Wall Bracing and Roof Anchorage

This training package covers wall bracing and roof anchorage, for improving cyclone, earthquake and tsunami resistance of village infrastructure and houses common in South-East Asia and the South Pacific region.

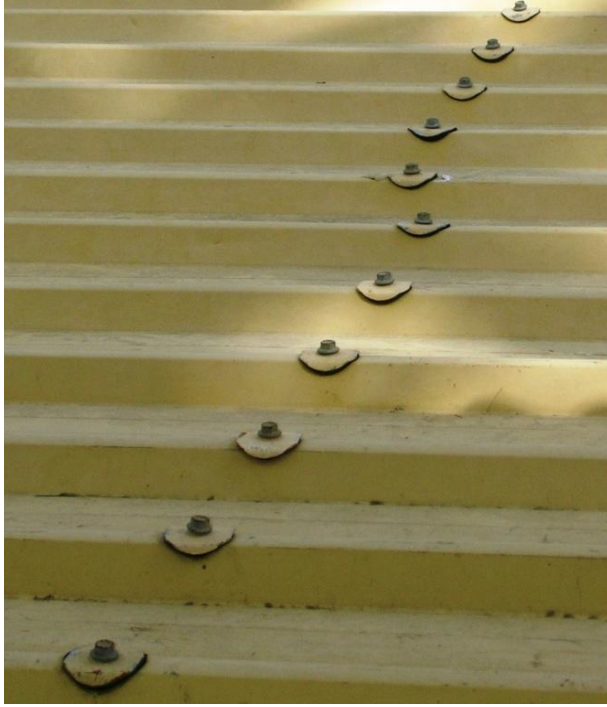
Photo: Cyclone Damage on Aitutaki in the Cook Islands
Courtesy of D Kaunitz (Emergency Architects Australia)

Roof Fixings and Cyclone Washers

Cyclonic wind can suck roof sheeting (and wall sheeting) off the framing if there is an insufficient number of appropriate roofing screws, or if the screws have been installed without cyclone washers.

Roof sheets should be fixed through the high point of the ribs using long screws, not valley fixed. Roof sheets shall be laid in continuous lengths where practical, with the upper end turned up using the correct tool.

In very high wind areas, turn the sheets down into the eaves gutter at the lower end.



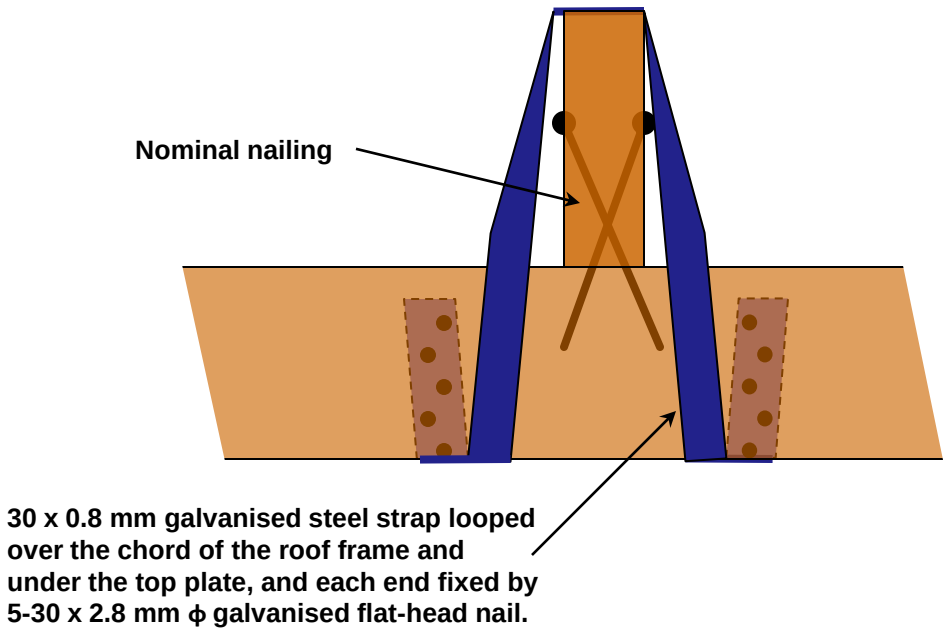
Suitable Spans and Fixing Arrangemetns of Corrugated Steel Sheeting (0.42 mm BMT)					
AS 4055 Wind Classification	**N1 N2 N3**	**N4 C1**	**N5 C2**	**N6 C3**	**C4**
Maximum end span without cyclone washers	950	900	750	Not suitable	Not suitable
Maximum end span with cyclone washers		1,200	900	Not suitable	Not suitable
Number of ribs to be fixed	Every second rib	Every rib	Every rib	Not suitable	Not suitable
Maximum internal span without cyclone washers	1,200	900	750	Not suitable	Not suitable
Maximum internal span with cyclone washers		1,200	900	Not suitable	Not suitable
Number of ribs to be fixed	Every third rib	Every rib	Every rib	Not suitable	Not suitable

Notes:
1. In some cirmstances, engineering analysis of test results may give improved spans.
2. Refer to roofing manufacturer's technical manuals for specification of fixing screws, details and material compatibility.
3. References include: Lysaghts "Cyclonic Area Design Manual". http://www.lysaght.com/roofing

Roof Framing Fixings

Cyclonic wind can suck the roof framing off the timber wall framing if there is an insufficient number of appropriate ties, or if the ties are not correctly fixed to the wall framing.

Capacity 13.0 kN
Based on AS 1684.3 Table 9.17

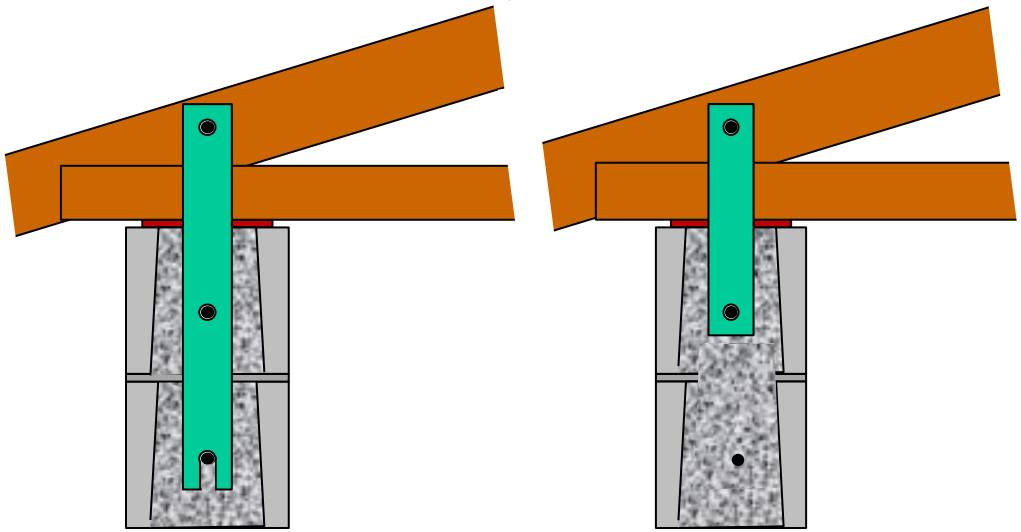


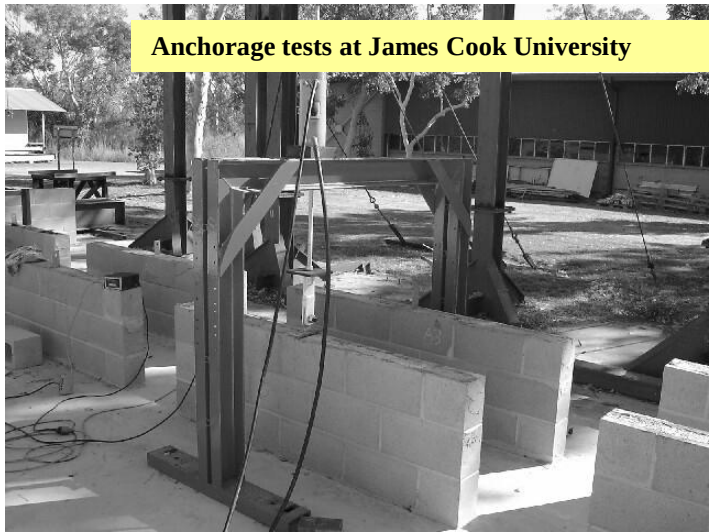
Roof Anchors for Reinforced Concrete Masonry Bond Beams

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.

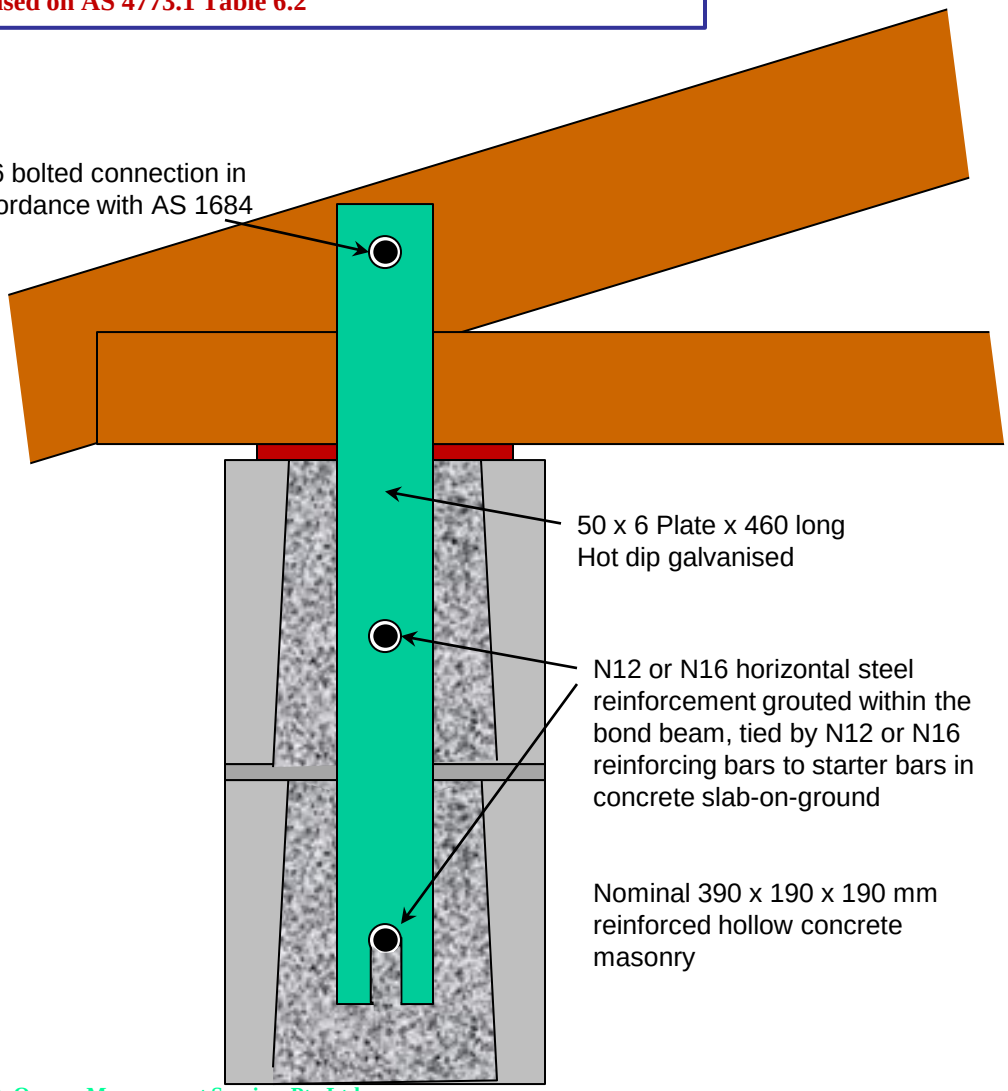


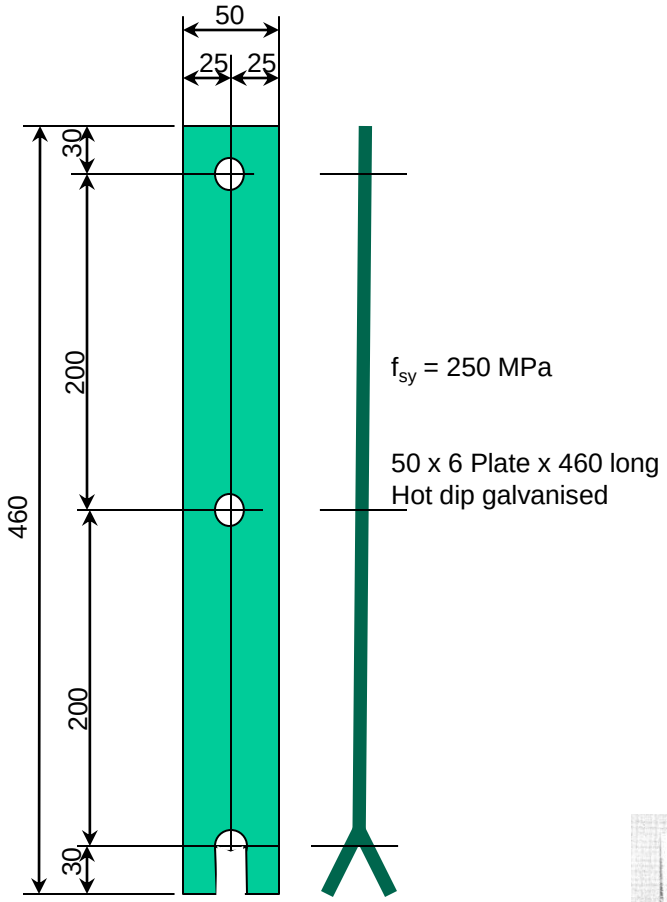


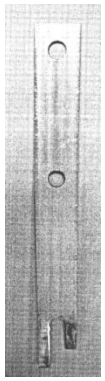
Anchorage tests at James Cook University

“Fishtail” Roof Anchors for Reinforced Concrete Masonry Bond Beams

Capacity
190 mm reinforced masonry 30 .7 kN
140 mm reinforced masonry 23.3 kN
Based on AS 4773.1 Table 6.2

