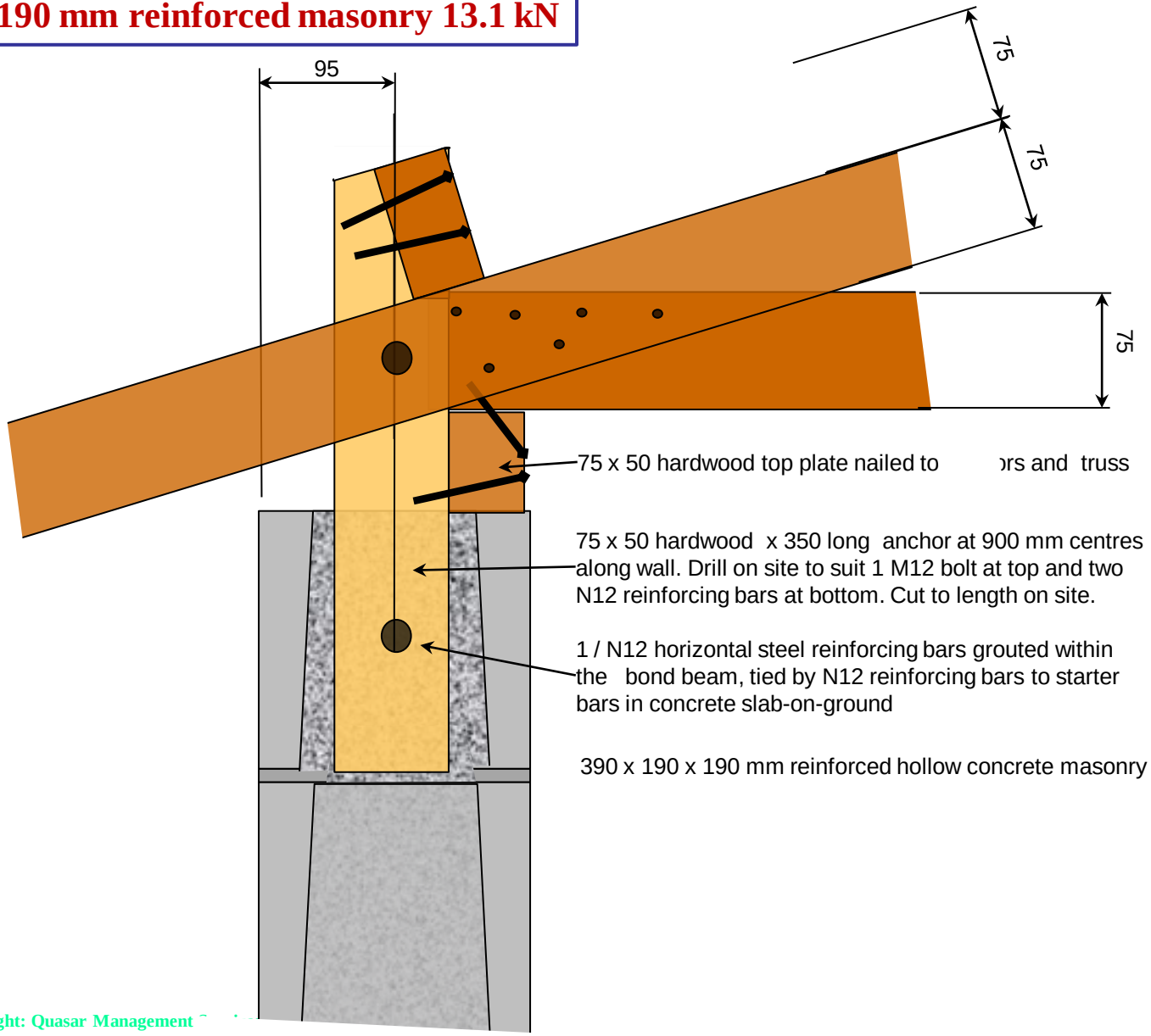
Roof Anchors for "Single" Reinforced Concrete Masonry Bond Beams

