Design and Setting Out

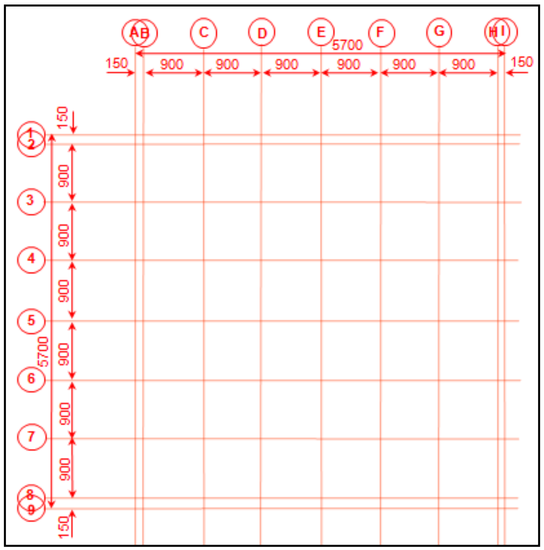
This training package provides information on design, drawings, specifications, setting out, profiles, pegs, grid lines and levels for village infrastructure and houses common in South-East Asia and the South Pacific region.

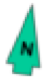
The example used in this training package is one of several standard designs that are available.

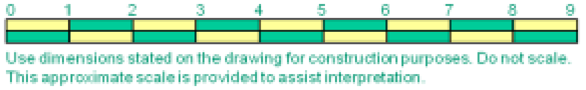
Information Required on Drawings

Construction drawings must include the following:

- Title block stating the client, building and location.
- A notation indicating whether the drawing is “Preliminary” or “Approved for Construction” etc. and by whom.
- Issue or revision number and date
- Location on the site (orientation and distance from side boundaries. This is normally provided by a surveyor.
- Grid lines and grid dimensions. These should define the principal dimensions, orientation and position of the building on site, and enable the setting out of footings and sub-floor structure,
- Height datum and finished floor level.
- North point. While this is not sufficiently accurate for setting out, it enables the drawing to be quickly oriented to avoid confusion in labelling particular elevations.
- An approximate scale. Often drawings show a numerical value for the scale of each view (e.g. 1 : 100). However, as the drawing is copied and reduced or enlarged, this will become misleading. In general, use the dimensions stated on the drawing for construction purposes. Do not scale. An diagram showing the approximate scale may be provided to assist interpretation.







Grid Lines and Dimensions

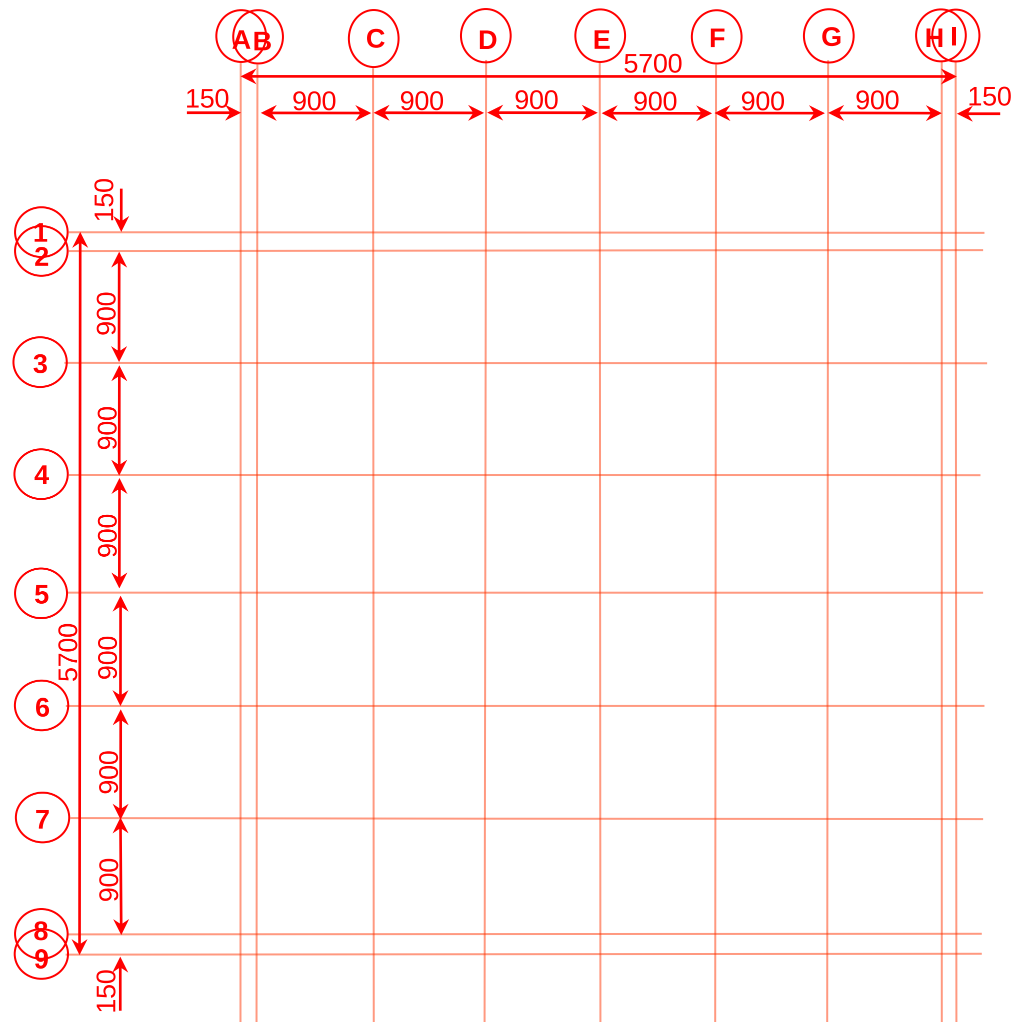
Grid lines should define the principal dimensions, orientation and position of the building on the site, and enable the setting out of footings and sub-floor structure.

When using CAD, the grid should be on a separate layer.

All dimension should be in millimetres.

Use A, B, C, ... to define the vertical gridlines

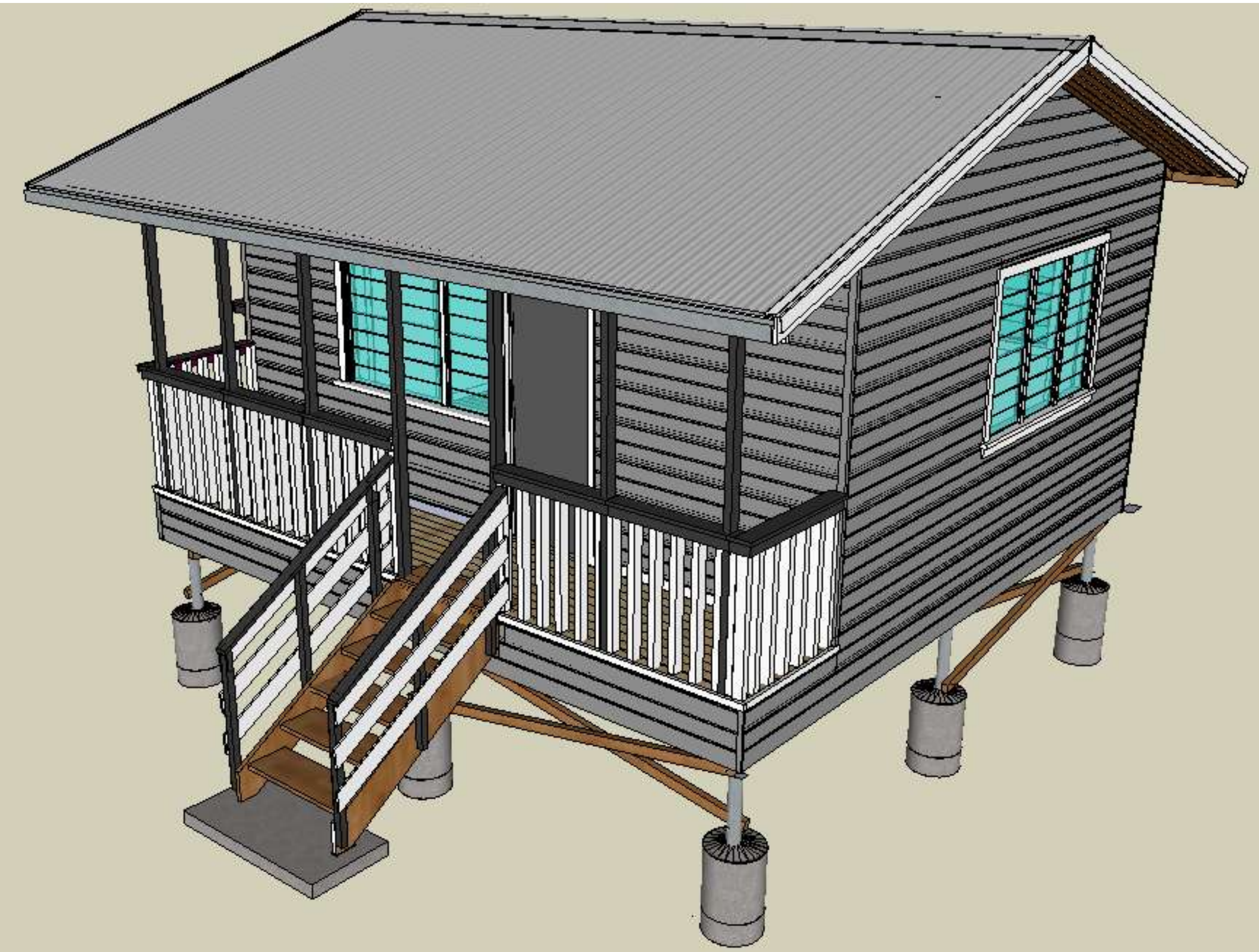
Use 1, 2, 3, ... to define the horizontal gridlines



Architectural Design

Example

Following are the architectural drawings necessary to describe the Partner Housing Standard Demonstration House with the following features - elevated timber framed 5.7 x 4.6 m house with an external balcony 1.1 m wide.



Floor Plan

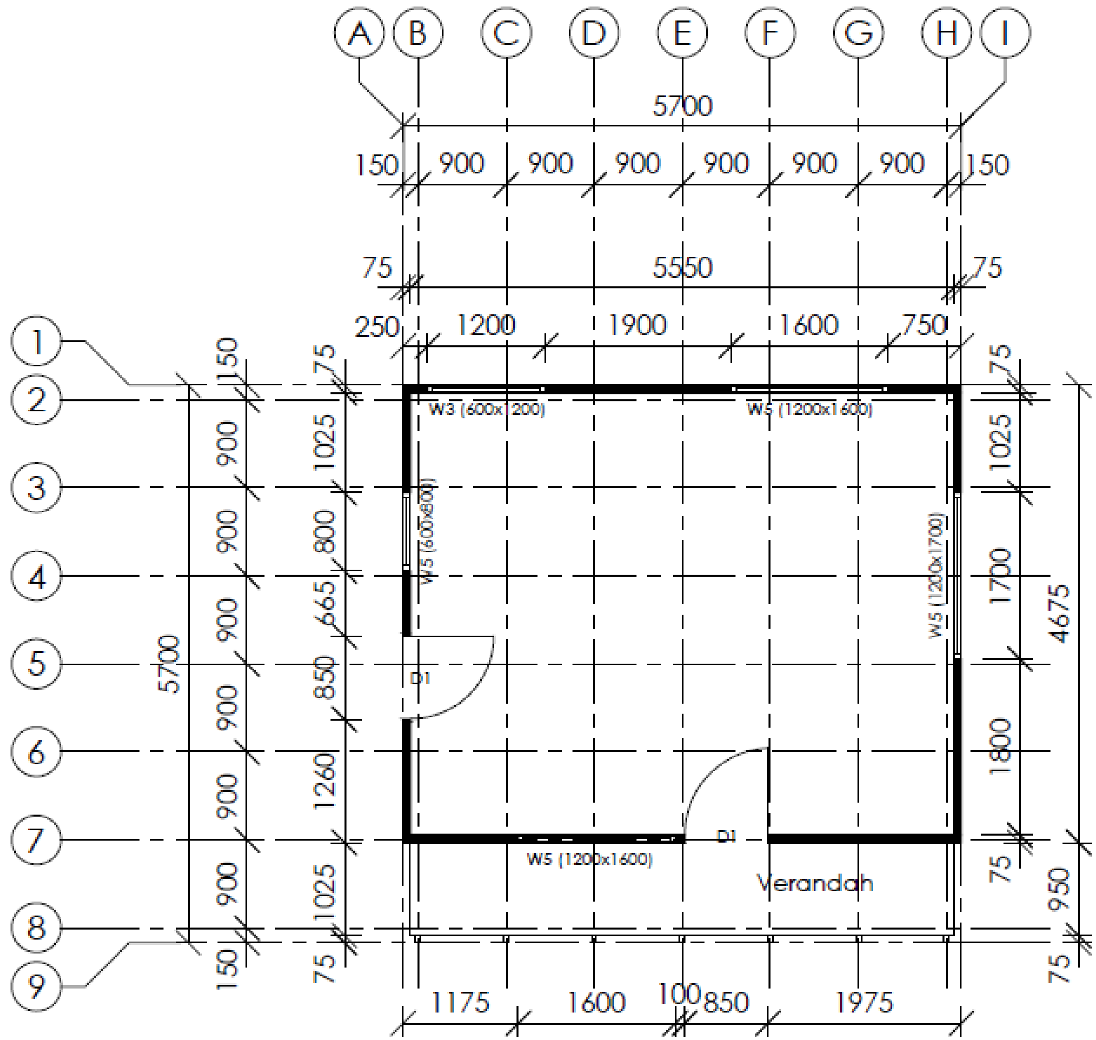
The floor plan is used for setting out all external walls, internal walls, doors and windows.

Dimensions of all components are related to the relevant grid lines.

Gridlines to which dimensions do not refer may be omitted.

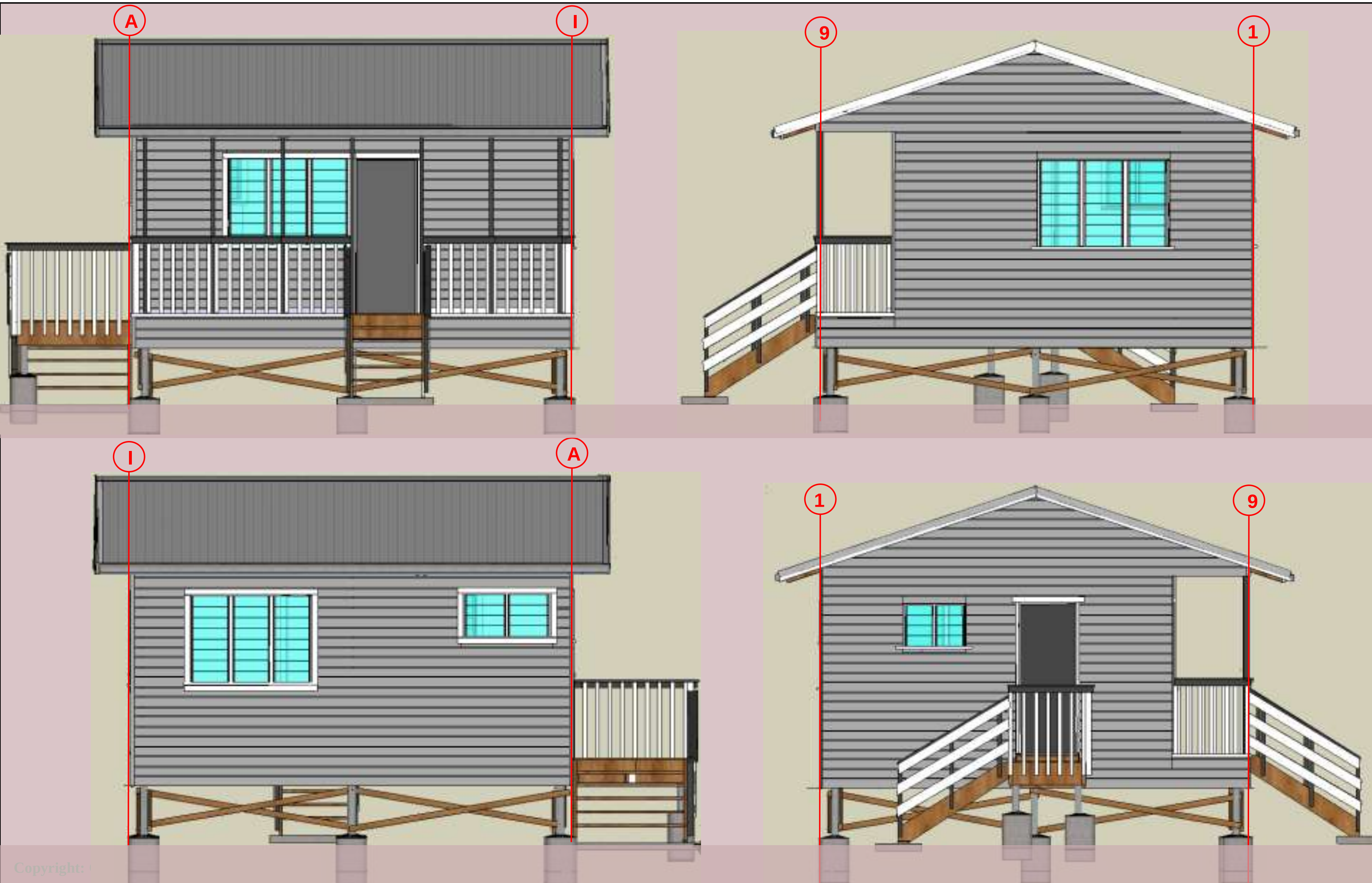
The floor plan should include:

- Dimensions to all rooms and walls
- Dimensions to windows and doors Nomenclature of window and door schedules
- Details of the walls
- Details of external cladding and internal lining
- Details of the stairs
- Details of the deck
- Roof line above.