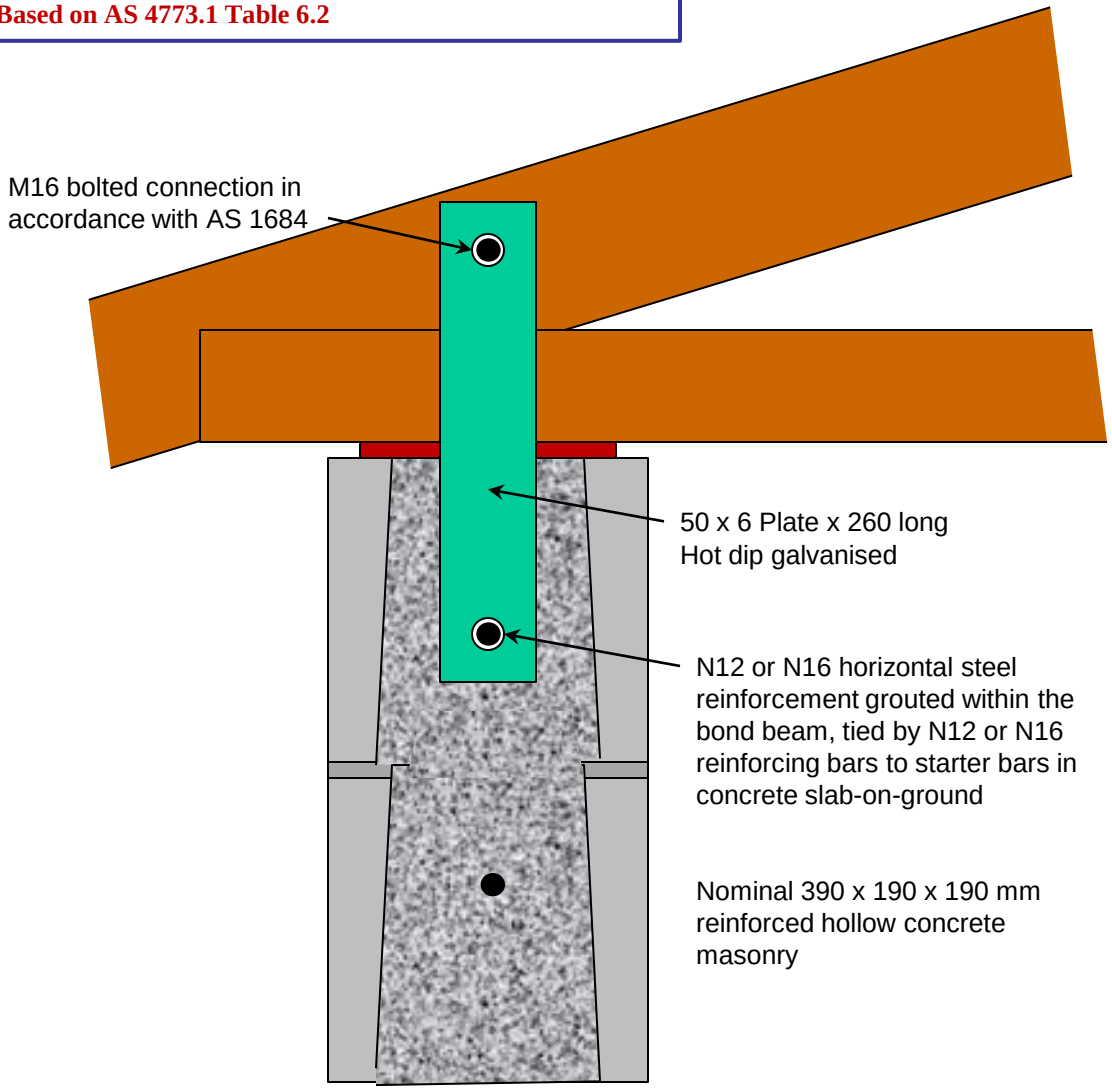


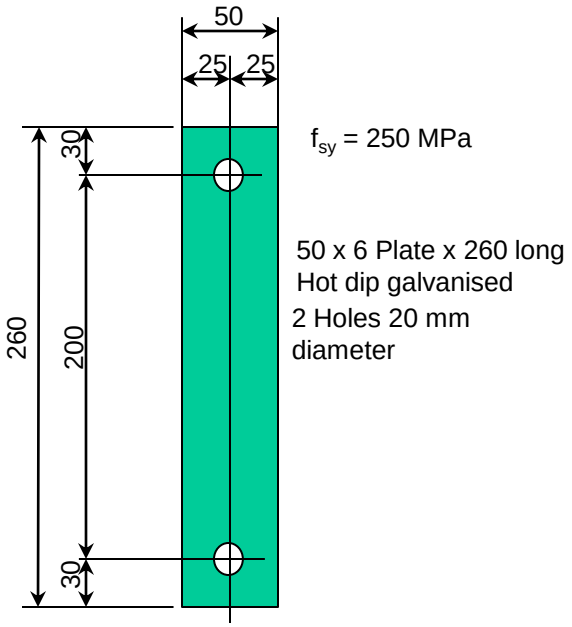


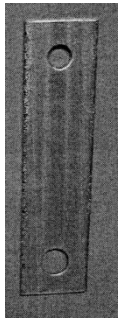


“Single” Roof Anchors for Reinforced Concrete Masonry Bond Beams

Capacity
190 mm reinforced masonry 13.1 kN
140 mm reinforced masonry 11.3 kN
Based on AS 4773.1 Table 6.2







Lateral Bracing

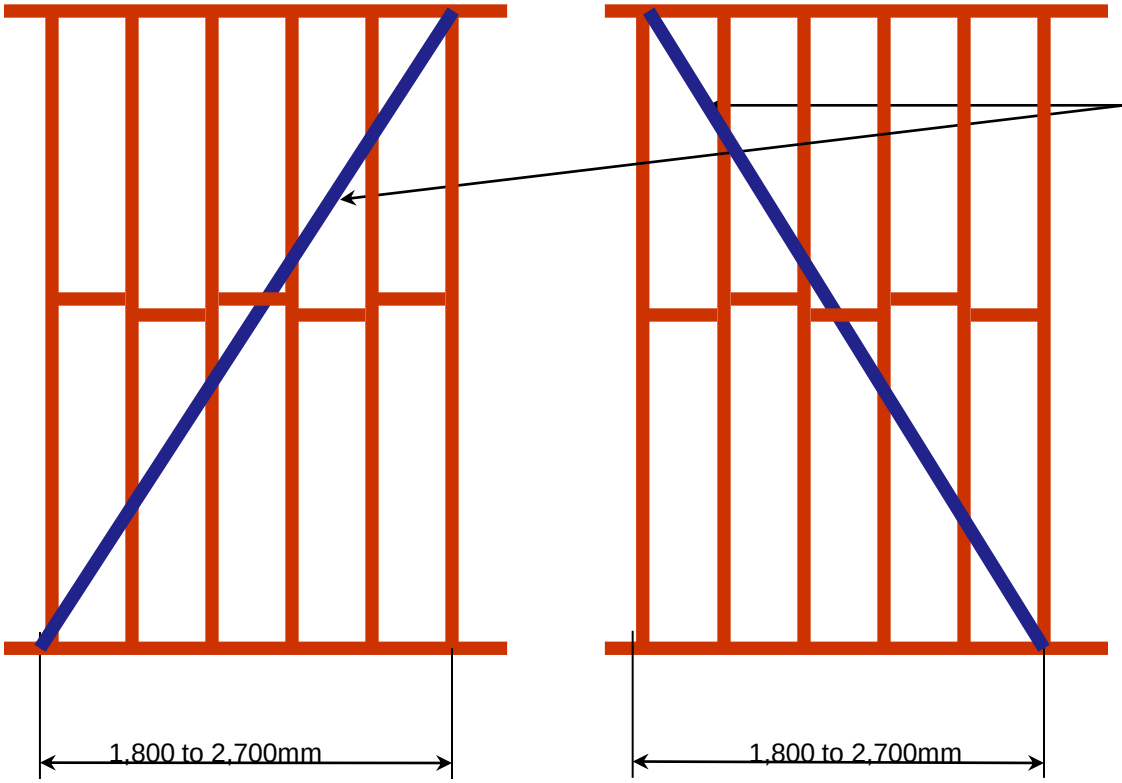
Failure to provide adequate cross bracing will make a building liable to collapse due to “racking” action caused by wind, earthquake or tsunami.

This may be prevented by installing:

- Wall bracing, and
- Subfloor bracing (in elevated buildings).

Wall Bracing – Two Diagonally Opposed Timber or Metal Braces

Capacity 0.8 kN/m length
Based on AS 1684.3 Table 8.18 (a)



45 x 19 mm or 70 x 19 mm hardwood timber braces fixed to each stud and plate by 1-50 x 2.8 mm ϕ galvanised flat head nail

OR

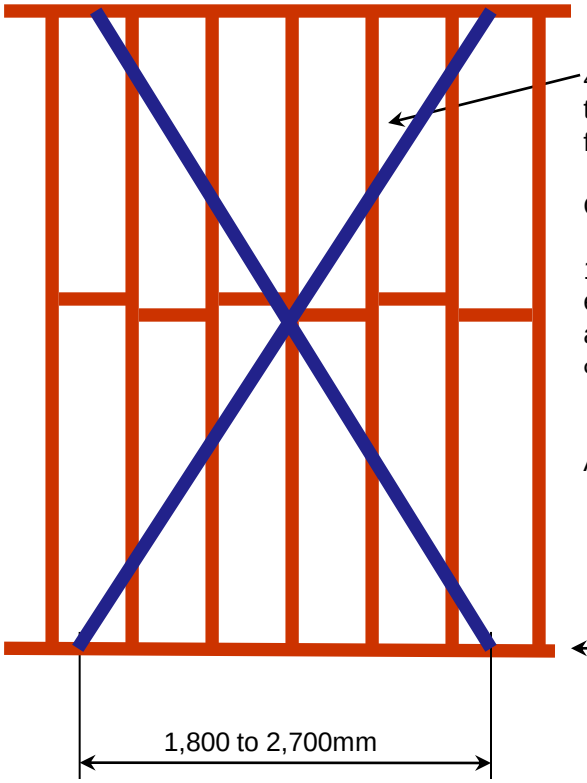
18 x 16 x 1.2 mm galvanised steel angle brace fixed to each stud by 1-30 x 2.8 mm ϕ galvanised flat-head nail and nailed to the top and bottom plates by 2-30 x 2.8 mm ϕ galvanised flat-head nails.

Angle of braces from horizontal between 30^{o} and 60^{o}.

Fix bottom plate to floor frame or concrete slab with nominal fixings

Wall Bracing – Pairs of Tensioned Metal Straps

Capacity 1.5 kN/m length
Based on AS 1684.3 Table 8.18 (b)



45 x 19 mm or 70 x 19 mm hardwood timber braces fixed to each stud and plate by 1-50 x 2.8 mm ϕ galvanised flat head nail

OR

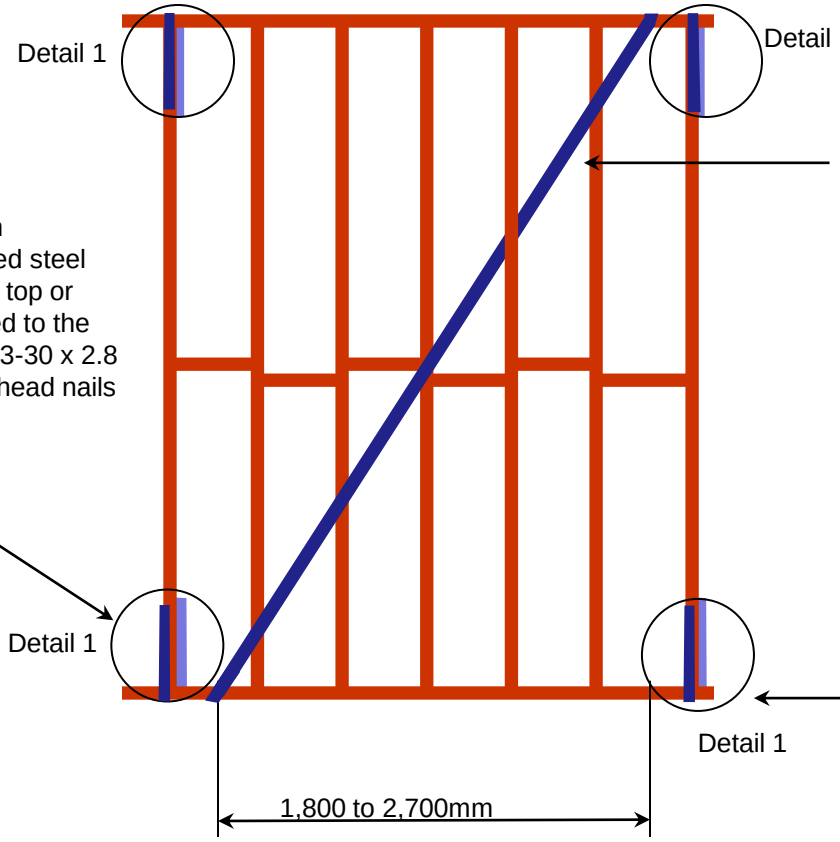
18 x 16 x 1.2 mm galvanised steel angle brace fixed to each stud by 1-30 x 2.8 mm ϕ galvanised flat-head nail and nailed to the top and bottom plates by 2-30 x 2.8 mm ϕ galvanised flat-head nails.

Angle of braces from horizontal between 30^{o} and 60^{o}.

Fix bottom plate to floor frame or concrete slab with nominal fixings

Wall Bracing – Timber or Metal Angle Braces

Capacity 1.5 kN/m length
Based on AS 1684.3 Table 8.18 (c)



Detail 1
Four sets of ties, each 30 x 0.8 mm galvanised steel strap looped over the top or bottom plates and fixed to the stud on both sides by 3-30 x 2.8 mm ϕ galvanised flat head nails

75 x 15 mm F8 timber brace fixed to each stud and plate by 2-50 x 2.8 mm ϕ galvanised flat head nails

OR

20 x 18 x 1.2 mm galvanised steel angle brace fixed to each stud by 2-30 x 2.8 mm ϕ galvanised flat-head nails

Depth of notch or saw cut in studs shall not exceed 20 mm

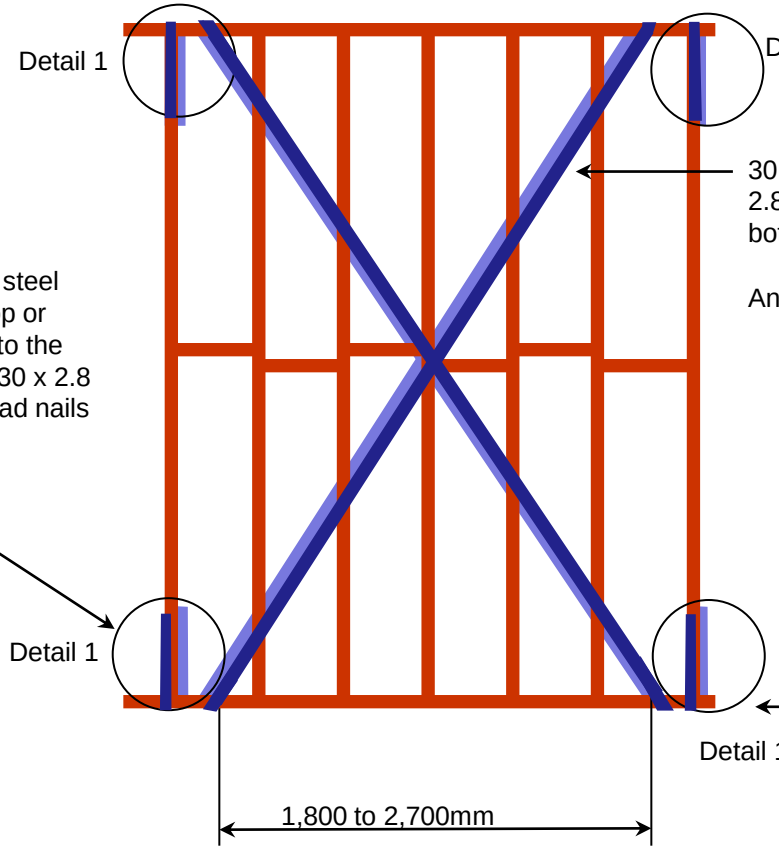
Drill if necessary to avoid end splits.

Angle of braces from horizontal between 30º and 60º.

Fix bottom plate to floor frame or concrete slab with nominal fixings

Wall Bracing – Tensioned Metal Straps with Stud Straps

Capacity 3.0 kN/m length
Based on AS 1684.3 Table 8.18 (d)



Detail 1
Four sets of ties, each 30 x 0.8 mm galvanised steel strap looped over the top or bottom plates and fixed to the stud on both sides by 4-30 x 2.8 mm ϕ galvanised flat head nails

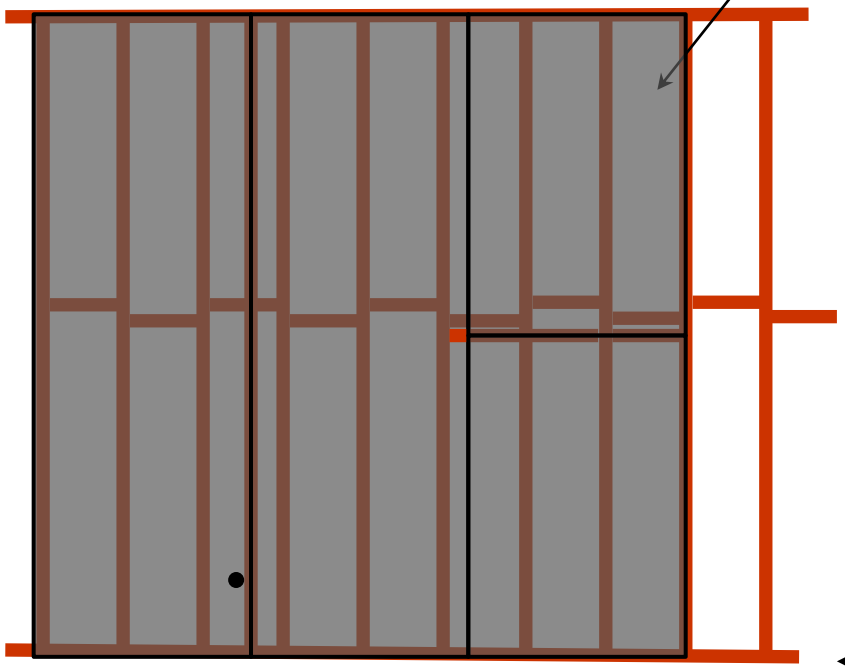
30 x 0.8 mm galvanised steel strap fixed to each stud by 1-30 x 2.8 mm ϕ galvanised flat-head nail and nailed to the top and bottom plates by 2-30 x 2.8 mm ϕ galvanised flat-head nails.