Non-cyclonic, Direct Anchorage Roof Truss System

Capacity
190 mm reinforced masonry 13.1 kN



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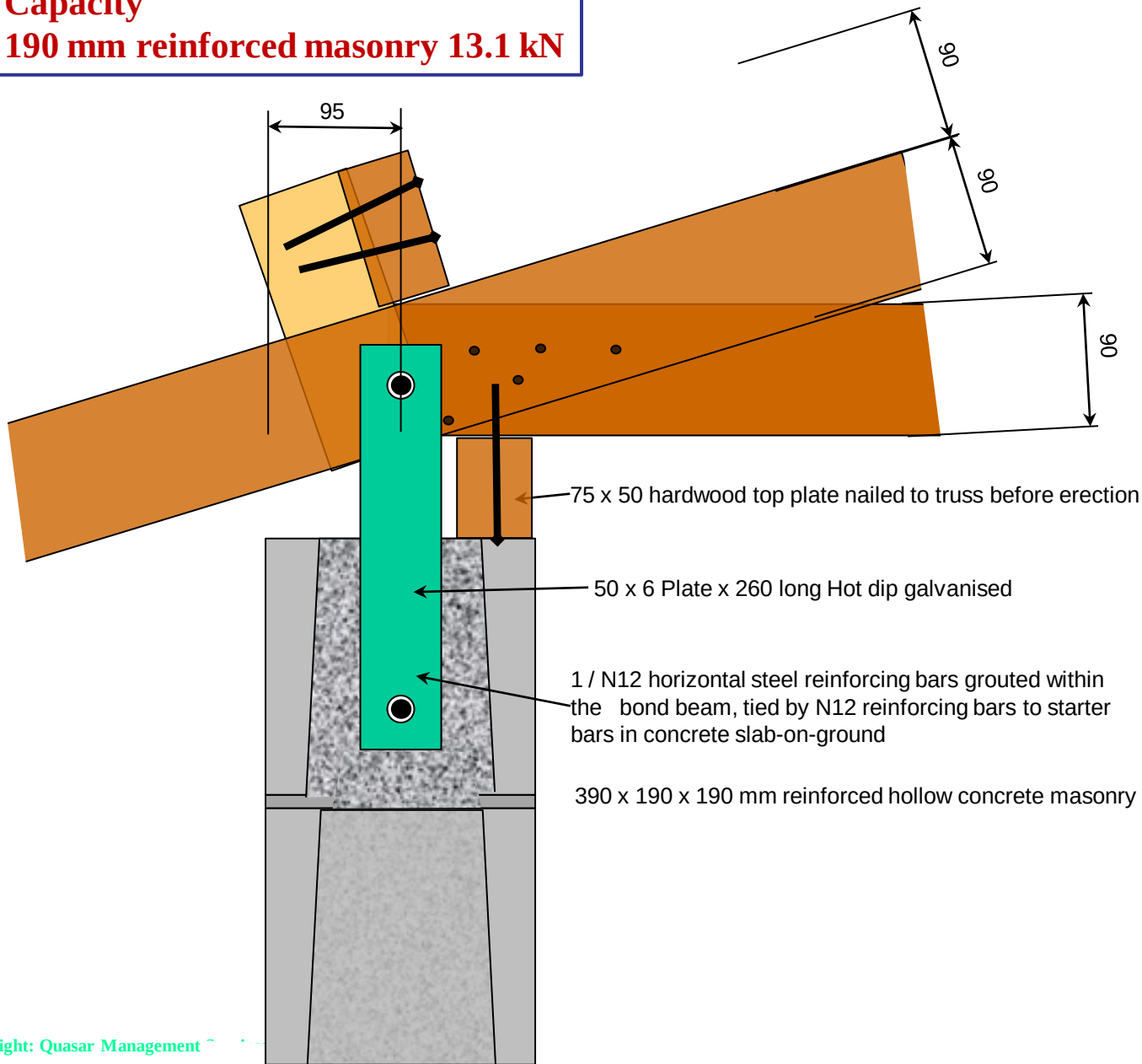
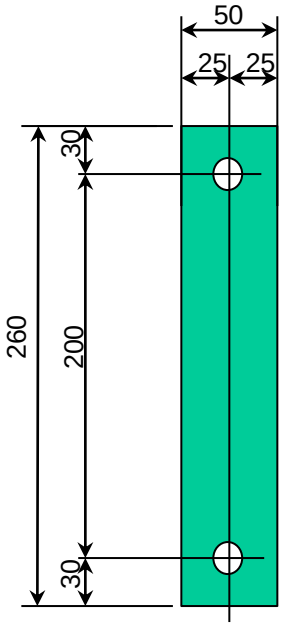
Roof Anchors for "Single" Reinforced Concrete Masonry Bond Beams