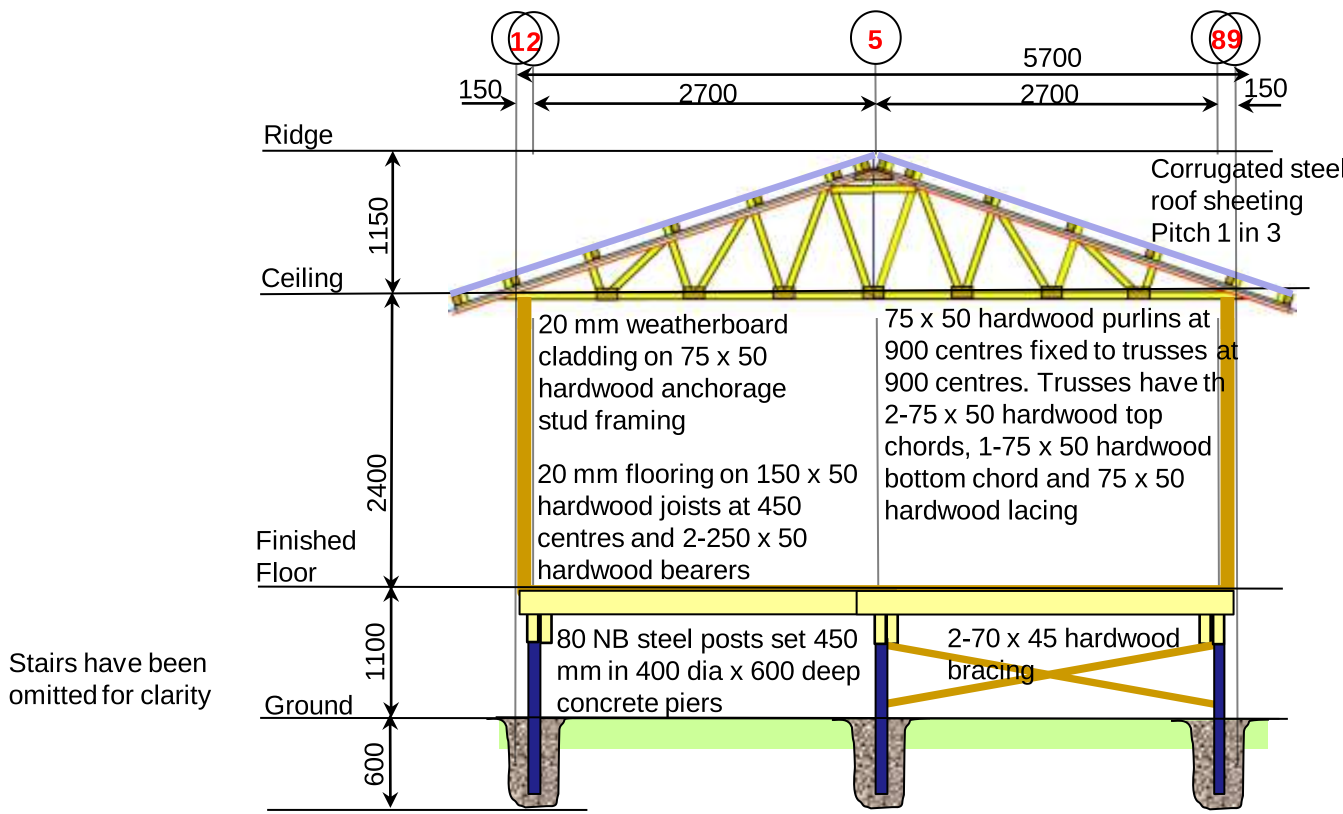
Elevations

The elevations are used to define the features, cladding, roof shape, external doors and windows.



Section

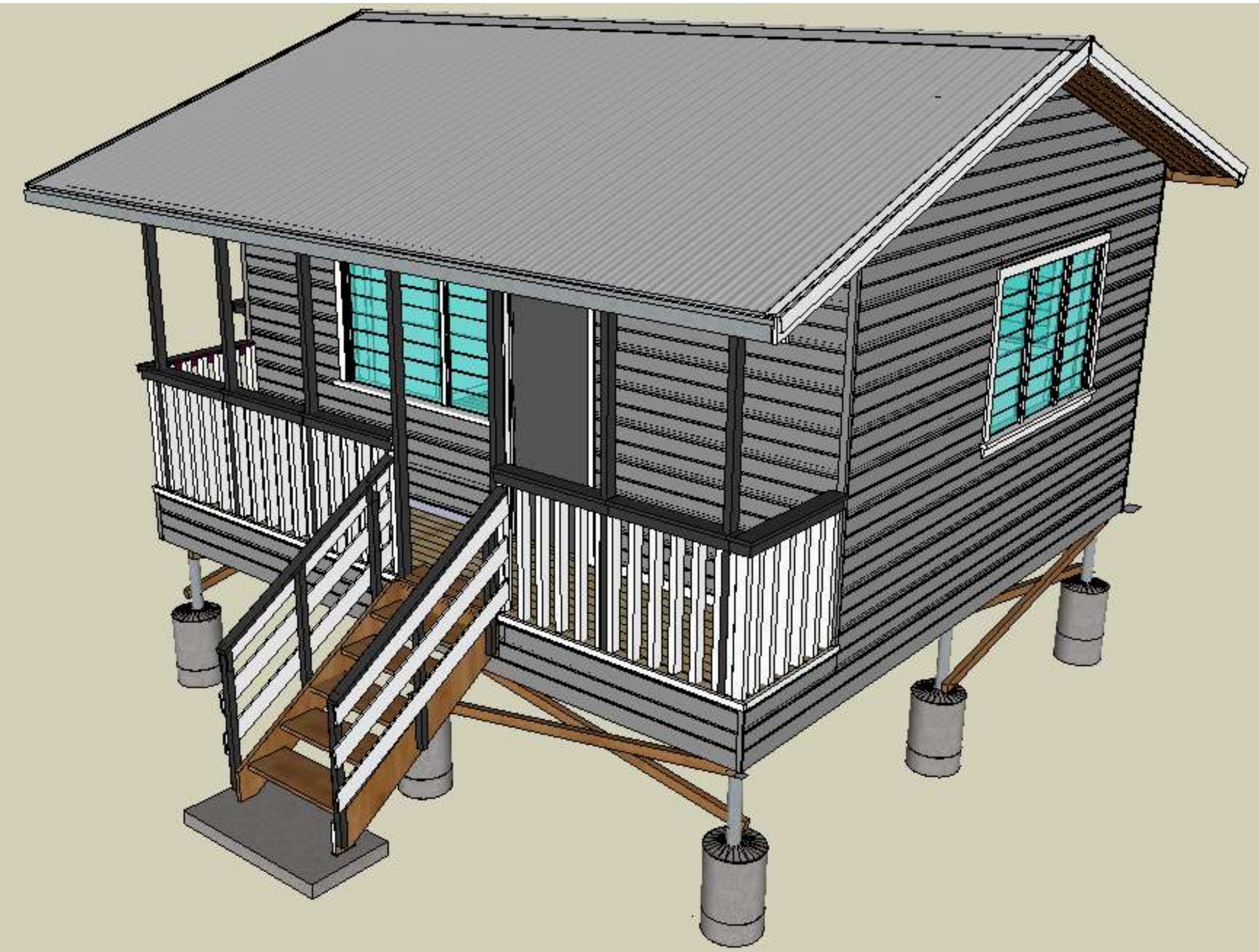
The section is used to define the heights and levels, including ground level, floor level, ridge level, and the principle features of the house.



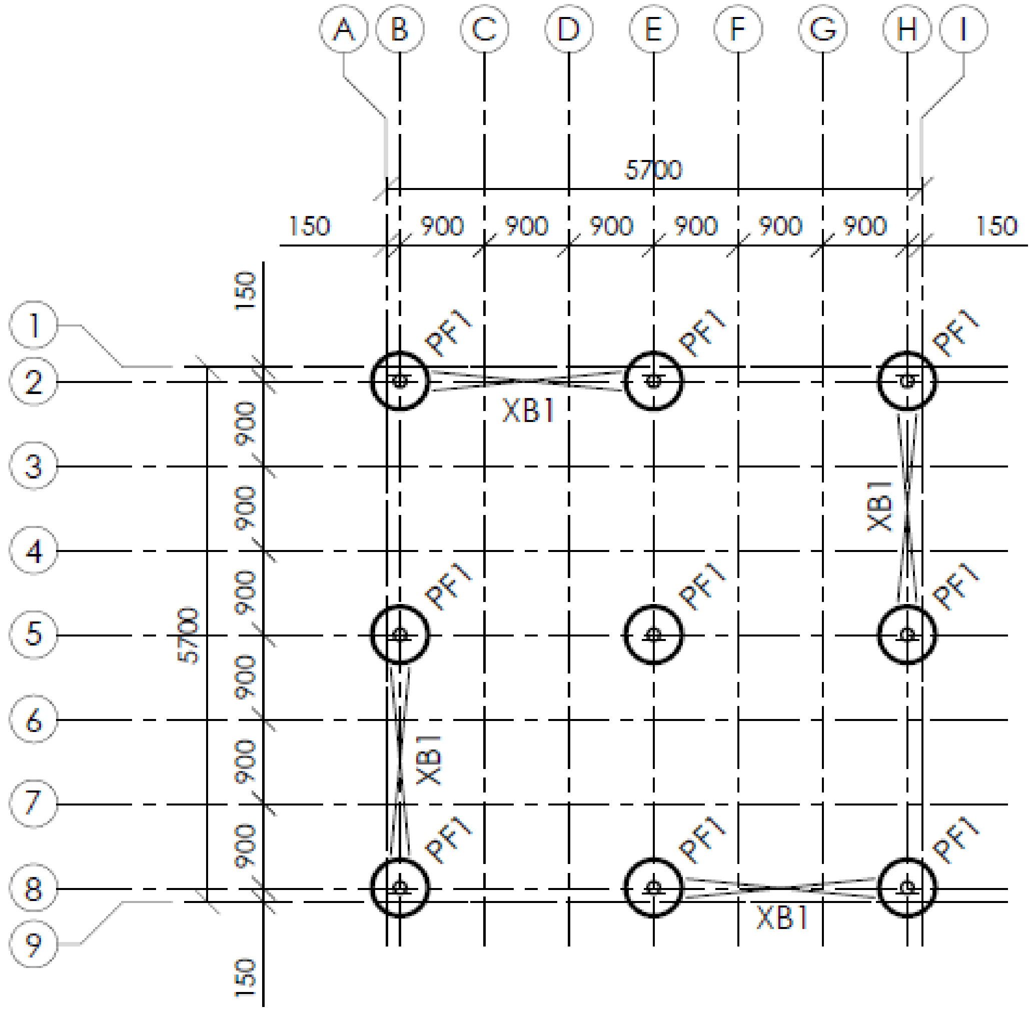
Engineering Design

Example

Following are the engineering drawings necessary to describe the Partner Housing Standard Demonstration House with the following features - elevated timber framed 5.7 x 4.6 m house with an external balcony 1.1 m wide. The house shall be suitable for non-cyclonic wind and significant earthquakes, on moderately reactive soils, but not subject to tsunami or flood.



Sub-floor Layout



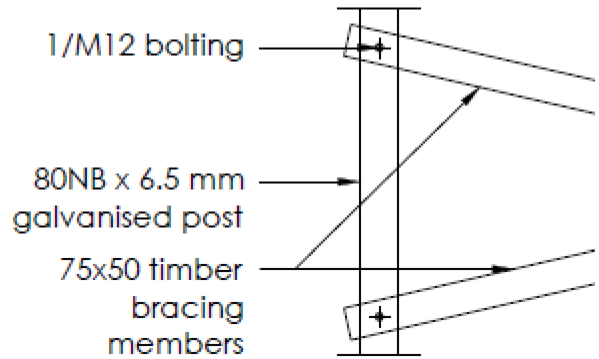
FOOTINGS & SUBFLOOR LAYOUT

SCALE 1:100

PF1 - 400Ø Concrete footing with steel post

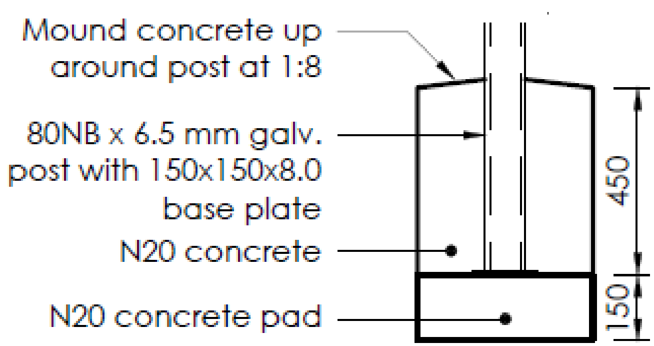
XB1 - 75x50 F11 timber subfloor cross bracing