Angle of braces from horizontal between 30^{o} and 60^{o}.

Fix bottom plate to floor frame or concrete slab with nominal fixings

Wall Bracing – Plywood Sheeting Without Additional Connections

Capacity 3.4 kN/m length
Based on AS 1684.3 Table 8.18 (g)



Plywood sheets fixed:

- Around perimeter to top plate, bottom plate and end studs at 150 mm centres by 30 x 2.8 mm ϕ galvanised flat head nails; and
- To internal studs (and noggings where required) at 300 mm centres by 30 x 2.8 mm ϕ galvanised flat head nails.

Sheets may be butt jointed horizontally, provided they are fixed horizontally at the edges to noggings. Provide an additional row of nogging at half height of the wall, if required.

Minimum Plywood Thickness				
Stud Spacing	450 mm	600 mm	450 mm	600 mm
Stress Grade	No nogging (except at horizontal butt joints)		One row of nogging	
F8	7 mm	9 mm	7 mm	7 mm
F11	4.5 mm	7 mm	4.5 mm	4.5 mm
F14	4 mm	6 mm	4 mm	4 mm
F27	3 mm	4.5 mm	3 mm	3 mm

Sheathed panels shall be fixed to the sub-floor. Fix the bottom plate to floor frame or concrete slab with nominal fixings.

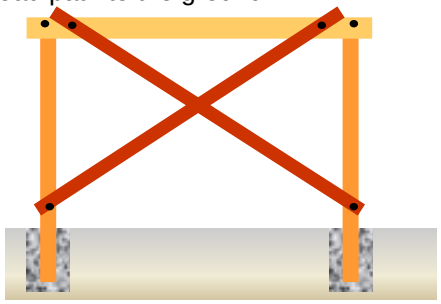
Sub-floor Tension Bracing

Capacity 15 kN
Based on AS 1684.3 Table 8.9

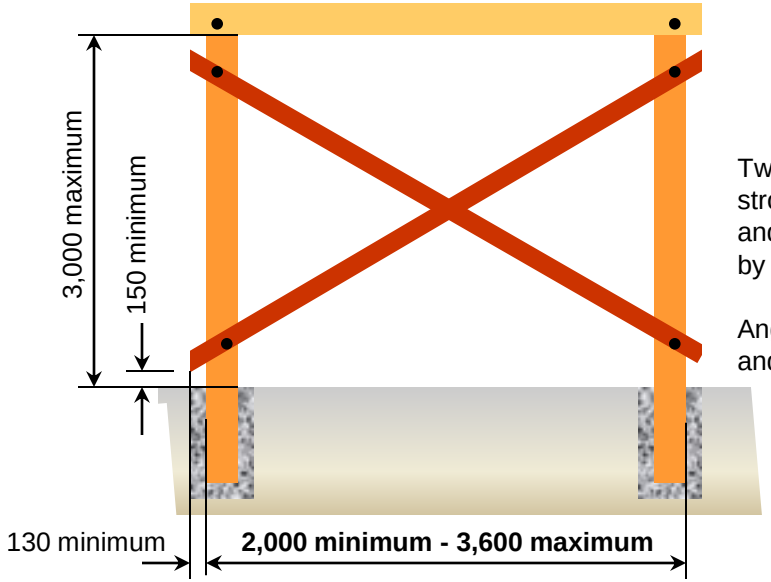
Columns, of dimensions not less than:

- 90 x 90 mm F11 (or stronger) hardwood
- 90 x 90 mm N20 (or stronger) concrete with 1 N12 reinforcing bar
- 190 x 190 mm 15 MPa reinforced concrete masonry with 1 N12 reinforcing bar
- 90 OD x 3 mm CHS galvanised steel hollow section

Alternative Detail:
Where practical, fix diagonal braces at the top directly to the bearers, to provide a more direct load path to the ground



Bearers fixed to columns with 1-M12 bolt or 2-M10 bolts

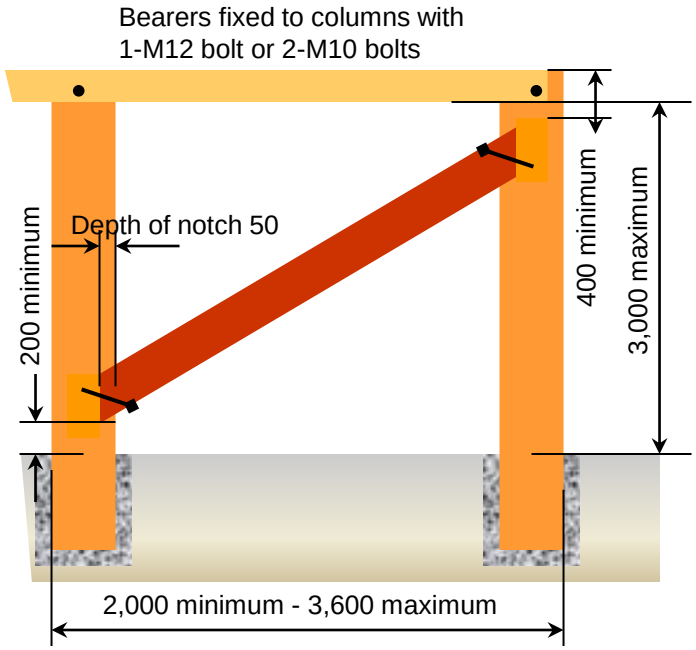


Two diagonal braces, 90 x 45 mm F11 (or stronger) hardwood, fixed to columns at the bottom and to the bearer (preferred) or column at the top by 1-M16 bolt (or stronger) .

Angle of braces from horizontal between 30° and 60°.

Sub-floor Compression Bracing

Capacity 15 kN (Nominal)



Columns, of dimensions not less than:

- 200 x 200 mm or 250 mm diameter F11 (or stronger) hardwood, or
- 150 x 150 mm or 200 mm diameter N20 (or stronger) concrete with 1 N12 reinforcing bar

Two diagonal braces in opposing directions in two bays on each side of building, at least 90 x 90 mm or 150 mm diameter F11 (or stronger) hardwood, notched into the columns to a depth of 50 mm and fixed at the top and bottom by at least 2 – 150 x 3.15 mm ϕ galvanised flat head nails (or stronger) .

Angle of braces from horizontal between 30^{o} and 60^{o}.

Construction Checklist

Builder:
Site:
Activity: Roof Fixing and Roof Anchors

Item or Product	Inspection Required	Accept Criteria	Hold Witness	Date	Inspector	Comment
Installation procedures	Visual inspection	Latest issue on site	Hold			
Location and condition of existing roof fixings and internal anchors	Visual inspection and assessment of installed capacities	Provide required design capacity	Hold			
Select appropriate types of roof fixings and internal roof anchors	Check procedures and required capacity	As per procedures	Hold			
Install the appropriate roof fixings and internal roof anchors as per the relevant procedures	Visual inspection	Installed as per procedures	Witness			

Construction Checklist

Builder:
Site:
Activity: Wall and Sub-floor Bracing

Item or Product	Inspection Required	Accept Criteria	Hold Witness	Date	Inspector	Comment
Installation procedures	Visual inspection	Latest issue on site	Hold			
Location and condition of wall and sub-floor bracing	Visual inspection and assessment of installed capacities	Provide required design capacity	Hold			
Select appropriate types of wall and sub-floor bracing	Check procedures and required capacity	As per procedures	Hold			
Install the appropriate wall and sub-floor bracing as per the relevant procedures	Visual inspection	Installed as per procedures	Witness			

Basic Shelter - Designed for Cyclone, Earthquake and Tsunami Resistance

The Basic Shelter provides shelter in the initial stages of reconstruction of permanent village housing in the Asia-Pacific region, following natural disasters such as cyclones, earthquakes or tsunamis.

Braced Bolted and Built

Rebuilding after Hurricane Haiyan

Proud owner of a 3.0 x 3.0 m Modular "Basic Shelter" with unique cyclone resistant features – The same structure serves as a transition house and as the shear core of an extended larger house.

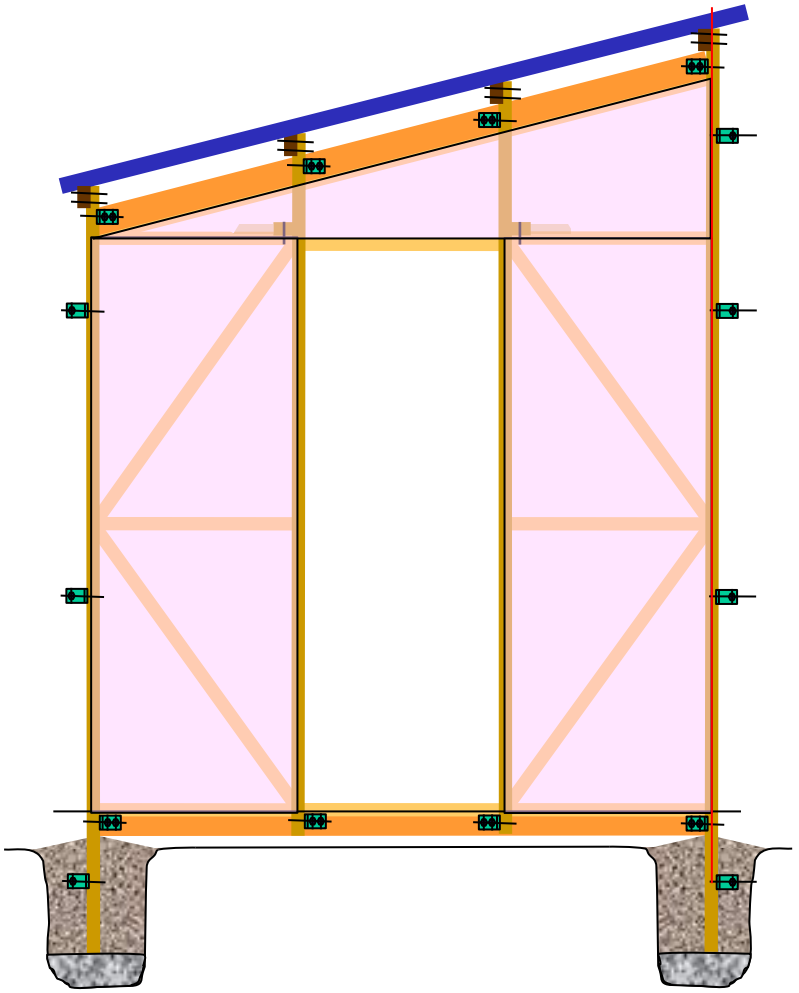
Basic Shelter

The Basic Shelter provides shelter and facilitate rainwater collection in the initial stages of reconstruction of permanent village housing in the Asia-Pacific region, following natural disasters such as cyclones, earthquakes or tsunamis.

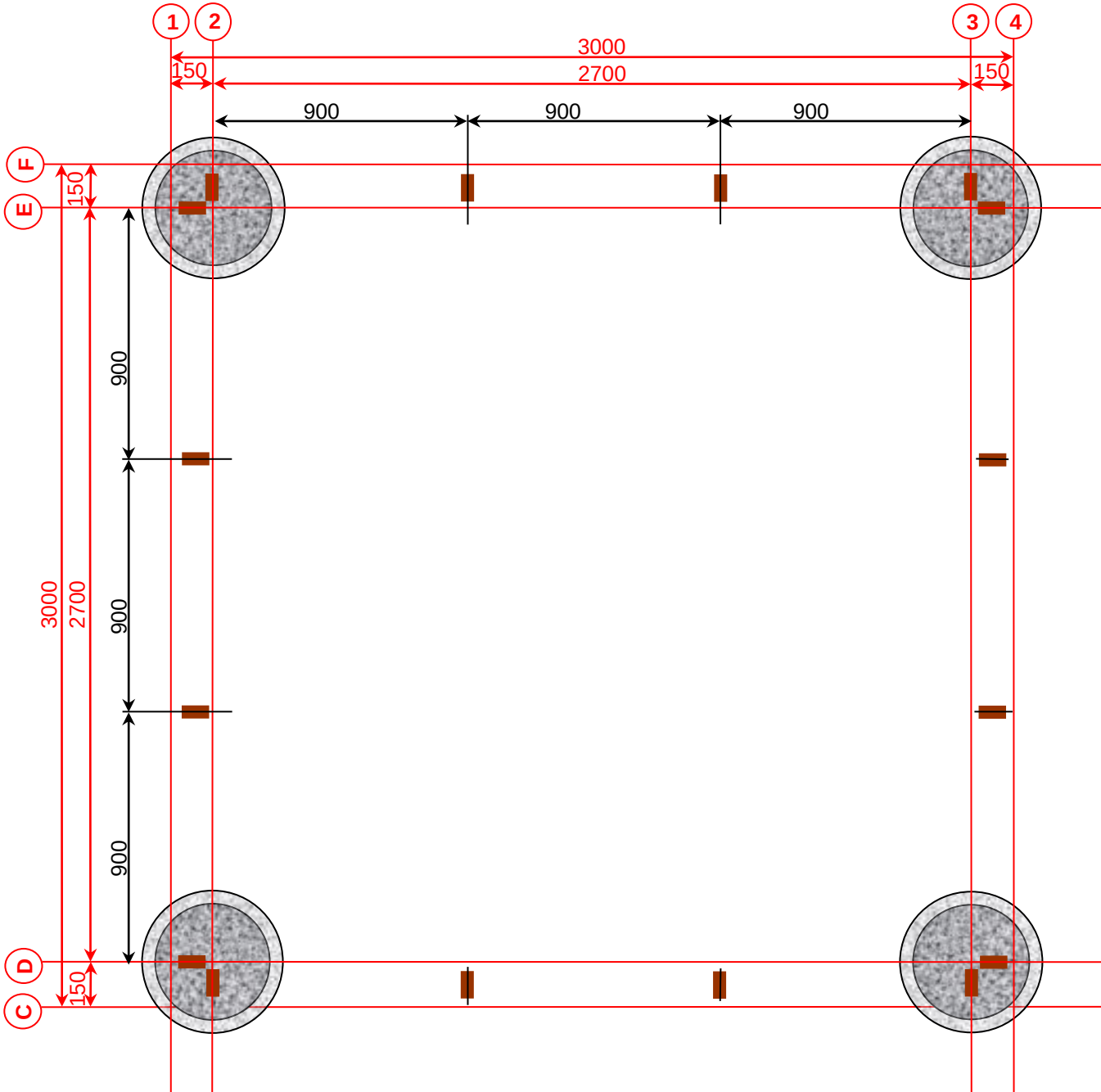
1. A sheet steel roof is site-fixed to a site-assembled braced frame, which is anchored to the ground via a concrete slab-on-ground or posts set in the ground. The overall dimensions of the Basic Shelter are 3.0 x 3.0 m.
2. The posts of the Basic Shelter are constructed on a 2.7 x 2.7 m square grid, providing stud centres at 900 mm. This facilitates extension of the Basic Shelter, which is the structural core of permanent houses with the external dimensions of 5.7 x 3.0 m, 5.7 x 5.7 m, 8.4 x 5.7 m or 8.4 x 8.4 m.
3. There are three forms of Basic Shelter, depending of the availability of materials and fabrication facilities. Both forms may be extended using either timber or steel members.
    a) Site-fabricated Plywood Bracing (PB1) – The posts, beams and braces are constructed of timber (either new or retrieved from demolished houses), and fixed together on site using imported bolt, nuts and steel brackets. Then plywood sheet bracing is nailed to this frame.
    b) Site-fabricated Timber Bracing (TB1) – The beams, posts and braces are constructed of timber (either new or retrieved from demolished houses), and fixed together on site using imported bolt, nuts, steel brackets and joiners
    c) Workshop-fabricated Steel Bracing (SB1) – The trusses, posts and braces of the prefabricated steel frame are site bolted. The maximum dimensions of items are 3.3 x 1.0 m
4. Eaves gutter, downpipe and polypropylene water tank are not part of the basic package, but may be provided simultaneously. Wall cladding, is included in PB1. Doors, windows, ceilings and the like (not included in the basic package) may subsequently be fitted when it is appropriate to convert the Basic Shelter to permanent housing.