Cyclonic, Direct Anchorage Roof Truss System

Capacity
190 mm reinforced masonry 13.1 kN





2 Holes 20 mm diameter

50 x 6 Plate x 260 long Hot dip galvanised

f_{sy} = 250 MPa

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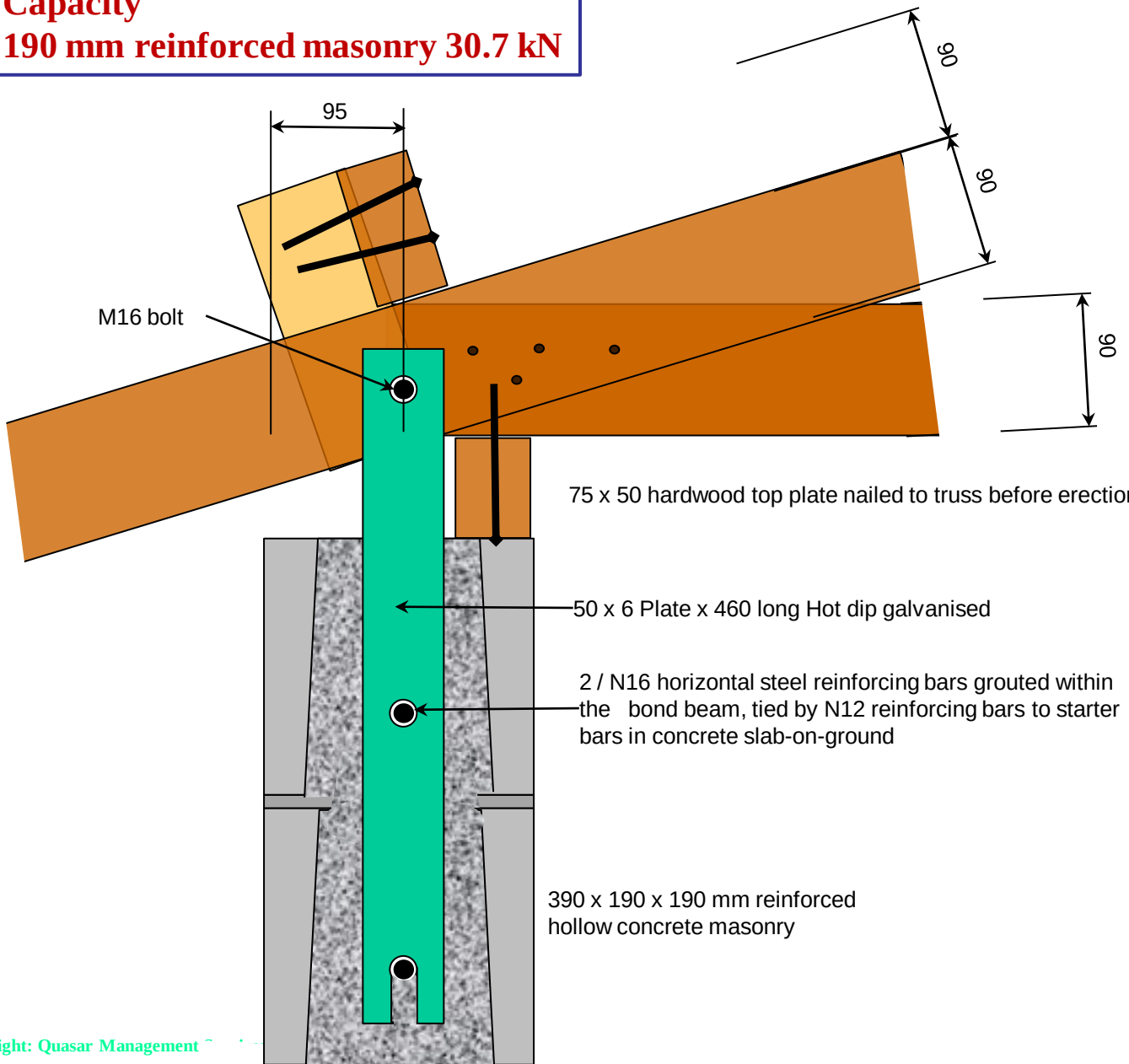
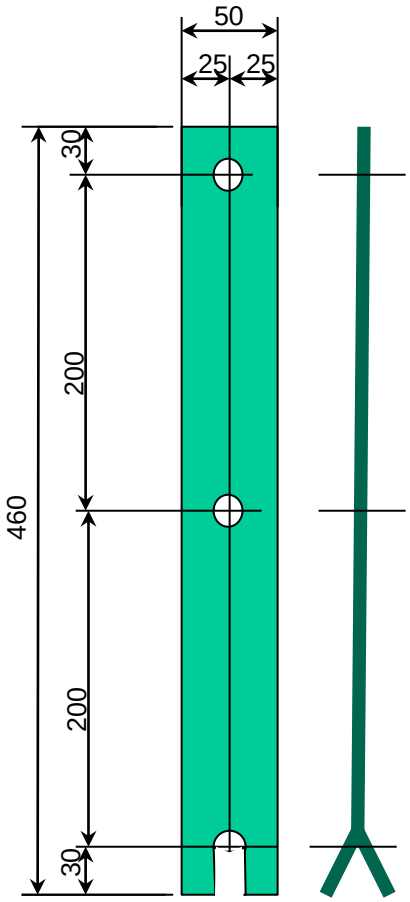
Roof Anchors for "Single" Reinforced Concrete Masonry Bond Beams