Sub-floor Posts, Footings and Bracing Details

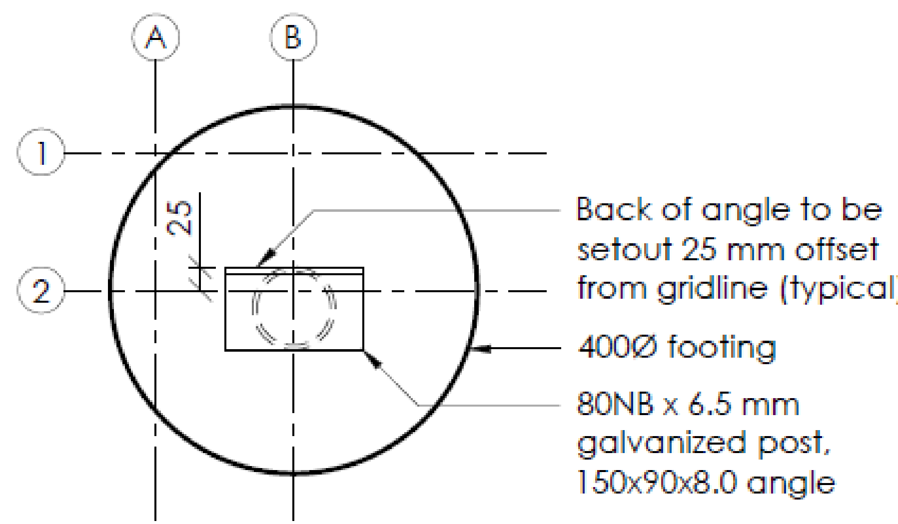


XB1 - SUBFLOOR BRACING DETAIL

SCALE 1:20

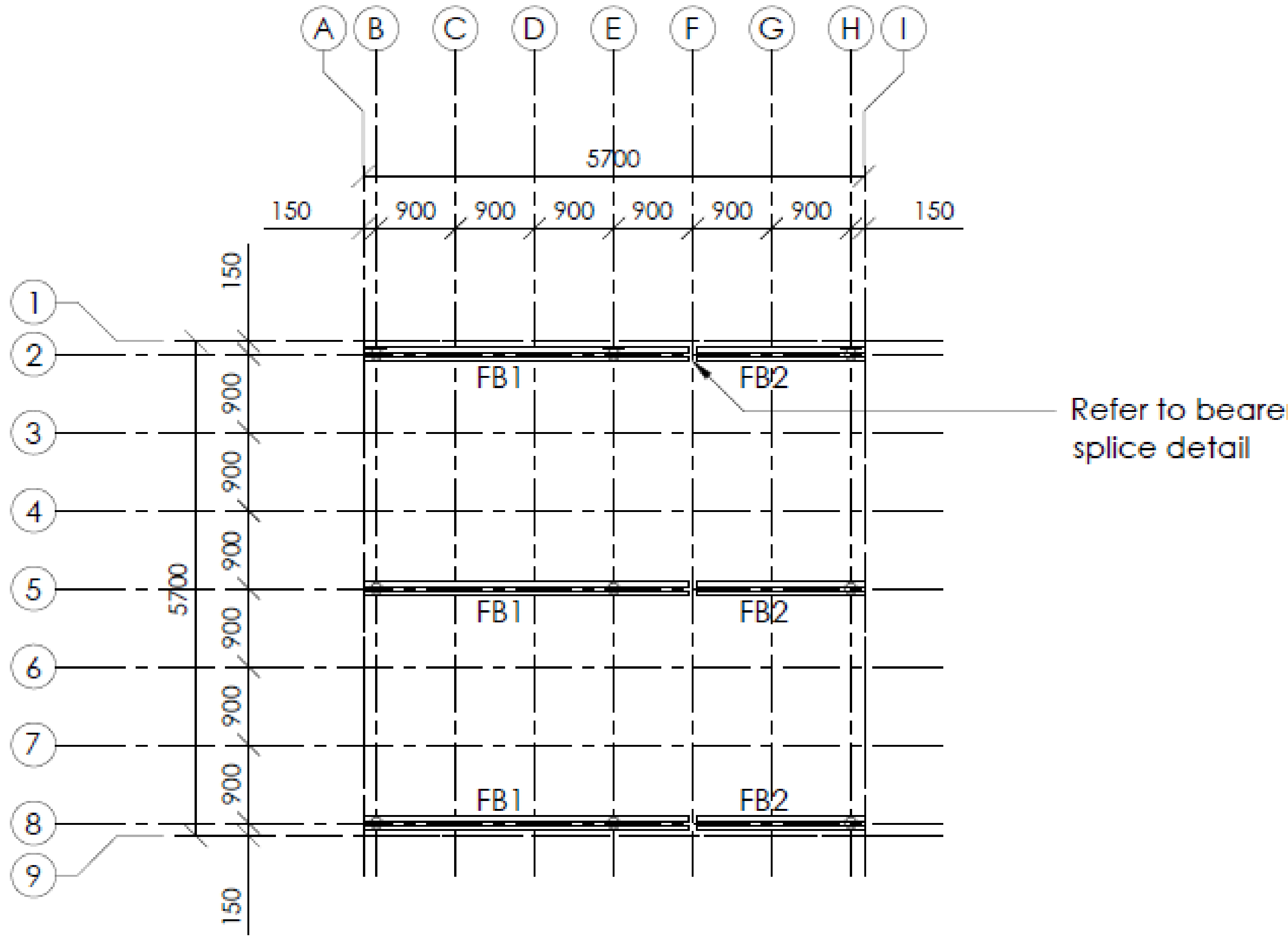


FOOTING DETAIL



STEEL POST SETOUT DETAIL

Floor Bearer Layout



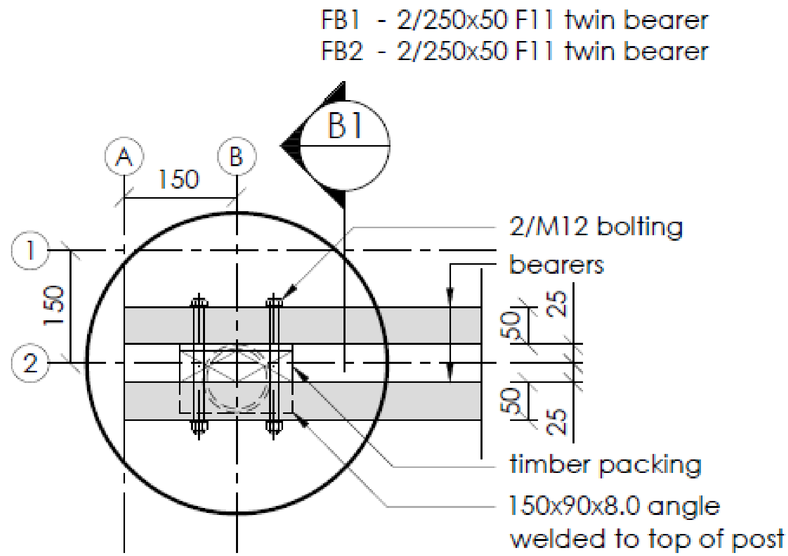
FLOOR BEARER LAYOUT

SCALE 1:100

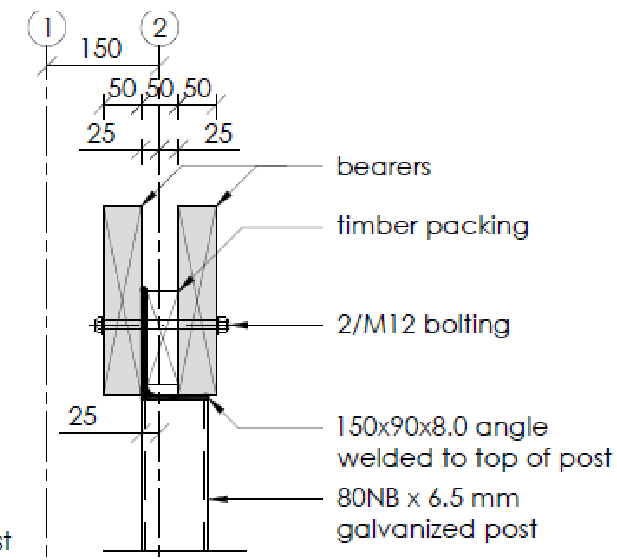
FB1 - 2/250x50 F11 twin bearer

FB2 - 2/250x50 F11 twin bearer

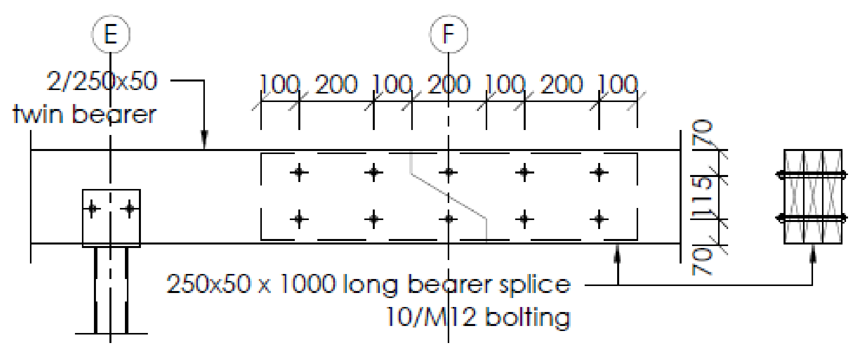
Floor Bearer Details



BEARER SETOUT DETAIL
SCALE 1:10

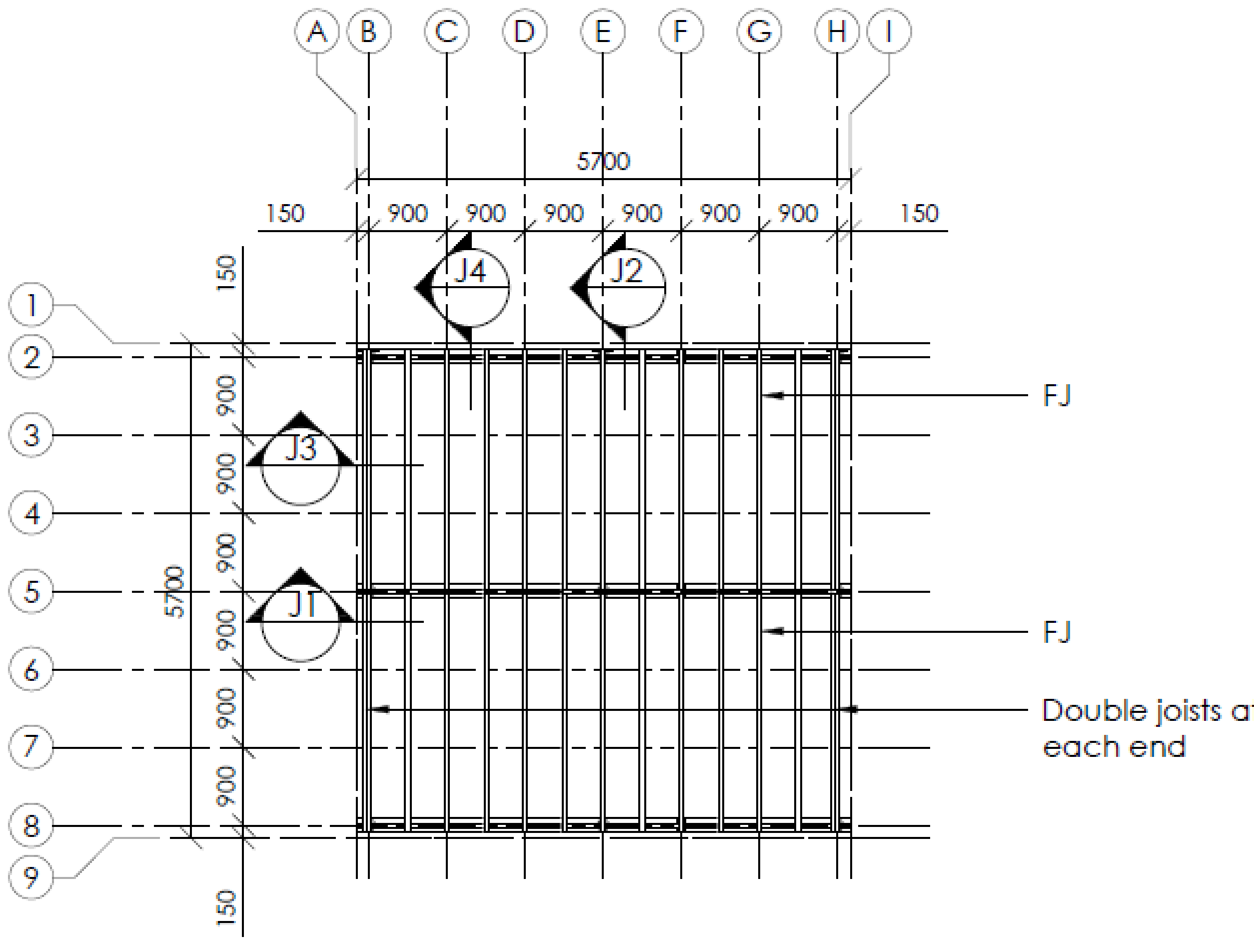


SECTION B1
SCALE 1:10



BEARER SPLICE DETAIL
SCALE 1:10

Floor Joist Layout

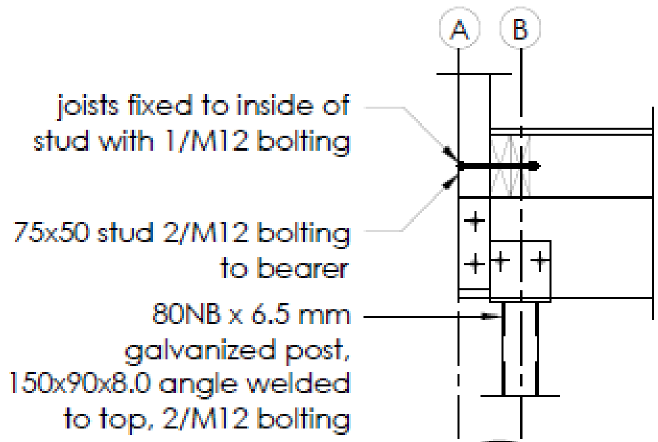


FLOOR JOIST LAYOUT

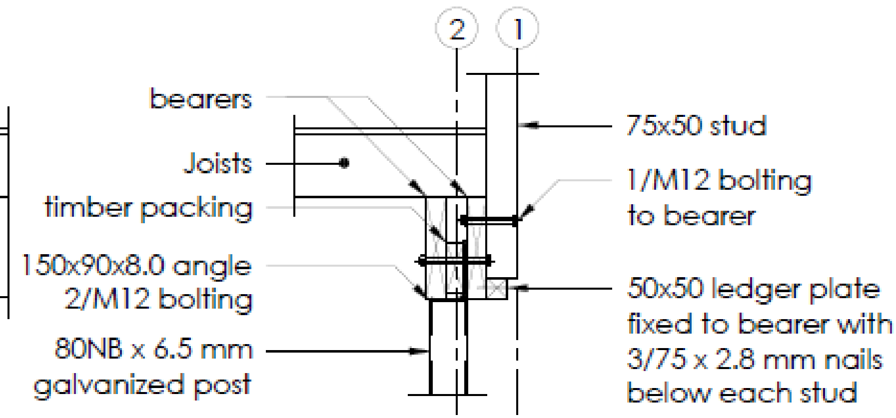
SCALE 1:100

FJ - 150x50 F11 joists @ 450 centres