Partner Housing
Basic Shelter PB1

Plywood Bracing



Partner Housing
Basic Shelter PB1
Footing Plan



Partner Housing Basic Shelter PB1 Elevation

Zincalume corrugated roofing steel, 0.42 BMT with cyclone washers and screws to rib.

Purlins 4 (4 total) / 75 x 38 F5 timber Fixed at each end by 2 M12 x 100 bolts

Beam 1 (4 total) / 75 x 38 F5 timber

15 (30 total) 100 x 100 x 4.5 L x 50 long drilled bracket zinc plated, 4 / 14 dia holes

58 (116 total) M12 x 100 long bolts, with nuts and washers, hot dip galvanised

Diagonal 75 X 38 F5 timber lateral bracing above ceiling , fixed by 1 / M12 x 100 bolt each end to 75 x 38 F5 noggings

75 x 38 F5 diagonal bracing nailed to vertical studs and horizontal nogging by 4 / 75 x 2.8 ϕ skew nails at each end

75 x 38 F5 horizontal nogging nailed to vertical studs by 2 / 75 x 2.8 ϕ skew nails at each end

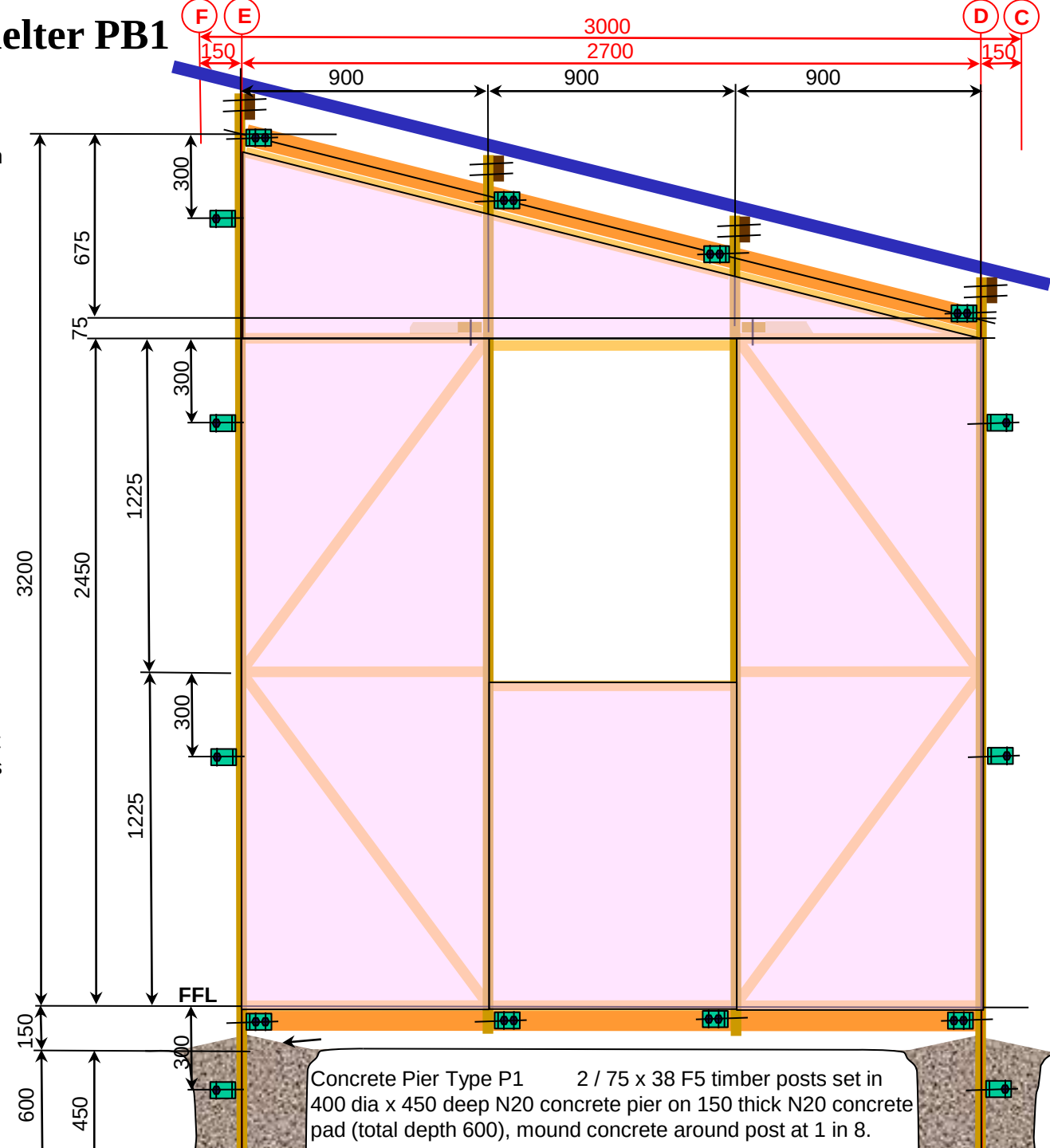
7 mm plywood bracing, fixed by 30 x 2.8 ϕ nails at 150 mm centres to studs, noggings and diagonals In only one 900 mm bay in each elevation, where there are doors or windows, the plywood bracing may be omitted.

Studs (posts) 4 (16 total) / 75 x 38 F5 timber

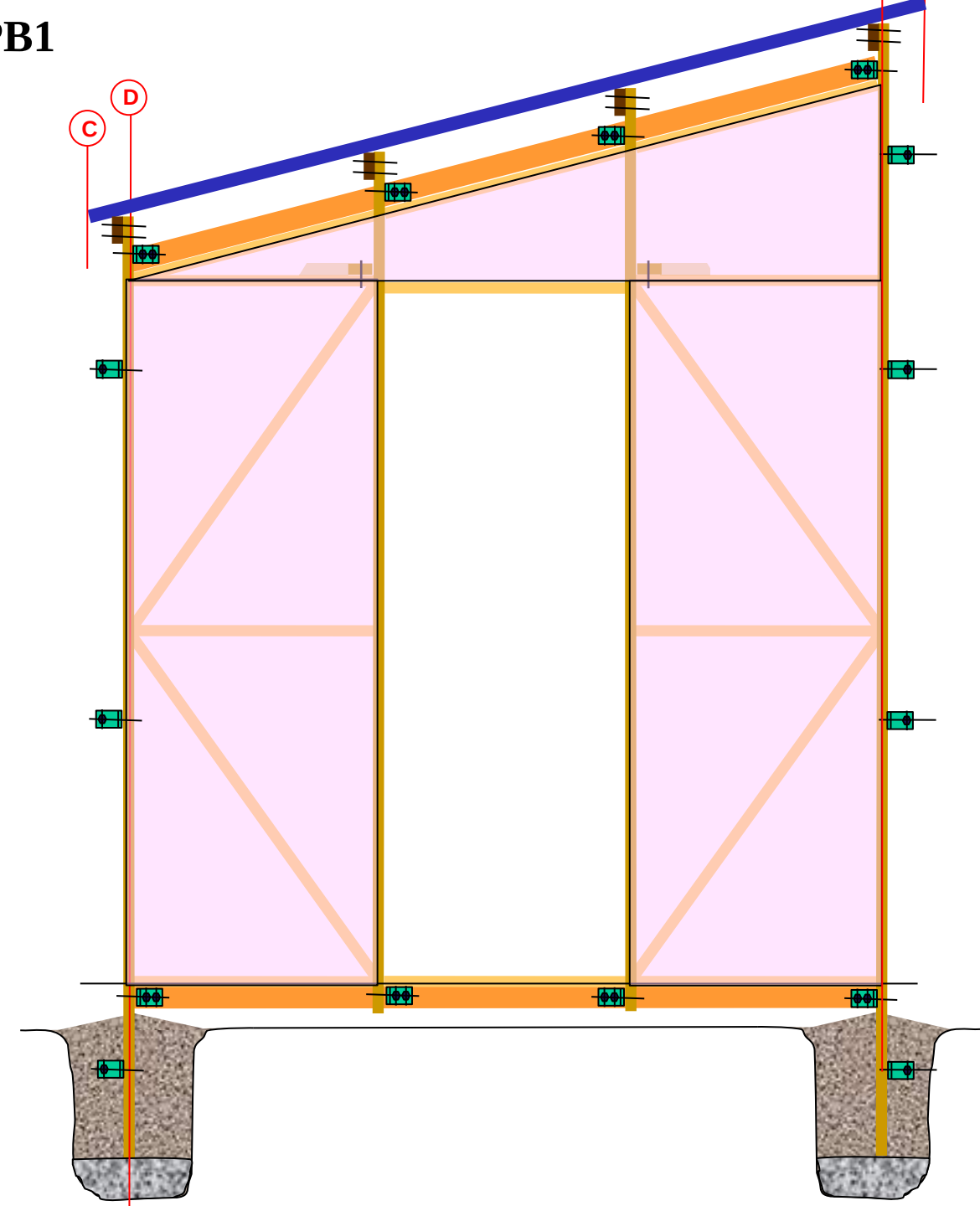
Bearer 1 (4 total) / 75 x 38 F5 timber

Section at Bracket

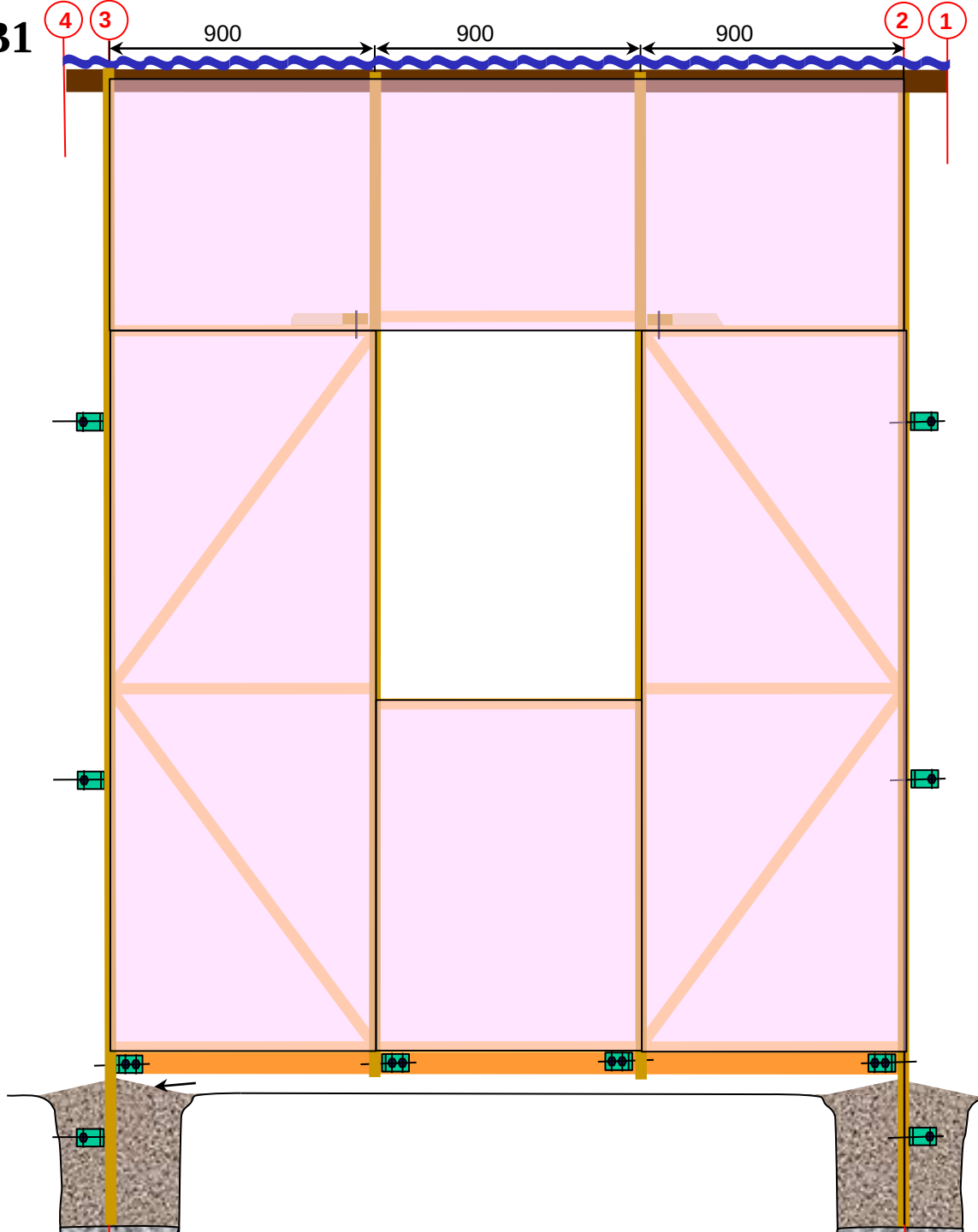
Section at Nogging



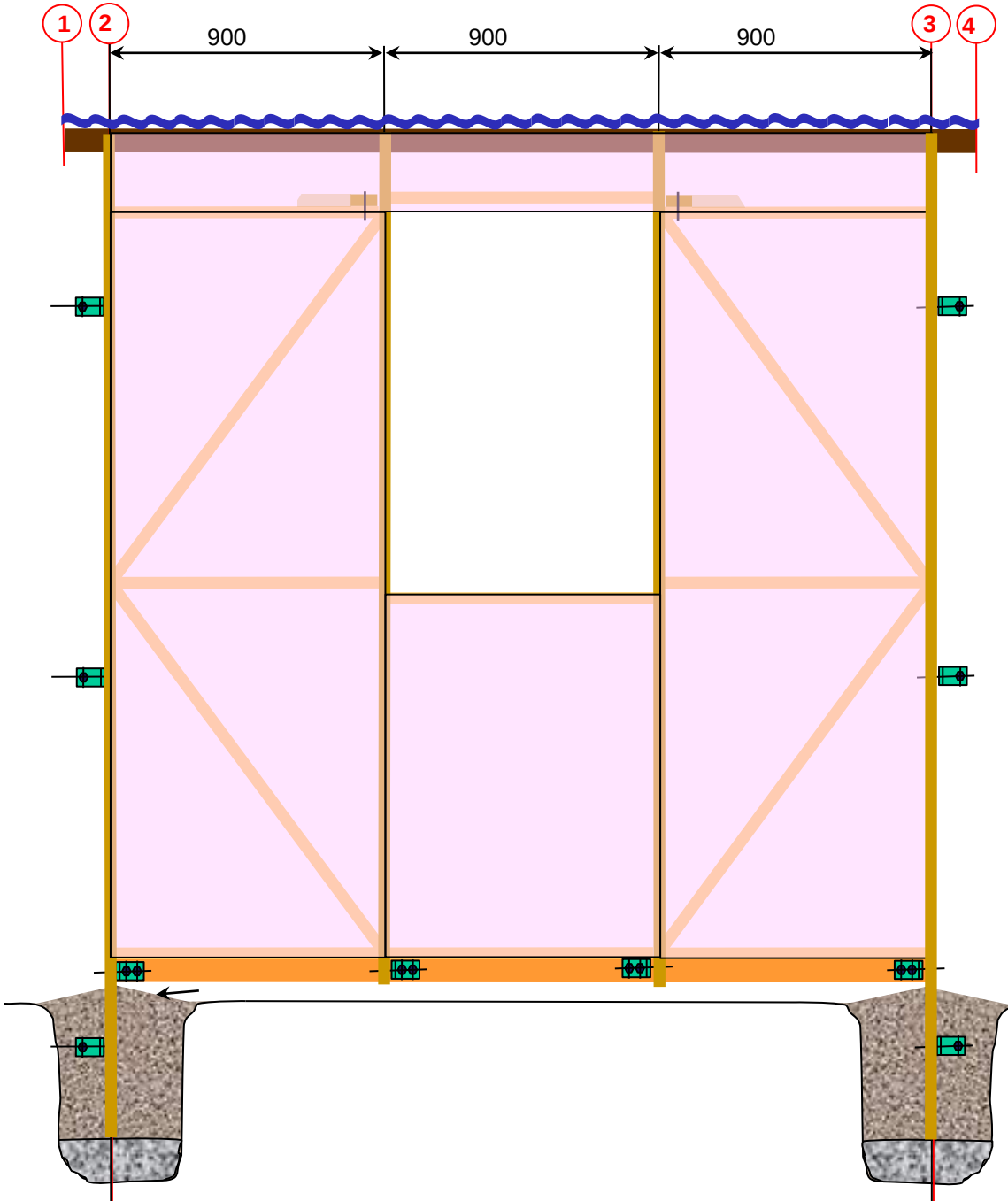
Partner Housing Basic Shelter PB1
Elevation