Cyclonic, Direct Anchorage Roof Truss System

Capacity
190 mm reinforced masonry 30.7 kN





Form a "fish tail" by bending each side of the cleat though 30°.

50 x 6 Plate x 460 long Hot dip galvanised

f_{sy} = 250 MPa

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Foundations and Formwork

The construction sequence commences with the construction and compaction of an appropriate mound.

For shallow footings, the edge beam may be formed on the mound. For deeper footings, they must be excavated.

The membrane is placed and the reinforcement tied in position.

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Concrete Slabs and Beams

Concrete slabs and ground beams are constructed incorporating starter bars. As a safety measure these should be capped. Alternatively, they may be hooked as shown below.

Because of the waterproof coating subsequently applied to the wall, it is not common to include a rebate in the slab.

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Concrete Blockwork

The concrete blockwork superstructure is constructed with a small overhang over the concrete slab, to ensure that it can be subsequently weather-proofed.

A suitable termite-proofing details is also incorporated.

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Wall Reinforcement

Vertical “wide spaced” reinforcement is placed in the walls in accordance with AS 4773.1 and AS 4773.2.

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Reinforced Bond Beams and Lintels

The reinforcement in the bond beams and lintels must be detailed in accordance with AS 4773.1 and AS 4773.2 to ensure the following:

- The reinforcement must transfer loads via the wall reinforcement and starter bars to the footings.
- The reinforcement must be correctly positioned using hangers, spacers and the like to provide both strength (effective depth) and durability (cover).
- The inclusion of a horizontal bond beam at each suspended floor level provides additional integrity to partially reinforced blockwork, and also provides a sound substrate for the fixing of floor anchors.