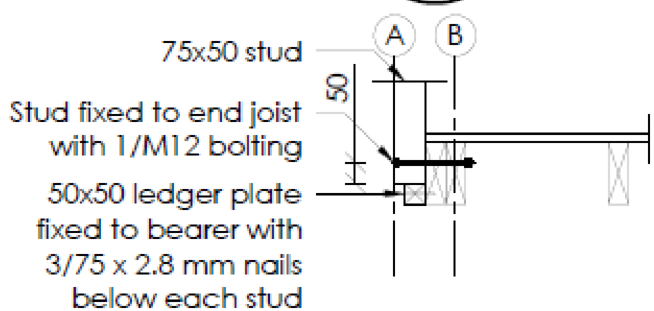
Floor Joist Details



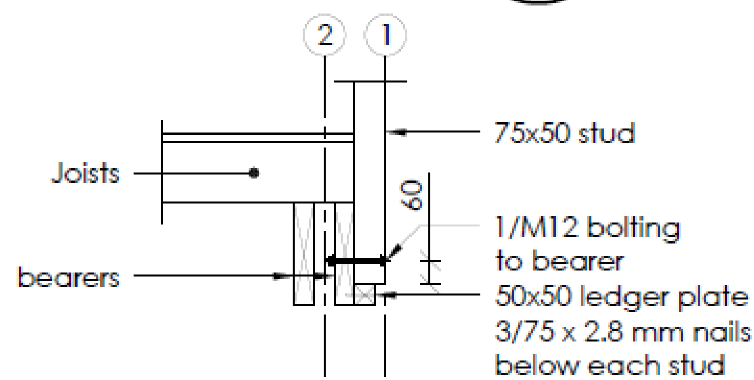
SECTION J1
SCALE 1:20



SECTION J2
SCALE 1:20

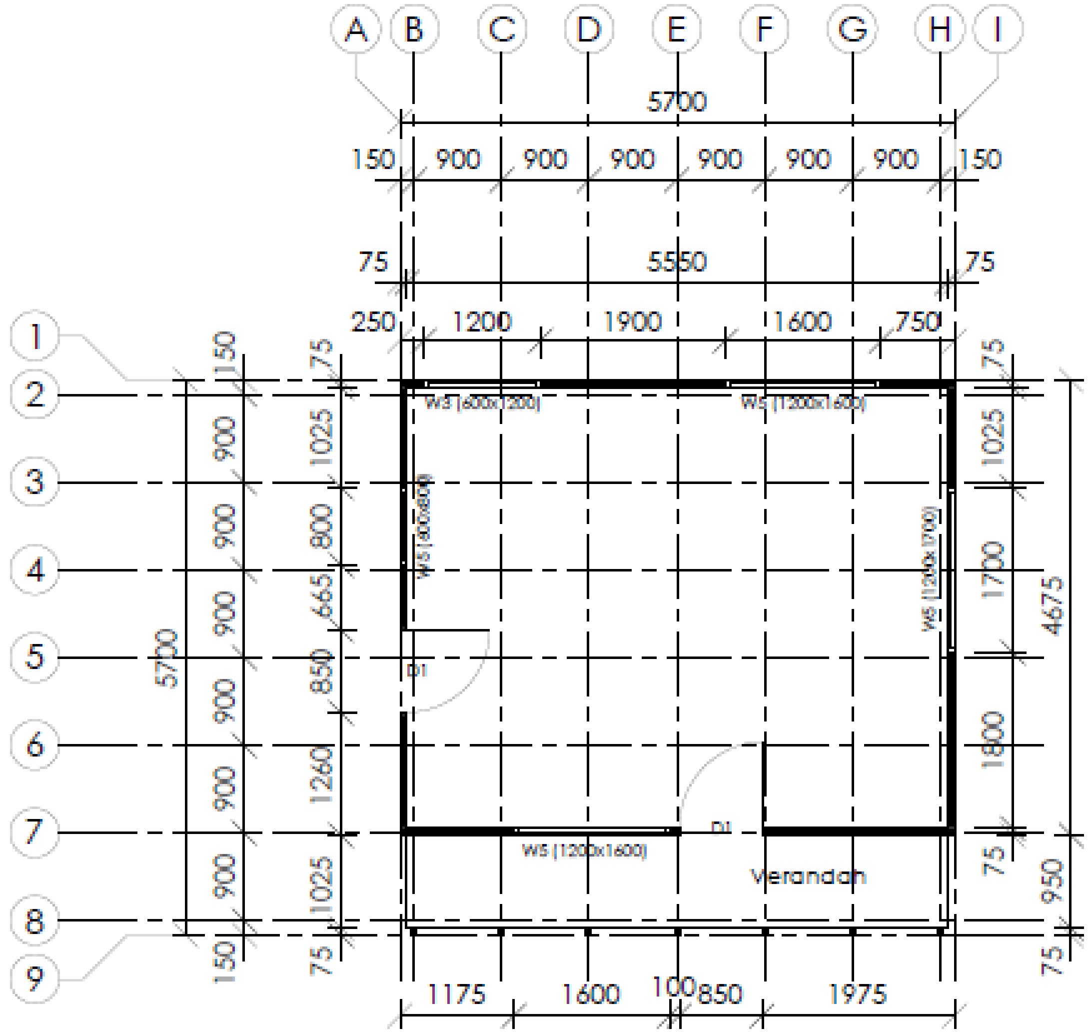


SECTION J3
SCALE 1:20



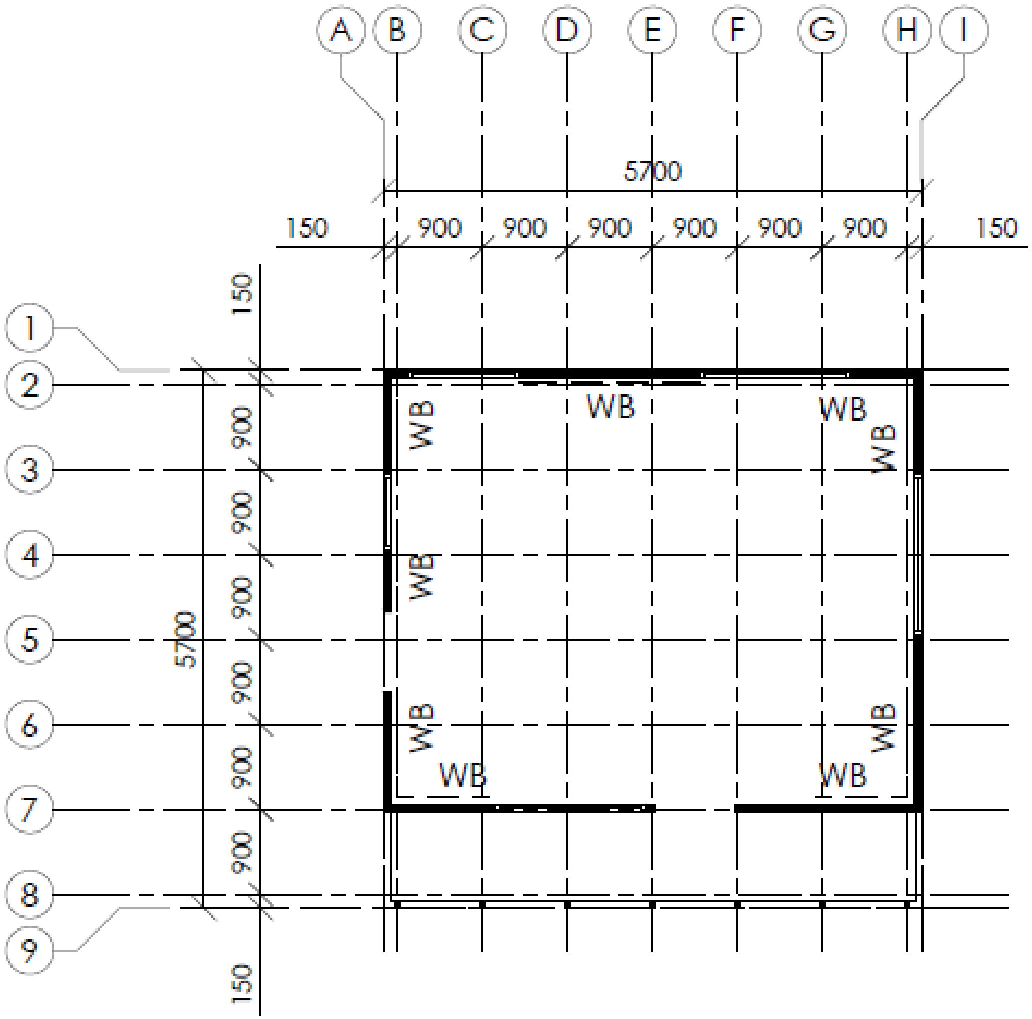
SECTION J4
SCALE 1:20

Wall Layout



WALL LAYOUT
SCALE 1:100

Wall Bracing Layout

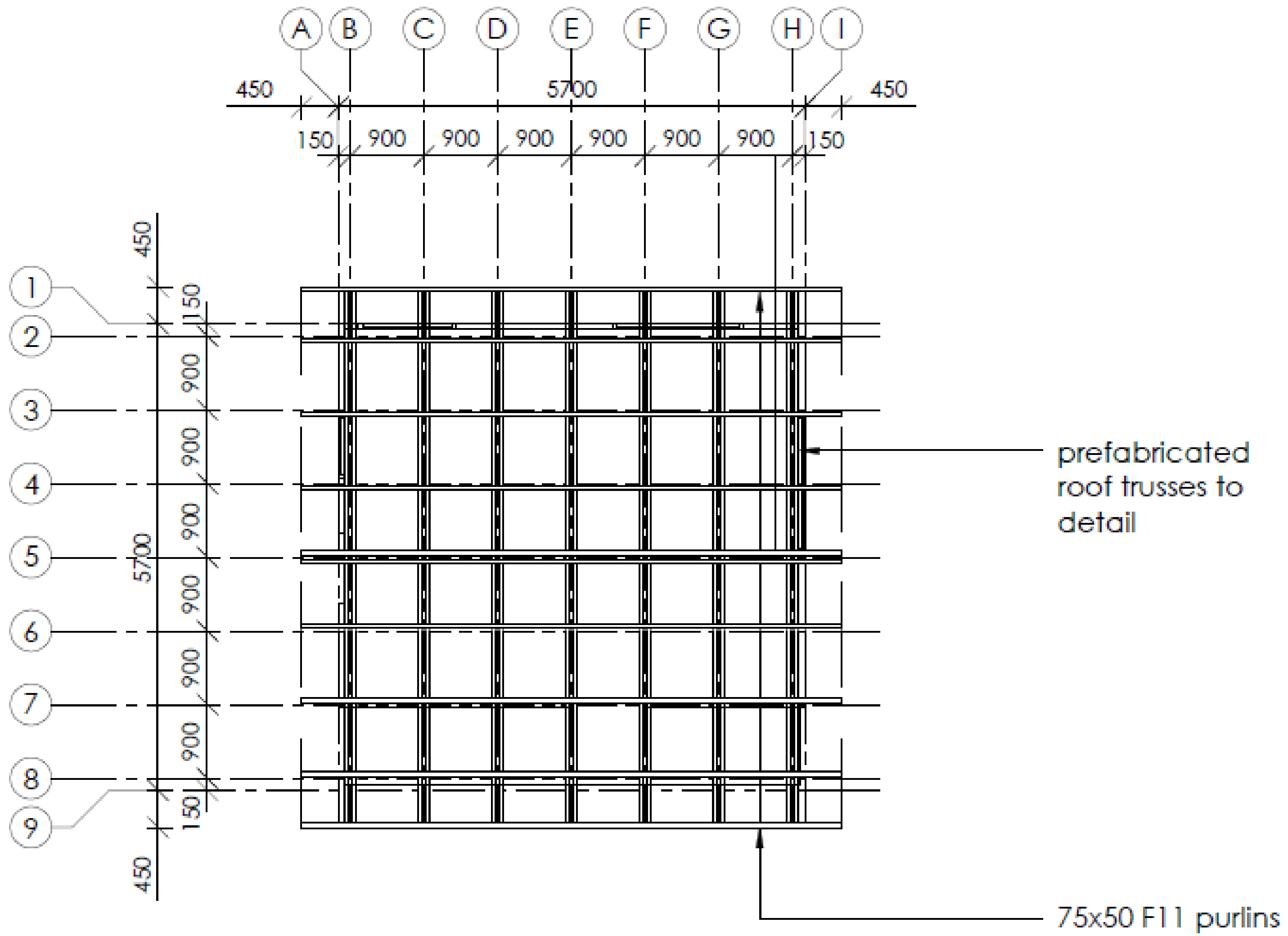


WALL BRACING LAYOUT

SCALE 1:100

WB - PLYWOOD WALL BRACING

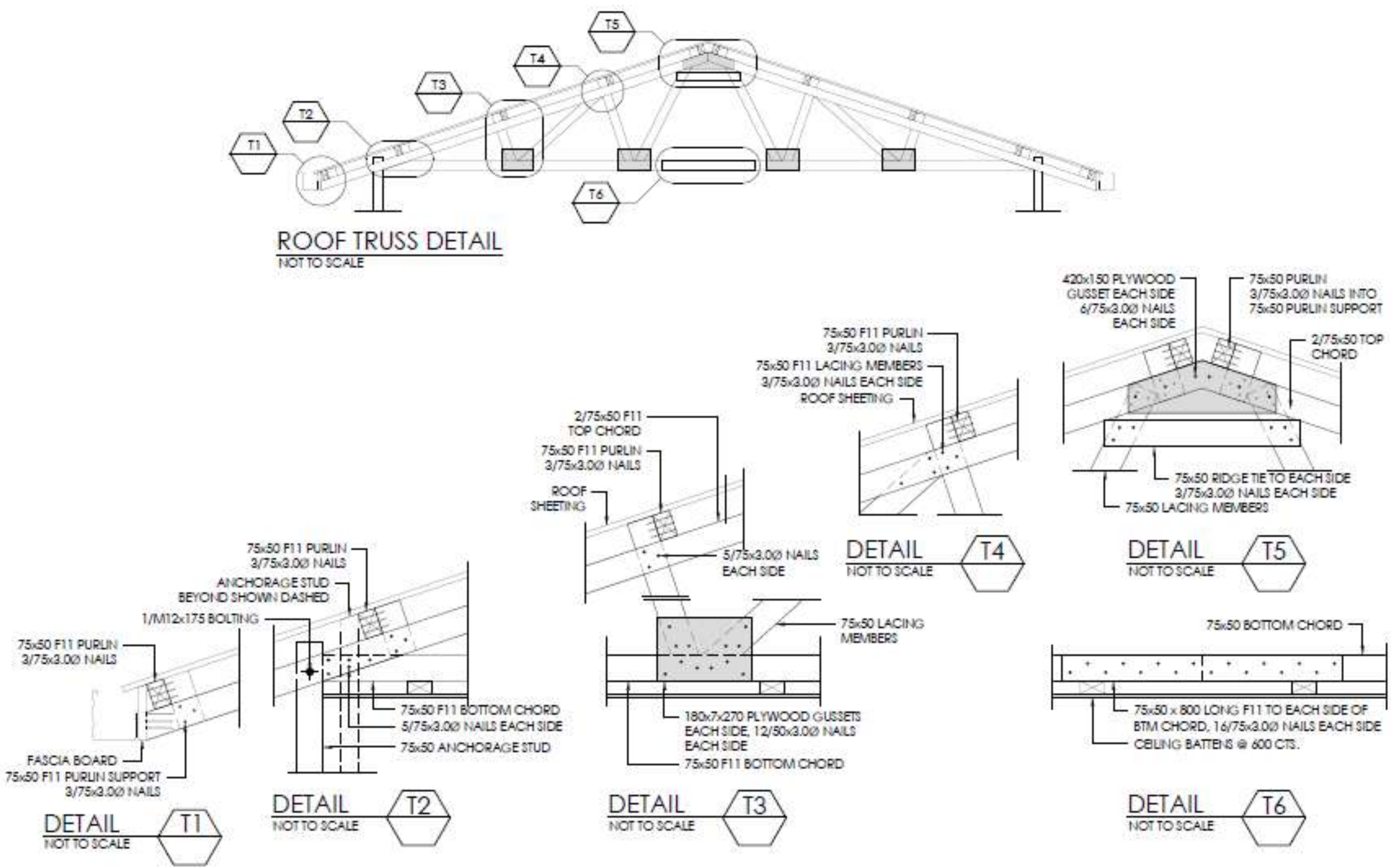
Roof Frame Layout



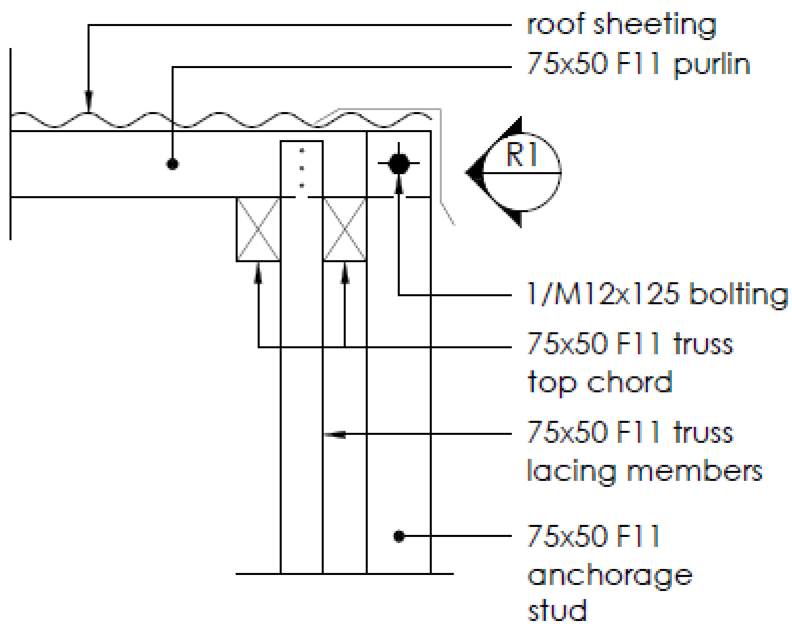
ROOF FRAME LAYOUT

SCALE 1:100

Truss Details

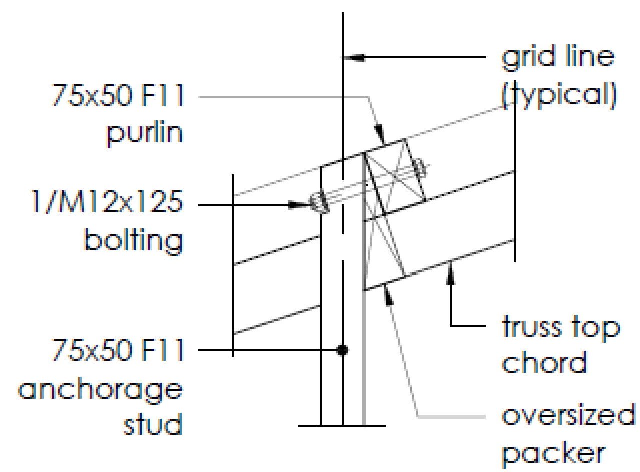


Purlin Connection Details



ANCHORAGE STUD TO PURLIN DETAIL

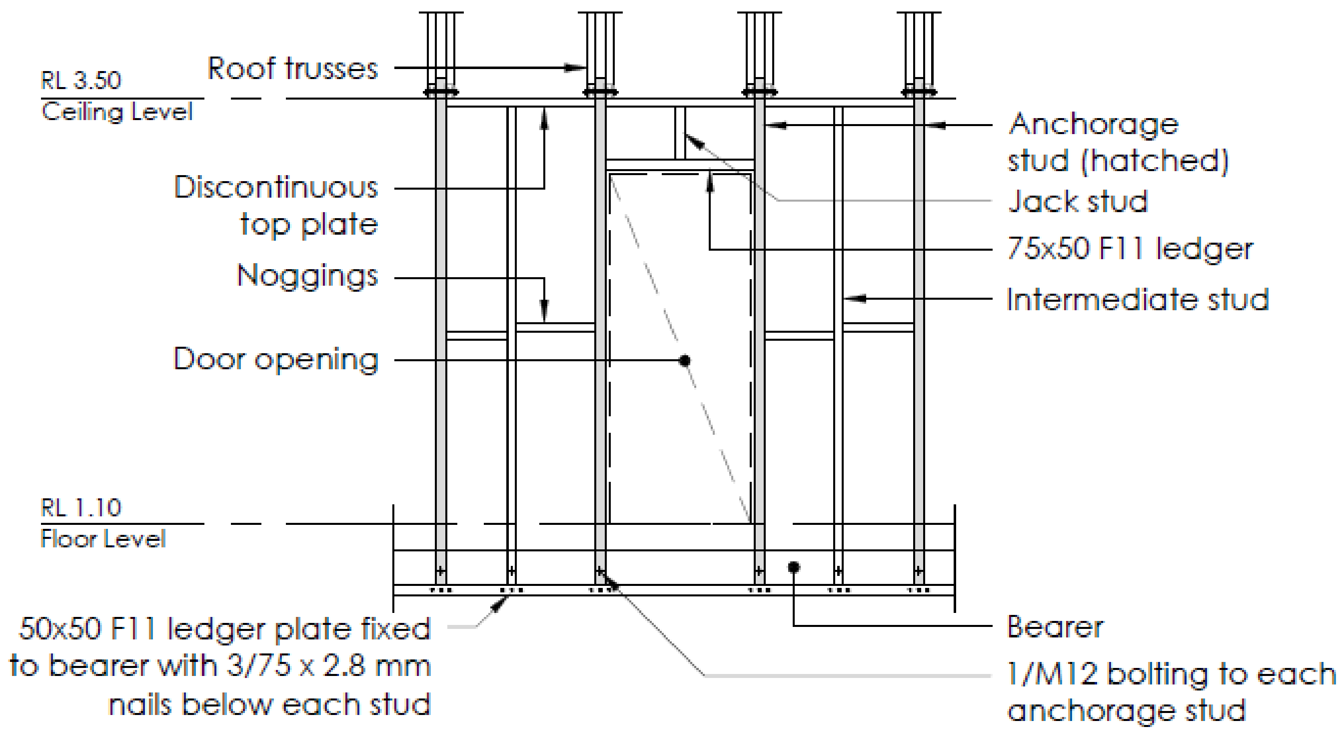
SCALE 1:10



SECTION R1

SCALE 1:10