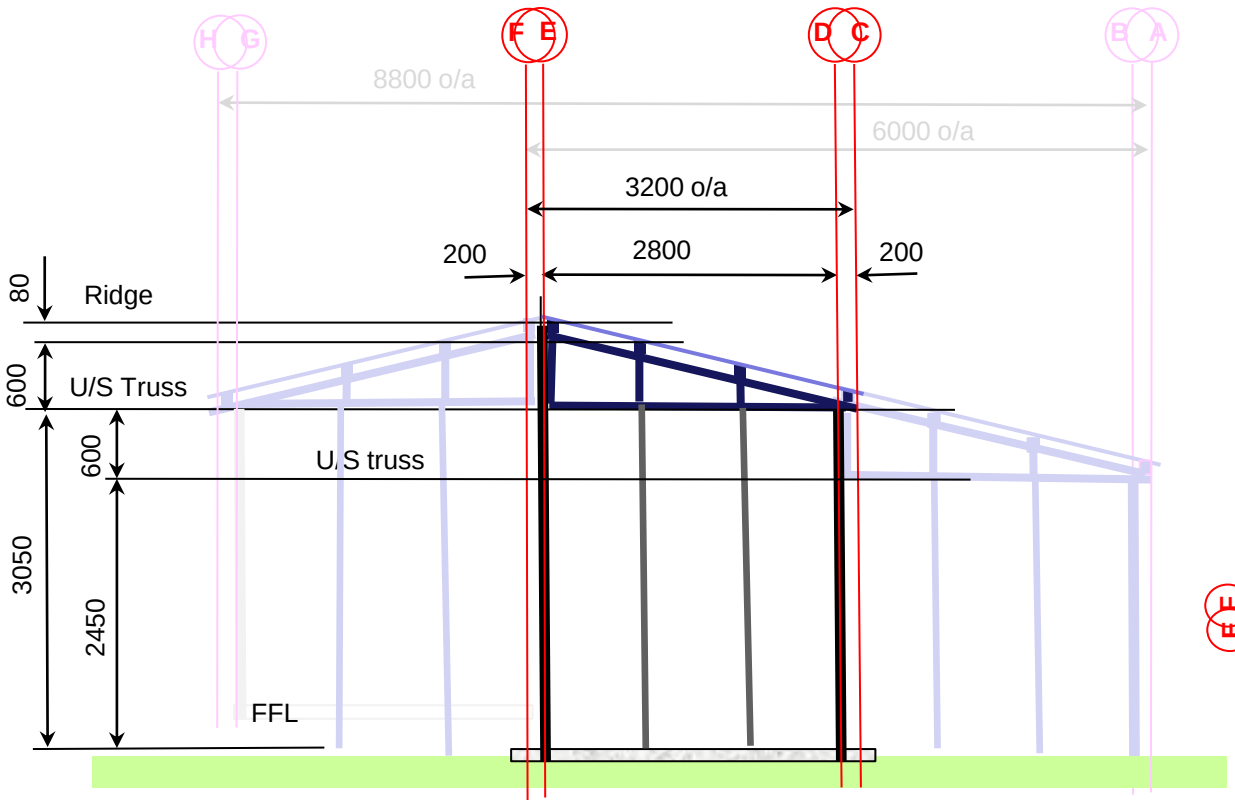
Partner Housing Basic Shelter PB1 Elevation



Partner Housing Basic Shelter PB1
Elevation



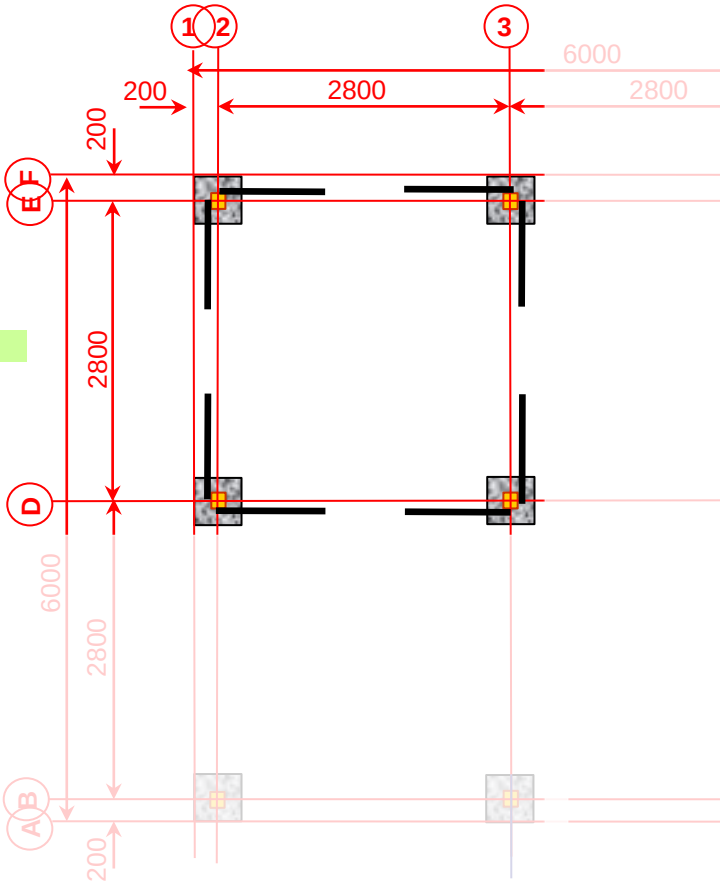
Partner Housing Basic Shelter– Section



0.42 BMT trapezoidal zincalume roof sheeting. Detail RS-C1-1

Structural steel or timber braced framing . Details RF-SS-2

0.42 BMT zincalume roof drainage and polyethylene water tank Detail RD-1



External Anchor Points with Temporary Tie Ropes

Improving Cyclone, Earthquake and Tsunami Resistance of Houses in the Asia / Pacific Region

Two levels of improvement are applicable.

1. Anchor points with temporary tie ropes.
   The anchor points are permanent and may be constructed cheaply. The tie ropes may be positioned and tightened at the commencement of the cyclone season (if not already in place). This is a cheap "quick fix", but is reasonably unattractive and provides only modest improvement.

2. Additional roof fixings and cyclone washers, roof framing anchors, timber diagonal bracing, steel diagonal bracing and/or sheet bracing.

   These are permanent structural features that should be installed as part of the construction of new buildings, but are often missing. They may be retro-fitted to existing buildings.

Both levels of improvement should be undertaken – commencing with "Anchor points with temporary tie ropes" in an initial program, and progressing to the more permanent features when there is sufficient funding.

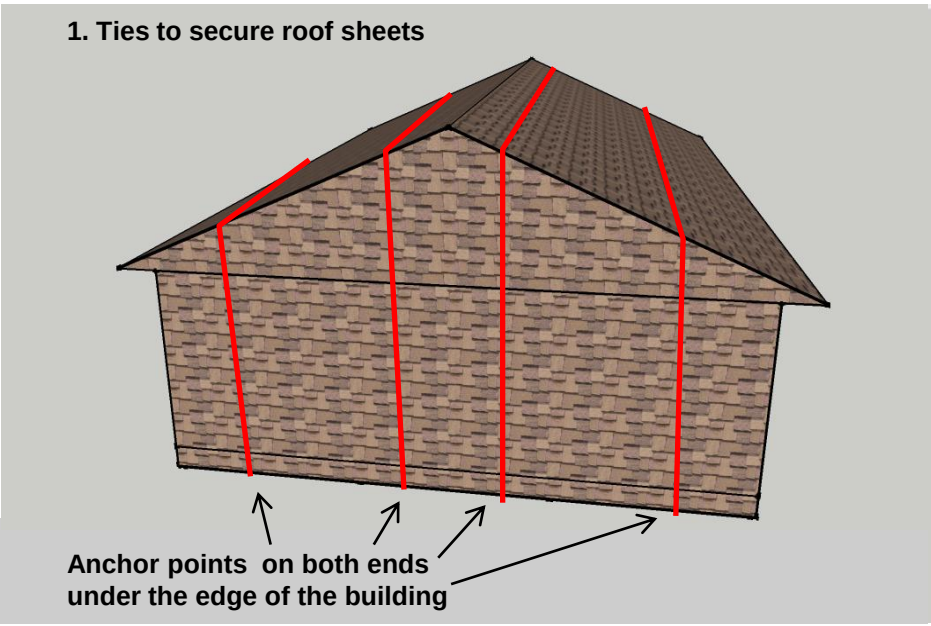
Anchor Points with Temporary Tie Ropes

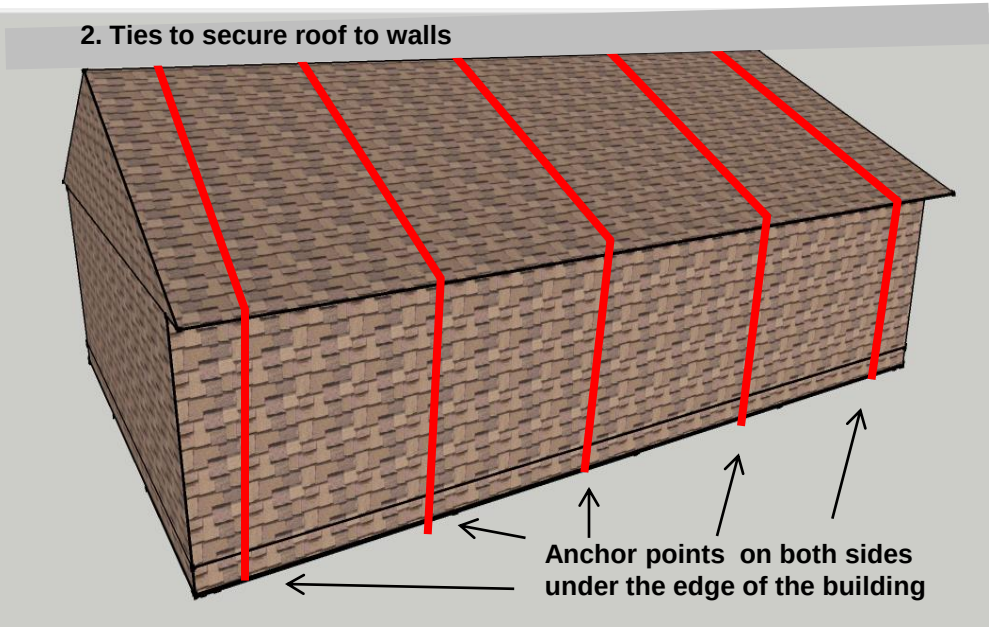
The first step in improving cyclone resistance is to construct strong anchor points, to which the roof tie ropes can be fixed. The spacing of anchor points should not exceed 3.0 metres.

There are two types on roof ties:

1. Roof ties that prevent roofing sheets from being blown off the house once it has become loosened by the wind. These generally run end-to-end along a gable roofed house. These are the most common form of roof tie.

2. Roof ties that anchor the roof framing to the walls and run across a gable roof.



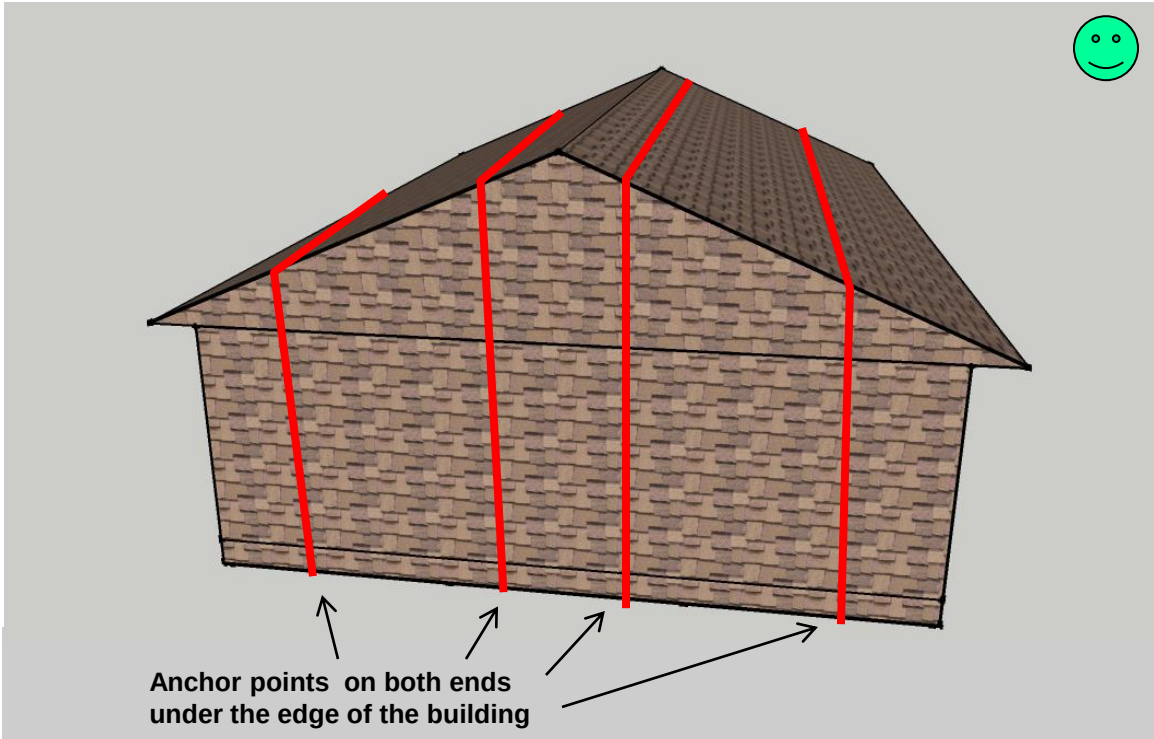


Anchor Points and Tie Ropes to Restrain Roof Sheeting

Although tie ropes that run from end-to-end will generally not be tight enough to prevent the sheeting for tearing loose from the roofing battens, they will prevent the sheeting from then being blown off the house.

In gable roof houses, the anchors for these tie ropes should be positioned opposite each other on both ends of the house, so that the tie ropes run across all roof sheets.

The ideal position for anchor points is under the edge of the building. This is because the weight of the building can be used to prevent the anchor points from being pulled out by strong wind. The spacing of anchor points should not exceed 3.0 metres.



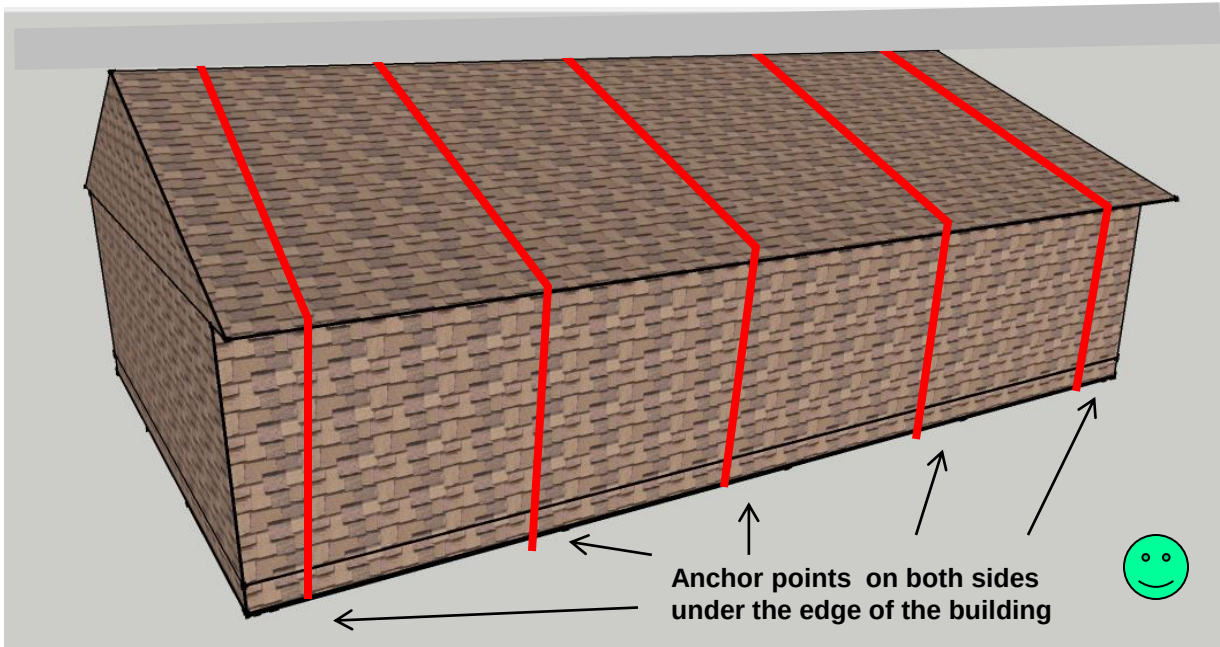
Anchor Points and Tie Ropes to Secure the Roof to the Walls

Anchor points for roof ties (running across a gable-roofed house) that secure the roof framing to the walls should be positioned opposite each other on both sides of the house.