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Roof Framing

The roof system must be adequately tied to the bond beams.
The Concrete Masonry Association of Australia has sponsored research projects at the Cyclone Testing Station of James Cook University.

The roof and ceiling system must also provide “diaphragm” action, transferring horizontal loads from the sides of the building to the shear walls at the ends.

Tests

Water-resistant Finish

No masonry systems are impermeable to water, and therefore single leaf reinforced concrete masonry houses must be coated with a water-resistant finish. There is a very wide range of suitable paints and renders commercially available.

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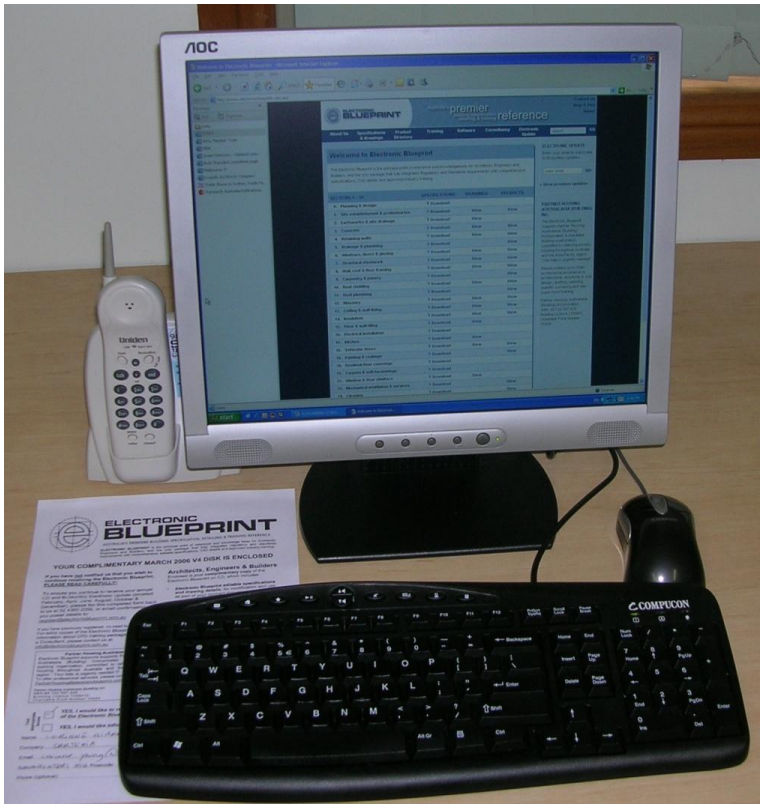
Strong Enough ???

Specification

This module provides typical specifications, summarised from the Electronic Blueprint.



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Specification

The design and construction of masonry should comply with AS 4773.1 and AS 4773.2 or AS 3700.

Australian Standards

All masonry components and installation shall comply with the Building Regulations and relevant Australian Standards, including AS 4773.1 and AS 4773.2 and the standards referred to therein.

AS/NZS 4455-2007 Part 1: Masonry units covers bricks and blocks to be laid in mortar to construct walls, piers and the like. The standard does not specify particular values for the relevant properties (strengths, tolerances, exposure grades, contractions, expansion and the like). The designer must determine this information and include it in the specification.

Masonry Units

Masonry units shall be concrete units complying with AS/NZS 4455.1 and the following requirements.

There are two different methods of determining the dimensional tolerances of masonry units.

"Method A" ensures the "average" dimension is within the stated tolerance, and is applicable to 230 x 76 mm etc bricks in 10 mm joints.

"Method B" ensures that both the "average" dimension is within the stated tolerance and the variability is controlled. This is applicable to 390 x 190 mm etc concrete blocks in 10 mm joints.

Concrete masonry units shall comply with Dimensional Category DW1 (determined using AS/NZS 4456.3 Method A), except that split or irregular faces may be DW0.

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Specification

Most masonry units are produced to General Purpose Salt Attack Resistance Grade.