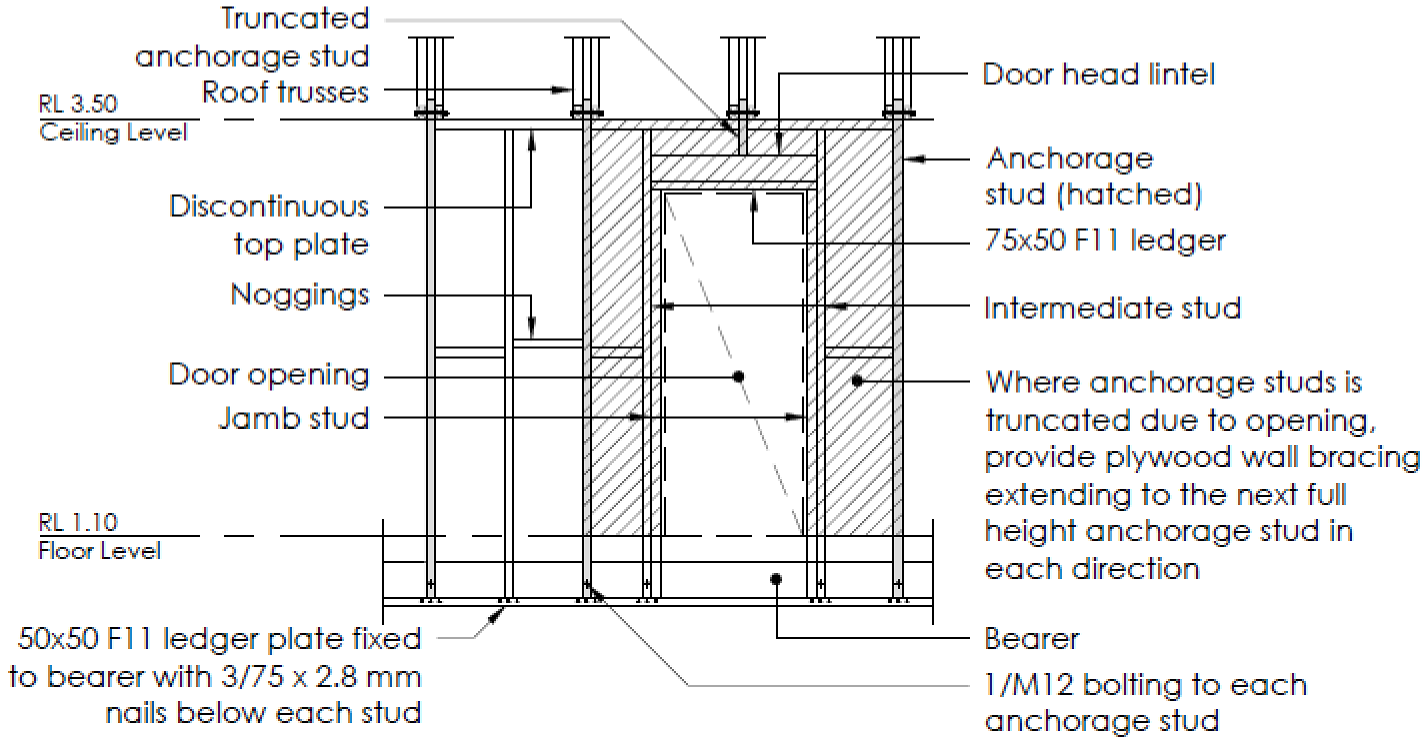
Door Opening Details



DOOR OPENING WALL FRAMING DETAIL 1

SCALE 1:50

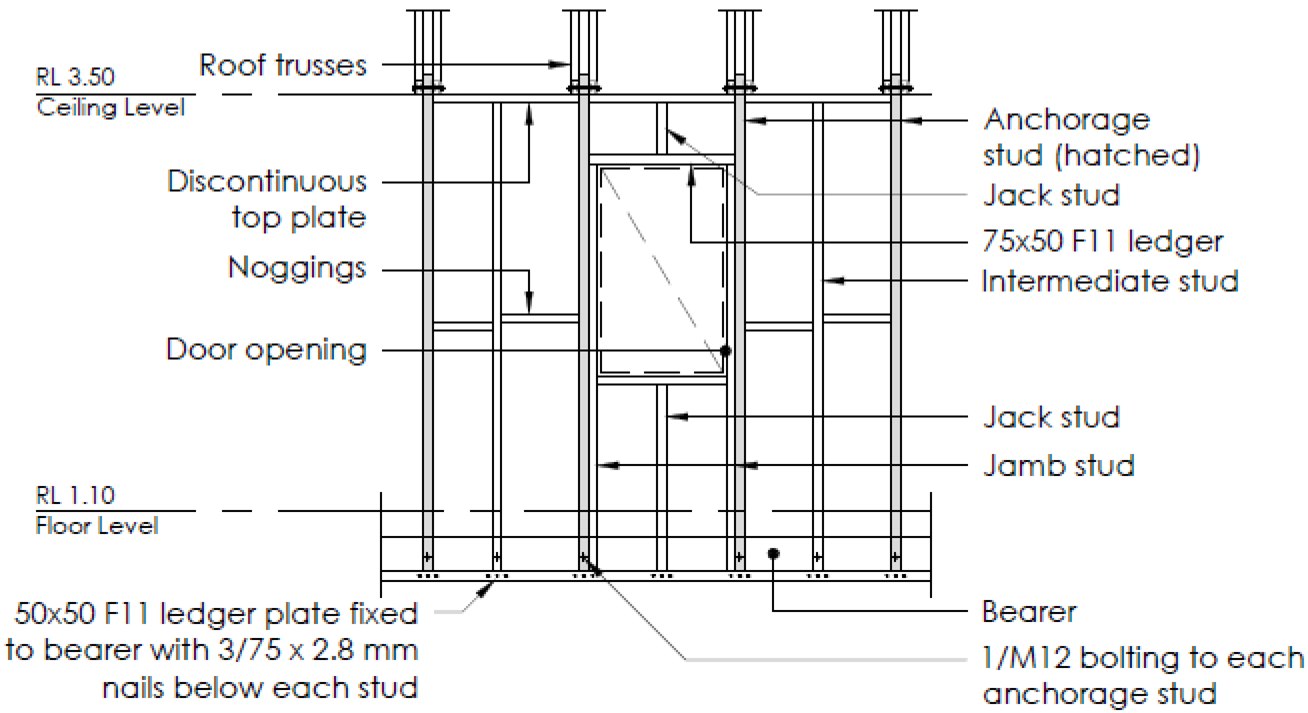
Door Opening Details



DOOR OPENING WALL FRAMING DETAIL 2

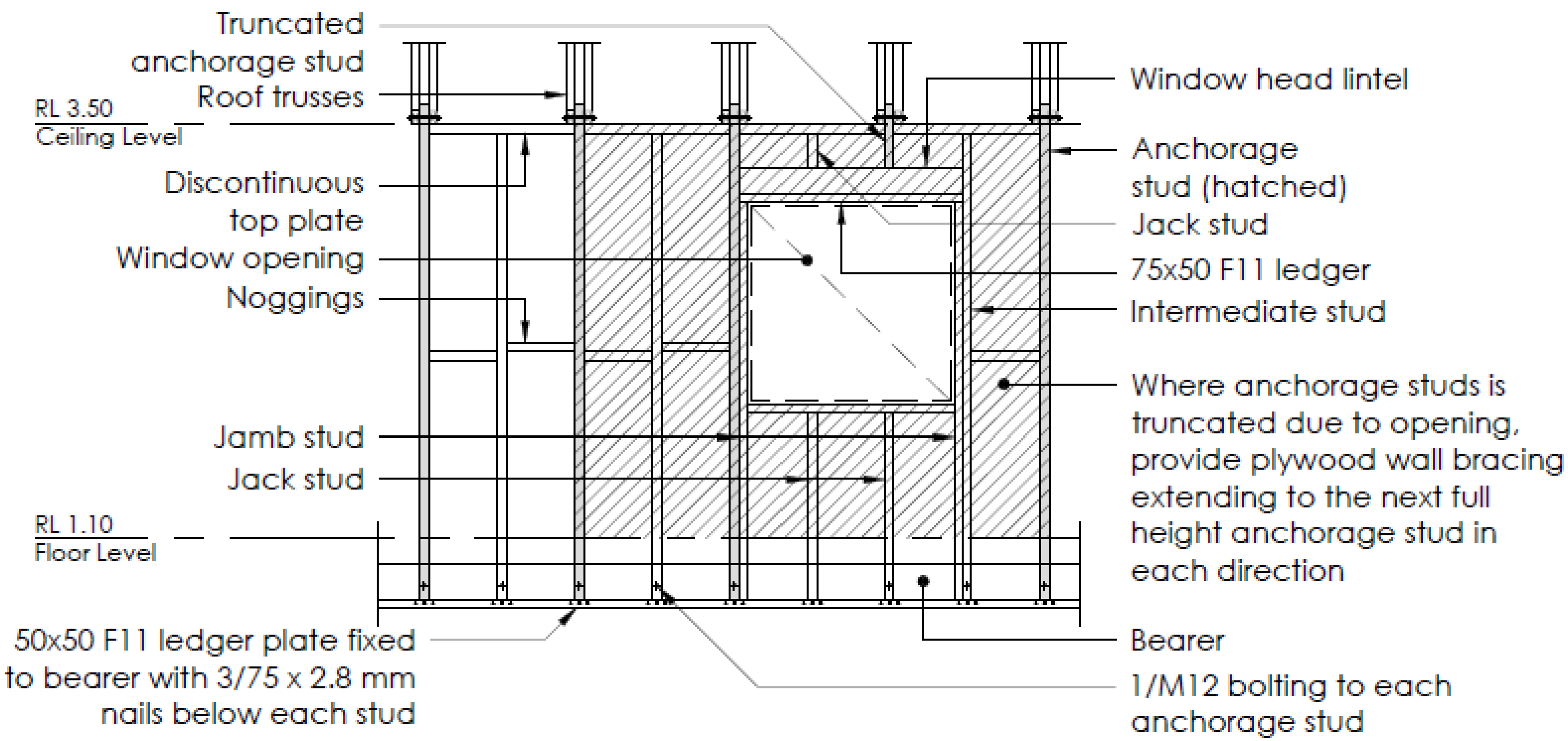
SCALE 1:50

Window Opening Details



WINDOW OPENING WALL FRAMING DETAIL 1
SCALE 1:50

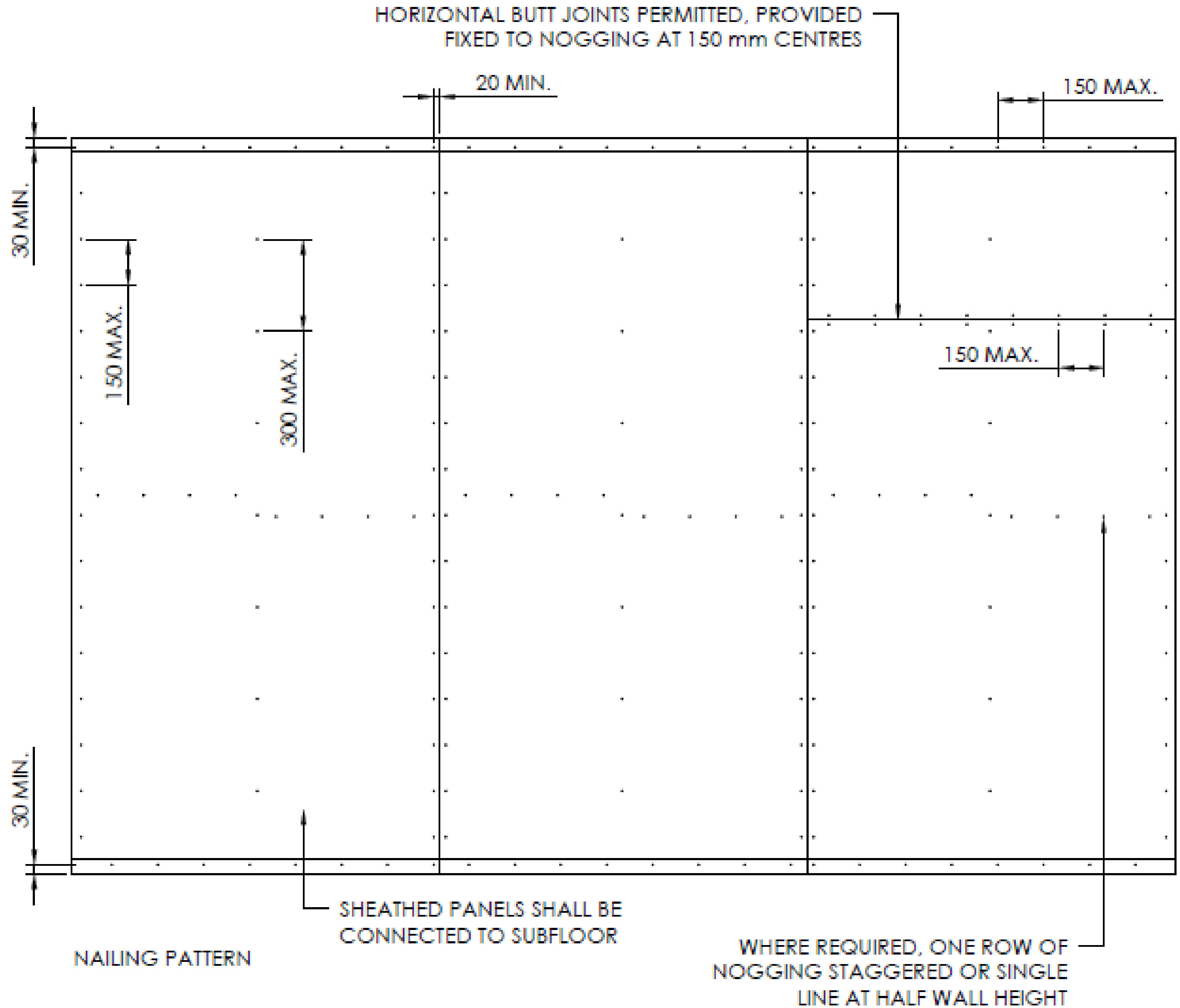
Window Details



WINDOW OPENING WALL FRAMING DETAIL 2

SCALE 1:50

Wall Bracing Details



WB - WALL BRACING DETAIL

SCALE 1:20

NOTE: PLYWOOD SHALL BE 7mm THICKNESS AND NAILED TO FRAME USING
30x2.8mm Ø GALVANISED FLAT HEAD NAILS OR EQUIVALENT.

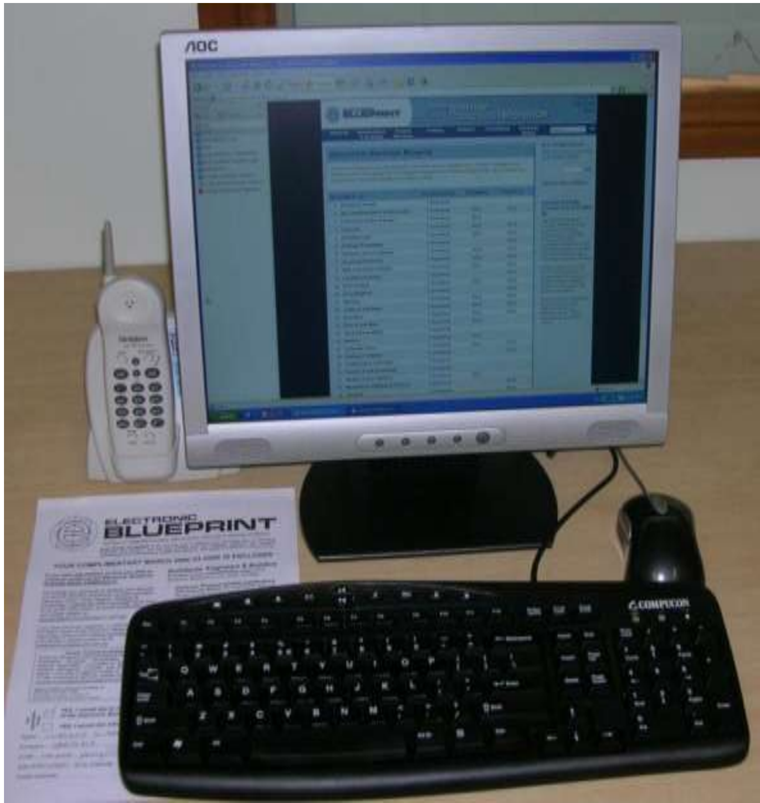
Selection of the appropriate timber

Select the appropriate timber from the following tables, based on AS 1720 and AS 1684.