The ideal position for anchor points is under the edge of the building. This is because the weight of the building can be used to prevent the anchor points from being pulled out by strong wind.

Ties that pass over the roof sheeting will anchor some of the sheets, the battens and roof framing. They are more likely to be pulled tight than ties that run from end to end, but cannot anchor all of the roof sheets.

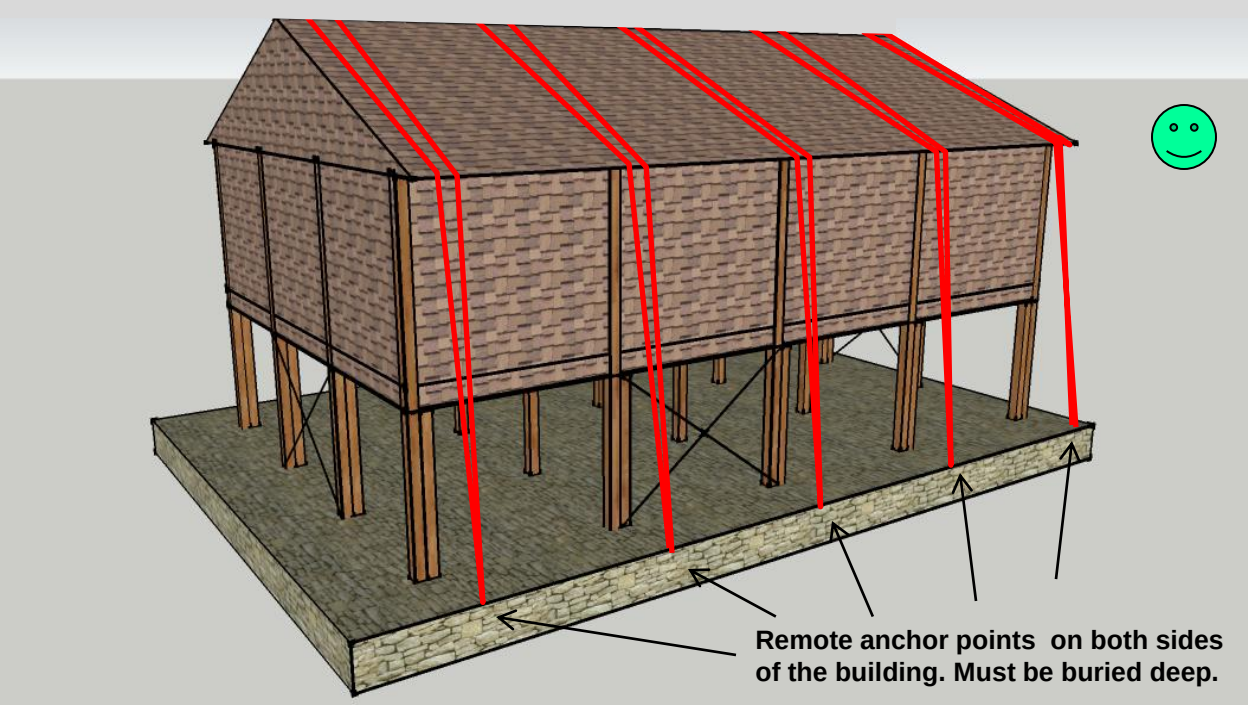
Ties that pass over the battens but under the roof sheeting will anchor the battens and roof framing, but will not secure the roof sheeting.



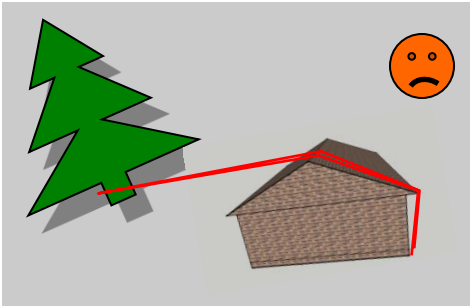
Remote Anchor Points

If it is impractical to place the anchors under the edge of the building or to fix the tie ropes the bottom of the posts, special anchor points may be constructed beside the building.

They must have sufficient weight or be buried deep to provide sufficient resistance to uplift.



Do not tie the building to trees or other small structures, because they may be blown away by high wind.



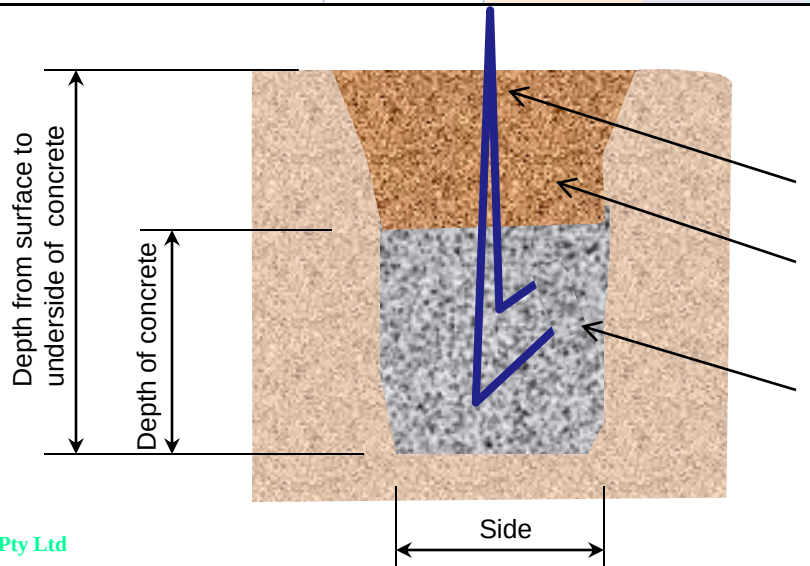
Permanent Remote Concrete Anchor Points

Concrete anchor points provide durable permanent remote anchorage. Capacity in the range of 120 kg to over 2 tonnes, depending on the side and depth of concrete, and total depth from the surface to the underside of the concrete. Burying the anchor point significantly increases the skin friction between the soil and concrete.

Recommended sizes (depending on application) are shown in large black type.

Uplift Capacity of Square Concrete Anchor Blocks in Sand

Length of side	mm	300	450	600	300	450	600
Depth of concrete	mm	300	450	600	300	450	600
Depth from surface to underside of concrete	mm	300	450	600	1,000	**1,000**	**1,000**
Volume of concrete	m^3	0.03	0.09	0.22	0.03	0.09	0.22
Factored uplift capacity	kN	1.2	4.0	9.6	8.7	14.3	21.0
Factored uplift capacity	tonnes	**0.1**	**0.4**	**1.0**	0.9	**1.5**	**2.1**



N12 reinforcement anchor 12 mm diameter 500 MPa reinforcing steel x 2,000 mm long, with standard hooks plus 400 mm embedment length on each of two legs, compacted 20 MPa concrete.

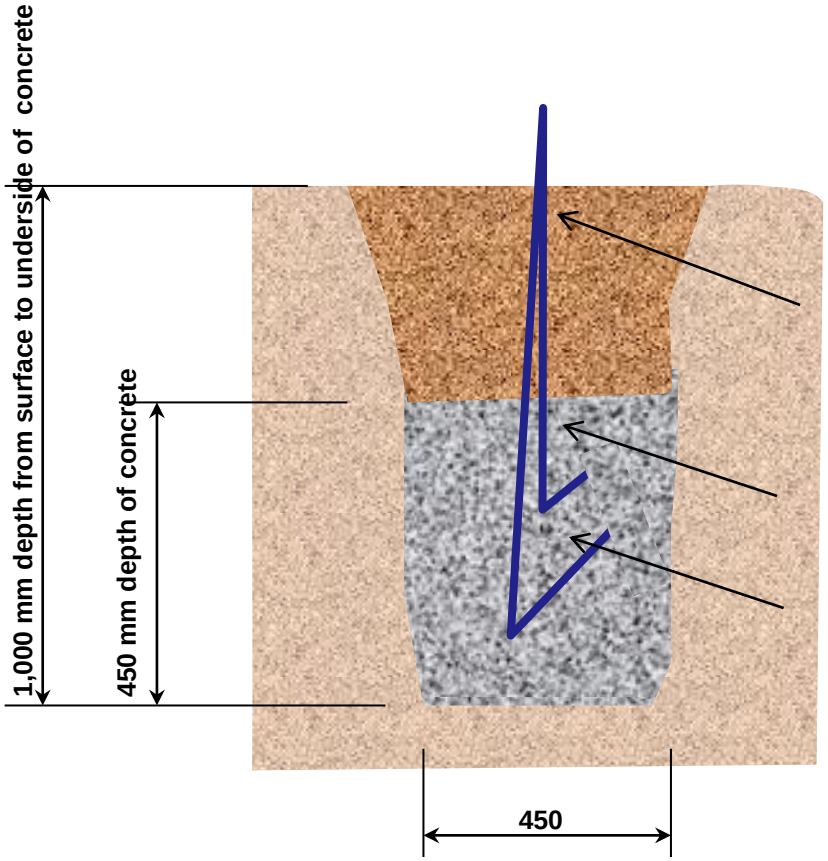
Compacted soil above concrete (if applicable)

N20 concrete (20 MPa) with steel anchor point set in position

1.5 tonne Capacity Permanent Remote Concrete Anchor Points

1. Excavate 450 x 450 x 1,000 deep hole.
2. Bend N12 reinforcement anchor.
3. Prepare a mold out of a 100 dia x 700 mm pipe, split down one side and hold together by two rings.

4. Place the anchor and install N20 concrete. Install the mold around the anchor.



N12 reinforcement anchor
12 mm diameter 500 MPa reinforcing steel x 2,000 mm long, with standard hooks plus 400 mm embedment length on each of two legs, compacted 20 MPa concrete.

Compacted soil above concrete (if applicable)

N20 concrete (20 MPa) with steel anchor point set in position

5. Remove the mold.

6. Expose the anchor.

7. Backfill and compact soil leaving anchor point exposed.

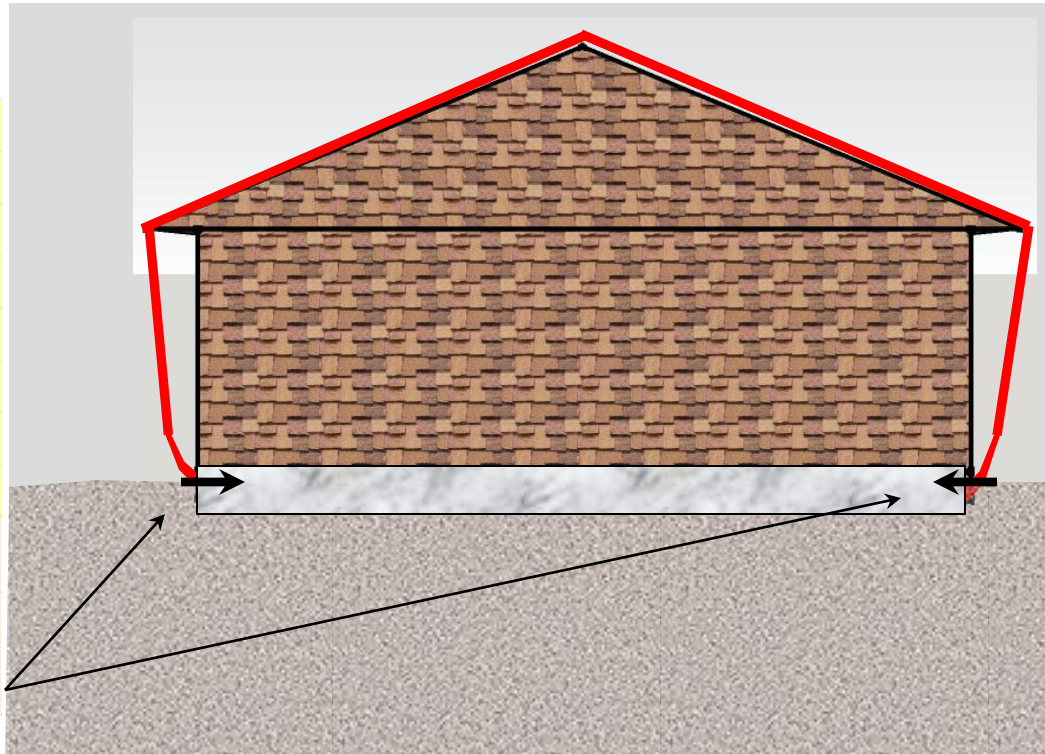
Epoxied Eye-bolt Slab Edge Anchor Point

1. Ensure that the concrete slab is of sufficient strength (at least 10 MPa) and thickness (at least 150 mm thick). Otherwise the anchor will rupture the concrete and pull out under wind load.
2. Drill holes in the concrete of the specified diameter, depth, edge distance and spacing.
3. Ensure the hole is clean.
4. Insert and fix the anchor in two-part epoxy as per the manufacturer's instructions.
5. Fix tie ropes.

Eye-bolts epoxied in concrete slab edge		
Eye-bolt size	M12	
Eye-bolt effective depth	110	mm
Diameter of hole drilled in concrete	14	mm
In-situ concrete strength	10	MPa
Minimum edge distance (bolt centre to	75	mm
Factored shear capacity of anchor	5.1	kN
	0.5	tonnes

Eye-bolt specification: M12 500 MPa bent steel eye-bolt

Rope Specification: Polypropylene twisted 3 strand 12 mm dia rope (R00QE)



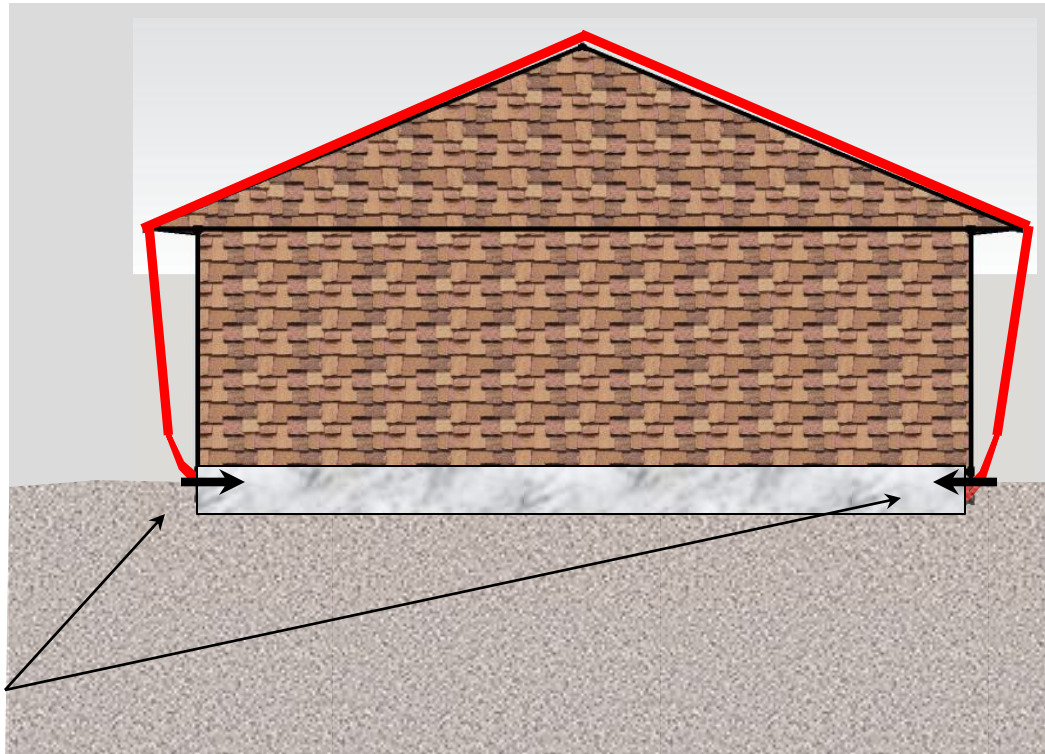
Chemset Slab Edge Anchor Point

1. Ensure that the concrete slab is of sufficient strength (at least 10 MPa) and thickness (at least 150 mm thick). Otherwise the anchor will rupture the concrete and pull out under wind load.
2. Drill holes in the concrete of the specified diameter, depth, edge distance and spacing.
3. Ensure the hole is clean.
4. Insert and fix the Chemset anchor in accordance with the manufacturer's instructions.
5. Bolt the connection bracket to the anchor if required and fix tie ropes.