If particularly severe conditions are expected (as defined by AS 3700 Table 5.1 or Table 12.2), then Exposure Grade may be appropriate to provide suitable durability.

Hollow concrete blocks are laid on thin strips of mortar (normally 25 to 35 mm wide), corresponding to the face shells of the blocks. Their strength is measured by supporting the hollow units on two strips of plywood, crushing, and dividing the crushing load by the width of the two face shells. For a typical 190 mm high unit, the platen restraint factor is taken as 1.0.

For masonry subject to high lateral loads, the Engineer may specify the Characteristic Lateral Modulus of Rupture. The specification of Coefficient of Residual Drying Contraction for concrete units is recommended as one means of controlling cracking in the finished masonry.

Concrete masonry units shall meet General Purpose Salt Attack Resistance Grade, except for applications requiring Exposure Grade. Applications requiring Exposure Grade are:

- saline wetting or drying,
- aggressive soils,
- severe marine environments,
- saline or contaminated water including tidal or splash zones, or
- within 1 km of a industry producing chemical pollutants

Concrete masonry units shall have a Characteristic Compressive Strength not less than 15 MPa measured using face shell bedding.

Concrete masonry units shall have a Characteristic Lateral Modulus of Rupture not less than 0.8 MPa.

Concrete masonry units shall have a Mean Coefficient of Residual Drying Contraction not more than 0.6 mm/m.

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Specification

Cement and lime used in the masonry mortar should comply with the relevant standards.

In some applications, as a substitute for lime, it is recommended that methyl-cellulose water thickener be used. This is a gel that holds the moisture in the mortar until it has time to hydrate and harden.

Methyl cellulose water thickener is quite different from air-entraining agent, which is commonly used to increase mortar workability. The over-dosing of air-entraining agent is often detrimental to the quality of the mortar.

Mortar sand should be well graded with a minimum of fine content, silt and clay passing the 75 micron sieve. This is to minimise mortar shrinkage and to maximise bond strength.

Cement

Cement shall be Type GP portland cement or GB blended cement complying with AS 3972.

Lime

Lime shall be hydrated building lime complying with AS 1672.1

Water Thickener

Water thickener shall be methyl-cellulose based.

Sand

Sand shall be well graded and free from salts, vegetable matter and impurities. Sand shall not contain more than 10% of the material passing the 75 micron sieve. Sand within the following grading limits complies with this requirement and is deemed suitable for concrete masonry.

Sieve	Percent Passing
4.76 mm	100
2.36 mm	95–100
1.18 mm	60–100
600 µm	30–100
300 µm	10–50
150 µm	0–10
75 µm	0–4

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Specification

The reinforcement specification is similar to most reinforced concrete applications.

Reinforcement

Reinforcement shall comply with AS/NZS 4671 and shall be:

- Deformed bars - 500 MPa, normal ductility (N)
- Fitments -500 MPa, low (L) or normal (N) ductility ribbed wires

Concrete grout must have sufficient portland cement to provide an alkaline environment that protects the steel reinforcement.

Limiting the size of aggregate to 10 mm insures against the formation of voids.

Specifying a high slump ensures that the grout can flow to all parts of the hollows

AS 3700 requires grout to have a strength of at least 12 MPa. AS 3700 limits the design strength of grout to 1.3 times the compressive strength of the concrete block.

1.3 times 15 MPa is 19.5 MPa. Therefore there is little point in specifying a strength in excess of 20 MPa.

Concrete Grout

Concrete grout shall have:

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

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Specification

Flashings are installed in masonry to prevent the migration of rainwater to the inside of the building.

Flashings shall be water resistant and sufficiently robust to remain intact during construction. They must not disrupt the structural function of the masonry.

Uncoated annealed lead shall not be used on any roof that is used to catch potable water.

Flashings and Termite Barriers

Flashings shall comply with AS/NZS 2904.

Metal and metal-cored flashings shall not be used in locations that expose them to saline ground water or rising salt damp.