General Specification	
Common name of timber species	Kwila
Seasoned or unseasoned?	Unseasoned
Hardwood or softwood?	Hardwood
Controlled stress grading?	No
Minimum stress grade	F11
Strength group	S2
Joint group	J2
Density	1,150
Toughness	M
Tangential shrinkage	2.5%
Durability class	2
Lyctid susceptibility	S
Termite resistance	R
Colour	Light to dark red
In-ground use	-
Exposed framing above ground use	Common
Protected framing above ground use	Common
Decking use	Common
Cladding use	-
Internal flooring use	Common
Panelling use	Common
External joinery use	-
Internal joinery use	-
Availability	Limited

Specifications

This module provides, an example specifications to timber framing, summarised from the Electronic Blueprint. More comprehensive editable building specifications may be downloaded from: www.electronicblueprint.com



Specifications

Scope

This section covers timber framing, such as columns, posts, beams, battens, rafters, trusses and the like, consisting of sawn timber, plywood, and glued-laminated timber.

Building Regulations and Standards

All materials and construction shall comply with the most recent version of:

- the relevant parts of the Building Regulations;
- the Standards referred to therein;
- other Standards nominated in this specification; and
- other relevant Regulations.

Relevant Standards

AS 1684.1 *Residential Timber Framed Construction – Design Criteria*
AS 1684.2 *Residential Timber Framed Construction – Non-cyclonic areas*

If the house is located in a cyclonic region, the relaavent standard will be AS 1684.3 *Residential Timber Framed Construction – Cyclonic areas.*

Specifications

Relevant Standards (continued)

AS 1604 Timber – Preservative treated – Sawn and round
AS 2082 Visually stress-graded hardwood for structural purposes
AS 2858 Visually stress-graded softwood for structural purposes
AS 2878 Timbers – Classification into strength groups
AS 3519 Timber – Machine proof grading

AS 4440 Installation of nail-plated timber roof trusses
AS/NZS 1328 Glued-laminated structural timber
AS/NZS 1748 Timber – Stress graded – Product requirements for mechanically stress-graded timber
AS/NZS 2098 Methods of test for veneer and plywood
AS/NZS 2269 Plywood – Structural
AS/NZS 4063 Timber – Stress graded In-grade strength and stiffness evaluation
AS/NZS 4357 Structural laminated veneer lumber
AS/NZS 4490 Timber – Procedures for monitoring structural properties
AS/NZS 4491 Timber – Glossary of terms in timber related Standards

AS 1111 ISO metric hexagon commercial bolts and screws
AS 1393 Coach screws (metric series) (with ISO hexagon heads)
AS 1397 Steel sheet and strip
AS 2334 Steel nails – Metric series
AS 3566 Screws – Self drilling – For the building and construction industries
AS 3660 Protection of buildings from subterranean termites
BS 1597 Specification of connectors for timber

Specifications

Commencement

Work shall commence as soon as practical after, but not before,

(a) the Builder has issued:

- a written order
- the relevant contract drawings, specifications and schedule of work
- written approval of any details provided by the Contractor

(b) concrete slabs and /or footings that support the frame are in place.

Design and Construction

Timber structures shall comply with the Drawings, Building Regulations and relevant Standard (AS 1684 [residential applications], AS 1720 [general applications]). Timber and timber products shall be graded as follows:

- Visually graded sawn timber – AS 2082 and AS 2858
- Mechanically graded timber – AS 1748
- Proof graded timber – AS 3519
- Structural plywood – AS/NZS 2269
- Laminated veneer lumber – AS/NZS 4357
- Glued laminated timber – AS/NZS 1328
- Round timber – AS 2209.
- Sawn timber, of nominated stress grades, shall have the following characteristic properties.

Specifications

Minimum Timber Properties for Particular Stress Grades

Locally sourced hardwoods shall comply with, or exceed, the following specifications for F11 unseasoned hardwood or better. Imported softwoods shall comply with, or exceed, the following specifications for MGP10 machine graded softwood or better.

Characteristic Properties of Timber							
Stress Grade and Commonly Available Timbers	Characteristic Strength					Characteristic short duration average modulus of elasticity parallel to grain	Characteristic short duration average modulus of rigidity
	Bending	Tension parallel to grain		Shear in beam	Compression parallel to grain		
		Hardwood	Softwood				
	MPa (N/m^2)	MPa (N/m^2)	MPa (N/m^2)	MPa (N/m^2)	MPa (N/m^2)	MPa (N/m^2)	MPa (N/m^2)
F 11 Unseasoned Hardwood	35	20	17	3.1	25	10 500	700

Characteristic Properties of Timber						
Stress Grade and Commonly Available Timbers	Characteristic Strength				Characteristic short duration average modulus of elasticity parallel to grain	Characteristic short duration average modulus of rigidity
	Bending	Tension parallel to the grain	Shear in beams	Compression parallel to grain		
	MPa (N/m^2)	MPa (N/m^2)	MPa (N/m^2)	MPa (N/m^2)	MPa (N/m^2)	MPa (N/m^2)
MGP 10 Seasoned Softwood (e.g. Radiata, Slash, Hoop, Caribbean, Pinaster Pines)	16 19 (45 mm thick)	8.0	5.0	24	10 000	670

Specifications

Durability

Timber shall comply with the durability requirements specified on the drawings for the particular application, Where required to achieve particular resistance to termite and/or borer attack, the species listed herein shall be treated to achieve the hazard levels listed in AS 1684.2, & 3 Table C1, but not less than the following. CCA (copper chrome arsenate) represents a health risk, and shall not be used. Where appropriate, particular health regulations shall apply.

Unless stated otherwise, timber shall comply with the following:

In-ground contact	Durability Class 1 or 2 timbers, with sapwood removed or preservative treated to H5 Softwood preservative treated to H5
External, above-ground, exposed	Durability Class 1 or 2 timbers, with sapwood removed or preservative treated to H3 Softwood preservative treated to H3 (Note: AS 1684 makes provision for the use of some Durability Class 3 and 4 timbers in some applications. These shall only be used with the express approval of the designer)
External, above-ground, protected	Durability Class 1, 2, 3 or 4 timbers
Internal, fully protected and ventilated	Durability Class 1, 2, 3 or 4 timbers (any timber)

Specifications

Levels, Dimensions, Squareness and Setting Out

The structure upon which the framing is to be constructed shall be within the specified tolerances, with particular attention given to levels, dimensions, squareness and setting out.

Notes

- Levels: It is critical that all floor framing is level. Before commencing the set out, check that slab or timber floor framing is level. It may be necessary to pack the frames in the low areas or to rectify the high areas.
- Dimensions and Squareness: Check the position and squareness of the concrete slab or footings before commencing construction. Measure diagonals to check squareness.
- Setting Out: When setting out the wall framing, a small error in position can lead to misalignment of the other components, such as the roof. Base the set out on the longest side of a building, since this will reduce the likelihood of errors in squareness.
- Prefabricated Trusses or Roof Framing: If there are setting-out errors in the walls, there is a possibility that prefabricated roof trusses or framing may fail to engage the required supports. In complicated buildings, check the position of walls, before constructing the roof. It is critical that all wall framing be fixed and braced plumb.

Specifications

Bracing

All buildings shall be adequately supported against lateral wind loads, as specified in the relevant Standard (AS 1170.2 or AS 4055). In some cases, lateral earthquake loads may be a design criterion. The bracing requirements shall be determined for the appropriate Region, Terrain Category, Topography and Shielding and recorded on the drawings by the design engineer.

Tie Down

All buildings shall be adequately tied down to resist overturning due to wind loads, as specified in the relevant Standard (AS 1170.2 or AS 4055). The tie-down requirements should be determined for the appropriate Region, Terrain Category, Topography and Shielding and recorded on the drawings by the design engineer. Ensure that all tie-down systems are continuous to the footings or to the specified location on the structure.

Nailing

Where architraves are required to be subsequently removed during construction, the nails shall be temporarily left proud. On completion they shall be driven in and punched where appropriate.

Specifications

Timber Shrinkage

Provision shall be made for timber shrinkage. Gaps that result from timber splitting shall be repaired, filled with wood filler and sanded smooth before completion.

<u>Notes</u>

Timber shrinks in cross section, although, due to the grain structure, it remains relatively stable in length. Cover strips should be provided at the edges of timber panelling to allow for shrinkage. The use of kiln-dried timbers will reduce shrinkage.

The following information in drawn from a number of references, including the following:

- Anon (1989), *Introducing Timber – An Introduction to Wood and Timber*, Timber Development Association (NSW) Ltd, Timber Information Leaflet No 1
- Anon (1997), *Decorative Floors – Guide to Decorative Floors of Timber*, Timber Development Association (NSW) Ltd, Timber Information Leaflet No 4
- Anon (1997), *Hardwoods – Native hardwoods of the East Coast*, Timber Development Association (NSW) Ltd, Timber Information Leaflet No 18
- Anon (1974), *Technical Timber Guide - Shrinkage*, TRADAC

As timber dries, it shrinks, and in some circumstances cracks can open. The moisture content varies with type and the degree of seasoning. Seasoned timber has moisture content in the range approximately 10% to 15%, and a variation of up to 2% within any lot of timber. Dense close-grained

Specifications

Preservatives

Timber in exposed applications shall be treated to minimize fungal decay and attack by insects. The following preservatives are available for the treatment of timber, subject to the health warnings below. Copper chrome arsenate (CCA) shall not be used.

- Ammoniacal copper quaternary (ACQ
- Copper azole
- Boron
- Creosote
- Pyrethroid- and metal-based light organic solvent preservatives (LOSPs).

Notes

Copper Chrome Arsenate (CCA) : CCA consists of heavy metals, copper, chromium and arsenic, which may leach from the timber and pose a health risk. CCA should no longer be used; and when timber treatment is required, one of the alternatives listed above may be used. If CCA-treated timber is already in use, the following precautions should be taken:

- Wear protective equipment when handling CCA treated timber.
- Wash hands thoroughly after handling CCA treated timber.
- Do not allow food to come into contact with CCA treated timber.
- Do not burn CCA treated timber in open fires, stoves, fireplaces or the like.

Specifications

Health Warning – Other Preservatives

Creosote: Creosote gives off a vapour that irritates the eyes and skin; and is therefore not recommended.

Pigment Emulsified Creosote (PEC): PEC is a combination of coal tar, with a heavy metal pigment used to stabilize it. PEC is not suitable normal building applications.

Light Organic Solvent Preservative (LOSP): LOSP is a solvent-based treatment, which inhibits fungal invasion of timber. It contains copper naphthenate, zinc naphthenate, tri-butyl tin oxide (TBTO) or pentachlorophenol (PCP), with resin or wax to improve its retention and increase the water repellency. LOSP will release, to the atmosphere, 30-40 litres of hydrocarbon solvent per cubic metre of treated timber. LOSP is suitable for above-ground applications where dimensional-stability is important, is used principally in external applications (e.g. fences, decks and outdoor furniture). LOSP is not suitable for in-ground applications because it does not chemically fix in the wood, and will leach into the soil. LOSP must not be used for food storage, except where LOSP formulation is of very low toxicity. Where LOSP treated timber is exposed, cut or drilled, the exposed surface should be coated with a post-protection treatment.

Pentachlorophenol (PCP): PCP (derived from sodium pentachlorophenate) is an organochlorine family, of the same chemical group as DDT and Agent Orange. PCP can cause fatigue, fever, weight loss and nausea. PCP dioxins can also cause birth defects, allergies or cancer. PCPs can be passed on to successive generations through sperm and breast milk. PCP must be disposed of without special technology and facilities. It is recommended that PCPs should not be used.

Reference: RIC Good Wood Project & the Good Wood Advisory Centre, Victoria, Preservatives

Timber and Timber Products for In-ground Use

Timber and timber products for in-ground use shall comply with the Drawings, Building Regulations and relevant Standard (AS 1684 [residential applications], AS 1720 [non-residential applications]), and shall be of the nominated stress grade (or strength group), durability class, and (where appropriate) lyctid susceptibility, shrinkage and ignitability.

Standard Trade Name	Preservative Requirement	Availability	Strength Group Seasoned	Durability Class	Lyctid Susceptible	Tangential Shrinkage %	Early Fire Hazard Ignitability
Grey Coast Box	O	R	SD1	1	S	8.2	
Grey Ironbark	O	R	SD1	1	N	7.5	
Grey Gum	O	R	SD2	1	N	7.0	
Tallowwood	O	R	SD2	1	S	6.1	12
Jarrah	O	R	SD4	2	S	7.4	13
Hoop Pine	P	R	SD5	4	N	3.8	14
Slash Pine	P	R	SD5	4	N	4.2	
Caribbean Pine	P	R	SD6	4	N	5.0	
Radiata Pine	P	R	SD6	4	N	5.1	14
Red Ironbark	O	L	SD3	1	S	6.3	
Gympie Messmate	O	L	SD3	1	N	6.0	
Bangkirai	P	L	SD3	2	S	5.0	
Keruing	P	L	SD3	4	S	9.5	
Forest Red Gum	O	L	SD4	1	N	8.6	
Celery Top Pine	O	L	SD5	1	N	3.0	
River Red Gum	O	L	SD5	2	S	8.9	

Notes:

1. This table is based on AS 1684.2 & 3 Table H1. For additional properties and definitions refer to source document.
2. Preservative requirement: P = Should be preservative treated, S = Should be seasoned ,O = Commonly used untreated
3. Availability: R = Readily available, L = Limited Availability
4. Durability Class: 1 = Highest natural durability to 4 = Lowest natural durability.
5. Where required to achieve particular resistance to termite and/or borer attack, the species listed herein shall be treated to achieve the hazard levels listed in AS 1684.2 & 3 Table C1.
   Lyctid Susceptible: S = Susceptible, N = Not susceptible, R = Rarely susceptible

Setting-out Elevated Timber Houses

This training module provides guidance for the setting out of simple houses.

Surveyor to Mark Boundaries, Corners and Levels

Preliminary Clearing

On a site with trees and other heavy vegetation, it may be necessary to carry out some site clearance prior to the survey to provide suitable lines of site.

Checking Requirements

Whilst it is tempting to set out a building based on previously established corner pegs, there is considerable risk that they have not been correctly located during the original survey, or have been subsequently moved. Use a registered surveyor to establish and record the site corner pegs, the building corner pegs and the local level datum. Before commencing the setting out work, the Surveyor should check the approved plans to ensure that the boundary distances, heights and other critical dimensions meet the requirements of the site and relevant regulations. Check that there have been no drawing errors incorporated into the approved plans. Once construction has started it is difficult, if not impossible, to correct problems of set out. In particular, check all heights and reduced levels (RLs). Any errors or potential conflicts shall be brought to the attention of the Builder.

Detailed Survey Drawings

Local authorities may require a survey on completion of building works before issuing occupation certificate. On completion of the survey, the Surveyor shall provide to the Builder certified plans showing the boundaries, corner points of the building, gridlines, benchmark and temporary benchmark.

Levels, Dimensions, Square, Setting Out

Levels

It is critical that all floor framing is level. Before commencing the set out, check that slab or timber floor framing is level. It may be necessary to pack the frames in the low areas or to rectify the high areas.

Dimensions and Square

Check the position and square of the concrete slab or footings before commencing construction. Measure diagonals and pairs of opposite sides to check square.

Setting Out

When setting out the wall framing, a small error in position can lead to misalignment of the other components, such as the roof. Base the set out on the longest side of a building, since this will reduce the likelihood of errors in square.

Profiles and Recovery Pegs

Sometimes profiles and corner pegs can be disturbed.

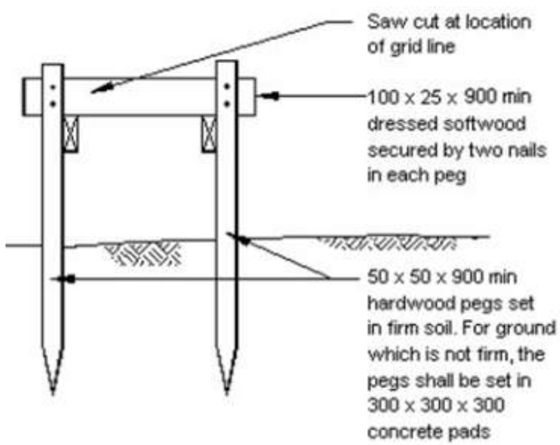
- To avoid disruption of profiles, ensure that they are placed an adequate distance from the earthworks.
- To recover lost profiles always measure from the principal grid line.