Chemset in concrete slab edge		
Chemset size	M12	
Chemset effective depth	110	mm
Diameter of hole drilled in concrete	14	mm
In-situ concrete strength	10	MPa
Minimum edge distance	75	mm
Factored shear capacity of anchor	5.1	kN
	0.5	tonnes

Chemset specification: M12 x 110 depth

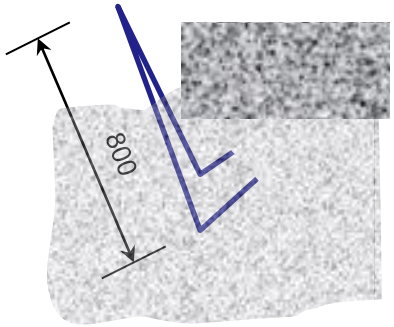
Rope Specification: Polypropylene twisted 3 strand 12 mm dia rope (R00QE)



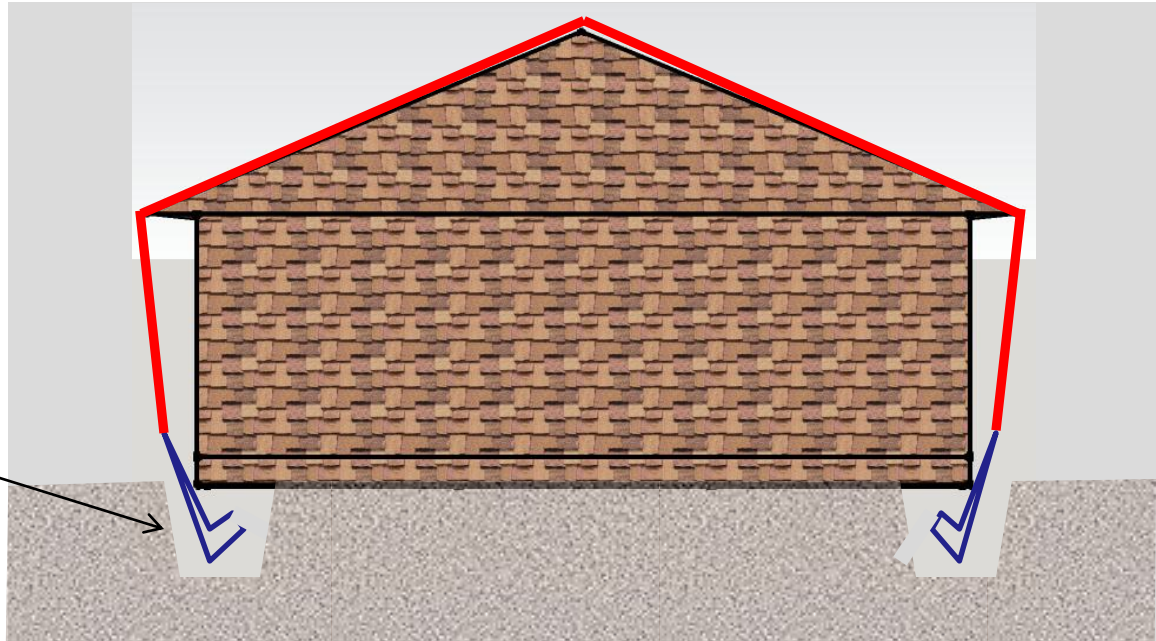
House Foundation Anchor Point

1. Excavate holes in the foundation under the edge of the house footings.
2. Bend 10 mm reinforcing bars to provide two legs, each with standard hooks, as shown. Hold the bars in position by timber supports.
3. Place and compact 20 MPa concrete (1 part cement : 2 parts sand : 4 parts gravel) in the holes.
4. Remove the support timbers.

	R10 reinforcement anchor		
Standard hook plus 400 mm embedment length on each leg			
Number of legs		2	
Factored capacity of anchor	$\phi N_{u\ anchor}$	35	kN
		3.6	tonnes



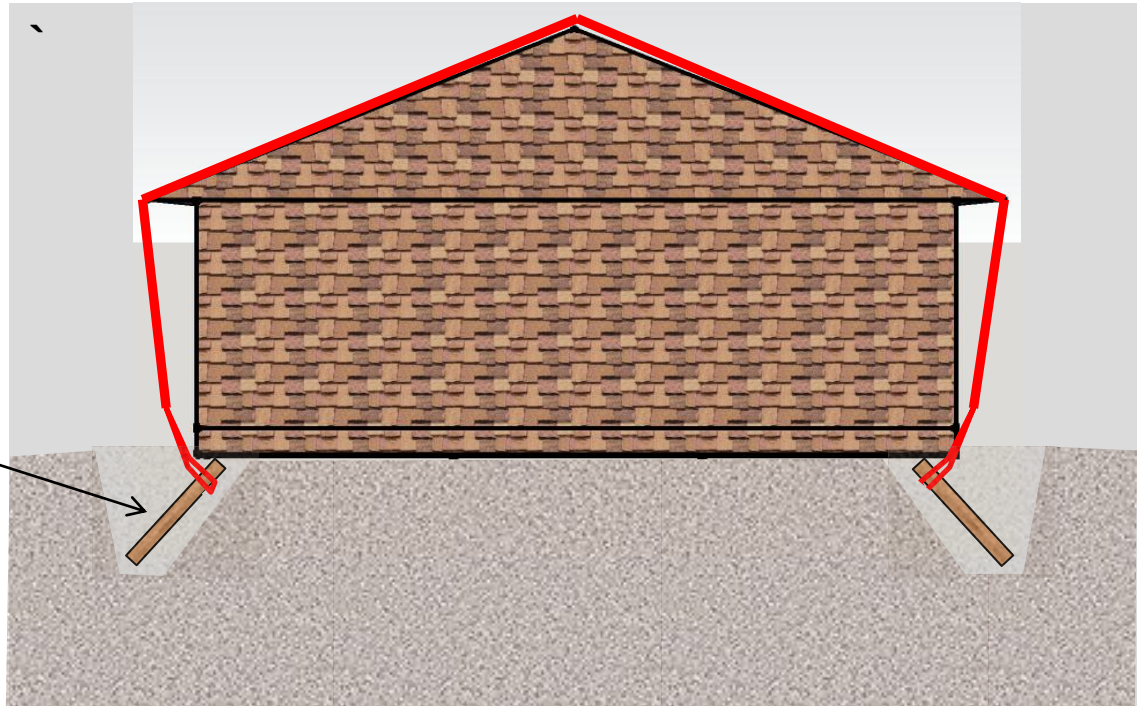
N12 reinforcement anchor
12 mm diameter 500 MPa reinforcing steel x 2,000 mm long, with standard hooks plus 400 mm embedment length on each of two legs, compacted 20 MPa concrete.



Temporary Edge Anchor Point

If permanent materials such as steel and concrete are not available, temporary edge anchor points may be constructed from timber and rope. These may be liable to termite attack or deterioration, and must be inspected regularly and renewed if necessary.

1. Excavate under the edge of the building.
2. Fix a rope loop to the diagonal strut, as near as practical to the top.
3. Position the top end of the diagonal timber strut as far as practical under the footing, and hammer the bottom end into place.
4. Pull the rope loop free, backfill and compact the soil.

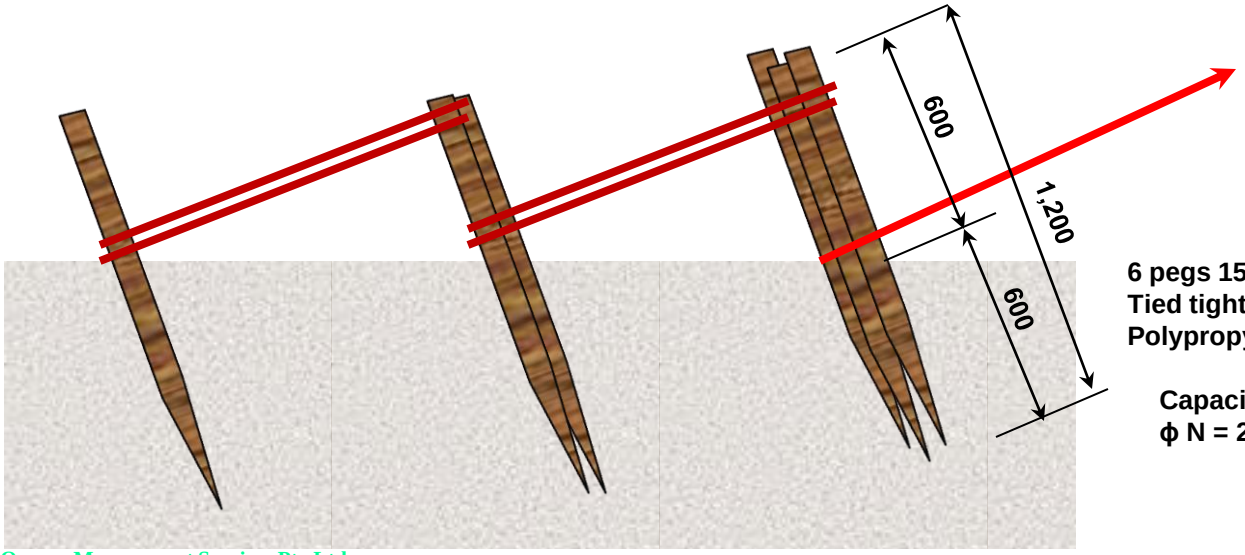


150 x 150 x 1,200 timber strut with rope anchor point (6 strands of polypropylene twisted 3 strand 8 mm dia rope) tied to the top end. Strut to be wedged into position diagonally at 45º. Backfill with compacted soil.
Capacity in compacted sand:
ϕ N = 25 kN

3 – 2 – 1 Temporary Remote Anchor Points

If permanent materials such as steel and concrete are not available, temporary 3 – 2 – 1 remote anchor points may be constructed from timber pegs. These may be liable to termite attack or deterioration, and must be inspected regularly and renewed if necessary.

1. Hammer three large timber pegs deep into the ground, and tie them together.
2. Behind this, hammer two large timber pegs deep into the ground , and tie them together.
3. Behind this, hammer one large timber peg deep into the ground.
4. Tightly tie the bottom of the rear peg to the top of the middle two pegs, and the bottom of the middle two peg to the top of the front three pegs.
5. Compact all of the ground surrounding the anchorage.
6. The anchorage is now ready for the tie rope to be fixed to the bottom of the front three pegs.



6 pegs 150 x 150 x 1,200
Tied tightly top to bottom with 6 strands of Polypropylene twisted 3 strand 8 mm dia rope

Capacity in compacted sand:
ϕ N = 25 kN

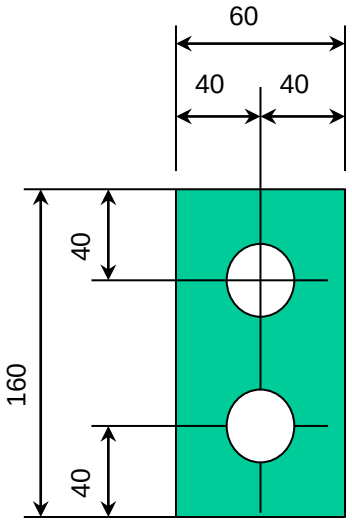
Connection Bracket for Slab Edge Anchor Point

Anchors commonly (but not always) consist of an eye-bolt set in the slab edge.

Where the anchor is a stud with nut, this connection bracket may be used tho provide a hole through which a tie can pass.

1. Bolt the connection bracket to the anchor.

2. Ensure that there are no sharp edges in the holes that could tear any rope ties. Use packing if appropriate.



f_{sy} = 250 MPa

60 x 6 Plate x 160 long

2 Holes 20 mm diameter

Tensile Capacity: 54 kN (5.5 Tonnes)

Construction Checklist

Builder:
Site:
Activity: External Anchor Points and Tie Ropes

Item or Product	Inspection Required	Accept Criteria	Hold Witness	Date	Inspector	Comment
Installation procedures	Visual inspection	Latest issue on site	Hold			
Location of anchor points	Visual inspection	As per procedures	Hold			
Condition of concrete slab	Hit with hammer	No shattering of cracking	Hold			
Condition of adjacent rock	Hit with hammer	No shattering of cracking	Hold			
Condition of soil	Dig 500 mm test hole	Firm soil with no rock or tree roots	Hold			
Select appropriate anchor type	Check procedures and required capacity	As per procedures	Hold			
Install the anchors as per the relevant procedures	Visual inspection	Installed as per procedures	Witness			
Proof load using the “Load Tester”	Apply proof load of half the nominated capacity or 0.5 tonne (whichever is less) to 5% of installed anchors	Must support the calculated proof load without loss of capacity	Witness			
Install tie ropes and partially tighten tie ropes	Visual inspection	As per procedures	Witness			
Label, remove and store tie ropes	Inspect and count stored tie ropes. Check register	All ropes must be marked, stored and registered	Witness			

Proof Load Site Tester

The Proof Load Site Tester is used to verify the capacity of connections in timber or steel frame construction, diagonal braces, anchors, tie ropes and the like, by applying a working load up to 2.0 tonnes (20 kN) to a representative sample, using a 10 : 1 lever.

Light Duty Proof Load Site Tester

Proof Load Site Tester

Use of the Proof Load Site Tester

The purpose is verify the capacity of connections in timber or steel frame construction, diagonal braces, anchors, tie ropes and the like, by applying a working load up to 2.0 tonnes (20 kN) to a representative sample. This is done using a 10 : 1 lever and a known load (e.g. applied by cement bags).

Proof Load Site Tester Specification

The Proof Load Site Tester consists of a 10 : 1 lever system (1,800 mm : 180 mm), of maximum dimensions 200 x 300 x 2,100 mm and corrosion resistant finish (e.g. hot dip galvanised).

Tester Type	Light Duty	Heavy Duty
Maximum Weight	16 kg	25 kg
Maximum load	80 kg (4-20 kg bags, 2-40 kg bags)	200 kg (10-20 kg bags, 5-40 kg bags)

Using the Proof Load Site Tester for Training

The Proof Load Site Tester may be used as a training tool in the classroom. Trainees assemble nailed, bolted and welded joints between short pieces of timber or steel. These are held in a jig on the floor, and tested using known weights. Standard weights or a load cell are more accurate than cement bags. Trainees may observe the relative strengths of joints and connections.