Metal flashings shall be compatible with the materials with which they are in contact, and shall not give rise to electrolytic action. If there is potential for electrolytic action to occur, flashings shall be isolated by inert materials.

Flashings intended to hold their shape shall be manufactured from rigid material. (e.g. metal cored material)

Flashings shall be one of the following:

- Uncoated copper having a mass not less than 2.8 kg/m^2 and having a thickness of 0.3 to 0.5 mm;
- Bitumen coated metal (normally aluminium) with a total coated thickness of 0.6 mm to 1.0 mm;
- Zinc coated steel of thickness not less than 0.6 mm.

Termite barriers shall comply with the requirements of AS 3660.1.

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Specification

Important considerations for reinforced masonry are the simultaneous provision of steel cover (which affects corrosion protection) and steel effective depth (which affects bending strength).

When specifying horizontal steel, the designer must carefully consider the potential problems surrounding corrosion in the perpendicular joints, and the difficulties associated with getting the grout to flow down cores and around horizontal bars.

Blockwork less than 190 mm should not be horizontally reinforced.

AS 3700 and AS 4773 permit lesser cover in some applications. However, covers less than 20 mm are generally less practical and could lead to honey-combing of the concrete.

Construction

General

All construction of reinforced concrete masonry shall comply with AS 3700.

Vertical steel reinforcement shall be tied using tie wire to steel starter bars through clean-out holes in each reinforced core and fixed in position at the top of the wall by plastic clips or template.

Starter bars shall be tied into position to provide the specified lap above the top surface of the footing.

The starter bars shall be held in position on the centre line of a reinforced blockwork wall by a timber member or template and controlled within a tolerance of +,- 5 mm through the wall and +,- 50 mm along the wall.

Horizontal steel may be laid in contact with rebated webs of blocks.

The minimum cover to the inside face of the block shall be 20 mm.

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Specification

Mortar should be selected to provide adequate durability, protection to the reinforcement and bond strength. For most applications, Type M3 mortar will be suitable, although Type M4 will be required in severe environments.

M4 applications are:

- Elements in interior environments subject to saline wetting and drying
- Elements below a damp-proof course or in contact with ground in aggressive soils
- Elements in severe marine environments
- Elements in saline or contaminated water including tidal splash zones
- Elements within 1 km of an industry producing chemical pollutants.

Mortar joints are commonly 10 mm thick. For hollow blockwork, the mortar joints should correspond to the face shells of the block. Mortar should not be laid across the webs of hollow blocks.

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M3 Mortar

For general applications (except as listed for M4), Type M3 mortar shall be used, and shall consist by volume of:

1 part GP or GB cement, 1 part lime, 6 parts sand (water thickener optional), OR

1 part GP or GB cement, 5 parts sand plus water thickener

M4 Mortar

For the applications listed below, Type M4 mortar shall be used, and shall consist by volume of:

1 part GP or GB cement, 0.5 part lime, 4.5 parts sand (water thickener optional), OR

1 part GP or GB cement, 4 parts sand plus water thickener

Mortar Joints

Mortar joints shall be 10 mm thick.

Mortar joints in hollow blockwork, shall be face shell bedded and shall be ironed, unless a flush joint is specified for aesthetic reasons.

Specification

Correctly sized anchorage must be installed with the drawings.

Safety during the construction is of paramount importance.

The specification is intended to assist the builder to determine the appropriate temporary bracing for the particular application.

Masonry walls are normally supported in a building by the roof, upper floors (if any), piers and cross-walls. During construction, some of these may not be present.

Anchorages

Anchorages shall be installed at locations specified on the drawings.

Temporary Supports

During construction, walls shall be supported by temporary props to guard against collapse due to high wind or accidental loading.

The spacing of supports for 190 mm shall not exceed 4.0 metres.

- Walls shall the supported from both sides.
- Supports in compression must be thick enough to prevent buckling.
- Supports must be anchored firmly to the slab and to the masonry to prevent sliding.
- Supports should be designed by an experienced and qualified structural engineer.

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