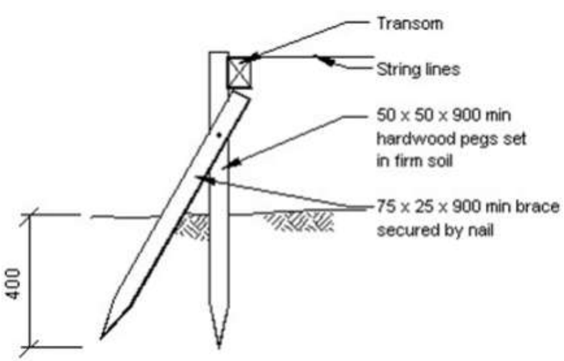
Marking Boundaries, Corners and Levels

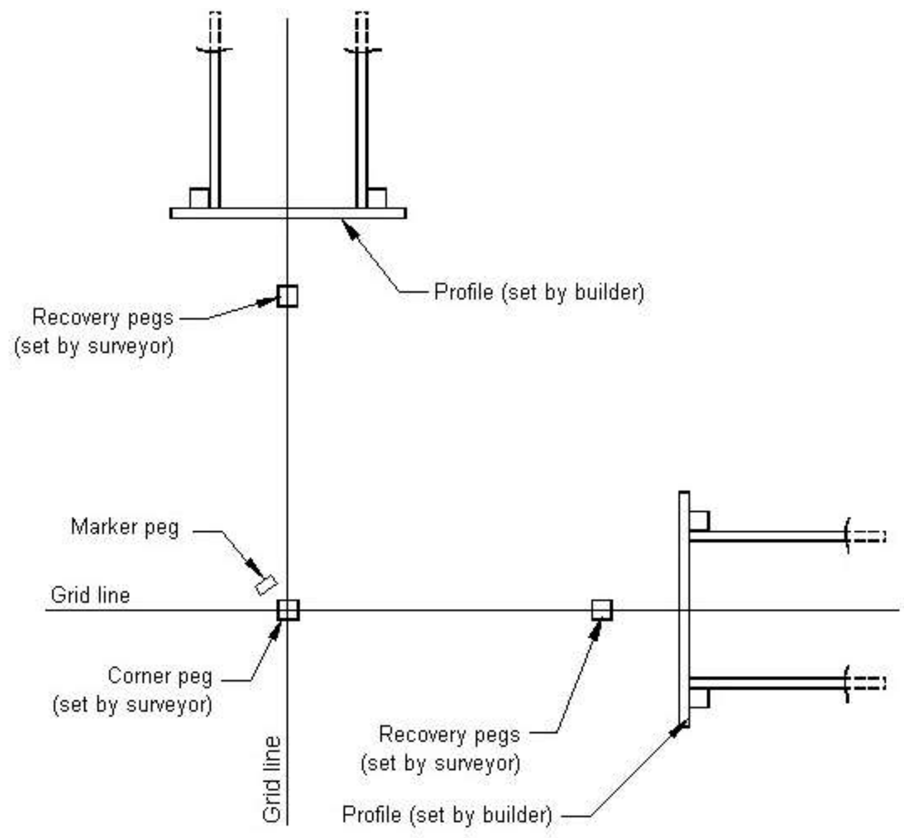
The Surveyor shall mark by means of pegs, nails and paint the site boundaries, corner points of the building, gridlines shown on the drawings, benchmark and temporary benchmark. All pegs, nails and other marks shall be clearly identified by paint, coloured ribbon and/or star pickets and protected against damage.

Profiles and Recovery Pegs

Where earthmoving machinery traverses the site, corner pegs will almost certainly be disrupted. Timber profiles (and perhaps offset pegs) are erected at some distance beyond the limits of any earthworks. Profiles establish the plan position of the main building grid lines. It is difficult (but not impossible) to simultaneously establish both plan position <u>and</u> level using the same profiles, although it is best to establish levels independently of the profiles. Pegs for marking gridlines and the like shall be 50 x 50 x 450 mm minimum hardwood with a sharpened point. Timber for profiles shall be dressed softwood.



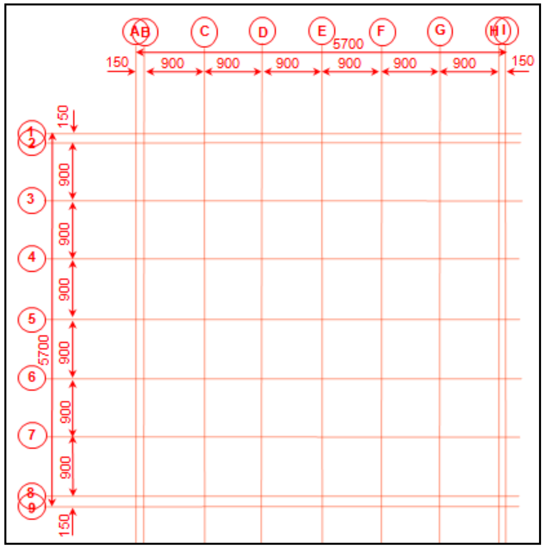


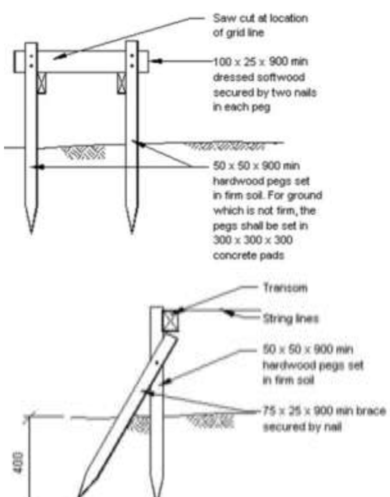


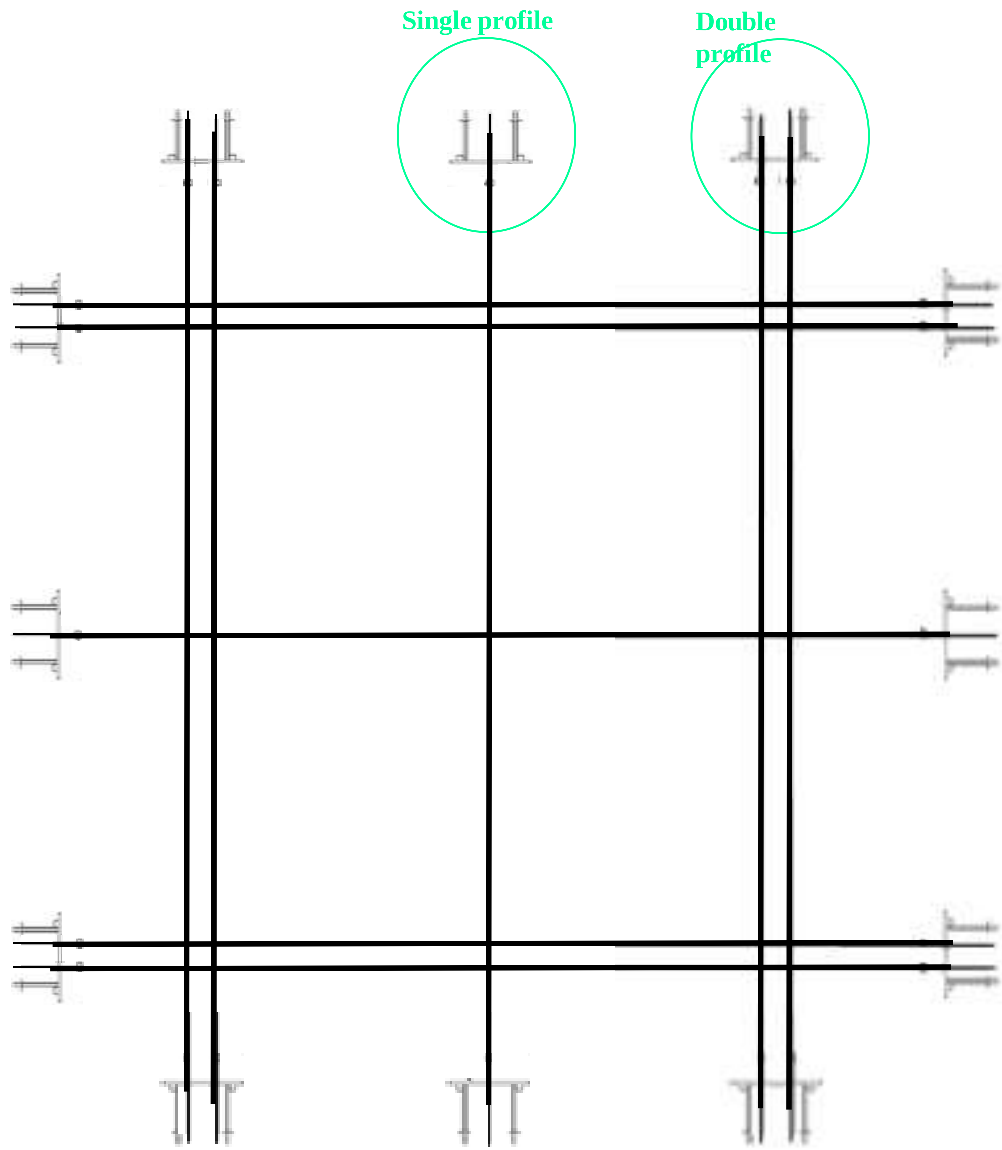
<u>Typical Layout of Profiles and Pegs</u>

Profiles Setting Out Gridlines

Set out grid lines as per the drawing.
Where to grid lines are close together,
set out both on the same profile



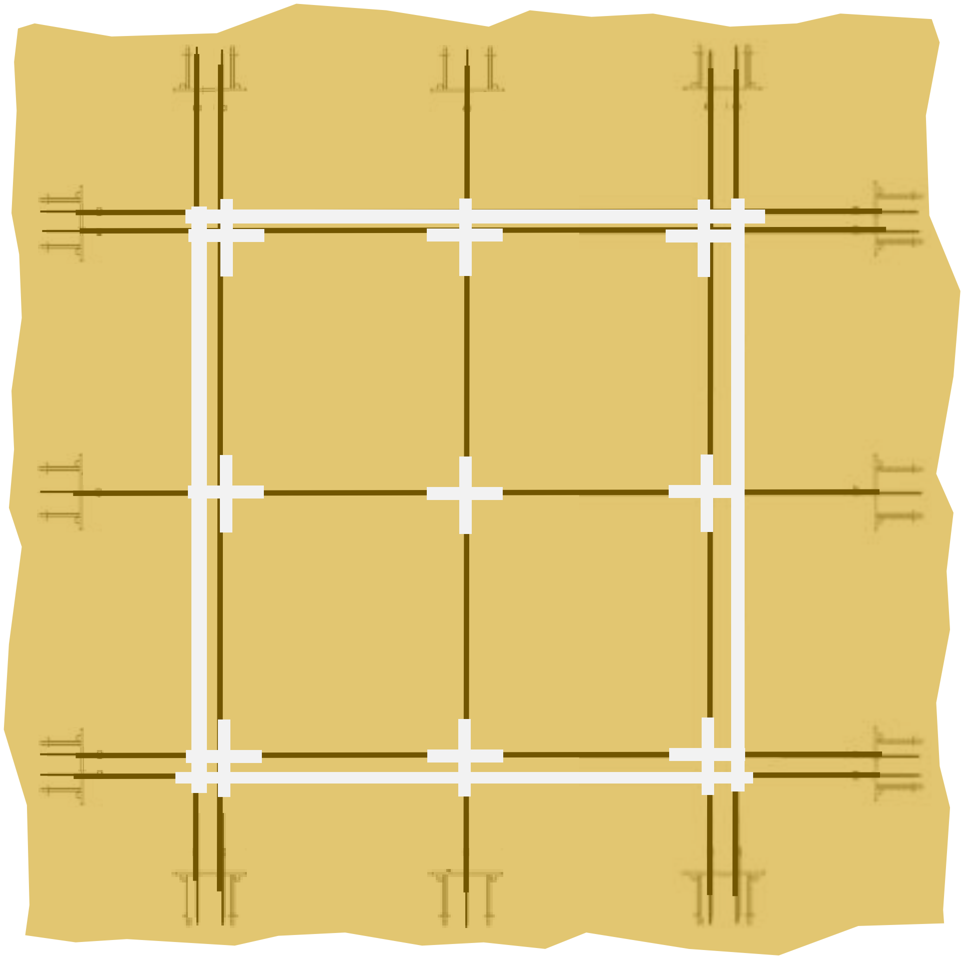




Marking with Lime

After the gridlines are established and the string lines positioned, the outline of the building and footing positions should be marked on the ground using hydrated lime.

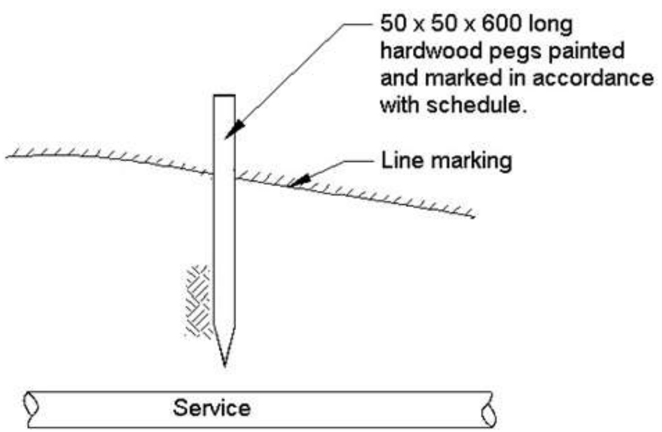
String lines are removed later to permit excavations to take place, and footings may by located using the lime outline.



Services

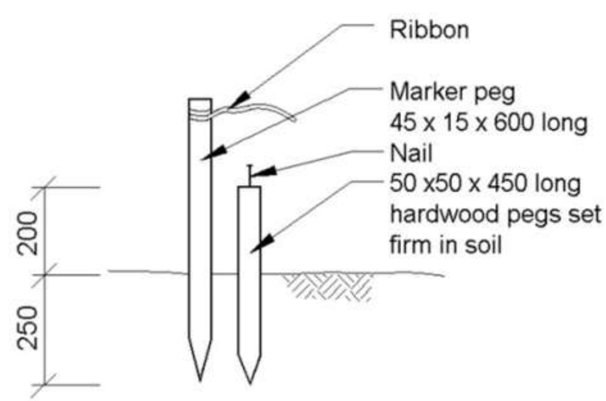
A common problem in urban areas is the unearthing of services such as sewer pipes, water pipes, electrical conduits, telephone, gas and the like.

- Emergency telephone numbers of a plumber and electrician shall be prominently displayed in the site office.
- Obtain from the local authority or services authorities the location of all services.
- Mark these clearly on a site plan.
- Mark their location on the ground using pegs and lime. Marker pegs shall be 45 x 15 x 600 mm minimum hardwood with a sharpened point.



SERVICE	COLOUR
Electricity	
Water	
Drainage	
Telephone	
Gas	
Survey	

Marking of Services



Corner or Offset Pegs with Marker Pegs

Dimensions, Square, Setting Out

Depending on the equipment available, setting out may be by one of the following methods:

- Electronic distance measuring equipment or electronic digital theodolite - generally used by surveyors or major builders.
- Manual theodolite - generally used by established builders.
- Tape and geometric calculation - generally used in remote locations where expert surveyors are not operating.

Acknowledgement: Universal
http://www.universalinstruments.com.au/

The following geometric calculations are useful:

Setting out a right angle (90^{o})

1. Establish a base line at least 8 metres long. Place pegs with nails in the top at each end of the base line “A”, and “B”, and draw a string line tight between the two nails.

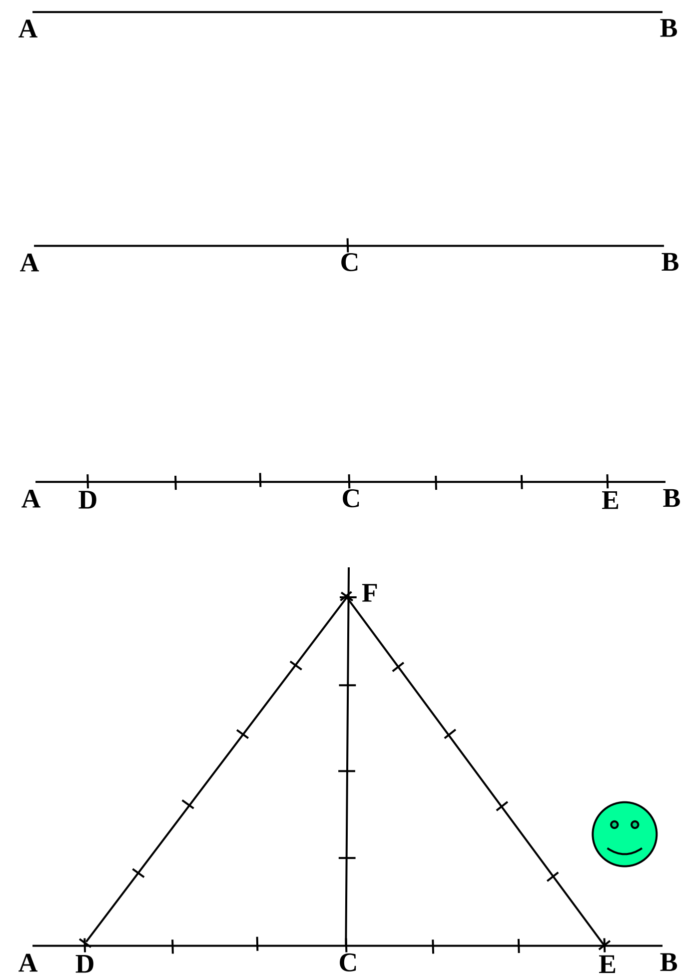
2. Locate on the base line the point where the line at right angles must intersect. Place a peg with a nail in the top at this point “C”.