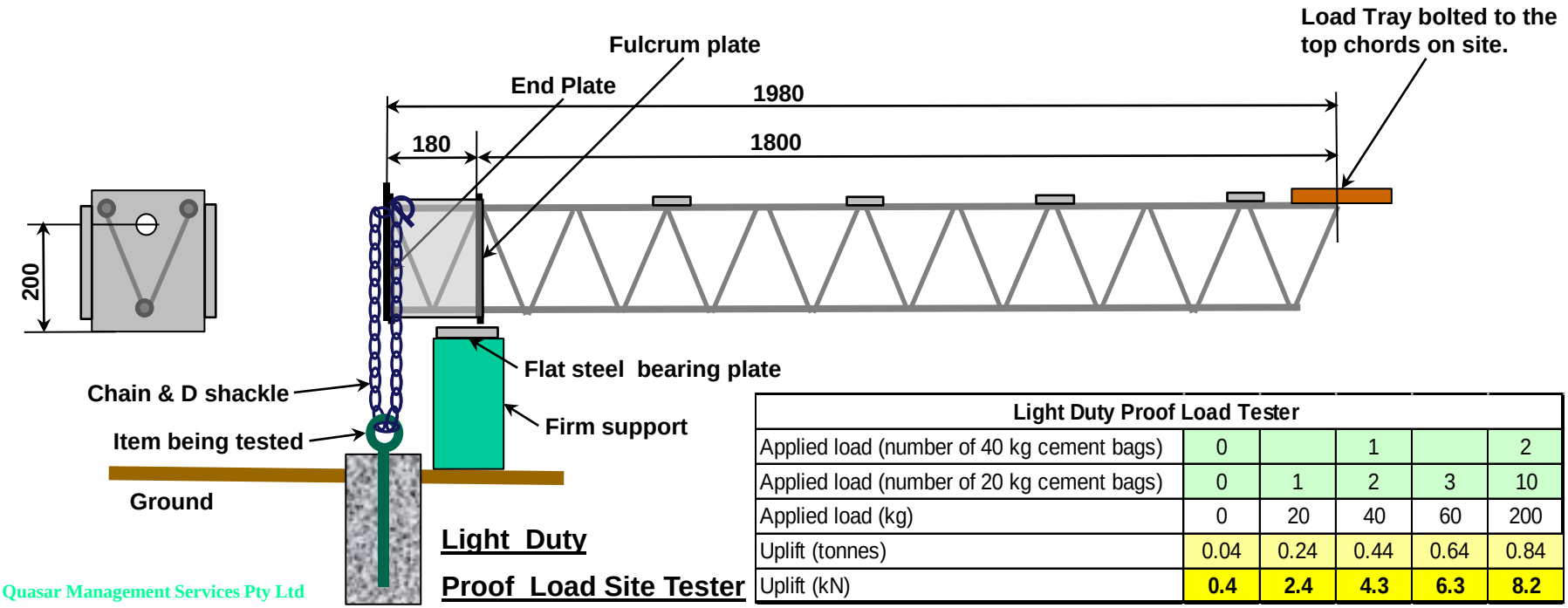
Prototype Proof Load Site Tester used in Mangaia, Cook Islands to test anchor bolts

Light Duty Proof Load Site Tester

Light Duty Proof Load Site Tester – Instructions

The Light Duty Proof Load Site Tester is used to verify the capacity of diagonal braces, anchor points, tie ropes, connections and the like by applying a working load, up to 0.87 tonnes (8.5kN) to a representative sample. This is done using a 10 : 1 lever assembly, in which the load is up to 2 - 40 kg or 4 - 20 kg cement bags (or equivalent).). When using multiple cement bags, prevent twisting sideways. Load carefully and shield observers from flying debris due to sudden failure.

- To apply an upward force, connect anchor to the end plate and pivot about the fulcrum plate.
- To apply a downward force, connect anchor to the fulcrum plate and pivot about the end plate.
- To apply a horizontal force, connect anchor to the end plate and pivot about the end plate.

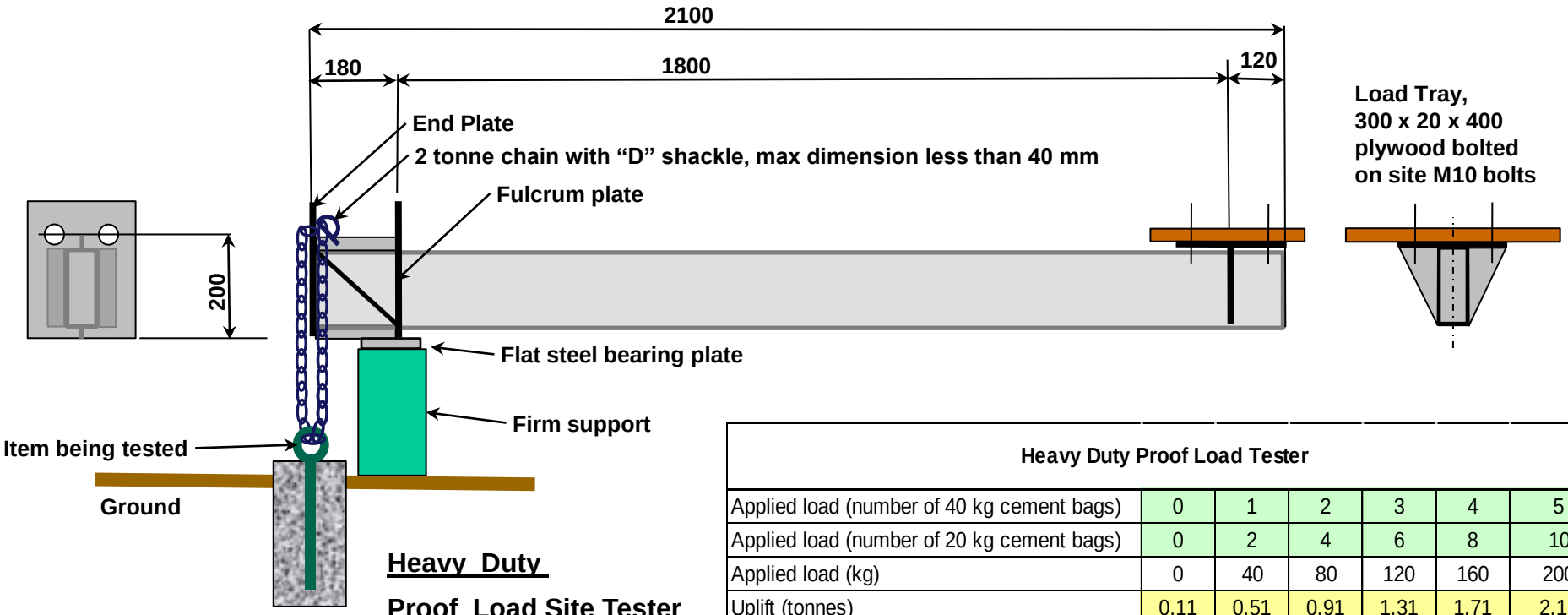


Light Duty Proof Load Tester					
Applied load (number of 40 kg cement bags)	0		1		2
Applied load (number of 20 kg cement bags)	0	1	2	3	10
Applied load (kg)	0	20	40	60	200
Uplift (tonnes)	0.04	0.24	0.44	0.64	0.84
Uplift (kN)	**0.4**	**2.4**	**4.3**	**6.3**	**8.2**

Heavy Duty Proof Load Site Tester – Instructions

The Heavy Duty Proof Load Site Tester is used to verify the capacity of diagonal braces, anchor points, tie ropes, connections and the like by applying a working load up to 2.0 tonnes (20 kN), using a 10 : 1 lever assembly, with a load up to 5 - 40 kg or 10 - 20 kg cement bags (or equivalent). When using multiple cement bags, prevent twisting sideways. Load carefully and shield observers from flying debris due to sudden failure.

- To apply an upward force, connect anchor to the end plate and pivot about the fulcrum plate.
- To apply a downward force, connect anchor to the fulcrum plate and pivot about the end plate.
- To apply a horizontal force, connect anchor to the end plate and pivot about the end plate.



Heavy Duty Proof Load Tester						
Applied load (number of 40 kg cement bags)	0	1	2	3	4	5
Applied load (number of 20 kg cement bags)	0	2	4	6	8	10
Applied load (kg)	0	40	80	120	160	200
Uplift (tonnes)	0.11	0.51	0.91	1.31	1.71	2.11
Uplift (kN)	**1.1**	**5.0**	**9.0**	**12.9**	**16.8**	**20.7**

Light Duty Proof Load Site Tester – Details

The Light Duty Proof Load Site Tester is used to verify the capacity of diagonal braces, anchor points, tie ropes, connections and the like by applying a working load, up to 0.87 tonnes (8.5kN) to a representative sample. This is done using a 10 : 1 lever assembly, in which the load is up to 2 - 40 kg or 4 - 20 kg cement bags (or equivalent).). When using multiple cement bags, prevent twisting sideways. Load carefully and shield observers from flying debris due to sudden failure.

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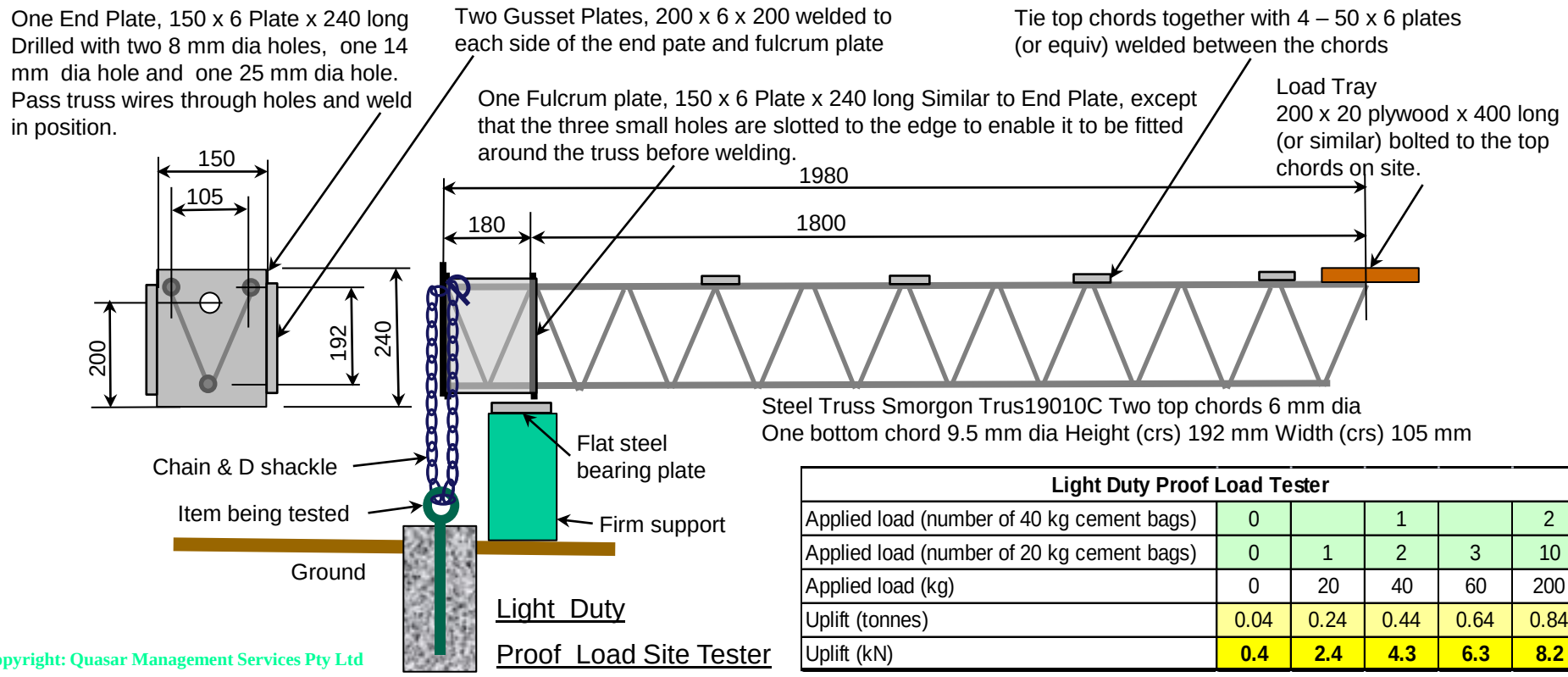
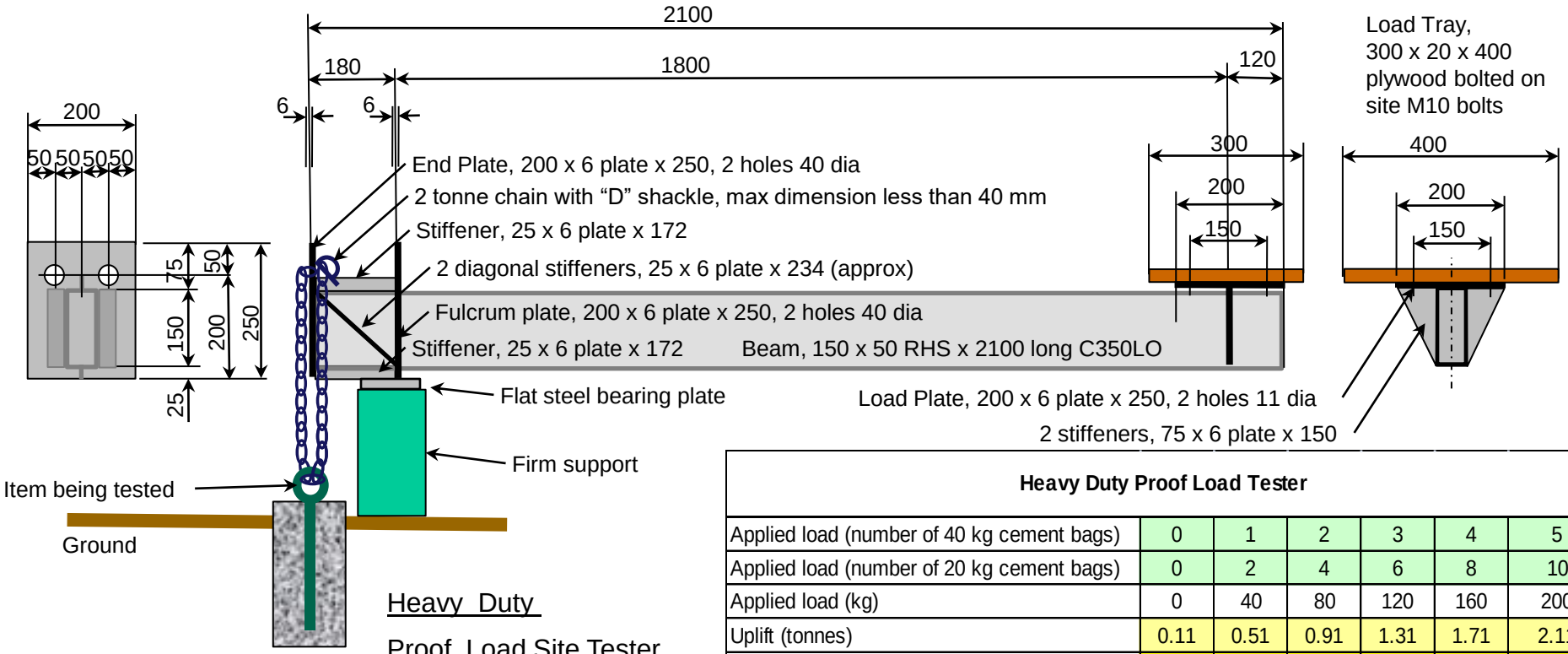


Light Duty Proof Load Tester					
Applied load (number of 40 kg cement bags)	0		1		2
Applied load (number of 20 kg cement bags)	0	1	2	3	10
Applied load (kg)	0	20	40	60	200
Uplift (tonnes)	0.04	0.24	0.44	0.64	0.84
Uplift (kN)	**0.4**	**2.4**	**4.3**	**6.3**	**8.2**

Heavy Duty Proof Load Site Tester - Details

The Heavy Duty Proof Load Site Tester is used to verify the capacity of diagonal braces, anchor points, tie ropes, connections and the like by applying a working load up to 2.0 tonnes (20 kN), using a 10 : 1 lever assembly, with a load up to 5 - 40 kg or 10 - 20 kg cement bags (or equivalent). When using multiple cement bags, prevent twisting sideways. Load carefully and shield observers from flying debris due to sudden failure.

- To apply an upward force, connect anchor to the end plate and pivot about the fulcrum plate.
- To apply a downward force, connect anchor to the fulcrum plate and pivot about the end plate.
- To apply a horizontal force, connect anchor to the end plate and pivot about the end plate.



Heavy Duty Proof Load Tester						
Applied load (number of 40 kg cement bags)	0	1	2	3	4	5
Applied load (number of 20 kg cement bags)	0	2	4	6	8	10
Applied load (kg)	0	40	80	120	160	200
Uplift (tonnes)	0.11	0.51	0.91	1.31	1.71	2.11
Uplift (kN)	**1.1**	**5.0**	**9.0**	**12.9**	**16.8**	**20.7**

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Disclaimer

This training package covers broad engineering principles and building practices, with particular emphasis on affordable housing and associated village infrastructure in the Asia-Pacific region. These broad principles and practices must be translated into specific requirements for particular projects by professional architects, engineers or builders with the requisite qualifications and experience. Associated sample specifications and drawings are available in electronic format, with the express intention that architects, engineers and builders will edit them to suit the particular requirements of specific projects. The design, construction and costing of structures must be carried out by qualified and experienced architects, engineers and builders, who must make themselves aware of any changes to the applicable standards, building regulations and other relevant regulations. The authors, publishers and distributors of these documents, specifications and associated drawings do not accept any responsibility for incorrect, inappropriate or incomplete use of this information.

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