3. Using a tape, measure and place pegs with nails in the top at a fixed distance (say 3 metres) in both directions along the base line, “D” and “E”.

4. Using two tapes simultaneously, measure a distance of 5 metres from both points “D” and “E”. Where these points coincide, place a peg with a nail in the top “F”.

5. The line “F-C” is perpendicular to line “A-B”. That is, angles “ACF” and “BCF” are both right angles (90^{o}).

6. To check the accuracy of this set out, measure the distance “F-C”. It should be 4.0 metres.

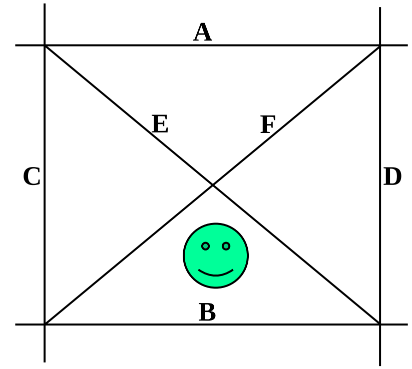


Checking for “square”

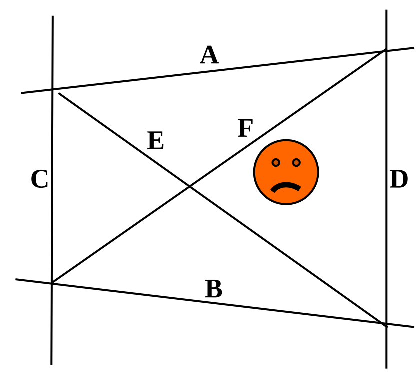
To check whether the grid lines are “perpendicular” to each other or are “skewed”, measure the diagonals across the rectangle formed by the grid lines and measure each pair of opposite sides of the shape.

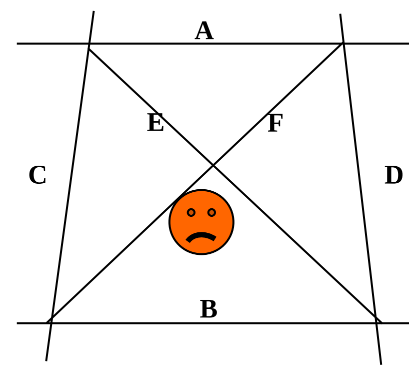
- If the diagonals are equal and both sets of opposite sides are equal, the grid lines correctly form rectangles; that is the lines are perpendicular to each other, at right angles (90^o) and the shape is a rectangle.

  A = B, C = D,   E = F

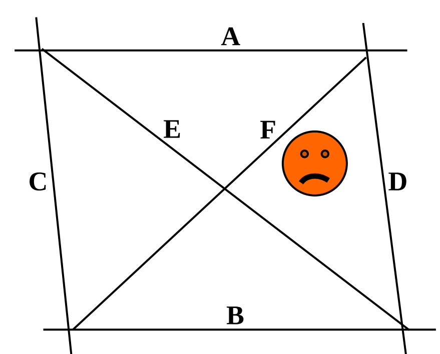


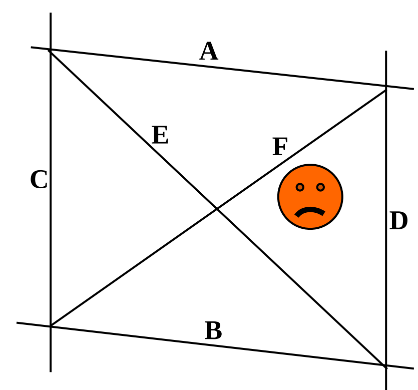
- If the diagonals are equal but the opposite sides are not equal, the grid lines are skewed and must be corrected.
  - Even though A = B and E = F, the shape will not be a rectangle if C ≠ D.
  - Even though C = D and E = F , the shape will not be a rectangle if A ≠ B.





- If the diagonals not are equal although the opposite sides are equal, the grid lines are skewed and must be corrected.
  - Even though A = B and C = D, the shape will not be a rectangle if E ≠ F.

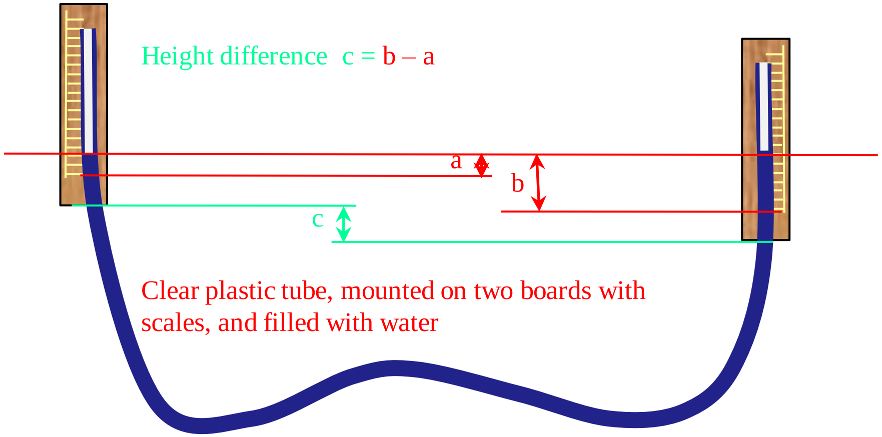




Levels

Depending on the equipment available, the establishment of levels may be by one of the following methods:

- Laser levels – generally used by surveyors or major builders
- Automatic levels – generally used by surveyors or major builders
- Manual tilting levels – less common on modern building sites
- Water level gauge – generally used in remote locations where surveyor's levels are not available

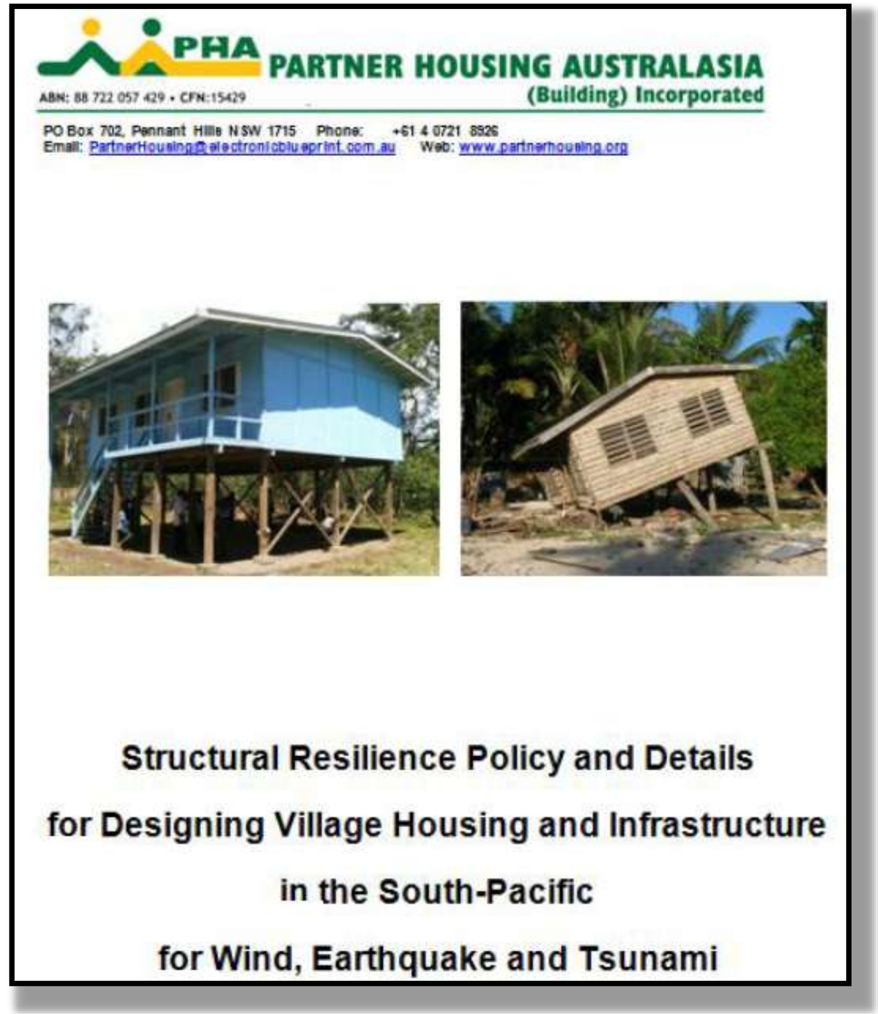


Setting Out

Design and Construction Checklist				
Site				
Activity	Setting Out			
Item or Product	**Inspection Required**	**Accept Criteria**	Hold Witness	**Date, Inspector, Comment**
Drawing showing: boundary pegs, corner pegs, gridlines, benchmark, temporary benchmark	Inspect latest copy of the drawing	Latest issue of drawing with the relevant information in file	W	
Boundary pegs	Visual spot check	Pegs in place and protected	W	
Corner pegs	Visual spot check	Pegs in place and protected	W	
Gridline pegs	Visual spot check	Pegs in place and protected	W	
Benchmark and temporary benchmark	Visual spot check	Benchmarks in place and protected	W	
Profiles	Visual spot check	Profiles in place and protected	W	

Structural Design

This module provides an example of the structural design of village houses in accordance with the Partner Housing policy document.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Structural Resilience Policy and Details

for Designing Village Housing and Infrastructure

in the South-Pacific

for Wind, Earthquake and Tsunami

Structural Design Loads on Village Housing

The following page shows the loads on this type of house in these locations. It is for use by the Design Engineer, but is also included here to define the limitations imposed on the structure. The Builder should ensure that the Design Engineer has based the design on this information. The loads are calculated in accordance with the following references, and are subject to amendment following site inspection and to suit the building regulations of the country :

- Design for Ultimate Limit State – The Reference Period (design life) is 25 years and the specified Annual Probability of Exceedance is 1 in 250, leading to a probability of exceedance during the life of 0.10. This does not mean that there is 10% probability of failure, since the "10% overload" must act on an "under-strength" component for failure to occur. Load factors (applied to the loads) and capacity reduction factors (applied to a specified "lower 5 percentile" characteristic strengths of components) ensure that the probability of failure is "low" (e.g. Target Reliability Index $\beta = 3.1$)
- Load Combinations– As per Australian and New Zealand Standard AS/NZS 1170.0
- Permanent Loads – As per Australian and New Zealand Standard AS/NZS 1170.1
- Imposed Loads – As per Australian and New Zealand Standard AS/NZS 1170.1
- Wind Loads – Analysis assumptions are set out in Standards Australia AS 4055:2012 *Wind loads for housing* and the wind speeds from Standards Australia HB 212 *Design wind speeds for the Asia-Pacific region*, 2002
- Earthquake Loads – Analysis assumptions are set out in AS 1170.4:2007 *Earthquake loads for Australia*, EDC II, except that hazard factors appropriate to the region are selected.
- Tsunami and Flood Loads – These must be analysed on a site-by-site basis, using the method in Australian Building Codes Board Handbook, *Construction of Buildings in Flood Hazard Areas*, Version 2012.2. The structural components shall be designed to withstand the design event, assuming that the cladding is partially destroyed.

Structural Design Loads on Village Housing

The following engineering data is provided for general information only. The design of the structure must be carried out be a suitably qualified and experienced structural engineer.

Wind Category	Description	Equation	$V_{250(3,10)}$ m/s	$V_{500(3,10)}$ m/s	$V_{50(3,10)}$ m/s
Zone I - Pacific islands adjacent to the equator, East Timor, Papua New Guinea, Solomon Islands , Indonesia, Malaysia, Singapore, Inland Karnataka (India),	Strong thunderstorms and monsoon winds	$70–56\ R^{-0.1}$	38	40	32
Zone II (A) - South-west tip of Papua New Guinea, most of southern India, western Indial coastal strip (Mumbai, inland Madhya Pradesh, Orissa), western Mindanao	Moderately severe thunderstorms and extra-tropical gales	$67–41\ R^{-0.1}$	43	45	39
Zone III (B) - Coastal strips of Tamil Nadu (including Chennai), Andhra Pradesh, Orissa, Gujaret, West Bengal (including Calcutta), Assam, northern India (inclusing Delhi), central Tamil Nadu, Eastern Mindanao, Palawan(Philippines)	Severe thunderstorms and moderate or weakening typhoons or tropical cyclones	$106–92\ R^{-0.1}$	53	57	44
Zone IV (C) - Pacific Islands below 6^{o}S, Tripiura & Mizoram, Ladakh (India), remainder of Philippines	Strong typhoons or tropical cyclones	$122–104\ R^{-0.1}$	62	66	52
Zone V (D) - Eastern Luzon (Philippines),	Very strong typhoons or tropical cyclones	$156–142\ R^{-0.1}$	74	80	60
Notes 1.Wind speeds are for a 3 second gust, at 10 m height in open country terrain. 2.Source: HB 212 Design wind speeds for the Asia-Pacific region, Standards Australia 2002					

Structural Design Loads on Village Housing

All loads are subject to amendment following site inspection and to suit the building regulations of the country.

Location: **Western Highlands of Papua New Guinea**

Building: Small detached village building; Presenting a low degree of hazard to life and other property in case of failure; Single storey; Cladding on elevated braced timber frame OR Reinforced concrete masonry on concrete slab-on-ground; Maximum dimensions: 12.5 x 8.0 m, 2.7 m storey, Maximum eaves height 6.0 m, Maximum ridge height 8.5 m, Maximum pitch 35°

Design: Design life 25 years; Annual probability of exceedance 1 in 250; Probability of exceedance during life: 0.10

Soil: Shallow sandy-clay, Characteristic internal friction angle 27°; Site classification “M”; Ultimate bearing capacity 300 kPa.

Permanent Loads: Elevated timber building, w = 2.5 kN/m^2 (floor area), Reinforced masonry building w = 3.5 kN/m^2 (floor area)

Imposed Loads: Floor load 1.5 kPa; Roof load 0.25 kPa

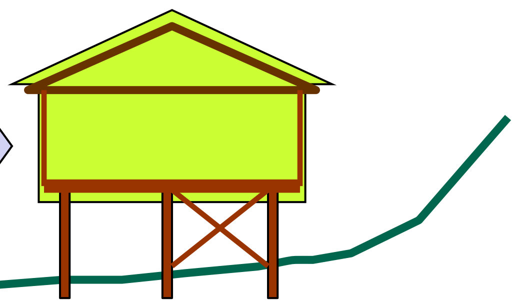
Wind: Non-cyclonic, Wind Class I (N1), $V_{250(3,10)}$ 38.0 m/s, V_u = 35.8 m/s; $q_{z\ u}$ = 0.77 kPa

Earthquake: Probability k = 0.84; Hazard Z = 0.40; Subsoil = C; Ordinate $C_{h(T1)}$ = 3.68; Ductility, μ = 2.00; Performance, S_p = 0.77

Tsunami: Tsunami risk factor $_{(1\ to\ 10)}$ Nil

Flood: Building must not be built in or close to a watercourse, Flood risk factor $_{(1\ to\ 10)}$ 0

Wind:
No shielding, Terrain Category 2, Topographic Category T0
Wall cladding within 1.2 of corner: +0.68 kPa, -1.03 kPa
Wall cladding over 1.2 m from corners: +0.68 kPa, -0.59 kPa
Roof edges: +0.48 kPa, -1.37 kPa
Roof general: +0.48 kPa, -0.75 kPa
Racking normal to ridge: 24.6 kN
Racking parallel to ridge: 26.5 kN



Tsunami or Flood
Cladding: Nil
Structure: Nil

Earthquake load for elevated timber building:
Wall racking = 0.21 x building weight (approximately 0.44 kN/m^2 $_{floor\ area}$)
Base shear = 0.47 x building weight (approximately 1.0 kN/m^2 $_{floor\ area}$)

Earthquake load for reinforced masonry building:
Wall racking = 0.48 x building weight (approximately 1.16 kN/m^2 $_{floor\ area}$)
Base shear = 0.95 x building weight (approximately 3.32kN/m^2 $_{floor\ area}$)

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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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